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shotcrete MAGAZINE

VOLUME 21, NUMBER 1 • WINTER 2019

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The opinions expressed in *Shotcrete* are those of the authors and do not necessarily represent the position of the editors or the American Shotcrete Association.

Editor's Note: Shotcrete is a placement method for concrete. However, for the sake of readability, the word "shotcrete" is often used either to identify the shotcrete process (method of placement) or the shotcrete mixture (product materials).

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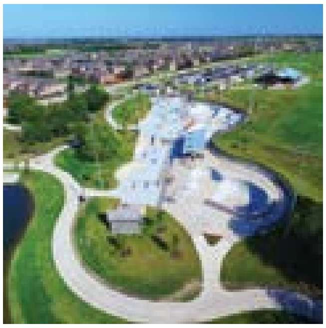
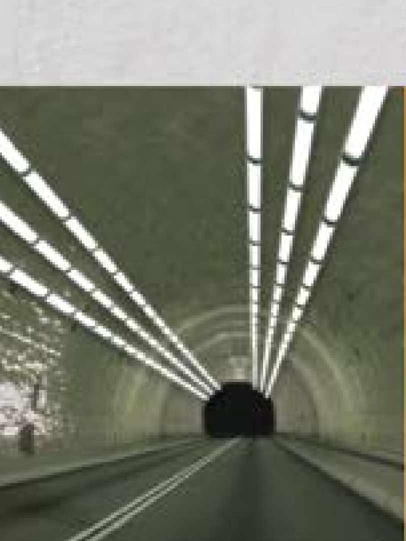


On the cover: Northeast Community Skatepark in Frisco, TX
Read the Outstanding Pool & Recreational Project article on page 16.

Ironically, repairing one of the busiest tunnels in Steel City required our shotcrete.



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ASA PRESIDENT'S MESSAGE

Shotcrete Technology Advancement

By Lihe (John) Zhang

Since Carl Akeley first developed the shotcrete process in 1907, the industry has evolved with over a century of technology advancement. Over the last three decades, we've seen major advancements, including:

1. Wet-mix shotcrete has wide acceptance in large infrastructure projects;
2. Robotic spray systems are increasingly used for ground support in mines and tunnels;
3. New chemical admixtures, such as alkali-free accelerator, hydration control admixtures, colloidal silica, and other admixtures are used to improve the workability and shootability of shotcrete mixtures;
4. Fiber reinforcement is widely used for shotcrete application in ground support and other applications. The incorporation of steel fiber or macrosynthetic fibers has greatly improved ground support schedules and provided cost savings; and
5. Structural shotcrete has increasingly been used in buildings and structures across the United States and Canada in urban environments in place of traditional form-and-pour. Civil concrete structural construction is using the distinct benefits of shotcrete placement in place of form-and-pour. On these projects, shotcrete reduces formwork and time of construction resulting in significant cost savings. As we look to the future, where are we expecting shotcrete technology to go? Here are some trends:

SOPHISTICATED AND COMPLEX CONCRETE STRUCTURES

Sophisticated and complex concrete structures with intricate reinforcement details are now being constructed with shotcrete. An example is in underground applications for the New York City metro system. Thick structural walls are being constructed using shotcrete as the final lining method. Future trends are for shotcrete to be used for construction of more of these types of structures, including subway final lining walls and station structures. The critical reason shotcrete is being used in these types of structures is primarily due to the inherent benefits of the shotcrete application. For successful shotcrete applications, contractors need relevant experience with shotcrete materials and mixture designs, equipment, and competent shotcrete crews. Rigorous quality control monitoring, inspection, and testing should be provided by the Owner. In addition, collaboration with the structural design engineer is also vitally important.

DURABILITY OF SHOTCRETE STRUCTURES

With more and more structures being built with shotcrete, proof of the durability of shotcrete is an important issue. Recent research projects and field applications have demonstrated that properly constructed shotcrete structures can provide equal or better durability to traditional form-and-pour placement methods. Ongoing research and

engineering projects will assess the long-term durability of shotcrete. Durability aspects being evaluated include chloride penetration, ionic migration, heat of hydration, and service life prediction and validation.

REPAIR AND REHABILITATION

The construction industry is increasing the use of shotcrete in a wider variety of repair, rehabilitation, repurposing, and strengthening projects. Examples include hydro dams, tunnels, water supply and treatment systems, and nearly any concrete structures requiring repair and rehabilitation. Each project is unique and requires special considerations during the design and construction phases. Repair with shotcrete is a great way to extend the life of a structure without incurring the cost of demolition and rebuilding.

NEW MATERIALS

The shotcrete industry has never been shy in developing and using new materials to enhance productivity and performance. A recently developed natural hemp-based fiber has proven results on shotcrete projects that it can greatly enhance the workability and shootability of shotcrete while reducing early-age plastic shrinkage cracking. It is important to note that not all new materials that may work for conventional form-and-pour applications will work for shotcrete.

EQUIPMENT INNOVATION

Use of robust shotcrete pumps is crucial for structural shotcrete applications. Innovative robotic sprayers are able to increase placement rates and safety to accelerate the mining cycle. With the mining industry increasingly going underground and more civil tunnels being built, advances in development of shotcrete equipment at a rapid pace is expected.

TO THE FUTURE OF THE SHOTCRETE INDUSTRY AND ASA

The future for the shotcrete industry is bright. The American Shotcrete Association, through the contributions of its working committees, publications such as *Shotcrete* magazine, and efforts of corporate and individual members, is playing a significant role in advancement of shotcrete technology. This is my last article as President of the American Shotcrete Association. It has been a privilege to serve in this capacity and I would like to thank the ASA Executive Director/Technical Director, Charles Hanskat, P.E.; Alice McComas, Senior Programs Coordinator; and Lacey Stachel, Editorial and Marketing Manager; as well as chairs and active members of our ASA committees for their invaluable contributions to shotcrete technology advancement during my tenure as President.

Publications Committee

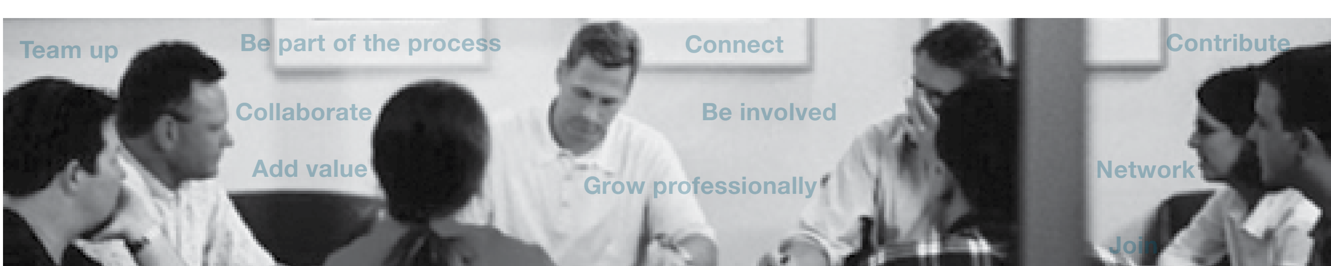
By Ted W. Sofis

In the 15 years that I've been an active member of the Publications Committee, we've accomplished a great deal. I want to thank Rusty Morgan and Marc Jolin for the years they served as the magazine's Technical Editors. There were several of us who, in addition to serving on the Publications Committee, assisted on other committees. However, *Shotcrete* magazine has always been a priority. It was through *Shotcrete* magazine that we put together a quality publication to educate and inform the construction industry about shotcrete. The magazine provided a vehicle to highlight and promote the advantages of shotcrete in many applications where it produced efficiencies and cost savings. We promoted good work practices; discussed specifications; and always stressed quality in preparation, materials, and application technique. We answered technical questions in the magazine and published technical papers. The quality of the magazine has raised the acceptance of shotcrete with the engineering community and the concrete construction industry.

It has provided a forum for discussion for everything relating to shotcrete. The American Shotcrete Association is made up of contractors, engineers, manufacturers, educators, students, and craftsmen. I believe this is our biggest strength. ASA members use shotcrete placement in a wide variety of applications and industries. In choosing themes for our issues, we selected relevant content to reflect this variety. We've had issues include topics on tunneling, pools and recreation, infrastructure, refractory, water and wastewater structures, domes, and artistic rock features.

Several years ago we began designating a spearheader for the theme selected. It was this spearheader's responsibility to help line up authors and relevant articles for the upcoming issue. We added the Committee Chair Memo feature, which rotated among the Committee Chairs, to brief our readers on what our committees had accomplished and updates on current committee work.

ASA has been proactive in addressing industry trends, such as the "Top 10 Sustainability Benefits of Shotcrete" series several years ago. ASA's active involvement of industry leaders allows the content of *Shotcrete* magazine to provide insightful, relevant information on emerging trends. I want to thank Charles Hanskat, our Executive Director, for serving as our current Technical Editor and Technical Director, in addition to the many other things he does. When I began writing articles and became involved with the Publications Committee, I worked with Melissa McClain and I want to acknowledge her work as well. However, a very special thank-you goes out to Alice McComas, our Managing Editor,



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who wears many hats and has done a fantastic job putting together each and every issue of *Shotcrete* magazine. I also want to thank all of you who have written articles for our magazine or served on the Publications committee. Without you, none of this would have been possible.

The Carl Akeley Award was established 18 years ago, at Rusty Morgan's suggestion, to recognize technical advances in the shotcrete industry. Carl Akeley, with his cement gun in 1907, invented the shotcrete process. The award, in honor of him, is given for the best technical article to appear in *Shotcrete* magazine each year. This award is presented at our annual Outstanding Shotcrete Project Awards Banquet.

Looking forward, I would like to welcome Lacey Stachel, our new Editorial and Marketing Manager. ASA has grown, and with growth, the work required for the magazine, certifications, and marketing has increased as well. Lacey will be a big help and a positive addition to the ASA staff. With Lacey's involvement and the reorganization of committee work revolving around our Strategic Goals, the work of the Publications Committee is now embedded within each of our other committees. At our Fall meeting in Las Vegas last October, the Board discharged the Publications Committee, thanking us for our services in developing the quality magazine we have today. We thank all current and past members for a job well done.

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Progress on Many Fronts

By Charles Hanskat, PE, FACI, FASCE, ASA Executive Director

We have reached several milestones for ASA and the shotcrete industry that I'd like to share with you.

OUR SECOND ANNUAL ASA SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE

Based on the success of our 20th Anniversary Shotcrete Convention in Napa, CA, last year we moved ahead to host another convention this year. We just wrapped up the convention and once again got rave reviews from our attendees. We enjoyed great attendance with almost identical numbers as last year's 20th anniversary celebration in Napa. The Omni Amelia Island Plantation Resort in Fernandina Beach, FL, was a unique and relaxing venue with a super staff and much better weather than back at our offices in Detroit, MI. The meeting rooms and exhibit hall were all in one location, allowing our members plenty of opportunities throughout the meetings, sessions, and food events to meet old friends and new attendees without being spread out across the convention center. Our 14th Annual ASA Outstanding Shotcrete Project Awards banquet, held at Walker's Landing, a unique facility overlooking an inland tidal marsh, was well attended and provided recognition to our many award winners.

We had excellent committee participation and some spirited conversations. All our committees are making good progress on their individual goals supporting our ASA Strategic Plan. Our Shotcrete Technology Conference included 18 technical sessions on a wide variety of shotcrete topics with speakers from across North America and Europe. Thank you to all our sponsors, attendees, and speakers for supporting this great event!

As you may imagine, a successful convention doesn't just happen. It takes a lot of behind-the-scenes work for many months to make an event of this scale successful. Our ASA staff, Alice McComas and Lacey Stachel, worked tirelessly on getting all the details covered. We also had great support from Susan Esper in AOE Publishing Services, and Cariann Nagy in AOE Event Services. My personal thanks to all our staff for their diligent work to make our second Shotcrete Convention such a great success. You can find more details and pictures from the convention in our Association News section of this issue.

WORLD OF CONCRETE 2019

2019 was our 19th year being a co-sponsor of the annual World of Concrete. As usual, we had a booth in a prominent location in the South Hall, put on several educational ASA seminars, hosted our annual General Membership Meeting, and had members presenting at WOC technical seminars. ASA provided three full-day classes: two ASA Shotcrete Nozzleman education classes (English and Spanish); and a Shotcrete Contractor education class. We also had a Wet-Mix ACI Shotcrete Nozzleman Certification session hosted by Hydro-Arch in Henderson, NV, at the end of the week. Thanks to Marcus von der Hofen and Frank Townsend for presenting on Advanced Shotcrete for the technical seminar. Our Membership Meeting was the best I've ever attended. Thanks to all who attended. Though I'd love to think it was because so many people were highly interested in our Association's performance in 2018, I do wonder if the reception that immediately followed the meeting might have had some influence on our attendance.

SHOTCRETE INCLUDED IN ACI 318

ACI 318 Building Code Requirements for Structural Concrete is THE reference for structural concrete designers around the world. Unfortunately, none of the previous ACI 318 versions included shotcrete. When a shotcrete contractor wanted to convince a design engineer to use shotcrete on one of their projects it was often an arduous task to get consideration because shotcrete was not included in ACI 318 in any direct fashion. It was not uncommon for the designer to be some-

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what conservative and just say "it isn't included in the design code so I'm not going to allow it." Though the International Building Code does have some rather antiquated shotcrete provisions, many engineers felt if shotcrete wasn't in the ACI 318 structural concrete Code they couldn't use it.

Well, with the ACI 318-19 version to soon be released, you will find shotcrete is directly covered in the Code!

Nearly 10 years ago Larry Totten (former ASA President and then Chair of ACI Committee 506, Shotcreting) and I attended an ACI 318 committee meeting asking about the coverage of shotcrete in the Code. Many members of the committee agreed that they could and in fact did use shotcrete on their projects despite it not being covered in the Code. We stressed to the committee that shotcrete was a method for placing high-strength, durable concrete and should be addressed in the Code. Fortunately, Jack Moehle, the incoming Chair of ACI 318 for the next Code cycle, listened and he identified inclusion of shotcrete as one of his goals for the new revisions of ACI 318.

ACI Subcommittee 318-A, General, Concrete, and Construction, chaired by ACI Past President Terry Holland, was charged with developing the shotcrete-specific revisions. I provided input to both Holland and 318-A member, Bruce Suprenant, the task group leader, on the many, many revisions and ballots needed to incorporate shotcrete in the Code through the consensus approval process at the subcommittee and then main committee level. I certainly thank Holland and Suprenant for their long battle in shepherding the shotcrete provisions through the consensus process. I also thank Moehle for including shotcrete as one of his goals for his term as Chair of ACI 318.

Inclusion in ACI 318 is a major achievement for shotcrete in the structural concrete world. Though shotcrete has certainly been covered in ACI 506 documents and other ACI Codes including ACI 350, "Code Requirements for Environmental Engineering Concrete Structures," and ACI 376, "Code Requirements for Design and Construction of Concrete Structures for the Containment of Refrigerated Liquefied Gases," being directly included in ACI 318 will lead many more engineers to routinely accept shotcrete on their projects.

However, we cannot rest on our laurels. With this vote of confidence from the concrete design community, we as an industry need to demonstrate in our work that we can consistently and efficiently produce high-quality, high-strength, durable structures with shotcrete placement. We all need to take to heart and prove by performance our ASA Vision, "Structures built or repaired with the shotcrete process are accepted as equal or superior to cast concrete."

2018-2019 Awardee

Antoine Gagnon *is a PhD Student in the Department of Civil and Water Engineering at Université Laval, Québec City, QC, Canada. The focus of his graduate research is in developing tools for the design and testing of fiber-reinforced shotcrete (FRS) for ground support. Gagnon has worked on shotcrete research projects with different companies in the industry. He also serves on technical committees of the American Concrete Institute. He received his bachelor's degree and his master's degree in civil engineering from Université Laval.*

Nomination for the scholarship for Gagnon came from Marc Jolin at Université Laval. Jolin's strong recommendation included the following: *"I have decided to nominate Antoine Gagnon, this time for his PhD project, for the quality of his dossier and the outstanding leadership and contribution he has offered to the shotcrete industry so far. Already 2 years in his PhD, Antoine has reached the position of Chair of ACI Subcommittee 506-B, Shotcreting-Fiber-Reinforced, where he has managed to jump-start the work of the committee. He is also Secretary of the WP-24 of the Rock Technique Centre, working on a document titled, "Guideline on the Applicability of Fibre-Reinforced Shotcrete for Ground Support in Mines." And if that is not enough, Antoine has also been doing a 96-month internship with the Australian Centre for Geomechanics (at the University of Western Australia). During this internship, he has made the case for high-quality shotcrete and nozzleman certification on many occasions and he is responsible for opening up many opportunities in R&D collaborations. It should be noted that all these extracurricular activities have been conducted while leading a strong PhD research program that will, in short, help better understand the potential of FRS and how to test and specify them."*

GAGNON'S GRADUATE RESEARCH

Design and Testing of Fiber-Reinforced Shotcrete (FRS) for Ground Support

FRS has been used for many years in the tunneling and mining industry. This composite is used as part of ground support programs to help control the movements of the ground, therefore maintaining the structural integrity of the excavation. This is becoming critical as mines reach deeper levels where seismic activities and high stresses are the source of dynamic events such as rock bursts.[1] These powerful events are known to be unpredictable, which makes them particularly dangerous. Unfortunately, our current knowledge and understanding of FRS make it difficult to use at its fullest, especially under dynamic loads.[2]

However, FRS and ground support programs are of great importance in underground activities, as they control productivity while protecting workers and equipment. Indeed, it is a construction method that can be deployed easily and rapidly. Therefore, it is crucial to investigate this issue and optimize the use of FRS in underground activities.

Objectives

In this context, the research project will work toward answering the general question: How can we take advantage of the full potential of FRS, especially under dynamic loads? To answer this main question, the project will focus on three specific objectives:

1. **Show the differences in the FRS performance measured with current test methods**
   Up to 20 different FRSs will be tested with five different ASTM and EN test methods to better understand how each test represents the behavior and performance of an FRS mixture. The idea is to identify how test

methods can be better adapted to certain contexts and why. Interesting preliminary results have already been published in Gagnon and Jolin.[3,4]

2. **Develop numerical analysis models to compare the potential of current test methods**
   Using a finite element modeling (FEM) software such as ABAQUS and previous fiber-reinforced concrete models, the data generated in the first phase will be compared in numerical models to confirm the previous conclusions and extend to new FRS mixtures. This will also highlight the significance of proper tuning for test methods under closed-loop control such as ASTM C1609 and EN 14651.
3. **Develop high-toughness FRS mixture designs for dynamic loads**
   In a parallel project, several different fibers have been tested to evaluate their behavior in FRS. The results will be used to evaluate their potential in high-toughness mixtures. Using the selected fibers at high dosages and in combinations, new FRS mixture designs will be developed with a focus on the ductility and toughness of the composite material. The challenge of maintaining a level of fluidity with such mixtures can be overcome with the use of air-entraining admixtures.[5]

Ultimately, this research will contribute to a better understanding of the behavior of FRS. It aids creation of design tools for engineers and presents high-performance alternatives to the shotcrete industry. These contributions will provide a safer underground environment for workers, provide access to previously inaccessible areas, and improve productivity in mine production cycles. It will also lead to an optimal use of FRS—this means less wasted material and less pollution as material often needs to be shipped to remote mine locations.

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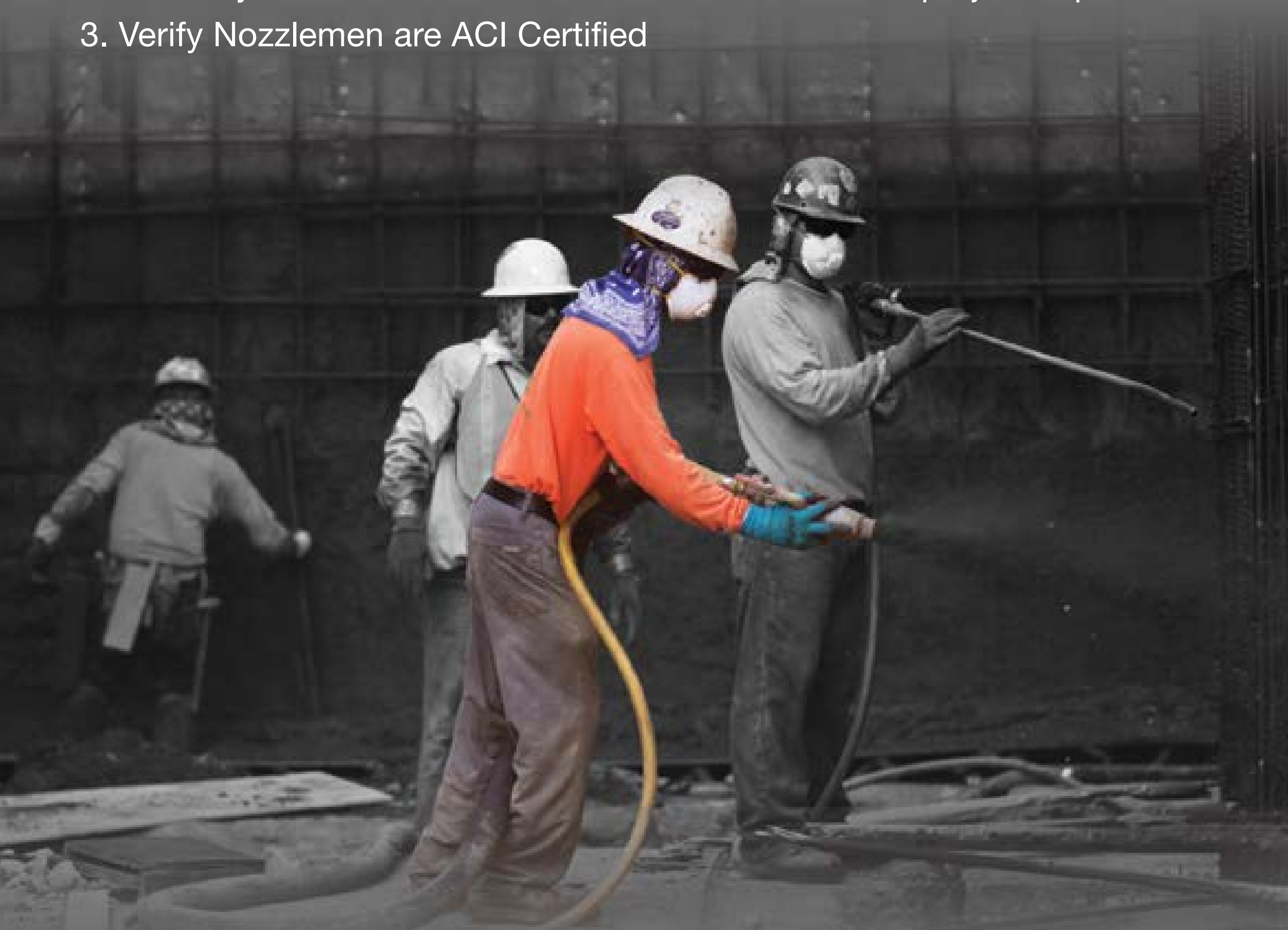

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2018 Outstanding Pool & Recreational Project

Making Concrete Waves at Frisco's Northeast Community Skatepark

By Jamie Curtis and Yann Curtis

The Northeast Community Skatepark in Frisco, TX, is a destination-scale, all-wheeled sports facility catering to skateboards, bikes, inline skates, and scooters (Fig. 1). The city's 75 acre (30 ha), $16 million project for phase one includes the skate park, concession and storage buildings, restroom facilities, a pond, new trails, and sports fields. As of writing this article, the 47,000 ft^2 (13,656 m^2) skatepark is the second largest facility of its kind in Texas and one of the largest in the United States as a whole. Newline Skateparks, Canada, designed the facility. SPA Skateparks, Austin, TX, was selected as the turnkey skatepark construction contractor.

