shotcrete

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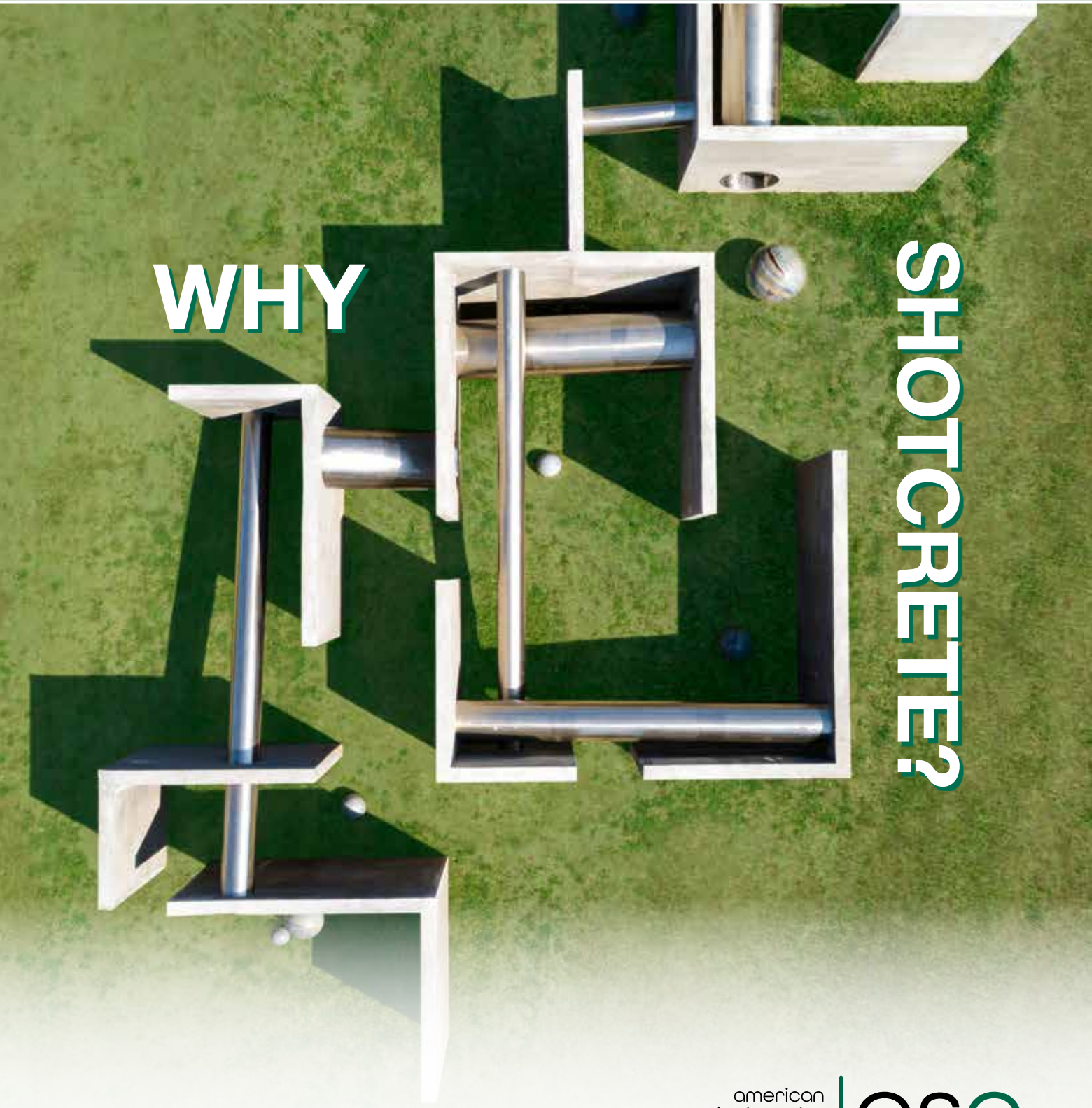

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FEATURES

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

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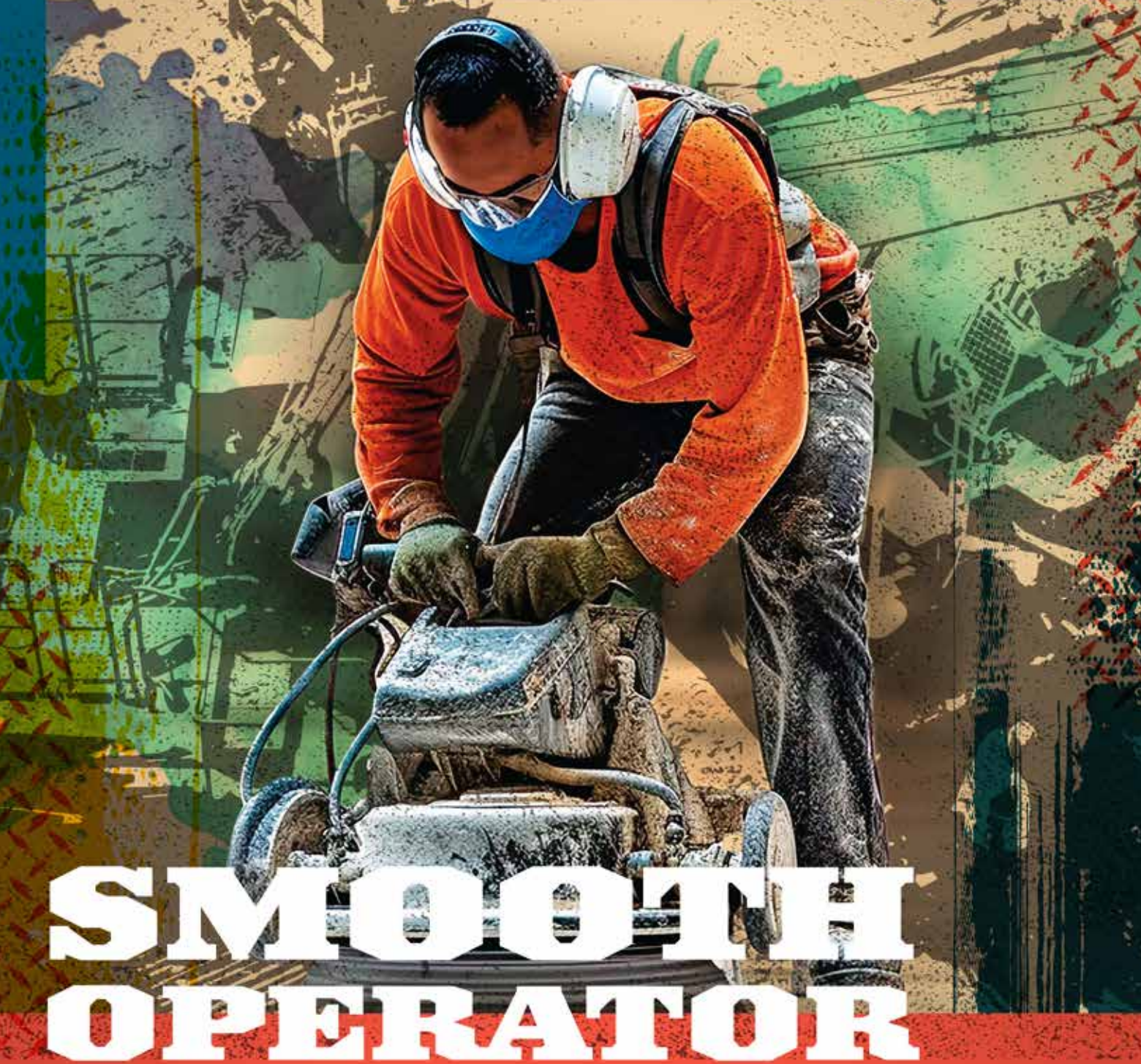
COVER PHOTO: *Alicja Kwade, TunnelTeller (2018). Stainless steel, concrete, natural stone (Azul Macaubas). Alicja Kwade, courtesy 303 Gallery, New York. Photography by Alon Koppel. (Art Omi credit), Pg. 16.*



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It has Been an Honor to Serve You

By Oscar Duckworth, F.ACI

As many of you know, my wife of 47 years passed away recently, thrusting me into undoubtedly the most difficult chapter of my life — she was my everything, and I will miss her for the rest of my life. Those of us who have experienced such a loss know the passing of a beloved life partner is an inescapable pain that words cannot define. And yet, it has also brought on a time to clearly reflect on life itself; to see what truly matters, and what does not. I was raised in a very small town in Oregon, a land of agriculture, of timber; a place where work mattered. I met my wife in high school, and soon thereafter eloped and moved away to begin a new life in a faraway place. We knew no one, had no jobs, no credit card, no money. We began our new life together at zero. Since then, we have followed two distinct career paths as a farmer and a shotcreter. The balance of these careers has provided opportunities that I could never have imagined as a young person.

WE ARE PEOPLE WHO WORK THE LAND

With farming, fundamentals matter. Patience, planning, and effort play a determining role in success. With the changing seasons come certain cycles — rituals that farmers have done for centuries. We begin our day in the darkness. There are ups and downs. Floods and drought. Abundance and famine. *Life and death.* Farmers help each other. They share. They do not compete against each other. Rather, they come and offer to help, to provide guidance learned from their own past successes or failures. My shotcrete career shares similar values. With the changing seasons come certain cycles: We begin our day in the darkness. Machines must run, and certain fundamentals matter: Patience, planning, and effort play a determining role in success. Shotcrete does differ from farming, however, in one very significant way.

Early in my career, people in the shotcrete industry did not tend to help each other. They seldom shared or freely discussed important lessons learned from their experiences. Information regarding wet-mix shotcrete or a standard methodology was not freely available. Back then, to a degree, we were left to our own devices and methodologies.

All that abruptly changed beginning with my involvement with the American Shotcrete Association (ASA). Our members were different: They shared. They came to help and to provide guidance learned from their past successes and failures. It's said that many hands make light work — I believe the cumulative wisdom learned from the many members of our Association have helped me in ways that would not have been possible on my own.

WHAT REALLY MATTERS

As we age, we learn that a career is much more than something we must do to pay the bills. If we are fortunate enough to be deeply engaged with a passion for what we do, our career tends to become an ever-increasing part of the very fabric of who we are. Whether working to achieve a successful crop each season or to attain a mastery of shotcrete, our work becomes an integral piece of our identity that reaches far deeper into our souls than the simple need for money.

In these darker times, I am reminded of the value of my career and what really matters in life. In American culture, success tends to be associated with wealth. But success isn't about how big of a home you have, your wealth, the gate in front of your estate; it's about our choices.

I admire those who come to help, those who share, those who strive to make a difference. These are the true attributes of success. With the loss of my wife, I can plainly see, in the final cycle, that our legacy will be determined by whether we made a difference. It's not what you take with you, but what you leave of yourself for others.

Success is being loved and adored by your family. It's having a deep connection with those who you have touched and have touched you. A long life is full of ever-changing cycles. Ups and downs. Floods and drought. Abundance and famine. And now, life and death.

94-year-old Clint Eastwood shared in a recent interview: "Do not look for luxury in watches or bracelets, do not look for luxury in forks or sails. Luxury is laughter and friends. Luxury is rain on your face. Luxury is hugs and kisses. Don't look for luxury in shops, don't look for it in gifts, don't look for it at parties, don't look for it at events. Luxury is being loved by people, luxury is being respected, luxury is having parents alive, luxury is being able to play with your grandchildren — luxury is what money can't buy."

DEFINE YOUR CAREER WITH ASA

My career as a shotcreter has provided opportunities that I could never have imagined possible. It has been a privilege to both learn from and educate the diverse members of this amazing Association who share the common goal of helping each other. Involvement in our Association requires a commitment of both time and resources: Trust that you will be paid back for your contributions in ways that can never be measured.

I admire those who strive to make a difference. In life, it's not what you take with you, but what you leave of yourself for others — and it has been an honor to serve you.

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Membership Matters!

By Jason Myers

The Membership and Marketing Committee is examining the role of each action item from our American Shotcrete Association (ASA) Strategic Plan within its membership this year, identifying how more efficient marketing might improve the shotcrete industry. These topics touch all of ASA's committees; whether through education, new pool documents, or the expertise and commitment to elevate shotcrete standards through the Qualified Shotcrete Contractor program. These programs and advocacy efforts are essential to ASA — but they also require an active membership.

Back in the nineties, a famous slogan of American Express was "Membership has is privileges". This lesson was true back then and still applies today. ASA has had a long history of promoting, defining, and improving the shotcrete industry, where the power of the organization is in its members. But just as the slogan goes, the only way to fully enjoy the benefits of ASA is by being an active member.

All of us can look at our bank statements and see the different clubs and memberships that we belong to but hardly ever use (or don't use to its full benefit). ASA is one where, if you can give a little of your time and effort, the rewards far outweigh the cost.

Since I have been an active member, I have enjoyed hearing our veteran members talk about the various discussions and arguments that have occurred over the years, the lessons they learned, and the positive effects that, as an association, we have had on the shotcrete industry. Members of ASA have been some of the most prominent figures in the discussions for ACI nozzleman (now shotcreter) certifications, as well as aiding in the writing of all of the ACI shotcrete technical documents that we use today. It's great listening to and observing veteran ASA members work toward common professional goals, and then seeing others who have benefited from the fruits of their labor.

ASA is presently working on numerous ways to advance the shotcrete industry. To name a few, different ASA committees are working through the OSHA silica and dust regulations, developing qualifications for being a shotcrete subcontractor, and updating a safety program specific to the shotcrete industry — as well as developing guidelines for shotcreting structurally durable pools.

By relying on the experience and knowledge we each possess, we wrestle with and solve these issues while discovering ways to raise the quality bar for the entire industry.

It's one thing to read the articles and position papers governing the industry and try to understand them in

isolation. It is another thing entirely, and so much more effective, to work as a team, have influence over the items, and engage in all the discussions that went into their publication, all while learning from others and building a network of relationships for future resource. I have had many meals and an even greater number of drinks with other ASA members, sharing information about how we go about our business and solve the problems we've faced (or could face in the near future).

Just as the members of the past have influenced the shotcrete industry, it is up to the present and future membership to decide how shotcrete is going to evolve and improve. There is only one way to be influential in that future, and that is being an active member — like so many tasks, while a single set of hands is limited, many hands can make anything possible. Our ASA committees are always looking for new active members, and it is through our discussions and conversations that we determine where the weak points of our industry exist and the hot buttons of the future lie.

> "It is up to the present and future membership to decide how shotcrete is going to evolve and improve."
>
> **– Jason Myers**

It's easy to get started. Read an interesting article in *Shotcrete* magazine or a resource from ASA's website? Email us at **info@shotcrete.org** and let us know. Whether it's to connect with the author to ask more questions or a committee chair to offer your expertise in an area, we can help connect you. Attending a show like World of Concrete? (**shotcrete.org/asa-at-world-of-concrete/**) Come stop by our booth and chat or attend one of our seminars, meet others, and introduce yourself to the speaker! Better still, come to our convention in Savannah, GA, next March (**www.shotcrete.org/convention**) to attend shotcrete-specific seminars, sit in on committee meetings, and meet a wonderful group of like-minded professionals! Let us know if you have any thoughts for future engagement opportunities!

The world is getting increasingly more complex, and the competitive edges are getting slimmer and slimmer. Why face this slim margin by yourself? Become an active ASA member, and let's work together to solve the problems of today and the future. Let's define the competitive edge, rather than being defined by it.

Why Shotcrete? Let Me Count the Ways!

By Charles S. Hanskat, P.E., F.ACI, F.ASCE, ASA Executive Director

The shotcrete process of placing concrete pneumatically at high velocity has been around for well over a century. In that time, the process vastly expanded in applications and refined the materials, equipment and placement techniques. We place high strength, low permeability, and durable concrete every day. This is no fluke, but is instead the concerted effort of those in the industry to push forward while ensuring quality and safety. Let's look at the American Shotcrete Association (ASA) Top Ten reasons why shotcrete placement is simply better than more conventional concrete construction.

1. REDUCED FORMWORK

Form-and-pour wall construction requires a two-sided form to contain the liquid concrete during casting. The forms need to carry the high pressure of the liquid concrete along the length of the wall and end up being significant structural members with form ties, walers, and bracing to carry the loads. Some studies say the forming material plus the erection, stripping, cleaning, and transport costs can be up to 40% of the construction cost.

With shotcrete, we only need a one-sided form. And that form only needs to be rigid enough to carry the 90 to 100 lb (40 to 45 kg) of force directed at it without vibration. As a result, our forms use less material as well as less time to erect and strip, providing not only a lower cost in material and labor but enhanced sustainability when compared to form-and-pour walls. Check out some prime examples of shotcrete for new structural applications at **structural.shotcrete.org**.

2. NO FORMWORK

In many projects we don't need any formwork. Consider the savings of a soil nail wall with shotcrete placement directly on the soil instead of a freestanding cast retaining wall that would require more excavation, a double-sided form, and backfill.

Or how about an underground tunnel or mine using shotcrete for the initial or final lining shot directly on the rock or soil surface, again with no forms. Check out some examples at **underground.shotcrete.org**.

Or a repair on concrete columns or the underside of concrete decks for a highway overpass or parking garage. Again, no forms. You can see shotcrete's benefits in repair at **repair.shotcrete.org**.

And when you don't need forms, you eliminate the cost of materials and time for building and stripping forms.

3. CREATIVITY

Just look at some of our past Shotcrete Project Award winners. Carved concrete walls that look as good, or better, than a natural rock face, but built with high strength, durable concrete. Or a zoo exhibit with water features and carved rock surfaces able to stand up to elephants or other wild animals, every day!

Or how about a double-curved dome. Can you imagine the cost of building a hemispherical dome form and then casting concrete? With an inflatable form and shotcrete placement, the construction of these large-scale domes is a routine and economical practice.

Or maybe a pool with an infinity edge and no straight flat sections to be found. Again, straightforward and efficient in shotcrete placement, difficult to form-and-pour. Look at our past award winner at **pools.shotcrete.org**.

Or a skatepark with all curves and no flat sections. Though some sections of skateparks may be cast and vibrated for consolidation, using shotcrete allows the entire structure to be placed by one system with high velocity impact, fully consolidated concrete throughout the park. See some prime examples of skateparks at **recreational.shotcrete.org**.

4. MOBILITY

Our shotcrete equipment is relatively compact and easy to move from job to job. Often, we can pull up to a project and be shooting in hours, not days. There is no need for a big boom concrete pump: We use a small line concrete pump for wet-mix, or an even smaller dry-mix rig. We can put our pump or gun at a convenient spot to receive concrete materials, then run the delivery line wherever we need to shotcrete. This results in lower mobilization costs, less site layout demands, much reduced on-site equipment (no cranes needed!), and flexibility in shotcrete placement.

5. EFFICIENT CONCRETE SECTIONS

In some structural concrete sections, the thickness needed to carry loads can vary. However, designers will often use a single wall thickness to facilitate wall construction with form-and-pour techniques. As one example, consider a cantilever retaining wall resisting the backfill loads on one side. It needs full thickness at the bottom of the wall but can taper to a minimum thickness at the top; easily accomplished using a one-sided form and shotcrete. Not so easy in form-and-pour. Using a tapered concrete wall significantly reduces the concrete material costs, as well as being more sustainable by requiring less concrete and the resultant CO_2 from cement production.

6. EQUAL OR BETTER DURABILITY

Research proves that the properties of shotcreted concrete which lead to long life are equal or superior to cast concrete. These transport properties show that when using shotcrete placement, we are building concrete structures that are serviceable and durable. Click or scan the QR code for reference.

Our relatively high-paste content in shotcreted concrete mixtures gives us excellent strength. It also provides an enhanced alkaline environment for embedded reinforcing steel. The alkalinity in concrete forms a passivating layer on the reinforcing steel. Higher alkalinity means that time to the start of corrosion is extended.

7. WIDE VARIETY OF SURFACE FINISHES

With shotcrete placement, we always have a fresh concrete surface that our talented shotcrete finishers can turn into a variety of textures.

- We can do a gun finish that is rough but visually interesting.
- We can do a cut finish that may have some nooks and crannies but produces a consistent wall thickness.
- We can do a float finish that looks like the plastered walls you see in your home or office.
- We can do a smooth, steel trowel finish.
- We can match original patterns by fabricating matching form boards to press onto the partially set placement.
- We can do a carved rock finish.
- Or we can even do statues and other works of art, shotcreted and carved.

And with all these finishes, we don't get the bug holes that you see in form-and-pour that need additional filling and finishing after stripping the forms. We also don't usually see the fins that are often seen between forms in form-and-pour sections.

