shotcrete
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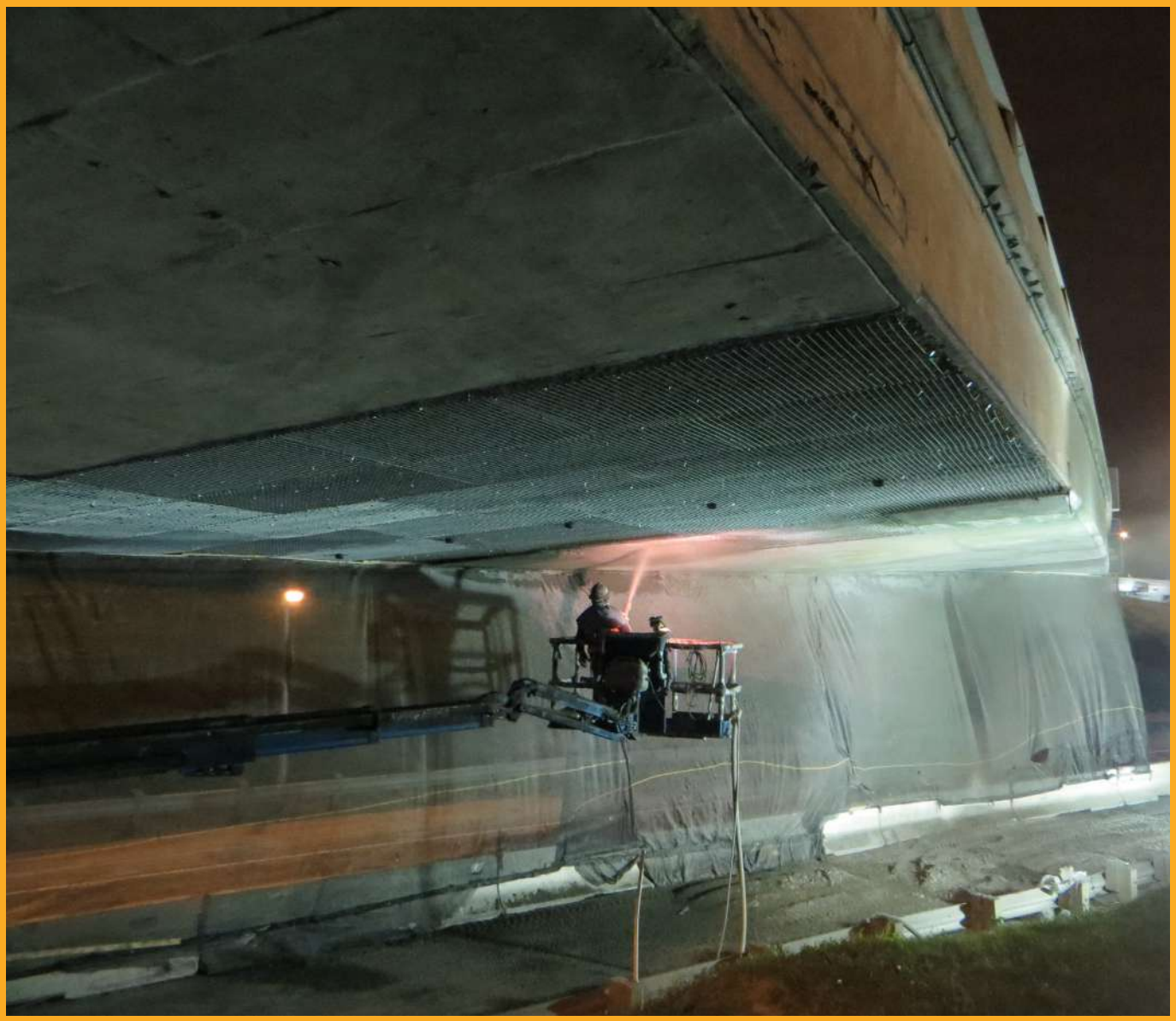
OUTSTANDING SHOTCRETE PROJECT AWARDS

25 american shotcrete association asa th anniversary 1998-2023



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

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

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Outstanding Architecture | New Construction Project Highline Garibaldi Springs Rockscape Retaining Wall in British Columbia, Canada. Photo courtesy of Polygon Highline Homes Ltd. Read about this project on page 16.