SHOTCRETE SCOPE

As is commonplace within the world of skateboard park construction, the project called for the wet-mix shotcrete process. Shotcrete is the most controlled and productive method to achieve the intricate, close tolerance shapes required of the skateboarding surface. Incorporated into the skatepark is approximately 850 yd^3 (650 m^3) of wet-mix

Fig. 1: Over 1 acre (0.4 ha) of skateboarding paradise at the City of Frisco's Northeast Community Skatepark

shotcrete work, accounting for roughly half of the 1800 total yd^3 (1376 m^3) of concrete placed. Shotcrete placement was continuous throughout the entire 9-month project duration and includes features such as banks, quarter pipes, skateable art, and other transitional elements.

As with all modern skateparks, the concrete is the final riding surface. Skateboard wheels are typically between 1.9 and 2.6 in. (50 and 65 mm) in diameter. Transitional skateboarding elements commonly have radii between 3 and 11 ft (1 and 3 m). Therefore, the utmost detail must be taken at all times during shotcrete operations to achieve the tightest of tolerances. Smaller-quantity, more controllable shotcrete "shoots" allow our specialized crews to focus each day on quality, shaping, and implementation of a Class A steel-trowelled finish. Placement of shotcrete in layers eliminates sloughing of the concrete and enhanced our control of tolerances.

A hot and cold weather protection and curing plan was implemented to mitigate any negative effects from the extreme Texas weather. Sun and wind-block structures helped minimize surface moisture evaporation and excessive water loss during placement. In the Texas heat, hydration curing blankets help keep the concrete surface cooler and enhance hydration by keeping moisture in. These blankets can be a costly addition to a project but greatly improve the surface quality and reduce potential shrinkage cracking. A detailed jointing plan aims to cut the concrete very soon after initial set (while still "green") to provide proper stress relief from the onset. Daily toolbox talks, preplacement checklists, weekly site inspections, and safety meetings ensure safe practice efforts and production goals are always top of mind.

SHOTCRETE MIXTURE DESIGN

Before construction, the shotcrete contractor and ready mixed concrete supplier developed a construction-friendly shotcrete mixture design that easily exceeded the 4000 psi (27.6 MPa) 28-day compressive strength requirement and other performance-based specifications. A 15% fly ash replacement of portland cement was used in the mixture design. Using fly ash is preferred over a cement-only mixture, as it creates a denser crystalline structure and ultimately a more durable product. Fly ash also helps improve concrete pumpability and finishability. The shotcrete mixture includes several industry-leading admixtures. Microfibrillated polypropylene fibers supplement the plastic shrinkage reduction efforts and also enhance resistance to impact and surface abrasion. A water-reducing admixture limits excessive free water while achieving proper slump and maintaining a water-cementitious materials ratio (*w/cm*) ratio of 0.35 to 0.45. A shrinkage-reducing admixture helps control drying shrinkage reduce shrinkage cracking. Finally, a hydration control product added during the warmer months, both at the plant and dosed as-needed on site, provided the crew additional time in the field for proper placement and finishing. Collectively, these admixtures provide substantial control over concrete quality, usability, set time, and slump. Aesthetics play a major role in any successful skatepark project. Concrete coloring was added to the concrete truck while on site. Integral color pigment was chosen over other decorative concrete techniques because of its durability and visual consistency. This step adds considerably to the shotcrete process and is yet another on-site task prior to placement. On-site dosing and proper mixing takes time and affects the slump. Jointing and color matching need to be taken into consideration in preshoot discussions and concrete truck ordering/scheduling.

SKATEPARK TERRAIN

The overall layout can be summarized in three main areas. First, an urban-inspired plaza area runs the entire length of the project and includes skate features such as granite capped ledges, custom metal ledge frames, stairs, banks, and hips. The second main area is an expansive, multi-depth flow bowl (Fig. 2). The bowl includes a notable 6 ft (1.8 m) tall vertical extension above the coping, a central pump bump used to maintain speed, two roll-in hips, a custom fabricated metal barrier, and an over-vertical capsule that is 15.5 ft (4.7 m) tall. Finally, a replica swimming pool has radii with vertical sections at the top and range in depth between 7 and 10 ft (2 and 3 m) (Fig. 3). It is accentuated with ceramic tile detailing and concrete pool coping. This pool feature is used

Fig. 2: Flow bowl section with speed and direction control features on the floor. A 6 ft (1.8 m) tall wall extends above the coping line

Fig. 3: Proper shotcrete preparation, crew positioning, and concrete placement. An initial layer placed early in the project assures protection of the compacted subgrade from damage due to adverse weather

during a normal day of use for all ages as well as a qualified site for professional-caliber contests. Standing out from the rest are several features that put Frisco's first skatepark on the wish list for skateboarders in the region.

Concrete Wave

A 14 ft (4 m) tall over-vertical, cantilevered "concrete wave" feature serves as a turnaround skate element where users can change direction while keeping their speed (Fig. 4). This feature required the expertise of a structural engineer to calculate concrete thickness, reinforcement configuration, and the design of a substantial concrete footing for support. The footing was cast and vibrated to ensure a structurally sound foundation structure. A few days later, the surface was roughened and brought to a saturated surface-dry condition. Bench shooting the wave in layers of uniform thickness eliminated any potential for sloughing of the concrete during placement.

Over-Vertical Capsule

A multi-depth "flow bowl" is highlighted with a 15.5 ft (4.7 m) tall over-vertical capsule (Fig. 5). The construction of the capsule included steel stucco lathe placed between the two curtains of reinforcement bar. The stucco lathe enabled the shotcrete to encapsulate each individual curtain of reinforcement while shooting from both outside and inside the capsule (Fig. 6). This process eliminated the need for any traditional formwork.

Fig. 4: Over-vertical, cantilevered concrete wave feature in foreground

Fig. 5: Second (final) concrete layer with Class A steel-trowelled finish. Over-vertical concrete capsule protected from overspray

Fig. 6: ACI Certified Nozzleman and blow pipe operator. Stucco lathe placed between reinforcement curtains. Shotcrete pump and equipment in background

Tombstone Extension

Another standout piece within the flow bowl is a 14 ft (4 m) tall "tombstone" (Fig. 7). This extension increases the height of the bowl above the coping line and is designed for more advanced riders. Again, vertical bench shooting in layers proved advantageous in preventing sloughing due to the weight of concrete during placement.

OPEN TO THE PUBLIC

After a year of public use, the City of Frisco's first skatepark has quickly become one of its most cherished park facilities (Fig. 8). The Texas Recreation and Parks Society (TRAPS) presented the project with the coveted Park Design Excellence Award during its 2018 North Region Annual Conference. The future of skateboarding and associated facilities is bright. Skateboarding will now be in the Summer Olympics, starting in Tokyo 2020. The sport's popularity and continued establishment has sparked a trend for cities to develop skate-friendly master plans. It is our company's obligation to provide owners and fellow skatepark users the most advanced construction techniques and products available. Shotcrete's role in our daily operations is truly vital in the development of these successful projects.

Fig. 7: Final shaping of transitional surface with pole tools

Fig. 8: City of Frisco's Northeast Community Skate Park in proximity to residential areas and complimentary park amenities

2018 OUTSTANDING POOL & RECREATIONAL PROJECT

Project Name
City of Frisco Texas Northeast Community Skate Park

Project Location
Frisco, TX

Shotcrete Contractor
SPA Skateparks

Architect/Engineer
New Line Skateparks*

Material Supplier/Manufacturer
Redi-Mix Concrete

Equipment Manufacturer
Putzmeister*

General Contractor
CORE Construction

Project Owner
City of Frisco

*Corporate Member of the American Shotcrete Association

***Jamie Curtis** is President of SPA Skateparks, a design-build firm of custom concrete skateparks for municipalities. Curtis serves as Senior Estimator and leads construction operations. Curtis is an ACI Certified Nozzleman and has been placing shotcrete for over 10 years. Curtis is also a Principal of Curtis Concrete Pumping (CCP), a related entity focusing on shotcrete placement for the commercial and public markets in Texas and the surrounding region.*

***Yann Curtis**, Vice President of SPA Skateparks, leads business development efforts and serves as Project Manager during design and preconstruction phases of development. As Vice President of CCP, Curtis frequently educates engineers, contractors, and project owners on shotcrete placement. Curtis is an ACI Certified Nozzleman who places a priority on being active in the field during technical projects.*

2018 Outstanding Infrastructure Project

Oroville Dam Emergency Recovery

By Mick Haggerty

Oroville Dam, built in 1957, is an earth-filled embankment dam located on the Feather River, east of the city of Oroville, CA, in the Sierra Nevada foothills east of the Sacramento Valley. At 779 ft (238 m) high, Oroville Dam is the tallest dam in the United States, 20 ft (7 m) taller than the Hoover Dam. The dam serves mainly for water supply, hydroelectricity generation, and flood control.

BACKGROUND

In February 2017, after an emergency discharge due to extensive rain events, Oroville Dam's main spillway chute and emergency spillway were damaged, prompting the evacuation of more than 180,000 people living downstream. The State of California, Department of Water Resources, enacted an emergency repair project shortly after the event.

The $1.1 billion emergency repair of the Oroville Dam Spillway spanned multiple wet seasons. The scale of the project is massive, including 1 million yd^3 (0.8 million m^3) of earth moved, 2.3 million yd^3 (1.8 million m^3) of aggregate crushed, and over 1.5 million yd^3 (1.15 m^3) of concrete placed—all completed in approximately 18 months.

REPAIR OF THE OROVILLE DAM

The repair job was divided into two phases because work on the main spillway is off-limits to construction during the winter, rainy season, from December until May. Phase 1 was predominately temporary structures to stabilize the dam spillways before another rainy season where the dam may be required to have water discharged. Phase 2 included removing portions of the temporary work and replacing them with permanent structures.

In Phase 1, roller-compacted concrete (RCC) was used to fill in the portions of the spillway that were washed out. A 1100 ft long, 200 ft deep (335 x 60 m) trench in the main spillway had been undercut and significantly damaged during the February 2017 emergency discharge. When it became clear that the volume of the repair would push the completion date beyond the Phase 1 deadline for the next rainy season and potential water discharge, shotcrete was chosen to accelerate the temporary spillway walls. With an aggressive schedule of extended, staggered shifts and weekend work, the spillway was completed in approximately 4 weeks.

The middle third portion of the 3000 ft (900 m) long spillway used 6 in. (150 mm) thick shotcrete for the spillway walls against the RCC berms on either side of the spillway. The 2500 ft (760 m) of walls were reinforced with welded wire mesh and epoxy anchors back into the RCC berm. The concrete mixture, furnished by Mathews Readymix, LLC, included 752 lb (341 kg) of cement and 3/8 in. (10 mm) pea gravel, with hot weather concrete provisions for ice and a set retarder. Slumps were 1 to 3 in. (25 to 75 mm). The walls were given a smooth trowel finish. Properly prepared construction joints were provided between placements.

Fig. 1: February 2017 Oroville Dam main spillway is damaged

Fig. 2: Middle third of the 3000 ft (900 m) main spillway chute

Fig. 3: RCC berm supporting main spillway walls

Fig. 4: Staggered and tiered work platforms on 25% slope

Surface transitions at the joint between placements were smooth and seamless. The smooth, durable surface, with no offsets, was paramount to reducing the risk of damage due to high flow rates against the wall during spillway discharge.

All the work was done on a 25% spillway slope. Scaffolding partner Safway Services provided staggered, tiered access scaffolding. The level work surfaces provided a safe and productive work platform to allow our shotcrete crews to produce the exceptionally smooth and durable concrete surface and meet the emergency repair schedule deadlines. Superior Gunite achieved a record of zero recordable incidents in this remote location exposed to high heat, heights, incline hazards, and movement of heavy equipment. An excellent result by our experienced crews with exceptional

Fig. 5: Shotcrete substrate of RCC berm and WWF reinforcing

Fig. 6: Deep trench in middle third of main spillway chute, temporary shotcrete walls

safety leadership provided on the project by the General Contractor, Kiewit Infrastructure West.

Conclusions

The decision to build the spillway walls with shotcrete saved time and money as compared to form-and-pour methods, ensuring the spillway was available for use in time for the rainy season. Using shotcrete allowed the dam to be repaired and strengthened to safely allow the dam to have water discharges during the rainy season.

2018 OUTSTANDING INFRASTRUCTURE PROJECT

Project Name
Oroville Dam Emergency Recovery Project

Project Location
Oroville, CA

Shotcrete Contractor
Superior Gunite*

Architect/Engineer
State of California, Department of Water Resources

Material Supplier/Manufacturer
Mathews Readymix, LLC

Equipment Manufacturer
Western Shotcrete Equipment*

General Contractor
Kiewit Infrastructure West Co.

Project Owner
State of California, Department of Water Resources

Trade Partner
Safway Services

*Corporate Member of the American Shotcrete Association

Fig. 7: View looking down spillway chute at temporary shotcrete walls

Acknowledgments

A special thank you to State of California, Department of Water Resources; all of Kiewit Infrastructure West support staff; and trade partners, Mathews Readymix and Safway Scaffold. Superior Gunite achieves or exceeds its customer's goals on the most difficult, schedule-driven projects, only through the efforts and pride of its co-workers.

Mick Haggerty *is Superior Gunite's Vice President of Operations for the Western U.S. He received his BS in civil engineering from Washington State University, Pullman, WA, and his MBA from Seattle University, Seattle, WA. Haggerty has over 30 years of experience in concrete construction, both as a subcontractor and prime contractor. He is an active member of the American Shotcrete Association, American Concrete Institute, American Society of Concrete Contractors, and the Associated General Contractors of America.*

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2018 Outstanding Architecture/New Construction Project

Academy Museum of Motion Pictures

The Saban Building and David Geffen Theater—the multifaceted use of structural shotcrete

By Lawrence Klein

The uniqueness of the David Geffen Theater and the May Company building, the Saban Building, dates back to 1939. The film and music industry were starting to gain steam as lucrative artistic outlets. However, it wasn't until 2012 when the iconic May Company building became available for the true transformation of what currently stands as the Saban Building to begin. To mimic the historic appearance, limestone used on the original structure was sourced near Austin, TX, where the previous stone was obtained for the store back in 1939. The theater bears the name of the renowned music and film executive David Geffen. Geffen donated an astounding $25 million to see this long-standing dream materialize. Geffen has also vastly contributed to other philanthropic endeavors surrounding the film and music industry, such as the Geffen Playhouse, the Geffen Academy, Los Angeles County Museum of Art (LACMA), and David Geffen Hall at Lincoln Center in New York, NY. Haim Saban, a film and music veteran in his own right and also the creator of the Mighty Morphin Power Rangers, along with his wife Cheryl, donated a wondrous $50 million to the Academy Museum, thus making them the new namesake for what soon became one of the most prominent construction projects in Southern California.

Fig. 1: Superior Gunite on site shooting the mockup

PROJECT DETAILS

Located in the heart of Los Angeles, CA, this project shares the zip code of other famed attractions such as LACMA and the La Brea Tar Pits and Museum. The owner, the Academy of Motion Picture Arts and Sciences, worked collectively with renowned architectural firms Renzo Piano Building Workshop and Gensler, and engineering firm BuroHappold Engineering to create a space dedicated to the admiration and legacy of the film industry. With over 290,000 ft^2 (27,000 m^2) including galleries, exhibit space, theaters, and a special event space, the concept for the Academy Museum of Motion Pictures began to take shape. The complex project required a team of highly skilled construction professionals. Superior Gunite was honored to provide the shotcrete placement. Others on the team included ready mixed concrete supplier Cemex, with Morley Construction Company serving as the concrete contractor and MATT Construction as the general contractor.

Superior Gunite helped bring this high-profile project with a truly unique and highly ambitious design concept to life while also meeting the demands of a hyperaggressive schedule. Overall for the Academy Museum project, Superior Gunite placed over 7000 yd^3 (5000 m^3) of 7000 psi (48 MPa) shotcrete for construction of a new basement, a seismic retrofit of the existing Saban Building, and an elevated theater structure that will be used for world-premiere viewings and special screenings.

This structure was created using precast panels to form its unique shape. From the interior of the structure, Superior Gunite shot 24 in. (610 mm) thick, full-height, three-dimensional complex-curve shear walls, rising to 50 ft (15 m) in height—all of this while adhering to the strict tolerances required for the distinctive curved walls. Also shot during the construction sequence were structural support walls

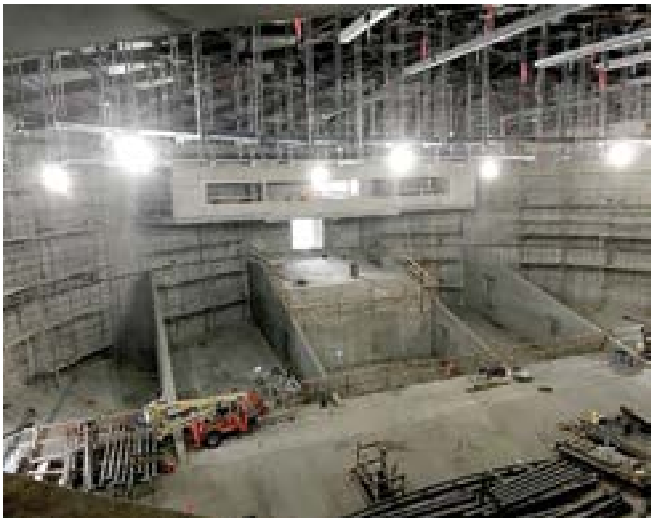
Fig. 2: Interior of David Geffen Theater


Fig. 3: Exterior of David Geffen Theater


Fig. 4: Trapezoidal columns shot by Superior Gunite


Fig. 5: Superior Gunite preparing to shoot the wing slabs

plus front- and back-of-house walls at opposite sides of the theater.

TRAPEZOIDAL COLUMNS

The versatility of shotcrete was further proven when Superior Gunite was confronted by the two large trapezoidal columns that provided primary support for the massive structure. At nearly 40 ft (12 m) high, the load-bearing structural columns stand with a twisted, trapezoid-like design. Originally, these columns were slated to be placed with the form-and-pour method, until Superior Gunite came up with the innovative solution to shoot the four sides leaving the inside empty and then filled in after the "walls" of the column hardened. The dowels coming out of the trapezoidal columns made forming virtually impossible, as they would have penetrated the forms vertically due to the taper and horizontal positioning. If the columns were attempted with conventional form-and-pour methods, the peculiar shape


Fig. 6: Interior of theater ceiling

would have produced unbalanced concrete pressures during casting and could have made the forms "walk." Shotcrete, however, has no internal hydrostatic pressure from liquid concrete and is able to produce nearly any shape due to the versatility of the material and skills of an ACI-certified nozzleman.

2018 OUTSTANDING ARCHITECTURE/ NEW CONSTRUCTION PROJECT

Project Name
David Geffen Theater at the Academy Museum of Motion Pictures

Project Location
Los Angeles, CA

Shotcrete Contractor
Superior Gunite*

Design Architect
Renzo Piano Building Workshop with contribution to design concept by Studio Pali Fekete architects

Executive Architect
Gensler

Engineer
BuroHappold Engineering

Concrete Contractor
Morley Construction Company

General Contractor
MATT Construction

Material Supplier/Manufacturer
Cemex

Equipment Manufacturer
Western Shotcrete Equipment*

Project Owner
Academy Museum Foundation

Owner's Representative
Paratus Group

*Corporate Member of the American Shotcrete Association

STRUCTURE HIGHLIGHTS

Within the sphere building, guests will find themselves inside the belly of the David Geffen Theater, a six-and-a-half-story structure 42,300 ft^2 (3900 m^2) and 150 ft (48 m) in diameter, housing a projection screen sporting a width of a whopping 60 ft (18 m). The lower level of the sphere holds a seating capacity of 1000 strategically placed viewing chairs to cater to the vast Cinephilia population residing in the entertainment capital of the world. The remaining areas will be dedicated to various purposes, from special events to exhibitions.

Adding to the uniqueness of this structure is the cascading glass-covered Dolby Family Terrace over the sphere, where guests have spectacular views of neighboring areas such as the natural expanse of the Hollywood Hills and the world-famous Los Angeles skyline. The sphere is supported by four columns with seismic isolators and weighs 26 million lb (12 million kg) and has the capability to move freely up to 24 in. (610 mm) in an earthquake. The seismic retrofit included the renovation of the Saban Building, where the structural strengthening walls were successfully completed using shotcrete. The Academy Museum is set to open in late 2019.

Lawrence Klein *is a construction industry veteran professional with over 25 years of experience. Currently, he serves as the Preconstruction Manager and Project Executive for Superior Gunite Southern California and Business Development Manager for Southern and Northern California. Klein also worked for The Walt Disney Company for 10 years. He is a third-generation Angeleno and enjoys spending time with his wife, daughter, and dog Chewy, as well as playing guitar and moutain biking SoCal trails.*

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2018 Outstanding International Project

Pampoen Nek Cutting

By Dustin Strever

Situated in a pristine part of the country near the Hartbeespoort Dam in the Gauteng province of sunny South Africa, the Pampoen Nek Cutting bisects the landscape into what will one day be an extension to the highway road network connecting the northern suburbs of Johannesburg with the mining towns of Brits and Rustenburg and the resort complex at Sun City. The cut needed extensive soil support along the highway. The owner decided that soil nails with shotcrete facing would provide a durable and economical solution to stabilize the soil slopes.

