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Outstanding Shotcrete Project Awards

american shotcrete association

asa

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shotcrete MAGAZINE

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FEATURES

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

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ALSO FEATURING

DEPARTMENTS

On the cover: Dome Technology Headquarters | Idaho Falls, ID

2016-2017 in Review

By Bill Drakeley

As my ASA presidential term comes to a close, I feel it is fitting to note the accomplishments of the entire ASA team over the past year. Our staff and volunteers amplified their efforts to meet our goal of promoting and advancing ASA, and ultimately improving the shotcrete industry as a whole. Over the past year, our team has worked diligently and their efforts were extremely productive. The following accomplishments have helped advance our position in the marketplace:

- Increased ASA membership;
- Introduced dual-track format for committee meetings;
- Increased committee membership and, more importantly, activity;
- Added three new shotcrete nozzleman examiners;
- Launched Spanish wet-mix certification sessions;
- Hosted both wet-mix and dry-mix certification sessions in conjunction with World of Concrete (WOC) 2017;
- Nozzleman certification is now increasingly a requirement found in job specifications;
- Implemented ACI's new Nozzleman-In-Training (NIT) Program;
- Reached and informed 785 engineers, architects, DOT officials, and owners on shotcrete applications and specification issues via our on-site presentations;

- Released a new Pool Committee Position Statement on cold joints;
- Availability of a Technical Director allows ASA to field technical inquiries in a timely fashion;
- Launched new Association logo, consistent graphics standards, and coordinating apparel;
- Presented an introduction to shotcrete to students at three universities;
- Exhibited at two international tradeshows: WOC 2016 and AREMA (American Railway Engineering and Maintenance-of-Way Association); and
- Better, more targeted tradeshow follow-up (which led to increased membership).

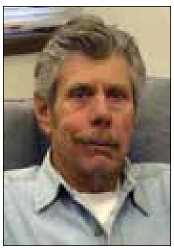
Every sitting president wants to leave their association in a better place than when they took office. As a team (and with full effort from all volunteers), I believe we have done that. Maintaining status quo in an ever-changing environment leads to a lack of credibility and diminishes the sustainability of an organization. Our accountability, structure, discipline, and subsequent accomplishments have helped shotcrete climb the ladder of credibility at a faster pace than ever before. I'm confident this momentum will continue under Scott Rand, our new ASA President. With his leadership, Scott will expand on this past year's success and continue propelling the shotcrete industry forward.

We have taken great strides toward becoming self-reliant as an Association, with full-time ASA staff providing the large majority of our Association's administration, organization, and guidance. This is evidenced as neither I nor our Executive Committee have needed to interact with our association management firm over the past year. I believe this to be a great indication that ASA has built a solid, self-sustaining foundation and is heading in the right direction. With our eminently qualified and trained staff, ASA has the opportunity to continue these efforts to grow and provide more options on how to best serve our members with an efficient and effective organizational structure.

Reputation is built upon quality and recognition—both of which take time and determination. We have all put in the time and effort to build our reputation over the past year. Because of this, ASA is approaching the black on the reputation ledger—let's keep it going.

ASA Contractor Qualification Committee

By Chris Zynda



I have been in the shotcrete business for over 50 years. I started as a laborer in the good old "gunite" days. Back then, there was no certification, or strict OSHA safety programs, but we did have a lot of beer to wash down the day's dust. However, our crews had heart and worked as a team—nobody got hurt and quality was good. Success in the shotcrete industry takes HEART, hard work, and a commitment to quality.

Over the last 50 years, I've seen a large increase in "state-of-the-art" equipment, sophisticated mixture designs, and admixtures for the shotcrete process. Computerized batch plants are light years ahead of the plants from the late 1960s and 1970s. Concrete pumps designed for wet-mix shotcrete use have been redesigned for increased reliability and performance to accept the challenge for today's fast-paced advancement of shotcrete more widely into the concrete construction industry.

The official ACI Nozzleman Certification Program has been available for the last 17 years and has helped make acceptance of the shotcrete process much more widespread. This certification has helped, yet in some ways, it's also hurt our industry.

In my area of the country, I have heard many instances where small concrete pumpers think just having a pump qualifies them to shoot shotcrete. Some don't have insurance or contractor's licenses, have very limited knowledge of the details required for successful shotcreting, and lack accountability for the quality of their work. I've also heard of individuals who have an ACI Nozzleman Certification and view it as a license to work as a free agent for any contractor who has a concrete pump, though those contractors may have little personal experience or other crew members experienced in all the details required to successfully plan, coordinate, shoot, finish, and cure shotcrete.

As one of the original ACI Committee C660 members charged with developing the ACI Nozzleman Certification Program, it was never our goal to have the ACI Nozzleman Certification Program even hint of going in this direction—where the only requirement for a quality shotcrete job is a certified nozzleman. The nozzleman is certainly an important part of the crew, but it takes the complete shotcrete team (owner, project manager, pump or gun operators, nozzleman, finishers) employed by an experienced contractor to consistently produce quality shotcreted projects. Our ASA Board of Direction Position Statement #1, "Shotcrete Contractor and Crew Qualifications," provides further specifics (**www.shotcrete.org/media/pdf/ASAPositionPaper_Board_1.pdf**).

In the spring of 2016, after much discussion, the ASA Board of Directors accepted the challenge to develop a Contractor Qualification Program (CQP) and created a standing committee—the Contractor Qualification Committee (CQC)—to both develop and administer the program. The ASA CQP is intended to be a straightforward program that helps to establish a shotcrete contractor's qualifications through review of the contractor's work by the ASA Contractor's Qualification committee, whose members have extensive experience in successful shotcrete work. This qualification program provides a distinct service to the industry. The qualification is expected to be highly beneficial to specifiers of shotcrete projects who want to be assured shotcrete contractors selected for their project have a proven work record. This qualification program is based on the previously referenced ASA Board Position Statement, "Shotcrete Contractor and Crew Qualifications."

At this point, the CQC has developed the overall guidelines for the qualification process. We are currently working on developing a 1-day seminar covering the basics required for shotcrete contractors. Topics for this 1-day seminar include: Program Overview; Site Planning/Logistics; Shotcrete Applications; Concrete Knowledge; Shotcrete Equipment; Shotcrete Knowledge; Shotcrete Testing; Equipment Maintenance; Safety; and Financial.

The intent of the seminar is for all qualified shotcrete contractors to have a working knowledge of all the aspects of producing quality shotcrete. As a result, the seminar will be a prerequisite for the contractor qualification.

We have a very active CQC and welcome your participation in what we feel is an essential part of what ASA is all about—helping to consistently prove to the concrete construction industry that quality shotcrete placement is a viable and desirable alternative to form-and-pour concrete.

ASA CONTRACTOR QUALIFICATION COMMITTEE

Chris Zynda, Chair | Shotcrete Concrete Contractors Association
Cathy Burkert, Secretary | American Concrete Restorations, Inc.

Lars Balck | Consultant
Michael Cotter | MP Solutions
Axel Nitschke | Shannon & Wilson Inc.
Ryan Oakes | Revolution Gunite
Ryan Poole | Consultant
Larry Totten | Totten Consulting Services
Frank Townsend | Superior Gunite
Marcus H. von der Hofen | Coastal Gunite Construction Co.

Smile! It's Awards Season 2017

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

Right up there with the Academy Awards, the Golden Globes, and other prestigious awards ceremonies, ASA celebrated another successful year of our Outstanding Shotcrete Project awards. Though we never did find the red carpet, our 12th Annual Awards Presentations and Banquet was hosted at the first-class Vdara Hotel in Las Vegas, NV, on the evening of January 17, 2017. The gala was very well-attended with over 150 members and guests in attendance.

Joe Hutter was our emcee again this year, and did a great job getting all the project awards (winners in each of our six categories and five honorable mentions) and individual honorees recognized in an organized and efficient manner. A big thank you to all the sponsors of this year's banquet. The sponsors' generous donations (we hit a record level this year) helped to offset the sharply increased banquet costs in Las Vegas, and thus keep our registration fees as low as possible. Look at our Association News section in this issue for photos and more details of the various awards at the event.

Our Executive Committee and Board of Directors also met in Las Vegas on Monday, January 16. They confirmed our commitment to refreshing our Strategic Plan at a special meeting before the spring ASA committee day, reviewed the 2016 financial performance, approved our 2017 budget, reviewed the status of our education and nozzleman certification programs, and received updates on our development of a Contractor's Qualification Program.

At the Executive Committee, Board, and General Membership meetings we also announced the results of the ASA election of Officers and Board members. Member voting overwhelmingly approved our slate of officers for 1-year terms (January 2017–January 2018):

- Scott Rand, President
- John Zhang, Vice President
- Ryan Poole, Secretary
- Cathy Burkert, Treasurer
- Bill Drakeley, Past President

Voters also approved three members for 3-year terms on the Board of Directors (January 2017–January 2020):

- Jonathan Dongell
- Mason Guarino
- Marcus H. von der Hofen

At the General Membership meeting, Bill Drakeley reflected on his last year as President and welcomed Scott Rand to take the reins of leadership of our Association. Scott cheerfully accepted and presented his thoughts on what he wants to accomplish in his term as President.

At World of Concrete (WOC) on Tuesday, we held a daylong nozzleman education session with excellent attendance. Then, later in the week, for the first time, we conducted both wet-mix and dry-mix nozzleman certification sessions to allow nozzlemen with the proper experience who had attended the education an opportunity to take the written and performance exams for nozzleman certification.

Additionally, an ASA-sponsored 1.5-hour technical session, "Shotcrete Technology: Advances, Research & Challenges in Using Shotcrete," produced by John Zhang and Chris Zynda, had over 70 attendees. As Chris Zynda had a last-minute conflict, I stepped in to help present Chris' portion of the talk.

Finally, we also had good traffic at our 20 x 30 ft (6 x 9 m) booth in the WOC South Hall. Thanks to all our members who volunteered their time to staff the booth throughout the exhibit hours Tuesday through Friday.

As a reminder, our spring 2017 committee meetings will be held at the American Concrete Institute (ACI) office in Farmington Hills, MI. The ACI Concrete Convention and Exposition will be held in downtown Detroit (Farmington Hills is a suburb of Detroit). We expect this new venue will help hold down costs for the meetings, and additionally let everyone see our Association headquarters. For security reasons, we do require RSVPs for our members attending the committee meetings, so if you haven't done so, please contact us before showing up.

Looking forward, 2017 is shaping up to be a very busy year, bringing new programs on board and pushing our committee activities to an even higher level. All members are welcome, and encouraged, to participate in our committees. The work of our volunteer members is what helps move our Association forward, and ultimately improves the recognition and quality of shotcrete in all types of concrete construction.

As always, if you have any questions about ASA or shotcrete, please feel free to contact me.

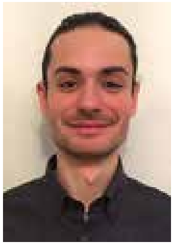
2016-2017 Awardees

ASA is pleased to announce the winners for this year's Graduate Student Scholarship: Thomas Jacob-Vaillancourt and Pierre Siccardi, both students of Laval University in Quebec, QC, Canada. The ASA student outreach programs have undergone some revisions this year to extend the visibility and reach to students.

The scholarship program, although certainly a worthy endeavor, has unfortunately attracted very few qualified applicants in the last couple of years. In reviewing our past scholarship awards, it was evident we have given at least one of our scholarships each year to a student at Laval University. As many know, Laval University, with the active involvement of Dr. Marc Jolin, has been at the forefront of a wide variety of shotcrete research. Thus, in 2016, the ASA Board decided to establish a standing, annual scholarship for a student in the shotcrete program at Laval. The Board felt that this scholarship would serve to assist a student actively involved in Laval's shotcrete research, and thus also help support the shotcrete research program overall. This year, with several generous individual contributions to the ASA Graduate Student Scholarship Program, we funded two scholarships.

The Board also decided to fund a student outreach program where experienced ASA members speak to student groups at their schools about shotcrete. The expectation is this type of outreach will help to inform many more students (and faculty) about the benefits of the shotcrete process. ASA also has a Student Outreach Task Group that is actively looking at potential programs and activities to promote and increase student education and participation in the shotcrete industry.

The following is a brief biography of the scholarship winners and their current research.



*Father of two **Thomas Jacob-Vaillancourt** received his bachelor's degree in civil engineering from Laval University, where he now pursues his master's degree. The goal of his ongoing research is to optimize curing and protection methods for shotcrete. The study will provide a better understanding of the curing impact on hydration and overall durability of dry-mix and wet-mix shotcrete. He is working on one of the projects of the Collaborative Research and Development grant supported by King Shotcrete Solutions and NSERC at Laval University.*

RESEARCH: OPTIMIZATION OF CURING AND PROTECTION METHODS FOR SHOTCRETE

Background and Industry Problem

The market for high-performance construction and repair materials is in continuous growth, and shotcrete has proven to be a method that produces durable, high-quality concrete at a low cost. Shotcrete, however, generally has a very high ratio of exposed area to volume. Once in place, it is rapidly exposed to the drying produced by local environmental conditions and can therefore be subjected to a great loss of water at a young age. In addition, the curing methods used for traditional concrete are ill-suited for shotcrete projects that have curved or overhanging shapes.

Objectives

The study takes place in two stages. The first objective aims at characterizing the effects of the cure in terms of durability of the in-place shotcrete. The second attempts to identify which of the market-available curing methods is best suited to extend the quality and service life of the sprayed concrete structures. In the present context, durability is defined as the potential for cracking and the quality of the surface produced in terms of porosity and abrasion resistance.

Research Significance

Because much of the study will be done on chemical curing agents (curing compounds and evaporation reducers/retardants), it is interesting to determine their effectiveness in limiting the loss of water from concrete depending on environmental conditions. For evaporation reducer agents, in addition to determining their effectiveness in reducing the evaporation of water from concrete, it is important to determine the length of efficacy of the protective film. To do this, precise scales were installed in a wind tunnel to allow us to monitor the loss of the concrete mass following the application of a curing compound or an evaporation reducer agent.

***Pierre Siccardi** is currently completing his master's degree in civil engineering at Laval University. Siccardi received his bachelor's degree in mechanical and industrial engineering from Arts et Métiers ParisTech, France, and his research project on shotcrete equipment allows him to take advantage of the diversified knowledge he has acquired along his university career. His research aims at developing shotcrete equipment technology that could bring together the shotcrete process and advanced mixtures such as UHPFC or CSA cement-based materials.*

RESEARCH: THE INFLUENCE OF EQUIPMENT ON SHOTCRETE PERFORMANCE

Background

Improvement of shotcrete is generally based on two main aspects: the mixture design and the equipment. Most of the research has been focused on the first item and the second hasn't really been studied in university laboratories.

My research project continues a series of research efforts established at Laval University in the last 5 years, and which has been profitable for advancements in the industry. Characterization of the spray pattern in dry- and wet-mix was one of the first challenges faced and had been overcome by using a high-speed camera. With the data collected, we are now able to understand the effect of multiple parameters that impact the shooting process. This promising information opens the doors for many research projects.

Objectives

The project aims to enhance the performance of shotcrete equipment in terms of versatility, rebound, and material uniformity. The study especially focuses on the nozzle and the water ring. In fact, a new dry-mix nozzle technology is currently being tested. This device has been designed to work with new mixtures such as very high early-strength shotcrete or ultra-high-performance fiber-reinforced shotcrete, and the results are already very encouraging. The long-term objective lies in the automation of the process, which would ensure that shotcrete consistency and consolidation is adequate while making shotcreting safer and less of a physical challenge for the nozzlemen. Moreover, this initiative combines productivity, safety, and sustainable development.

Research Significance

There are two main aspects explaining the need for development of new shotcrete equipment: first, it hasn't evolved in many years, and second, there are many complex components involved in the shotcrete process. Thus, there are numerous ways for us engineers to improve the shotcrete equipment.

The American Shotcrete Association extends a sincere thank-you to our 2016 Outstanding Shotcrete Project Awards Sponsors!

BIG SHOOTERS

King Shotcrete Solutions/King Shotcrete Equipment

Minova Global

Quikrete-Spec Mix

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- Dome Technology Corporate Headquarters
- Mexico City Deep Sewer Repair
- 2018 PyeongChang Winter Olympics Sliding Track
- The Pacific
- Ayla Golf Resort Comfort Stations

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2016 OUTSTANDING SHOTCRETE PROJECT AWARDS

The Outstanding Architecture | New Construction Project — **Elephant Lands, Oregon Zoo**

The Outstanding Infrastructure Project — **Bordeaux Prison: Rehabilitation and Repair of the Perimeter Walls**

The Outstanding International Project — **Holcim New Zealand Cement Terminal**

The Outstanding Pool & Recreational Project — **Coveleigh Club Pool Construction**

The Outstanding Repair & Rehabilitation Project — **Shotcrete Segment of the O'Hare and Midway Reconstruction Project**

The Outstanding Underground Project — **Rehabilitation of the Suhurlui Irrigation Pipeline**

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Sika Schweiz AG (Aliva Shotcrete Equipment)	Vesta Mine Supply	

2016 Outstanding Architecture | New Construction Project

Elephant Lands

By John Fulford

Controversy surrounding keeping large mammals in zoos has recently increased in the zoological community. The Oregon Zoo responded strongly and positively to this challenge by dedicating six acres (24,000 m^2) of their facility to the most ambitious and largest exhibit built in their 128-year history: "Elephant Lands." With the health and welfare of the Portland community's beloved elephants as the guiding principle, a world-class exhibit was constructed over the course of 3 years, all while the popular herd was kept on view to the public through a complicated series of construction phases. The result is a robust habitat that keeps the six elephants of the Oregon Zoo's herd mentally and physically active with abundant behavioral enrichment opportunities (such as mud wallows and a 160,000 gal. [605,000 L^3] pool for swimming and cavorting) while providing the public with an exciting and enriching experience that honors these magnificent animals.

This $57 million project was designed by CLR, a Philadelphia-based architectural firm that is widely known and highly regarded in the zoo construction industry. The innovative engineering of the project's shotcrete elements was performed by Armour Unsderfer Engineering, and the General Contractor/Construction Manager for the project was Lease Crutcher Lewis, one of the Pacific Northwest's premier builders.

The Turnstone Construction, Inc., crew had the pleasure of building the previous home for these elephants back in 1992, and so we were happily aware of some of the habits and personalities of these behemoths. We knew that Packy, the 54-year-old patriarch, enjoyed rubbing his belly on rocks with striated rib-like textures at about 4 ft (1.2 m) above grade. We also knew that the removal of the existing work to make way for the new exhibit would entail patience and heavy equipment. We happily left that work to a demolition contractor who exclaimed, "We had no idea concrete could get that hard," as they spent weeks breaking apart the old shotcrete rockwork and pool. Shotcrete structures held up to their notoriety as the strongest concrete in the zoo!

Fig. 1: Clay models were developed to show mass and scale of the shotcrete elements of the exhibit

This was the fourth elephant exhibit Turnstone had constructed, which allowed us to participate in preconstruction meetings with the zoo's animal management staff and the architectural and engineering team. We knew that the concrete surface textures needed to have high compressive strengths to withstand the rubbing of an elephant's leathery skin and at the same time be easy for them to walk on, and that walls had to be engineered to withstand the same impacts as a highway guardrail (a long-used standard).

Our staff also brought construction options to the design process that used shotcrete's sustainability advantages. As an example, we promoted top-down soil nail construction techniques to help save many of the trees in the areas that abutted the exhibit's containment walls. This was an important success because modern zoo design is based on the concept of habitat immersion—creating a sense of timelessness to help zoo visitors realize the importance of preserving the world's natural habitats. Being able to save large, mature trees in the background of these large mammals is particularly important to this illusion. It is also important to note that the substantially reduced excavation required by the shotcrete-based method provided multiple benefits, from less disruption to the animals and the public, environmental advantages (saved emissions and lowered fuel use), substantial cost savings, and schedule enhancement. Thousands of yd^3 (m^3) of soil remained in place due to this approach.

The construction process began with carefully shaped clay models of the exhibit and three-dimensional samples of each texture we would be sculpting. This was an important means of communicating to the owner and design team how we were interpreting a very subjectively judged scope of work. We requested an interactive workshop to develop the clay forms and review the samples so that we would not have to reconfigure our shotcrete during the construction process—clay being a much easier material to re-sculpt

Fig. 2: Earthen textures with embedded cobbles, roots, integral pigments, and topical stains

Fig. 3: Three-dimensional samples displaying the different textures were prepared for approval prior to production

Fig. 4: Shotcrete finishing for bedrock textures

than hard shotcrete. This stage of the project built strong team dynamics and trust that positioned us to work through the challenges of a complex construction project.