8. ALLOWS USE OF RAPID-SET ACCELERATORS

Only shotcrete allows placement of concrete that sets in minutes and get high early strength in hours. We can inject a rapid-set chemical accelerator into the concrete stream at the nozzle for wet-mix. In dry-mix, we can use a dry accelerator in prepackaged material that is activated by the water added at the nozzle. In both cases we get the desired rapid set and strength which would be impossible from a ready-mix truck or at the pump. The rapid set is often needed to stabilize freshly excavated underground work or in time-critical repair work that needs to be put back into service quickly after shotcrete placement.

9. ARCHITECTURAL CONCRETE

Though architectural concrete may inherently be a function of shotcrete's "creativity", shotcrete placement provides architects with a new concept of what can be achieved in concrete. Shotcrete can eliminate complex, expensive, one-time forms for curved or undulating shapes. Shotcrete has been textured and colored to replace expensive stone. Architects are learning that shotcrete placement yields strong, durable concrete no matter what the shape. Check out more past architectural award winners at **architectural.shotcrete.org**.

10. THE AMERICAN SHOTCRETE ASSOCIATION

Rounding out our top ten reasons on "Why Shotcrete" is: our association has become an essential part of the shotcrete community in North America and increasingly, around the world. ASA brings together the best of the shotcrete industry to improve the acceptance, quality, and safety of shotcrete in the concrete construction world. We also provide a forum — at conventions, in committee meetings, and online — for our members to network and share experiences in their day-to-day shotcrete work. Together as an association, we have a stronger presence to develop and improve relevant codes and standards. Further, as a strong voice for shotcrete's benefits, we confirm to engineers, architects, and owners that quality shotcrete placement fully deserves consideration in their current and future projects.

That's it for ASA's Top Ten reasons for "Why Shotcrete". Of course, all of you know the answer is this: For many concrete applications, *it is simply better.*

Sustaining Corporate Members

Thank you, Sustaining Corporate Members, for your investment in the industry! ASA Sustaining Corporate Members show true dedication to ASA's vision to see "structures built or repaired with the shotcrete process accepted as equal or superior to cast concrete." These industry leaders are recognized for their exemplary level of support for the Association in a variety of ways.

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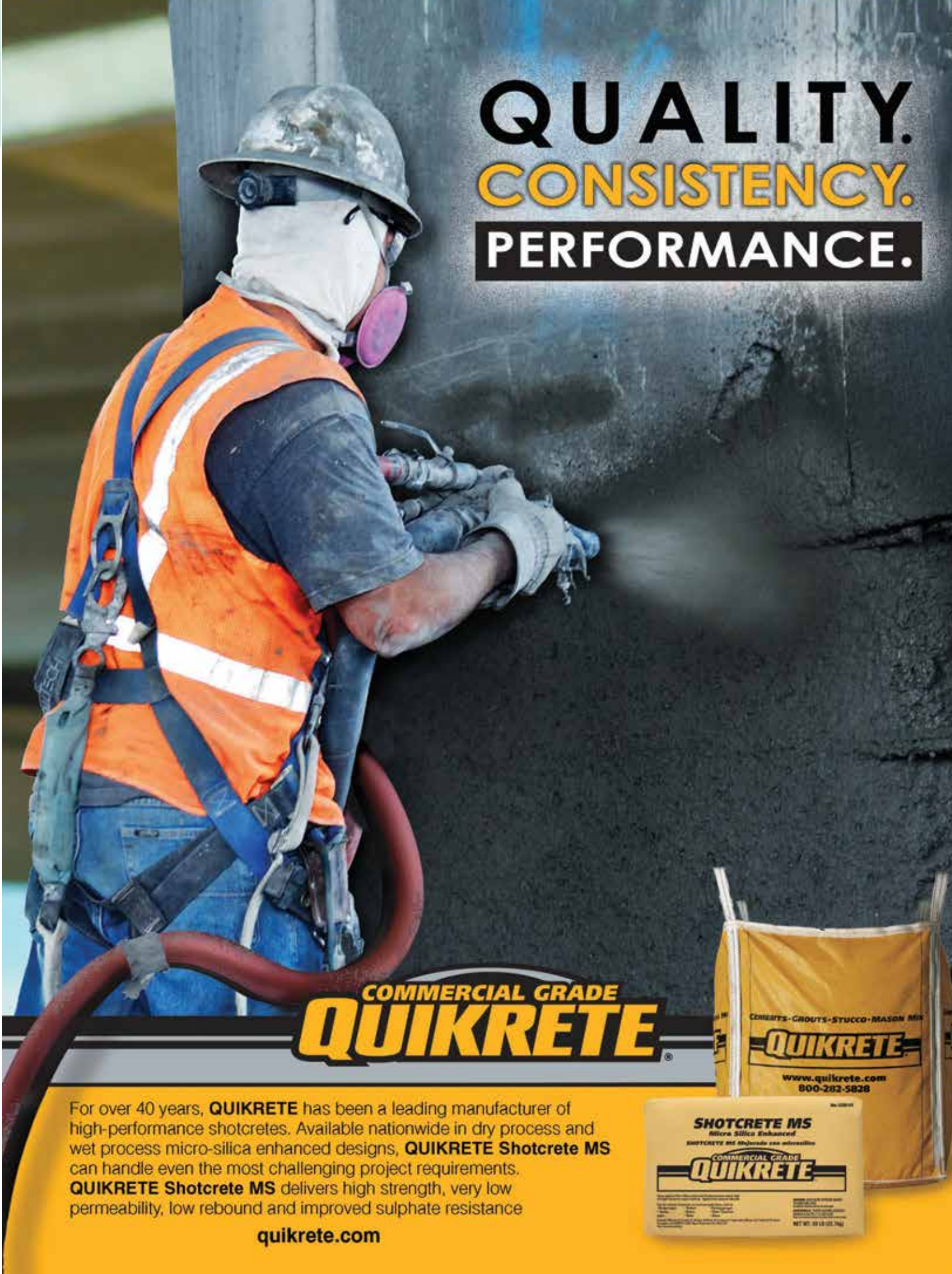

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The Diversity of Shotcrete

By Clint Jenkins, Jason Bossier, and Joe Swann

Since 1953, CROM has been using shotcrete to build and restore essential infrastructure. In striving to provide a comprehensive and long-lasting solution for even the most complex structures and systems, our team relies on the strength, durability, creativity and adaptability of shotcrete in wide ranging and complex construction scenarios, making it a compelling choice for our clients.

The two case studies highlighted give evidence of the versatility shotcrete provides when contractors face unique challenges.

CASE STUDY #1

SHOTCRETE TUNNEL STABILIZATION (8TH AVENUE RESERVOIR IMPROVEMENT PROJECT)

Metro Water Services in Nashville, TN determined that their historic 51-million-gallon (190-million-liters) reservoir, built in 1889, had reached its useable life. Faced with the decision to either demolish the existing structure and build a new tank in its place or rehabilitate the structure to extend its life, Metro Water Services determined the

Nashville Tunnel

Nashville Interior

Nashville Tunnel Mid-Construction

Nashville Shotcrete Application

historic 8th Avenue Reservoir played a crucial role in the community — the tank was not only a landmark fixture in the community but was still needed to supply drinking water to a significant component of the Nashville population. Metro Water Services decided to construct a new tank on the interior of the existing reservoir wall and leave the exterior reservoir wall in place, capturing the historical architectural features.

The design approach required construction of a tunnel through the base of the original reservoir to facilitate access to the interior, for the construction and maintenance of the new wall. CROM was selected as the shotcrete specialty contractor to install the reinforcing steel and apply shotcrete to the tunnel walls and overhead. CROM used both a silica fume-enhanced fiber-reinforced mortar as well as a 5000 psi traditional wet-mix shotcrete. The excavation and rock anchor installations were performed by outside specialty contractors.

After the tunnel was excavated, all exposed surfaces were abrasive blasted then rock anchors and reinforcing steel were installed. During shotcrete placement, thin strips of foam rubber material were used as a guide to ensure proper coverage over the reinforcing steel. Finally, the final shotcrete surface used a soft broom finish.

In the end, CROM placed 1400 bags of shotcrete material and 36 yd^3 (28 m^3) of 5000 psi shotcrete.

Nashville Soft Broom Finish Shotcrete

Nashville Tunnel Final

Steel Silo Lining Project

Steel Silo Lining Project

Steel Silo Lining Project

CASE STUDY #2

STEEL SILO LINING PROJECT (MID-WESTERN UNITED STATES)

CROM was asked by Robinson Mechanical Contractors Inc. to be the specialty shotcrete contractor in the shotcrete lining of two existing steel lead ore storage silos. The silos were originally built in 1967 as part of the mill's lead ore refining process, and after 50 years of use, the original structural steel shell had degraded.

The general contractor's design team provided CROM with the specifications for an interior liner solution, applying 8 in. (200 mm) of wet-mix shotcrete over the existing steel supporting members and attaching it to the shell using welded Nelson studs and a mat of reinforcing bars tied at 12 in. (300 mm) on center each way. The 5000 psi designed shotcrete mix would be applied in successive layers until the section thickness of 8 in. was achieved with a tolerance of plus or minus 0.5 in. (13 mm) The final application of shotcrete would receive a fine-broom finish.

Working together, CROM, the silo owner, and the general contractor created a plan that would consider and address any obstacles before beginning construction. The owner requested that renovation of the

two silos be conducted while their refining process remained in operation. This meant that there would be no interior inspection of the structure prior to construction start. CROM knew some remedial structural repairs would need to take place prior to applying shotcrete to the liner, as a visual inspection showed there were many areas in the silos' outer shell that were severely corroded from age, use, and environmental degradation.

The general contractor repaired all defects and holes in the original steel silo walls. CROM's Vehicle Mounted Aerial Platform (VMAP) then provided safe access for shotcreters (formerly called nozzlemen) and finishers. The hopper-floors at the bottom of the silos were leveled off with existing ore to provide a flat base for staging. Using the VMAP, CROM craftsmen attached the reinforcing steel to the Nelson studs welded to the steel shell.

The general contractor's team designed, cut, and removed a section of the steel silo wall for construction access, allowing CROM to place the VMAPs, staging, and work platform. This also served as access to remove shotcrete rebound and debris associated with the shotcrete placement of the liner. Upon set-up completion, we were able to begin the shotcrete placement of the concrete liner on the silo walls.

In the end, CROM placed 500 yd^3 (380 m^3) of 5000 psi shotcrete to restore the two silos for the client.

It is truly paramount to recognize the diversity of solutions available because of the versatility that shotcrete offers. Shotcrete placement provided more efficient, sustainable and durable concrete solutions in these two cases than could have been achieved with a form-and-pour approach.

Clint Jenkins *is a preconstruction advisor with more than 40 years of experience in the construction industry. Clint's experience with the construction of post-tensioned concrete systems and concrete repair and restoration have made him an asset when advising on projects. Clint is a member of the International Concrete Repair Institute (ICRI).*

Jason Bossier *is a project manager for CROM's coatings and restoration division with more than five years of experience managing restoration projects from start to finish. Jason is a member of the International Concrete Repair Institute (ICRI) and the Association for Materials Protection and Performance (AMPP).*

Joseph C. Swann, PE *is the Chief Operating Officer of CROM. With 29 years of industry experience, Joe has successfully managed and completed more than 200 heavy civil turnkey construction projects. He is a member of the American Water Works Association (AWWA), Water Environment Federation (WEF), the American Society of Civil Engineers (ASCE), American Concrete Institute (ACI), and the International Concrete Repair Institute (ICRI). Joe is currently serving as chair of ACI E706, associate member of ACI 506, and member of the American Shotcrete Association (ASA) Membership & Marketing Committee.*

An Intersection of Art and Engineering in Shotcrete

A Testament to Shotcrete Application, Located at the Art Omi Sculpture Park in Ghent, New York — Captivating Explorations of Space, Perception, and Materiality

Chemi Rosado-Seijo, Ceremonial Pearl-Hole (The Ceremonial Bowl), 2020. Shotcrete. Courtesy Art Omi. Photo Credit: Alon Koppel.

By Jasper Kahn

THE CEREMONIAL BOWL

In 2019, Kaaterskill Kahncrete collaborated with Nor'easter Skateparks to build artist Chemi Rosado-Seijo's Ceremonial Pearl-Hole (The Ceremonial Bowl) at Art Omi.

"In this site-specific work, Rosado-Seijo explores the parallels between skateboarding and contemporary art. The functional skate bowl is designed to exist as both a sculpture and social space — for skating, meeting, performances, and more. Ceremonial Pearl-Hole (The Ceremonial Bowl) references both the indigenous heritage of the Hudson Valley and the Batéy, a special plaza around which the Taíno people built their settlements in Puerto Rico and throughout the Caribbean, usually surrounded by stones. The bowl pays homage to skateboarding history through its concrete depth and curves reminiscent of a pool, in which vertical skateboarding originated." (Art Omi Website- Courtesy of the artist and Embajada, San Juan.)

ART OMI PRESENTS THE WORKS OF MORE THAN 60 CONTEMPORARY ARTISTS AND ARCHITECTS OVER 120 ACRES OF FIELDS AND FOREST AT THEIR SCULPTURE & ARCHITECTURE PARK. THIS VENUE OFFERS THE GUESTS AN OPPORTUNITY TO EXPERIENCE A RANGE OF LARGE-SCALE WORKS IN A SINGULAR OUTDOOR ENVIRONMENT. (ART OMI WEBSITE)

A Bowl-in-One! Kaaterskill Kahncrete and Nor'easter Skateparks shape artist Chemi Rosado-Seijo's "The Ceremonial Bowl" at Art Omi in Ghent, NY. Photo credit: Bart Friedman

To construct the bowl, we placed 30 yd^3 (23 m^3)of shotcrete in a 12-ft (3.6 m) diameter at 7.5 ft (2.3 m) deep with 9.5 ft (2.9 m) extensions. We had an army of people to shoot, shape, and finish this bowl-in-one.

It was a great success from the artist's and sculpture park's standpoints and is being used daily. People come to skate who may not have come to view the art otherwise — the skaters discover art, and art-driven guests discover skating.

The art director of the sculpture park had closely observed our shotcrete placement and concrete finishing during development, and advised he would reach out for us to do concrete projects in the future.

TUNNELTELLER

A year later, the art director reached out to us to execute the unique and intricate TunnelTeller sculpture by Berlin-based contemporary artist Alicja Kwade. It is designed to be a maze of concrete walls suspending stainless steel pipes as a visual interactive piece.

The sculpture had been previously built (at another location), however when the art director visited the site, he was disappointed by the execution of the build. The walls were 2 in. x 6 in. (50 mm x 150 mm) wood studs covered with cement board and parged over.

He felt as though the TunnelTeller was missing its density — to lean against the walls and know that they were hollow and fake concrete was disappointing to him. When he had the opportunity to bring this dynamic sculpture to Art Omi, he was determined to have it built with solid concrete and told us, "You guys are the only crew to bring this piece to life!"

The scope of work for this project would truly be a one-of-a-kind build, with a very elaborate set of drawings created to construct the piece to the artist's requirements and vision. We cast footings for the walls and fabricated steel brackets to suspend stainless steel pipes. The form work was critical because of the specific lengths and miters of the pipes. It was clear that shotcrete was the only way to place the concrete to fully encase the pipes.

THE BUILD

The stainless steel pipes came from Poland, with diameters from 16 to 36 in. (400 mm to 1200 mm) and custom polished to a mirror finish on the inside. In the sculpture, they are placed in different directions and angles to give the viewer the ability to look through them as a kaleidoscope. Needless to say, these pipes were very precious — when shotcreting around them, it was imperative to keep them undamaged.

Once the pipes were in place, the formwork for the walls began. Decisions on whether to form the inside or the outside of the walls varied: For our forms, we used 0.5 in. (13 mm) plywood and 2 x 4 in. (50 x 100 mm) to frame the walls. Reinforcement was #3 (#10M) reinforcing bars spaced 16 in. on center with 6 in. welded wire mesh tied to the bars.

The goal was to make 8 in. (200 mm) thick walls 8 ft (2.4 m) tall finished on both sides. We used lumber forms for the back of the wall while the outer shotcreted surface used guide wires to allow cutting and shaping to the desired surface.

Mirror finished stainless steel pipes from Poland, suspended in place before shotcrete application.

Wall formwork with Kahncrete dog inspectors Lex & Heyla.

Guide wires set to define outside corner of the wall.

The concrete is in — almost finished cutting.

Once forms were set, the reinforcing bars and mesh were placed, the pipes protected, and guide wires tightened to the perfect pitch, it was time to shoot! We shotcreted the walls lift by lift, placing material to approximately 0.75 in. (19 mm) higher than finish grade, enabling us to cut the wall to the precise plane defined by our guide wires. Once the exposed wall surfaces were floated and sealed with a trowel, the cover caps of the pipes and wall forms were removed while the concrete was still plastic. This strip and face method allowed us to achieve a uniform finish on all sides of the walls. The final sponge finish of the walls was requested by the artist to juxtapose a raw feel against the polished pipes.

Team Kahncrete L to R: Brandon ChrisJohn, Lex Kahn (dog), Ryan Cardone, Justin McDowell, Heyla Kahn (dog) and Matty Sorrano. Photo Credit: Jasper Kahn.

Alicja Kwade, TunnelTeller (2018). Stainless steel, concrete, natural stone (Azul Macaubas). Alicja Kwade, courtesy 303 Gallery, New York. Photography by Alon Koppel. (Art Omi credit)

Alicja Kwade, TunnelTeller (2018). Stainless steel, concrete, natural stone (Azul Macaubas). Alicja Kwade, courtesy 303 Gallery, New York. Photography by Alon Koppel. (Art Omi credit)

Curing for each wall involved wrapping them in plastic and then keeping them covered for weeks. Over a 10-day period, nineteen different wall panels were built using the same process, shooting 140 yd^3 (107 m^3) of concrete. From the precision required in the finishing to the seamless integration of stainless-steel pipes, shotcrete was the ideal solution for bringing TunnelTeller to life.

When the piece opened to the public it was the new highlight of the park. The visual and physical interactions created by the mixed materials were loved by all ages.

These projects were a great success thanks to the innovation of shotcrete!

Rosado-Seijo and Kwade's sculptures stand as a testament to the power of collaboration between artists and shotcrete specialists, exemplifying the possibilities that arise when creative artistic vision meets shotcrete's technical capability.

Jasper Kahn *is a passionate shotcrete specialist and the founder of Kaaterskill Kahncrete, established in 2019. His journey began at age 18, watching his local skatepark being built — a moment that sparked a lifelong commitment to shotcrete placement. Over 15 years and more than 100 skateparks around the globe later, Jasper has developed a reputation for quality and leadership in the skatepark industry. An ACI-certified shotcreter, he emphasizes the importance of proper shotcrete application, teamwork, and perseverance. Jasper's dedication to best practices drives his mission to elevate the industry.*

Rapid Strength Gain Dry-Mix Shotcrete: A Unique Solution for Highly Complex Projects

By Christine Poulin

As the construction industry faces new needs and challenges, shotcrete undergoes constant evolution through research and development in materials, equipment, and construction procedures. Widely employed in concrete repairs and underground applications, shotcrete offers numerous advantages over conventional form-and-pour concrete. Its distinctive pneumatic placement technique employs high-velocity spraying to place concrete conveyed by hose to the nozzle onto the receiving surface. Renowned for its convenience and cost-effectiveness, shotcrete often reduces or eliminates the need for formwork, enables access to difficult work areas, and allows for variable thicknesses and finishes within close tolerances. Due to its high compaction effect, shotcrete achieves excellent adhesion to the receiving surface and effectively encapsulates reinforcing bars, both of which are crucial design considerations for projects (ACI PRC-506-22, 2022).

1. SHOTCRETE PROCESSES

There are two distinct processes for shotcrete: Wet-mix and dry-mix. In the wet-mix process, the concrete mixture, thoroughly mixed with water, is introduced into a concrete pump and conveyed by hose to the nozzle. Compressed air is then added to the nozzle to achieve high velocity and ensure proper concrete compaction on the receiving surface. Fig. 1 illustrates the wet-mix shotcrete application.

In the dry-mix process, only dry pre-mixed components are used, without water, to feed a shotcrete gun. Compressed air is used to convey the dry concrete materials (or slightly damp if a predampener is used) through the hose to a nozzle body. The nozzle body includes a water ring through which pressurized water is introduced to be uniformly mixed with the concrete materials. Simultaneously, the concrete is projected through the nozzle at high velocity onto the receiving surface.