SELECTING THE WET-MIX PROCESS

Shotcrete Africa SCP, the subcontractor to Aveng Ground Engineering, was awarded the shotcrete portions of the contract. Aveng Ground Engineering was responsible for all of the piling and soil nails for the project.

During the beginning phase of the planning process, Shotcrete Africa SCP proposed to the engineering consultants, Aurecon, and the overall client, South African National Roads Agency (SANRAL), that more consistent quality and better daily production could be achieved with wet-mix shotcrete placement as opposed to the specified dry-mix process (gunite). Test panels were shot and tested at 14 days. The uniformity of the compressive strength results and the minimal dust created while shooting facilitated approval of the wet-mix alternative. It should be noted that wet-mix shotcrete is in its infancy in above-ground civil works in South Africa. Shotcrete Africa SCP is a pioneer in bringing mainstream education and acceptance of wet-mix shotcrete to the engineers and clients.

While there was a contract pay item for "colored gunite," the original on-site specification called for a screeded and brushed shotcrete finish.

ROCKSCAPING

Due to the poor collapsible soil conditions, maintaining the screeded and brushed finish required significant quantities of fill shotcrete (void filling) that also potentially added time to the project. With strict budgets to keep, alternative solutions were needed. Because the project was in such a pristine part of the country, Shotcrete Africa SCP proposed rockscaping. We then sprayed some mockup panels with a simple rockscaping finish that once painted would mimic the surrounding rock strata. SANRAL approved of the approach and Shotcrete Africa SCP went onto the fast track to respray the already completed work while still keeping up with the drill teams that were installing over 18 m (60 ft) long soil nails. Budget constraints limited Shotcrete Africa

Fig. 1: Shotcrete finish—woodfloated and brushed

Fig. 2: Sample of rockscaping, woodfloat, and brushed finish for the clients to inspect

SCP to a nominal 50 mm (2 in.) additional shotcrete, requiring our team to get more creative. A minimal application on larger flat areas of the face was applied and thickened up to 200 mm (8 in.) where a nice shadow needed to be placed. More shotcrete than originally planned was used; however, it was necessary to complete the job efficiently.

As the wall placement progressed, the project developed an audience who would pop past every day giving "recommendations and advice." Shotcrete Africa SCP found it best to smile and nod and then continue to just let the shotcrete carvers to do what they thought was best. The poor ground

Fig. 3: Completed wall with aesthetically pleasing outcrop and shadowing

Fig. 4: Completed works on the eastern side

conditions, and in some cases very large voids formed by the excavators, now started to add value as shotcrete could follow the large earth shapes to give the wall the depth and naturalness that was desired at the start.

Mixture Design

The specified shotcrete strength was 30 MPa (4350 psi). Shotcrete Africa SCP with the collaboration of the material supply partner, 3Q Concrete, designed a mixture that included for 1 m^3:

- Water (195 L ([51 gal.]);
- OPC cement (360 kg [794 lb]);
- Silica fume (20 kg [44 lb]);
- Fly ash (90 kg [198 lb]);
- Coarse aggregate - crushed (<6.7 mm [0.3 in.]) Dolomite stone (1235 kg [2723 lb]);
- Fine aggregate (530 kg [1168 lb]);
- Superplasticizer (2.925 L [0.772 gal.]); and
- Air-entraining admixture (675 mL [23 fl oz]).

This mixture design provided a water-cementitious materials ratio of 0.43 and consistent compressive results of over 40 MPa (5800 psi) on the 116 cores tested on the project. Only two were less than the required compressive strength of 28.5 MPa (4150 psi)—a fantastic result and testament to 3Q Concrete as this was the first time the ready mixed supplier had supplied concrete for wet-mix shotcrete. Granted, there were some teething problems with getting the slump correct when the concrete truck arrived on site. An 80 mm (3 in.) slump was requested, but our REED C50HP had no issues dealing with the slightly stiffer mixture. In fact, other than bursting into flames (aftermarket light over the hopper spontaneously combusted), the REED pumped beautifully, and the client became used to seeing daily production rates of over 30 m^3 (40 yd^3). Our production rate was limited only by the face of the wall available to shoot at any time.

Maintaining the Freeform Nature of the Rockscaping

One aspect of the shoot that was a bit more challenging than the rest of the project was a 20 m (66 ft) high pile wall with a perfectly level capping beam cast across the top for 40 m (131 ft). This very straight line and flat surface had no place in the freeform nature of our rockscaping, so we placed all types of items in the concrete to provide unevenness, including 250 mm (10 in.) diameter cores varying in height from 200 to 400 mm (8 to 16 in.) along with some local boulders that were found. The steel welded wire reinforcing was then extended over this “unevenness” and then shotcreted, resulting in no visible straight lines.

Matching the Existing Surrounding Rock

The last stage of the contract was to apply several layers of non-toxic paint from access boom lifts to match the colors of the surrounding rock. Again, all manner of folks provided their input; however, a good balance was achieved between matching the surrounding colors and adding age and watermarks with the streaks of black running down the face. You can’t please everybody when it comes to subjective art, but the client was happy and that’s what counts.

Conclusions

We sprayed a total of 763 m^3 (1000 yd^3) of shotcrete over 3500 m^2 (38,000 ft^2). The design thickness was 200 mm including the rockscaping. Our waste factor was just under 10%. The final result speaks for itself—the client has a

Fig. 5: From an absolutely flat-topped and flat-faced piled wall to this

Fig. 6: Final wall with a view over the Hartebeespoort Dam

safe and durable concrete soil retention solution. And it's expected that "Joe Public" as they drive past at 120 km/h (75 mph) probably won't even notice our shotcrete creation. That's the idea, right? A shotcrete solution that blends in so seamlessly that unless you get up close, you'll miss it!

***Dustin Strever** is the Founder and Managing Director of Shotcrete Africa SCP—Africa's largest specialist shotcrete contractor. Based in Johannesburg, South Africa, Shotcrete Africa SCP offers a variety of shotcrete application services, ranging from small concrete repair using the dry-mix process to bulk structural using the wet-mix shotcrete application. Together with his wife Lynne, Business Manager, they employ over 75 staff. Dustin has been involved in the shotcrete industry for over 15 years and was first exposed to dry-mix shotcrete when a client asked him to spray a 7 km (4 mile) precast concrete wall to add robustness. Since then, Dustin has made it his mission to improve the perception and quality of shotcrete in South Africa, educating himself and staff with the assistance of the American Shotcrete Association and other leaders in the field. Shotcrete Africa SCP has been a corporate member of the ASA since its inception 6 years ago.*

2018 OUTSTANDING INTERNATIONAL PROJECT

Project Name
Pampoen Nek Cutting

Project Location
Hartbeespoort, Gauteng, South Africa

Shotcrete Contractor
Shotcrete Africa SCP*

Architect/Engineer
Aurecon Consulting Engineers/Aveng

Material Supplier/Manufacturer
3Q Concrete

Equipment Manufacturer
REED Shotcrete Equipment*

General Contractor
Aveng Ground Engineering

Project Owner
South African National Roads Agency

*Corporate Member of the American Shotcrete Association

2018 Outstanding Repair & Rehabilitation Project

Queens Midtown Tunnel Rehabilitation

By Ashley Cruz

The Queens Midtown Tunnel (QMT) is a twin-tube, tolled, four-lane highway that serves over 90,000 vehicles each day. With a height of 12 ft-1 in. (3.7 m), it measures 6414 ft (1955 m) in the north tube, and 6272 ft (1912 m) in the south tube. This critical thoroughfare was designed by Ole Singstad in 1921, with groundbreaking in 1936, and opened to traffic in 1940. This was the first roadway to go under the East River, connecting the east side of Midtown Manhattan to Queens and Long Island.

On October 29, 2012, the area of the Mid-Atlantic coastline, stretching from the Jersey Shore through the south shore of Long Island, was hit by the catastrophic hurricane, Superstorm Sandy. The floodwaters inundated large sections of New York City's shoreline with water surges of over 10 ft (3 m), devastating much of New York City's infrastructure.

The hurricane flooded the QMT with 12,000,000 gal. (45,000 kl) of contaminated saltwater, forcing the tunnels to close for 10 days and damaging the majority of traffic, mechanical, electrical, plumbing, and safety systems in the 1.2 mile (1.9 km) commuter tunnel.

After the immediate emergency repairs allowed the tunnel to be placed back into service, MTA Bridges and Tunnels expedited the damage assessment and remediation program for long term permanent repairs and upgrades. The *Superstorm Sandy Repair and Capital Improvement Project* QM-40S at the QMT was announced and awarded to Judlau Contracting-OHL North America (Judlau) on April 23, 2015. The project was completed on May 11, 2018, with a cost of $265,000,000. It included a new fireproof ceiling with new wall tiles, duct banks, curbs and gutters, LED lighting, traffic signals, and improved evacuation signage.

Repair and restoration work included replacing all the major systems in the tunnel, including electrical, lighting, communications, monitoring, and control systems. Restoration and mitigation efforts included new submersible pumps at the mid-river pump room.

SIGNIFICANCE OF SHOTCRETE

Shotcrete's use in this project stems from Cruz Concrete & Guniting Repair Inc. (Cruz) being awarded a subcontract from Judlau. Cruz's contract scope included repair of all concrete spalls throughout the fresh-air and exhaust-air ducts of both tubes, drainage chase repairs, and the encasement of the new fire standpipes.

As a seasoned contractor in shotcrete construction, as well as having experience working on many large transit infrastructure projects in the Tri-State Area, Cruz saw an opportunity in the project to save time, money, and resources, all while doing what they are great at—shotcrete. Cruz proposed to use shotcrete for the standpipe encasement, and spall repairs as Cruz provided a similar application on past successful projects at the QMT. All parties involved agreed to use this method, with the only caveat being a troweled finish.

Many in the shotcrete industry are familiar with the fact that this sector of construction is susceptible to setbacks and delays, often the result of workflow delays with tasks

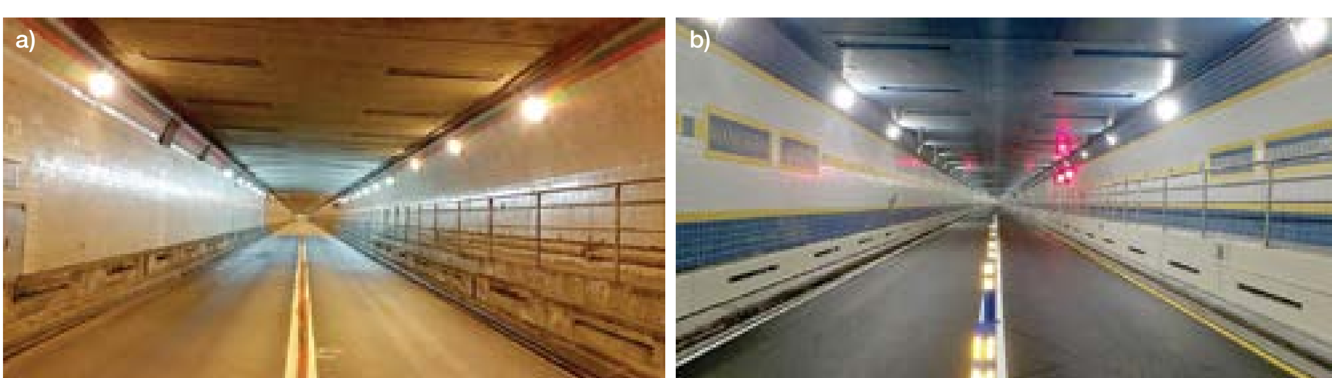

Fig. 1: (a) Before; and (b) after images of QMT
(Photo courtesy of Metropolitan Transportation Agency)

Fig. 2: Preconstruction, highlighting the light trenches ready for wet-mix shotcrete (top left), hollow wall niches (right wall) and exposed ceiling for patch repair
(Photo courtesy of Judlau)

needing completion by other disciplines first. One example was parging of the light trench followed by the installation of LED light fixtures. The light fixtures and other subsequent work activities hinged on the timely placement of the finished concrete in the light trench. Cruz recognized an opportunity to perform the parging work with shotcrete. It would result in an accelerated critical path, with a more sustainable product. Cruz completed an in-place mockup and was awarded the work in the North Tube (the first scheduled tube to be rehabilitated), zone by zone. With the promised schedule accelerations realized, the work proceeded to the South Tube and included filling the nearly 1000 hollow wall niches throughout both tubes with shotcrete.

This work established Cruz as an integral part of the project team and the "critical path" subcontractor, where they used maximum production rates and were able to accelerate the project schedule. This sequence allowed Judlau to commission the zonal light systems, meeting its milestones, and contributing to the early completion of the project.

Cruz's shotcrete methodology on the project, in place of the traditional form-and-pour, made shotcrete the main method of structural strengthening, as well as vertical, overhead, and large leak repairs. Shotcrete provided quicker and more cost-effective production than originally anticipated, while maintaining the required quality of work stipulated in the specifications. Cruz's workmanship increased the sustainability of this project, saving resources, time, and money while extending the service life of these integral concrete repairs.

Fig. 3: During construction, repair of the drainage chases
(Photo courtesy of Cruz)

Fig. 4: Post-construction image of shotcrete, light trenches have been repaired (top left), the drainage chases have been chipped out and replaced (vertical lines) and ceiling has been patched and encased with fireproof panels
(Photo courtesy of Judlau)

CHALLENGES LEAD TO INNOVATION

Time is of the Essence

Due to the high traffic volume of the QMT, traffic control restricted reconstruction to one tube at a time, limiting closure only for overnight work. This posed a challenge to Cruz as the available work hours not only included the work to be performed in the contract but also required daily mobilization and demobilization within the tube. Shotcrete, as opposed to the traditional method of form-and-pour concrete, allowed the crew to get off the road quickly while providing accelerated production during the short window of overnight hours, adding cost savings and increasing efficiency.

PROJECT QUANTITIES

Parging
12,902 ft^2 (1199 m^2)

Fireline
10,133 ft^2 (941 m^2)

Light trench
25,395 linear ft (7740 m)

Roadway soffit
2963 ft^2 (275 m^2)

Drainage chase
4185 linear ft (1275 m)

Deep concrete repairs
6748 ft^2 (626 m^2)

Shallow concrete repairs
1197 ft^2 (111 m^2)

About the Product

Both dry- and wet-mix shotcrete were used in this project in innovative and sustainable ways. To provide increased production, Cruz used a 5000 psi (35 MPa) wet-mix shotcrete for the fire standpipe encasement. The velocity of the shotcrete eliminated the risk of poor bond strength and is a stronger product because of the low water-cementitious materials ratio (*w/cm*).

Wet-mix shotcrete also proved useful to repair the random leak holes, some large enough to accommodate 0.5 yd^3 (0.4 m^3) of material, located under the roadway tunnel liner (soffit) throughout the fresh-air duct and exhaust-air plenum. Dry-mix shotcrete allowed Cruz to increase the speed of repair by 30 to 50%, keeping labor costs down and construction productivity up, on top of producing an extremely well-bonded repair. The prebagged, dry-mix product, with accelerator, fibers, and polymers, manufactured by USCP, exceeded the 5000 psi specification. The advantage of using a specifically designed concrete mixture for each situation added value to each man-hour and allowed for the timely and economical completion of the project.

Human Comfort

Cruz worked the night shift in the QMT for 3 consecutive years. The fire standpipe encasement of both tubes spanned a total distance of 1.2 miles, located about 5 ft (2 m) off the ground. The combination of the location and duration of the project caused Cruz to have concern for its crew in regard to occupational health and safety, and limited mobility. As a result, Cruz devised a mechanism that would support the hose and nozzle, with an adjustable height between 4 ft-5 in. and 12 ft (1.3 and 3.7 m) above the ground, as well as the ability to pivot side to side and up and down. This device was extremely mobile, being wheel-mounted, and boosted productivity by 15%, ultimately creating better

Fig. 5: Working in the air ducts provided for tight work spaces for the entire crew. Cruz devised methods to ease human comfort while working in these situations. Crew chipping away deteriorated concrete
(Photo courtesy of Cruz)

Fig. 6(a) and (b): A prepared fireline sits within the walls of the QMT (top). Cruz's device to reduce the stress of employees while ramping up productivity (lower)
(Photo courtesy of Cruz)

working conditions for the nozzleman and the assistant guiding the hose behind.

OVERALL PROJECT SUCCESS

The QMT Rehabilitation project was a success from both a financial and reputational standpoint for Judlau, as the project was finished on May 11, 2018, 11 months ahead of the original completion date of April 23, 2019. Cruz's experience, inputs, skills, and expertise played an important role in the early completion of the project. Cruz shotcreted hollow wall niches, the replacement of the PROMAT light trench, and the tiled wall. These were major work activities where Cruz delivered and contributed to the overall success of the project.

Overall, the experience and versatility in Cruz's shotcrete performance contributed to this multi-million-dollar Capital Improvement Project located in America's largest city to be completed on time and under budget.

ABOUT CRUZ CONCRETE & GUNITING REPAIR

Cruz Concrete & Guniting Repair, Inc. has been in business since 1984, incorporated in 1986. Cruz performs a wide range of concrete repair and rehabilitation work throughout the New York City and Tri-State Areas. Its services run the gamut from shotcrete roofs shot post-Sandy in Breezy Point, NY; "bathtub" walls in the new World Trade Center, after 9/11; retaining walls of manufacturing plants; sub-roadway repairs to the George Washington Bridge; to historic restoration projects.

Cruz has been a corporate member of the American Shotcrete Association since 2010. Working on this project were three ACI-certified nozzlemen; two certified in both wet- and dry-mix shotcrete and one certified in wet-mix shotcrete. They all worked on portions of this extensive shotcrete contract and couldn't have done it without its team of finishers and laborers.

Ashley Cruz *is the newest member to the family-owned and operated business. She joins the company with 10 years of experience in urban planning and landscape architecture. Cruz is the Director of Operations and aims to take Cruz Concrete to the next level in sustainability and blending of creative design decisions with quality construction.*

2018 OUTSTANDING REPAIR & REHABILITATION PROJECT

Project Name
Queens Midtown Tunnel Rehabilitation – QM40S

Project Location
New York, NY

Shotcrete Contractor
Cruz Concrete & Guniting Repair, Inc.*

General Contractor
Judlau Contracting – OHL North America

Architect/Engineer
URS

Material Supplier
US Concrete Products*

Equipment Manufacturer
Putzmeister*

*Corporate Member of the American Shotcrete Association

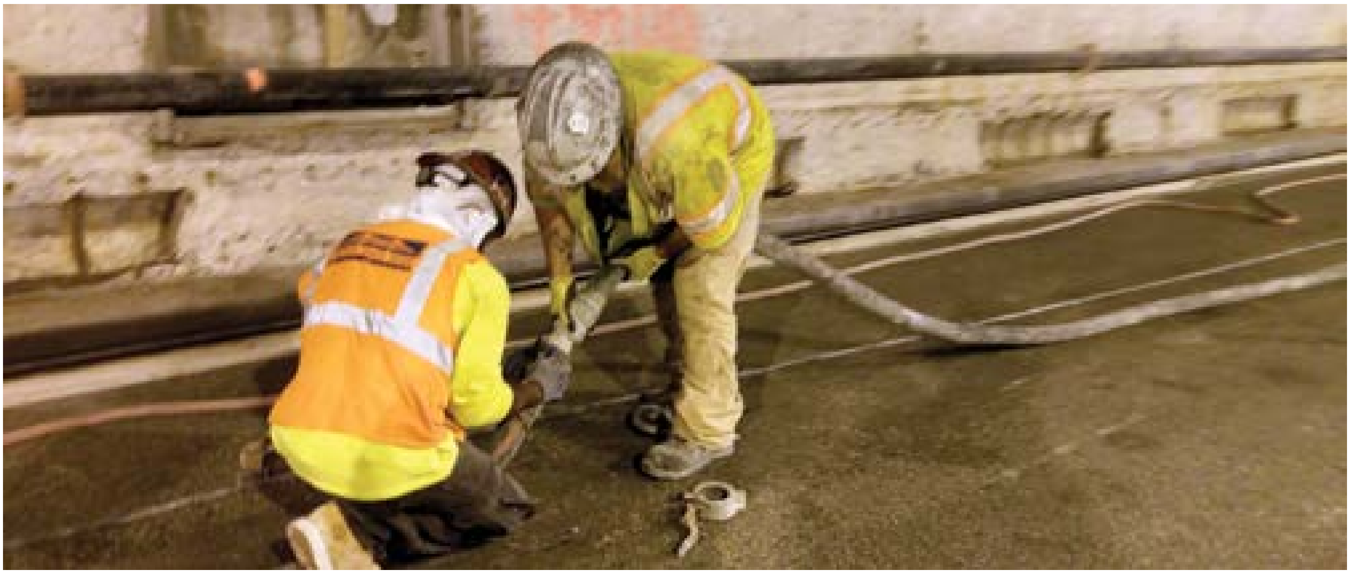

Fig. 7: Cruz's collaborative nature helps to expedite workflow, delivering projects on time and within budget
(Photo courtesy of Cruz)

ASA CONTRACTOR QUALIFICATION PROGRAM

Quality, durable, and economical shotcrete placement requires an experienced shotcrete team, not just an ACI-certified nozzleman.

The ASA Contractor Qualification (CQ) Program provides education and expert review of a shotcrete contractor's past projects. Those contractors who fully meet the requirements will be designated and publicly listed as ASA-Qualified Shotcrete Contractors.

WHO BENEFITS FROM THE PROGRAM?

- Owners wanting a quality, durable concrete structure with shotcrete placement
- Shotcrete contractors wanting public acknowledgment of their commitment to quality
- Specifiers who want expert guidance on the shotcrete contractor's qualifications

WHAT'S INVOLVED

1. Attend an ASA full-day Shotcrete Contractor Education Seminar and successfully complete the CQ written exam by the company's Qualifying Individual; and
2. Complete the CQ online application for the process (wet- or dry-mix) and level sought (basic or advanced).