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Where We Came From and Where We Are Going

By Frank Townsend

Carl Akeley first developed the shotcrete process in 1907. The industry has evolved with over a century of technological advancements from pumps to nozzles, to admixtures, to new Type 1L cement, to remotely manipulated equipment, to acceptance in the larger infrastructure world. Many laid the groundwork for the growth of this industry: Larry Totten and Tony Federico out West; Lars Balck and Charles Hanskat from CROM; George Yoggy, Patrick Bridger, and "Mr. Pool" Bill Drakeley in the Northeast; and the Alabama dynasty of Curt White, Bill Snow, Tony McDougal, and Tom Pirkle. It is now up to us to *expand* it further.

If you aren't aware of the benefits of shotcrete placement in lieu of form-and-pour, they ar. time, money, and carbon footprint. Shotcrete's reduction of formwork and time of construction results in significant cost savings. Sophisticated and complex concrete structures with intricate reinforcement details are now being constructed with shotcrete. Thick structural walls are being constructed using shotcrete as the final lining method and for foundation and boundary elements from NY to CA. This is the message that is true and that needs to be spread and proved by us all. From Superior Gunite to Thorcon, Coastal Gunite to Eastco, and everyone in between — carry the message and show what *right* looks like.

For successful shotcrete applications, contractors need relevant experience with shotcrete materials and mixture designs, equipment, and competent shotcrete crews. Rigorous quality control monitoring, inspection, and testing should be provided by the owner. In addition, collaboration with the structural design engineer is also vitally important.. ACI Shotcrete Nozzleman Certification has obviously helped, but the ASA Qualified Contractor program offers an additional resource. This program provides another measure of quality control by prequalifying contractors for different levels of complexity on shotcrete applications, which could be a boon for engineers who are just not as familiar. Likewise, the new shotcrete inspector seminar (aka Quality Shotcret. – Know It When You See It) is not only a great resource to educate engineers and inspectors, but it also informs the industry on what *right* looks like. It is up to all of *us* to *show* them quality shotcrete applications as the standard it should be.

Recent research projects and field applications have demonstrated that properly constructed shotcrete structures can provide equal or better durability than traditional form-and-pour placement methods. Ongoing research and engineering projects will confirm the long-term durability of shotcrete. Durability aspects currently evaluated include chloride penetration, ionic migration, heat of hydration, and service life prediction and validation. So, things are moving in the right direction.

Our plan is to be the global resource for shotcrete and to educate the industry to "Know Quality Shotcrete When You See It." How we get there is the fun part. Currently ASA conducts dozens of presentations annually to construction companies, engineers, architects, owners, and students. Our current focus is on the students; we want to teach them about the value of shotcrete, so they have that knowledge

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Fig. 1: Lars & Lynn Balck

to use going into their careers where so many others have not even heard of shotcrete. We have a team targeting 56 schools nationwide to support ASA's effort in connecting with professors and offering them our Shotcrete 101 presentation as a lecture for their students. You can collaborate with us by contacting your local university or trade school. Help us make those connections and contribute to the growth of your future generation of local engineers, architects, and specifiers, enlisting them early in their careers on the virtues of shotcrete.

We are also actively exploring opportunities to make a significant impact globally as an association. Currently we are in discussions with EFNARC (European Federation of National Associations Representing producers and applicators of specialist building products for Concrete) on how we can help each other bring a certification to remotely manipulated shotcrete. Currently EFNARC's certification is focused more on safety, while quality placement needs to encompass more. ASA has conducted nozzleman certification sessions in Australia and connected with associations in the UK. Rusty Morgan, Raul Bracamontes, and John Zhang are some of our members who also have a global footprint. We are increasing in numbers and more and more people see the tool that shotcrete is in their Concrete Construction toolkit.