There are several industry-recognized variants to ensure homogeneous mixing and reduce dust emission with the dry-mix shotcrete, such as the use of a predampener or placing the water ring in the delivery hose up to 10 ft (3 m) before the nozzle, also known as hydromix nozzle. These two variants are distinguished by the point at which the water is introduced through the nozzle body before the concrete is sprayed. Fig. 2 illustrates dry-mix shotcrete application with the use of a predampener.

Either process can be suitable for various construction requirements. Their distinctive characteristics may make wet-mix or dry-mix process more suitable for a specific

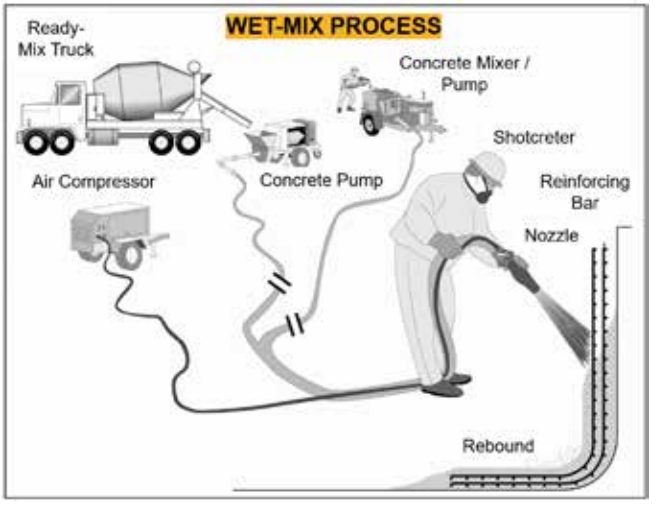

Fig. 1: Wet-mix shotcrete

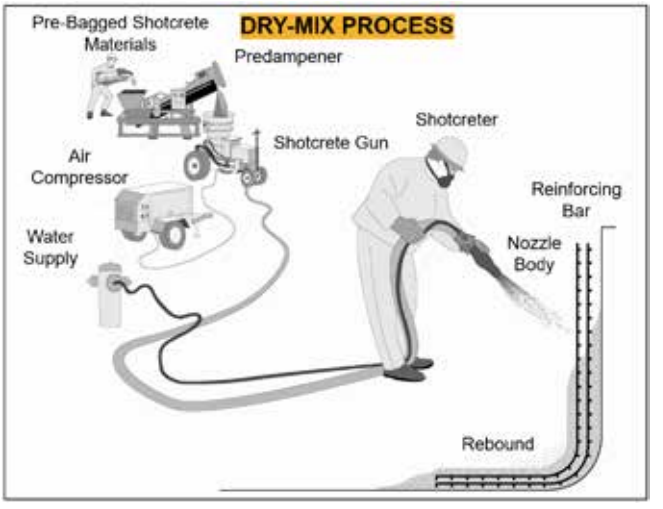

Fig. 2: Dry-mix shotcrete

application due to differences in equipment, operational features, availability of concrete materials, and placement characteristics. According to the American Concrete Institute (ACI) Shotcrete - Guide from Committee 506 (ACI PRC-506-22, 2022), Table 1 illustrates the significant differences and features offered by both shotcrete processes.

As illustrated, wet-mix and dry-mix shotcrete processes complement each other, offering to designers and contractors great versatility for use in various applications, ranging from concrete repairs to underground constructions like in tunneling and mining. While the wet-mix process provides greater volume capacity and relatively low material wastage due to reduced rebound, the dry-mix process uses lighter and smaller equipment, making it more suitable for specific applications. Dry-mix process also offers instant consistency control to adapt to field conditions. Typically, experienced industry professionals, such as experienced shotcrete contractors, are best positioned to determine which process is most suitable for specific applications and serve as excellent advisors to ensure successful shotcrete works.

In today's construction industry, there is an increasing demand for higher efficiency and speed to meet tight schedules while ensuring safe access. As a result, the industry is continuously enhancing shotcrete mixtures by integrating alternative binders and fibers, along with various admixtures. These ongoing research and development efforts enable the industry to meet rigorous quality standards, rendering shotcrete one of the premier construction techniques for ensuring both safety and performance.

Working underground comes with its own set of challenges, from demanding conditions to limited equipment access. Rapid strength gain shotcrete is often required in these environments, where suppliers and contractors must meet strict performance standards and tight deadlines. The need for quick equipment mobilization, immediate concrete availability, and the possibility of stop-and-go situations during application call for effective solutions. Sika Canada has therefore introduced various technologies in dry-mix shotcrete to consistently improve performance and meet the demands of these complex applications.

2. CEMENT TECHNOLOGIES

There are a wide variety of cement options to produce high-quality shotcrete mixes tailored to project needs. One of the most commonly used in the industry is ordinary portland cement (OPC). When combined with a high-level of setting accelerator, OPC-based shotcrete achieves faster setting and early-age strength development.

OPC-based concrete comprises four primary phases: Calcium silicates (C_2S and C_3S), tricalcium aluminate (C_3A), and tetracalcium aluminoferrite (C_4AF). The main product of OPC hydration, resulting from the reaction of C_2S and C_3S in solution, is calcium silicate hydrates (CSH), which contributes to the great rigidity of the system. In cement production, gypsum, serving as a source of calcium sulfate, is added to induce a period of low chemical activity, termed the dormant phase (a necessary step to avoid flash set). The dormant period ensures the requisite workability for proper concrete placement on site and can typically last up to 4 hours, depending on the temperature and environmental conditions. Once the calcium sulfates are depleted and the solution becomes saturated with ions, the initial setting of OPC-based shotcrete begins, followed by a strength gain of around 15 MPa (2200 psi) at 24 hours.

Wet-Mix Process	Dry-Mix Process
Mixture water is controlled at the mixing equipment and can be accurately measured	Instantaneous control over mixture water and consistency of the mixture at the nozzle to meet variable field conditions
Better assurance that the mixture water is thoroughly mixed with other ingredients	Better suited for placing mixtures containing lightweight aggregates or refractory materials
Less dust and cementitious materials lost during the shooting operation	Delivery hoses are easier to handle
Normally has less rebound, resulting in less waste	Well suited to conditions where the timing of placing the shotcrete cannot be predicted or is intermittent
Higher volume per hose size	Lower volume per hose size

Table 1. Comparison of wet-mix and dry-mix processes

Setting accelerators are widely employed in shotcrete to rapidly accelerate the reaction rate of standard OPC systems. Sika Canada promotes only alkali-free setting accelerators, which are commonly used today to improve the performance and durability of shotcrete, unlike the highly alkaline setting accelerators previously used in the industry. These alkali-free setting accelerators, primarily composed of aluminum sulfates, impact the hydration kinetic by reducing the setting time of OPC-based shotcrete to around 5 to 10 minutes. They contribute to early strength development, with a gain of approximately 1 MPa (150 psi) per hour, allowing the shotcrete to reach a strength of around 21 MPa (3000 psi) within 24 hours when a high-level of setting accelerator is used.

However, this solution has limitations in terms of achieving early-age strength gain in this standard system. Excessive use of setting accelerator during shotcrete placement can also negatively impact the quality, strength and durability of the concrete in place

(Morgan & Jolin, 2022). As a result, alternative cements, such as calcium sulfoaluminate cements (CSA), are commercially available, and serve as an excellent alternative option to achieve very high early-age strengths.

CSA cement-based concrete consists of a predominant phase, ye'elimite ($C_4A_3\bar{S}$), which plays a pivotal role in the overall hydration of the system. This reaction is influenced by the proportions of calcium sulfates (generally hemihydrate and anhydrous) and hydrated lime. When placed in solution, the chemical reaction is almost instantaneous due to the formation of ettringite, the primary hydration product of CSA cement. This hydrate reacts very quickly due to its mineralogy, allowing for very high initial strengths. Compared to OPC, CSA cement-based shotcrete exhibits a strength gain of around 21 MPa at 3 hours, with a final setting time that is nearly instantaneous.

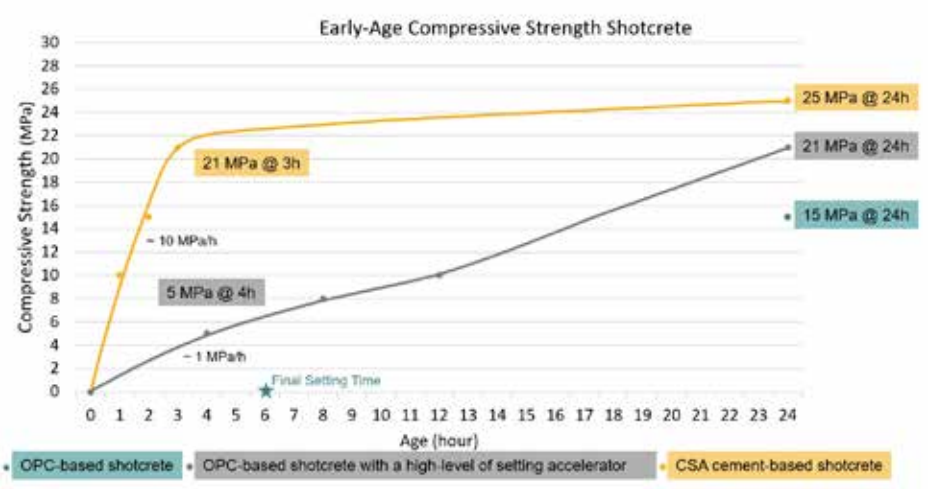

Fig. 3: Comparison between shotcrete of different binder systems and setting accelerator

Fig. 3 illustrates the correlation between early-age compressive strength development for shotcrete mixes based on OPC, with and without a high-level of setting accelerator, and CSA cement.

CSA cement-based shotcrete exhibits outstanding performance in comparison to OPC-based shotcrete, whether with or without a high level of setting accelerator. While OPC-based shotcrete without setting accelerator has not yet achieved its final setting, the strength development of CSA cement-based shotcrete is four times higher than that of OPC-based shotcrete with a high-level of setting accelerator. For reference, the compressive strength result for OPC-based shotcrete without setting accelerator is only displayed at 24 hours. The OPC system is not meant for achieving early-age strength development and has insufficient strength for testing shortly after placement. It takes about 6 hours to reach its final setting time, whereas OPC-based shotcrete with a high-level of setting accelerator takes place within the first few minutes after spraying, and CSA cement-based sets almost instantaneously.

In addition to its rapid strength advantages, the unique hydration process of CSA cement offers shrinkage compensation properties. There are alternatives to OPC-based shotcrete mixtures to also provide volumetric stability along with rapid strength development. This was demonstrated by a research project at Laval University (Lemay, 2013), which utilized ternary mixtures comprising OPC, Calcium Aluminate Cement (CAC), and calcium sulfate. However, the proper dosage of calcium sulfate is fundamental for ensuring the volumetric stability of the system; otherwise, uncontrolled expansion may occur. This complex kinetic was effectively illustrated in Fig. 4, highlighting the interaction among these components

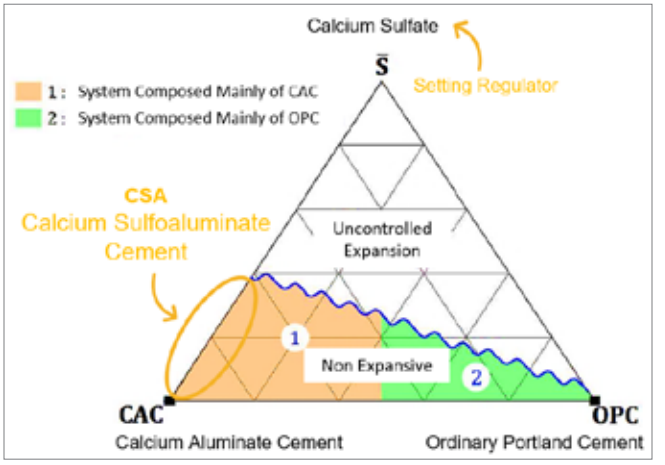

Fig. 4: Ternary diagram with expansive limits with OPC, CAC and Calcium Sulfate (Lemay, 2013)

upon the addition of calcium sulfate.

This expansive threshold observed in systems primarily composed of OPC and CAC demonstrates how an excessive dosage of calcium sulfate can lead to undesired expansion of concrete. The exact boundary between the expansion of each system, although is not entirely clear due to variability in the sources of these components, thus requiring further investigation for a better understanding of these ternary systems (Lemay, Jolin & Gagné, 2014). Therefore, the use of CSA cement sourced from the industry, already pre-blended, ensures stable concrete when employing this technology, thus benefiting from rapid strength development and shrinkage compensation properties. Indeed, CSA cement, typically positioned to the left of the diagram, containing calcium aluminate phases, remains below the threshold for uncontrolled expansion.

From an ecological standpoint, it is relevant to mention that CSA cement is more environmentally friendly. Its

production efficiency is improved compared to OPC, resulting in lower CO_2 emissions per ton of cement. These advantages are particularly valuable considering the current challenges confronting the industry (Juenger et al., 2011).

In traditional form-and-pour concrete, setting retarders are commonly used to ensure the necessary workability of CSA-based concrete. However, with dry-mix shotcrete, no retarding admixture is required because mixing occurs at the nozzle just before the concrete is sprayed. This exceptional combination enables the deployment of an ultra-performing technology that no other concrete method can match.

3. CASE STUDY

An excellent case study showcasing the effectiveness of CSA-based dry-mix shotcrete is the construction of tunnels and underground structures within the Eglinton Crosstown project in Toronto, Canada.

The Eglinton Crosstown project stands as Canada's largest infrastructure endeavor, initially estimated at $8.4 billion CAD in 2011, but now valued at $12.5 billion CAD. This project entails the construction of a light rail transit system (LRT) designed to transport commuters from east to west within the city of Toronto. Commencing in 2011, the project was originally slated for completion in 2021 but has encountered delays, leading to a revised completion target of late 2024. Spanning a 19 km (12 mi) corridor, the project includes a 10 km (6.2 mi) underground section and incorporates 25 stations along with 2 connections to the existing Toronto Transit Commission subway line, illustrated by the stars in Fig. 5 (KPMB, 2024). The Cedarvale station is located at the Eglinton West intersection, and the Yonge station at the Eglinton intersection.

The technical challenges faced at these intersections of the existing subway lines and the future LRT line, where a new tunnel had to be constructed under the operational subway tunnel, necessitated the use of underpinning techniques. While the contractor used dry-mix shotcrete with a high-level of setting accelerator at the Cedarvale station, CSA-based dry-mix shotcrete was used at the Yonge station, as shown in the figures 6 and 7.

CSA-based dry-mix shotcrete played an important role at the Yonge station for ensuring rapid and safe excavation. The project demanded specific early-strength development that highly accelerated shotcrete could not achieve. The contractor met these requirements with the CSA-based mixture, ensuring timely and durable completion of tunnel linings and support structures. Moreover, the versatility and adaptability of dry-mix shotcrete has been advantageous in navigating the complex underground terrain and meeting the stringent project requirements. The results obtained with CSA-based dry-mix shotcrete on the project were around 10 MPa (1500 psi) at 1 hour and 20 MPa (2900 psi) at 2 hours. The strengths were measured on-site at the time required to meet project requirements.

For testing at such an early age, strength measurements were carried out on-site using the beam-test method with a manual hydraulic pump and a calibrated pressure gauge, following the ASTM C116 (withdrawn) test standard (ASTM, 1999), as shown in Fig. 8.

As explained by Heere & Morgan (2002), within roughly 24 hours after initial spraying, the compressive strength of shotcrete is typically insufficient for using core extraction and conventional testing procedures. Therefore, the

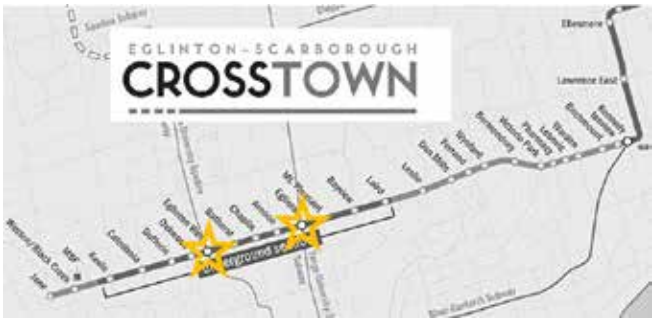

Fig. 5: Eglinton Crosstown Underground Line

Fig. 6: Cedarvale Station, Eglinton West Intersection, courtesy of HC Matcon Inc.

Fig. 7: Yonge Station, Eglinton Intersection

beam-test method has been developed, where each side of the flexural beam serves as modified cubes for loading. This test method is considered best suited for testing shotcrete at an early age and has the advantage over other indirect, early-age shotcrete test methods (such as penetrating probes or pins, and pullout tests) of directly measuring compressive strength.

The specifics of the CSA-based dry-mix shotcrete chosen, and the test methods employed, offer valuable insights into the properties and performance of the dry-mix shotcrete in this critical application. This case study highlights how Sika Canada, with this technology, contributed to the success of the Eglinton Crosstown project, underscoring its effectiveness in large-scale infrastructure developments.

4. CONCLUSION

The construction industry must embrace new technologies and innovations to address today's challenges. With its unique features, shotcrete stands out as a placement solution, meeting the most stringent project standards and offering unmatched benefits compared to traditional form-and-pour concrete.

By combining the advantages of shotcrete with alternative cements, CSA cement-based dry-mix shotcrete offers high-performance results under complex site conditions. This unique solution achieves a compressive strength gain of approximately 21 MPa (3000 psi) within 3 hours, whereas OPC-based shotcrete with a high-level of setting accelerator requires 24 hours to reach similar strength. As a result, CSA cement-based dry-mix shotcrete allows higher efficiency and speed to meet demanding project timelines.

The Eglinton Crosstown project is an excellent example of how Sika Canada, working closely with contractors and designers, successfully tackles these challenges by implementing cutting-edge solutions in tunneling and mining industries.

Christine Poulin, P. Eng., M. Sc., *is the Key Technical Engineer for shotcrete and tunneling at Sika Canada Inc. She studied civil engineering at Université Laval in Quebec City, where she received her master's degree in civil engineering in shotcrete in 2019, supported by a Mitacs Accelerate Research Grant with the American Shotcrete Association. Following her work experiences in research and materials consulting, Christine joined Sika's Shotcrete, Tunneling, and Mining division in 2021, where she focuses on the shotcrete and tunneling market.*

Fig. 8: Beam-test method

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A Retrospective: The American Shotcrete Association

By Ted Sofis

It was 1998. We were doing shotcrete repairs on the Prince Gallitzin Dam project near Altoona, PA, when I saw something unusual in the documents: The specifications called for an ACI Certified Nozzlemen on the project. I had never seen that in a specification, and we had been using shotcrete since the early 1960s. I wasn't overly concerned because I felt confident in our skilled people — all of them had over 20 years of experience preforming shotcrete work, and much of our industrial work was by invitation only, meaning that the owners only invited contractors who they felt were qualified to bid on their projects. I remember feeling annoyed, however, that we needed evaluation by someone whose level of experience we had no way of knowing.

There was a phone number listed, so I called about getting my nozzlemen certified and spoke to someone who I assumed was an engineer. I don't even recall today to whom I spoke with, but I was told that the program was not up and running yet. I was then asked if I would be interested in certifying people.

My first thought was, why do I need these guys? It sounded like a dog and pony show. How could the Department of Environmental Resources ask me to provide them with something that did not yet exist?

I called the project engineer and apprised him of the situation. I then submitted resumes for our nozzlemen, superintendent, and other personnel, along with a long list of projects and owner phone numbers. That was my first exposure to the American Shotcrete Association (ASA).

THE BEGINNINGS OF THE ASSOCIATION

As Patrick Bridger recollects, the idea for a shotcrete association came up at an October American Concrete Institute (ACI) meeting. A group including Patrick, Curt White, Meryl Isaak, Rusty Morgan, Marc Jolin, JF Dufour, Pierre Lacombe, Chris Zynda, Michael Cotter, Pete Tatnall, Lars Balck and others that felt there was need for a group to represent this widely misunderstood process of pneumatically placed concrete.

People fear or discount things that they don't understand. It would be necessary to educate not only the owners and contractors, but the engineering community as well. This diverse group of shotcrete professionals included contractors, engineers, equipment manufacturers, and material suppliers — it was a good cross section of the industry.

STREETSBORO, OH

Lars Balck told me that it was Ted Crom who had pushed for a certification for nozzleman (now called shotcreters) by ACI. ACI 506.3R-91: Guide to Certification of Shotcrete Nozzlemen was written and although the guide was later removed when ACI certification was developed, Marc Jolin and JF Dufour put together the first craftsman's book for ACI certification. George Yoggy, a spokesman

An early ACI Nozzleman Certification session at our Sofis Company shop with Ray Schallom in Clinton, PA.

and life-long advocate for shotcrete, made the Master Builders facilities in Streetsboro, Ohio, available for the ASA/ACI Shotcrete Nozzleman Certification's trial run.