AVAILABILITY

1. Shotcrete Contractor Education Seminars will be offered at various venues around the country—at trade shows and as sponsored by companies. Find available Seminars: **www.shotcrete.org/events**
2. Find the CQ online application: **https://asacq.secure-platform.com:443/a/solicitations/home/1002**

QUESTIONS

Program details: https://www.shotcrete.org/pages/education-certification/cq-program.htm

Contact: info@shotcrete.org | 248.848.3780

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2018 Outstanding Underground Project

Tiber Creek Sewer Rehabilitation

Old structural improvements are replaced safely while maintaining integrity

By John Becker and Randle Emmrich

As part of the DC Clean Rivers Project – Division 1 Main Pumping Station Diversions, the Tiber Creek trunk sewer was designated to receive a new structural liner in a 122 ft (37 m) section near the intersection of New Jersey Ave. and Tingey St. in southeast Washington, DC. The rehabilitation involved creating new supporting arch structures using the shotcrete placement method between previously installed steel bents. Once the shotcrete arches reached the required strength, the steel bents were removed, a new mat of reinforcing steel was installed, and the entire length of repair was fitted with a new continuous 6 in. (150 mm) shotcrete liner.

Accessing the Project Site

Throughout the planning and construction processes, site access was a major concern and hurdle to overcome. First, entry into the project site was limited to two 36 in. (900 mm) manholes, and the normal sewer flow could not be redirected during a rain event. The ability to place concrete using the shotcrete method lent itself well to the situation, given it could be installed quickly and efficiently in all positions with minimal footprint in the sewer. Shotcrete also allowed the use of a rapid-set accelerator which could achieve initial set within an hour, ensuring no damage from potential storm water flow should there be rain or failure in the flow diversion systems. Also, the shape of the sewer, with one big line diverting into two smaller ones, would have made the formwork to support a form-and-pour concrete method complicated, expensive, and interfered with the flow during a rain event.

Site access was also a consideration in the selection of the concrete repair material. The material availability needed to synchronize with the availability of work in the sewer. Concrete trucks were not considered a viable option due to past negative experiences trying to get relatively small quantities of concrete delivered on time and still meet the required specification through Washington, DC's notoriously foul traffic. The project site was in the middle of high-end residential and commercial buildings, so the dust creation associated with dry-mix placement methods was also a concern. Ultimately, prepackaged shotcrete material was mixed on site and placed with a combination concrete mixer-pump. King Packaging Materials MS-W1, a silica fume-enhanced, prepackaged shotcrete mixture designed for wet-mix placement, was selected for its superior consistency and excellent pumpability, though limited storage space on site necessitated a careful control of material lead times and delivery schedules. The concrete was ordered in bulk bags and loaded into the hopper of a volumetric

Fig. 1: Installing first shotcrete layer

Fig. 2: Removing preexisting bents


Fig. 3: Installing second mat of steel


Fig. 4: Single bore prepared to receive second mat of steel

concrete mixer truck that fed the mixer on the pump. Mixing the material in smaller batches helped maintain stricter quality standards because the amount of water added to the mixture and the mixing time were both closely monitored. The staging area required for the entire shotcrete operation was small and mobile. The only equipment needed on the project were a volumetric mixer, concrete mixer-pump, and air compressor. On a busy, crowded construction site, this small footprint and setup flexibility was appreciated as the surrounding construction continued and the site setup needs evolved. If the traditional form-and-pour method was used, a significantly larger staging area would be needed to accommodate all the equipment.

SHOTCRETE PLACEMENT

Not only was shotcrete a viable option for restricted access reasons, but it also reduced the labor required to complete the rehabilitation work because there was no earthwork or formwork needed. The shotcrete was placed on existing prepared surfaces, which greatly reduced the overall cost of both the labor and material.

The original plans called for the use of wire mesh reinforcement to be installed during each phase of construction. However, because all materials had to be brought into the tunnel via a 36 in. manhole, it was determined to substitute a mat of No. 3 reinforcing bar, which could be more easily handled and manipulated into place given the restricted access and complicated shape of the sewer. The small diameter of the reinforcing bar made it easy and quick to cut and bend on site as needed.

Coastal Gunite convinced the Owner and Engineer to allow us to shoot in multiple layers as opposed to full-thickness applications. This is possible because properly prepared and placed shotcrete in layers structurally acts as monolithic concrete. This was a faster and more efficient method for placing the material and allowed for easier removal of the existing steel supports between the shotcrete arches. Sika Sigunit L72 AF liquid accelerator was introduced at the nozzle allowing a rapid initial set and the shotcrete to be installed in thicker layers (8 to 10 in. [200 to 250 mm]) than otherwise would have been possible. It also


Fig. 5: First layer of shotcrete installed with preexisting support bents still in place


Fig. 6: Second mat of steel installed

allowed the concrete to be pumped with a greater slump, reducing the risk of plugged delivery lines and reduced stress on the shotcrete pump. The rapid strength gain and high compressive strength value allowed for more production during short working periods. The shotcrete was placed overhead in an underground arched sewer, which added complexity to the project, but it was easily overcome with good-quality, wet-mix shotcrete and a qualified contractor with an ACI-certified nozzleman.

ON-SITE DUST CONTROL

Due to the new OSHA silica regulations, the worksite was constantly being vacuumed and dust producers were wet-down to prevent any excess dust. All employees were also fitted with the appropriate respirators to comply with the new regulations and the confined space environment. Airborne silica was also of great concern as the work was being performed in a busy pedestrian area; containment and filtering systems were key to ensuring their safety. Because the site was also an active sanitary sewer, after every rain event, the site had to be cleaned again before work could be safely performed. Strict decontamination procedures were required for all people and equipment after removal from the line to prevent the potential spread of disease to workers and the surrounding public in close proximity.

Fig. 7: Placement of second layer of shotcrete

COLD WEATHER OPERATIONS

Measures were taken so that the project could continue to progress efficiently even during cold weather. A propane tankless water heater was plumbed into the concrete mixing system to raise the concrete material temperatures to meet the specified requirements. The sewer also had to remain both ventilated and warm, so the fresh air supply was also heated using a vented propane heater. The work area itself was separated from the rest of the sewer as the natural airflow was too cold for work to be performed.

MONITORING OF WATER LEVELS

The main flow of the sewer line was diverted because, even under normal flow conditions, the flow would have been a serious hazard to our workers. Water level monitors connected to alarms were installed on both ends of the work area to alert workers of rising water. A strict lock-out tag-out procedure was also implemented in conjunction with DC Water to protect against the accidental release of the diverted flow into the work area. Due to variables including weather and normal water treatment repair and maintenance operations, access to the sewer was highly variable and nearly impossible to predict with any accuracy. Fortunately, another project also performed by Coastal Gunite at DC Water's nearby water treatment plant allowed our out-of-state workers to remain productive and kept the manpower

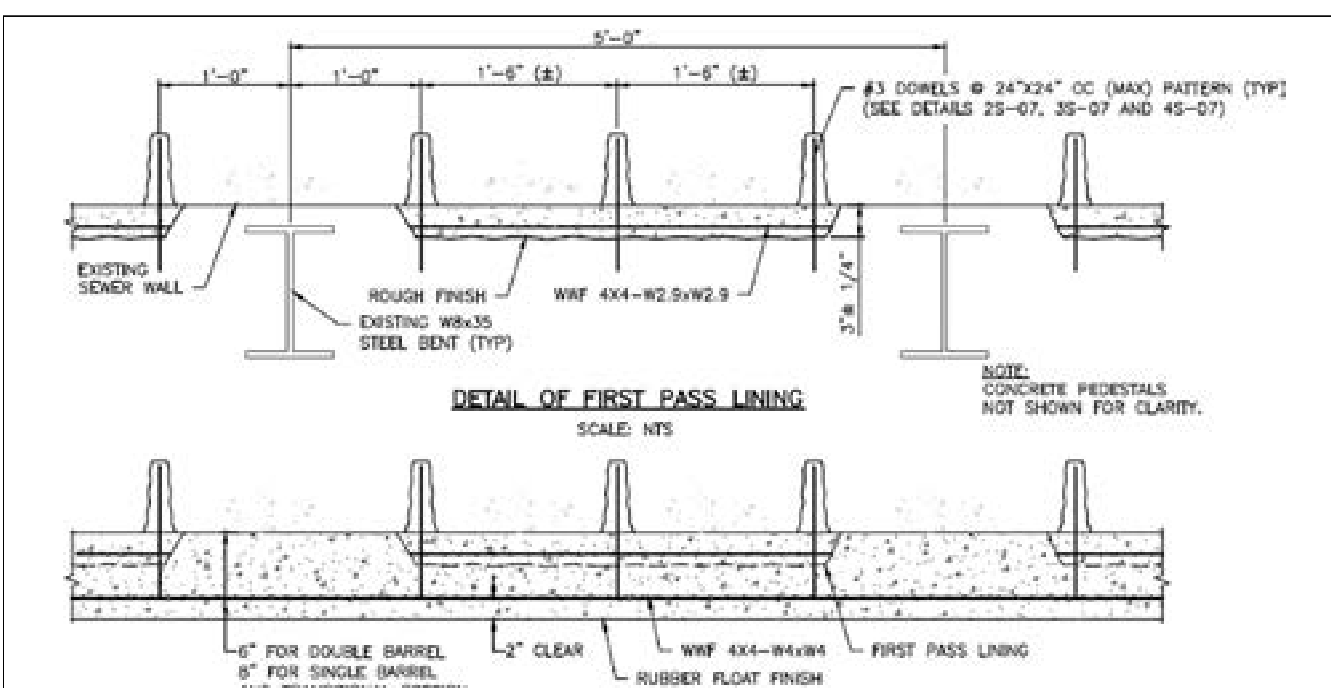

Fig. 8: Sequencing of shotcrete installation in two phases

available for the Tiber Creek Sewer project when access was permitted.

Conclusions

Shotcrete placement for rehabilitating the sewer allowed traffic to continue uninterrupted and the sanitary sewer could remain in active service throughout the project. Even though access to the sewer for work was often limited due to regular rain events and other on-site construction activities, shotcrete's flexibility made for maximum efficiency and productivity when the sewer was accessible.

In summary, a heavily traveled street in downtown Washington, DC, plus an active sanitary sewer that needed to remain fully functional with only a standard manhole available to access the work meant that shotcrete was THE option to complete the rehabilitation of this large-diameter sewer.

Fig. 9: Placement of second layer of shotcrete

Fig. 10: One barrel of double barrel section completed

John Becker *is an ACI-Certified Nozzleman who for over a decade has worked in many capacities, most recently as Project Manager for Coastal Gunite Construction Company based in Cambridge, MD. He has been involved with many shotcrete projects including the $15 million Bonner Bridge Rehabilitation Project in Nags Head, NC; the $5 million Old Mill Creek Sewer Rehabilitation Project in St. Louis, MO; and the $19 million Fort McHenry Tunnel Rehabilitation in Baltimore, MD.*

Randle Emmrich *is Vice President for Coastal Gunite Construction Company, Bradenton, FL. She received her BS in civil engineering from Bucknell University, Lewisburg, PA. In her 20 years in the shotcrete business, she has overseen many projects, including the rehabilitation of bridges, piers, manholes, aqueducts, and sewers. Her projects have served various clients, such as the U.S. Army Corps of Engineers, ESSO Inter-America, the Maryland Transportation Authority, the Virginia Department of Transportation, the City of Atlanta, and the City of Indianapolis. Emmrich serves as Secretary of the ASA Membership Committee. She is also a member of ASCE; Chair of ACI Committee C660, Shotcrete Nozzleman Certification; and ACI Subcommittee C601-I, Shotcrete Inspector Certification; and a member of ACI Committee 506, Shotcreting.*

2018 Outstanding Underground Project

Project Name
Tiber Creek Sewer Rehabilitation

Project Location
Washington, DC

Shotcrete Contractor
Coastal Gunite Construction Company*

Architect/Engineer
Greeley & Hansen/Jacobs Associates

Material Supplier/Manufacturer
King Packaged Materials*

Equipment Manufacturer
Putzmeister*, Cemen Tech*

General Contractor
Corman Construction

Project Owner
DC Water and Sewer Authority

*Corporate Member of the American Shotcrete Association

2018 Honorable Mention

Brattleboro Bridge Project

By Nick Durham and Frank E. Townsend III

In August 2016, Superior Gunite was awarded a subcontract from PCL Civil Constructors to shoot and carve eight web fins on the piers of the I-91 Brattleboro Bridge, in Brattleboro, VT. PCL Civil Constructors had been placing precast sculpted rock form panels going up the piers of the bridge but was unable to place panels at the arched and inverted section near the top of the piers. The issue was not only how to place the concrete on the fins but also how to get it to seamlessly match the sculpted rock forms that had already been placed. Using shotcrete for this architectural application provided ready access for placement as well as the ability to carve the wet concrete to match the look of the previously placed precast panels.

TEMPORARY MOCKUP

The main concern of the architect was how the shotcrete would match the already-placed precast panels. Before starting placement on the bridge, Superior Gunite produced a temporary mockup to demonstrate the placement process and the appearance of the final product. The entire pier was already intended to be stained, so color was never an issue or a concern. Once the mockup was approved, Superior Gunite was quickly instructed to begin permanent placement to avoid delays in schedule.

Fig. 1: Two fins at the northern pier prior to being shot. Reinforcing bar and stayform

CONSTRUCTION OF THE FINS

Each fin was approximately 28 ft (9 m) high and expanded in width from 8 ft (2 m) at the bottom to 24 ft (7 m) at the top, totaling approximately 390 ft^2 (36 m^2) each. Shotcrete thickness was determined by a radius, with the top and bottom

Fig. 2: Precast panel installed at the bottom of the pier

Fig. 3: Mockup immediately after spraying and early stages of sculpting

Fig. 4: Completed mockup

Fig. 5: First day shooting a fin, bringing shotcrete just past the reinforcing bar

Fig. 6: Second day of shooting a fin, flash and sculpt the rock face

ends at 3.6 ft (1.1 m) thick and a minimum of 1 ft (0.3 m) thick at the center height of each fin. The only formwork necessary was stayform on the underside of the curvature of the fin, which was installed by Superior Gunite. Permanent shotcrete installation required Superior Gunite employees to work out of three 120 ft (37 m) manlifts anywhere from 70 to 100 ft (21 to 31 m) off the ground. The only access was from below the bridge and pumping upwards. Due to space, only two manlifts could be used at the location of the shoot at any given time. One manlift held the nozzleman and a lift driver and the other held two concrete sculptors, one of whom also drove the lift.

SUCCESS OF SHOTCRETE

Superior Gunite worked on two fins a day. Fins were bulked out in 1 day, then a flash coat would be applied the second day, allowing the sculptors to carve the rock formation into the wet shotcrete. Carroll Concrete provided the shotcrete in the summer heat, requiring Superior Gunite to unload trucks quickly and avoid problems with the line while pumping up to 100 ft upwards. In total, 335 yd^3 (256 m^3) of concrete were placed. Each fin was about 42 yd^3

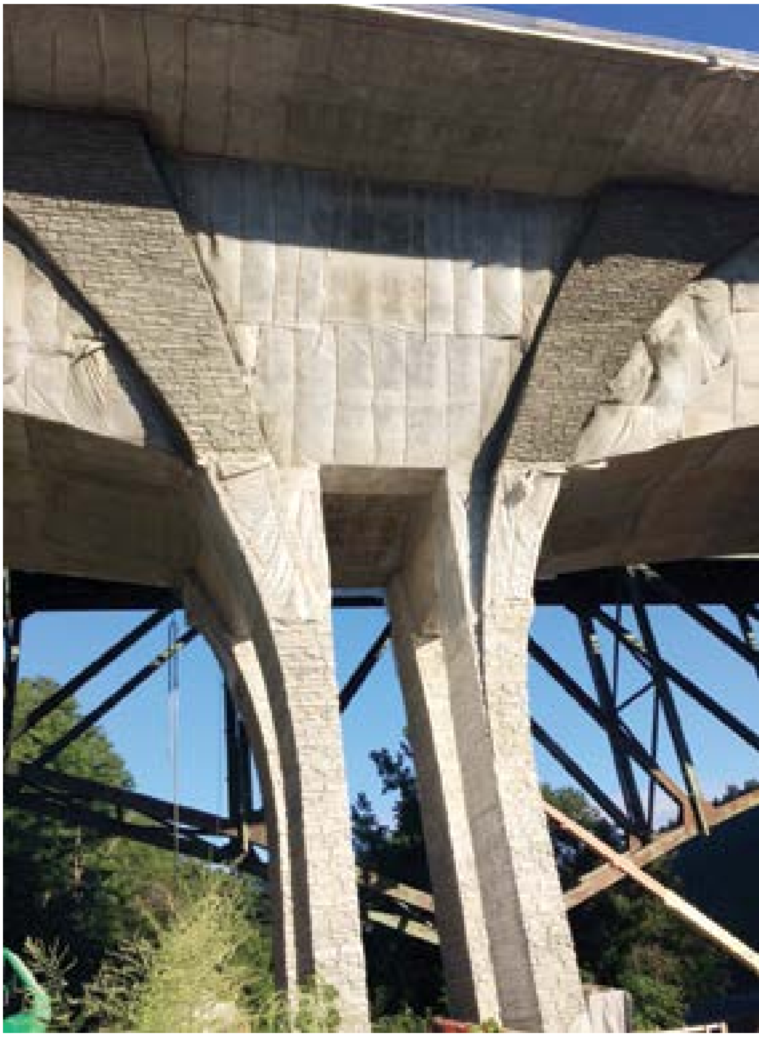

Fig. 7: Finished fins. Darker material is shotcrete, lighter is precast panels

(32 m³). In total, the shotcrete segment was completed in just 9 days. The piers were completed at least four times faster by using shotcrete as opposed to forms. Not only did the contractor avoid delays on the project by using shotcrete but time was also reduced on the schedule; using shotcrete for the fins took them off the critical path. By the end of the job, the owner mentioned that the sculpted shotcrete was a better final product than the precast panels.

Fig. 8: Staining the piers

Fig. 9: The completed bridge

Nick Durham is a Project Manager at Superior Gunite. After receiving his degree in civil engineering from Columbia University, New York City, NY, he spent time working in concrete foundations and high rises in New York City before entering the world of shotcrete and joining Superior Gunite. Along with the I-91 Brattleboro Bridge, he has successfully managed jobs in New York City; Norfolk, VA; and Needham, MA, among others.

Frank E. Townsend III is the Vice President East for Superior Gunite. He received his bachelor's degree in civil engineering from Worcester Polytechnic Institute, Worcester, MA, and his master's degree from the University of Missouri, Columbia, MO. Townsend is an active member of ACI Committee 506, Shotcreting, and currently serves on the ASA Board of Directors. He has been Awarded the U.S. Army Corps of Engineers deFluery Medal and Engineering News-Record *New York's "Top 20 under 40" design and construction leaders in 2016. Townsend is an active member of ASA; ACI; the New Jersey Chapter – ACI; Concrete Industry Board, an ACI New York City Chapter; The Moles and the Beavers (heavy construction organizations); American Society of Concrete Contractors; American Society of Civil Engineers; and Society American Military Engineers (SAME), remaining a lifelong soldier.*

2018 HONORABLE MENTION

Project Name
I-91 Brattleboro Bridge

Project Location
Brattleboro, VT

Shotcrete Contractor
Superior Gunite*

Architect/Engineer
Sebago Technics

Material Supplier
Carroll Concrete Co.

Equipment Manufacturer
Western Shotcrete Equipment*

General Contractor
PCL Civil Constructors

Project Owner
Vermont Agency of Transportation

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This strategic position enables us to service all shotcrete and gunite markets.

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2018 Carl E. Akeley Award

Akeley

Yun

The 13th annual Carl E. Akeley Award was presented to Kyong-Ku Yun for his article, "Cellular Sprayed Concrete," published in *Shotcrete* magazine, Summer 2018. The article discusses cellular sprayed concrete as an innovative method of remixing ordinary portland cement (OPC) concrete into a high-performance concrete (HPC) by adding cellular material and silica fume or other powdered admixtures at a jobsite. Yun addresses topics such as the concept of cellular concrete, its fresh properties, hardened properties, durability, validation of silica fume dispersion, and provides examples of field applications. This research was supported by the National Research Foundation (NRF) of Korea (grant No. NRF-2017R1A2B4005625).

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

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

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

References

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

Kyong-Ku Yun, recipient of the 2018 Carl E. Akeley Award

PAST AKELEY AWARD RECIPIENTS

- 2006—Dufour, Reny, and Vézina, "State-of-the-Art Specification for Shotcrete Rehabilitation Projects"
- 2007—K. F. Garshol, "Watertight Permanent Shotcrete Linings in Tunneling and Underground Construction"
- 2008—E. S. Bernard, "Embrittlement of Fiber-Reinforced Shotcrete"
- 2009—Dufour, Lacroix, Morin, and Reny, "The Effects of Liquid Corrosion Inhibitor in Air-Entrained Dry-Mix Shotcrete"
- 2010—Dr. L. Zhang, "Is Shotcrete Sustainable?"
- 2011—C. S. Hanskat, "Shotcrete Testing—Who, Why, When, and How"
- 2012—R. Curtis White Jr., "Pineda Causeway Bridge Rehabilitation"
- 2013—Jolin, Nokken, and Sawoszczuk, "Sustainable Shotcrete Using Blast-Furnace Slag"
- 2014—Dr. L. Zhang, "Variability of Compressive Strength of Shotcrete in a Tunnel-Lining Project"
- 2015—E. Yurdakul and K.-A. Rieder, "Effect of Pozzolanic-Based Rheology Control Agent as a Replacement for Silica Fume"
- 2016—M. von der Hofen, "East End Crossing"
- 2017—Axel Nitschke, "Modeling of Load-Bearing Behavior of Fiber-Reinforced Concrete Tunnel Linings"

2018 ASA President's Award

Morgan

The ASA President's Award was established in 2005 to recognize a person or organization that has made exceptional contributions to the shotcrete industry. It is the sole responsibility of the immediate outgoing President of ASA to select the recipient of this award. Since 2006, 12 well-deserving individuals and one organization have been awarded the ASA President's Award, all of whom dedicated their time and energy to advancing the shotcrete industry.

For 2018, at the ASA Shotcrete Awards Banquet in Amelia Island, FL, the immediate outgoing President of ASA, Lihe (John) Zhang, presented this award to Dudley R. (Rusty) Morgan, for his lifetime contributions to the shotcrete industry. Over the past four decades, Morgan has made major contributions to the advancement of shotcrete technology in North America and around the world.