The construction schedule was particularly interesting because the elephants were to remain on view throughout, which required safe and secure areas while the other sections of the new yard were being built. Every day counted as we choreographed a ballet of large animals moving between enclosures. Shotcrete as a method of construction contributed to schedule enhancement in multiple ways. As an example, the conventional concrete construction of the deepest life support vault of the project's pool would have required closing the main access road to the site. However, using temporary shotcrete walls constructed with top-down soil nail techniques kept this from occurring, saving weeks on the overall schedule. Animal management staff worked closely with the construction team to develop the phasing strategy and reported that the changes in location kept the elephants mentally and physically active while they were moved between spaces.

Construction also kept us mentally and physically active while we deployed plans and methods that used the full range of shotcrete's versatility. On this site, we built tall, architecturally finished walls that provided containment for the elephants (this required that the walls were at least 9 ft [3 m] tall with an overhang). These were textured with embedded roots and real cobbles to simulate the aesthetic of eroding embankments in Asia. To make them as authentic in appearance as possible we searched for images from Asia so we could replicate specific features of the land. We manipulated our textures to display the stratigraphy of the soil lens, replicating various soil types, including clays and sandy loam. We stained the surface of integrally colored shotcrete to replicate the rich colors of Asian soils. In some areas, we purposefully showed the dynamic process of slumping soil by building erosional remnants of the same soil in the area below the eroded section of wall—a subtle effect but one that strengthened the intended illusion and allowed further opportunities for the elephants to rub against different shotcrete textures.

The project included two water-containing structures—one being a large pool able to accommodate up to 10 mature elephants and deep enough to allow them to fully submerge. These watertight shotcrete structures were placed monolithically. Both pools accommodated complex support systems crucial to the elephants' health that required detailing our finishes around 40 pipe penetrations. The construction of these pools also entailed slab textures carefully detailed to be friendly to elephant feet. These water features have proven to be efficacious at inspiring play among members of the herd.

Other applications of the shotcrete method included the lagging for top-down shoring techniques that were used to tuck a large building up against a hillside to keep it out of the sightlines of the public, again while saving the mature landscape above. Shotcrete was also used to provide a permanent wall face over a mechanically stabilized earthen structure and over a soldier pile wall. Existing form-and-pour walls were overlaid with shotcrete that was then textured to appear as large sections of native bedrock. Cantilevered retaining walls were formed on one side and built with shotcrete. Two bridge abutments were installed using shotcrete that allowed viewers to walk over the elephants' space. In each case, the structural method was chosen for its cost effectiveness and schedule benefits, and in each case the shotcrete process was central to the method elected. Ultimately, these structures were camouflaged using naturally textured shotcrete, which allowed them to blend in as an element of the elephants' natural habitat. Shotcrete's superior adhesion qualities were important to many facets of the work.

The construction and finished result of Elephant Lands is a testament to the versatility of shotcrete. Over 1250 yd^3 (956 m^3) of shotcrete was placed with ACI Certified Nozzlemen in the exhibit scope of work, and five different mixture designs were created to meet the shotcrete requirements of the project, including waterproofing,

Fig. 5: Finished bedrock textures included painted lichens native to the Asian habitat

Fig. 7: Mother Rose-Tu and baby Lily cavorting in their new pool

Fig. 6: Part of the Oregon Zoo elephant herd traveling through their new exhibit

Fig. 8: The youngest member of the herd exploring her new habitat

structural strength, aesthetic finishing, and pumpability. Integral pigments were added to the textural mixture designs to help develop the organic palette of colors for the habitat. All the shotcrete material was supplied by the Cemex Corporation.

Building a home for such magnificent animals made the challenges along the way much easier to keep in perspective. At completion, it was exhilarating to witness the Oregon Zoo herd walking together over sustained distances in a large exhibit yard that appeared to be from the forests and savannas of Asia. This is particularly unusual for elephants in captivity. This feeling was only eclipsed by the joy of watching the youngest elephant, 4-year-old Lily, swim with exuberance while being carefully watched over by the older members of the herd!

THE OUTSTANDING ARCHITECTURE | NEW CONSTRUCTION PROJECT

Project Name
Elephant Lands, Oregon Zoo

Project Location
Portland, OR

Shotcrete Contractor
Turnstone Construction, Inc.*

General Contractor
Lease Crutcher Lewis

Architect/Engineer
CLR Design, Armour Unsderfer Engineering

Material Supplier/Manufacturer
CEMEX CEMENTO

Project Owner
Oregon Zoo

*Corporate Member of the American Shotcrete Association

This project won the 2016 Project of the Year Awards with both the *Daily Journal of Commerce* (Oregon) and the Oregon Concrete and Aggregates Producers Association. Special thanks to the Oregon Zoo, Lease Crutcher Lewis, AUE Engineering, CLR Architects, and the Cemex Corporation.

John Fulford *founded Turnstone Construction, Inc., in 1997. Based in the Pacific Northwest, Turnstone has been building unusual shotcrete structures ever since, including zoo and aquarium exhibits, complex water features, climbing walls, naturalistic hot spas, salmon spawning streams, Hobbit houses, and simulations of famous caves. Fulford has been involved in five zoological projects that have won the prestigious "Best Exhibit" award from the American Zoo and Aquarium Association.*

Fig. 9: The highlighted area shows the scale of the six-acre elephant exhibit in relation to the rest of the zoo

Bordeaux Prison: Rehabilitation and Repair of the Perimeter Walls

By Kevin Robertson and Pierre Brassard

In 1891, the city of Montreal, QC, Canada, purchased land in Bordeaux (now the borough of Ahuntsic-Cartierville) for construction of a new prison to replace the outdated 1820s Pied-du-Courant prison, located in the Ville-Marie borough.

The prison, one of the few Pennsylvanian-styled prisons in Canada, was designed by Jean-Omer Marchand and R.A. Brassard, and built between 1908 and 1912 at a cost of $2.5 million, an astronomical amount in 1912.

On November 18, 1912, Bordeaux Prison opened its doors for the first time to 100 prisoners. It was then, as it is now, the largest provincial prison in Quebec; it was built to hold 500 prisoners but now has a capacity of 1189 inmates. The star-shaped building consists of a central 12-sided domed hub from which spring six cellblock wings that feature large outside cells ranged along the exterior walls. The new jail included state-of-the-art workshops placed at the heart of the prison, in front of the cellblock, and on both sides of the administration building. The whole complex stands within a five-sided compound surrounded by a double wall.

Today, Bordeaux Prison is the largest and most important prison in the province of Quebec. It is owned and operated by Société québécoise des infrastructures (SQI). The prison is protected by two peripheral concrete walls separated by an interior path. The heights of the inside and outside walls are 25 and 14 ft (7.4 and 4.4 m) and approximately 30 ft (9.1 m) wide, respectively. Exposure to over 100 years of the freezing-and-thawing cycles experienced during Montreal winters resulted in significant deterioration throughout the concrete walls. Core samples revealed that concrete deterioration ranged from 2.5 to 4 in. (65 to 100 mm) in depth. This contract was the fourth phase of the entire restoration project.

The first two phases called for a removal of the deteriorated concrete. Lightweight precast panels were installed using a steel stud hanger system to protect the walls from any further deterioration. Phase three called for removal of the deteriorated concrete and replacement using the form-and-pour method. Upon evaluation, however, it was evident this method was more costly and created longer delays. The section of walls that were to be repaired using the form-and-pour method required construction of a temporary wall in front of the existing wall to prevent inmates from climbing the wall formwork and escaping. The formwork had to be fireproof and thicker to provide room for the concrete to be placed within the form. The entire work area required an around-the-clock security patrol to prevent escape attempts.

Phase four of the project was released for tender in late 2014 and was awarded in 2015 to General Contractor Construction Jessiko Inc. Shotcrete-related work was a large portion of the project and included surface preparation, shotcrete placement, and curing. Jessiko chose Groupe Lefebvre M.R.P., an experienced and well-known concrete repair, waterproofing, and shotcrete contractor from the greater Montreal region for that portion of the contract.

SIGNIFICANCE OF SHOTCRETE

For phase four, the structural engineering firm Geniex investigated the use of shotcrete to place the significant amount of concrete that would be required to replace the removed deteriorated concrete. Although they had never before specified shotcrete as a concrete placement method, the engineers conducted considerable research into the benefits of the shotcrete process and eventually determined that the dry-mix shotcrete process would provide the best option. The main benefit offered by the shotcrete process was the speed of repairs (extremely important because the courtyard could not be shut down for long periods of time unless a new, temporary wall was constructed in front (as was the case using the form-and-pour method). A long-term durable concrete repair was also critical to ensure overall performance.

The engineer specified the use of King MS-D1 SY, a silica-fume-enhanced, prepackaged shotcrete material for dry-process applications. Among the important factors in selecting this product was the fact it was air-entrained. Although some believed that achieving consistent air content in dry-mix shotcrete was impossible, test data from repeated projects, provided by King, verified that not only could dry-mix shotcrete be air-entrained but also results of freezing-and-thawing salt-scale testing were dramatically improved when compared with non-air-entrained dry-mix shotcrete.

Among the many challenges faced by the contractor on this project was dealing with high-level security throughout the facility. Construction workers, equipment, and material delivery trucks had to pass through mandatory security checkpoints to make sure no illegal contraband was being smuggled into the prison. All workers were required to sign in and out and wait for a security guard to be escorted to the work area. Each work area was monitored by a trained, high-level security team.

SCOPE OF WORK

The shotcrete portion of the work required removal and replacement of deteriorated concrete on both inside and outside of the perimeter walls. The original scope called for the removal of 32,000 ft^2 (3000 m^2) of concrete at an average depth of 4 in. (100 mm). Hydrodemolition was used to remove the deteriorated concrete and prepare the concrete surface. This removal method was chosen because it would provide an ideal surface for the shotcrete material to bond to and minimized microcracking that often accompanied the use of conventional mechanical chipping equipment. The original concrete mixture was produced using very large aggregates 1 to 1.5 in. (25 to 38 mm) in diameter. Special attention to the removal was critical to make sure that any large stone that was exposed would stay intact and not loosen because that could potentially create a bonding issue.

During the demolition phase, it was revealed that the depth of deterioration was far greater than expected. In some cases, the outside of the perimeter wall had sections that required up to 18 in. (450 mm) of concrete removal. Apparently, the hydrodemolition equipment penetrated much deeper into the poor-quality concrete than originally expected. Thus, a special depth gauge was eventually used to maintain the proper depth of concrete removal. The specification also called for the installation of a 4 x 4 x W2.9 x W2.9 (102 x 102 x MW18.7 x MW18.7) galvanized wire mesh mounted every 20 in. (500 mm) center-to-center.

In one particularly large section, approximately 10,000 ft^2 (930 m^2) of the inside of the perimeter wall, the specification called for removal of the light scaling from the concrete surface and to repair with conventional hand-applied mortar. Geniex initiated conversations with King Shotcrete Solutions to investigate an alternative using the high-velocity dry-mix shotcrete to shoot and finish a thin layer of shotcrete and create the same look as the original construction. The engineer accepted the proposal after it was explained that the extremely strong bond between the shotcrete and the parent concrete would ensure a longer life and help minimize the progression of corrosion that had begun. However, this portion of the work was put off until the next phase of repairs.

Fig. 1: Hydrodemolition machine setup

Fig. 2: Close-up of hydrodemolition concrete ready for shotcrete

Fig. 3: Repairs ranging from 2.5 to 18 in. (64 to 450 mm)

Fig. 4: Mesh installed using gunite hooks

Fig. 5: Soaker hose creating a saturated surface-dry surface on area to be repaired

Fig. 6: Soaker hose used to cure the dry-mix shotcrete

Fig. 7: Shotcrete application and finishers

In each section of wall, a vertical expansion joint was placed to full depth at approximately 15 ft (4.5 m) spacing and a horizontal joint was placed 7.2 ft (2.2 m) up from the ground to help control any potential drying shrinkage that may occur from shooting these large concrete sections. A 7-day wet cure was specified to further reduce the potential for shrinkage cracking. Perforated water dripper hoses were installed at the top of the wall and turned on once the shotcrete reached final set. The specification originally called for burlap to hang down from the top of the wall, but this was removed from the plan as it could also provide a climbing device for the prisoners to escape.

A specific sequence had to be followed to assure that the security personnel could still see and maintain order in the prison. The walking platforms that sat on the top of the walls had to be removed section by section, allowing work on only one section of the perimeter wall at a time. An entire section of the wall had to be completed and the walking platform had to be replaced before allowing work to begin on another section.

Periodic compressive strength testing using the ASTM C1604 method was conducted throughout the project. In addition, bond strength testing using ASTM C1583 was conducted to ensure that the shotcrete had a strong bond with the large exposed aggregates and especially on the large, relatively thin sections that had no wire mesh or a mechanical tie to the original structure concrete.

SHOTCRETE MATERIALS

Specifying a prepackaged, preblended dry-mix shotcrete provided the engineer with confidence that the quality control would be maintained throughout the project and the skill and expertise of the experienced ACI-certified nozzlemen, along with an experienced shotcrete team, ensured that the placement would be completed to meet the project specifications. Groupe Lefebvre (the concrete repair contractor) has been in the concrete repair, waterproofing, and shotcrete industries since its inception over 25 years ago. Groupe Lefebvre also brought on the team from Béton projeté MAH to help with the shotcrete portion. The management team of Béton projeté MAH Inc. has over 120 years of combined shotcrete placement experience.

The dry-process mixture design chosen included silica fume to reduce the permeability of the concrete and to increase resistance to moisture and increase protection the reinforcement bars. Air entrainment was provided to help protect against damage from freezing-and-thawing cycling. Synthetic fibers were included to help minimize potential early-age plastic shrinkage cracking, especially because of the large surface area and some areas that had extremely deep repair thicknesses. Aggregate gradation No. 2 from ACI 506R with up to 3/8 in. (10 mm) stone was used to help with compaction and reduce the shrinkage

Fig. 8: Dry-mix shotcrete equipment setup on trailer

potential. The fact that the King MS-D1 SY was silica-fume-enhanced allowed the contractor to shoot thicker passes to accelerate the work to bring the repair back to the original surface dimensions. By doing so, they minimized the hours of security personnel required and shortened the closure of the courtyard. A total of seven-hundred-sixty-eight 2205 lb (1000 kg) bags were used on the project.

2016 OUTSTANDING INFRASTRUCTURE PROJECT

Project Name
Bordeaux Prison: Rehabilitation and Repair of the Perimeter Walls

Project Location
Montreal, QC, Canada

Shotcrete Contractor
Groupe Lefebvre M.R.P. Inc. & Béton projeté M.A.H., Inc.

General Contractor
Jessiko Inc.

Architect/Engineer
Héloise Thibodeau architecte Inc., Geniex (Engineer)

Material Supplier/Manufacturer
King Shotcrete Solutions*

Project Owner
Société québécoise des infrastructures

*Corporate Member of the American Shotcrete Association

***Kevin Robertson** is the Business Development Manager, U.S. Markets, for King Shotcrete Solutions. He began his career with King in 2007 as a Technical Sales Representative. Over the past decade, Robertson has played a key role in the growth of King's concrete rehabilitation and tunneling business in Eastern Ontario, Quebec, and Northeast United States markets. His area of expertise includes shotcrete materials, applications, and equipment, focused mainly on concrete rehabilitation applications. Robertson is a member of ASA, the American Concrete Institute (ACI), and the International Concrete Repair Institute (ICRI), and has also served on the Board of Directors for the Quebec Chapter of ICRI, most recently as its Vice President.*

***Pierre Brassard**, Eng., is a graduate of construction engineering from L'École de Technologie Supérieure (ETS) in 1994. He spent nearly 12 years as team leader of the project management office (PMO) for major projects in Quebec and abroad for Hydro-Quebec. Since 2005, Brassard has been the President and Senior Engineer of the Quebec-based engineering firm he founded. Geniex Ingénierie specializes in structural and foundation design for residential, commercial, and industrial buildings. In mid-2015, he co-founded Geniex Construction Ingénierie, which provides a full design-build value-engineering service for the Montréal and regional areas.*

2016 Outstanding International Project

Holcim New Zealand Cement Terminal

By Benjamin Davis

In 2013, Holcim New Zealand, a part of the Lafarge-Holcim Group, set out to design and build two cement storage terminals in New Zealand. With earthquake devastation in mind following severe earthquakes in 2010 (Stuff Reporters 2010) and 2011 (CNN 2011), finding a durable bulk storage structure resilient enough to handle seismic events and a company with a verifiable track record of building such buildings was paramount. Holcim described the entire project as consisting of two 33,000 ton (30,000 tonne) capacity dome silos, two 660 ton/hr (600 tonne/hr) pneumatic ship unloaders, a 720 ton/hr (650 tonne/hr) ship loader at Timaru, and bulk cement tanker loading facilities, all supported by equipment auxiliary buildings, office buildings, roadways, security, and dispatch facilities for a total cost of NZ$105 million (USD$70.8 million) (Williams and Cowie 2016).

The storage domes would be built on two ports and had to be aesthetically pleasing, environmentally friendly, cost-effective, and allow as sustainable an operation as possible. Their thorough evaluation of various types of storage structures selected concrete domes as the best choice. In the end, Domtec International was chosen as the preferred dome vendor in a “Best for Project” approach (Downer Group 2014). Two sites were chosen for Holcim’s domes. On the South Island, the dome was to be built in Timaru, a port city approximately 93 miles (150 km) south of Christchurch. The other dome would be located on the North Island in the most populous city in the country, Auckland, with a regional population of over 1.4 million (New Zealand Government, 2013).

This article focuses on the project built in Timaru, on New Zealand’s South Island, although both domes are pictured and explained in this article.

WHY A SHOTCRETE DOME?

Although Domtec had built for Holcim in other parts of the world, this was the first shotcrete dome to be built for the storage of cement in Australasia and was quite an innovative design and technique. Holcim cited several reasons for choosing a dome over traditional slip-form or jump-form cylindrical concrete silos, steel silos, or warehouse-type storage silos. Economy and speed of construction were the key factors in choosing a dome, but there were others, such as:

- Control over environmental impact during construction and operation phases due to the weather tightness and dust control properties of the dome. The external air-form and the polyurethane foam lining provide excellent insula-

Fig. 1: Aerial view of Holcim Cement Terminal in Auckland, New Zealand. Dome is 135.2 ft (41.2 m) diameter and 90.2 ft (27.5 m) tall and stores 33,000 tons (30,000 tonnes) of cement powder and used 1400 yd^3 (1100 m^3) of shotcrete to construct

Fig. 2: Aerial view of Holcim Cement Terminal in Timaru, New Zealand. Dome is 118.1 ft (36 m) in diameter and 103.3 ft (31.5 m) tall and stores 33,000 tons (30,000 tonnes) of cement powder and used 1923 yd^3 (1470 m^3) of shotcrete to construct

Fig. 3: Street view of Timaru cement storage dome. Aesthetics were a major consideration when deciding on a storage solution. The dome durability, white fabric color, insulation, price, and Domtec's reputation also figured into the contract award

tion and isolation properties, a benefit during construction and operation of the dome.

- Dome silos can be fitted with a complete reclaim floor, guaranteeing 98% extraction rates.
- The dome shape provides a high volume of storage within a relatively small footprint.
- This port had height and space constraints. The dome could achieve the tonnage required within a footprint and height that would work.
- The dome shape is inherently strong because of the seamless blending of the wall and roof. This provides excellent structural integrity, resistance to earthquakes, and severe weather conditions. This inherent strength also allows the cement to be placed high against the walls and roof.
- The technique of using shotcrete allows efficient and economical construction (eliminating the need for formwork, shoring, and waste). It also enables rapid construction of the domes regardless of weather conditions because after the inflatable form is erected, all works are performed inside the dome.
- Domes are ideal for combining with pneumatic extraction equipment from ships, to dome, to truck loading, and can accommodate high-volume filling and discharge rates.
- The dome supports heavy loads on the apex and asymmetrical loading against the walls, allowing side discharge and avoiding sub-grade reclaim tunnels. Each of the Holcim domes were designed to support 150,000 lb (68,000 kg) without any interior bracing or exterior bents.
- Building authorities had no experience with dome construction, but the lead contractor, together with Domtec International, put together a presentation that answered all questions and alleviated all risk and safety concerns (Williams and Cowie 2016).