I spoke with Ray Schallom, and he told me they all worked together for 2 weeks on the curriculum, the education slides, and the craftsman's study book. In addition to Ray and Lars were Neil McAskill and Milt Collins, the first ASA Executive Director. Some test panels were made and shot. Ultimately, they certified 16 nozzlemen. A second session with George Yoggy was held the following year in 1999, working with Baker Concrete in Orlando, FL.

JOINING THE ASA

Fast forward to 2004, and Bill Fortuna of Quikrete told me that I should join the American Shotcrete Association — it was a good group, they had a lot going on, and I should be involved. After Bill planted the seed in my mind, I spoke with Tom Norman of Airplaco-Gunite Supply, a good friend and supplier, who encouraged me as well. The next thing I knew, I was off to the World of Concrete Convention in Las Vegas where the ASA committee meetings were being held.

We were at the Monte Carlo the first year that I attended, and from our first few meetings I realized that I had a lot to offer. I learned, in discussions with other contractors, that we all were experiencing the same problems. Material manufacturers were specifying products and systems for shotcrete that really didn't work well. We were all having difficulties using these systems and bonding compounds with shotcrete.

I wasn't a lone a voice in the woods. We had to educate our customers and the engineering community on what works with shotcrete, and what doesn't.

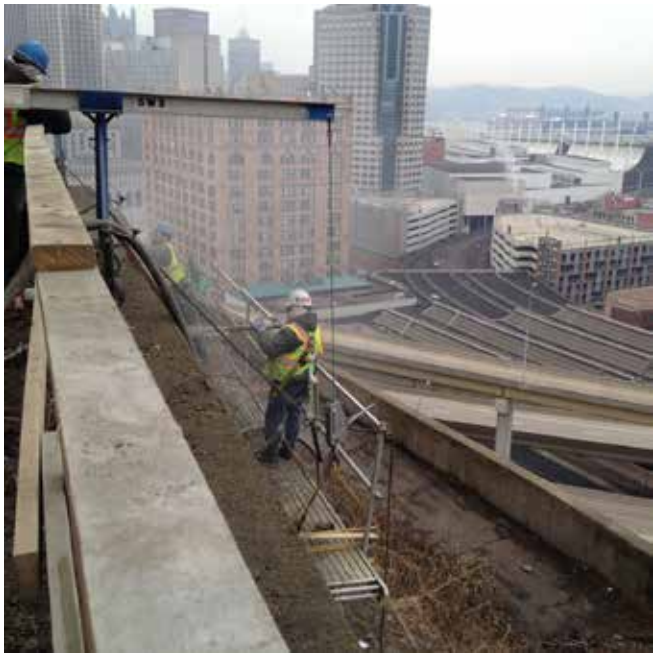
The specifications were outdated and in need of revision. I volunteered on several committees and began writing articles on various shotcrete-related topics. One thing that appealed to me was the variety of people involved: The ASA wasn't just a contractor's association. It included engineers, educators, equipment manufacturers, and material suppliers. We had a lot of experience and talent in the group, and all of us were interested in advancing the industry. It was time to raise the bar, which meant encouraging good practices, writing better specifications, educating the engineering community, doing a better job in training our workers and stressing quality shotcrete placement.

Poor workmanship over the years had owners and engineers wanting better assurance that the people performing the work had the necessary skills and training (hence the previous request that my nozzlemen be ACI-Certified). That became a major factor behind the ACI Nozzleman [Shotcreter] Certification program.

WORKING ON COMMITTEES

During those early years, we members did almost everything ourselves. When we had committee meetings for marketing, education, and publications, we would ask for volunteers to write articles on various topics. Our diverse membership

At Sofis Company, In Clinton, PA, with ACI Examiner, Ray Schallom after after an early Nozzleman Certification session.



Shotcrete repair to a retaining wall over an embankment overlooking downtown Pittsburgh.

Slope stabilization in Westernport, MD. One of the advantages of shotcrete is being able to effectively place material in hard to access areas.

gave us a wealth of experience on everything from tunnels, dams, bridges, structural walls, concrete repair to industrial refractory installations. In many cases it was a labor of love: These were topics and things that we cared about.

Rusty Morgan wore many hats and served as our technical editor. A group of us would respond and answer shotcrete-related questions on our ASA website. I remember working with Marcus von der Hofen and Ray Schallom on the presentations for nozzleman education. I recall nice messages that I received from the late Pete Tatnall about articles that I had written for the magazine. Encouraging new voices — that was always a priority for us.

One my favorite memories was of a breakfast I had with Oscar Duckworth at the Monte Carlo in Las Vegas. Oscar wanted to share the viewpoint from a shotcreter's perspective, but he was not comfortable writing. I assured him that it would be okay, none of us were going to win the Pulitzer Prize, and we would help him with any editing that might be necessary. This led to a regular feature authored by Oscar called "Nozzleman's Knowledge" (now known as Contractor's Corner).

We developed close relationships working together on a variety of projects. Charles Hanskat, Marcus von der Hofen and I worked on a series of sustainability articles. As our Association grew, we brought Charles Hanskat on board as both Executive and Technical Director. As the Executive Board, we met in Detroit to work on the long-range strategic plan. Our group included Scott Rand, Joe Hutter, Charles Hanskat, Michael Cotter, Patrick Bridger, and myself. Scott Rand spearheaded the effort to take the goals identified at the Strategic Planning initiative and establish a timeline to achieve them.

THE ASA TODAY

We've come a long way since those early years, and the ASA has achieved many of its goals and objectives. Shotcrete is now widely accepted and specified in a variety of applications. We have published technical papers and provided resources for shotcrete-related information. Although we still rely on volunteers for content and technical expertise, our Association staff does a great job keeping all the moving parts running smoothly:

- Charles Hanskat serves both as our Executive Director and Technical Director.
- Alice McComas is the Assistant Director.
- Tosha Holden is the Member Engagement and Marketing Manager
- Cara Baker is our new Managing Editor and Graphic Designer for Shotcrete magazine.

We needed to educate people about the advantages of shotcrete, such as the ability to place material overhead, as on this bridge hammerhead outside of Pittsburgh, PA.

Dry Process Shotcrete repairs on the base of a dam in central Pennsylvania. Conveying and efficiently placing material is one of many hidden advantages of using shotcrete.

AN OVERVIEW

This is by no means a detailed history. While I've provided a few recollections from my own perspective in this article, I know there are many, many important members and contributors I have not mentioned. The ASA was and is largely a collective effort. I am very proud of our organization and of all that we have achieved in roughly a 25-year span of time.

I would also like to offer a very special recognition of the ASA members who are no longer with us. I thank all of you who have unselfishly given your time and efforts to the advancement of the industry.

***Ted W. Sofis** recently retired as owner of Sofis Company Inc. with 47 years of experience in the shotcrete industry. He is an ACI Shotcreter Examiner and has served on the ASA Executive Board of Directors, the ASA Board, and 11 years as the Chair of ASA's Publications Committee, as well as being a member on several other committees. Ted began performing shotcrete work during summers while in college from 1971 to 1974. After graduating from Muskingum College in 1975, he began full time as a shotcreter and gun operator gunning refractory in ladles and blast furnace troughs in the steel industry. Ted has worked in the shotcrete industry performing work in the power generation and steel industries, and on bridges, tunnels, dams, spillways, slope-protection, and a variety of other installations over the years.*

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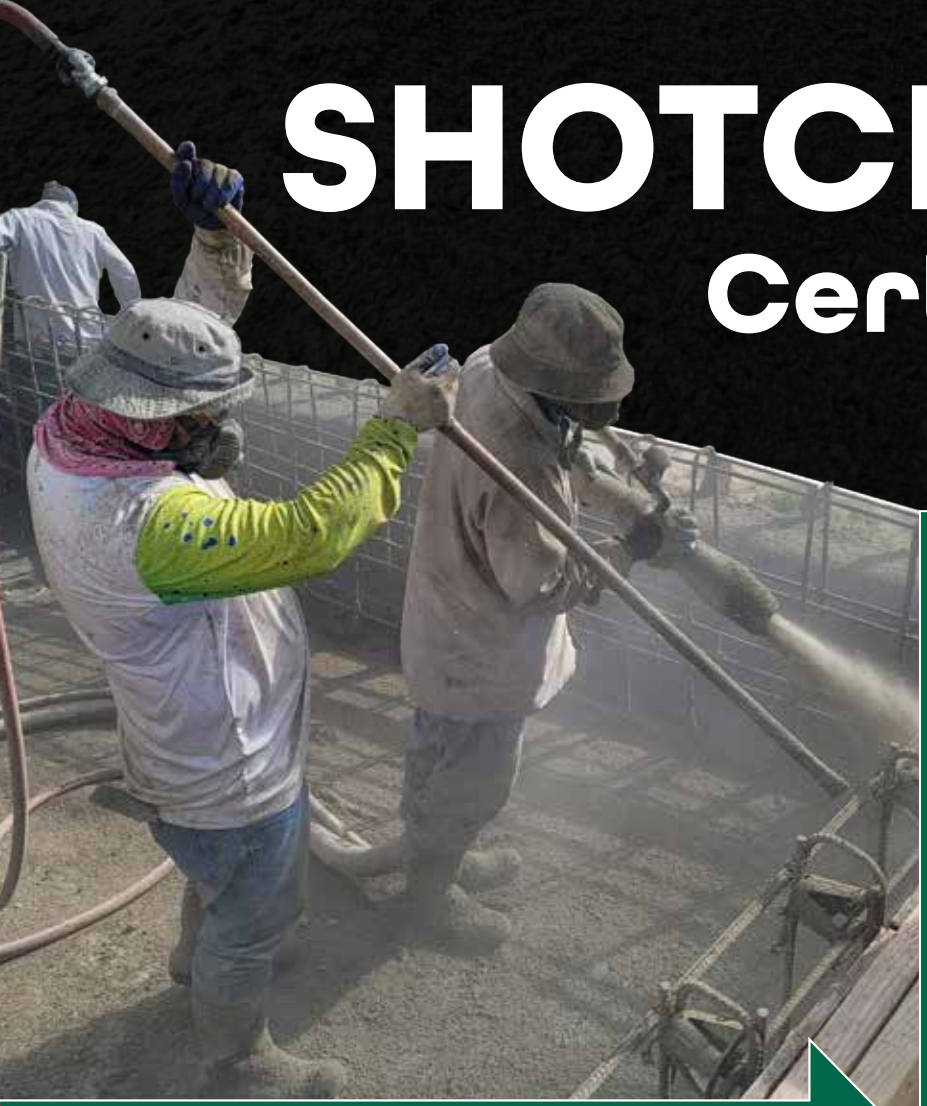

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The remotely manipulated nozzle spraying concrete along the 1-65 interstate corridor.

Geohazard Mitigation: Why Shotcrete?

By Rouse Slape

Geohazard mitigation encompasses a wide range of strategies and techniques aimed at reducing the risks and impacts of geological hazards, such as landslides, rockfalls, sinkholes, earthquakes, and soil erosion. These natural events can cause severe damage to infrastructure, property, and lives, making effective mitigation essential for ensuring safety and stability.

In regions prone to rockfalls, protective measures like rockfall nets, barriers, and drapery systems are crucial for safeguarding infrastructure by catching or deflecting falling rocks. To support unstable slopes, embankments and retaining walls, soil nail walls, Geosynthetic Confined Soil Walls (GCS®) and mechanically stabilized earth (MSE) systems are constructed to prevent soil movement. Ground improvement techniques such as compaction grouting and deep foundation systems are also employed to enhance soil stability, particularly in areas vulnerable to sinkholes or subsidence.

HOW IS SHOTCRETE USED IN GEOHAZARD MITIGATION?

In the geohazard mitigation industry, shotcrete is primarily used for slope stabilization, rockfall protection, and erosion control. By spraying concrete onto surfaces at high velocity, shotcrete creates robust earth retention systems and structural support structures, such as soil nail walls, shotcrete-faced soldier pile walls, and shotcrete-faced lagging walls.

WHAT IS THE PROCESS FOR APPLYING SHOTCRETE?

The process involves cleaning the surface, setting up reinforcement like steel reinforcing mesh and reinforcing bar, and then shotcreting the concrete mix at high velocity using a hose. The concrete is applied in layers, and it adheres to the surface, forming a strong and durable coating. One of the

most interesting properties of shotcrete is that when properly applied in layers, research by the American Shotcrete Association (ASA) and American Concrete Institute (ACI) has proven that no cold joints are formed.

WHY IS SHOTCRETE A BETTER SOLUTION THAN FORM-AND-POUR CONCRETE?

Shotcrete offers similar strength, density, and durability to form-and-pour concrete but is more versatile and economical. It can be applied to vertical or overhead surfaces and is particularly useful in hard-to-access areas. This method also reduces the need for extensive formwork and reduces the need for building access roads, saving time and resources.

WHAT ARE SOME OF THE ADVANTAGES OF USING SHOTCRETE?

Shotcrete's versatility allows it to be applied to any shape or structure, making it customizable for various projects. This is a particularly important characteristic in geohazard work where the project goals involve stabilizing soil or rock that is exhibiting sliding and toppling characteristics. It can be applied quickly to irregular excavations and rock surfaces and sets rapidly, leading to more efficient project completion.

HOW DO YOU USE SCULPTED CONCRETE?

Sculpted concrete is shaped shortly after spraying it while it is still wet and malleable. This technique is used to emulate natural rock or to create decorative textures or stained finishes in various projects. In geohazard mitigation, sculpted concrete often blends in with the surrounding geological environment, enhancing functionality and aesthetics.

WHAT ARE THE ENVIRONMENTAL BENEFITS OF SHOTCRETE?

Shotcrete offers several environmental benefits, including reduced material waste, minimized ground disturbance, long-lasting durability, and effective erosion control. It also reduces runoff and sedimentation, improving water quality. Shotcrete materials also often incorporates recycled materials, further enhancing its sustainability.

HOW HAS THE USE OR APPLICATION OF SHOTCRETE EVOLVED OVER TIME?

Shotcrete has a rich history in shaping and preserving America's infrastructure. Initially, shotcrete was a dry-mix process (originally call "gunite"), and this was true until swing-tube concrete pumps were introduced in the 1970s. Today, shotcrete can be either "wet-mix" or "dry-mix". The process selected depends on the shotcrete contractor, and project characteristics.

Shotcrete has benefited from the same advancements as the concrete industry, including the benefits of today's modern admixtures and the use of steel or synthetic fibers that help in both the application and design of shotcrete. The most recent

Before (ABOVE) and after (BELOW) images of the rockfall mitigation project, increasing safety for the traveling public.

innovation making an impact on the industry are remote manipulated shotcrete nozzles we term “shotcrete robots”. GeoStabilization International introduced the shotcrete “robots” to our fleet in 2022. These robots are not intelligent but allows our ACI-certified shotcreters to safely and efficiently spray concrete in hard-to-reach areas, improving job site safety, and application speed.

WHAT PROJECT, USING SHOTCRETE, ARE YOU MOST PROUD OF?

To improve safety and mitigate the risks of rockfall events along I-65 in Giles County, TN, GeoStabilization partnered with the Tennessee Department of Transportation and a local construction company. The team provided traffic control, erosion control, clearing and grubbing, and mechanically scaled and trimmed the overhang to prepare the area for a buttress using 3070 yd^3 (2350 m^3) of shotcrete.

The highlight of this project was seeing technological advances in action. The shotcrete robot allowed us to connect directly to the Super Nailer, limiting the amount of equipment needed on site. We were also able to create efficiencies by shifting from drilling nails to shotcrete placement all in the same day. Because the shotcrete robot is managed remotely, we were able to access hard-to-reach locations effectively and maximize productivity. As a steward of public safety, we were proud to be able to increase safety on the jobsite and for the traveling public.

Rouse Slape *is a seasoned construction professional with 25 years of industry experience, including 14 years focused on geohazard mitigation. Currently at GeoStabilization International, Rouse has held various operations positions, rising to the role of Director of Operations. He earned his MBA from MIT in 2023, complementing his extensive field expertise. Throughout his career, Rouse has managed over 1500 projects and overseen the installation of tens of thousands of yards of shotcrete, making him a leading expert in the application of this vital construction technique. GeoStabilization International has applied nearly 3,000,000 ft^2 (280,000 m^2) of shotcrete on more than 3 thousand projects across the United States and Canada to date.*

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Relieving Water Pressure on Shotcrete Lining by Integrating a Drainage Mesh

By Johnny Poulsen & Sergii Tabachnikov

Since the first shotcreting patent issued in the United States in 1911 to Carl E. Akeley, the technique and equipment have undergone substantial advancements, leading to its widespread adoption in construction practices around the world. Nowadays it is a well-proven technique for applying one or more layers of concrete onto a prepared surface, which enables use of conventional reinforcement or metallic and non-metallic fibers as structural reinforcement components.

Even with all the technical and efficiency advantages of shotcreting, a major challenge remains in constructing underground and soil retaining structures: The presence of free and capillary water in fissures of rock formations and the non-rocky soil base, which impacts the structure during construction and maintenance. Water pressure on tunnel structures, whether shotcreted or cast-in-place, is a leading design challenge that often requires creative solutions to mitigate water flow and potential damage.

WATER PRESSURE ISSUES

Water seeping through cracks in the rock can hinder the effective application of the initial layer.

The creation of voids in rock masses or saturated soil during tunnel construction can prevent the drainage of water, leading to increased hydrostatic pressure on portions of the tunnel lining. Hydrostatic pressure can force water through cracks or defects in concrete, causing dripping onto trains, vehicles, and tunnel components below (Fig. 1a). Dripping onto roads can pose a risk to traffic — especially with the formation of ice on the road or icicles falling from the ceiling (Fig. 1b) — and water saturating the concrete can create damage from frequent freeze/thaw cycles.

In the worst case, excessive water pressure, when combined with inadequate design or poor quality construction, can lead to the collapse of the underground structures during construction or operation (Fig. 2).

Repairs and maintenance of damaged tunnel structures are complicated, expensive, and carry socio-economic costs. Closing the tunnel, locating all areas of damage, and fully repairing the tunnel with today's solutions can take substantial time. The repair work may require multiple steps, including additional shotcrete layers, new anchors, and grout injection

Fig. 1: Some of examples of water pressure effects: a) Leaking tunnel in waterproofing process (ABOVE); b) Icicles causing damage to a concrete structure (BELOW) (photo: Washington State Dept. of Transportation).

Fig. 2: Collapsed tunnel

work under difficult working conditions. With planning and design efforts to systematically drain the external water pressure against the structure, repairs can be accomplished safely and within a much shorter time frame.

NEW APPLICABLE CONCEPT FOR MANAGING WATER IN UNDERGROUND CONSTRUCTION

One of the key technical conditions for applying shotcrete in underground retaining structures is the absence of water seepage at the receiving surface. If flowing water is likely to form at the receiving surface, measures must be taken to divert it away to allow for the planned shotcrete placement. Creating a drainage path is a method that can help provide drainage away from the receiving surface.

Because a tunnel lining, as with most underground structures, is often exposed to ground water pressure and requires some form of ground water management, an integrated drain mesh solution (IDMS) behind the tunnel lining of a shotcrete layer or sprayed membrane can safely and efficiently reduce water buildup.

Dolenco Drain (Fig. 3) is a patented network drainage module for tunnels that prevents the accumulation of water and the resulting hydrostatic pressure behind structural tunnel walls. It measures 32 x 48 x 0.6 in. (800 x 1200 x 14 mm) and can drain 2100 gal (8000 l) of water per 3 ft (0.9 m) of wall width per hour. The modules are made from low-density or high-density polyethylene (LDPE/HDPE), which are 100% recyclable and CO_2-neutral. The system also has additional benefits including easy installation, a long design life, and lower maintenance. The life expectancy of the system in normal conditions is estimated at up to 120 years. Dolenco Drain is currently made with 100% recyclable material and we are working on further improvements with a focus on saving the earth's resources. Not only in product development, but also in supporting the reduced need for construction materials and construction time, via design optimization and maintenance/repair reduction.