Morgan is a specialist in concrete technology and his involvement with shotcrete first began in 1978 when he carried out research into steel fiber-reinforced shotcrete (SFRS) and introduced this technology into Canada. In the 1990s, Morgan carried out the first macro-synthetic fiber-reinforced shotcrete (SnFRS) research and development work in the world and introduced this technology to the tunneling and mining industries. Morgan carried out the first research in North America into the use of silica fume in wet- and dry-mix shotcretes in 1984. Silica fume modified shotcrete is now routinely used around the world for such applications.

Morgan was one of the founding members of ASA in 1998. He served as a Technical Editor of *Shotcrete* magazine for the first 10 years of its publication and served as President of ASA in 2006 and 2007. He has published over 170 papers and edited seven books on concrete and shotcrete technology. He was a long-time Secretary of ACI Committee 506, Shotcreting, and has also served on ASTM, Canadian Standards Association, and International Tunneling Association (ITA) technical committees.

In 2010, Morgan retired from full-time consulting at AMEC (now Wood), and moved to Vancouver Island near Victoria, BC, Canada. He continues to contribute to the shotcrete industry, providing specialist consulting services.

The contributions that Morgan has made to the shotcrete industry have had a major impact on the recognition and growth of this industry and will continue to have impact in the decades ahead. He is a worthy recipient of the 2018 ASA President's Award.

Morgan (right) accepting the 2018 ASA President's Award at the ASA Awards Banquet with Cathy Burkert, ASA President (left), and Lihe (John) Zhang, ASA Past President

Understanding What Can Cause Problems with Concrete and Shotcrete—Part 1

By Raul Bracamontes

This is Part One of a two-part series on potential causes of problems in concrete and shotcrete. Part One includes an introduction, then leads into an investigation into problems due to insufficient design or project specifications, and then issues with the planning process. Part Two will be published in a subsequent issue and discuss problems related to production, including the type and quantities of materials chosen, problems during the placement process, and issues from commissioning and maintenance of the completed structure.

Shotcrete is defined in ACI Concrete Terminology (ACI CT-18) as "concrete placed by a high-velocity pneumatic projection from a nozzle." Thus, shotcrete is simply a placement method for concrete. We need to take care of shotcreted concrete as we do with the traditional form-and-pour concrete.

INTRODUCTION

Damage or deterioration of concrete can have many causes. To address a concrete problem, we must first know its root cause. We thus need to determine:

- The exposure conditions;
- The deterioration process;
- The symptoms;
- The history of the placement; and
- Its current state.

This set of aspects is what is sometimes known as concrete forensics or concrete pathology. The pathology of concrete can be defined as the systematic study of the processes and characteristics of the damage that concrete can suffer, its causes, consequences, and when understood can lead to potential solutions. Concrete structures may suffer defects or damages that alter concrete's internal structure and behavior. Some problems may result from the concrete preparation or placement. Others may occur during some stage of its service life, and others may be the result of accidents, such as a fire or crash.

SYMPTOMS

Problems with shotcrete placements often present visual clues at the surface of the concrete (although some exceptions can happen) that allow one to deduce the nature, origin, and mechanisms of the problem, and estimate their probable consequences. The most common symptoms of problems in concrete are cracks, efflorescence, deformations, stains, corrosion of reinforcing steel, surface voids, delaminations, voids behind the reinforcement, lack of cover, surface erosion, and poor quality due to trapped rebound or overspray.

Mechanism of Deterioration or Damage

Every problem has a process that causes the damage and can change over time. The process may affect the environmental or exposure conditions or the physical properties of the materials. Except for cases of extreme loading, the deterioration mechanisms are usually gradual, cumulative, and in some cases irreversible.

Origin or Cause of Problems

The origin or cause of problems with concrete may be due to issues with the design, the construction process, or the completed structure. For identification of the causes it is necessary to carry out an exhaustive investigation by means of a root-cause analysis of problem areas to determine the factors that could cause it.

The causes of concrete problems can be included in five categories:

- Problems related to an insufficient design or project;
- Problems related to the planning process;
- Problems related to type and quantities of materials chosen;
- Problems related to the placement process; and
- Problems related to the operation or useful life and maintenance.

Pathological problems usually occur when the structure is in use. Proper diagnosis can indicate at what stage the problem arose. If the problem originated in the project phase, the responsibility falls on the designer. When the root

Entendiendo lo que puede causar problemas con concreto y concreto lanzado — Parte 1

Por Raul Bracamontes

Esta es la primera parte en una serie de dos partes sobre posibles causas de problemas en concreto y concreto lanzado. La primera parte incluye una introducción, después conduce a una investigación de problemas debidos a diseños o especificaciones insuficientes del proyecto y luego problemas con el proceso de planificación. La segunda parte se publicará en una edición posterior y discutirá los problemas relacionados con la producción, incluidos el tipo y la cantidad de materiales elegidos, los problemas durante el proceso de colocación y asuntos desde la comisión hasta el mantenimiento de la estructura terminada.

El concreto lanzado se define en la Terminología de Concreto ACI (ACI CT-18) como "concreto colocado por una proyección neumática de alta velocidad desde una boquilla". Por lo tanto, el concreto lanzado es simplemente un método de colocación para concreto. Tenemos que cuidar del concreto lanzado tal y como lo hacemos con el concreto tradicional de encofrado y vertido.

INTRODUCCIÓN

El daño o el deterioro del concreto pueden tener muchas causas. Para abordar un problema con el concreto, primero debemos conocer su causa principal. Por lo tanto, tenemos que determinar:

- Las condiciones de exposición;
- El proceso de deterioro;
- Los síntomas;
- La historia de la colocación; y
- Su estado actual.

Este conjunto de aspectos es lo que a veces se conoce como concreto forense o patología de concreto. La patología del concreto se puede definir como el estudio sistemático de los procesos y características del daño que el concreto puede sufrir, sus causas, consecuencias y cuando entendido puede conducir a soluciones potenciales. Las estructuras de concreto pueden sufrir defectos o daños que alteran la estructura interna y el comportamiento del concreto. Algunos problemas pueden resultar de la preparación o colocación del concreto. Otros pueden ocurrir durante alguna etapa de su vida útil y otros pueden ser el resultado de accidentes, como un incendio o un choque.

SÍNTOMAS

Los problemas con la colocación de concreto lanzado a menudo presentan pistas visuales en la superficie del concreto (aunque algunas excepciones pueden ocurrir) que permiten deducir la naturaleza, el origen y los mecanismos del problema y estimar sus consecuencias probables. Los síntomas más comunes de problemas en el concreto son grietas, eflorescencia, deformaciones, manchas, corrosión del acero de refuerzo, vacíos superficiales, delaminaciones, vacíos detrás del refuerzo, falta de cobertura, erosión superficial y mala calidad debido al rebote atrapado o pulverización excesiva.

Mecanismo de deterioro o daño

Cada problema tiene un proceso que causa el daño y puede cambiar con el tiempo. El proceso puede afectar a las condiciones ambientales o de exposición o a las propiedades físicas de los materiales. A excepción de los casos de carga extrema, los mecanismos de deterioro suelen ser graduales, acumulativos y, en algunos casos, irreversibles.

Origen o causa de los problemas

El origen o la causa de los problemas con el concreto puede ser debido a problemas de diseño, el proceso de construcción o la estructura completada. Para la identificación de las causas es necesario llevar a cabo una investigación exhaustiva, mediante un análisis de causa raíz de las áreas problemáticas para determinar los factores que podrían causarlas.

Las causas de los problemas del concreto pueden incluirse en cinco categorías:

- Problemas relacionados con un diseño o proyecto insuficiente;
- Problemas relacionados con el proceso de planificación;
- Problemas relacionados con el tipo y la cantidad de materiales elegidos;
- Problemas relacionados con el proceso de colocación; y
- Problemas relacionados con la operación o vida útil y mantenimiento.

Los problemas patológicos usualmente ocurren cuando la estructura está en uso. El diagnóstico adecuado puede indicar en cual etapa surgió el problema. Si el problema se originó en la fase de proyecto, la responsabilidad recae en cause is in the quality of the materials, the manufacturer of the concrete or concrete materials will be responsible. If the problems originated in the placement, the contractor may be at fault for not following the guidelines of a constructive process of quality. Problems that arise when the structure is in service will be the responsibility of operation and maintenance.

In this timeline of the pathological process, we can distinguish three well-defined parts: the origin, the evolution, and the result. For the study of the pathological process, it is convenient to go through this sequence in an inverse manner. Start by observing the result of the problem, then study the symptom to follow the evolution back to its origin—the cause.

Evaluation of Concrete Deterioration

Various factors cause concrete damage. A large portion of the defects result from the use of poor-quality materials, poor placement, exposure to harsh environments during the concrete's service life (for example, freezing-and-thawing cycles, proximity to seawater, and chemical exposure), or the poor choice of components (for example, the type of cement) for a specific purpose.

Before starting to repair damaged concrete, the cause of the damage should be identified. Sometimes the cause is obvious; other times it is necessary to more fully investigate the source of the damage. Damage can be divided into two large groups:

- Direct damages: Caused by exposure or loading, such as stress cracking, earthquake, shock, chemical attack, and freezing; and
- Indirect damages: Caused by design errors, choice of materials or construction methods, inadequate thickness, and lack of reinforcing steel.

Fig. 1: Damaged concrete

An accurate diagnosis may require field and laboratory tests as well as the collaboration of specialists. The diagnosis must be focused on finding the true cause of the problem. A problem should not be resolved until the cause is addressed. When only the damage is corrected—without solving the cause—the failure is likely to reoccur.

The essential stages of any diagnostic method can include: observation (visual examination), sampling or testing (nondestructive tests, core extraction, laboratory tests), and diagnosis. Observation involves making an initial survey to identify the main characteristics of the damaged area and detect symptoms of injury or damage. The result of the diagnosis will determine if it is necessary to repair, reinforce, or replace it.

The visual examination includes looking for surface defects in the concrete, such as excessive deformations, appearance changes, and cracks. Sampling or testing in this stage includes obtaining the information necessary to further identify the potential cause. This may be nondestructive or destructive testing as required. Diagnosis is the last stage of the process, where the information collected is analyzed and conclusions are drawn. The result of the diagnosis will determine if it is necessary to repair, reinforce, or replace the structure.

PROBLEMS RELATED TO AN INSUFFICIENT DESIGN OR PROJECT

In some applications, the concrete structure may fail because the engineering design is inadequate to support the load conditions in its service life. This may mean the concrete section does not have adequate thickness, reinforcement, or concrete strength. Once the element is in service it will eventually exhibit problems. In underground projects, one of the causes of insufficient design is it is often difficult to accurately determine the soil load acting on the concrete structure. This can result from hydrostatic pressure from underground water, varying types of soil or rock, superimposed stresses, excavation processes, and damage from blasting.

In underground construction, the shotcrete support is designed to act as an arch taking advantage of the relatively high compressive strength provided by concrete. Proper design and placement of the arch allows a good transfer of the loads on the roof and the walls to the floor. But if the concrete arch does not have adequate thickness and reinforcement it can fail. The design of the shotcrete placement will depend on the type of application (temporary or permanent), the life expectancy, and the service conditions.

Figures 2 through 5 show examples of concrete failures because of its design.

el diseñador. Cuando la causa principal está en la calidad de los materiales, el fabricante del concreto o de los materiales de concreto será responsable. Si los problemas se originaron en la colocación, el contratista puede ser culpable por no seguir las pautas de un proceso constructivo de calidad. Los problemas que surgen cuando la estructura está en servicio serán responsabilidad de operación y mantenimiento.

En esta cronología del proceso patológico, podemos distinguir tres partes bien definidas: el origen, la evolución y el resultado. Para el estudio del proceso patológico, es conveniente pasar por esta secuencia de manera inversa. Comience por observar el resultado del problema, luego estudie el síntoma para seguir la evolución hasta su origen, la causa.

Evaluación del deterioro del concreto

Varios factores causan daños en el concreto. Una gran parte de los defectos resultan del uso de materiales de mala calidad, la mala colocación, la exposición a entornos adversos durante la vida útil del concreto (por ejemplo, ciclos de congelación y descongelación, proximidad al agua de mar y exposición química) o la mala elección de componentes (por ejemplo el tipo de cemento) para un propósito específico.

Antes de comenzar a reparar el concreto dañado, la causa del daño debe ser identificada. A veces la causa es obvia; otras veces es necesario investigar la fuente del daño más a fondo. El daño se puede dividir en dos grupos grandes:

- Daños directos: Causados por exposición o carga, como agrietamiento por esfuerzo, terremoto, choque, ataque químico y congelación; y
- Daños indirectos: Causados por errores de diseño, elección de materiales o métodos de construcción, espesor inadecuado y falta de acero de refuerzo.

Fig. 1: Concreto dañado

Un diagnóstico preciso puede requerir pruebas de campo y de laboratorio, así como la colaboración de especialistas. El diagnóstico debe centrarse en encontrar la verdadera causa del problema. Un problema no debe resolverse hasta que se resuelva la causa. Cuando sólo se corrige el daño, sin resolver la causa, es probable que el fallo vuelva a ocurrir.

Las etapas esenciales de cualquier método de diagnóstico pueden incluir: observación (examen visual), muestreo o pruebas (pruebas no destructivas, extracción de núcleos, pruebas de laboratorio) y diagnóstico. La observación implica realizar una encuesta inicial para identificar las características principales del área dañada y detectar síntomas de lesión o daño. El resultado del diagnóstico determinará si es necesario repararla, reforzarla o reemplazarla.

El examen visual incluye la búsqueda de defectos superficiales en el concreto, tales como deformaciones excesivas, cambios de apariencia y grietas. El muestreo o pruebas en esta etapa incluyen la obtención de información necesaria para identificar mejor la causa potencial. Esto puede ser un ensayo no destructivo o destructivo según sea requerido. El diagnóstico es la última etapa del proceso, donde se analiza la información recogida y se extraen conclusiones. El resultado del diagnóstico determinará si es necesario reparar, reforzar o reemplazar la estructura.

PROBLEMAS RELACIONADOS CON UN DISEÑO O PROYECTO INSUFICIENTE

En algunas aplicaciones, la estructura de concreto puede fallar porque el diseño de ingeniería es inadecuado para soportar las condiciones de carga en su vida útil. Esto puede significar que la sección de concreto no tiene espesor, refuerzo o resistencia de concreto adecuados. Una vez que el elemento está en servicio, eventualmente exhibirá problemas. En los proyectos subterráneos, una de las causas de diseño insuficiente es que a menudo es difícil determinar con precisión la carga del suelo que actúa sobre la estructura de concreto. Esto puede resultar por presión hidrostática procedente de agua subterránea, diferentes tipos de suelo o roca, esfuerzos sobrepuestos, procesos de excavación y daños causados por voladura.

En la construcción subterránea, el soporte de concreto lanzado está diseñado para actuar como un arco aprovechando la resistencia relativamente alta a la compresión proporcionada por el concreto. El diseño y la colocación adecuados del arco permite una buena transferencia de las cargas en el techo y los muros al piso. Pero si el arco de concreto no tiene el espesor y el refuerzo adecuados, puede fallar. El diseño de la colocación de concreto lanzado dependerá del tipo de aplicación (temporal o permanente), la expectativa de vida y las condiciones de servicio.

Las figuras 2 a 5 muestran ejemplos de fallas de concreto debido a su diseño.

Fig. 2: Very-thin shotcrete

Fig. 4: Very-thin shotcrete caused a mine collapse

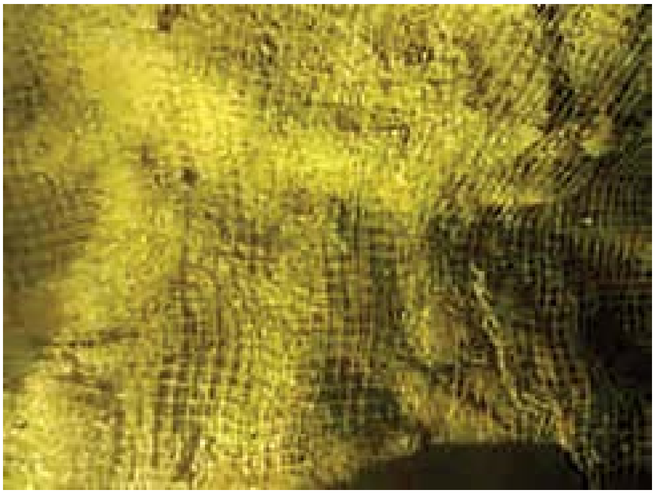


Fig. 3: Very-thin shotcrete with all the mesh exposed

Fig. 5: Pillar collapse due to the lack of reinforcing steel

PROBLEMS CAUSED BY THE PLANNING PROCESS

Planning is a primary part of any project. It helps to identify the steps that will be carried out in the construction, including the methods, the strategies, and the resources. In the planning process, all necessary information must be gathered to plan the project effectively and make the appropriate decisions.

Shotcrete Placement Planning

The planning process is a way to use strategies and identify resources to meet objectives during the construction. Here are some factors that must be considered planning for shotcrete placement:

- Concrete delivery rate, yd^3/h (m^3/h);
- Placing equipment rate, yd^3/h (m^3/h);
- Placing crew production, yd^2/h (m^2/h);
- Finishing crew production, ft^2/h (m^2/h);
- Crew qualifications;
- Mixture design;
- Forms (type and design);
- Compressors (air pressure, flow rate, quantity);
- Length of shotcrete pumping (vertical, horizontal);
- Availability of equipment or staffing in case of a breakdown or shortage;
- Steps to install an emergency construction joint;
- Cold or hot weather concreting;
- Jobsite conditions and access;
- Surface preparation;
- Additional equipment (cranes, scaffolds, heaters);
- Construction schedule;
- Concrete setting time;
- Construction sequence and process;
- Power, light, water, resources;
- Waste management (rebound, waste concrete);

Fig. 2: Concreto lanzado muy delgado

Fig. 4: Concreto lanzado muy delgado causó un colapso de la mina

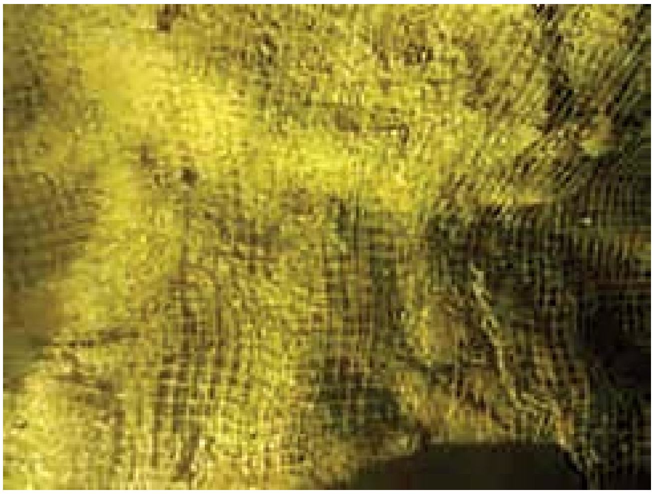


Fig. 3: Concreto lanzado muy delgado con toda la malla expuesta

Fig. 5: Derrumbe del pilar debido a la falta de acero de refuerzo

PROBLEMAS CAUSADOS POR EL PROCESO DE PLANIFICACIÓN

La planificación es una parte principal de cualquier proyecto. Ayuda a identificar los pasos que se llevarán a cabo en la construcción, incluyendo los métodos, las estrategias y los recursos. En el proceso de planificación, se debe reunir toda la información necesaria para planificar el proyecto de manera efectiva y tomar las decisiones apropiadas.

Planificación de la colocación del concreto lanzado

El proceso de planificación es una forma de utilizar estrategias e identificar recursos para cumplir los objetivos durante la construcción. Aquí hay algunos factores que deben ser considerados al planificar para la colocación de concreto lanzado:

- Tasa de entrega del concreto, yd^3/h (m^3/h);
- Tasa del equipo de colocación, yd^3/h (m^3/h);
- Producción de la cuadrilla de colocación, yd^2/h (m^2/h);
- Producción de la cuadrilla de acabado, pie^2/h (m^2/h);
- Calificación de la cuadrilla;
- Diseño de la mezcla;
- Encofrados (tipo y diseño);
- Compresores (presión de aire, caudal, cantidad);
- Longitud del bombeo de concreto lanzado (vertical, horizontal);
- Disponibilidad de equipamiento o personal en caso de avería o escasez;
- Pasos para instalar una junta de construcción de emergencia;
- Colocación de concreto en clima fría o calido;
- Condiciones de trabajo y acceso del lugar;
- Preparación de la superficie;
- Equipamiento adicional (grúas, andamios, calentadores);
- Horario de la construcción;
- Tiempo de fraguado del concreto;
- Secuencia y proceso de construcción;
- Energía eléctrica, luz, agua, recursos;
- Gestión de desechos (rebote, concreto residual);

- Acceptance of the concrete;
- Corrective actions if the concrete is not accepted;
- Tolerances;
- Acceptance of concrete finish;
- Jobsite safety; and
- Type of curing.

ESTABLISHING AN ACTION PLAN

Based on the goal, "proper shotcrete placement," the action plan answers five questions: What, When, How, Where, and Who. An action plan consists of action steps or changes to be implemented in your job—the logistics of how the job is going to be done. It also lists resources and potential barriers to achieve good-quality shotcrete. Most defects and problems that occur in shotcrete are due to poor placement (lack of air, distance, nozzle position, velocity) or material deficiencies. The in-place concrete properties are highly dependent on the skill and actions of the nozzleman. Satisfactory shotcrete placement requires full compaction—free of overspray and rebound—and proper encasement of reinforcement.

The Pennsylvania State University suggests there are Seven Steps of Successful Action Planning. We can apply this process to shotcrete placement.

Step 1: Define the Problem(s)

How you can get proper placement of shotcrete? Evaluate the situation—the formwork, substrate, environmental conditions, and concrete supply. Have all possibilities been considered? During this stage, try to explore all possible difficulties in placement. Ask all involved or interested individuals for their input in identifying the potential problems. Is there just one problem or are there more?

Step 2: Collect and Analyze the Data

Now that we have identified the potential problem(s), collect and analyze the system to develop appropriate processes and solutions. We analyze the situations by asking questions: What, When, How, Where, and Who?

Step 3: Clarify and Prioritize the Problem(s):

If there is more than one problem, you should prioritize the problems to focus on the most important problems first. Ask the following questions to help you sort the problems with the higher-priority issues to the top of the list.