DOME DESIGN

The dome storage building went through a strict peer review process that involved structural engineers in five countries on three continents. The dome was engineered using ACI, New Zealand/Australia, and Eurocode standards

Fig. 4: View of dome apex from inside of dome. When completed, each apex was designed to support 150,000 lb (approximately 62 tons [68 tonnes]) without any interior supports

Fig. 5: Finished interior wall of dome. The dome used roughly 1923 yd^3 (1470 m^3) of shotcrete

and codes to ensure all peer review engineers had a good understanding of loads and forces. After looking through the peer reviewed drawings, the owner and founder of Domtec, who has been in the dome business for over 35 years, remarked, "This will be the most stoutly constructed cement storage dome in the world."

Fig. 6: Timaru dome air form ready for inflation. The DomeSkin™ air form is 38,350 ft^2 (3563 m^2)

DOME CONSTRUCTION

Construction of a concrete dome with an air form is relatively unique compared to conventional methods of concrete construction but allows for rapid construction and superior strength and durability. The method for building domes involves inflating a heavy-duty industrial fabric, which serves as a formwork or "air form." Domtec's DomeSkin™ air forms are each custom designed to fit the volumetric capacities of the product to be stored, while also fitting into height and width restrictions of each site. Domes can be built as true hemispheres or a dome on a cylindrical wall and are referred to as "SiloDomes™." Each SiloDome in New Zealand had to be built within a limited available footprint area, which also resulted in decreasing the cost of the reclaim system. Although the cylindrical part of the dome is more expensive to build than a hemisphere, the money saved by decreasing the floor size and reclaim equipment is typically greater than the additional cost to build a cylindrical portion of a dome structure.

The DomeSkin has a dual purpose. It serves as the air form during construction and ultimately, it also performs as the finished exterior roof membrane. The construction takes place on the inside of the DomeSkin, so the dome is built

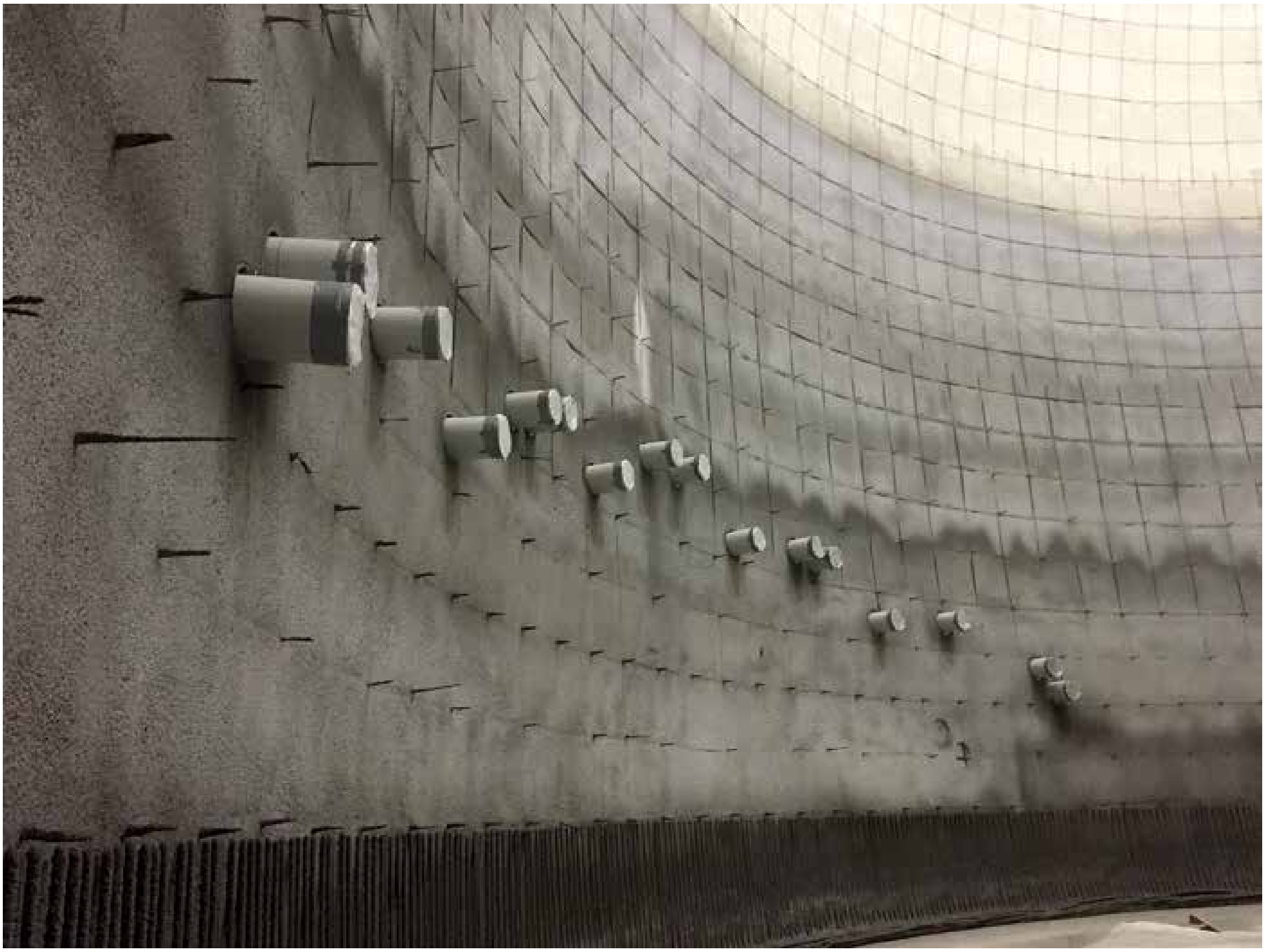

Fig. 7: First pass of shotcrete over first mat of structural bar. Both domes were completed on budget and ahead of schedule

from the outside in: roof, insulation, and finally the structural concrete structure. All reinforcing bars and heavy equipment to be used in the project such as cranes and forklifts must be placed under the air form before it is inflated because once inflated, the form must remain under pressure for the duration of construction. The construction equipment only leaves the interior once the dome is complete. This meant a 38 ton (35 metric ton) mobile crane, a telehandler, and all the reinforcing bar had to be strategically positioned within the pile cap and under the air form prior to it being inflated.

In February 2015, construction began on the Timaru dome, a 120 ft (36 m) diameter, 103 ft (31.5 m) tall dome. First, the custom-fabricated DomeSkin air form was carefully attached and bolted down to the foundation and then inflated. The dome was built following Domtec's quality control methodology and safety procedures. 1923 yd^3 (1470 m^3) of shotcrete were placed in the dome along with 562 tons (510 tonnes) of reinforcing bar. After the Timaru dome was completed, Domtec's specialty equipment was shipped to Auckland to build the 33,000 ton (30,000 tonne) cement storage dome there. The Auckland dome was 135 ft (41.2 m) diameter and 90.2 ft (27.5 m) tall and required approximately 529 tons (480 tonnes) of reinforcing bar and roughly 1400 yd^3 (1100 m^3) of shotcrete (Downer 2014). The dome structure stayed on schedule and was completed in 14 weeks from inflation of the air form to the final layer of shotcrete.

Downer also worked closely with Domtec to create specific methodology and safety controls, and set up a workshop with WorkSafe NZ, the government's health and safety regulator. The presentation was accepted the first time without any comments or changes.

Overall, the two 33,000 ton (30,000 tonne) cement storage domes were built on-time and Domtec proved to be a suitable supplier to Holcim's chosen General Contractor, Downer Group. This project marks the first two concrete domes in New Zealand and has overall been well received.

To learn more about Holcim New Zealand, please visit **www.holcim.co.nz**. To learn more about Downer Group, please visit **www.downergroup.com**. To learn more about Domtec International, visit **www.domtec.com**.

Fig. 8: Typical dome structural reinforcing bar mat; over 550 tons (500 tonnes) of reinforcing bar was used in the Timaru dome

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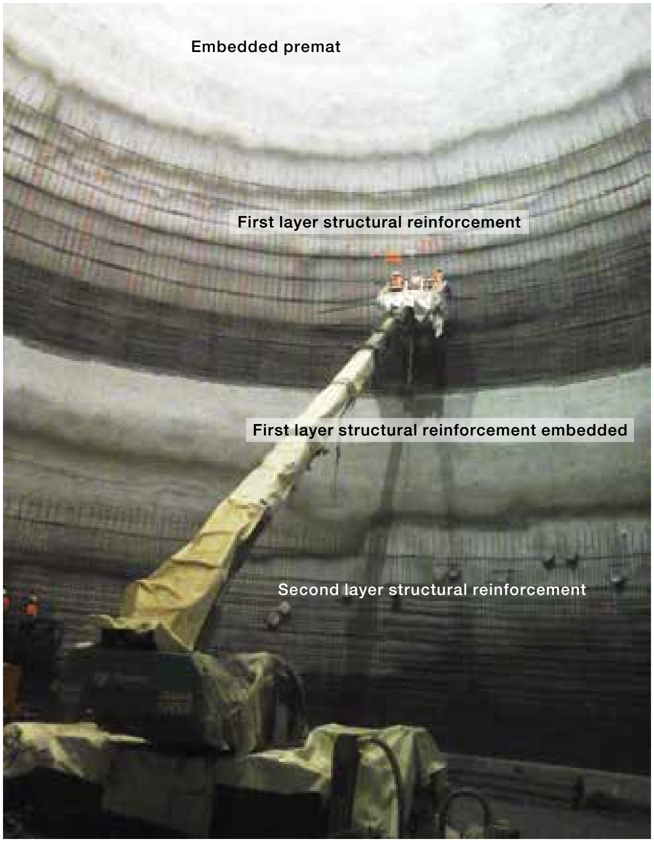

Fig. 9: View showing multiple phases of dome building process. Domtec shotcrete technicians average over 25 years of experience each

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THE OUTSTANDING INTERNATIONAL PROJECT

Project Name
Holcim Cement Market Supply Project (CMSP)

Project Location
Timaru, Canterbury, New Zealand

Shotcrete Contractor
Domtec International*

General Contractor
Downer Group

Architect/Engineer
Chris Zweifel, ZZ Consulting

Material Supplier/Manufacturer
Lafarge Holcim*

Project Owner
Holcim New Zealand, Ltd.

*Corporate Member of the American Shotcrete Association

Benjamin Davis *is the Vice President of Business Development at Domtec International, an industrial construction company specializing in insulated, reinforced concrete storage domes, typically storing dry bulk commodities such as grains and fertilizers, cement powder, wood pellets, and mining ores in quantities from approximately 5000 to 100,000+ tonnes. He has worked with leading global firms such as Lafarge, Holcim, Cemex, Italcementi, Votorantim, CalPortland, and Kinder Morgan. Davis has presented at Intercem, World of Coal Ash, American Shotcrete Association, and BioEnergy Conferences and his publications can be found in periodicals like* World Cement, International Dry Cargo, *and* International Mining. *He is a member of the Institute of Electrical and Electronics Engineers (IEEE) and American Concrete Institute (ACI). Davis is a Leadership in Energy and Environmental Design Accredited Professional (LEED AP BD+C) a credential awarded by the US Green Building Council (USGBC) to professionals with expertise in the design and construction phases of green buildings who pass rigorous testing and maintain on-going continuing education. He is also a Certified Green Professional, a credential from the National Association of Home Builders (NAHB). Davis received his master's degree in construction management from Brigham Young University and his bachelor's degree in public relations and business management from Utah State University. He was also an adjunct professor at BYU-Idaho.*

2016 Outstanding Pool & Recreational Project

Coveleigh Club Pool Construction

By Mason Guarino

The swimming pools in this country are aging, whether it is because of outdated shapes, changes in desired use, or a deteriorating finish or pool shell. This makes the pool renovation industry a big one. Some owners just want a new finish installed to make the pool look new. Other owners want an entirely new pool. Lately, it has become commonplace for country clubs, beach clubs, and yacht clubs to want to upgrade their aging facilities, including their swimming pools. Sometimes this is accomplished by simply adding a set of steps or two, but for the Coveleigh Club in Rye, NY, it meant completely ripping out their old pool and replacing it with a bigger, newer, more efficient pool. Before South Shore Gunite Pools & Spas, Inc. (SSG), was involved, the Club, along with a team of swimming pool and construction professionals, teamed up to make this dream a reality.

The design process for the replacement swimming pool portion of the project was extensive. This involved building a pool that had a water surface area of 7700 ft^2 (715 m^2) with a maximum depth of 13 ft (4 m) located approximately 40 ft (12 m) from the Atlantic Ocean. The design team had to figure out the best way to put a pool of this size in this location that had a constant and difficult water condition. A major concern to the design team was how to keep the pool in place when the pool was empty and the ocean tide was high. In these situations, a normal pool can float out of the ground and cause severe structural damage. The designers, with the help of Bill Drakeley as their special inspector/sprayed applications consultant, came up with the idea to anchor a monolithic pool structure to the earth with a system that consisted of driven piles, grade beams, and a monolithic pool structure all tied together with concrete and reinforcement. With the monolithic pool structure requirement, the design team decided that shotcrete would be their concrete placement method of choice for the swimming pool structure.

Fig. 1: Grade beams installed and under-pool piping being installed between grade beams

After design was complete, it was time to move onto construction. At this point, however, it was getting late in 2014. The build team did some research and called around to get information on which swimming pool builders were capable of building a pool this size with the complications that go along with building a pool next to the ocean in the winter and do it correctly. The team ended up deciding in August 2014 that they wanted SSG to build their new pool. In their research, they found that no other pool builder in their area met the criteria they were looking for. With a desired start date in September 2014, the build team asked SSG if they could begin the project. Unfortunately, that late in 2014, there was not room in SSG's construction schedule to complete the project in time for an opening on Memorial Day 2015. Thus, the Coveleigh Club's build team decided to put the construction on hold for 1 year so SSG would be available to build their pool.

Construction started when the club's pool was closed for the winter in September 2015. First, the existing pool and adjacent area were demolished and the excavation brought down to as much as 6 ft (1.8 m) below finish pool floor elevation to install the piles and grade beams. Working on a constantly wet and mucky site in the winter makes everything move slowly. The pool construction team was not able to start anything until December 2015, just in time for winter. The somewhat mild winter helped with the construction process, but it was still cold. Throughout the majority of the construction of the pool structure, the nights were below freezing with the occasional day where it might have reached 50°F (10°C) for 5 minutes in the afternoon but for the most part we were working in below-freezing weather. Under-pool piping was installed, which included a maze of schedule 80 polyvinyl chloride (PVC) pipes ranging from 2 in. (50 mm) for the returns up to 12 in. (300 mm) for the main drains. The plumbing had to be coordinated to fit in and through the grade beam system that supports the pool structure from settling or floating.

Setting the formwork followed the installation of the grade beams, PVC piping, and final stone grade. Forms consisted of 2 x 4 in. (51 x 102 mm) and 1 x 3 in. (25 x 76 mm) lumber, strapping, and stay-in-place expanded steel mesh. The 2 x 4 in. (51 x 102 mm) pieces were used for the main supports, with the smaller 1 x 3 in. (25 x 76 mm) lumber used to tie the 2 x 4 in. (51 x 102 mm) pieces together and support the steel mesh. This forming system is pretty minimal, as it only needs to support the impact of the shotcrete from the nozzle and help keep the walls upright. It consists of far less material and erection time than forms that would support the weight of fluid concrete. After the shotcrete cures, the lumber is stripped and the stay-in-place steel mesh remains on the back side of the wall that will be backfilled.

After the forms came time for installation of the reinforcing bars. While on 99% of SSG jobs installation of all reinforcement is completed in-house, this job was a little different. This pool contained 50 tons (45 metric tons) of reinforcing bar ranging from No. 4 to No. 7 (No. 10M to No. 12M), all arranged in double mats in the walls and floors. The decision was made to subcontract this job to Merkel Rebar from Pennsylvania, as they had the capability to install all this reinforcing bar in under 3 weeks. A 12-person crew installed the reinforcing bar, including the Merkel

Fig. 2: 50 tons (45 metric tons) of reinforcing bar being installed

Rebar team and a few SSG employees to provide equipment support for Merkel and some supervision.

With a Memorial Day completion date, SSG did not have the luxury of waiting for good weather to be able to start the shotcrete process. Shotcrete work took place from February 22 through March 4, 2016—a cold time of year in New York. The shotcrete portion of the project was estimated to require approximately 550 yd^3 (420 m^3) of shotcrete because both the floor and walls were to be shotcreted. The 7700 ft^2 (715 m^3) floor had many different breaks and shapes in the floor, so it was decided that shotcrete would be the best way to create a monolithic floor. It would have been very difficult to cast over 300 yd^3 (230 m^3) of concrete with all the contours of the floor in one continuous pour. SSG decided to mobilize their on-site batching equipment for the job. The on-site batching is the first choice for SSG because it allows us to stop and start as needed without worrying about concrete trucks backing up. It also makes it a lot easier to shoot large amounts of material in regular working days without the downtime of concrete trucks switching out or being late.

When SSG is shooting pool walls along with pool floors, there is a strict rule of no stepping in the concrete once placed. Once concrete has been placed, it should be allowed to reach final set without any excessive vibration. Additionally, at SSG, cuttings or rebound are never allowed to fall to an area that has exposed reinforcement. To shoot this pool, they began shooting 4 ft (1.2 m) wide strips approximately 3 ft (0.9 m) off of the walls. They then placed more 4 ft (1.2 m) wide strips approximately 10 ft (3 m) apart from one another. These 4 ft (1.2 m) wide strips are easy to finish by hand, along with allowing them to roughen the edge surface to create good joints. The open 10 ft (3 m) wide strips are then filled in later in the process.

With the use of a spinning screed, it typically only takes three to four workers to shoot and finish these areas. The simplicity of the spinning screed allows relatively inexperienced laborers to work with the nozzlemen and place a good section of floor while the more experienced finishers are finishing the section of wall that was just shot. After shooting the 4 ft (1.2 m) wide strips, they then shot the coves and up the walls, essentially jumping back and forth between the floors, cove, and walls based on which sections were ready for more material. The pool floor ranged from 10 to 24 in. (250 to 610 mm) thick and the walls were all approximately 14 in. (350 mm) thick.

SSG had two wet-mix ACI Certified Nozzlemen and two dry-mix certified nozzlemen on site. The wet-mix process was chosen because of the overall quantity and section thickness of shotcrete required. SSG chooses wet-mix for most commercial pool applications because it allows faster material placement than the dry-mix process. While the dry-mix certified nozzlemen are less familiar with the details of wet-mix placement, they were still helpful to have on the team. With the amount of reinforcing bar in this pool, the ACI Certified Nozzlemens' knowledge was truly tested. Shooting through two mats of No. 7 (No. 22M) bar certainly requires the skill of a highly trained nozzlemen with classroom education and field experience as well as requiring a highly skilled blow pipe operator. With the quantity and sizes of the reinforcing bar, SSG chose to use non-contact lap splices in the reinforcement on this project. The team used a broom finish on the floor and a cut finish on the walls that would later accept a combination of tile and marcite plaster finishes.

Because the business is located in the Northeast, SSG is very familiar with handling cold weather shotcrete projects and was fully equipped for this one. Part of the mobilization

Fig. 3: Shotcrete installation—4 ft (1.2 m) wide strips being installed and the 10 ft (3 m) wide openings to be filled in later

Fig. 4: Covering with thermal blankets to protect from freezing

process included bringing an excavator to the site to charge the batch plant with sand and stone. This excavator was towed with a tri-axle dump truck also loaded with thermal insulation blankets for the job. Raw materials were delivered to the site in dump trucks where truck exhaust passed through the body to keep the sand and stone from freezing along their over-60-minute trip to the site. The material was delivered free of frozen materials and then kept from freezing with more thermal blankets while on site. SSG limited material deliveries to reduce or eliminate the amount of material that had to be kept warm overnight, if there was any left over at the end of the day.

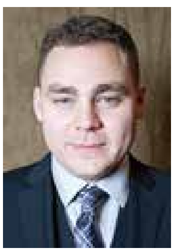
It is common practice to start using jobsite hot water heaters once the cold weather sets in, but on this job, they got lucky and there was a hot water spigot on the side of the building that they were allowed to use. The weather was accommodated by washing everything down with hot water and then covering in the sections to be shot with thermal blankets. With this process, SSG was able to keep the substrate above 40°F (4°C) before shooting began. The non-frozen raw materials were mixed together with 120°F (49°C) water and pumped down 100 ft (30 m) of 2.5 in. (63 mm) slick line to 60 ft (18 m) of 2.5 in. (63 mm) concrete hose to another 100 ft (30 m) of 2 in. (50 mm) concrete hose.