The network drain module is embedded in concrete, so the

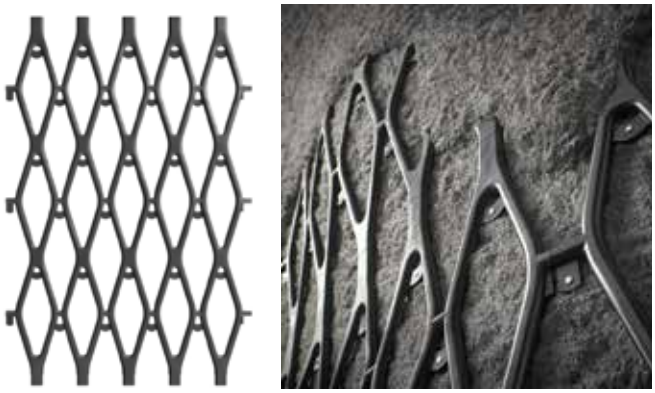

Fig. 3: View of Dolenco Drain network drainage module

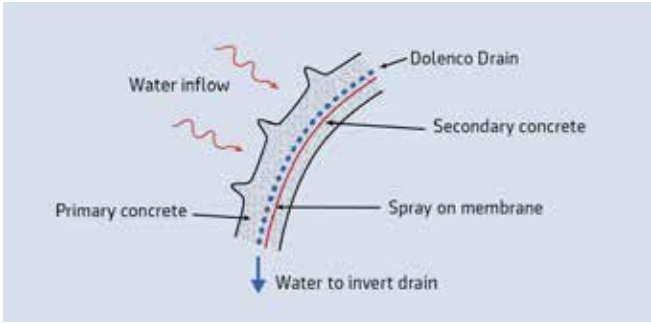

Fig. 4a: Application of Dolenco Drain: Basic approach of Dolenco Drain for preventing the build-up of water and resultant pressure in the concrete sections.

Fig. 4b: Application of Dolenco Drain: Cross section of shotcreted sample showing a network of channels that lead water away, alleviating pressure.

lining remains monolithic, creating a thinner concrete section with a network of embedded drain channels (Figs. 4a, 4b).

The installed modules connect and overlap one another with a simple anchoring system nailed to the surface (Fig. 5) to fully cover all surfaces. Then, an initial layer of shotcrete protects it before another layer of reinforced shotcrete is applied for structural integrity. The final structural thickness may be fiber or conventionally reinforced.

Fig. 5: Installing Dolenco Drain to tunnel crown and next covering with another layer of shotcrete.

As installation does not need drilled anchors, it reduces the initial and life cycle cost (LCC), extends the life span, and in the event of physical damage, allows quick and safe repair with minimal downtime in the tunnel. This solution can also reduce fire damage potential giving water vapor a channel to exit rather than spalling the concrete.

CURRENT CONSTRUCTION METHODS, THEIR CHALLENGES, AND THE TECHNICAL AND ECONOMICAL ADVANTAGES OF AN IDMS

To manage water in tunnels, the solutions available today are complicated, costly, time-consuming, and can cause significant disturbances to traffic. We can clearly use additional options.

Let's review some of today's solutions with their respective challenges. Several key technical solutions to the challenges related to accommodations for water and the required drainage can be identified. Then we will explore how these solutions might be optimized by combining them with an IDMS.

The appropriate design method for temporary or permanent shotcrete linings depends on the structural role the shotcrete is fulfilling. Table 1 summarizes common construction methods and how implementation of an IDMS is applicable. The design thicknesses of shotcrete are impacted not only by external water pressure, but also by soil or rock loads, overburden, or other external loadings. The values in Table 1 are provided as a comparison, but design thicknesses must be determined by the design engineer with the site-specific loadings and requirements.

Whether for new projects or the repair and renovation

Construction methods	Application area	Challenges	Constructing with IDMS	Technical and economical advantages of IDMS
Solution 1a - Shotcrete only It is a widely used technique in tunnel construction for stabilizing and reinforcing the exposed soil or rock surface after excavation.	**Tunnels:** • Blasting • Boring • Digging **Construction approach:** • Pre-injection grout; • Stabilizing shotcrete layer ≈1 in. (25 mm); • Final shotcrete layer ≈3 to 4 in. (75 to 100 mm).	• Higher risk of water pressure damaging the structure; • Water pressure can build up over time; • Absence of possibility of water pressure reducing.	• Pre-injection grout; • Stabilizing shotcrete layer ≈1 in. (25 mm); • Application of IDMS • Covering IDMS with shotcrete up to ≈1 in. (25 mm); • Final shotcrete layer ≈3 to 4 in. (75 to 100 mm).	• Drains the water away from the structure without damage to the concrete; • Prevents water pressure buildup on the structure; • Reduces risk of medium to long-term deterioration, damage, and repair related to water pressure.
Solution 1b - Shotcrete with sprayed waterproofing membrane This technique involves a process of tunnel excavation and support, where shotcrete is applied in two stages along with the installation of a sprayed waterproofing membrane to prevent water ingress.	**Tunnels:** • Blasting • Boring • Digging **Construction approach:** • Pre-injection grout; • Stabilizing shotcrete layer ≈1 in. (25 mm); • Covering initial layer with a waterproofing membrane; • Final shotcrete layer ≈3 to 4 in. (75 to 100 mm).	• Waterproofing membrane doesn't ensure water pressure can't build up over time creating a higher risk of water pressure damaging the structure.	• Pre-injection grout; • Stabilizing shotcrete layer ≈1 in. (25 mm); • Application of IDMS • Covering IDMS with shotcrete up to ≈1 in. (25 mm); • Spraying waterproofing membrane; • Final shotcrete layer ≈3 to 4 in. (75 to 100 mm).	• Drains the water away from the structure without damaging the concrete; • Prevents water pressure buildup on the structure; • Reduces risk of medium to long-term deterioration, damage, and repair related to water pressure.
Solution 2 - Shotcrete with sheet waterproofing membrane This technique uses a similar approach to Solution 1b but with differences in the type of waterproofing membrane. A thicker layer of shotcrete is applied over the membrane. This final layer is usually reinforced for added structural integrity.	**Tunnels:** • Blasting • Boring • Digging **Construction approach:** • Pre-injection grouting; • Anchors installed • Stabilizing shotcrete layer ≈1 in. (25 mm); • Fastening waterproofing membrane sheets to initial layer surface with; • Final shotcrete layer ≈3 to 12 in. (75 to 300 mm).	• Sheet often made of flammable material that can cause spalling and scaling damage from fire; • Waterproofing membrane doesn't ensure water pressure can't build up over time making higher risk of water pressure damaging the structure.	• Pre-injection grout; • Stabilizing shotcrete layer ≈1 in. (25 mm); • Application of IDMS; • Covering IDMS with shotcrete up to ≈1 in. (25 mm); • Fastening to initial layer surface with waterproofing membrane sheets (if required to minimize the risk of damages to the structure); • Final shotcrete layer ≈3 to 4 in. (75 to 300 mm).	• Drains the water away from the structure without damage to the concrete; • Prevents water pressure build-up on the structure; • Reduces risk of medium to long-term deterioration, damage, and repair related to water pressure; • Possible reduction in the total volume of concrete due to a reduction in the thickness of the final layer and; • Construction time reduction.

Table 1: Construction methods and how implementation of an IDMS is applicable. *Continued next page.*

Construction methods	Application area	Challenges	Constructing with IDMS	Technical and economical advantages of IDMS
Solution 3 - Shotcrete only for temporary water protection This technique focuses on managing groundwater ingress that occurs unexpectedly during tunnel boring machine (TBM) operations. To manage this, shotcrete is used as an immediate solution to reduce water flow and create safer working conditions.	**Tunnels:** • With a tunnel boring machine (TBM). **Construction approach:** • Pre-injection grout; • Temporary stabilizing and water protection shotcrete layer ≈1 in. (25 mm).	• Water pressure can build up over time creating a higher risk of water pressure damaging the temporary shotcrete layer; • Challenging underground working conditions; • Difficult or impossible to manage the water seeping and flowing into the tunnel during construction.	• Pre-injection grout; • Nailing of IDMS directly onto the rock; • Covering IDMS and stabilizing shotcrete layer ≈1 in. (25 mm).	• Drains the water away from the rock; • Prevents water pressure build-up on the shotcrete layer; • Allows construction work to continue.
Solution 4 - Shotcrete for sealing the gaps between the secant piles Shotcrete is often used to seal gaps between the secant piles, adding an additional layer of water resistance. However, while shotcrete is functionally watertight, this technique doesn't allow for the dissipation of groundwater pressure behind the piles and shotcrete, which can lead to problems.	**Underground stations:** • Secant piling for shafts; • Retaining walls for stations. **Construction approach:** • Pre-injection grout; • Filling the surface and water protection shotcrete layer up to 12 in. (300 mm) in gap.	• Surface preparation on the piles may be poor; • Water pressure can build up over time making a higher risk of water pressure damaging the temporary shotcrete layer; • Challenging soil support working conditions; • Difficult or impossible to manage the water seeping and flowing into underground space during construction; • Requires some type of difficult, time-consuming, technically challenging and costly injection.	**Variant 1:** • Pre-injection grout; • Nailing of IDMS directly onto the piled wall; • Final shotcrete layer ≈2 to 3 in. (50 to 75 mm). **Variant 2:** • Pre-injection grout; • Leveling the surface shotcrete layer up to 12 in. (300 mm) in gap; • Nailing of IDMS; • Final shotcrete layer ≈2 to 3 in. (50 to 75 mm).	• Drains the water away from the pile wall; • Prevents water pressure build-up on the shotcrete layer; • Allows construction work to be continued.

Table 1 Continued: Construction methods and how implementation of an IDMS is applicable.

of existing structures, Dolenco Drain is an innovative and versatile IDMS solution specifically designed for drainage of water in underground construction. Its effectiveness stems from its adaptability to various construction methods, particularly in shotcrete placement for linings commonly used for stabilizing underground surfaces.

PROJECT EXAMPLES USING DOLENCO DRAIN

SOLUTION 1A

Built in 1968, the Tuscarora Mountain Tunnel is one of the key highway tunnels located on the Pennsylvania Turnpike in the United States. It is part of the infrastructure that allows vehicles to traverse through the Tuscarora Mountain, a part of the Appalachian Mountain Range, and is a significant engineering achievement due to the mountainous terrain it penetrates.

During refurbishment, water ingress challenged the repair method for a permanent, sustainable solution. Removing the outer layer of concrete and mounting Dolenco Drain before finishing with shotcrete made the repair possible and sustainable (Fig. 6a).

A similar solution was used to renovate a road tunnel in Switzerland. The problem was water seeping through the existing shotcrete layer. After removing a layer of shotcrete, a new layer of shotcrete was applied. The thin structure severely limited what could be done to address the leaking water, the solution was to mount Dolenco Drain onto the surface and

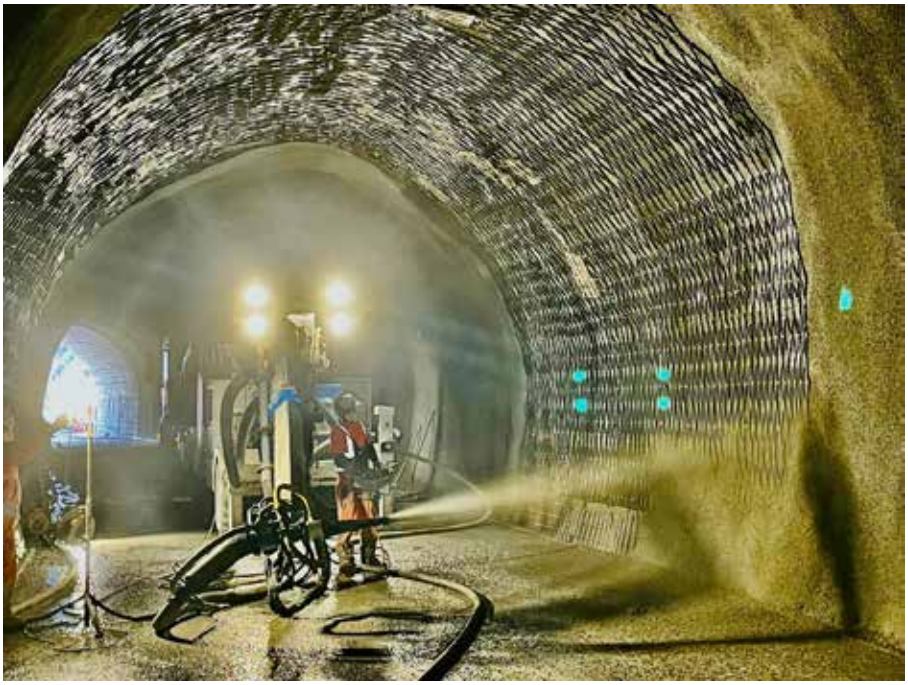

Fig. 6: Solution 1a application: a - LEFT) Dolenco Drain is covering the entire surface of the repaired area and secures permanently against water pressure (Tuscarora Mountain Tunnel); b - ABOVE) Renovating seeping road tunnel (La Tzoumaz, Switzerland)

cover with a thin layer of shotcrete (Fig. 6b). At the bottom of the wall, a detail for collecting the draining water was added.

SOLUTION 1B

The Réseau Express Métropolitain is an electric and fully-automated light-rail transit network designed to facilitate mobility across the Greater Montreal Region, Canada. It is the largest public transit project undertaken in Québec in the last 50 years. With an overall length of 42 miles (67 km) and 26 stations, it connects with the Montreal metro with initial excavation started in 2021. The original design with a spray membrane incountered problems with water ingress. Dolenco Drain was installed to control the water behind the shotcrete smoothening layer (Fig. 7a). This prevented water pressure buildup on the shotcrete and resultant leakage, thus facilitating the application of the spray-on membrane. The design required: 12 in. (300 mm) of shotcrete (for safety) placed directly onto rock, installation of the Dolenco Drain, then a 1 to 2 in. (25-50 mm) smoothening layer, sprayed membrane, and finally 5 in. (125 mm) of reinforced shotcrete on each umbrella section.

Also, depending on specific field conditions, project requirements, and designer decisions, it is possible to use Dolenco Drain in combination with sprayed membrane, as was the case during the Canfranc, Spain railway tunnel repair (Fig. 7b).

Fig. 7: Solution 1b application: a - ABOVE) Dolenco Drain was used to control the water by installing behind the shotcrete smoothening layer (Réseau Express Métropolitain); b - BELOW) Repair of railway tunnel (Canfranc, Spain).

SOLUTION 3

Dolenco Drain was used at a project in Toronto, Canada, where the drainage system was installed directly onto the rock surface. Afterward, a steel wire reinforcement net was mounted, followed by the application of a stabilizing shotcrete layer (Fig. 8).

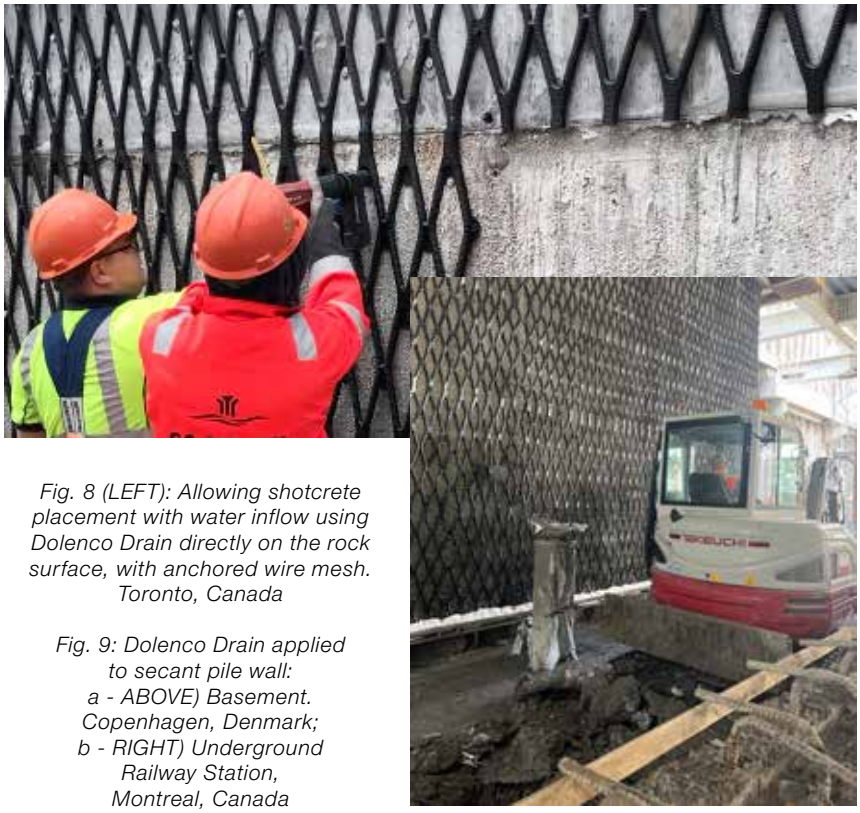

Fig. 8 (LEFT): Allowing shotcrete placement with water inflow using Dolenco Drain directly on the rock surface, with anchored wire mesh. Toronto, Canada

Fig. 9: Dolenco Drain applied to secant pile wall: a - ABOVE) Basement. Copenhagen, Denmark; b - RIGHT) Underground Railway Station, Montreal, Canada

SOLUTION 4

A project in Copenhagen, Denmark (Fig. 9a) and the Réseau Express Métropolitain Railway Station 40 ft (12 m) underground (Fig. 9b) in Montreal, Canada, both used Solution 4.

Work on the station started in 2020. To address seeping water and water pressure behind the secant pile walls of the station and ramp, the design included Dolenco Drain between the secant piles and the final shotcrete layer. To permanently prevent pressure on the shotcrete and to ease the application of the spray membrane, Dolenco Drain was mounted behind the sprayed membrane.

TECHNICAL, ECONOMIC, AND ENVIRONMENTAL ADVANTAGES

Preventing or minimizing post-construction injections and repairs, Dolenco Drain is a quick, simple, safe, and permanent solution. It prevents pressure and leaking, keeping the tunnels dry. Once installed, the Dolenco Drain improves the tunnel durability with an estimated lifespan of 120 years.

Used for both new and existing structures, the thin and monolithic design of Dolenco Drain can be installed with little space required. The solution requires minimal downtime of the tunnel and is a quick and safe repair of concrete after physical damage.

Comparing a Dolenco Drain solution with conventional drainage systems is complicated, because it is not a direct substitute for the solutions available today. It is often used to complement existing solutions, because it improves the overall tunnel design. However, a comparison has shown significant reduction in repair and maintenance, which saves on time and cost. Using an IMDS to prevent water ingress facilitates surface preparation before applying the first layer of shotcrete and the membrane or second layer.

Summarizing the overall comparison for tunnels, the use of IMDS leads to savings in construction cost and time savings to the scheduled repair. With design changes recognizing control or elimination of external water pressure, reduced concrete thicknesses may be needed, resulting in a significant reduction in the carbon footprint of the tunnel construction.

If we consider cases where the installation of anchors is necessary (incurring possible problems with membrane damage during installation, subsequent expenditure of time and effort to eliminate the problems, subsequent maintenance of the finished structure, and care for the final layer of shotcrete), then the difference becomes even greater and the advantages more pronounced.

CONCLUSIONS

Finding a solution to alleviate water pressure and subsequent through section leakage is important. Today's solutions can be complicated, costly, and exhibit limited success in channeling water away from the exterior of the tunnel. Most common damage in tunnels includes water inflow, accumulation of water, and cracking and spalling of the surface. The solutions available today do not address all the challenges of removing water pushed into and through cracks in the concrete by the accumulated water pressure.

Dolenco Drain provides a solution that is tailored to the specific project. It is suitable for both new and existing structures, and the thin and monolithic design can be installed

with little available space — even on wet and seeping structures. Once installed, Dolenco Drain improves the tunnel serviceability and durability. The solution requires minimal downtime when repairing tunnels and provides a quick and safe repair of a tunnel after physical damage.

Underground construction, especially a tunnel, is one of the most complex challenges in the field of civil engineering. Dolenco Drain is an innovative solution which addresses many of the difficulties with controlling or eliminating water pressure in an easy, safe, long-term, and cost-effective manner.

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Early Age Strength Testing for Shotcrete: 2024

By Christoph Goss, Norbert Fuegenschuh, Lauro Lacerda, Kevin Robertson, and Shaun Radomski

Knowing the early strength of shotcrete has always been an important part of tunneling and underground mining. Unlike in other fields, personnel need to work under freshly placed overhead shotcrete to continue advancing the tunnel or drift. This typically requires the use of a rapid-set accelerator. A recent development in the industry is the use of ASTM C495 Type 1L cement to replace the well-proven ASTM C150 Type I/II cements which has led to more variability in accelerator dosing and thereby time to achieve a given strength. This requires us, as an industry, to take a fresh look at early age strength testing methods.