- Which problem could result in negative consequences on the project?
- Are any of the problems putting the operation in danger of being in noncompliance with regulations?
- Which problems have the greatest impact on the long-term economic stability of the operation?
- Which problems have short-term impact on the stability of the operation?

Step 4: Write a Goal Statement for Each Solution

The next step in the process is setting S.M.A.R.T. goals. These are goals that are Specific, Measurable, Achievable, Relevant, and Timely. The team needs to go through the problem areas and evaluate them for each from their S.M.A.R.T characteristics. When all the goals are S.M.A.R.T. goals, you are ready to move on to monitoring progress. Otherwise, work with the team to make the necessary adjustments to make the goals:

- S – Specific: Specific goals are clear and focused, not broad, ambiguous, or general. Specific goals provide specific information on the behaviors that are associated with the goal. These goals indicate who will do what, when, and how;
- M – Measurable: Measurable goals provide a measurable indicator of success so that it becomes easy to monitor progress and determine when success has been attained. Measurements of success may be quantified with numbers or a simple yes or no determination;
- A – Achievable: Achievable goals are realistic and well within the abilities, responsibilities, and resources of the management and staff. This does not mean that goals must be easy to achieve. Every effort should be made to reach a higher level of performance. Sometimes "stretch" goals can encourage someone to step out of their comfort zone and tackle tasks in a new, challenging, yet achievable way that results in overall improvement for the operation;
- R – Relevant: A relevant goal is appropriate to a person who will be attempting to achieve it and to the overall goals and objectives of the project; and
- T – Timely: The attainment of a goal should not be open-ended but set for a specific time. When possible, set a specific date for accomplishing the goal. When a goal has a deadline, it provides a measurable point and speeds progress toward critical goals. Employees will generally put more emphasis on goals that have specific deadlines than for those which have no time measurement.

Step 5: Implement Solutions—Write the Action Plan

Step five is to write an action plan that addresses the problems. An action plan is written so that any employee can

- Aceptación del concreto;
- Acciones correctivas si no se acepta el concreto;
- Tolerancias;
- Aceptación del acabado del concreto;
- Seguridad en el lugar de trabajo; y
- Tipo de curado.

ESTABLECIMIENTO DE UN PLAN DE ACCIÓN

Basado en el objetivo, "colocación adecuada del concreto lanzado," el plan de acción responde a cinco preguntas: Qué, cuándo, cómo, dónde y quién. Un plan de acción consiste de pasos de acción o cambios a implementarse en su trabajo: la logística de cómo se va a realizar el trabajo. También enumera los recursos y las barreras posibles para lograr concreto lanzado de buena calidad. La mayoría de los defectos y problemas que ocurren con el concreto lanzado se deben a una mala colocación (falta de aire, distancia, posición de la boquilla, velocidad) o deficiencias materiales. Las propiedades del concreto en el lugar dependen en gran medida de la habilidad y las acciones del lanzador. La colocación satisfactoria de concreto lanzado requiere una compactación completa, libre de exceso de rocío y rebote, y una envoltura adecuada del refuerzo.

La Pennsylvania State University sugiere que hay siete pasos de una planificación de acción exitosa. Podemos aplicar este proceso a la colocación del concreto lanzado.

Primer paso: Definir el (los) problema(s)

¿Cómo se puede obtener la colocación adecuada del concreto lanzado? Evaluar la situación: el encofrado, el sustrato, las condiciones ambientales y el suministro de concreto. ¿Se han considerado todas las posibilidades? Durante esta etapa, trate de explorar todas las dificultades posibles en la colocación. Pida a todas las personas involucradas o interesadas por su contribución para identificar los problemas potenciales. ¿Hay solo un problema o hay más?

Segundo paso: Recopilar y analizar los datos

Ahora que hemos identificado el (los) problema (s) potencial (es), recorremos y analizamos el sistema para desarrollar procesos y soluciones adecuados. Analizamos las situaciones haciendo preguntas: ¿Qué, cuándo, cómo, dónde y quién?

Tercer paso: Aclarar y priorizar el (los) problema(s):

Si hay más de un problema, debe priorizar los problemas para centrarse primero en los problemas más importantes. Haga las siguientes preguntas para ayudarle a clasificar los problemas con los problemas de mayor prioridad en el tope de la lista.

- ¿Cual problema podría tener una consecuencia negativa para el proyecto?
- ¿Hay algũn problema que pone a la operación en peligro de incumplimiento de las normas?
- ¿Qué problemas tienen mayor impacto en la estabilidad económica a largo plazo de la operación?
- ¿Qué problemas tienen impacto a corto plazo en la estabilidad de la operación?

Cuarto paso: Escriba una declaración de objetivos para cada solución

El siguiente paso en el proceso es establecer objetivos S.M.A.R.T (por sus siglas ingles). Estos son objetivos específicos, medibles, alcanzables, relevantes y oportunos. El equipo necesita recorrer las áreas problemáticas y evaluarlas para cada una de ellas a partir de sus características S.M.A.R.T. Cuando todos los objetivos son objetivos de S.M.A.R.T., usted está listo para seguir a monitorear el progreso. De lo contrario, trabaje con el equipo para hacer los ajustes necesarios para hacer los objetivos:

- S — Específicos: Los objetivos específicos son claros y centrados, no amplios, ambiguos o generales. Los objetivos específicos proporcionan información específica sobre los comportamientos que están asociados con el objetivo. Estos objetivos indican quién hará qué, cuándo y cómo;
- M — Medibles: Los objetivos medibles proporcionan un indicador de éxito mensurable, de modo que resulte fácil supervisar el progreso y determinar cuándo se ha logrado el éxito. Las mediciones de éxito pueden cuantificarse con números o con una simple determinación de sí o no;
- A — Alcanzables: Los objetivos alcanzables son realistas y están dentro de las capacidades, responsabilidades y recursos de la administración y el personal. Esto no significa que los objetivos deban ser fáciles de alcanzar. Se debe hacer todo lo posible para alcanzar un nivel más alto de desempeño. A veces, los objetivos "extendidos" pueden animar a alguien a salirse de su zona de confort y hacerle frente a tareas de una manera nueva, desafiante y alcanzable que resulta en una mejora general de la operación;
- R — Relevantes: Un objetivo relevante es apropiado para una persona quien intentara alcanzarlo y para las metas y objetivos generales del proyecto; y
- T — Oportunos: El logro de un objetivo no debe ser de carácter indefinido, sino que debe fijarse a un tiempo especifico. Cuando sea posible, establezca una fecha específica para alcanzar el objetivo. Cuando un objetivo tiene una fecha límite, proporciona un punto mensurable y acelera el progreso hacia objetivos críticos. Por lo general, los empleados pondrán más énfasis en los objetivos que tienen plazos específicos que a aquellos que no tienen fechas de plazo.

Quinto paso: Implementar soluciones: escriba el plan de acción

El quinto paso es escribir un plan de acción que aborde los problemas. Se escribe un plan de acción para que cualquier do the task alone successfully and is followed much like a recipe. It converts the goal or plan into a process.

Step 6: Monitor and Evaluate

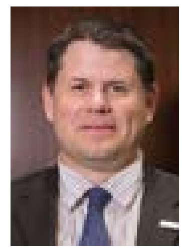
Our next step in the problem-solving process is to design a method for monitoring the outcome. The method we select should assess whether the goal and action plan correct the problem. In addition, a well-designed monitoring method will help the team to determine when the action plan needs to be improved.

Step 7: Restart with a New Problem or Refine the Old Problem

The problem-solving steps are cyclical. If the first cycle is successful, the process starts over with a new problem. If the same problem persists, there must be refinement, so the process starts over with refinement of the original problem as more current data is analyzed.

CONCLUSIONS

The lack of good planning can create problems that affect the final quality of the shotcrete placement. Planning is critical before placing the shotcrete to ensure you have enough resources, personnel, and material to accomplish the work productively and safely.



Raúl Armando Bracamontes Jiménez*, Ing., graduated from ITESO University (Instituto de Estudios Superiores de Occidente) in 1994 with a degree in civil engineering and has been working in the concrete industry ever since. Currently the owner of ADRA Ingeniería S.A. de C.V. since 2005, he is fluent in Spanish and English with multiple publications and courses given on shotcrete on his résumé. He is an ACI Certified Wet-Mix Nozzleman and Approved Examiner. Bracamontes is a member of Instituto Mexicano del Cemento y del Concreto (IMCYC), Colegio de Ingenieros Civiles de León (CICL), and the American Shotcrete Association.*

SAFETY GUIDELINES FOR SHOTCRETE

Chapter topics include:

- Personal Protective Equipment;
- Communications;
- Lighting;
- Back and Spine Safety;
- Shotcrete Materials;
- Shotcrete Equipment; and
- Shotcrete Placement: Wet- and Dry-mix Processes.

As a significant benefit of membership, all Corporate Members will receive one complimentary copy of this publication. Additional copies are available through the ASA Bookstore for $25 each (for members; $100 for nonmembers). Available in both print and electronic formats.

For more information or to purchase a copy of this publication, visit the ASA Bookstore at **www.shotcrete.org/BookstoreNet/default.aspx**.

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empleado pueda hacer la tarea por sí solo con éxito y se siga como una receta. Convierte el objetivo o plan en un proceso.

Sexto paso: Supervisar y evaluar

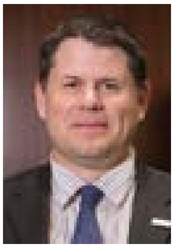
Nuestro siguiente paso en el proceso de resolución de problemas es diseñar un método para monitorear el resultado. El método que seleccionamos debe evaluar si el objetivo y el plan de acción corrigen el problema. Además, un método de supervisión bien diseñado ayudará al equipo a determinar cuándo es necesario mejorar el plan de acción.

Séptimo paso: Reinicie con un problema nuevo o refine el problema antiguo

Los pasos para resolver problemas son cíclicos. Si el primer ciclo tiene éxito, el proceso comienza de nuevo con un nuevo problema. Si el mismo problema persiste, debe haber refinamiento, por lo que el proceso comienza de nuevo con el refinamiento del problema original a medida que se analizan los datos más actuales.

CONCLUSIONES

La falta de una buena planificación puede crear problemas que afectan la calidad final de la colocación del concreto lanzado. La planificación es fundamental antes de colocar el concreto lanzado para asegurarse que se dispone de suficientes recursos, personal y material para realizar el trabajo de manera productiva y segura.



Raúl Armando Bracamontes Jiménez*, Ing., egresado por la Universidad ITESO (Instituto de Estudios Superiores de Occidente) en 1994, licenciado en ingeniería civil y desde entonces trabaja en la industria del concreto. Actualmente es propietario de ADRA Ingeniería S.A. de C.V. desde 2005, domina español e inglés con múltiples publicaciones y cursos impartidos en concreto lanzado en su currículum. Es un Lanzador de concreto de mezclado en húmedo certificado por ACI y Aprobado Examinador del ACI. Bracamontes es miembro del Instituto Mexicano del Cemento y del Concreto (IMCYC), del Colegio de Ingenieros Civiles de León (CICL) y de la American Shotcrete Association.*

GUÍA DE SEGURIDAD PARA EL CONCRETO LANZADO

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Los temas del capítulo incluyen:

- Equipo de protección personal;
- Comunicación;
- Iluminación;
- Seguridad de la espalda y la columna;
- Materiales de concreto lanzado;
- Equipo de colocación de concreto lanzado; y
- Colocación de concreto lanzado: vía húmeda y vía seca.

Como beneficio significativo de la membresía, todos los miembros corporativos recibirán una copia gratuita de esta publicación. Copias adicionales están disponibles a través de la librería ASA por $25 USD cada una (para miembros; $100 sin membresía).

Para obtener más información o para comprar una copia de esta publicación, visite el Librería de ASA en **www.shotcrete.org/BookstoreNet/default.aspx**.

SHOTCRETE FAQs

As a service to our readers, each issue of *Shotcrete* magazine 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 at http://shotcrete.org/pages/products-services/technical-questions.htm.

Question: *I would like to better understand the limitations related to the height of install when it comes to gunite application. Since gunite is a dry concrete mixed with water at the nozzle of the applying apparatus, I have been told by others in the industry that the application is only intended for use on walls less than 4 or 5 ft tall. If that is the case, it is safe to assume that the gunite application strategy should not be used for below-grade vaults exceeding a height of 5 ft? I am looking for design literature specific to gunite.*

Answer: Dry-mix shotcrete adds mixing water to the dry concrete materials as the concrete materials flow through and out the nozzle. Gunite is the original tradename for dry-mix shotcrete. Though you may not find design information using the old gunite name, you will find numerous current design references to dry-mix shotcrete. This includes ACI 506R-16, "Guide to Shotcrete"; ACI 506.2, "Specification for Shotcrete"; ACI 506.6T-17, "Visual Shotcrete Core Quality Evaluation Technote"; ACI 372, "Guide to Design and Construction of Circular Wire-and-Strand-Wrapped Prestressed Concrete Structures"; ACI 350-06, "Code Requirements for Environmental Engineering Concrete Structures"; ACI 350.5, "Specifications for Environmental Concrete Structures"; as well as seven ASTM standards that directly cover shotcrete. ACI 318-19, "Building Code Requirements for Structural Concrete," has also added specific shotcrete provisions. Dry-mix shotcrete has been used for decades to build structural concrete walls over 50 ft (15 m) high in circular prestressed concrete tanks that withstand a full head of water pressure. This is substantially greater water pressure than your 5 ft vault wall would experience. There are no limitations in the dry-mix placement process that would preclude use in high walls. Both dry-mix and wet-mix shotcrete using quality materials, proper equipment, and experienced placement crews will produce in-place concrete of equal strength, durability, and low permeability. However, generally wet-mix shotcrete can offer placement rates up to four times higher than dry-mix. Thus, in thicker, longer walls, wet-mix shotcrete may be more cost effective because it can be placed faster.

Question: *How much shotcrete coverage is required over No. 4 reinforcing bar?*

Answer: Shotcrete is simply a placement method for concrete. The specified concrete cover over reinforcing bar is usually included in contract documents for construction and values vary depending on exposure conditions. ACI 318 provides cover requirements for structural concrete in buildings, and ACI 350 provides cover requirements for concrete liquid-containing structures. Local building codes and fire codes may also require specific cover in concrete construction. If your project doesn't specify the cover requirements, we recommend you consult with a professional engineer experienced in the type of project you are working on to learn what the code requirements may be.

Question: *I am working on a restoration of a small 1870s train station constructed of serpentine stone in the Philadelphia, PA, area. In many areas, the stone has deteriorated, leaving deep "divets" in the exterior wall faces and in some cases, there is no stone at all. Our intent is to build (infill) the walls back to a flush face for stucco treatment for the lower portions of the wall and to repair or replace stone above that point.*

Is there a minimum amount of treatment recommended for a shotcrete application? If it can be used for such an application, is reinforcing required? The stone is rather friable, and I don't want to attach too much to it for fear of further damaging the stone. If shotcrete is not an appropriate approach for this repair, can you advise of other repair methods?

Answer: This is a great application for shotcrete placement of high-quality concrete without formwork. If you are merely adding shotcrete to fill out to a uniform surface profile without any structural requirements, you may not need reinforcement. However, it may still be advisable to include fibers in the shotcrete mixture to help control plastic shrinkage cracking. Generally, you would want to keep a minimum thickness of 1 in. (25 mm) to provide enough thickness for finishing. If you need the shotcreted sections to be self-supporting and carry loads as structural concrete, you should consult with a structural engineer to determine the appropriate thickness and reinforcement for the expected loads. Shotcrete is a placement method for concrete so standard reinforced concrete design is appropriate for shotcreted sections.

Question: *ACI 506R-16 discusses surface preparation requirements for various substrate surfaces and notes that for earth surfaces shotcrete shall not be placed on frozen ground. There does not appear to be any specific temperature requirement for other substrate materials, however. For concrete or masonry sub-straight surfaces, are there temperature requirements for shotcrete application in situations where bond is not required?*

Answer: All surfaces receiving shotcrete should be above freezing. The mandatory requirements of ACI 506.2-13, "Specification for Shotcrete," specifies:

"3.4.5 Cold weather shotcreting—Unless otherwise specified, shooting may proceed when ambient temperature is 40°F and rising. Stop shooting when ambient temperature is 40°F and falling, unless measures are taken to protect the shotcrete. Shotcrete material temperature, when shot, shall not be less than 50°F. Do not place shotcrete against frozen surfaces."

Your question then asks about substrate temperatures for sections not requiring bond. The concern of frozen concrete is not only bond, but an issue with freezing of some thickness of the concrete that would prevent strength gain. For requirements on this, ACI 301-16, "Specifications for Structural Concrete," would likely apply and 5.3.2.1(b) requires:

"5.3.2.1(b) Cold weather—Concrete temperatures at delivery shall meet the requirements of 4.2.2.5. Do not place concrete in contact with surfaces less than 35°F. Unless otherwise specified, this requirement shall not apply to reinforcing steel."

There is a discrepancy between ACI 301 and ACI 506.2. The ACI 301 value (35°F) is somewhat more conservative, though ACI 506.2 provisions (32°F) have proven to produce quality shotcrete. You may consider asking the Engineer of Record for your project what minimum substrate temperature is acceptable on your specific job.

Question: *I am currently researching shotcrete machines for a sewerage channel. Would dry-process or wet-process be more functional and efficient? I am new to the industry, so could you please give me some background information regarding the equipment used as well as information about the techniques and processes you would use? Could you also inform me about the factors like humidity and what effect they would have on what process you would use and how you would apply it? Please also let me know about any other information that you would consider as having a significant effect on the overall process.*

Answer: The thickness of the shotcrete placement, site logistics, and the availability of ready-mixed concrete, as well as expertise of the shotcrete contractor would likely determine the most cost-effective method for shotcrete placement. Both dry-mix and wet-mix will produce structural concrete in place with similar physical properties and durability. Wet-mix can generally produce more volume of material placed per hour than dry-mix. You had several basic questions about shotcrete that can be answered by visiting sections of **Shotcrete.org**. On our website, you will find the informational pages **www.shotcrete.org/Resources** and **www.shotcrete.org/ArchiveSearch** beneficial. The Resources page lists many shotcrete-specific articles and web resources. The Archive Search allows you to search through our *Shotcrete* magazine archive for past articles using keywords. You may also find ACI 506R-16, "Guide to Shotcrete," an informative primer on all aspects of shotcrete. You can purchase a PDF copy of the Guide from ACI at **www.concrete.org/store/productdetail.aspx?ItemID=50616**. ACI Committee 506, Shotcreting, also has several other technical documents available for specification for shotcrete, evaluation of shotcrete cores, specifying underground shotcrete, and fiber-reinforced shotcrete you can find on the ACI website.

Question: *We are applying a new shotcrete shell to an existing building. We are calling for a 5 in. (125 mm) base coat with a 1/4 in. (6 mm) brush-finished flash coat. We are specifying a color admixture for all of the shotcrete. It is a large building and we anticipate several days of shotcrete operations. Would it be wise to allow (or even specify):*
1) the color admixture to be used in the flash coat only?
2) all of the flash coat to be applied at once, possibly days after all of the base coat has been installed, to achieve a more uniform final appearance?

Answer: If you only need color in the exposed shotcrete surface, just putting color in the flash coat should be adequate as long as the flash coat is continuous across the entire area. You may want to specify the final "flash" layer to be thicker, perhaps 1/2 in. (12 mm) to 1 in. (25 mm) thick. This would help assure consistent color and still allow the finishers to produce a consistent final texture. As long as the concrete materials are the same in the production, you wouldn't need to shoot the final layer all in one day. Also, be sure curing methods are the same for the entire area as varying moisture can sometimes affect the early appearance of the coloring, though it usually balances out over time.

Question: *With structural shotcrete walls, what is the anticipated shear strength of the sprayed shotcrete to a vertical wall with geotextile fabric applied to a retention system? What is the anticipated dead load of the sprayed shotcrete at the base of the sprayed wall when the shotcrete wall is sprayed to a nominal thickness of 6 in. (150 mm)? Also, what is the maximum wall thickness that can be sprayed in a single pass application with a normal mixture design to achieve 4800 to 5000 psi strength?*

Answer: Shotcrete is a placement method for concrete. Thus, structural properties are equivalent to those of concrete with specified strength. Shotcrete compressive strengths will normally range from 4000 to 7000 psi at 28 days, so your 4800 to 5000 psi (33 to 35 MPa) is very normal. Density of shotcrete placed concrete is the same as cast concrete ranging from 145 to 150 lb/ft^3. Walls can generally be built at any required thickness because we will create the wall by bench shooting building the wall from the bottom to the top in vertical lifts.

NEW PRODUCTS & PROCESSES

AMERICAN CONCRETE PUMPING ASSOCIATION ANNOUNCES NEW SAFETY RESOURCES

The American Concrete Pumping Association (ACPA) announced new and updated safety materials to provide concrete pumpers with resources about safely working on jobsites. The new materials are available for free download on the association's website.

New "Safety Procedures When Maintaining a Concrete Pump" Manual

This guide outlines safety procedures when maintaining a concrete pump. Operating and maintaining a concrete pump requires a serious commitment to safety and a clear strategy for the day's work. The document covers basic hazards such as slip-and-fall, safety signals, burn hazards, and serious injury or death hazards. With detailed text and accompanying graphics, the new ACPA "Safety Procedures When Maintaining a Concrete Pump" manual includes sections on shop mechanics, safety signal definitions, rules for working with concrete boom pipelines, and scheduled maintenance.

This manual is available for hard-copy purchase in the publications section of ACPA's online safety store at **www.concretepumpers.com/content/safety-procedures-when-maintaining-concrete-pump**. The hard-copy price for ACPA members is $3 and $5 for nonmembers. The manual is available for a free download at **www.concretepumpers.com/sites/concretepumpers.com/files/attachments/acpa-mechanics-manual_final_rs.pdf**.

Updated Hose Whipping Safety Bulletin

Special care must be taken to prevent hose whipping injuries when operating a concrete pump with a boom. ACPA's new Hose Whipping Safety Bulletin has an expanded section on reducing hose whipping injuries, including steps to take when it's impractical to move personnel away from the hose. The updated bulletin also outlines ways the pump operator can communicate with the pour supervisor on preventing injuries with the placing crew. Finally, the new bulletin explains how the pump operator can safely troubleshoot hose blockages that could potentially lead to hose whipping injuries. To download a copy of the bulletin, visit **http://files.constantcontact.com/62832818001/c19089dd-20cc-4b62-b334-9b158e12a216.pdf.**

An Updated New Hand Signals PDF

A PDF with graphical representations of safety hand signals is available on the Contractors section of the ACPA website for free download. ACPA previously employed 14 hand signals and has adopted two new signals to reference the actions of safely approaching a hose and moving away from a hose. This safety resource is available in both English and Spanish.