At the end of every day, all the shotcrete placed that day was covered in thermal blankets, along with what was planned to shoot for the following days. In addition to the cold, they also had to deal with adjacent Atlantic Ocean creating problems with a brackish ground water on the site. Many submersible pumps were running continuously throughout the project to keep the ground water levels down. Every day before shooting in the deep end, all the reinforcing bar had to be thoroughly cleaned with pressure washers to get the residual salt coating off them.

They shot all 550 yd^3 (420 m^3) of the project in 8 shooting days. On one day, over 120 yd^3 (92 m^3) was installed in one shift, which was exciting considering they were not allowed to start our equipment until 7:30 a.m. and needed to stop shooting by 4:00 p.m. to allow enough time to finish, clean up, and cover everything before it got too dark. Light towers were used to help with the final finishing and cleanup, but they try not to shoot under the lights unless it is truly necessary as, by that time, the crew starts to get fatigued and the shadowing makes it a bit more difficult. The equipment for this project included a Cemen Tech portable batch truck, Cemen Tech portable cement silo, a Western Shotcrete Warrior 3050HP shotcrete pump, a CAT 315 excavator, and Gunite Supply shotcrete finishing tools.

Fig. 5: Completed pool

The pool was finished on time for their opening weekend. A lot goes into swimming pool construction—more than most know. Many of the pools require tolerances of ±1/16 in. (1.5 mm) due to swimming competition regulations. The plumbing system on this pool circulates 1000 gal./min (3800 L/min) with a 25 hp pump just to keep the water clean. The pool also has automated heating, chemical control, and circulation. Some owners find it imperative that their projects are completed on time. Recognizing that, they are willing to spend a little more on the company that has never had a problem meeting a project deadline.



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

2016 OUTSTANDING POOL & RECREATIONAL PROJECT

Project Name
Coveleigh Club New Pool

Project Location
Rye, NY

Shotcrete Contractor
South Shore Gunite Pools & Spas, Inc.*

General Contractor
DHI Construction Services

Architect/Engineer
Gary Spilatro, Architect

Material Supplier/Manufacturer
Cemen Tech Inc.,*
Western Shotcrete Equipment Inc.,*
Lafarge Holcim*

Project Owner
Coveleigh Club

*Corporate Member of the American Shotcrete Association

2016 Outstanding Repair & Rehabilitation Project

Shotcrete Segment of the O'Hare and Midway Reconstruction Project

By Cathy Burkert

This project was part of a 5-year, $39 million contract to repair both Midway and Chicago O'Hare International Airports and its surrounding property. American Concrete Restorations (ACR) was hired to perform over $2 million of concrete repairs. The first task for this contract was to repair all concrete at O'Hare located at the lower level on the "Arrivals" ramp. This ramp spans approximately 3000 ft (900 m) and is the pickup location for passengers arriving at Chicago O'Hare International Airport from the domestic airlines. The repairs consisted of a majority of the overhead areas located throughout the concrete slab and beam structures at Domestic Terminals 1, 2, and 3.

CHALLENGES

Prior to the start of the project, the specification called for formed concrete repair. The General Contractor submitted the use of shotcrete due to the many site and condition challenges on the project. O'Hare Airport is always hectic, with flights arriving 24/7. To work around some of the busiest times for terminal congestion, the contractor was directed to work at night.

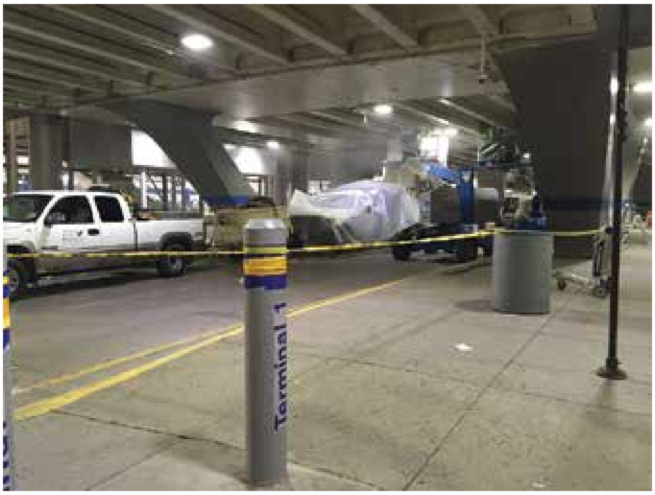
Working night shifts always has major risks and challenges. However, the night shift work for this project was further complicated by a 6-hour shift working time. This 6-hour limit included daily mobilizing of equipment from off site, setup, and cleanup. Because the airport and the arrivals ramp were required to be kept operational during the repairs, these shifts were often interrupted due to delayed flights. The contractor's shifts were often postponed for several hours after the scheduled start, thus shortening its shift by that much more. Weather was usually the cause of these delays and sometimes it wasn't a weather issue in Chicago, but rather in departure cities for arriving flights. Another factor leading to delay was the nightly security checks. Every night, the contractor's equipment needed to be cleared by security, including a thorough search by police dogs.

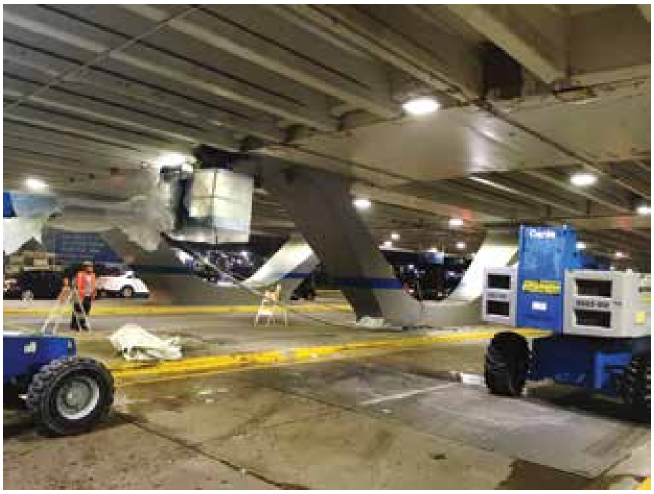
An additional challenge was managing the congestion of the pedestrian and motor traffic. The contractor was only given 100 ft (30 m) of one lane or roadway at a time. O'Hare's arrivals ramp has five lanes, all separated by pedestrian medians, including two taxi lanes (Lanes 1 and 2), two bus/limo lanes (Lanes 3 and 4), and a regular commuter pickup/rental car lane (Lane 5). The contractor was given the first 100 ft (30 m) of Lane 1 for a period of time until completed and the second 100 ft (30 m) of Lane 1 upon completion of the first 100 ft (30 m) and so forth. No more than 100 ft (30 m) of one lane could be closed off at the same time. Not only was the contractor given restricted access, some of the repairs were in areas with difficult access, such as repairs over the taxi vestibules. Most of the areas were also congested with lighting, police cameras, and other conduits throughout, not to mention the actual vestibules the passengers exited from the airport terminals.

Most of the "obstructions" used sheet plastic for protection from dust, debris, and overspray. The pedestrian vestibule exits were closed and pedestrians detoured to other vestibules. Each 100 ft (30 m) work area was surrounded by orange barriers and caution tape to help keep the exiting passengers from entering the work zone. Because some pedestrians were focused more on their phones than the world around them, the contractor set up safety officers around the work zone to help direct the pedestrian traffic.

Motor traffic was another challenge, specifically the taxi cabs. The taxi drivers seem to be oblivious to construction zones and, as you can imagine, are not the most relaxed drivers. To ensure the safety of the workers and surrounding area, arrow boards and traffic control were set up in close coordination with the airport operations manager. It was imperative to maintain excellent communication with the operations manager, as the contractor was only allowed access to the site after the operations manager approved it each night. The contractor's access was strictly controlled by operations, and sometimes resulted in mobilization delays from the staging yard that was totally out of the contractor's control.

While logistics was a very large challenge on this project, performing the actual work came with its challenges as well. As previously mentioned, each shift included daily mobilization from the staging yard, cleanup, and demobilizing. The work zone had to be completely opened to the public and spotless come sunrise. Dust was certainly an issue during





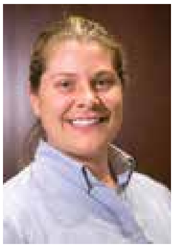
Challenging restrictive work conditions concrete removal, but we also found cleaning of the debris created during the shotcrete operation—for example, from breaking the prepackaged shotcrete bags—was an issue. While the construction workers were protected with proper personal protective equipment including respirators, the pedestrians were not. Therefore, the contractor used water to control the airborne dust and large fans to move the air.

In addition, the contractor was challenged with keeping overspray and rebound from attaching to the nearby "obstructions." While plastic, tarps, and netting were used to try to contain the majority of overspray and rebound, many of our workers' only task was to continually clean the work area of all debris, overspray, and rebound. Additionally, each night, the entire work area needed to be power-washed to ensure the area was clean and safe when opened back to the public.

SIGNIFICANCE TO THE PROJECT

As in all projects, time is of the essence. The use of shotcrete and its versatility had many advantages compared with form and pour. The use of prebagged shotcrete material that was mixed on-site for wet-mix placement provided a high-quality, consistent mixture that was fresh and never a problem with being "too old." Ready mix that would have been used in a form-and-pour approach would have a much shorter open time to work with after factoring in the drive time from the plant. There would have also been risk of a form blowout and the potentially catastrophic impact on the motor and pedestrian traffic below. In comparison, our shotcrete used accelerator in the wet-mix process to ensure that each patch reached a sustainable final set before opening the site back to the public. With only 100 ft (30 m) of area available at any one time, the small area needed for the shotcrete equipment was significantly less than bringing in large ready mixed concrete delivery trucks. Also, if a problem occurred with concrete placement in the middle of a form-and-pour patch, it would require removal of the form. The shotcrete placement by ACI Certified Nozzlemen, provided by a qualified contractor and inspectors, enables constant visual confirmation of full encapsulation of the reinforcing bar. Pumping into a blind form could result in voids, poor consolidation, or reduced bonding to the original concrete, thus requiring removal and replacement of the patched areas after form removal.

This substantial shotcrete project was the result of the general contractor recognizing the benefits of shotcrete placement as a substitute for the originally specified form-and-pour method of concrete repair. Proven past experience by ACR with its credentials and qualifications on other high-profile shotcrete projects demonstrated the benefits to using shotcrete on a project, allowing the airport work to be accomplished more efficiently, more safely, with higher quality and significant time savings. Ultimately, the Owner was thrilled about the limited amount of disruption the construction project caused its customers and operations, allowing them to keep the airport fully functional throughout construction.



***Cathy Burkert** received her bachelor's degree in business management and thereafter started working at American Concrete Restorations, a Chicago-based shotcrete contractor. She joined the laborers' apprenticeship program to learn the intricate details of the trade. After 2 years in the program, she began running her own shotcrete crews and shortly after earned the title of Field Office Coordinator. In March 2009, Burkert became the first female ACI Certified Nozzleman for the wet-mix, vertical, and overhead processes. She has been involved with two award-winning ASA infrastructure projects: the Abraham Lincoln Memorial Bridge in 2008 and the Dan Ryan Expressway in 2009. Burkert currently serves as Treasurer for ASA.*

2016 OUTSTANDING REPAIR & REHABILITATION PROJECT

Project Name
Structural Bridge Repair at O'Hare International and Midway Airports

Project Location
Chicago, IL

Shotcrete Contractor
American Concrete Restorations, Inc.*

General Contractor
McDonagh Construction

Architect/Engineer
CARE Plus, LLC

Material Suppliers/Manufacturers
Spec Mix Inc.* and Putzmeister Shotcrete Technology*

Project Owner
City of Chicago – Department of Aviation

*Corporate Member of the American Shotcrete Association


GUNNING RIG
STANDALONE SOLUTION
MEETS MOBILE REVOLUTION.

2016 Outstanding Underground Project

Rehabilitation of the Suhurlui Irrigation Pipeline

By Calin Mircea, Ofelia Corbu, Eugen Maier, and Cristian Rus

The Suhurlui Irrigation Pipeline is located in the southeast of Romania, Galati county, in the vast planes formed by the Danube river, 50 miles (80 km) upstream of the river's discharging point into the Danube Delta and 90 miles (150 km) from the Black Sea.

The pipeline is part of a larger irrigation system that supplies water to roughly 195,000 acres (75,000 hectares) of agricultural land, the largest single irrigated plot in the country. The Suhurlui Irrigation Pipeline is made of two parallel steel pipes spaced 100 ft (30 m) apart, and constructed from 1984 to 1986 by welding 20 ft (6 m) steel segments. The nominal diameter of the pipes is 10 ft (3.05 m), with a wall thickness of roughly 0.4 in. (10 mm).

View of one of parallel pipes of Suhurlui Irrigation Pipeline

The Suhurlui Irrigation Pipeline is supplied with water pumped from the Danube river (the largest river in Europe) and transported via open canals for roughly 28 miles (45 km) until entering the underground pipeline where the terrain slopes severely. The pipeline follows the natural topology of the terrain and is buried at depths from 6.5 to 16 ft (2 to 5 m) along its 2.2 mile (3.6 km) length, crossing under a road and a river.

CHALLENGES

Since its initial commissioning in 1986, exposure of the steel shell to groundwater, through a failure in external waterproofing, led to severe damage to the pipeline. The steel pipe wall reduced in thickness and was eventually pierced, leading to heavy water losses of roughly 40% of the total irrigation water transported. An additional cause of the steel deterioration was the 110 kV power line that runs parallel to the pipeline that induced significant electrical corrosion.

The geotechnical survey revealed the groundwater table started at roughly 1.5 ft (0.5 m) below grade, which created a significant risk of floating if the pipes were emptied without loading them with extra weight. Other particular challenges were raised by the position of the pipes at a 30-degree angle for roughly 500 ft (150 m) along a steep hill descend, as well as a road and a river undercrossing where the pipes descended further into the ground.

PROJECT SPECIFICATION AND CAD SIMULATIONS

Artifex Engineering Ltd. conducted the detailed technical design, including three-dimensional (3-D) modeling of the pipeline before and after the shotcrete job. Given the requirement for extending the service life of the pipes for a minimum of 15 years, the only feasible solution was determined to be to create a new reinforced concrete jacket inside the existing pipe by shotcrete placement.

The software used for CAD simulation was RISA 3D Structural Engineering, which revealed the need for a high-strength watertight concrete (C30/37) that can withstand 145 psi (10 bar) of water pressure, made of high-grade Type I 52.5N cement, aggregates up to 3/8 in. (10 mm) in grain size, and water. No admixtures were used in this project.

The scope of the rehabilitation project consisted of:

- Laying a 5 ft (1.5 m) tall wall of dirt on top of the pipes to create enough gravity loading to prevent the pipe from floating after draining them;
- Cleaning the pipe's interior with high-pressure water jetting at roughly 36,000 psi (2500 bar);
- Placing the 6.5 x 20 ft (2 x 6 m) wide, 0.25 in. (6 mm) thick steel-welded wire reinforcement on the inside wall of the pipes; and
- Shotcreting a 3.15 in. (80 mm) concrete jacket over the interior surface of the pipes.

EXECUTION OF SHOTCRETE

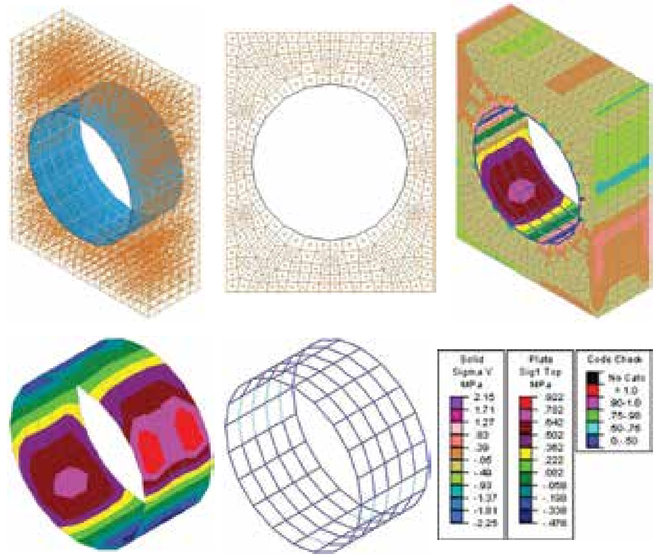
A dry-mix, thin-flow shotcrete process was used throughout this project, chosen for three main reasons:

- The very high early strength of the concrete required for shooting overhead in a thick layer;
- The extreme weather conditions at surface, with temperatures ranging from 95°F (35°C) in mid-August to –4°F (–20°C) in January, which prevented the use of wet mix process; and
- The need to push the concrete through delivery lines over large distances of up to 650 ft (200 m), thus minimizing the need for access points into the pipes.

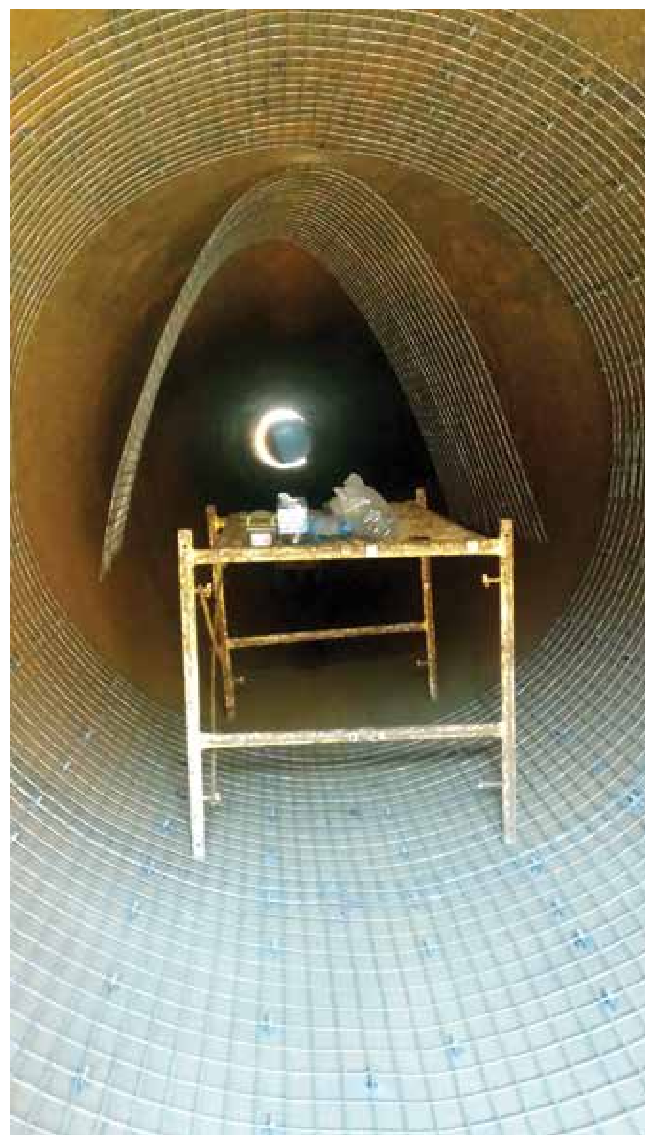
Crushed stone sands were supplied by a local gravel pit, with a grading curve that extended up to 3/8 in. (10 mm) grain size. The cement was supplied in silo trucks and stored on site in a 47 yd^3 (36 m^3) horizontal silo. The dry-mix process concrete was prepared using a 2.6 yd^3 (2 m^3) self-loading mobile batching plant and delivered underground to the shotcrete pumps through metal tubing placed in the air vents and access points.

The rebound varied greatly with the type of aggregates (washed river or crushed stone aggregates) and position of the sprayed surface (overhead or bottom half of the pipe). Crushed stone generated 18% rebound on overhead surfaces, 14% on the vertical side parts of the pipes, and 9% on the floor, while washed river aggregates generally created 5% less rebound. On any given section of the pipes, the bottom half would be sprayed first, with a minimum of 24 hours passing before stepping onto the shotcreted concrete and applying the shotcrete overhead. The rebound material was removed using a pneumatic industrial vacuum pump and manually by shoveling.