RE-ENTRY

Re-entry criteria vary and consist of both time and strength requirements. To minimize downtime, the goal is as low as possible but as high as necessary. NIOSH 2015 provides a summary table:

Region	Early Strengh, MPa (psi)	Re-entry time, hr
United States*	0.5–3.0 (75–435)	2–6
Canada	1.6–2.0 (232–300)	2
Austria	0.8–1.6 (116–232)	2–6
Australia	0.5–3.0 (75–435)	1-6

**1 MPa (145 psi [1 MPa]) has become more common*

Initial set begins in 5 to 60 minutes, depending on the accelerator; but no matter what the set time is, crews should wait at least 30 minutes before re-entry. This reduces the chance of shotcrete debonding from the ground and falling under its own weight — i.e. pancaking (Rispin 2005).

Since they concern both safety and construction means and methods, re-entry protocols should be determined by the tunnel or mining contractor based on the underground span, ground conditions, temperature, shotcrete thickness, and accelerator use. In support of this, the contractor should have on staff or hire a qualified shotcrete consultant and inspector to develop the concrete mixture design, work methodology, and calibration of the delivery system, including pumping stroke rate and accelerator dosage to shoot overhead without fallout or over-dosage.

Trials and testing should be conducted to validate the work methodology. The testing should be done before the start of construction for each proposed shotcrete mixture and range of accelerator dosing. Where Type 1L cement is used, the testing should include various mixtures with an expected range of powdered limestone and the proportional accelerator dosages. If the mixtures change during construction, a new set of tests should be conducted. Confirmatory tests should be conducted at various times throughout the project, especially if issues are encountered.

EARLY AGE SHOTCRETE

Early age typically refers to shotcrete that is less than 24 hours old and where standard compressive strength panels cannot be effectively cored, typically before 10 MPa (1450 psi). Once cores can be obtained, standard UCS testing on shot panels is the preferred approach. The early strength testing methods have been discussed in previous papers including Bernard 2005, Rispin 2005, Bernard & Geltinger 2007, Morgan, McAskill & Heere 1999, and Clements 2009. These papers provide more background and include lab and field testing that compare the methods more rigorously. The methods include:

- Soil Penetrometer
- Needle Penetrometer
- Hilti Gun (new & old)
- Schmidt Hammer (not recommended)
- Beam End Tester

ACI 506.5-22 Guide for Specifying Underground Shotcrete lists the needle penetrometer, stud driving, and beam end testing, but makes no recommendation for which method(s) to use. One of the goals for this paper is to review these methods, see if and how much they are currently being used in North America, and identify new technologies. Based on meetings with the American Shotcrete Association (ASA) Underground Committee, Underground Construction Association (UCA) Working Group 12, and other informal

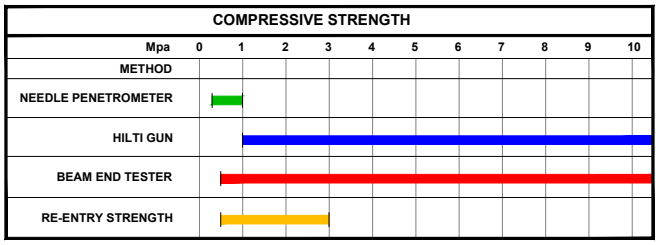

Chart 1

discussions that the authors have had at job sites and conferences, the same methods are still being used but no new methods have been employed on a large scale. Chart 1 provides a graphic summary of the most applicable methods with their effective ranges up to the point where standard cores can be taken.

Note that for all the early strength testing, panels and beams must be kept in the same environment as actual placement for the results to be valid. Note also that this paper only addresses standard cementitious shotcrete.

SOIL PENETROMETER

There are many types of soil penetration needles and, as the name implies, they are generally used to evaluate soil compressive strength. They are made with one smaller sliding cylinder and a spring inside another larger cylinder. A 6 mm (0.25 in.) diameter solid steel plunger is attached to the end of the small cylinder which also has a reading gauge and sliding red ring. The operator pushes the plunger into the fresh shotcrete 25 mm (1.0 in.) and a reading is taken. The process is repeated 12 times (at random surface locations). Then, the high and low readings are discarded, and the average of the remaining 10 readings calculated. Their range of application is around 0.7 MPa (100 psi) to 4.8 MPa (700 psi).

The main advantages of the soil penetrometers are that they are very compact, inexpensive, give direct strength readings, and are easy to use. The main disadvantage is they are not very accurate because the large needle diameter can encounter aggregate and fiber and give high results. Given this combination of the advantages and disadvantages, soil penetrometers should be used to evaluate if shotcrete is gaining strength and setting, but more accurate methods should be used to obtain more representative compressive strength values.

ABOVE: Soil penetrometer top (smaller) Needle penetrometer bottom (larger)

NEEDLE PENETROMETER

The Meynadier needle penetrometer or Meyco© Penetration Needle reads a resistance to a force that can be correlated to compressive strength (psi or kPa). It corresponds to ASTM C1117-94 (Standard Test Method for Time of Setting of Shotcrete Mixtures by Penetration Resistance) which was withdrawn in 2003 but is still considered valid. The device is an all-steel 700 mm (27 in.) device with a needle on one side and 200 mm (8 in.) long T-handle on the other end. The needle is very thin with a 2.5 mm (0.1 in.) diameter which is fixed to a cylinder by a screw. The cylinder houses the spring. The other end is a T-handle which is marked and contains a floating ring. The floating ring marks the force needed to push the needle about 15 mm (0.6 in.) into the shotcrete at a constant rate. As with the soil penetrometer, 12 readings are taken, the high and low readings are discarded, and the remaining 10 readings are averaged. If the needle goes into shotcrete without moving the floating ring, that reading is recorded as zero. From the average readings on the rod (12 to 67) there is a table that converts the applied force reading to pressure. In general, penetration needles are more accurate and require less applied force than soil penetrometers.

RIGHT: Close up of needle penetrometer (left) soil penetrometer (right)

Shooting Hilti Gun stud into a panel

Their range of application is from 0.3 MPa (45 psi) to about 1 MPa. Their main advantages are that they are compact, inexpensive, and easy to use. Their main disadvantages are that they require replacement of worn-out needles (that are currently only available in Europe) and the readings must be converted to compressive strength using a calibration chart. Given their relatively accurate readings at low strength, the needle penetrometer is a useful tool for evaluating strength for re-entry, if the re-entry standard is 1 MPa . If the re-entry requirement is a strength greater than that, the needle penetrometer method should be followed up or replaced by the Hilti Gun or Beam End Testing described below.

A related beneficial use of the Needle Penetrometer method is for routine checking of the initial and final set times to confirm that the accelerator dosing rate is correct. This can quickly alert the field team to problems with the accelerator pump, hose, or valve. Initial set is when a needle of 1/10 in^2 bearing surface achieves a resistance of 3.4 MPa (500 psi), or a reading of 22.7 kg (50 lb) shown by the floating ring. Final set is when a needle with 0.025 in^2 bearing surface achieves a resistance of 28 MPa (4000 psi), or a reading of 45.4 kg (100 lb) shown by the floating ring.

Shooting into an end beam form. Photo credit PCiRoads, LLC.

HILTI GUN

The Hilti Gun stud driving method (also called the bolt-setting method) is used for early strength ranging between 1 and 16 MPa (2300 psi) which positions the method in between compressive strength measurements using the needle penetrometer and testing of drilled cores.

This "classic" stud (nail) driving method, which has been used almost exclusively for approximately 30 years (and which is still widely used around the world) consists of a stud gun that shoots studs into freshly sprayed shotcrete. The depth of penetration of the stud is measured. Subsequently the studs are pulled out from the concrete while measuring the pull-out force. The ratio of pull-out force to penetration depth is the parameter used to determine the compressive strength. It is important to use the correct equipment since the powder-actuated tool needs to drive the studs with a defined energy for at least 20 mm (0.8 in.) into the shotcrete. The method was developed and calibrated by Hilti and contacting the manufacturer will result in the right combination of stud gun (DX 450-SCT), studs (there are 3 different lengths available – the younger the shotcrete, the longer the nail needs to be), powder-actuating cartridge, and pullout force tester.

Further development of this method by Hilti led to the Hilti BX 3-SCT system, which uses a battery actuated fastening tool. Therefore, no powder cartridges are required anymore. Another advantage of this upgraded method is that measuring of the pull-out force is no longer required. The method can be used from a concrete strength upwards of 1 MPa. A calibration curve was empirically evaluated based on experimental investigations performed by Professors Charlotte Thiel and Wolfgang Kusterle at the Regensburg University of Applied Sciences in Germany.

After release of the BX 3-SCT system, Hilti stopped selling the DX 450-SCT tools — however maintenance of existing tools is still provided, and studs and cartridges are still available. The simplicity of the methods described makes them widely used all over Europe and also in North

America. However, based on the author's own experience on several North American tunnel sites, many manufacturer representatives in North America are not really familiar with the system due to the fact that shotcrete projects where early strength measurements need to be performed are relatively rare. Initial difficulties in this regard are usually quickly overcome as soon as European counterparts are contacted.

The products are imported from Europe, leading to extended lead times, which must be taken into account when developing a test program at the beginning of a project. On top of that, local and site-specific safety precautions and regulations need to be considered. Some countries, and states in the US, require special safety classes (provided by the manufacturer) to be passed by the group of people operating the stud guns. The test measurements are usually performed either by one of the site engineers or the superintendent in charge.

A quick survey performed in May 2024 — including three construction sites in Austria, England and in the US (New York, NY) — confirmed that both stud driving methods are used. The site in Austria works with existing older DX 450-SCT equipment in combination with pull out force testing. The site in England opted for the new battery actuated system since black powder was not permitted on site. The site in New York bought new BX 3-SCT equipment at the start of the shotcrete placements.

Both stud driving methods are easy to use and provide quick results, which makes them front row candidates for use on all shotcrete sites where early strength development is of importance.

SCHMIDT HAMMER

A Schmidt Hammer, Type L is sometimes used to test shotcrete between 10 to 62 MPa (1450 and 9000 psi) but requires a minimum thickness of 100 mm (4 in.) or more to be used. Given that at this range actual cores can be taken which provide much more accurate results, the Schmidt Hammer should not be used for definite strength results; it is appropriate only for approximations or to identify problem areas.

BEAM END TESTER

Unlike the previous methods, the beam end tester directly measures compressive strength. It is a modified version of ASTM C116 (Test Method for Compressive Strength of Concrete Using Portions of Beams Broken in Flexure) which was withdrawn in 1999 but is still considered valid. In this method, beams are made by shooting shotcrete into forms 75 x 75 x 400 mm (3 x 3 x 16 in.). After the shotcrete reaches at least 0.5 MPa (73 psi), the beams are removed from the mold and then placed into a testing frame with 25 to 50 mm (1 to 2 in.) of beam sticking out past the 75 x 75 mm platens. Compressive strength is determined by applying stress to the beam using a hydraulic pump on the ram until the shotcrete fails. A gage indicates the hydraulic pressure during the test and records the maximum value. Calibration of the apparatus allows for conversion of hydraulic pressure recorded, into stress applied to the shotcrete. Depending on the size of the ram, the effective testing range is 0.5 MPa (73 psi) to 5, 8, or 13.7 MPa (725, 1160, or 2000 psi).

The main advantage of this method is obtaining direct compressive strength which requires no calibration and results in less variability between tests. The main disadvantage is that beams can be difficult to remove from molds, particularly in cold environments though form oil can help.

The Sika/King Shotcrete End-Beam Tester is a commercially available product that uses a steel frame and hand pumped hydraulic jack. In addition, the Office of Mining Safety and Health Research at the National Institute for Occupational Safety and Health (NIOSH) developed a beam end tester that is portable and programmable-logic-controller (PLC) controlled. The PLC control loads the beam at the ASTM loading rate and stops when the required displacement is reached. The NIOSH

End beam sample removed from form ready for testing

system also uses smaller 100 x 100 x 150 mm (4 x 4 x 6 in.) partial beam molds, in accordance with ASTM C116.

CONCLUSION

For improved safety in tunneling and mining projects that use shotcrete for ground support, early shotcrete strength should be evaluated by testing. Based on their range of effectiveness, two procedures stand out: The new Hilti BX 3-SCT stud driving method and the beam end tester. The Hilti system is indirect but fast and can be used on existing panels or directly on thick shotcrete. The beam end testing provides direct compressive strength results but requires special beam panels and more time and effort to produce the test samples and then test. The Hilti system appears to be more popular in Europe while the beam end tester seems to be more common in North America. Both systems should be considered by the shotcrete contractor, and should certainly replace any method of "winging it".

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Lauro Lacerda *holds B.Sc. and M.Sc. degrees in mining engineering with specialization in rock mechanics. He is a Professional Engineer licensed in Nevada. He is Business Development & Key Account with SNF Holdings, a water science company involved in heavy Civil Engineering construction (tunneling and deep foundation). He started using dry-mix shotcrete in underground projects in 1986 and has vast experience in tunnel/mine project engineering including concrete/shotcrete infrastructure design and application. Mr. Lacerda has collaborated on several articles & position papers for ASA and was awarded the Carl Akeley Award in 2007 for the article "Watertight Permanent Shotcrete Lining in Tunneling and Underground Construction.*

Kevin Robertson *is the National Sales Manager, STM – Shotcrete, Tunneling & Mining for Sika Corporation. His area of expertise include shotcrete materials, application and equipment for all shotcrete applications. Robertson is a member of American Concrete Institute (ACI), Underground Construction Association (UCA of SME), and previously served on the Board of Directors for the International Concrete Repair Institute (ICRI) as the Region 4 Representative, and past member of the of ICRI Committee 320, Concrete Repair Materials and Methods. Kevin currently serves on the Executive Committee as treasurer for ASA and is a member of the Underground, Membership and Marketing Committees.*

Norbert Fuegenschuh *holds a masters degree in Civil Engineering, University of Technology in Graz, Austria (1989). He started working for BEMO Tunnelling in Innsbruck, Austria in February of 1990, is still employed by BEMO and gathered 34+ years of experience in SEM/ NATM tunneling. After work in the estimation department he started his on-site career filling different positions on construction sites in Germany, among others on the subway system in Munich, two SEM high speed railway tunnels between Frankfurt and Cologne and the Egge-Tunnel near Kassel in the North of Germany. In 2001 he became the Tunnel Manager on the Russia Wharf Tunnel in Boston, MA (MBTA Silverline subway between South Station and World Trade Center) and spent the time between 2004 and 2011 in Sweden as BeMo`s Area Manager for Scandinavia. Major projects there were Tunnel Troeingeberg, a 1,100 m long high speed railway tunnel in Falkenberg, Sweden and an 8,000 m long sewer tunnel from Lerum to Partille, Sweden – both are drill and blast tunnels with extensive hard rock pre-grouting. After his move back to the US in 2011 he started working as BEMO`s Area Manager North America and got involved in several high-ranking SEM projects, among others:*

- *MUNI China Town Station, Central Subway San Francisco Quikspray*
- *Cross over cavern on Regional Connector, Metro Los Angeles*
- *Quarters LRT Tunnel in Edmonton, Alberta*
- *John Hart Hydro Power Station in Campbell River, Vancouver Island, BC*
- *Plymouth Tunnel as part of the Purple Line in Silver Spring, Maryland (excavation and shotcrete final lining)*
- *Cross Passages on Purple Line extension Westside 1, Metro Los Angeles*
- *Frozen Ground Adits at 4th Street and Florida Avenue on the North East Boundary CSO Tunnel in Washington, D.C.*
- *McGill South Tunnel rehabilitation, REM in Montréal, Quebec (excavation and shotcrete final lining)*
- *Grand Central/ 42nd Street passageway circulation improvement Tunnel in New York City (excavation and shotcrete final lining)*

It is the goal of the ASA Underground Committee to issue this paper as it's fifth Position Statement, contributing to our growing library of best practice resources for shotcrete placement. Towards that end, the Underground Committee welcomes any feedback or comment on the content of this article, for consideration in the final Position Statement. Please send your comments, feedback, or questions to **Info@shotcrete.org** by January 31, 2025 for review prior to our Spring Committee Meetings in Savannah, GA, next March. Thank you!

Brayman Construction Corporation: Innovative Solutions Since 1947

Established in 1947, Brayman Construction Corporation has evolved from a small family business into a nationally recognized leader in heavy civil and geotechnical contracting. The company specializes in complex projects such as large-scale bridges, deep foundations, dams, and marine construction, serving a diverse clientele in both the public and private sectors.

We leverage the capabilities of shotcrete technology to deliver specialized repair and protection solutions for a variety of slope stabilization challenges. With expertise in slope stabilization and support of excavation (SOE) techniques for earth retention, we use shotcrete's versatility and strength to deliver reliable solutions for challenging geotechnical conditions. Our approach ensures durability and efficiency, even in the most demanding environments. Our ACI-certified shotcreters are dedicated to quality, safety, and innovation that positions us as the go-to contractor for projects that require the precision and resilience of shotcrete.

REINFORCEMENT FOR DAM REHABILITATION WORK:

At the Bluestone Dam project in Hinton, WV, we used a soil nail wall reinforced with shotcrete to stabilize a critical slope, providing essential support before the installation of the anchors required for dam repairs. This solution involved drilling and installing soil nails and shotcrete for the retaining structure. The combined use of soil nailing and shotcrete ensured the slope's stability throughout the project, allowing for safe and efficient completion of the necessary dam repairs.

The North Fork Spillway Improvements Soil Nail Wall project in Ashville, NC, involved complex geotechnical solutions to stabilize the spillway and ensure its long-term functionality. This project required reinforcing steep slopes and controlling erosion, making the application of soil nailing and shotcrete essential to maintaining structural integrity. We used pressure grouting to install permanent tiebacks, achieving pressures of up to 140 psi (1.0 MPa) for maximum stability. To improve efficiency,

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CONSOL Coal Refuse Disposal Area 7 Project
Greene County, PA

Bluestone Dam - Hinton, WV

North Fork Spillway Improvements - Ashville, NC

we applied shotcrete to form 21 custom anchor blocks in place, instead of relying on standard precast blocks. This approach allowed for more streamlined block placement and faster tieback testing, significantly enhancing the overall project timeline and performance.

STRENGTHENING INFRASTRUCTURE:

To accommodate the expansion of the third lane of the Pennsylvania Turnpike from mile post (MP) 43.56 to MP 47.07, nearly 50,000 ft^2 (4600 m^2) of soil nail walls for the PA turnpike were required. Our scope of work consisted of two temporary "fill walls" (needed to support the existing roadway in fill areas until new mechanically stabilized earth walls could be constructed) and two permanent "cut walls" (needed in areas where the new third lane construction required cutting existing embankments).

SLOPE STABILIZATION:

The Tombs Run Slide project presented a challenging slope stabilization effort along Route 44 in Lycoming County, PA. We were subcontracted to install a soil nail system to address a roadway slip near Pine Creek. Over 1350 soil nails will be installed to stabilize the slip, combined with a shotcrete finish wall. Reinforced wire mesh will be incorporated in critical areas for additional support. The steep slope adjacent to the creek poses unique logistical challenges, particularly due to limited workspace and proximity to an active hellbender habitat. The third phase will start in 2025, for the installation of fabric mesh anchors below the shotcrete wall for further stability and safety. The design needed to accommodate newly established utility poles, integrating their support into the constructability plan and turning a complex problem into a positive solution.

In 2022, we completed the drilling and installation of 1250 Nails and installed 29,000 ft^2 (2700 m^2) of shotcrete as part of the CONSOL Coal Refuse Disposal Area 7 Project in Greene County, PA. The nails and shotcrete were installed as part of a system to line the side walls of the emergency spillway for the disposal area sediment pond.

The project was completed in two phases as overburden was excavated from the emergency spillway area. In the first phase, soil nails were installed and grouted down to the next excavation level. During the second phase, additional soil nails were drilled at heights reaching up to 16 ft (4.9 m) above the spillway base. The wall face was scaled, cleaned, and reinforced with a welded wire mesh. Shotcrete was applied to complete the structural support. In addition to our safety policies, the crew had to obtain MSHA Surface Miner certifications and follow MSHA regulations while working onsite.

Pennsylvania Turnpike
Allegheny County, PA

Tombs Run Slide - Lycoming County, PA

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GEO-ROPE

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CASE STUDY

For a landslide and erosion repair on the slope below the A82 road at Glen Gloy, Scotland, the designed solution was to install an anchored shotcrete wall where the bedrock outcropped to prevent further failures and erosion.

The client required a design life of 120 years, which necessitated the installation of double corrosion protection

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(DCP) anchors drilled into bedrock to fix the shotcrete wall in position. Geo-Rope Ltd used a combination of long reach plant and rope access A-frame to achieve this.