With this, ASA is well underway for a succession plan and has hired a new staff member to help Tosha and Alice with both Shotcrete magazine and Certifications, which are ever on the rise. A new superhero has entered ASA to help you get your job done!

Lastly, I want to thank our Past President, Lars Balck, one more time. For those who don't know, he was ASA's first president and has graciously served as president three times. He exemplifies devotion to craft. Lars served this country in Vietnam as an army combat engineer, and for that, we also thank him for his service. He led the Association through COVID, and his strong leadership and clear vision helped the Association thrive in its midst. Retirement seems to be a relative term, and we thank you for your willingness to step up when needed. Enjoy Spain my friend!

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Getting the Word Out!

By Ashley Cruz, Marketing Committee Chair

Hello! Thank you for reading this column and our quarterly shotcrete publication. Without your support, interest, and dedication to this specialized field of concrete installation – shotcrete – the American Shotcrete Association would not be as strong as it is today.

A large part of the Marketing Committee is based around education and advocacy for shotcrete through presentations to engineers, architects, agencies, educators, and students. In 2022, we were able to hold 86 presentations and reach over 607 people. Thank you to our presenters and all who were in attendance. As Sustaining or Corporate members, you have the opportunity to contribute to these efforts simply by helping your specifiers and project owners learn more about shotcrete. Host a seminar and invite these stakeholders to an Introduction to Shotcrete presentation where they can earn professional development hours for their licenses. Contact ASA at info@shotcrete.org to schedule a session or help coordinate an opportunity for ASA to speak at a local chapter meeting of other associations such as ACI, ICRI, PHTA, etc. Utilize the resources your ASA membership gives you to market your work! ASA will also provide a seminar for student chapters at universities or come lecture as a guest speaker for a class. If you have any connections to local university engineering or construction management programs, please consider putting ASA in contact to aide in these outreach efforts.

Last fall, we had the opportunity to update our Strategic Plan, and it identified the need for us to update our website. We are beginning efforts to revamp the site, making the shotcrete knowledge base developed by ASA more accessible to you, your clients, and the construction industry. Looking at current trends, we see the need for more "bite sized" chunks for folks to find what they need when they need it. Feel free to email (info@shotcrete.org) your thoughts on how our website could be more useful to you, and we will try to incorporate your suggestions.

In February 2023, we held our Shotcrete Convention and Technology Conference at the Ojai Valley Inn in Ojai, California. With the generous support of our sponsors, we were able to host over 100 attendees comprised of members, sponsors, and educators. Our awards banquet showcased the winners of our Outstanding Shotcrete Project Awards. In this issue of Shotcrete magazine, you will be introduced to the winners and read more about their outstanding projects. This program is an exceptional opportunity to promote the amazing versatility of the shotcrete process. Not only can you promote your own outstanding projects by submitting a project for the opportunity to win, but you can also show your clients and potential project owners what can be done and what they can design and build with your assistance. The 2023 program is now open, and you may submit your nominations through October 2, 2023. This year's winners will be showcased and celebrated at our 19th Annual Outstanding Shotcrete Project Awards banquet at the ASA 2024 Convention in Lakeway Resort & Spa in Austin, TX. (www.shotcrete.org/convention). Get involved! Submit a project! Grow and connect with peers at the 2024 Convention!

Know that our doors are always open, and we want you to come in. Whether you are interested in becoming a part of the Marketing Committee or any other committee, have an idea for a magazine article, wish to see more content on a specific subject, or simply want to say "hello," shoot us an email or message on any of our social media outlets. Be well, and let's strive to leave things better than we found them.

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2022 Outstanding Shotcrete Project Awards

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

Every year, I am heartened to see the many shotcrete projects submitted for our annual ASA Outstanding Shotcrete Project Awards. The winners in our annual awards program exemplify the creativity, quality, and breadth of applications that make shotcrete placement truly unique. Please take some time to review the articles from each award winner in this issue. These exemplary illustrations of what has been done with shotcrete spark the imagination and visions of architects, engineers, and owners who now know - "Well yes, we CAN do that with shotcrete."

Our 2023 Awards Program application is open on our website at www.shotcrete.org/projectawards. We look forward to your submittals this year!