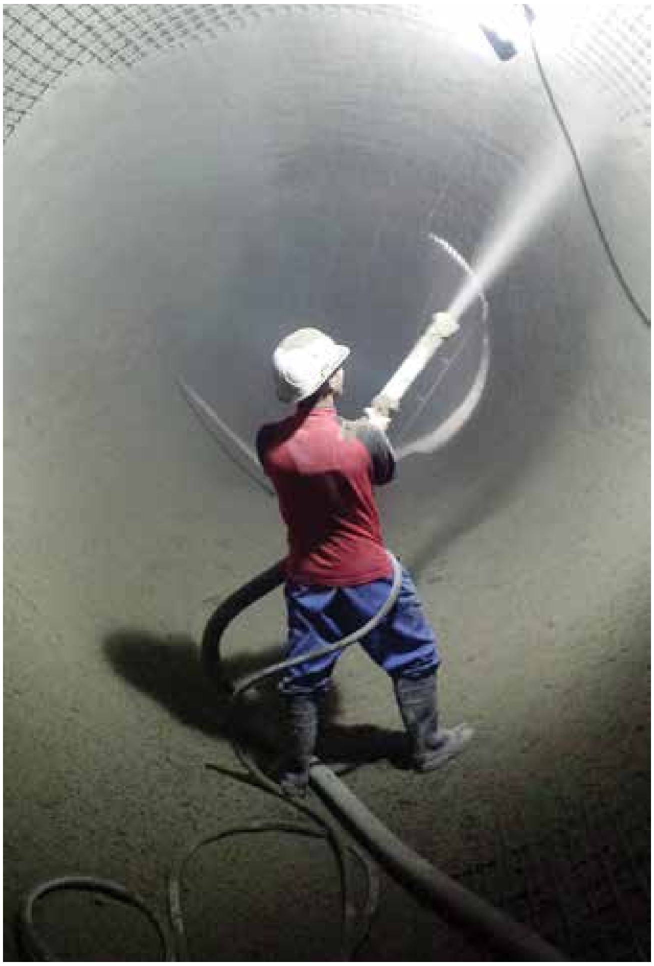
We aggressively undertook the work and completed the project by working two crews per shift with two long shifts per day, with a 2-hour cleanup and maintenance break in between. A total of 1500 yd^3 (1150 m^3) of concrete were shot. Each shift's crew consisted of three interchangeable skilled workers, three unskilled workers, one mechanic who was the operator for both pumps, and one highly-skilled



Simulation of nominal load stress for steel pipes



Detail of placing steel-welded wire reinforcement



Shotcrete placement

foreman. Given the long shifts, the entire crew benefited from the exceptional food of a canteen run in a nearby village by a multinational corporation working in a nearby gas field.

SHOTCRETE EQUIPMENT

Two OCM 036 UNICA rotary shotcrete pumps were used throughout the project. The pumps are manufactured by OCMER Co. Ltd, an Italian company with a longstanding tradition in the design, production, and sale of machines and equipment for sprayed concrete and refractory mixes.

The shotcrete pumps had an hourly yield of around 8 yd^3 (6 m^3), with an air consumption of 400 to 600 ft^3/min (12 to 17 m^3/min) depending on the moisture content of the aggregates. The OCM 036 UNICA is an average-size pump

The OCM 036 UNICA shotcrete pump

Shotcrete placement

which was selected from the contractor's fleet of rotary machines given its compact size, maneuverability, and continuous electronic adjustment of rotor speed. The pumps were placed underground inside the pipes directly under the pipeline air vents, and filled continuously by the mobile batching plant above. The dry-mix material was delivered by compressed air through metal tubes to the nozzle operator at a maximum distance of 650 ft (200 m) from the pump.

COLLABORATION WITH TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

The initial and early strengths were determined by means of penetrometer and stud driving testing on site, using an off-the-shelf penetrometer and a Hilti DX 450 SCT tool, respectively. The final compression strength was determined on 6 in. (150 mm) sample cubes cut from 3.3 ft (1 m) square panels. One test panel, which yielded three test cubes, was shot every 130 yd^3 (100 m^3) of sprayed concrete. The standards used for testing were: EN 12390-2, EN 14488-1:2011, EN 12390-3:2002, and EN 12390-4:2002. Each test was performed on the three cubes of a test panel, with average compression strength measured at 28 days between 5600 and 6100 psi (39 and 42 MPa), resulting in a concrete class of C30/37 (30 being the class of compression strength and 37 the specific compression strength on standard 6 in. [150 mm] sample cubes). The testing was performed on a state-of-the-art Avantest 9 servo-hydraulic machine. For future works, the Faculty of Civil Engineering's Laboratory suggested performing energy absorption tests on slabs according to EN 14488-5:2006.

SIGNIFICANCE OF SHOTCRETE WORK

Shotcrete was proven to be the most effective method for the rehabilitation of the Suhurlui Irrigation Pipeline, given the constraints imposed by the project Owner:

- Extension of the service life of the pipeline for a minimum of 15 years;
- Minimum disruption to the crops and agricultural land: digging was necessary only to create access holes; and
- Minimum cost: no expensive, large-diameter replacement steel pipes were required.

Using the existing degraded metal pipe wall as formwork, a new reinforced concrete pipe was created inside the existing pipe, with a minimum reduction of nominal diameter.

ABOUT THE CONTRACTOR

Matei Construct Constructii Speciale Ltd. (MCCS) is a leading Romanian company headquartered in Cluj-Napoca, the city-capital of Romania's Transylvania region, that delivers specialized civil, industrial, and infrastructural works. Shotcrete is a process used by the company's three business units: Environment Engineering (Water Plants and Waste Water Treatment Plants), Infrastructure (tunnel lining, anchoring and slope stabilization), and Industry (large water and sewer pipes, canals, and refractory).

2016 OUTSTANDING UNDERGROUND PROJECT

Project Name
Rehabilitation of the Suhurlui Irrigation Pipeline

Project Location
Galati, Romania

Shotcrete Contractor
Matei Construct Constructii Speciale SRL

General Contractor
Matei Construct Constructii Speciale SRL

Architect/Engineer
Artifex Engineering SRL, Romania

Material Supplier/Manufacturer
Ocmer Co. SRL, Italy

Project Owner:
F.O.U.A.I. Campia Covurlui

***Calin Mircea**, PhD, is the Chair of the reinforced concrete course at the Technical University's Faculty of Civil Engineering in Cluj-Napoca, and Owner of Artifex Engineering Ltd.*

***Ofelia Corbu**, PhD, is the Head of the Central Laboratory of the Faculty of Civil Engineering in Cluj-Napoca.*

***Eugen Maier**, BSc, specializes in technologies for environment engineering and currently serves as Technical Director of MCCS.*

***Cristian Rus**, PhD, is the Commercial Director of MCCS.*

2016 Honorable Mention

Dome Technology Corporate Headquarters

By Jason South

Dome Technology recently completed a new corporate office in Idaho Falls, ID. The office is a stunning achievement in concrete thin-shell construction.

The achievements showcased in the construction include an open free-span concrete thin-shell building exposed by arching openings and beautiful light window glazing around the building perimeter, a sleek porcelain tiled exterior with an insulated durable shotcrete interior, and geothermal cooling incorporated into the shotcrete shell.

"We wanted to be able to show people what we could do. We bring in people from all over the world to meet with us, and we needed an upgrade," said Dome Technology Project Manager Daren Wheeler.

With this building, the Dome Technology team did something with a concrete thin shell that has never been done before: constructing a free-span open thin-shell geometry using air-formed shotcrete technology without a single conventional concrete form or shore. We gave it a 100-plus-year roof, made it watertight and fully insulated, and we uniquely heat and cool the building using geothermal energy.

Fig. 1: Reinforcing bars and shotcrete are integral parts of the dome construction process

Dome Technology builds bulk-storage and architectural concrete thin-shell domes all over the world and specializes in customized solutions to meet customer needs. Because "technology" is part of its name, Dome Technology sought an architectural style for its new office that would complement its cutting-edge engineering and construction. "It's a modern office showcasing the stunning geometry achievable using Dome Technology's air-formed shotcrete construction process," Wheeler said, adding that visitors can't help but notice the open free-span area with open views and tremendous natural light.

The open spans of the building are made possible due to the strength and geometry of the reinforced concrete thin shell. Concrete thin shells are inherently strong due to their double curvature and robust concrete materials.

Application of the shotcrete and reinforcement followed Dome Technology's standard application process but was uniquely modified to achieve the large arched openings in the building—an elliptical air form fabricated with high-strength architectural polyvinyl chloride (PVC) fabric by Dome Technology's affiliate, Fabric Span, was inflated, and polyurethane foam insulation was applied inside, forming a layer 3 in. (75 mm) thick. Workers then applied layers of reinforcement and shotcrete in a strategic sequence. Multiple applications of shotcrete and steel reinforcing bar were applied until the necessary thickness was achieved and the dome met its strength requirement.

Arched openings were achieved by placing a thin amount of shotcrete and reinforcement in the area to be removed. This shotcrete was integral with the remainder of the shell. Later these areas were cut out and removed from the shell, leaving the arched opening.

The orientation of the building and placement of the arched openings in the shell were designed with the aid of a lighting study to shade the glazing like an eave or shade structure in the summer. This prevents unwanted thermal gain and cools the building in the summer. In the winter, however, the sun is lower in the sky, and the arched opening is sized to allow light to touch the glazing, providing thermal gain that aids in the heating of the building. The glazed window system is light and free of supports, showcasing the light, open span of the shell from the exterior.

The porcelain tile provided a sleek exterior. An earth-tone green color and smooth pattern were chosen to mimic the

Fig. 2: Workers apply shotcrete to form the thin shell

Fig. 3: Openings are made to the dome shell, which allow light to enter the completed office

Fig. 4: An innovative system of piping runs throughout the shotcrete

look of freshly placed green concrete. Similar porcelain tile has a life expectancy of more than 100 years.

A PVC membrane doubles as the air-supported concrete form and a single-ply membrane waterproofing system over the entire concrete shell. Three inches (75 mm) of polyurethane form provides superior insulation for the building. In addition to economically protecting against thermal gain or loss of the interior of the building, it protects the concrete shell from thermal stresses induced by uneven radiant heat gain from the sun.

Burns Concrete of Idaho Falls, ID, provided the shotcrete for the project, an easy choice based on a long-term working relationship between the two companies. "They have a good understanding of technical shotcrete mix designs, so they fit our style of construction very well, and they have good quality-control measures in place," Wheeler said. The interior surface of the shell was rodded and troweled smooth, leaving a beautiful 7500 psi (52 MPa) shotcrete finish that will be long lasting and durable.

Perhaps the most remarkable features of the building that are not obvious are the heating and cooling systems, both of which are housed within the shotcrete and the concrete. All heating is achieved through in-floor radiant heat with hot water routed through the floor in multiple zones for flexibility in climate control.

The innovative cooling system is radiant too. According to Justin Judy, a Principal at Engineering Systems Solutions (ES2) who performed engineering on the project, cooling begins with the concrete shell absorbing heat. "As lights are turned on, as people are in the building, and as computers are turned on, that heat rises, and the shell acts as a thermal battery. It essentially collects that heat, so you don't necessarily have to air condition the building because the heat is going into the shell," Judy said.

Because the shell holds heat exceptionally well, coming up with a way to discharge the energy was necessary. The ES2 team designed a system that circulates 55°F (13°C) ground water from an exterior well through 3 miles (5 km) of PVC tubing routed within the shell. As the water flows through the shell, it collects the heat, then is dumped into an injection well outside. "We aren't paying to air-condition a large portion of the dome because we're using groundwater to do it," Judy said.

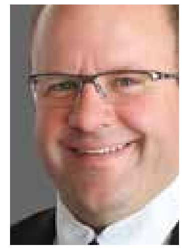
Besides long-term cost savings, the heating system provides an ideal work environment for employees. "Particularly with all the openings we have, it's pretty remarkable we can stay as warm as we do with just the radiant heating," said Dome Technology Vice President of Sales, Rod South. "Because the dome shell and the floor are integrated into one concrete thermal mass and we have the radiant heating throughout, it stays nice and toasty through the winters," which can dip to –20°F (–29°C).

The heating and cooling systems provide an effective way to show potential customers the efficiency of heating and cooling a dome. “Just having the concrete building reduces your cooling costs in the summer because it absorbs the heat,” Wheeler said.

“We feel really proud to be able to show people the office. It’s a highlight of our work. Without shotcrete, this building would not be economically feasible today. This building really highlights what shotcrete construction is capable of. Due to this outstanding showcase of construction (customers) have an inherent trust that the building we’re going to deliver to them is going to be a quality product as well,” South said.

Fig. 5: A view of the dome before exterior finishes were added

Fig. 6: The free-span area lends an open and spacious feel to the office



***Jason South**, Dome Technology Vice President of Engineering, has more than 15 years of international experience in the field of dome structural engineering and has been involved in projects throughout the world. He has been the Engineer of Record for the vast majority of reinforced concrete, thin-shell Dome Technology domes constructed globally. For the Dome Technology corporate office project, South acted as one of the building chief designers.*

HONORABLE MENTION

Project Name
Dome Technology Corporate Headquarters

Project Location
Idaho Falls, ID

Shotcrete Contractor
Dome Technology*

General Contractor
Dome Technology*

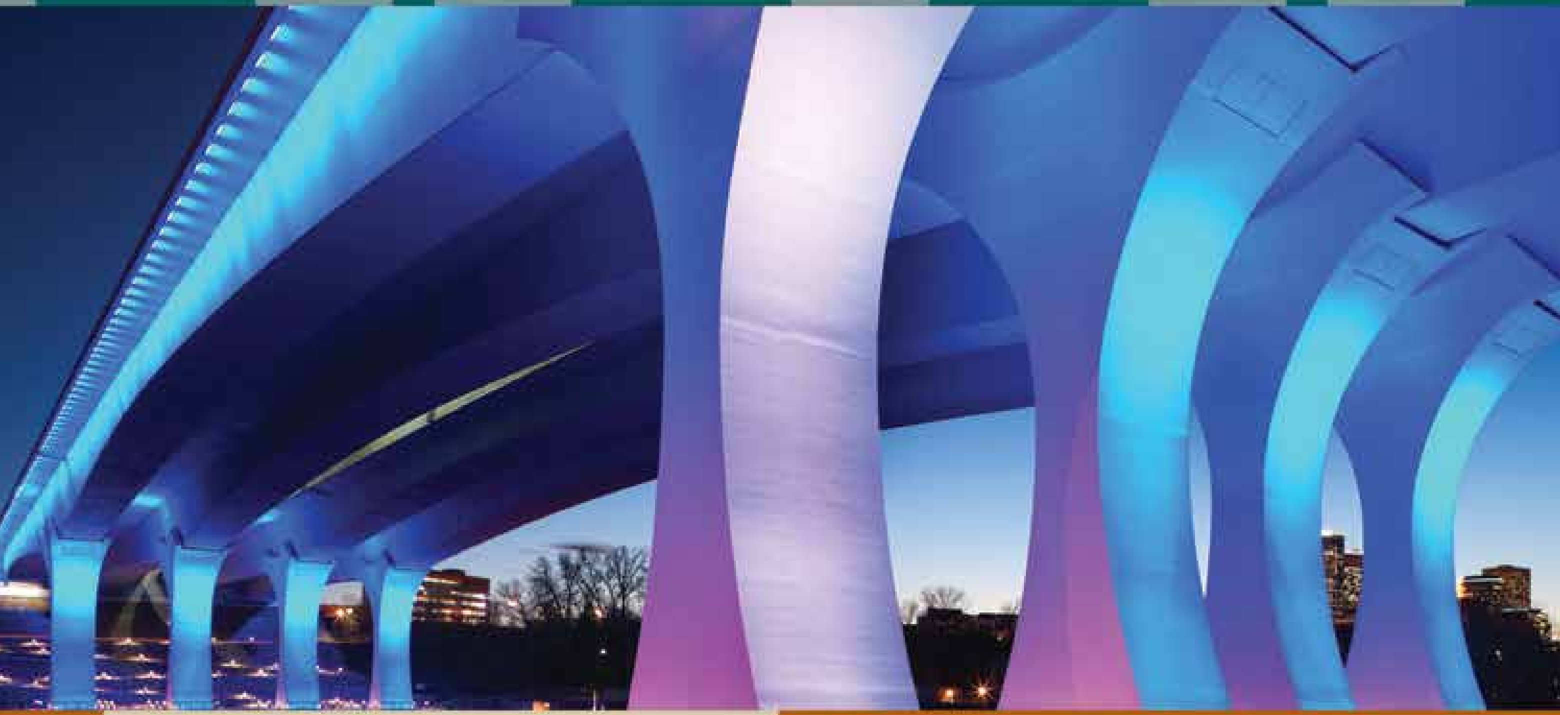
Architect/Engineer
Engineering System Solutions (ES2)
Ben Smith and Jason South

Material Supplier/Manufacturer
Schwing America, Inc.*

Project Owner
Dome Technology, Bradley Bateman, CEO

*Corporate Member of the American Shotcrete Association

Fig. 7: The corporate office’s modern exterior complements the innovative work Dome Technology does



2016 Honorable Mention

2018 PyeongChang Winter Olympics Sliding Track

By Kyong-Ku Yun, Yong-Gon Kim, and Kyu-Woon Lee

The 2018 PyeongChang Winter Olympic sliding center is a structure built in PyeongChang-gun, Gangwon Province, to host bobsleigh, luge, and skeleton events. It is currently hosting test events. This sliding center was constructed from January 2014 to October 2016, occupying an area of about 37 acres (150,000 m^2). Shotcrete construction on the main track was completed in a short period of time—from July 2015 to January 2016. Figure 1 shows a bird's-eye view of the sliding center.

The track production sequence included:

- Placing the formwork;
- Installing the curve retention screed pipe;
- Floor shotcrete placement;
- Removal of rebound material from the space between the floor and the wall;
- Wall shotcrete placement;
- Surface finish with a temporary screed pipe;
- Surface finish after the removal of temporary screed pipe;
- Surface treatment; and
- Wet curing.

TRACK MOCKUP TEST

For the mockup test, a full-sized mockup with a reduced 16 ft (5 m) length was constructed by simulating the transition curve section of the bobsleigh track. Two initial mockup tests were conducted at Kangwon National University, and the final mockup was built at the PyeongChang Alpensia site with inspection by FIBT and FIL. The main mockup test was conducted from May 22 to June 6, 2014.

On June 4, 2014, the main mockup was built by Daesang E&C Co. LTD, constructors of the track, with the help of Dr. Kyong-Ku Yun, Professor of civil engineering at Kangwon National University, Chuncheon, Korea, and with additional consulting by Dr. D. R. Morgan, P.Eng., FACI (Fig. 2).

SHOTCRETE MATERIALS

The main purpose was to develop a structural shotcrete with high strength and high durability by incorporating admixtures. Air content and slump test were measured to assess the basic properties of the concrete. Strength characteristics of the material were evaluated by compressive

Fig. 1: Overview of the sliding track

Fig. 2: Members of the mockup test

Fig. 3: Shotcrete pump with a mobile volumetric mixer

and flexural strength testing. For durability assessment, we used rapid chloride ion permeability, freezing and thawing, and surface-scaling resistance tests. Table 1 shows the targeted shotcrete's basic properties and durability characteristics, including the evaluation methods.

The pumpability was improved by incorporating 10 to 15% more air content before shooting. The air content was measured to be 3 to 6% after shooting, thus providing the desired in-place strength and durability. The durability properties were improved by substituting silica fume for 8.7% by weight of the cementitious content. The mixture design also helped to suppress early-age shrinkage cracks by substituting 7% of an expansive admixture by weight of the cementitious content. The concrete mixture was economical because the fine aggregate was set at 75% of the total aggregate weight to reduce the amount of rebound. The mixture proportions are shown in Table 2.

SHOTCRETE EQUIPMENT

Shotcrete Machine

In this project, a Putzmeister TK20 shotcrete pump was used. This delivers the concrete using two hydraulic pistons and it can produce up to 17 yd^3/h (13 m^3/h) with a maximum concrete pressure of 2000 psi (138 bars). In addition, a Putzmeister TK10 was used at the initial mockup test at Kangwon National University, where a 10 ft^3 (280 L) mixer was used. This small mixer is ideal for small-scale projects such as this. Figure 3 shows the shotcrete equipment and mobile volumetric mixer used at the track construction site.

Air Compressor

An air compressor with a maximum capacity of 390 ft^3/min (11 m^3/min) was used to provide air pressure at the nozzle.

CONSTRUCTION PROCEDURE

Bobsleigh Track Support Frame Work

First, the support frame, where the bobsleigh track will be installed, had to be placed. The support frame secures the space where the left and right walls of the bobsleigh track are attached and defines the working environment. The support frame was manufactured using steel H-beams and was designed and produced to carry the load applied to the back of the wall.