Rebar and sprayed concrete (shotcrete) were installed using a combination of rope access techniques, hand spraying, and the excavator mounted remotely manipulated nozzle (telespray) to achieve the finished shotcrete wall.

Why ASA?

By Cara Baker, Managing Editor

You may have noticed in the last issue that I only just started as Managing Editor of Shotcrete magazine for the American Shotcrete Association (ASA) in May. As a newer addition (and with little knowledge on shotcrete myself), it has certainly been an interesting learning curve. I have a whole new community to get to know, and boy howdy — y'all aren't shy!

So, since we're focusing our Q4 issue on "Why Shotcrete?", I figured, let's take that one step further and find out why this incredible group of people supports the ASA. What does our association do for you? Here are some of your answers.

TED SOFIS — RECENTLY RETIRED OWNER OF SOFIS COMPANY INC.

Two suppliers told me, "You should belong to [ASA]." So, I went to Vegas for World of Concrete in 2004 and was immediately hooked — I found others with the same issues and problems I had, and I was no longer a lone voice in the woods. I enjoy the association and love the people: Talking to people about things we care about is important! And if you look at it like, 'What am I going to get from this,' then sure, you'll get A, B, and C; but the sum is worth much more than the parts. Involvement is the true magic of the association — get involved and meet the people.

ANDY DUCK — THE ARTISAN GROUP, LTD.; ARTISAN POOLS NC, INC.; ARTISAN CONCRETE SERVICES, INC.; AND ARTISAN SKATEPARKS

I instantly found the wealth of knowledge at ASA to be inspiring and extremely useful in all our operations. Over time I was encouraged to sit in committee meetings and joined as a contributor, ultimately becoming an officer of said committee. I personally stay involved with ASA for the ability to work toward future goals, bettering the industry and our respective trades. Bringing staff into the association helps solidify our industry knowledge, while enforcing and maintaining best practices. We're also very grateful for the resources that are openly distributed — we've used many position papers, etc., in our efforts to educate architects and engineers about our process and final products.

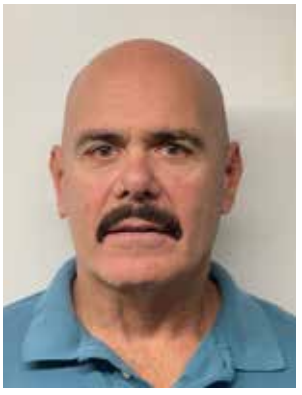
DEREK PAY — PRESIDENT AND CEO OF OCEANSIDE CONSTRUCTION IN SALT LAKE CITY, UT

I joined the ASA after my job required me to get certified, and now I'm on the Board and chair the Education and Safety Committee. For me, the benefit of the ASA is all about all the new stuff that comes in and keeping up with the times — learning from other people and tricks of the trade from around the world — and then teaching people about it. This is what shotcrete is, what we do, where we come from, and where we're trying to move forward. I really want to encourage members to invite more people in; I was once a new person, and it can be kind of intimidating. So, finding those new people and mentoring them, inviting them to join and get involved; that's really what it's all about.

I said it before, and I'll say it again; the folks in the ASA are an incredible group of people. Not only do the membership hold a wealth of knowledge, but they are also generous in sharing their experience with others! In fact, efforts are underway to provide a more formal program to mentor the next generation. Our members are creative, innovative, open to learning new things every day, and are frankly some of the most down-to-earth and easy-going people I've met in years — and I couldn't be prouder to have joined this team. Discover more benefits and become a member at **shotcrete.org/join-asa** today!

George Machikas
Patriot Shotcrete

Nominated by Frank Townsend



George Machikas entered the shotcrete industry many moons ago in Philadelphia, PA, starting and running a successful construction and ready-mix company from 1984-2010. He is a husband, as well as a father to four amazing young women whom he adores and helps out at their homes on the weekends and holidays. The definition of this man: indispensable. George is a fantastic father to them and his wolf dog, Bodie, who is — yes — a wolf.

George is primarily Patriot's contracts manager and projects manager. He is a tough negotiator and knows his craft well. He is determined and fights to the end, which is a great guy to have on your team. He is also an estimator, business developer, great coworker, and friend. When things get hot and busy, George is the one who will methodically examine it, analyzing all the facts. Submittals are not banged out with George: Each one is specific to the specs and detailed. George is a can-do person and often dives in to help with anything from a vehicle or pump issue to estimates. He also participates in company volunteer efforts to help children with special needs.

SHOTCRETE SPOTLIGHT NOMINATIONS

Highlight the individuals or teams that make your company shine. Scan or click the QR code to learn more or nominate someone!

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NEW ASA MEMBERS

american shotcrete association | asa

CORPORATE

Green Infrastructure Partners Inc.
Markham, ON Canada
www.gipi.com
Primary Contact: Mark Reinders
mreinders@gipi.com

T.O.P. Drilling & Excavation Services Inc.
Fenelon Falls, ON Canada
Primary Contact: Ashley Kay
ashley@the-top.ca

Swank Construction Company, LLC
New Kensington, PA
https://swankco.com/
Primary Contact: Chad Basinger
cbasinger@swankco.com

Geotech Services, Inc.
Oakwood Village, OH
www.geotechservicesinc.com
Primary Contact: Paul Stubbs
pms@geotechservicesinc.com

INDIVIDUAL

John Power
Power Construction
San Francisco, CA

Ted Sofis
Sofis Company, Inc.
Pittsburgh, PA

Jose Lora
MATPRO Materials Proyectados
Santiago, Dominican Republic

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Leveraging the ASA Online Community | A Sustaining & Corporate Member Benefit

By LaTosha Holden

The American Shotcrete Association (ASA) is dedicated to advancing the shotcrete industry and supporting its members through education, certification, qualification, resources, standards development and networking. One of the key benefits of ASA membership is access to your online community — a platform designed for collaboration, networking, and exclusive member resources. Whether you're a seasoned professional or new to the industry, the ASA Community is a tool that can enhance your membership experience.

ASA's largest online community comprises all **Sustaining and Corporate members**, including any additional memberships from their respective companies. Each working Committee then also has an online Community as a platform to collaborate and accommodate the work of the committee. All Sustaining and Corporate members have access to their Community group. Your membership alone allows you access to the resources and opportunities available to connect with your peers. Additionally, Sustaining and Corporate members, along with Individuals, Employees of Public Agencies and Academic (both students and faculty) have the opportunity to join the roster of ASA's working committees: Contractor Qualification, Education & Safety, Membership & Marketing, Pool & Recreational, and Underground. The Technical Committee operates a little differently and participation is by invitation only. To learn more about the mission of each committee, see shotcrete.org/about-asa/asa-committees. These committees meet face-to-face twice a year in the Spring at ASA's annual Shotcrete Convention & Technology Conference, and the Fall (usually the Saturday before the American Concrete Institute's (ACI) Fall Concrete Convention.) Additional virtual meetings, within each committee, are coordinated within the committees to further their work throughout the year and may be facilitated by documents shared within their online community. The face-to-face meetings are open to all, but if you wish to be actively involved, access their respective communities, and contribute to the work of our Association through these committees, you must be on the roster. If you are interested, email the Chair to discuss your areas of interest and opportunities to contribute. If you have any questions, reach out to me for assistance at **tosha.holden@shotcrete.org**.

WHAT ARE THE BENEFITS OF THE ASA COMMUNITY?

1. **Access to Member Resources:** Members gain access to ASA-exclusive content, including ASA's Safety Guidelines for Shotcrete (a 20 page PDF in both English and Spanish, intended to guide safety considerations for shotcrete applications), Safety Shooter Toolbox Talks (quick 1 to 2 page PDFs addressing safety topics companies may use in their morning toolbox talks specific to shotcrete related safety concerns), and discussion threads focused on specific topics. This library of resources is designed to provide insights that directly benefit your projects and professional development.
2. **Knowledge Sharing:** Members can connect with one another to ask questions and share insights about best practices, developing technologies, and industry challenges. This exchange of information is beneficial for staying up-to-date on industry trends.
3. **Professional Networking:** Networking within the shotcrete industry is essential for career growth and business development. The ASA Community allows members to connect with peers, industry leaders, and potential collaborators from across the country. Unlike traditional networking events, the community platform allows access at your convenience, supporting your work/life balance.
4. **Collaboration and Support:** The ASA Community fosters a spirit of collaboration. Members can share project experiences, seek advice on challenges, and offer solutions. Whether you're troubleshooting a technical issue or seeking feedback on a new approach, the collective knowledge within the community is a valuable asset.

As a trade association, we have a responsibility to not share information between members that would lead to antitrust violations. This includes, but is not limited to, price fixing, bid rigging, market allocation, and group boycotts. Our ASA Board established our antitrust policy in 2006:

"The American Shotcrete Association assigns the highest priority to full compliance with both the letter and spirit of antitrust and trade regulation laws. Therefore, all meetings and activities of the Association are to be conducted in a manner consistent with this policy. Officers, directors, members, and staff are directed to adhere to this policy when engaging in any Association activity and to immediately report to the Association's Executive Director any incident that may violate antitrust regulations. Violation of this policy is unequivocally contrary to the policy of the American Shotcrete Association."

ACCESSING THE ASA COMMUNITY IS AS SIMPLE AS 1, 2, 3!

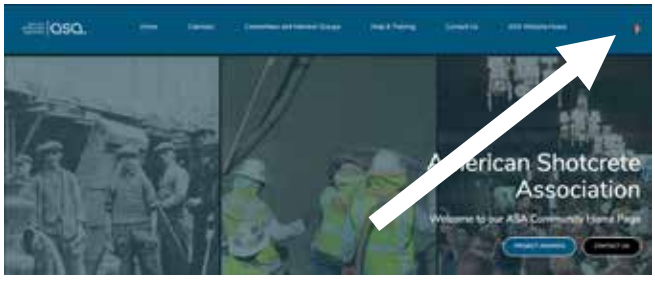
1. Visit our website at shotcrete.org and click My ASA (top right side)
2. Type in your username: Youremailaddress.asa (NOTE the ".asa" at the end of your email address)
3. Enter your password
4. New users or those forgetting their password use the "Forgot Password" link to receive a reset email
5. You are in and now have access to the Sustaining & Corporate member Community

The password reset link is only active for 72 hours. If you don't reset your password within this time frame, you'll need to click the "Forgot Password" button again.

If you are an Individual, Employee of Public Agencies or Academic member, wishing to join the roster of one of our working committees, you will need to reach out to me for access after you and your Chair have connected and agree. You will then have access to the working platform for that committee.

I'M LOGGED IN, NOW WHAT?

First things first: Now that you're logged in, you should complete your Profile. A well-rounded profile helps other members understand your background and expertise, making it easier to connect with peers who share your interests. To update your profile, start by clicking on the profile icon at the top-right of the screen.



Once the profile is open, it will allow you to:

1. **Upload a current photo:** Allows others to recognize you more readily, even if they didn't know you by name.
2. **Edit your Contact Information:** Ensures your copy of Shotcrete magazine reaches you!
3. **Profile Visibility Settings:** you choose how visible you would like to be in the community.
4. **Review any active Ballots:** For Committees working on Position Statements or other programs, your review of documents and vote is important to keep the document/program moving forward!
5. **Notification frequency:** Initially, while everyone becomes more familiar with the community, we recommend the maximum frequency: "Email on Each Post." You will be sure to catch each post as soon as it is sent. Then, over time, you may choose to change to receive notifications less frequently. There are several options to choose from.

DON'T BE SHY!

The internet is a big place, but the ASA Community is a space for like-minded individuals, just like you. Once you've logged in and set up your profile, start to engage with fellow members by asking questions and sharing insights. Consistent engagement helps strengthen connections.

Joining a committee through the community allows you to dive deeper into areas that align with your professional interests. The more you contribute, the more valuable the community becomes, whether it's offering advice, providing resources, or answering questions — your contributions help everyone. Make sure you also take advantage of your member resources.

And remember: The ASA Community feature is more than just an online forum; it's a dynamic network of professionals committed to advancing the shotcrete industry. By actively participating, you'll unlock invaluable insights, build lasting connections, and contribute to a stronger industry. Take full advantage of this member benefit to enhance your experience and help shape the future of shotcrete.

NEW! SAFETY SHOOTER TOOLBOX TALKS!

Everybody needs them, and now ASA is helping to provide content for your next Toolbox Talk! Focused on shotcrete-related safety concerns, ASA has a task group reviewing and updating a collection of previously published Safety Shooter columns to refresh and repackage them into 1 to 2-page downloadable PDFs for your use! These are a Sustaining and Corporate Member benefit only, available via the ASA website Community for Sustaining and Corporate members.

You just read about how to access your Community page, now go in and take a look! We currently have six Talks available, with more rolling out throughout 2025: *Concrete Burns* by Marcus H. von der Hofen • *Construction Project* by Scott Strandridge • *Pre-Job Safety Checks* by Mark Corner • *Third-Rail Safety* by Ray Schallom III • *What's Wrong with This Picture?* by Ray Schallom III • *Workers' Dust Protection* by Ray Schallom III

We've chosen to showcase one in this issue to highlight the launch of this new resource. Let us know if you have topics you wish for us to explore (or write about!). Our email is always available: **Info@shotcrete.org**

Pre-Job Safety Checks

By Mark Corner

Today's shotcrete placement, equipment, and personnel have evolved over the years, bringing a number of new safety items and topics. Every project is unique and possesses unique hazards that need to be addressed. Even before the shotcrete machine is started, we are responsible, as professional shotcreters, to plan for placing quality shotcrete and maintaining safety at all times while working on jobsites. One of the most important aspects is pre-job safety planning for the project to protect the worker from injury and mitigate damage to the equipment or site.

Job organization is an essential part of the pre-job safety process. The responsibility falls to the foreman of the job to correctly identify the hazards and communicate them to the crew and workers on-site. The equipment and other shotcrete placements should be laid out to meet the safety requirements. The foreman should also ensure that all equipment is properly maintained and working smoothly, while being aware of necessary precautions and providing for unseen disruptions.

PRE-JOB SAFETY

As we know, safety starts with the individual. In shotcrete processes, we have to consider many aspects of planning jobs and keeping safe. The following are some key points in my Pre-Job Safety checklist.

- Before operating any type of machinery, the crewman should be very clear on how the machinery operates. Sure, reading manuals can be boring, but you know what's worse? Lying in a hospital bed because you used a shotcrete pump with no training. STAY SAFE, READ MANUALS.
- Communicate with key personnel such as the Project Contractor and other subcontractors, making sure everyone is aware who is responsible for identifying hazards. Also, we must always be informed of and follow local laws and regulations. All shotcrete

Fig. 1: On-site safety talks provide timely communication during a project.

projects are unique and have their own set of hazards that must be addressed. These discussions should take place before the start of the project. They can include procedures to respond to weather limitations, special site conditions, and work limitations (for example, evening work should ensure that proper lighting is provided). Restrictions that local laws place on noise and hours of work need to be communicated clearly and work planned accordingly. Even the physical setup of the equipment should be planned to allow the pump or gun operator a visual line of sight with shotcreters or radio communication provided when visual access is not feasible.

- Safety talks or tailgate meetings are a key element in the daily operations. This is the opportunity to pinpoint hazards for the day. This may include potential hazards that may be encountered and/or may have changed due to changes in weather or other trades working close to the shotcrete placement. Let everyone ask questions and ensure everyone understands the answers and the potential hazards you address. Ensure employees are aware of the location of safety stations and know how to use them in the event of an emergency. A safety plan is a great idea for the work crew as well as a daily reminder of procedures in the event of an emergency. On most commercial job sites or in mining, you are required to participate in a "line-up" or meeting to go over the day's production processes and discuss who is working in the area and potential hazards. Hazards are identified and documented before work starts. Each employee will record the day's events as well as any hazards encountered, turning that into a report at the end of the shift (Fig. 1).
- Ensure each worker is competent. More and more project owners are now requiring ACI certification for shotcreters.
- Equipment arrival on-site: During initial setup, the equipment should be checked for any defects and all safeguards verified in place. Inspect all components before start-up and confirm the proper hose and fitting are being used with special attention to the level of wear in the fittings or hoses, which could be a potential hazard during operations. Identifying the hazard early can eliminate injury and lost time.
- Jobsite production may require using equipment such as scissor lifts, man lifts, or scaffolding. Ensure this equipment is adequate for the job, is in compliance with local laws and regulations, and is serviced according to manufacturer's recommendations. Ensure your shotcrete equipment is adequate for the job and properly serviced. Prompt service is essential to keep expenses down time to a minimum (Fig. 2)!

Fig. 2: Man lifts allow for quick, convenient access to hard-to-reach spaces.

In summary, a well-planned job with a focus on safety will bring profit to your company, and your customers will appreciate a job done on-time and on-budget. Spending the proper time every day pre-planning and ensuring the job is safe will benefit all.

RESOURCES

1. How to Safely Use Shotcrete," Concrete Pump Supply, Dec. 2013, http://www.concretepumpsupply.com/blog/how-to-safely-use-shotcrete/.
2. "Personnel, Duties, and Safety Precautions for the Shotcrete Gunning Crew," based on Chapter 3 of Gunite: A Handbook for Engineers by T.F. Ryan, published by The Cement and Concrete Association, 1978, London, UK, 3 pp.
3. ASA, "Safety Guidelines for Shotcrete," American Shotcrete Association, Farmington Hills, MI, 2014, 20 pp.

Mark Corner *is a Manager at Interconcrete Limited based in Sudbury, ON, Canada. Corner is a member of ASA and the Ready Mix Concrete Association of Ontario Technical Committee and his certifications include ACI Concrete Field Testing, CCIL Field and Laboratory Category II, ACI wet and dry, vertical and overhead shotcrete, and EFNARC Shotcretertt. He has knowledge in underground shotcrete processes, has assisted in setting up mines with wet-shotcrete processes including delivery from surface via slick lines, and has designed and developed shotcrete mixtures.*

Revisiones de Seguridad Preliminares al Trabajo

Por Mark Corner

El equipo, el personal y los métodos de colocación de concreto lanzado (shotcrete) han evolucionado a lo largo de los años, introduciendo nuevos elementos y temas de seguridad. Cada proyecto es único y presenta peligros específicos que deben ser atendidos. Incluso antes de poner en marcha el equipo de shotcrete, como profesionales, tenemos la responsabilidad de planificar para colocar concreto lanzado de calidad y mantener la seguridad en todo momento en las obras. Uno de los aspectos más importantes es la planificación de seguridad previa al trabajo para mitigar lesiones o daños en el equipo y proteger al trabajador.

La planeación del trabajo es una parte esencial del proceso de seguridad previa al trabajo. La responsabilidad recae en el capataz para identificar correctamente los peligros y comunicarlos al equipo y a los trabajadores en el lugar. Él debe colocar el equipo y realizar las operaciones de lanzado de manera que cumplan con los requisitos de seguridad. El capataz también debe asegurarse de que todo el equipo esté en condiciones de operación y funciona sin problemas, teniendo en cuenta las precauciones necesarias y previendo para eventualidades imprevistas.

SEGURIDAD PREVIA AL TRABAJO

Como sabemos, la seguridad comienza con el individuo. En los procesos de shotcrete, debemos considerar muchos aspectos de planificación y seguridad. A continuación, algunos puntos clave en mi lista de verificación de seguridad previa al trabajo.

- Antes de operar cualquier tipo de maquinaria, el operador debe estar capacitado en cómo funcionan los equipos. Claro, leer los manuales puede ser aburrido, pero ¿sabes qué es peor? Estar en una cama de hospital porque usaste una bomba de shotcrete sin capacitación. MANTÉNGASE SEGURO, LEA LOS MANUALES.
- Comuníquese con el personal clave, como el Contratista del Proyecto y otros subcontratistas, asegurándose de que todos sepan quién es responsable de identificar los peligros. Además, siempre debemos estar informados y seguir las leyes y regulaciones locales. Cada proyecto de shotcrete es único y tiene su propio conjunto de riesgos que deben atenderse. Estos puntos deben revisarse antes de comenzar el proyecto. Pueden incluir procedimientos para atender situaciones climáticas, condiciones especiales del sitio y restricciones de trabajo (por ejemplo, el trabajo nocturno debe garantizar que se tiene la iluminación adecuada). Las restricciones impuestas por las leyes locales en cuanto al ruido y las horas

Fig. 1: Las charlas de seguridad en el sitio brindan comunicación oportuna durante un proyecto.

de trabajo deben ser claramente comunicadas y el trabajo planeado en consecuencia. Incluso la disposición física del equipo debe planearse para permitir que el operador de la bomba tenga visión con los lanzadores de shotcrete o se les proporcione comunicación por radio cuando el acceso visual no sea factible.