Online Safety Resources

For additional resources on general safety, visit the Safety/Training resources page on the ACPA website. It features a variety of safety publications and materials to create a safe environment when working around concrete pumps on jobsites.

For more information, call 614.431.5618 or visit **www.concretepumpers.com**.

CEMEN TECH EXPANDS ACCU-POUR TECHNOLOGY SUITE

Cemen Tech introduced AP Office and AP Mobile, a new set of tools in its ACCU-POUR™ technology suite available for volumetric concrete mixer users. The cloud-based technology provides users a complete view of their concrete business operations.

AP Office

AP Office is a front-end solution for scheduling, dispatch, and fleet management functions. Using telematics technology, the software allows business owners to keep track of the status and location of each mixer in their fleet in real time. AP Office also documents and stores all key mixer production statistics, which allows users to make accurate real-time business management decisions. AP Office also simplifies assignments and orders by allowing users to create one order, then divide it into multiple trucks if needed and still track under one job.

AP Mobile

Designed for use on a phone, tablet, or other mobile devices, AP Mobile allows users to wirelessly send and receive production data between AP Office and the mixer, as well as view mixing parameters in real time. Once a placement is complete, final job data sync automatically with AP Office.

With AP Office and AP Mobile working jointly in real time, information goes to the unit and then directly back to the office. After an order is placed, dispatch enters the job parameters into AP Office. AP Mobile then receives those parameters and wirelessly sends all information to the mixer. The operator completes the placement, while all production data is automatically sent back to AP Office for analysis.

For more information, call 800.247.2464 or visit **www.CemenTech.com**.

PUTZMEISTER AMERICA, INC. ANNOUNCES NEW TRUCK-MOUNTED 51Z-5 METER CONCRETE BOOM PUMP

Putzmeister America, Inc., announced the new 51Z-5 Meter Concrete Boom Pump to enhance the Putzmeister 50-Meter class portfolio. The new 51Z-5 features a reduced outrigger footprint and the latest Ergonic® 2.0 technology.

The reduction of the outrigger support width is further reduced with the One-Sided Support System (OSS) on the new 51Z-5 Meter. With the OSS in use, the 51Z-5 Meter outrigger width reduces by roughly 9 ft (2.74 m). The 51Z-5 features an OSS reduction of approximately 10 ft (3 m), saving an extra foot, and allows the operator to maximize horizontal reach from the front edge of the truck to the fully supported side.

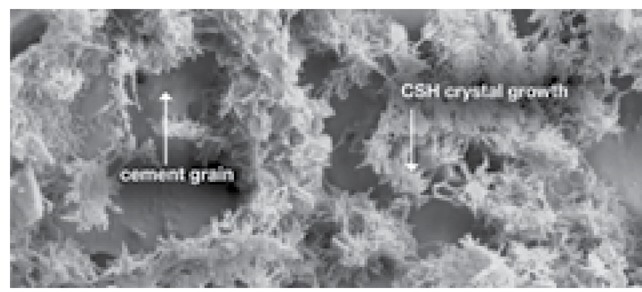
The Putzmeister pump features the Ergonic Pump System (EPS) and Ergonic Output Control (EOC) that work together to optimize the pumping process and regulate the optimum engine speed, ensuring the pump operates smoothly with fuel efficiency and low wear and tear on the equipment. The EOC can reduce fuel consumption by up to 25%. The 51Z-5 also comes standard with the Ergonic 2.0 remote control.

For more information, call 800.884.7210 or visit **www.Putzmeister.com**.

BASF MASTER X-SEED 55

BASF's Master X-Seed 55 is a strength-enhancing admixture that improves both early- and late-age strength development in concrete, while supporting sustainable construction. Master X-Seed 55 admixture is based on a technology that facilitates improved cement hydration, thus enhancing strength development. The admixture meets ASTM C494/C494M requirements for Type S, Specific Performance, admixtures. The strength-enhancing property of Master X-Seed 55 admixture permits a reduction in the total cementitious materials content of a given concrete mixture while maintaining compressive strength development equivalent to that of reference concrete, with associated benefits in CO_2 emissions reduction.

For more information, call 800.526.1072 or visit **www.basf.com**.



LEARN MORE ABOUT THE SHOTCRETE PROCESS—
FOR ARCHITECTS, ENGINEERS, AND SPECIFIERS

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

Arrange for an ASA Onsite Learning Seminar today!

info@shotcrete.org or 248.848.3780

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NSPF AND APSP TO UNIFY TO FORM NEW ORGANIZATION

The National Swimming Pool Foundation® (NSPF) and the Association of Pool & Spa Professionals (APSP) unified to form the Pool & Hot Tub Alliance. Work is currently underway to establish and formalize governance, structure, and operations. The unified organization is scheduled to officially begin operations on April 1, 2019.

The new organization will operate with The Pool & Hot Tub Alliance as the umbrella, leading industry-wide advocacy, alliances, and promotions. Trade and foundation activities will be conducted separately for procedural and legal purposes, under the banners of The Pool & Hot Tub Professionals Association, and The Pool & Hot Tub Foundation, respectively.

All three groups will be governed by a single Board of Directors to ensure sustained unity of mission and vision and will be initially composed of five members each from the current boards of NSPF and APSP. The leaders of both NSPF and APSP agreed that the new structure, with its "Celebrate the Water" mission, will offer greater community benefits by facilitating the expansion of swimming, water safety and related research, and outreach activities aimed at introducing more people to swimming, making swimming environments safer, and keeping pools open to serve communities. In addition, the unified organization will expand growth opportunities for aquatics professionals and businesses by promoting demand for swimming and increasing the efficient delivery of educational and training opportunities. Finally, by speaking with a single, united advocacy voice, The Pool & Hot Tub Alliance will be better positioned to protect the interests of the industry through an unprecedented and expanded network that includes both nationwide and international alliances and relationships.

For more information about APSP, call 703.838.0083 or visit **https://apsp.org**. For more information about NSPF, call 719.540.9119 or visit **www.nspf.org**.

ICRI ANNOUNCES LAUNCH OF NEW BRANDING

Restore | Repurpose | Renew

The International Concrete Repair Institute (ICRI), an association of contractors, engineers, consultants, and manufacturers that work together to improve the understanding of and training within the concrete repair industry, announced the launch of its updated branding. The organization's past branding had been in place since it was renamed from the International Association of Concrete Repair Specialists (IACRS) almost 30 years ago.

Branding research and discovery led ICRI to a new brand, which now evokes a modern and memorable message, while projecting leadership, strength, professionalism, and innovation. The new ICRI branding also stresses the importance of displaying that it is forward-thinking, and inclusive to a wider, more diverse demographic. It was also important to keep the international/global theme top of mind, while elevating the brand to a more modern, yet timeless look. The new logo was developed to elevate the brand to better reflect ICRI's current position and values, as well as to better align itself with evolved attitudes, practices, and changing demographics within the industry, the general public, and ICRI's growing membership.

ICRI ELECTS NEW OFFICERS AND BOARD MEMBERS

ICRI announced the election by the membership of new officers and Board members for the calendar year 2019 and Chris Lippmann, HDSupply, as its President. To support Lippmann, the ICRI membership also elected the following officers: President-Elect, Mark LeMay, AIA, JQ Engineering, LLP; Vice President, Elena Kessi, Aquafin Building Product Systems; Treasurer, John McDougall, Baker Roofing Co., Inc.; and Secretary, Pierre Hébert, MAPEI. Ralph C. Jones served as President in 2018 and will continue his service on the Board as Immediate Past-President. The 1-year terms began on January 1, 2019.

Fred Goodwin, BASF, will continue serving as an ex-officio member of the Executive Committee in his role as Chair of the Technical Activities Committee (TAC).

In addition to the President and Officers, the membership voted in the following new Board members who began serving 3-year terms on January 1, 2019, ending on December 31, 2021: Pat Gallagher, PULLMAN; Dan Wald, BASF Construction Systems; Jim Spiegel, Alchemy-Spetec; and Rick Edelson, Edelson Consulting Group, LLC. David Marofsky, MAPEI Corporation, was re-elected to a 3-year term ending December 31, 2021.

ASCC ELECTS 2019 OFFICERS

Chris Forster, Largo Concrete, Tustin, CA, has been elected President of the American Society of Concrete Contractors (ASCC) for 2019-2020. Bill Bramschreiber, Charles Pankow Builders; Anthony DeCarlo, TWC Concrete Services; and Mario Garza, Barton Malow, were re-elected Vice Presidents. Chris Klemaske, T.B. Penick & Sons, was elected a Vice President and Kevin Riley, Belfast Valley Contractors, was elected Treasurer. Heather Brown, Middle Tennessee State University; Maizer Ouijdani, Conco; and Keith Wayne, Wayne Brothers, were elected as Directors and Heston Hamilton, Ductilcrete Slab Systems;

Forster

David Somero, S&S Concrete Floors; and Jason Swagert, Citadel Contractors, were re-elected Directors.

The Decorative Concrete Council (DCC), a specialty council of ASCC, elected Karen Keyes, The Art of Concrete, Denver, CO, as Council Director. Jeff Eiswerth, H&C Decorative Concrete Products, Cleveland, OH, was elected Secretary. John Anderson, Solomon Colors; Marshall Hoskins, Butterfield Color; Tonia Primavera, SUNDEK; and C.J. Salzano, Salzano Custom Concrete, are newly elected Directors.

The ASCC Safety & Risk Management Council (SRMC) re-elected Mike Schneider, Baker Concrete Construction, Monroe, OH, as Council Director for 2019. Aron Csont, Barton Malow, Southfield, MI, was re-elected Secretary. Rodney Hartline, BURNCO, was elected as a new Director. Heather Baines, North Coast Concrete; Jamie Czuba, Breigan Concrete Construction; Jason Sisk, Wayne Brothers; and Matt Stier, McD Concrete Enterprises, were re-elected as Directors.

Jeremy Clark, Stego Industries, LLC, Chicago, IL, was re-elected Council Director of the Manufacturers' Advisory Council Board for 2019. Jeff Wells, SUNDEK, was re-elected Secretary. Jim Becker, W.R. Meadows; Jeff Johnson, Allen Engineering Corp.; and Doug Rhiel, Schwing, were re-elected as Directors and Mike Tracy, ARDEX Americas, was elected as a new Director.

The Concrete Polishing Council (CPC) elected Shawn Halverson, Surfacing Solutions, Temecula, CA, as council Director and Scott Metzger, Metzger & McGuire, Concord, NH, as Secretary. Re-elected as a Director was Bruce Ferrell, PROSOCO. Newly elected Directors are Bill Bencker, David Allen Co.; Lance Drabzcyk, Jon-Don; John Haines, Hyde Concrete; and Jessica Ledger-Kalen, Royale Concrete.

For more information, call ASCC at 866.788.2722 or visit **www.ascconline.org**.

Concrete Pumping Association of Canada Merges with American Concrete Pumping Association

The American Concrete Pumping Association (ACPA) announced the Concrete Pumping Association of Canada (CPAC) will now operate as an ACPA chapter, continuing under the CPAC name. The merger will provide ACPA members from Canada a dedicated forum for addressing issues affecting Canadian pumpers. Current CPAC

members will benefit from ACPA's strong safety, training, and concrete pump operator certification program.

"CPAC's merger with ACPA is a very positive step forward for the entire concrete pumping industry," says Christi Collins, Executive Director, ACPA. "It creates synergy and alignment on both sides of the border as we advocate and lobby for shared resources for the greater concrete pumping community."

Concrete pumpers in the United States and Canada share many issues, including safety, workforce development, and promotion of the industry. The merger solidifies the concrete pumping industry's presence in the North American marketplace and brings increased visibility to concrete pumping across the borders.

For more information, call 614.431.5618 or visit **www.concretepumpers.com**.

SIKA CANADA AGREES TO ACQUIRE KING PACKAGED MATERIALS COMPANY

Sika Canada has agreed to acquire King Packaged Materials Company, a large independent Canadian manufacturer of dry shotcrete and mortars for concrete repair. Closing of the transaction is expected to take place in the second quarter of 2019.

King is a family-owned business and a well-established manufacturer of products for the construction and mining industry as well as for the home improvement distribution channel. The portfolio includes shotcrete solutions, grouts, and repair and masonry mortars.

The company has an excellent reputation for its recognized brands, its high-quality and reliable product solutions, and its strong technical sales expertise. King operates three large state-of-the-art plants: one in Brantford, ON, Canada; one in Sudbury, Ontario; and one in Boisbriand, Quebec.

The owners of King Packaged Materials Company, the Hutter and Macpherson families, strongly believe that Sika is the ideal partner to continue the growth of King products in all of their market sectors. They look forward to the joint business and sales activities which offer great potential to expand the product portfolio across Canada and internationally.

NEW ACI MIDDLE EAST REGIONAL OFFICE OPENS IN DUBAI, UAE

The American Concrete Institute (ACI) announced the opening of its regional office in Dubai, United Arab Emirates (UAE)—its first physical presence outside the United States. A grand opening celebration was held on January 6, 2019, at the new office, located in the Dubai World Trade Center, Dubai, UAE.

The Middle East Regional Office, headed by Ahmad Mhanna, ACI's appointed Middle East Regional Director, will serve as a vehicle for increasing awareness of regional concrete design and construction practices, in addition to strengthening strategic relationships and increasing access to the Institute's consensus-based technical and educational resources.

For more information on ACI's activities in the Middle East region, visit **www.concrete.org/MiddleEast**.

Left to right: Ahmad Mhanna, ACI Middle East Regional Director; David A. Lange, ACI President; Hassan Al Hashemi, Vice President, International Relations, Dubai Chamber of Commerce & Industry; and Ronald G. Burg, ACI Executive Vice President, welcome guests to the ACI Middle East Regional Office grand opening in Dubai, UAE, on January 6, 2019

KING CONSTRUCTION PRODUCTS GROUP APPOINTS TECHNICAL SALES ENGINEER (EIT)

Jackson Rand joined the KING Construction Products group as Technical Sales Engineer. Rand will be responsible for the promotion and technical support of the construction products line, primarily as it applies to the engineering community. He will also be retaining the responsibility for technical support and promotion of the ultra-high-performance concrete (UHPC) product line for Ontario. Rand began his career as a summer student with the KING Paving & Construction group in 2012. After he received his bachelor's degree in civil engineering from Queen's University, Kingston, ON, Canada, in May 2016, Rand joined KING's Engineering Services Team, where he acquired a strong knowledge of many product technologies.

Rand

KING Construction Products include prepackaged concrete, grout, and repair mortar. KING Packaged Materials Company supplies prepackaged, preblended, cementitious products to North American and international construction and mining markets. Through the brand, KING Shotcrete Solutions, this company also offers shotcrete material, as well as mixing and placement equipment, intended for mining, tunneling, refractory, concrete construction, and concrete rehabilitation projects.

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WORLD OF CONCRETE 2019

Now in our 19th year as co-sponsors of World of Concrete (WOC), ASA's booth in South Hall continues to provide a great networking spot for those with an interest in the shotcrete industry. We love the opportunity to answer questions, sign up subscriptions for *Shotcrete* magazine, and welcome new members to the Association, as well as direct visitors to member companies also exhibiting at WOC as it brings together many of our partners in a single venue. ASA hosted meetings and organized educational opportunities to continue our mission to provide "knowledge resources, qualification, certification, education, and leadership to increase the acceptance, quality, and safe practices of the shotcrete process."

ASA's annual General Membership Meeting was Tuesday afternoon, followed by a first-time ASA-hosted reception in South Hall. The well-attended meeting and reception provided both new and old acquaintances an opportunity to connect.

This meeting followed ASA's Tuesday Shotcrete Nozzleman Education course, offered in both English and Spanish this year. Nozzleman Education is a required class for those pursuing full certification, but also a great resource of information for all members of the crew and project team to gain a better understanding of the process. Many from this class went on to complete their ACI certification exams later that week in Henderson, NV. Hosted by member company Hydro-Arch, participants pursuing wet-mix certification were able to take both their written and performance exams.

This year, ASA also offered our new Shotcrete Contractor Education at WOC. Very well attended, this seminar provided those pursuing the ASA Contractor Qualification Program and company leaders in general with best practices for the shotcrete contractor to help elevate their businesses.

Finally, ASA Board members Frank Townsend and Marcus von der Hofen again teamed up to bring an "Advanced Shotcrete" 90-minute presentation to the annual show. Due to the presentation's success last year, show officials requested it again specifically this year.

ASA SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE

SHOTCRETE CONVENTION &
TECHNOLOGY CONFERENCE
February 24-26, 2019 | Fernandina Beach, FL

ASA proudly hosted our second Shotcrete Convention and Technology Conference at the Omni Amelia Island Plantation Resort in Fernandina Beach, FL, this past February. Following the successful 20th Anniversary celebration in Napa, CA, last year, this year's Convention proved just as memorable. Fun options this year included golf, deep sea fishing, and a tennis clinic. Eighteen Technology Presentations were available to choose from, with two encore presentations voted by the attendees. The additional presentations (Duckworth's "Concrete Mixture Design for Shotcrete" and Siccari, Jolin and Gagnon's "The Shotcrete Placement Method: The Past, The Present, and The Future") provided attendees the opportunity to have a presentation repeated if it conflicted with another they wanted to attend. This addressed the feedback from last year that there were too many good options and attendees could not attend multiple presentations that were held concurrently. We again welcomed ACI Committee 506-H, Shotcrete Pools, that met at our convention along with a special brainstorming session for ACI Committee C660, Shotcrete Certification.

New this year, attendees enjoyed a successful dessert reception Sunday evening, prior to the start of Convention meetings. This too followed last year's feedback requesting an opportunity to meet others before the programs began. Monday evening's dinner also afforded an informal venue with restaurant seating to meet and network before culminating with our capstone celebration—the 2019 Awards Banquet at nearby Walker's Landing, an off-site venue reserved exclusively for ASA to celebrate our 2018 Outstanding Shotcrete Project Award winners featured in this issue. The Omni kept us well fed and quite adequately pampered during our 2-1/2-day event. Thanks to all for supporting us with your attendance, sponsorships, and feedback this year! Stay tuned for future events.

2018 OUTSTANDING SHOTCRETE PROJECT AWARD WINNERS

CATEGORY	PROJECT
Architecture | New Construction	**David Geffen Theater at the Academy Museum of Motion Pctures**
Infrastructure	**Oroville Dam Emergency Recovery Project**
International	**Pampoen Nek Cutting**
Pool | Recreational	**City of Frisco Texas Northeast Community Skate Park**
Repair | Rehabilitation	**Queens Midtown Tunnel Rehabilitation**
Underground	**Tiber Creek Sewer Rehabilitation**
Honorable Mention	**I-91 Brattleboro Bridge**
Honorable Mention	**Pier 10 Prestressed Concrete Girder Repairs**

2019 ASA OFFICER AND BOARD OF DIRECTORS APPOINTMENTS

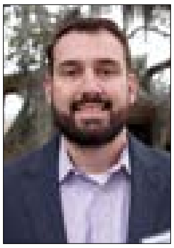
ASA announced its new officers and Board members who were elected by membership. **Cathy Burkert**, American Concrete Restorations Inc., will serve a 1-year term as ASA President. **Lihe (John) Zhang**, LZhang Consulting & Testing Ltd., assumes the position of Past President.

To complete the Executive Committee, the ASA membership also elected the following for 1-year terms: **Ryan Poole**, Consultant, as Vice President; **Lars Balck**, Consultant, as Secretary; and **Axel Nitschke**, WSP USA, as Treasurer.

Pictured from left to right: Lihe Zhang, Past President; Lars Balck, Vice President; Cathy Burkert, President; and Axel Nitschke, Treasurer (not pictured: Ryan Poole, Secretary)

Newly elected ASA Directors to serve 3-year terms include **Frank Townsend**, Superior Gunite; **Mike Reeves**, Gunite Specialists, Inc.; and **Jason Myers**, Dees-Hennessey Inc.

Myers



Reeves

Townsend

Returning ASA Directors include **Jonathan Dongell**, Pebble Technologies; **Oscar Duckworth**, Valley Concrete Services; **William Geers**, Bekaert-Maccaferri Underground Solutions; **Mason Guarino**, South Shore Gunite Pools & Spas, Inc.; **Marcus von der Hofen**, Coastal Gunite Construction Company; and **Ryan Oakes**, Revolution Gunite. To support the mission and work of ASA, the following individuals serve as Chairs of ASA Committees: **Marcus von der Hofen**, Chair, Coastal Gunite Construction Company, and **Ryan Oakes**, Vice Chair, Revolution Gunite, Contractor Qualification Committee; **Oscar Duckworth**, Valley Concrete Services, Education Committee; **Tait Pirkle**, Eastco Shotcrete LLC, Marketing Committee; **Jason Myers**, Dees-Hennessey Inc., Membership Committee; **Mason Guarino**, South Shore Gunite Pools & Spas, Inc., Pool and Recreational Committee; **Andrea Scott**, Chair, Hydro-Arch, and **Frank Townsend**, Vice Chair, Superior Gunite, Safety Committee; **Lihe (John) Zhang**, LZhang Consulting & Testing Ltd., Technical Committee; and **Axel Nitschke**, WSP USA, Underground Committee. Committee meetings are open to the public and ASA welcomes and encourages the participation of all interested parties in the shotcrete industry. The next committee meetings are scheduled for October 19, 2019, immediately preceding the ACI Concrete Convention and Exposition in Cincinnati, OH. For more information, visit **www.shotcrete.org**.

THANK YOU, SPONSORS AND EXHIBITORS

ASA extends a special Thank You to our 2019 Gold and Silver sponsors! Exhibitors at our Shotcrete Convention enjoyed many opportunities to meet and interact over meals, break times, and between meetings. ASA is indebted to our Sponsors for investing in the work of ASA, allowing for the success of our Conventions, Awards Programs, and many outreach opportunities to advance the work of the Association. Sponsors and exhibitors were noted throughout the event and highlighted at the Awards Banquet. We invite others to join in as sponsors next year as your investment has helped ASA grow to be the influence maker it is today for the shotcrete community!