Table 1: Shotcrete Material Properties Targeted

Test item	Targeted	Note	Test method
Slump test, mm	70 to 130	Fresh	KS F 2402
Air content, %	10 to 15	Before shooting	KS F 2421
	3 to 6	After shooting	
Compressive strength test, MPa	40 or more	Age 7, 28 days	KS F 2405
Flexure strength test, MPa	5.0 or more	Age 28 days	KS F 2408
Rapid chloride ion permeability test, Coulombs	>1000	Age 28 days	KS F 2711
Surface delamination resistance, rating	1 to 2	Age 28 days	ASTM C 672
Freezing-and-thawing test, %	80 or more	Age 28 days	KS F 2456

Table 2: Mixture Proportion of Shotcrete for the Sliding Track

Gmax, mm	Slump, mm	Air, %	*w/b*, %	*S/a*, %	Unit weight, kg/m^3				AEA, %	SP, %
					W	B	S	G		
10	70 to 130	10 to 15	40	75	184	460	1322	436	0.03	0.3

Jig Support Frame Installation and Cooling Pipe and Reinforcement Placing

The jig support frame is an essential support where all the reinforcement, cooling pipes, and stay-form are installed. Hence, the jig support frame installation is critical and required setting to a tolerance of 0.2 in. (±5 mm).

The jig support frame was produced by laser cutting 1 in. (25 mm) thick metal plate. Cooling pipes were installed in the jig support frame with a 3.5 in. (90 mm) spacing, then No. 3 (10 mm) reinforcing bars on 4 in. (100 mm) spacing in the front and rear surfaces in an orthogonal layout. The reinforcing bars behind the longitudinal reinforcing bars were placed after the lateral reinforcing bars to facilitate the stay-form installation.

Formwork and Stay-Form Installation

The floor and head portions were mounted with a wooden form. A stay-form was used in the curved portion because removable wooden formwork could not be used here. The stay-form reduced the rebound during shotcrete placement and it also served to densely fill the interior.

Temporary Screed Pipe Installation

Temporary screed pipes were used as guides to place the shotcrete with a uniform thickness. The temporary screed pipes were mounted by taping a 1.1 in. (28 mm) plastic tube in place to get a 1.2 in. (30 mm) thickness. The screed pipes alternated in the upper and lower part of the track to allow easier shotcrete placement., The pipes were installed perpendicular to the axis of the track with 3.3 to 4.9 ft (1 to 1.5 m) spacing as shown in Fig. 4.

Reinforcement Layout and Spacing Inspection

Prior to shotcreting, the invited experts from both Korea and abroad inspected the reinforcement layout and spacing of the bobsleigh track after the foundation and placing of reinforcement was completed. The 6.3 in. (160 mm) thick supports satisfactorily accommodated the cooling pipe and stay-form with the 4 in. (100 mm) spacing of the reinforcement both in the front gradient and the back right-angled portion of the track.

Shotcrete Placement

The full-size bobsleigh track was built without forming construction joints. Shotcrete placement provided monolithic sections throughout the final cross section of the track. When shooting the floor, 50% of the arranged reinforcement was still visible after placing the first layer. During shooting,

Fig. 4: Track section ready for shotcreting

Fig. 5: Shotcreting the sliding track wall

rebound had to be constantly removed using an air lance (blow pipe). The upper and lower head parts were shot with lower air pressure, and then the in-place concrete was compacted with a vibrator. The shotcrete process was completed with placement to just above the temporary screed pipes on the primary layer. Figure 5 shows the shotcreting of the inner wall surface.

Fabricating Test Specimen

For compressive strength and durability test, a 20 x 20 in. (500 x 500 mm) panel was shot and cores from the panel were tested for compressive strength. Flexural strength and a freezing-and-thawing test were performed with samples from 18 x 18 in. (460 x 460 mm) panels.

Screed and Surface Finish Using Temporary Screed Pipe

After shooting was completed, the freshly placed concrete was screeded to the 1.1 in. (28 mm) plastic tubes installed on the upper reinforcement as a temporary screed pipe. In the straight portions, it was set at a 3.3 to 4.9 ft (1 to 1.5 m) spacing to give the bobsleigh track a smooth surface and uniform thickness, necessary for the cooling pipe to efficiently create ice on the surface. The temporary screed pipes were removed after the surface was screeded and the remaining void was filled with hand-applied concrete.

Wet Curing

After the final surface finish, the concrete surface was wet-cured with a wetted woven fabric that was continuously watered. No curing membranes were applied.

CHALLENGES/CONCLUSIONS

Kangwon National University has carried out technical research on shotcrete material and construction methods for many years and is the only specialized shotcrete research institute in Korea that owns shotcrete equipment. To evaluate the best methods for use of shotcrete on this project, university staff conducted an overseas field trip, and encouraged technology and knowhow transfer by inviting foreign experts to help develop the appropriate bobsleigh track construction technology.

Fig. 6: A curved track section

The advanced research can be broadly divided as material production and construction method development. First, a concrete material appropriate for shotcrete placement with excellent strength, freezing and thawing, and surface-scaling resistance was developed and used because sleigh collisions happen frequently in bobsleigh races. Additionally, the track is continuously exposed to a very cold environment to keep ice frozen on the surface. Second, the overall frame for the bobsleigh track was constructed to place the cooling pipe and reinforcement bars by using a jig support frame with consideration of the required shotcrete placing technique to build the desired shape of bobsleigh track. Because normal formwork or lining cannot be effectively used in creating multiple-curved surface structures, the inner wall stay-form and temporary screed pipe techniques were used. Thus, with these approaches, the multi-curved concrete structure of the track creatively and efficiently used shotcrete placement as the primary construction method.

For this project, two initial mockup tests were performed at the university to confirm the materials and placement methods. The final mockup test was successfully performed at the project site in the presence of the FIBT and FIL officials and was accepted with only one trial. This is exceptional compared to other countries' experience, which

Fig. 7: Bird's-eye view of the sliding track

Fig. 8: Bobsleigh at the track on test event

HONORABLE MENTION

Project Name
2018 PyeongChang Winter Olympics Sliding Track

Project Location
PyeongChang, South Korea

Shotcrete Contractor
Daesang E&C

General Contractor
Daelim Co.

Architect/Engineer
Daesang E&C

Material Suppliers/Manufacturers
Daesang E&C | Putzmeister Shotcrete Technology*

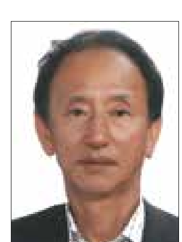
Project Owner
Gangwon-do Province

*Corporate Member of the American Shotcrete Association

required several trials to get an approval and host the Winter Olympic Games. The sliding track was constructed by Daesang E&C Co. LTD with help and consultation from Prof. Kyong-Ku Yun at Kangwon National University and Dr. D. R. Morgan from Canada, respectively. With this level of cooperation and learning from previous similar shotcrete projects, the Korean sliding track for the 2018 Winter Olympics was constructed smoothly with shotcrete placement of high-quality and durable concrete with a minimum of formwork and in a short period of time (Fig. 6-8).

__Kyong-Ku Yun__ is a Professor at Kangwon National University Chuncheon-si, Gangwon-do, South Korea. He received his PhD from Michigan State University, East Lansing, MI, in 1995. His research interests include shotcrete and concrete materials. Recently, he has been heavily involved in shotcrete research and has consulted on the shotcrete material and overall procedures for this rehabilitation project.

__Yong-Gon Kim__ is CEO of Daesang E&C, a leading Korean company for shotcrete research and application. He received his PhD from Kangwon National University in 2010, with an emphasis on latex-modified concrete and steel fiber-reinforced concrete. His research interests include shotcrete application.



__Kyu-Woon Lee__ is a Director General of Construction at Gangwon Headquarters for the PyeongChang 2018 Winter Olympic Games. He is an inspector and is responsible for this Sliding Track project.

2016 Honorable Mention

The Pacific

By Jason Myers

The Pacific, at 2155 Webster Street in San Francisco, CA, is a concrete building with two levels below grade and nine levels above grade with a total of over 250,000 ft^2 (23,000 m^2) of usable space. The building was constructed and completed in 1967 and spent most of its life as the University of Pacific School of Dentistry. The Dentistry school moved to a new location in 2014. After the school departed, the building was repurposed into 77 condominium units and 10 townhomes.

As part of the repurposing, the existing façade of precast concrete was removed to allow for the installation of full-height windows. This lightened the weight of the building considerably but in turn reduced its structural strength and rigidity. As part of the repurposing, the building needed to be brought up to current seismic codes. As a result, the building required extensive new strengthening of the shear walls and columns. The shotcreted additions to the shear walls were between 8 and 18 in. (20 and 45 mm) thick with typical field reinforcement of No. 7 (No. 22 metric bar) bars at 6 in. (15 mm) on center with various boundary element conditions. Additionally, all the columns not encased in existing or new shear walls were jacketed with shotcrete. This typically involved over 20 columns per floor. Overall, the project used over 1750 yd^3 (1340 m^3) of shotcrete and covered 65,000 ft^2 (6000 m^2) of surface area.

One of the difficulties on the project was coordination, but ultimately this also showed one of the strengths of shotcrete. Due to existing site conditions, there were a lot of redesign issues as well as wall modifications because existing concrete sections were not plumb and straight. With the flexibility of shotcrete, we were able to easily increase the wall thickness areas as required to get proper reinforcement clearances. Also, with our easily moved shotcrete operations, we could move to different walls as the schedule

Fig. 1: Typical reinforcement for shear walls and boundary elements on the fourth floor

Fig. 2: Column encasement and shear walls reinforcement on the first-floor level

required. Sometimes the moves were at the last minute because wall sections had not been signed off on due to unanswered questions or new field discoveries dealing with existing conditions. With the minimal formwork required by shotcrete, the other trades were able to work above the walls until just before shotcrete operations started. This would not have been possible with a standard form-and-pour concrete operation. Often modifications of the reinforcement and required demolition would be completed immediately before shotcreting started on a particular wall. With shotcrete's inherent flexibility, the schedule of the General Contractor was significantly less impacted by these changes than would have occurred with a form-and-pour operation because the formwork wouldn't be able to be started until all issues were resolved or, even more time-consuming, having to remove and replace the formwork when additional issues arose.

One of the requirements of the project was the Owner's desire for LEED certification. One of the ways that shotcrete was able to help improve the sustainability and in turn the LEED rating was by using recycled supplementary cementitious materials (SCMs), including slag and fly ash in the shotcreted concrete mixture. The design 28-day compressive strength of the shotcrete was 6000 psi (40 MPa) and the final concrete mixture used a 45% replacement of the cementitious material with 30% slag replacement and 15% fly ash replacement. Because of the high replacement of cement, the shotcrete mixture was very difficult to pump, but with the use of pumping aids, such as Rheomac VMA, they were still able to get a production rate of over 90 yd^3 (69 m^3) per shift through over 500 ft (150 m) of delivery pipe and hose. The Owner was also concerned about potential cracking in all of the concrete surfaces. This issue was resolved by using a shrinkage-reducing admixture (Masterlife SRA). Shrinkage tests were not performed on the project, so it is not known how much of a benefit the admixture provided, but the Owner was very satisfied with the results.

The largest issue on the project that shotcrete was able to solve was with site logistics. The project was located in a very congested part of San Francisco with narrow streets, a lot of vehicle and pedestrian traffic, and numerous local businesses. When the project was bid, one of the conditions allowed use of both Sacramento Street (the long axis of the project) and Webster Street (the short axis of the project). However, by the time Dees Hennessey Inc.'s (DHI) portion of the work began, the project's only allowable pumping location was from Webster Street, the narrower of the two streets. The General Contractor had numerous difficulties throughout the project with all of their concrete pours because of this narrowness of the street and numerous times had to perform off-hour pours due to space and traffic limitations. With the smaller footprint of a shotcrete operation, they were able to easily slide into the single parking lane that was available and shotcrete the entire project from the far end of the building. As mentioned previously, some of the pumping distances were up to eight stories high

Fig. 3: Basement perimeter walls during shotcrete wire installation

Fig. 4: Shotcrete installation for column encasement

(because of the slope gradient) and across the entire long-axis length of the building for a total pumping distance of over 500 ft (150 m).

The Pacific was a difficult project to work through and had many issues that had to be resolved. The inherent advantages of shotcrete provided efficient solutions to many of these issues on the job. With the Owner, General Contractor, and DHI working together, they were able to make this a mutually successful project for a building that has already served for 50 years and is ready for its next season of service.

HONORABLE MENTION

Project Name
The Pacific

Project Location
2155 Webster Street, San Francisco, CA

Shotcrete Contractor
Dees Hennessey, Inc.*

General Contractor
Plant Construction Company

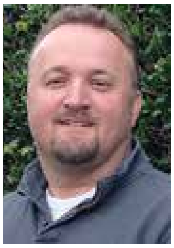
Architect
Handel Architects

Structural Engineer
Holmes Culley

Material Supplier
Central Concrete

Project Owner
Trumark Urban

*Corporate Member of the American Shotcrete Association



Jason Myers *graduated from California Polytechnic University, San Luis Obispo, CA, in 1995 with his bachelor's degree in civil engineering and from Golden Gate University, San Francisco, CA, in 2015 with his master's in business administration with an emphasis in project management. Myers started out his professional career working for an earth retention subcontractor, where he learned the importance of budgeting, scheduling, and client relationships. Also during this time, he was introduced to the use of shotcrete and its applications. After working for a general contractor for a couple of years he realized that he enjoyed the tighter knit of working for a subcontractor and the ability to construct projects on a tighter time frame with several going at once. Myers also enjoys the process of handling most of the procedures that go into constructing a project rather than seeing only a small portion of the process. Myers joined Dees Hennessey in 2004 and has been a part owner of the company since 2007. He currently serves as the Vice President of Operations as well as the Safety Director.*

Fig. 5: The Pacific after construction completion

2016 Honorable Mention

Ayla Golf Resort Comfort Stations

By Beat Huesler

Looking to the natural dunescapes and mountains of the surrounding desert—an unadorned local architectural heritage and the ancient Bedouin traditions as primary design references—Oppenheim Architecture's innovative design for the Ayla Golf Resort Comfort Stations, or on-course rest areas, is intended to achieve consistency with the firm's concept and technique for the Ayla Golf Academy & Clubhouse design. Both projects are part of an

Framing the Ayla Golf Comfort Stations
Photo credit: Oppenheim Architecture

Completed Ayla Golf Comfort Station structural framework
Photo credit: Oppenheim Architecture

Ayla Golf Comfort Station shotcrete application
Photo credit: Oppenheim Architecture

approximately 17 mile^2 (44 km^2) leisure development currently under construction in Aqaba, Jordan—the Ayla Golf Resort. The architecture of the 40,000 ft^2 (3700 m^2) Golf Academy & Clubhouse and accompanying Comfort Stations are sure to become a primary focus and iconic symbol of this highly anticipated mixed-use resort, not to mention the region.

The distinct architectural form of each structure is shaped by a massive concrete shell that precisely drapes over the programmed areas. Once programmatic elements are modeled spatially based on specific client requirements, bringing the shells from Oppenheim's computer-generated model to the built environment is achieved through a process of individual sectional cuts, which are first built on-site with flexible thin-gauge steel ribbons, then adding reinforcing bars and an outer steel mesh. An adjustable "blanket" mesh is laid over the top, enveloping each independent volume, followed by a layer of insulation. Shotcrete is then applied to both the interior and exterior walls to serve as the final shell finish, achieving the raw, unadorned look that stays true to its context and inspiration.

The Project Owner, Arab Supply & Trading Company, and the Project Team demonstrated an unwavering commitment to the use of local resources in creating these magnificent structures. Native raw materials and additives were incorporated wherever possible, particularly to achieve the desired appearance and texture of the façade. Additionally, the shotcrete contractor, Switzerland-based Greuter AG, recruited and trained local Bedouin laborers on site at the Comfort Stations, with the objective of employing them through completion of the Academy and Clubhouse.

The overall development will eventually encompass residential, hotel, and commercial space, all centered around an 18-hole, Greg Norman-designed, USPG tournament-rated

Completed Ayla Golf Comfort Station interior detail
Photo credit: Oppenheim Architecture

Completed Ayla Golf Comfort Station
Photo credit: Oppenheim Architecture

golf course (Jordan's first). Once completed, the Clubhouse will feature retail, dining, bar/lounge, banquet, fitness, and spa components; the Golf Academy will include retail, dining, and indoor/outdoor swing analysis studio components; and the two on-course Comfort Stations will include a snack/refreshment kiosk and restroom facilities.

ABOUT THE ARCHITECT/ENGINEER

Oppenheim Architecture (OA) is a full-service architecture, interior design, and planning firm with offices in Miami, FL; New York, NY; and Basel, Switzerland. Oppenheim's design strategy is to extract the contextual essence from each program, creating an experience that is dramatic and powerful, yet pragmatic and constructible. The firm's award-winning work, throughout 25 countries worldwide, is based on both a physical and spiritual contextual sensitivity, supported by evocative and economic design solutions. The firm leverages its green design expertise to minimize the impact on the environment and maximize the end-user experience and overall project performance. It is Oppenheim Architecture's intent to create landmark architecture that is highly sensitive and responsive to its context and climate.

***Beat Huesler**, Director of European Operations for Oppenheim Architecture, is a licensed architect with over 26 years of industry experience. He developed his professional training at firms in New York, NY, and Basel, Switzerland, and his extensive experience in the modern and sensitive intervention of historic structures won him the Gutes Bauen in Kanton Baselstadt and Baselland Award 2002. Huesler is the European partner of Chad Oppenheim who, together in 2009, founded Oppenheim Architecture Europe based in Basel/Muttenz, Switzerland. Huesler's relationship with Oppenheim extends back to their joint studies at Cornell University in New York, where Huesler received his Bachelors and Masters of Architecture. Huesler has coordinated many Oppenheim Architecture project efforts, including the Ayla Golf Academy & Clubhouse and Comfort Stations, which recently received the Leisure Led Development Future Projects category award at World Architecture Festival (2016) in Berlin, Germany.*

HONORABLE MENTION

Project Name
Ayla Golf Resort Comfort Stations

Project Location
Aqaba, Jordan

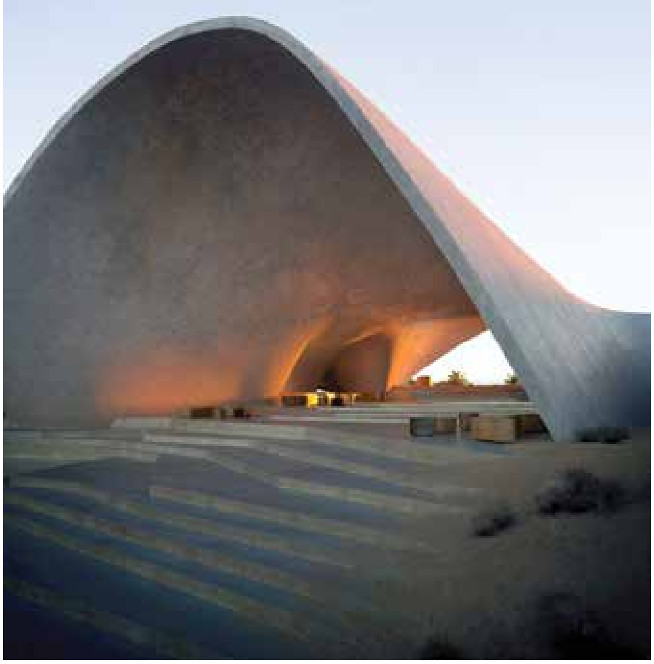
Shotcrete Contractor
Greuter AG – Zurich, Switzerland

General Contractor
NINO Constructional Engineers & Contractors – Amman, Jordan

Architect/Engineer
Oppenheim Architecture

Material Supplier/Manufacturer
Arab Supply & Trading Company (ASTRA)

Project Owner
Arab Supply & Trading Company (ASTRA)



Ayla Golf Academy & Clubhouse Entrance (Rendering credit: MIR)

Ayla Golf Academy & Clubhouse (Rendering credit: Luxigon)

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2016 Honorable Mention

Mexico City Deep Sewer Rehabilitation with Shotcrete

By Raúl Armando Bracamontes Jiménez

Mexico City's deep drainage system is a complex underground network composed of a series of tunnels designed to convey sewage and storm water to discharge and treatment facilities. The system covers almost 125 miles (200 km) of tunnels. Construction on this deep drainage system began in 1967, with its first phase concluding in 1975.

Fig. 1: Initial conditions—note deterioration at the top of the drainage tunnel

Fig. 2: Surface prepared and supplemental reinforcement in place ready to cover with shotcrete

Evaluation of two of the interceptor lines found significant damage to this concrete tunnel primarily in the top quadrant of the tunnels. Exposure to corrosive gases from the sewage and storm water contributed to this damage. The two interceptor lines were 16 ft (5 m) in diameter and had 11 access "ports," which totaled 11 miles (18 km) in length. Additional problems included thinning of the walls of the channel from chemical attack and corrosion from the reinforcing steel.