- Las charlas de seguridad o reuniones de campo son un elemento clave en las operaciones diarias. Esta es la oportunidad para identificar los peligros del día. Esto puede incluir peligros potenciales que hayan cambiado debido al clima o a otras actividades cercanas a la colocación de shotcrete. Permita que todos hagan preguntas y asegúrese de que todos comprendan las respuestas y los posibles peligros que se están tratando. Asegúrese de que los empleados sepan la ubicación de las estaciones de seguridad y sepan cómo usarlas en caso de emergencia. Un plan de seguridad es una gran idea para el equipo de trabajo y sirve como recordatorio diario de los procedimientos en caso de emergencia. En la mayoría de los sitios comerciales o en minería, se requiere participar en una "alineación" o reunión para repasar los procesos de producción del día y discutir quién está trabajando en el área y los peligros potenciales. Los peligros se identifican y documentan antes de que comience el trabajo. Cada empleado reportará las actividades del día y cualquier peligro encontrado, entregando un informe al final del turno (consulte la Fig. 1).
- Asegúrese de que cada trabajador está capacitado. Cada vez más, los propietarios de proyectos exigen certificación para los trabajadores de shotcrete.
- Llegada del equipo al sitio: Durante la inspección inicial, el equipo debe ser irevisado para detectar defectos y se deben verificar todas las medidas de protección. Inspeccione todos los componentes antes de comenzar y confirme que se estén utilizando la manguera y el accesorio adecuados, prestando especial atención al nivel de desgaste en los accesorios o mangueras, lo cual podría representar un peligro durante las operaciones. Identificar el peligro a tiempo puede evitar lesiones y pérdidas de tiempo.
- La colocación en el sitio puede requerir el uso de equipos como elevadores de tijera, elevadores de personal o andamios. Asegúrese de que este equipo sea adecuado para el trabajo, cumpla con las leyes y regulaciones locales y se le dé servicio de acuerdo con las recomendaciones del fabricante. Asegúrese de que su equipo de shotcrete es adecuado para el trabajo y está con los mantenimientos requeridos. Un servicio rápido es esencial para mantener los costos bajos y el tiempo de inactividad al mínimo (consulte la Fig. 2).

Fig. 2: Las plataformas elevadoras permiten un acceso rápido y conveniente a espacios de difícil alcance.

En resumen, un trabajo bien planificado con un enfoque en la seguridad aportará beneficios a su empresa, y sus clientes apreciarán un trabajo realizado a tiempo y dentro del presupuesto. Dedicar el tiempo adecuado a la planificación previa y asegurar que el trabajo es seguro beneficiará a todos.

RESOURCES

1. How to Safely Use Shotcrete," Concrete Pump Supply, Dec. 2013, http://www.concretepumpsupply.com/blog/how-to-safely-use-shotcrete/.

2. "Personnel, Duties, and Safety Precautions for the Shotcrete Gunning Crew," based on Chapter 3 of Gunite: A Handbook for Engineers by T.F. Ryan, published by The Cement and Concrete Association, 1978, London, UK, 3 pp.

3. ASA, "Safety Guidelines for Shotcrete," American Shotcrete Association, Farmington Hills, MI, 2014, 20 pp.

Mark Corner *es Gerente en Interconcrete Limited, con sede en Sudbury, ON, Canadá. Corner es miembro de ASA y del Comité Técnico de la Asociación de Concreto Premezclado de Ontario, y sus certificaciones incluyen Pruebas de Campo de Concreto ACI, Categoría II de Campo y Laboratorio de CCIL, shotcrete vertical y horizontal de ACI en condiciones húmedas y secas, y Shotcretertt de EFNARC. Tiene conocimiento en procesos de shotcrete subterráneo, ha asistido en la configuración de minas con procesos de shotcrete húmedo, incluyendo la entrega desde la superficie mediante líneas de deslizamiento, y ha diseñado y desarrollado mezclas de shotcrete.*

WORLD OF CONCRETE 2025 – REGISTRATION NOW OPEN

January 21 – 23, 2025
Las Vegas Convention Center
Las Vegas, NV

Use ASA's source code A17 for the lowest discounted exhibit-only admission pass at just $25 (75% discount!), available online until December 12, 2024! Rates will increase afterward. Pass this discount code to your colleagues and clients! Registering with ASA's code is an easy way to support your association, even after December 12th! Stop by our Booth, South Hall #10919, to meet us! Our General Membership meeting and reception will be held on Tuesday, January 21st, after the show. Scan or click on the QR code for more information.

Highlighted shotcrete opportunities at WOC include:

- Shotcreter Education (pre-requisite for those pursuing ACI's Shotcreter Certification)
- Quality Shotcrete – Know It When You See It (supporting the ACI Shotcrete Inspector Certification)
- Wet-Mix Shotcrete Certification (Henderson, NV)

SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE

2025 ASA SHOTCRETE CONVENTION AND TECHNOLOGY CONFERENCE

March 9 – 11, 2025
The DeSoto | Savannah, GA

Registration is now open! We are hosting our annual ASA Shotcrete Convention and Technology Conference at The DeSoto in Savannah, GA, where the warmth and charm of Savannah meet modern comfort to create an unforgettable atmosphere. Our convention offers a unique opportunity to explore shotcrete applications, innovations, and future advancements in the shotcrete industry. Attendees are also invited to participate in ASA's 2025 Spring Committee and Board meetings, and ASA will be celebrating our 2024 Outstanding Shotcrete Project Award winners at our Annual Awards Banquet on Tuesday. Join us for this excellent networking and learning experience! Check out the details and register today: **shotcrete.org/convention**

PRE-CONVENTION SEMINAR OPPORTUNITIES

Contractor Qualification Education Seminars – Structural & Pool (NEW!)
Sunday, March 9, 2025 (additional fees apply)
The DeSoto | Savannah, GA

Recognizing that the shotcreter (formerly known as nozzleman) alone cannot be responsible for a successful shotcrete project, ASA's Contractor Qualification program was developed to help the industry recognize self-performing shotcrete contractors who have the experience and company support to accomplish projects of similar scope and work (Structural work – Level I or II; QCI or QCII, respectively). Towards that end, this seminar was designed to support the program, focusing on the many aspects of successful contracting and how shotcrete construction compares to more traditional form-and-pour concrete construction. This seminar, along with its corresponding written exam, are pre-requisites for those seeking to apply for ASA's Contractor Qualification program.

NEW: ASA will launch the Qualified POOL Contractor (QPC) designation at the Convention in Savannah. Though many aspects of qualified contractors are similar, the seminar will break out in the afternoon to focus on either Structural OR Pool specific information tailored to their respective designations. Those seeking the QPC will need to take the QPC written exam to add on this qualification. Topics covered in the seminar include:

1. Overview of the CQP
2. Site planning/Logistics
3. Diversity of Shotcrete Applications
4. Concrete Knowledge
5. Shotcrete Equipment
6. Shotcrete Knowledge
7. Shotcrete Testing
8. Equipment Maintenance
9. Shotcrete Specific Safety
10. Financial Responsibilities

Attendees seeking Shotcrete Contractor Qualification for their company (one representative per company) will be required to take a written examination (either Structural or Pool), offered at the conclusion of the seminar.

SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE

BOOST YOUR BRAND VISIBILITY AND CONNECT WITH YOUR TARGET AUDIENCE: BECOME A SPONSOR TODAY!

Make sure your company is recognized among the leaders of the shotcrete industry by sponsoring the 2025 ASA Shotcrete Convention & Technology Conference! As a sponsor, you will receive a variety of exposure opportunities:

- Convention Venue – banners onsite, in the program, & the opportunity for a tabletop exhibit
- Awards Banquet (reception, dinner, & awards program)
- 1st Quarter 2025 Awards Issue of Shotcrete magazine
- ASA What's in The Mix (eNewsletter) & Social Media promotions
- ASA Website, Convention page – all year

Lock in your sponsorship
TODAY in one of the following sponsorship categories:

BIG SHOOTER ($5000): Exposure with the most prominent placement of your company logo throughout all promotional materials; one complimentary tabletop exhibit (first come, first served — must confirm interest at time of application); and unlimited Half Price Awards Banquet Tickets.

GOLD ($2500): Exposure (prominently placed after Big Shooters) of your company logo throughout all promotional materials; one complimentary tabletop exhibit (first come, first served — must confirm interest at time of application); and one (1) Half Price Awards Banquet Ticket.

SILVER ($1000): Exposure — prominently placed after Gold Sponsors — of your company logo throughout all promotional materials.

WOMEN IN SHOTCRETE: SURVEY

Call to all women working in the shotcrete industry! The 4th Quarter 2025 issue of Shotcrete magazine wants to recognize you! Scan or click this QR code and share your journey to encourage and celebrate the women in shotcrete!

SUBMISSIONS NEEDED FOR SHOTCRETE SPOTLIGHT

ASA members, here's your chance to highlight the individuals and teams in your companies that help you shine! Scan or click the QR code to learn more or nominate someone!

JOIN OUR SHOTCRETE MAGAZINE ADVERTISERS!

2025 Media Kit is now online! Place your insertion orders now to ensure inclusion in all four 2025 issues of Shotcrete magazine!

Advertising in Shotcrete magazine will position your company at the forefront of the shotcrete industry. With an average savings of 25% or more compared to other leading trade association magazines, you can reach the companies and people that you need to grow your business at a competitive price. These rates certainly provide you with the most bang for your advertising dollars! Visit **shotcrete.org/MediaKit** for more information or contact us **info@shotcrete.org** to submit your insertion order.

MAPEI EXPANDS U.S. OPERATIONS WITH NEW ADMIXTURES PLANT IN DENVER, COLORADO

Deerfield Beach, Florida – MAPEI Corporation, a global leader in chemical products for the construction industry, is proud to announce the opening of a new 32,000 ft² (2,973 m²) admixtures plant in Denver, Colorado. The new plant features an advanced mixing and batching facility, warehousing, a state-of-the-art concrete laboratory and product-quality control.

This advanced facility is part of MAPEI's ongoing commitment to strategically expand its operations across the United States, joining existing admixtures plants in Dalton, Georgia; Garland, Texas; Swedesboro, New Jersey; Eagan, Minnesota; and Madison, Illinois.

Additional facilities are set to open in Houston, Texas, and Chicago, Illinois, in 2024, and in the southwestern and northwestern parts of the United States in the first half of 2025. With these openings, MAPEI continues to strengthen its production capabilities to meet the growing demands of the construction industry nationwide.

"The opening of our new Denver plant marks another landmark in MAPEI's strategic growth in the U.S.," said Luigi Di Geso, President and CEO of MAPEI North America. "This facility will enhance our ability to serve the Western region with high-quality admixtures, ensuring faster delivery times and superior customer service."

Gerald LaPier, Director of Construction Chemicals for MAPEI Corporation, added, "Our Denver plant is designed with the latest technology to maximize efficiency and quality. This is another milestone as we expand our network of facilities; we are committed to maintaining the highest standards in production while reducing our environmental impact."

For more information about MAPEI's admixtures and other construction products, visit **www.mapei.com**.

SHOTCRETE INSPECTORS WANTED

Shotcrete Projects with ACI-Certified Shotcreters Need ACI-Certified Shotcrete Inspectors

ACI Resource Centers have teamed up with ASA to present ASA's Shotcrete Inspector Education, which supports the ACI Shotcrete Inspector Certification program.

Look for one near you:

COLUMBIA, MD
Mid-Atlantic Resource Center
January 29, 2025
August 8, 2025

ELK GROVE VILLAGE, IL
Midwest Resource Center
April 29, 2025
October 10, 2025

SAN BERNARDINO, CA
Southern California
Resource Center
March 5, 2025
September 10, 2025

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SHOTCRETE CALENDAR

Please check with the meeting provider as some meetings may be postponed or cancelled after publication of this issue of Shotcrete.

JANUARY 11, 2025	**Quality Shotcrete — Know It When You See It** Dees-Hennessey Inc | San Francisco, CA
JANUARY 21-23, 2025	**2025 World of Concrete** Las Vegas Convention Center | Las Vegas, NV
JANUARY 21, 2025	**ASA Shotcreter Education** Las Vegas Convention Center | Las Vegas, NV
JANUARY 21, 2025	**ASA General Membership Meeting & Reception** Las Vegas Convention Center | Las Vegas, NV
JANUARY 22, 2025	**Quality Shotcrete - Know It When You See It** Las Vegas Convention Center | Las Vegas, NV
JANUARY 23-24, 2025	**ACI Shotcreter Certification —Wet-Mix** World of Shotcrete | Henderson, NV
JANUARY 28-30, 2025	**2025 Pool & Spa Show** Atlantic City Convention Center | Atlantic City, NJ
JANUARY 29, 2025	**Recognizing Quality Shotcrete** Mid-Atlantic Resource Center | Columbia, MD
FEBRUARY 4-8, 2025	**2025 Southwest Pool & Spa Show** George Brown Convention Center | Houston, TX
FEBRUARY 6, 2025	**WU C2241 Quality Shotcrete for Pools — Know It, Demand It** George Brown Convention Center | Houston, TX
FEBRUARY 7, 2025	**WU C4231 ASA Best Practices for Shotcrete** George Brown Convention Center | Houston, TX
FEBRUARY 23-26, 2025	**Mine Exchange - 2025 SME Annual Conference & Expo** Colorado Convention Center | Denver, CO
MARCH 5, 2025	**Recognizing Quality Shotcrete** Southern California Resource Center | San Bernardino, CA
MARCH 9-11, 2025	**ASA Shotcrete Convention & Technology Conference 2025** The DeSoto | Savannah, GA
MARCH 9, 2025	**ASA Contractor Qualification - Structural** The DeSoto | Savannah, GA
MARCH 9, 2025	**ASA Contractor Qualification - Pool** The DeSoto | Savannah, GA

SHOTCRETE CALENDAR, CONT'D

MARCH 10-11, 2025	**ASA Spring Committee Meetings - 2025** The DeSoto | Savannah, GA
MARCH 11, 2025	**ASA Outstanding Shotcrete Project Awards Banquet** The DeSoto | Savannah, GA
MARCH 21-23, 2025	**ACI Shotcreter Certification (Wet-Mix) | Skatepark Summit** Kaaterskill Kahncrete | Saugerties, NY
MARCH 30-APRIL 2, 2025	**ACI Concrete Convention - Spring 2025** Sheraton Centre Toronto Hotel | Toronto, ONT Canada
APRIL 13-16, 2025	**2025 IRCI Spring Convention** Austin Marriott Downtown | Austin, TX
APRIL 29, 2025	**Recognizing Quality Shotcrete** Midwest Resource Center | Elk Grove Village, IL
JUNE 22-25, 2025	**ASTM Committee Meetings - C09 Concrete & Concrete Aggregates** Sheraton Centre Toronto Hotel | Toronto, ONT Canada
AUGUST 8, 2025	**Recognizing Quality Shotcrete** Mid-Atlantic Resource Center | Columbia, MD
SEPTEMBER 10, 2025	**Recognizing Quality Shotcrete** Southern California Resource Center | San Bernardino, CA
OCTOBER 10, 2025	**Recognizing Quality Shotcrete** Midwest Resource Center | Elk Grove Village, IL
OCTOBER 19-22, 2025	**2025 ICRI Fall Convention** Intercontinental Hotel | Chicago, IL
OCTOBER 25, 2025	**ASA Fall Committee Meetings - 2025** TBD | Baltimore, MD
OCTOBER 26-29, 2025	**ACI Concrete Convention - Fall 2025** Hilton Baltimore & Marriott Baltimore Inner Harbor | Baltimore, MD
NOVEMBER 18-20, 2025	**International Pool | Spa | Patio Expo 2025** Las Vegas Convention Center | Las Vegas, NV
DECEMBER 7-10, 2025	**ASTM Committee Meetings - C09 Concrete & Concrete Aggregates** Hilton Atlanta | Atlanta, GA
MORE INFORMATION	To see a full list, current updates, and active links to each event, visit www.shotcrete.org/calendar.

SHOTCRETE FAQs

As a service to our readers, Shotcrete magazine includes selected questions and answers by the American Shotcrete Association (ASA). Questions can be submitted to info@shotcrete.org. Selected FAQs can also be found on the ASA website at www.shotcrete.org/FAQs.

QUESTION:

Are there any parameters to accommodate possible vibrations in the surrounding area while shotcrete operations are ongoing? For example, the impact of driving a backhoe 20 ft (6 m) away from a wall that is being shotcreted: Are there specific guidelines that we need to follow for vibrations? Driving vehicles, heavy equipment, blasting, etc.

ANSWER:

No, we're not aware of any specific vibration guidelines. However, if the freshly placed shotcrete sags or sloughs, it could be because of:

1. Reinforcing not tied securely and vibration from adjacent placement is vibrating the steel
2. Form work is not rigid enough and vibration from adjacent placement is vibrating the form
3. Concrete is being placed at too high a slump (usually shows up quickly)
4. Sources of excessive external vibration (again hard to quantify)

So, before shooting, check the rigidity of the formwork and reinforcing steel. For wet-mix, slump at the pump is usually 3 in. (75 mm), maybe up to 4 in. (100 mm) for congested reinforcing steel layouts. If you have removed all significant sources of external vibration, watch closely soon after shooting for any sags to verify if the problem goes away.

Equipment such as a big vibrating compaction roller or an adjacent active railroad track would cause problems if close by. Distance to minimize the effect likely depends on the type of soil between the equipment and the point of placement.

QUESTION:

We are using shotcrete to repair the underside of a concrete floor slab. Can we apply spray foam insulation to the shotcrete?

ANSWER:

Shotcrete is just a placement method for concrete. Check with the spray foam material manufacturer to see what their application recommendations are for applying to fresh concrete. Many coating manufacturers recommend a 28-day cure time before application.

QUESTION:

What should be the acceptance criteria for core strength of M30 grade of shotcrete when performing field suitability tests of panels (target strength) and in-situ strength after finalizing the concrete design mixture?

ANSWER:

The coring process reduces the tested compressive strength when compared to cast concrete cylinders. ACI Code 318-19 Building Code Requirements for Structural Concrete - Section 26.12.6.1(e) has this provision when testing cores are taken from concrete structures:

> "Concrete in an area represented by core tests shall be considered structurally adequate if (1) and (2) are satisfied:
> (1) The average of three cores is equal to at least 85 percent of fc'.
> (2) No single core is less than 75 percent of fc'."

You can take cores from panels using ASTM C1140 or cores from shotcreted structural sections (not panels) by ASTM C1604. Take care to follow the moisture conditioning requirements of the ASTM standards. Also, if using test panels make sure they are protected from damage in handling and environmental conditions such as freezing weather, excessive heat or evaporation. They should not be disturbed until they have reached an adequate strength to tolerate handling stresses. Depending on the concrete mixture, the panels may not be able to be moved for several days.

QUESTION:

A recent project specification required shotcrete at 5 to 10 miles/hr (8 to 16 km/hr). Is this shotcrete?

ANSWER:

5 to 10 miles/hr is not even close to shotcrete's required velocity. That specification is appropriate for low-velocity sprayed mortar. Shotcrete is 60 to 80 miles/hr (100 to 130 km/hr). Shotcrete requires high velocity to provide full compaction and encasement of embedded reinforcing. Shotcrete gets good bond to the substrate by the high velocity. Low-velocity sprayed mortar usually requires an integral bonding chemical to enhance the bond to a substrate. Though low-velocity sprayed mortar is sprayed with air flow, it uses a much smaller air compressor than we need for shotcrete. You may want to review a recent article in the Q2 2024 Shotcrete magazine "A Study on Low-Velocity Sprayed Mortars". You can search our magazine article archive at **shotcrete.org/articles** using the key word "low-velocity."

QUESTION:

Can a waterproofing admixture or material be added to dry-mix shotcrete when a pool shell is being shotcreted?

ANSWER:

Good quality shotcrete is functionally watertight. Thus, there is generally no need to add any supplemental waterproofing agents to the dry-mix materials. When using the proper proportion of concrete materials, an adequately-sized air compressor, a high-pressure water booster pump, and an experienced shotcreter (formerly called nozzleman) using the appropriate application techniques, you should expect dense, low permeability and high strength concrete in place.

A minimum 28-day compressive strength of 4000 psi (28 MPa) is needed to have adequate paste for consolidation and encasement of the embedded reinforcing steel. You should check our website pool portal at **pools.shotcrete.org** for our pool position statements. The position statement "Watertight Shotcrete for Swimming Pools" has a comprehensive look at watertightness of shotcreted pool shells.

DISCLAIMER

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

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