ASA SPRING 2019 COMMITTEE MEETINGS

ASA's Spring 2019 Committees met in Fernandina Beach, FL, at ASA's Shotcrete Convention, February 25-26, 2019. Committee meetings are open to all and we welcome active participation. Each Committee has been tasked with items on the ASA Strategic Plan and we are seeing more activity than ever before. Voting members require a current ASA individual membership or higher and attendance at meetings. If you are interested in joining a committee, contact the Committee Chair or info@shotcrete.org for more information.

It is exciting to see new faces attend and have interest for greater participation. At these meetings, Cathy Burkert, American Concrete Restorations, stepped down from the Membership Committee, appointing Jason Myers, Dees Hennessey Inc., as Chair. Frank Townsend, Superior Gunite, assumed his newly appointed role as Vice Chair to the Safety Committee alongside Andrea Scott, Hydro-Arch. Pool & Recreational Shotcrete Committee Chair, Mason Guarino, South Shore Gunite Pools & Spas, Inc., appointed both Ryan Oakes, Revolution Gunite, as Vice Chair, and Mike Reeves, Gunite Specialists, as Secretary to the Committee. Thank you for your efforts on behalf of the Association!

A task group was assigned to update ASA's Bylaws after the Fall 2018 Meetings in Las Vegas, NV. The Board reviewed and approved the updated Bylaws. These Bylaws can be found at **www.shotcrete.org/media/pdf/ASABylawsRevised.pdf**.

2018-2019 ASA GRADUATE SCHOLARSHIP AWARDED

The 2018-2019 ASA Graduate Scholarship was awarded to Antoine Gagnon. He received a stipend of $3000 (USD) for tuition, residence, books, and materials. His bio and a summary of his research project can be found on pg. 10 of this issue.

Our annual graduate scholarship provides a scholarship to a Laval University graduate student engaged in shotcrete research. Evaluation of the entries includes a review of the relevance of the project's objectives with regards to the needs of the shotcrete industry, quality, originality, and scope of the research project, and integration of sustainability elements in the project. Laval University has been a leader in shotcrete research and ASA recognizes and supports their contributions to the industry through this scholarship and funding of other research needs.

Antoine Gagnon pictured with ASA President Cathy Burkert at the 2019 ASA Awards Banquet

ACI FOUNDATION'S STRATEGIC DEVELOPMENT COUNCIL ANNOUNCES NEW LEADERSHIP

Hanskat

The ACI Foundation's Strategic Development Council (SDC) announced that Charles Hanskat, P.E., FACI, FASCE, is the organization's new Chair, effective January 1, 2019.

Hanskat is a former Vice Chair of SDC. Hanskat is Executive Director and Technical Director for the American Shotcrete Association. He is a licensed professional engineer. Hanskat has been involved in the design, construction, evaluation, and repair of environmental concrete, marine, building, and shotcrete structures for 40 years.

He is an active voting or consulting member of many ACI technical and certification committees including Joint ACI-ASCE Committee 334, Concrete Shell Design and Construction, and ACI Committees 350, Environmental Engineering Concrete Structures; 506, Shotcreting; and C660, Shotcrete Nozzleman Certification. He is a Board member of ACI's Strategic Development Council. He was also 2014 President of the American Shotcrete Association, and chairs ASTM Committee C09.46, Shotcrete.

Hanskat has been active in professional and technical engineering societies. He served as president of the Florida Engineering Society (FES) and a national director of NSPE. He is a fellow member of ACI, ASCE, and FES, and an active member of ACI, ASA, ASCC, AREMA, ASTM, ICRI, and SDC.

He received his bachelor's and master's degrees in civil engineering from the University of Florida, Gainesville, FL.

CALL FOR ENTRIES FOR 2019 OUTSTANDING SHOTCRETE PROJECT AWARDS PROGRAM

ASA will begin accepting applications for it 2019 Outstanding Shotcrete Project Awards program in April 2019. These awards confirm and demonstrate the exceptional advantages of shotcrete placement of concrete. Awards are bestowed in the following six categories: architecture/new construction, infrastructure, international projects, pool & recreational, rehabilitation & repair, and underground. The deadline for submissions is October 1, 2019. For more information about the Outstanding Shotcrete Projects Awards and to view past award-winning projects, visit **www.shotcrete.org/ASAOutstandingProjects**, or contact us at 248.848.3780 or info@shotcrete.org.

AUTHORS' SUPPLEMENTARY CONTENT

Editor's Note: The article in our Fall 2018 Underground themed issue of Shotcrete *included an article "Shotcrete Lining Innovations in the United States". During our reviews, we asked the authors to provide some clarification on the terminology adopted by the NYC MTA. Unfortunately, due to production deadlines, their additional contributions were not included in the Fall issue before it went to press. Thus, we have provided the extra content here. You can find a PDF of the original article at **www.shotcrete.org/media/Archive/2018Fal_Thompson-Townsend.pdf**.*

"So, what are the benefits and differences of freeform concrete linings, also referred to as pneumatically applied concrete linings (PAC)? How does it compare to shotcrete final lining (SFL), and what are the potential drawbacks?

"The inherent difference between PAC and SFL is that PAC does not conform to the steel reinforcing requirements as detailed in older versions of ACI 506 that have been carried through into the New York State Building Code (NYSBC) and the International Building Code (IBC). The Code requirements allow a waiver to be granted to the reinforcement restrictions upon demonstration of successful encapsulation of the rebar at the most congested location. This required a significantly different and more onerous preconstruction testing regime to be developed for such applications. SFL linings by comparison were considered to be compliant with the Code requirements requiring no waiver to be granted for their use and therefore a less detailed testing program was needed. At the time that PAC terminology was introduced to the MTA Capital Construction program there were already two shotcrete specifications in existence. The significantly different testing requirements and design details led to the adoption of the term PAC and creation of a separate specification to simply provide differentiation between the various applications processes."

"PAC in contrast to SFL is used with the same reinforcing bar design used for a form-and-pour lining; thus, no specific design changes are needed to accommodate its use. It can be used around extremely heavy and congested reinforcement and against polyvinyl chloride (PVC) or spray-applied waterproofing membranes. Shotcrete is applied in layers that act monolithically in the completed concrete section. The layer thickness depends on the specific application but would typically be addressed as follows, 1) the rear layer of rebar is installed and the shotcrete sprayed to provide 2 to 3 inches of cover, 2) the front layer of rebar is fixed to the support anchors and then the shotcrete is brought out to the finished profile with the last pass having the accelerator dosage adjusted to provide a suitable workable concrete that can be finished to meet the design criteria. It can be hand finished to achieve any standard of finish required, including textured architectural finishes."

Guide to Shotcrete

ACI 506R-16, "Guide to Shotcrete," available from the American Concrete Institute, serves as a companion document to the mandatory language in ACI 506.2, "Specification for Shotcrete." Additional industry-leading education and certification programs are available from the American Concrete Institute and American Shotcrete Association.

Shotcrete—Guide and Specification Webinar

A webinar explaining changes in ACI 506R and how it serves as a companion document to ACI 506.2 "Specification for Shotcrete," is available as an ACI On-Demand Course. More details available at **www.ACIUniversity.com/webinars**.

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SHOTCRETE CALENDAR

JUNE 2-5, 2019	**ASTM International Committee C09, Concrete and Concrete Aggregates** Sheraton Denver Downtown Hotel | Denver, CO **www.astm.org**
JULY 22-26, 2019	**Professors' Workshop** ACI Headquarters | Farmington Hills, MI **www.concrete.org**
AUGUST 27-29, 2019	**SDC Technology Forum 46 | Concrete 2029** Kimpton Hotel Monaco Pittsburgh | Pittsburgh, PA **www.acifoundation.org/sdc**
SEPTEMBER 19-20, 2019	**Chicago Build** McCormick Place | Chicago, IL **www.chicagobuildexpo.com**
OCTOBER 19, 2019	**ASA Fall 2019 Committee Meetings** Convention Center and Hyatt Regency Cincinnati | Cincinnati, OH **www.shotcrete.org**
OCTOBER 20-24, 2019	**The ACI Concrete Convention and Exposition – Fall 2019** Theme: "A River of Knowledge" Convention Center and Hyatt Regency Cincinnati | Cincinnati, OH **www.concrete.org**
NOVEMBER 11-13, 2019	**ICRI Fall Convention** Theme: "Historic Restoration" Doubletree Hilton Philadelphia Center City | Philadelphia, PA **www.icri.org**
DECEMBER 8-11, 2019	**ASTM International Committee C09, Concrete and Concrete Aggregates** Marriott Marquis Houston | Houston, TX **www.astm.org**
FEBRUARY 4-7, 2020	**World of Concrete 2020** Las Vegas Convention Center | Las Vegas, NV **www.worldofconcrete.com**
FEBRUARY 23-26, 2020	**2020 SME Annual Conference & Expo** Phoenix Convention Center | Phoenix, AZ **www.smeannualconference.com**
MARCH 29 – APRIL 2, 2020	**The ACI Concrete Convention and Exposition – Spring 2020** Theme: "Concrete in the Windy City" Hyatt Regency O'Hare | Chicago/Rosemont, IL **www.concrete.org**
JUNE 28 – JULY 1, 2020	**ASTM International Committee C09, Concrete and Concrete Aggregates** Boston Marriott Copley Place | Boston, MA **www.astm.org**
SEPTEMBER 28-30, 2020	**MINExpo International** Las Vegas, NV **www.minexpo.com**
MORE INFORMATION	To see a full list with active links to each event, visit **www.shotcrete.org/calendar**.

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- EDUCATE the construction world on the advantages of the shotcrete process through Onsite Learning Seminars 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

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

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For more information on ASA membership, visit www.shotcrete.org/membership

MAPEI Underground Technology Team

We are in the tunnel with you from the start to the end of the job

MAPEI's Underground Technology Team (UTT) provides the construction market with a range of products dedicated to underground construction work. In addition to the "regular" construction challenges faced on above-ground jobsites, each underground job features additional unique challenges due to the often severe locations. MAPEI's UTT group and the products it represents were created to meet the expectations of these challenging environments.

From the project specification to the admixtures for shotcrete and concrete to the final protective coatings, MAPEI's UTT group and technology are there "for the whole job," said Bill Allen, UTT Business Development Manager – Tunneling. The UTT group is a successful division of MAPEI Group, which has provided proven construction system solutions for more than 80 years.

BACKGROUND

Established in 1937, MAPEI Group is a global corporation based in Milan, Italy, and includes 87 subsidiaries that comprise 81 plants in 35 countries. MAPEI is a world-leading manufacturer of mortars, grouts, and adhesives, as well as complementary products for installing floor and wall coverings. MAPEI manufactures chemical products for

Fig. 1: MAPEI's UTT products were used to help a tunnel boring machine dig the Anacostia River Tunnel, which extends for 2.37 miles (3.81 km) from Robert F. Kennedy Stadium in northeast Washington, DC, to Poplar Point in southeast DC

Fig. 2: MAPEI's UTT products have commercial as well as industrial applications. Its additive technology was added to shotcrete to create the walls of this high-tech wine cave

building, including waterproofing products, admixtures for concrete and repair products, and decorative and protective exterior coatings, as well as the UTT product line.

"The UTT group started in earnest in the U.S. in 2015," stated Wesley Morrison, UTT Regional Manager – North America. "But the business has grown substantially since then."

In the underground industry, speed is essential—not only of the products themselves but also of the evolution of technology. MAPEI reinvests a considerable percentage of its annual profits back into research and development (R&D) to maintain a leading technological advantage.

MAPEI's commitment to R&D ensures that the UTT line comprises innovative and technologically advanced products that the UTT team is trained to use.

MAPEI UTT PRODUCTS

The UTT product line is divided into six categories:

- Concrete technologies include more than 70 products, ranging from superplasticizers, accelerators, and retarding agents to "accessory" products dedicated to every type of underground concrete application, including shotcrete, ready mixed concrete, and precast concrete;
- Injection, consolidation, and anchoring products consist of a complete range of ready-to-use cementitious mixtures, chemical mixtures, and chemical resins designed for underground injection into rock, soil, and concrete structures. These products help to improve soil properties, stop water leaks, improve internal cohesion, and anchorage;
- Waterproofing systems feature a wide range of waterproofing options, including synthetic geomembranes and spray-applied membranes for all moisture conditions;
- Renovation, maintenance, and repair technologies include products for repairing concrete, fireproofing mortars, equipment for ready-to-use shotcrete, and injected products;
- Coatings for underground construction include protective paints, cementitious mortars, and ceramic coatings; and
- Mechanized tunneling offerings from UTT encompass a range of products and on-site technical assistance services to support clients throughout tunneling projects, from start to finish.

No matter the division or the product line, MAPEI is known for quality products and for providing system solutions. As Allen stated, "The distinguishing point for UTT is our field support, and our applied technology in the field. Simply put, we don't just sell a product, but rather we go into the field and help our customers *use* our products—on their jobsite, with their conditions, personnel, and equipment. There are many salesmen who do not know how to make their products work under field conditions. Customers/contractors appreciate and recognize this fact."

Morrison concurred, agreeing that UTT's technical services and agility are unbeatable. "We service a project from the very beginning to the very end like no one else in the industry does," he said. "We also have the agility to adjust to the customers' needs when necessary."

Fig. 3: Mapequick CBS 2 Holding Tanks

MAPEI
UNDERGROUND TECHNOLOGY TEAM

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Torrent Shotcrete

With offices in Vancouver and Toronto, Torrent Shotcrete serves the Canadian marketplace providing quality structural shotcrete. Since 2010 in Vancouver and 2014 in Toronto, Torrent has provided innovative shotcrete solutions in Canada, such as new building construction, civil infrastructure, building restoration, seismic upgrades, geotechnical applications, and industrial and architectural projects. We continuously improve our equipment and construction processes to create efficient, high-quality, high-volume shotcrete application processes. We help our clients build faster and more efficiently. Our signature line is More Wall. Every Day. And it's something we're proud to say we deliver on without compromise. We understand the requirements and expectations of contractors and our ability to work hand-in-hand with them on all phases of project development, from design to execution, has positioned us as an invaluable partner to our clients. Torrent works tirelessly and consistently to open our clients' thinking to the wide and exciting range of applications for structural shotcrete.

TORRENT VALUES

Torrent's direction today is driven by our core values—integrity, curiosity, and excellence in three key strategic areas including, operations, service, and innovation. Torrent is a market leader in Canada and our curiosity, the same curiosity that was instrumental in bringing Torrent to life, is as strong as ever. It's our foundation and it continues to

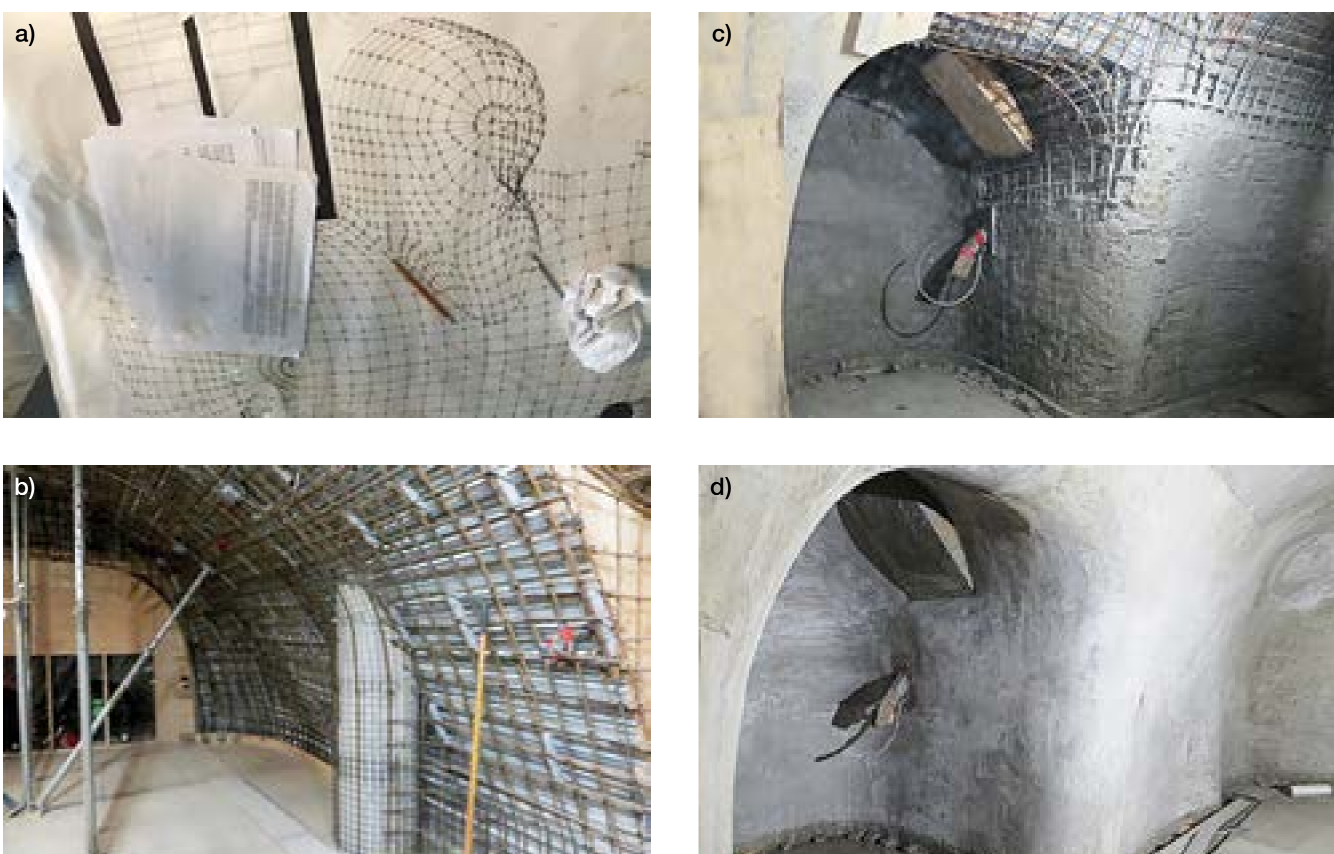

Fig. 1: The Spa at One Bloor West in Toronto and its adjacent amenities will occupy over 33,000 ft² upon its completion in 2022. The totality of design engages every surface in continuous movement, with planes and spaces overflowing into each other, collapsing interior and exterior and embracing nature. The uniqueness of the design presented numerous forming challenges that could only be addressed with structural shotcrete. Torrent's team of planners and shotcrete craftsmen were able to successfully provide all requirements to produce walls of this design: (a) drawings of the complex design; (b) intricate and precise staging; (c) shot walls are beginning to take shape; (d) the finals walls create a flowing dreamscape

Fig. 2: Construction on the ground-breaking Vancouver House project in the downtown core is well underway and Torrent provided the project owners a significant scheduling advantage. As a result of its shotcrete application technology, Torrent provided an average schedule acceleration of over 3.5 days per floor and was able to complete all concrete placement for 7.5 floors up to ground level an impressive 28 days ahead of the original schedule: (a) Torrent applying shotcrete for a structural wall; (b) Torrent's skilled craftsmen finishing to exacting client standards; (c) Ongoing consultation between Torrent superintendents and the shoot crew ensure high-quality results and production targets are met

drive our evolution. For us, curiosity means a real passion for recognizing possibilities and creating solutions, because we know this is what is needed to solve the evolving challenges facing urban construction today and in the future.

TORRENT TEAM

None of this happens without the right people; uncommonly passionate individuals who possess a sincere spirit of caring and a commitment to excellence. We only hire people who share our values and are devoted to genuine, ongoing contribution. We insist our people think from a customer's point of view and use their very best judgment to address challenges. Our approach often involves a very high level of creativity and that's part of what makes Torrent unique; searching beyond the obvious to find better ways to build better outcomes. We are more than just a shotcrete supplier, we are a trusted strategic partner to our clients who can be trusted to work cooperatively to find the most effective and efficient solutions.

TORRENT CULTURE

Our culture is all about pushing boundaries, learning new things, and being committed to continuous improvement. Shotcrete for building construction has come a long way since Torrent brought it to the Canadian marketplace, but we are just getting started. We know we're still in the early days of the continuing evolution of possibilities for shotcrete. As more and more architects and project developers learn about the many advantages of shotcrete over traditional form-and-pour methods, we're confident shotcrete's flexibility will generate an explosion of new and creative structural concrete applications. Through it all, Torrent will continue to provide innovative solutions and an unparalleled commitment to strategic partnership.

TORRENT SHOTCRETE

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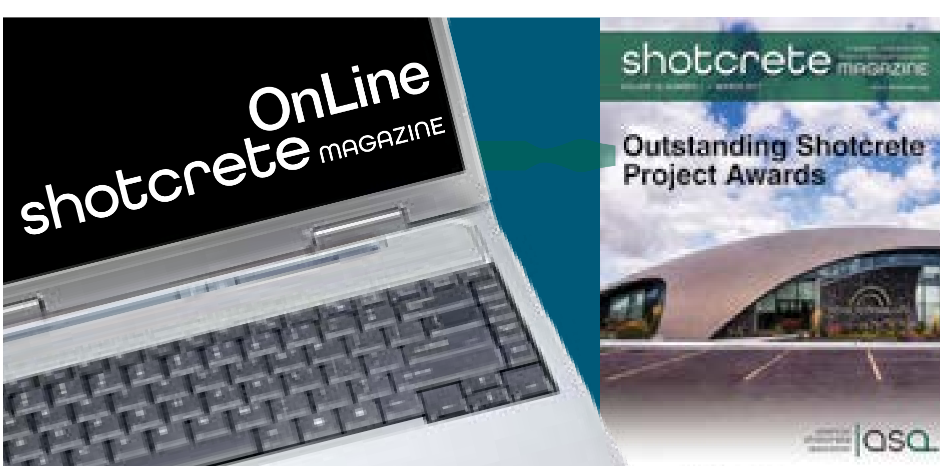

All ASA members and subscribers have access to the electronic version of *Shotcrete* magazine. A link to this e-magazine is sent as an item in the "What's in the Mix" e-newsletter. To ensure that you receive access to every issue of the electronic version of the magazine, send your e-mail information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

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The QUIKRETE Companies, Columbus, OH

Frank Townsend
Superior Gunite, Jersey City, NJ

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Craig Nelson
Bekaert Maccaferri Underground Solutions, Boise, ID

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Ing. Maria Graciela Hormigonart-Alvarez, Quito, Pichincha, Ecuador

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