The repair process started with hydrodemolition to remove the damaged concrete, then preparing the remaining concrete surface, placement of a corrosion inhibitor on the existing reinforcing steel, placing a new layer of supplemental steel reinforcement, and applying a 6 in. (150 mm) thick shotcrete layer to reinforce the existing drainage sections in the upper middle of the tunnel.

For the placement of the shotcrete, we had a concrete pump at the ground surface to pump concrete from the surface up to 4900 ft (1500 m) below ground to a second pump that discharged to the final shotcrete delivery hose and nozzle. We opted for a robotic application to increase

Fig. 3: Shotcrete equipment in position within the tunnel

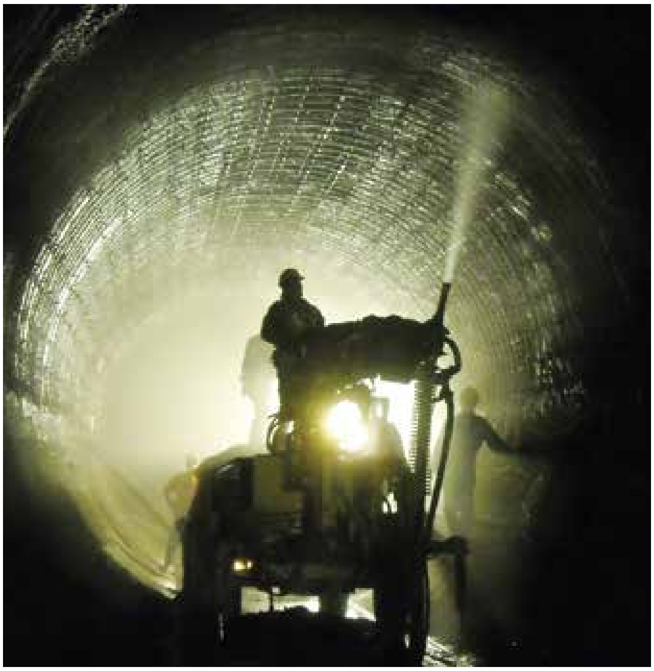


Fig. 4: Shotcreting operation

Fig. 5: Final job

productivity and placed an average of 210 yd^3 (160 m^3) of shotcrete daily.

In the below-ground locations, we used a Putzmeister Spraymobil PM400 with a diesel engine. The repairs were performed before the start of the rainy season and we worked 24 hours a day. Once the rains began, the tunnels would be flooded, regardless of equipment or materials. The ease of use and deployment of the shotcrete process, as well as proper surface preparation, allowed us to complete the job with a successful and durable application before the rains began.

HONORABLE MENTION

Project Name
Mexico City Deep Sewer Repair

Project Location
Mexico City, Mexico

Shotcrete Contractor
ADRA Ingeniería S.A. de C.V.

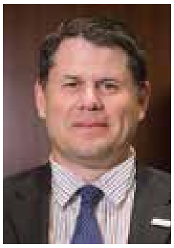
General Contractor
Ingenieros Civiles Asociados

Architect/Engineer
Raul Bracamontes

Material Supplier/Manufacturer
Putzmeister Shotcrete Technology*— Cemex Cemento

Project Owner
Ingenieros Civiles Asociados

*Corporate Member of the American Shotcrete Association



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.*

2016 Carl E. Akeley Award

Carl E. Akeley

Marcus von der Hofen

The 11th annual Carl E. Akeley Award was presented to Marcus von der Hofen of Coastal Gunite Construction for his paper, "East End Crossing." Shotcrete's ability to efficiently and effectively place concrete mitigated problems that occurred during the construction of these twin 1940 ft (591 m) tunnels. The paper, published in the Spring 2016 issue of *Shotcrete* magazine, discussed the challenges of this Kentucky project designed to improve access between the Kentucky and Indiana border while preserving the integrity of an historic Olmsted-designed estate. The award was presented by ASA Publications Committee Chair Ted Sofis.

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

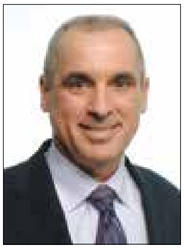
1. Teichert, P., "Carl Akeley—A Tribute to the Founder of Shotcrete," *Shotcrete*, V. 4, No. 3, Summer 2002, pp. 10-12.

(Left to right) Marcus von der Hofen, Ted Sofis, and Joe Hutter

PAST AKELEY AWARD RECIPIENTS

- 2006—J. F. Dufour, "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 ASA President's Award


Joe Hutter

The ASA President's Award was established in 2005 to recognize the person or organization that has made exceptional contributions to the shotcrete industry. It is the sole responsibility of the current ASA President to select the recipient of this award.

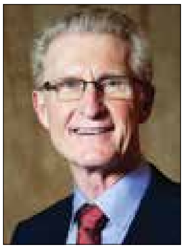
Since 2006, nine well-deserving individuals and one organization were awarded the ASA President's Award, all of whom dedicated their time and energy to advance the shotcrete industry.

For 2016, outgoing President Bill Drakeley presented the ASA President's Award to Joe Hutter for his outstanding service to ASA and the shotcrete industry. Hutter has been a pillar of the shotcrete community since ASA's inception. He is a former ASA President, has been Chair of the ASA Marketing Committee since its inception, and has more than 25 years of experience in the cement/shotcrete industry.

Hutter's commitment to ASA has helped keep daily shotcrete business steady and viable, and his willingness to help any struggling Committee attain their goals is truly commendable. As Master of Ceremonies for the Annual Awards Banquet, Hutter continuously handles himself with the utmost grace and professionalism. In the rough and tumble world of sprayed concrete, Hutter's character justifiably stands out above the rest. ASA and the entire shotcrete industry are indebted to Hutter for his generosity, commitment, and dedication.


(Left to right) Bill Drakeley and Joe Hutter

ASA Honorary Lifetime Member Award


Larry Totten

The Bylaws of the American Shotcrete Association provide for Honorary Memberships bestowed at the discretion of the ASA Board of Direction. The Board voted unanimously to award an ASA Honorary Membership to Larry Totten. The citation reads, "*For your outstanding contributions to ASA, ACI, and the shotcrete industry; your exceptional leadership in a variety of ASA officer positions and on ACI shotcrete committees; and your dedication to improving the quality and acceptance of shotcrete in concrete construction*." Marcus von der Hofen, Past President, presented this honor to Totten at the 2017 Annual ASA Awards Banquet in Las Vegas, NV.


(Left to right) Marcus von der Hofen, Joe Hutter, and Larry Totten

Trouble in the Air: Common Air System Errors Influence Shotcrete Quality

By Oscar Duckworth

Shotcrete, as defined in ACI CT-16 Concrete Terminology: "Concrete placed by a high velocity pneumatic projection from a nozzle."

Ever try to place wet-mix shotcrete without enough compressed air? To many, a crash course on the importance of sufficient air energy immediately follows an unexpected compressor malfunction. Clearly, experienced shotcrete workers realize the importance of compressed air in shotcrete placement. However, what means do workers have to readily identify that they are actually receiving the CORRECT amount of air energy necessary to achieve optimum placement consolidation and compaction quality?

Fig 1: Longer hose lengths can lead to reduced air flow

To most, providing sufficient air energy is as simple as connecting a properly sized compressor to the opposite end of the hose supplying the nozzle (Fig. 1). A deeper look may reveal that the use of an appropriately sized compressor does not assure correct air energy. Many easy-to-overlook factors directly influence the ability to attain optimum air energy for wet-mix shotcrete placement. Do you know what they are?

IS YOUR COMPRESSOR *REALLY* FUNCTIONING PROPERLY?

Concrete material projected at high velocity differentiates shotcrete placement from traditional concrete placement methods. An adequate supply of compressed air is the energy source that provides sufficient impact velocity, the key element for full compaction and consolidation.

Without sufficient air energy, shotcrete placement simply conveys and loosely packs materials onto a receiving surface, resulting in less than required compaction and consolidation. Air compressor pressure and volume output is rated by a numerical value derived from the developed air pressure in pounds per square inch (psi), and the amount of compressed air that can be produced in cubic feet per minute (ft^3/min), at the rated pressure.

Example: A 375 ft^3/min (11 m^3/min) compressor is designed to provide air at a volume of 375 ft^3/min at an operating pressure of 125 psi (0.86 MPa).

Although compressors will produce at or above their rated output in "as-new" condition, air bypass within internal components due to wear, dirty filters/separators, or other factors will impact compressor output. Because wear and deferred maintenance reduce output levels gradually, workers may not realize that a problem exists (Fig. 2). A compressor that is running smoothly does not assure that a compressor is delivering its rated output. Many compressor problems have been identified only after mechanical repairs or replacement with a similar-sized compressor that produced far more air.

Fig 2: Although nice and clean outside, poorly maintained components may significantly reduce available air flow

Fig. 3: Larger-diameter air supply lines may be necessary to maintain sufficient nozzle velocity

Fig. 4: Although identical in exterior appearance, non-full-flow couplers (left) can be easily identified by their restrictive interior diameter

WHY AIR ENERGY MATTERS

The dry-mix process requires much higher air volumes than wet-mix placement. Because dry-mix materials are conveyed through the delivery line by compressed air energy, more air volume is necessary to deliver material to the nozzle. With the dry-mix process, air compressors rated from 500 to 900 ft^3/min (14 to 25 m^3/min) at 100 to 125 psi (0.70 to 0.86 MPa) are necessary. Larger air flow also equates to the need for larger air delivery lines; 1.5 to 2 in. (38 to 50 mm) air delivery lines are common.

With wet-mix, hydraulic pumping equipment, rather than compressed air, conveys material through the delivery line. Compressed air introduced at the nozzle accelerates the concrete mixture delivered through the hose to create the high-velocity stream that impacts the receiving surface—the critical component to achieving quality compaction and consolidation. Wet-mix nozzle air requirements vary by nozzle size and design. Robotic-style 2.5 to 3 in. (64 to 75 mm) tunneling nozzles are designed to accelerate far more material per minute than a typical hand nozzle. These nozzles require air volumes of 600 ft^3/min (17 m^3/min) or more to function properly. Supplying sufficient air to these powerful nozzles requires large air supply lines often 2 in. (50 mm) and larger.

The most common hand nozzle is the 2 in. (50 mm) diameter nozzle. Hand nozzle designs differ significantly by manufacturer. Each configuration requires a predetermined minimum air flow rate and pressure at the nozzle to produce its designed impact velocity. Because these nozzles must be operated by hand, their weight and size limit efficiency at converting air flow energy into nozzle stream velocity (think short pistol versus long rifle). Therefore, unlike the larger (robotic) nozzles, small changes in supplied air volume and pressure to the nozzle directly correlate to very large changes in the impact energy generated from the nozzle material stream velocity.

SIZE MATTERS: THE RELATIONSHIP OF AIR LINE DIAMETER TO DELIVERY DISTANCE

Many shotcrete placement companies use 0.75 in. (19 mm) air delivery lines for wet-mix hand nozzle applications. In very short delivery line length applications, a 0.75 in. (19 mm) air delivery line may supply adequate air volume for proper nozzle function to some, but not for all hand nozzle designs. Occasionally, jobsite configurations require greater distances between the air compressor and the placement location. As air delivery line length increases, internal resistance restricts the delivery lines available air-carrying capacity. For air delivery lines longer than approximately 100 to 150 ft (30 to 45 m), a small 0.75 in. (19 mm) air delivery line would never be capable of supplying adequate air volume to most modern wet-mix hand nozzles. Conveying air for greater distances requires an air delivery system with a larger inside diameter. Air supply lines of 1 in. (25 mm) or (much) larger are necessary to provide adequate air energy for hand nozzles in longer-distance placement conditions. Using hoses too small to convey air long distances defeats the design of the nozzle by restricting incoming air energy. Workers must move compressors closer or increase air delivery hose inside diameter to maintain sufficient air energy to the nozzle (refer to Fig. 3).

HIDDEN TROUBLE WITH COUPLERS

All air delivery systems rely on couplers as a means to connect various individual components, but coupler designs vary between manufacturer and country of origin. Most major coupler manufacturers have produced full flow couplers for decades.

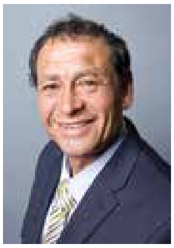
Fig. 5: Beware of prefabricated air hoses supplied with restrictive couplers

This type of coupler has an interior diameter that is nearly the same as the interior diameter of the delivery line to diminish internal restriction. Unfortunately, many currently available imported couplers do not incorporate a full-flow design (refer to Fig. 4).

Because a low-price, non-full-flow coupler may be identical in exterior appearance and primary function to a full-flow design, these couplers are currently in use on countless applications such as inexpensive prefabricated air supply lines, jackhammers, valves, or air-operated tools (refer to Fig. 5).

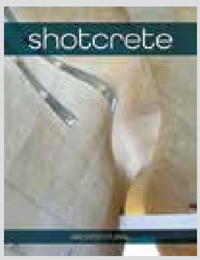
Unfortunately, if used in even one location within a 0.75 in. (19 mm) wet-mix shotcrete air delivery system, the coupler will act as an air restricting device, limiting air flow to levels well below the minimum requirement for nearly every common nozzle in current production. Because restrictive coupler designs do not create obvious differences in the sound or feel of the wet-mix equipment operation, workers may not realize that a serious problem is occurring. It is important to inspect each 0.75 in. (19 mm) air coupler within the system and replace any coupler or other delivery component that does not incorporate a full-flow design.

High-velocity placement is a key element for producing the full compaction and consolidation required for quality concrete. It is essential that the correct amount of air energy be delivered to the nozzle to achieve the needed velocity. Insufficient air delivery to the nozzle, whether caused by air delivery line choices, restrictive couplers, or the use of an air compressor with less than the required output present major obstacles to attaining acceptable compaction and consolidation. If low air energy is suspected, check by inspecting for poor air compressor function, restrictive couplers, or an air delivery system that may be too small for the project. Simple steps are useful to help assure that your air delivery system is functioning properly. Can you be sure yours is?

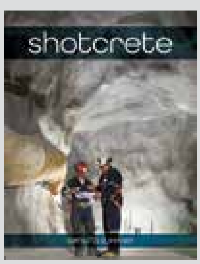


*ACI Certified Nozzleman **Oscar Duckworth** is an ASA and American Concrete Institute (ACI) member with over 15,000 hours of nozzle time. He has worked as a nozzleman on over 2000 projects. Duckworth is currently an ACI Examiner for the wet- and dry-mix processes. He currently serves on the ASA Board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

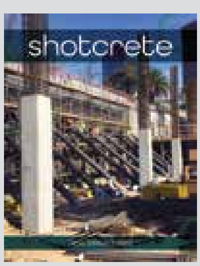
NEW! shotcrete brochures



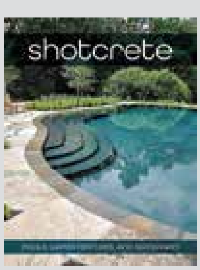
Architectural



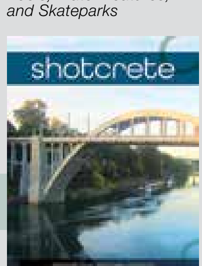
Ground Support



New Structures



Pools, Water Features, and Skateparks



Repair and Rehabilitation

Streamlined and targeted to specific markets, ASA has developed a series of affordable four-page promotional brochures to help you promote shotcrete! All brochures include basic introduction to shotcrete information and have market-specific images.

Brochures are sold in bundles of 25.

Per bundle:
ASA Members: $8.00 Nonmembers: $15.00

MARKET SEGMENT	EXAMPLES INCLUDED	ORDER CODE
Architectural	Free-formed and curved structural sections, simulated rock	SBA
Ground Support	Tunnel linings, subway stations, soil nails, retaining walls, channels	SBGS
New Structures	Foundations, domes, tanks, channels, retaining walls, luge/bobsled runs	SBNS
Pools, Water Features, and Skateparks	Pools, skateparks, landscaping water features	SBPWS
Repair and Rehabilitation	Seismic retrofit, bridges, parking garages, historic restoration, dams	SBRR
Sampler Pack	Five (5) copies of each market segment	SB5

Visit the ASA website to order!

www.shotcrete.org

american shotcrete association | asa

CanCrete Equipment Ltd.

CanCrete Equipment Ltd. aims to be a leading supplier of shotcrete equipment, parts, and associated repair in the Canadian industrial pumping market. Established in 2013, CanCrete Equipment acquired the Toronto location of Shotcrete Plus, which was previously operated in the late 1980s and '90s by Bill Toth as Kato Construction Equipment. CanCrete is a family-run business that has a long history of supporting the shotcrete industry in Ontario, and more specifically the Greater Toronto area.

Leveraging decades of concrete forming and pumping experience within the family, CanCrete puts a large emphasis on ensuring that all employees gain significant "hands-on" site experience to equip them in supporting customers every day.

QUALITY

With a focus in recent years on product sourcing, you can count on CanCrete having the right part in stock with the best available quality—always at a fair price. Having worked with concrete for over 25 years, the team understands the capabilities of cementitious materials—with knowledge stemming from mixture design to the type of pump used, to the nozzle used to spray the material. This experience drives the parts that CanCrete keeps in stock every day, ready when a customer calls—be it a gasket, a 2 in. (50 mm) HD shotcrete nozzle, pipe, hose, an S-tube, or a hydraulic pump.

RELATIONSHIPS

Whether a client is purchasing a pump, renting a pump, or picking up a length of hose, the team intends to foster the relationship with ongoing support. The Mississauga shop is always ready for a seasonal service or an urgent repair; our factory-trained mechanics understand the urgency of minimizing downtime and are thorough in checking over equipment to ensure that it hits the jobsite running. We support our clients with site training, warehouse demonstrations, partnerships with material suppliers, and in-house training with our manufacturers. CanCrete aims to provide solutions that are focused on customer profitability and success.

EQUIPMENT EXPERIENCE

Proudly representing several superior quality brands, CanCrete has established a robust network with a focus on the end user and their needs on the jobsite. As the Ontario Putzmeister dealer, CanCrete has extensive knowledge on the product lineup, leading the industry in both wet- and dry-process shotcrete. If the project demands a pump of a different sort, CanCrete offers the peristaltic Quikspray, the functionality and versatility offered by the AirPlaco portfolio, Graco pumps, as well as IMER equipment. CanCrete can provide Oztec vibrating equipment and stocks Vibco hopper grate vibrators. For fleet cleaning, CanCrete offers Back-set Platinum concrete dissolver, which has proven

Putzmeister TK70: Jobsite-ready, this used pump is available for rent or purchase. This pump can handle the harshest of mixtures—up to 74 yd³/h

Putzmeister Magnum: A favorite in the CanCrete rental fleet, this versatile pump is ideal for your wet-process shotcrete project with its ability to pump ready mixed concrete, as well as mix and pump bagged materials tried and true on our own fleet for many years. All products represented have been tested to ensure that they meet the high standards we set on behalf of our customers. CanCrete stands behind the performance of each brand offered.

With a fleet of equipment in the rental warehouse and staff experienced in on-site operation and customer training, CanCrete is prepared to allow clients the opportunity to "try before you buy" to allow for fine tuning of their exact needs at the point of purchase. This model has worked well, as it puts the equipment's performance to the test, and allows the team's learnings to extend beyond our typical boundaries and into very diverse and complex projects. Our expertise further extends into site-specific engineering of pipelines and placing systems.

CANCRETE EQUIPMENT LTD.

Marcia Duiker
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Mississauga, ON L5T 1H5, Canada
Phone: (416) 749-2843
Website: www.cancrete.ca
E-mail: sales@cancrete.ca

HERE FOR YOU

With several exciting years under our belt, CanCrete is gearing up for another busy season. The team is ready to support you with your shotcrete needs—be it equipment, parts, service, or just advice. Please don't hesitate to call us about your next project; CanCrete will do everything possible to support your business to achieve a successful pour.

Quikspray 2-in. Grout Plant: This machine is simple to operate and is effective at moving grout for your smaller repair/restoration projects

SHANNON & WILSON ANNOUNCES 2017 PROMOTIONS

Shannon & Wilson announces the following promotions for 2017: Christopher Darrah to Vice President; Jeri-Beth Bowman to Senior Associate; and Jeremy Butkovich, Andy Caneday, Kathy Corbett, Matt Gibson, Kathryn Petek, and Tyler Stephens to Associate.

Christopher Darrah joined Shannon & Wilson in 1987 and has been in the firm's Fairbanks, AK, office, which he currently leads, since 1992. As a geologist and environmental scientist, his professional focus is on environmental assessments and regulatory compliance for both public and private clients.

Jeri-Beth Bowman has been with Shannon & Wilson for more than 17 years, supporting many of the firm's administration and human resources functions. She is currently the Director of Human Resources, managing the recruiting and retention of more than 300 employees in 12 offices.

Jeremy Butkovich joined Shannon & Wilson in 2005 after completing his master's degree at the University of Illinois at Urbana-Champaign. As a licensed professional engineer in Washington, he leads a variety of geotechnical engineering projects for transportation, education, and utility clients.

Andy Caneday is a licensed engineering geologist in Washington and has been with Shannon & Wilson since 2002. He manages subsurface exploration programs and characterization of complex subsurface conditions to support engineering for a large range of infrastructure projects.

Kathy Corbett is Shannon & Wilson's Corporate Data Systems Administrator. She has been an integral part of the company's information technology staff for more than 17 years coordinating systems and software for maximum efficiency and reliability.

Matt Gibson joined Shannon & Wilson in 2008. He provides geotechnical and earthquake engineering expertise on large infrastructure projects along the west coast of the United States and Canada. He received his master's degree in geotechnical engineering and is a licensed professional civil engineer in both Washington and California.

Kathryn Petek joined Shannon & Wilson in 2006 after completing her doctoral degree in civil and environmental engineering. Kathryn has provided geotechnical expertise on a wide variety of transportation and building projects throughout the northwest United States and Canada.

Tyler Stephens joined Shannon & Wilson in 1999 as a geotechnical engineer, and has worked extensively with the firm's Railroad Services Group for more than 6 years. His projects have included tunnel rehabilitation, rock slope stability, rock slope design, landslides, embankment failures, and bridge foundations.

Shannon & Wilson is an employee-owned consulting firm with more than 60 years of experience providing geotechnical and environmental consulting services from 12 offices across the United States.

TBM EXPERT JOINS SHANNON & WILSON'S UNDERGROUND SERVICES PRACTICE

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS


Kennedy

Shannon & Wilson is continuing its expansion of their underground services practice with strategic hire Edward R. Kennedy. Kennedy joins the firm as a Vice President and Senior Project Manager for Tunnels and Systems. He has more than 40 years of experience in all major phases of heavy civil construction projects and significant expertise with soft ground and hard-rock tunnel boring machines (TBMs).

Kennedy has served as Resident Engineer for large, complex water/wastewater, transportation, and other infrastructure-related projects in challenging urban environments. He is also an established leader and innovator in the tunneling/underground industry, having participated in much of the development history of the TBM and working with Robbins, who pioneered hard-rock TBMs and disc cutters. He is recognized by contractors, engineers, owners, and manufacturers as an innovative engineer and hands-on TBM expert with unique knowledge of mechanical excavation and its application. He has also worked on the design, operation, and troubleshooting of both soft-ground and hard-rock TBMs around the world.

"Adding Ed to our team strengthens Shannon & Wilson's construction management and engineering services for TBM projects, and adds capabilities to our growing eastern U.S. services," states Axel Nitschke, Director of Operations for Underground Services and Manager of Shannon & Wilson's DC Metro office.

CEMEN TECH SIGNS VAN KEPPEL AS AUTHORIZED DEALER

Cemen Tech, the leader in the volumetric mixing industry, announced they have recently signed The G.W. Van Keppel Company as the exclusive dealer for Cemen Tech volumetric mixers in Kansas, Missouri, Oklahoma, and Arkansas. Van Keppel has over 90 years of experience and has grown to become one of the leading providers of equipment and services for construction, material handling, trench safety, and quarry supply industries in the Midwest.

Van Keppel represents many well-known international brands, including Volvo, John Deere, Caterpillar, Cascade, Hyundai, Kawasaki, Komatsu, Toyota, Yale, Sany, New Holland, and Terex Trucks, in addition to Cemen Tech volumetric concrete mixers. Van Keppel's pledge is to meet all their customers' equipment and service needs with the highest level of quality and integrity.

Van Keppel also offers used equipment and carries an extensive inventory of parts and provides equipment service, repair, and maintenance. The addition of Van Keppel to Cemen Tech's dealer network will provide improved customer service and support for Cemen Tech customers in these four states.

"We feel that our partnership with Cemen Tech will allow us to provide our customers with the solutions they need to grow margins in an increasingly competitive marketplace," said Taylor Killion, Regional Sales Manager CE Group at The G.W. Van Keppel Company.

"The addition of Van Keppel is an exciting next step to the expansion of our global dealer network," stated Mark Rinehart, Director of Sales and Marketing for Cemen Tech. "Partnering with Van Keppel will allow us to greatly expand the number of businesses that can benefit from using volumetric mixers."

Cemen Tech, Inc., has 47 years of manufacturing and engineering experience in the volumetric mixing industry. As the industry leader, the company strives to provide the highest-quality concrete mixers to its customers. Cemen Tech currently operates in over 52 countries, services mixers across the globe, and supplies equipment to the United States military. Cemen Tech believes that people, businesses, and communities around the world should have the infrastructure to access clean water, to transport goods and services, and to access reliable housing. Their products provide the foundation and stability to meet the needs of a growing world in an environmentally conscious way. Visit **www.CemenTech.com**.

The G.W. Van Keppel Company is a diversified equipment provider in the Midwest. With over 200 employees and locations across seven states, the G.W. Van Keppel Company is a leading provider of new equipment, rental equipment, new and used parts, as well as service in the aggregates, construction, underground, and material handling industries. Visit **www.vankeppel.com**.

CALL FOR PAPERS: THE SHOTCRETE CONFERENCE AND EXHIBITION 2018, ALPBACH, AUSTRIA

The Shotcrete Conference and Exhibition 2018 will take place in Alpbach/Tyrol, Austria, January 11-12, 2018.

Abstracts should be submitted by e-mail to spritzbeton@kusterle.net as a Word file before May 15, 2017. No special format is required.

For more information, visit **www.spritzbeton-tagung.com**.

The conference language will be German and English summaries of all presentations will be available. Some presentations will be in English. The Conference Chair is Wolfgang Kusterle, Professor for Building Materials at the OTH Regensburg University of Applied Sciences, Regensburg, Germany.

The conference will be held at the Alpbach Conference Centre located in the central Alps. This is an excellent meeting facility and also provides excellent skiing facilities. Many call Alpbach "the most beautiful village of Austria."

The final program will be available by October 16, 2017.

CEMEX SELLING U.S. REINFORCED CONCRETE PIPE UNIT FOR $500M TO QUIKRETE HOLDINGS

Global building materials company CEMEX is selling its U.S. reinforced concrete pipe manufacturing business to Quikrete Holdings Inc. for $500 million and an additional $40 million dependent on future performance, the Monterrey, Mexico-based company announced.

The divestment by one of CEMEX S.A.B. de C.V.'s American subsidiaries is expected to close in the first quarter of 2017.

Rinker Materials, the reinforced concrete pipe company sold to Quikrete, has more than 30 pipe and precast plants in the United States, and the acquisition will "propel Quikrete Holdings to leadership in the concrete drainage products market," reported Concrete Products.

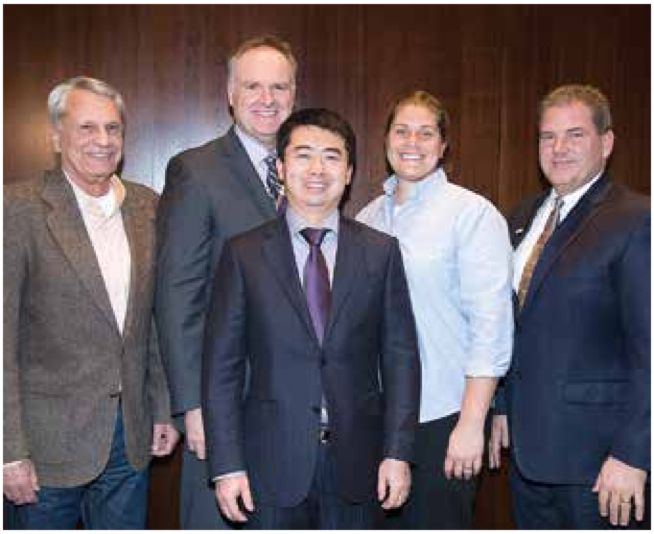
ASA OFFICERS AND DIRECTORS ELECTED

Executive Committee

The ASA membership elected the following individuals as officers in the association, with terms beginning January 16, 2017: President, Scott Rand, King Packaged Materials Company; Vice President, Lihe "John" Zhang, LZhang Consulting & Testing Ltd; Secretary, Ryan Poole, Consultant; and Treasurer, Cathy Burkert, American Concrete Restorations, were all elected to 1-year terms. William Drakeley, Jr., Drakeley Industries, will serve as Past President to complete the Executive Committee for 2017.

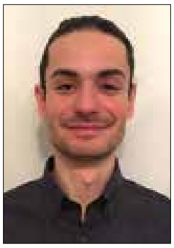
Board of Direction

Three individuals were elected to 3-year terms as ASA Directors, beginning on January 17, 2017. Mason Guarino, South Shore Gunite Pools & Spas Inc., was re-elected to a second term. Jonathan Dongell, Pebbles Technologies, and Marcus H. von der Hofen, Coastal Gunite Construction Company, were elected to first terms. These three Directors join the previously elected Directors and the ASA Executive Committee to form the 14-member 2017 ASA Board of Direction.



Left to right: Poole, Rand, Zhang, Burkert, and Drakeley

2016-2017 ASA GRADUATE SCHOLARSHIP AWARDED



Jacob-Vaillancourt

Siccardi

The 2016-2017 ASA Graduate Scholarships have been awarded to Thomas Jacob-Vaillancourt and Pierre Siccardi. They each received a stipend of $3000 (USD) for tuition, residence, books, and materials. Their bios and a brief summary of their research projects can be found on p. 10 of this issue.

Our annual graduate scholarship program was recently revised by the Board to provide the scholarship to a Laval University graduate student engaged in shotcrete research. ASA's Student Outreach Task Group was established at the same time to actively engage in pursuing broader-based programs and activities to promote and support student education in the shotcrete industry.

TWELFTH ANNUAL ASA OUTSTANDING PROJECT AWARDS BANQUET

The Vdara Hotel & Spa in Las Vegas, NV, again hosted ASA's Annual Outstanding Shotcrete Project Awards Banquet on Tuesday, January 17, 2017. This annual event scheduled in conjunction with World of Concrete remains a very popular venue for leaders in the shotcrete industry to gather and celebrate the top projects of 2016 that have exemplified the creative and effective uses of shotcrete placement in concrete construction. This year's award-winning projects can be seen beginning on p. 18 of this issue.

Special thanks are in order to ASA's banquet sponsors, without whose generous donations this event would not be possible. A complete list of these companies can also be found in this issue, beginning on p. 12.

We urge all ASA members to begin thinking now about current shotcrete projects that may be worthy of consideration in 2017 as a Thirteenth Annual ASA Outstanding Shotcrete Project. Let the outstanding projects you complete this year be the ones we celebrate at next year's ASA Awards Banquet!

The 2017 Awards Program will accept projects completed between January 1, 2015, and September 1, 2017; multiple projects may be submitted from the same company. The deadline for submissions will be October 2, 2017. Stay tuned for the announcement of a new entry format to be released this spring. This announcement, as well as others with up-to-date information on current ASA activities, is readily available when you sign up for ASA's monthly eNewsletter, What's in the Mix, at **www.shotcrete.org/pages/news-events/e-news-subscribe.htm**.

ASA AT WORLD OF CONCRETE (WOC) 2017

ASA again saw a large crowd come by the booth at this year's event in Las Vegas. New to the ASA lineup this year was a successful launch of two concurrent certification sessions held in conjunction with the Shotcrete Nozzleman education class regularly offered at WOC. Both dry- and wet-mix certification sessions were held to complete the certification requirements for a number of candidates who participated on Tuesday in our very well-attended "Shotcrete Nozzleman Education" WOC class. Both the written and performance exams were administered, including accommodations for Spanish-speaking participants. New nozzleman certifications, re-certifications, and nozzleman-in-training designations were issued from these sessions. This was so positively received; ASA looks forward to continuing the opportunity at future World of Concrete shows.

ASA SPRING 2017 COMMITTEE MEETINGS IN FARMINGTON HILLS, MI

ASA is pleased to host this spring's Committee meetings at the headquarter offices in Farmington Hills, MI. Because The ACI Concrete Convention and Exposition – Spring 2017

will take place in downtown Detroit, MI, this afforded the opportunity to invite our members and guests to visit the headquarters in nearby Farmington Hills, MI.

The following committees have scheduled working meetings: the ASA Executive Committee, Education Committee, Pool & Recreational Shotcrete Committee, Safety Committee, Marketing Committee, Membership Committee, Underground Committee, Contractor Qualification Committee, and the ASA Board of Direction. These meetings offer participants the opportunity to network with colleagues, provide input on shotcrete materials and publications, and take part in carrying out ASA's overall mission. Please see our Calendar on p. 80 for a schedule of meetings.

ASA meetings are open and free to anyone with an interest in the shotcrete process, but this spring's meetings will require an RSVP to gain entry into the building and attendance at the meetings. If you are active in the shotcrete industry, you are welcome and encouraged to attend. Scheduled times for all meetings are also posted at **www.shotcrete.org/pages/news-events/calendar.htm**.

ACI Announces Marc Jolin as Recipient of Certification Award

Marc Jolin

The ACI Certification Award was established in 2004 to recognize individuals and organizations who have made notable contributions to the advancement of ACI Certification. Notable contributions may be but are not limited to: involvement in the general areas of developing, maintaining, delivering, promoting, specifying, or enforcing requirements for ACI Certification programs. Nominees need not be ACI members.

ACI announced the recipients of the ACI Certification Award and the ACI Construction Award at a press conference during World of Concrete, Las Vegas, NV, January 18, 2017.

Marc Jolin, FACI, is a Professor at Laval University Quebec City, QC, Canada. He received the ACI Certification Award for outstanding leadership and service on ACI Certification committees, and tireless service in developing, promoting, supporting, and delivering ACI Certification programs worldwide. Jolin has been an ACI member since 1998. Jolin is a very active member of ASA and we congratulate him on this honor bestowed by ACI. He is one of our shotcrete nozzleman certification examiners, and regularly participates in our ASA committee activities.

Certification in Australia

April 27-29, 2017 | Queensland, Australia

The Concrete Pumping Association of Australia (CPAA), in partnership with ASA, will again bring Wet-Mix Shotcrete Nozzleman certification to Australia. This time, located on the Gold Coast, a full day of ASA's Shotcrete Nozzleman education along with both the written and performance exams will be available. The certification workbook ACI CP60 and a complimentary 1-year nozzleman membership with ASA are included. Take advantage of this opportunity to become ACI shotcrete certified! You can find more information on CPAA's website at **www.cpassoc.com.au**.

SHOTCRETE CALENDAR

MARCH 7-11, 2017	**CONEXPO-CON/AGG 2017** Las Vegas Convention Center | Las Vegas, NV **www.conexpoconagg.com**
MARCH 8, 2017	11:00 am–12:30 pm "Architectural Shotcrete – Creative, Sustainable and Durable Concrete Structures Using Shotcrete" Speaker: **Charles Hanskat**, PE, F.ACI, F.ASCE, ASA
MARCH 15-16, 2017	**New York Build 2017** The Leading Construction Expo for New York Javits Center | New York, NY | **Visit ASA at Booth#: B46** **www.newyorkbuildexpo.com**
MARCH 16, 2017	2:20 pm–3:10 pm "Shotcrete: Flexibility, Economy & Durability in Infrastructure" Speaker: **Frank Townsend**, ASA Board Member
MARCH 15-17, 2017	**ICRI 2017 Spring Convention** Theme: "Bridges and Highways" Le Westin Montreal | Montreal, QC, Canada **www.icri.org**
MARCH 15, 2017	9:00 am–9:30 am "Shotcrete – The Creative, Sustainable and Economical Solution" Speaker: **Charles Hanskat**, PE, F.ACI, F.ASCE, ASA
MARCH 25, 2017	**ASA Spring 2017 Committee Meetings*** ASA Headquarters | Farmington Hills, MI | RSVP Required **www.shotcrete.org**
MARCH 26-30, 2017	**The ACI Concrete Convention and Exposition†** Theme: "Driving Concrete Technology" Detroit Marriott at the Renaissance Center | Detroit, MI **www.concrete.org**
APRIL 27-29, 2017	**Wet-Mix Shotcrete Certification in Australia** Concrete Pumping Association of Australia | Queensland Gold Coast **www.cpassoc.com.au**
JUNE 4-8, 2017	**The International Bridge Conference** Gaylord National Resort and Convention Center | National Harbor, MD **www.miningamerica.org**
JUNE 11-14, 2017	**ASTM International Committee C09, Concrete and Concrete Aggregates** Sheraton Toronto | Toronto, ON, Canada **www.astm.org**
OCTOBER 11-13, 2017	**First International Conference on Underground Mining Technology** Radisson Hotel Sudbury | Sudbury, ON, Canada **www.umt2017.com**
OCTOBER 14, 2017	**ASA Fall 2017 Committee Meetings** Disneyland Hotel | Anaheim, CA **www.shotcrete.org**
OCTOBER 15-19, 2017	**The ACI Concrete Convention and Exposition** Theme: "Making Connections" Disneyland Hotel | Anaheim, CA **www.concrete.org**

NOVEMBER 1-3, 2017	**International Pool | Spa | Patio Expo** Orange County Convention Center (North Halls A&B) | Orlando, FL **www.poolspapatio.com**
DECEMBER 3-6, 2017	**ASTM International Committee C09, Concrete and Concrete Aggregates** Sheraton New Orleans | New Orleans, LA **www.astm.org**
JANUARY 22, 2018	**ASA Meetings at World of Concrete** Las Vegas Convention Center | Las Vegas, NV **www.shotcrete.org**
JANUARY 23-26, 2018	**World of Concrete 2018** Las Vegas Convention Center | Las Vegas, NV **www.worldofconcrete.com**
MARCH 24, 2018	**ASA Spring 2018 Committee Meetings** Grand America & Little America | Salt Lake City, UT **www.shotcrete.org**
MARCH 25-29, 2018	**The ACI Concrete Convention and Exposition** Theme: "Concrete Elevated" Grand America & Little America | Salt Lake City, UT **www.concrete.org**
WANT MORE INFORMATION?	See this full list online with active links to each event: visit www.shotcrete.org and click on the Calendar link under the News & Events tab.

*ASA Committee Meetings, March 25, 2017

Time	Multipurpose Room	Meeting Room A
8:00 am–9:00 am	Education	Underground
9:00 am–10:00 am	Membership	Pool & Recreational
10:00 am–10:30 am	Break	
10:30 am–11:30 am	Marketing	Safety
11:30 am–12:30 pm	Lunch	—
12:30 pm–1:30 pm	Contractors Qualification	—
1:30 pm–1:45 pm	Break	—
1:45 pm–4:15 pm	Board of Direction	—

†The ACI Concrete Convention and Exposition, March 26-30, 2017
Shotcrete Meetings of Interest – Registration Required

Committee Code	Committee Name	Day	Time	Room
C601-I	Shotcrete Inspector Certification	Sun	1:00 pm–2:00 pm	GM-Training Room 15
C660	Shotcrete Nozzleman Certification	Sun	10:00 am–12:00 pm	H-Richard B
506	Shotcreting	Tues	8:30 am–11:30 am	H-LaSalle A&B
506-A	Shotcreting-Evaluation	Mon	1:00 pm–2:30 pm	GM-Training Room 10
506-B	Shotcreting-Fiber-Reinforced	Mon	2:30 pm–4:00 pm	GM-Training Room 10
506-C	Shotcreting-Guide	Mon	8:30 am–11:00 am	GM-Training Room 12
506-E	Shotcreting-Specifications	Mon	8:30 am–11:00 am	GM-Training Room 12
506-F	Shotcreting-Underground	Mon	4:00 pm–5:00 pm	GM-Training Room 10
506-H	Shotcreting-Pools	Sun	2:00 pm–3:00 pm	GM-Training Room 15

NEW ASA MEMBERS

CORPORATE MEMBERS

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Ntam Nda-Ngye
Société de transport de Montréal
Montreal, QC, Canada

STUDENTS

Thomas Jacob-Vaillancourt
Quebec, QC, Canada

INTERESTED IN BECOMING A MEMBER OF ASA?

Read about the benefits of being a member of ASA and find a Membership Application under the ASA Membership tab of www.shotcrete.org.

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.

Grow your business

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

Grow your industry

- EDUCATE the construction world on the advantages of the shotcrete process through 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 grow your organization and industry—become an ASA Corporate Member today

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