STRATEGIC PLAN UPDATE

Last fall, we updated our strategic plan to ensure we stay in tune with our members' and the industry's evolving needs. Our committees, Executive Committee, Board, and staff are working on rolling the broad objectives into their goals and tasks for the coming years. Here's a quick overview of the direction we're heading.

Objectives:

1. Elevate Communications
   - Update the website to include all audiences
   - Develop application portals to target application areas (for example, pool, underground, education, certification)
   - Drive an always-on campaign to help with recruitment and perception of the organization
   - Increase accessibility of materials that educate and promote sustainability
2. Prioritize Inclusion of Younger Members
   - Develop and launch a mentorship program with measurable results
   - Conduct a membership journey exercise to personalize the experience in ASA
   - Strive to get more younger members involved with all parts of ASA programs
3. Modernize the Association
   - Social media programming led by Marketing taskforce
   - Audit content to turn into snackable content
   - Develop Shotcrete University plan and deploy (podcasts, video knowledge hub)
   - Staff succession planning

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- Shift magazine from print to digital which includes email capture

4. Increase Participation
   - Clarify plan & ownership for member recruitment
   - Secure at least 4 to 6 qualified contractors
   - Establish or expand liaison programs with EFNARC, ACPA, and ASCC
   - Gap analysis of offerings by the audience and additional programs, as needed (changes in mixes, increase # of inspector classes, pool & residential)
5. Maintain a healthy and stable financial standing
   - Review revenue enhancements
   - Explore diversifying revenue opportunities
   - Ensure 6+ months of cash reserves

Finding ourselves already in the second half of 2023, many of these objectives are well on the way to being addressed, including

- A completely new website is being developed
- Membership dues and certification fees have increased to provide better support of our programs (current and future)
- Staff and Frank Townsend (2023 President) are working on a comprehensive succession and cross-training plan for staff
- Printed magazine distribution has shifted to paid members only, with digital copies freely available on the web.

But, as you can see from the objectives, we have more work to do. Mentorship, outreach to students, better onboarding of new members, better engagement and involvement of younger members, and enhanced educational opportunities, are objectives that will keep us busy in the coming years. We also need to be continually mindful of the engineering and architectural community to increase shotcrete's recognition and acceptance of the quality work we do.

We have a great team of officers, Board members and committee members. These are the active members that help move ASA and the shotcrete industry. If you aren't a committee member, we're always open to more members becoming active on our committees. If you have any questions about how to get involved on a committee, please contact me at Charles.Hanskat@Shotcrete.org. Every member who brings their experience and knowledge makes our initiatives and programs better. We can use your help to achieve the lofty objectives delineated above that will keep ASA relevant in the years ahead.

2022 OUTSTANDING SHOTCRETE PROJECT AWARDS

OUTSTANDING ARCHITECTURE | NEW CONSTRUCTION PROJECT

Highline Garibaldi Springs Rockscape Retaining Wall | British Columbia, Canada

OUTSTANDING INFRASTRUCTURE PROJECT

Eglinton Crosstown LRT Project at Mt Pleasant Station | Toronto, Canada

OUTSTANDING INTERNATIONAL PROJECT

South East Asia Jungle Track Auckland Zoo, New Zealand

OUTSTANDING POOL & RECREATIONAL PROJECT

Thunderbird Falls, British Columbia, Canada

OUTSTANDING REPAIR & REHABILITATION PROJECT

Replacement of Flume 4/5/6 and 30 Pollock Pines, CA

OUTSTANDING UNDERGROUND PROJECT

Exchange Place Station – 9 Car Program West Corridor Jersey City, NJ

2022 HONORABLE MENTION

Pennsylvania Turnpike Commission – Tuscarora Tunnel Rehabilitation Pittsburgh, PA

2022 HONORABLE MENTION

Atlanta Airport Plane Train Tunnel - West Extension Atlanta, GA

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2022 – 2023 Awardee

Aimerick Vincent *is currently an M.Sc. candidate in the Department of Civil and Water Engineering at Université Laval, Québec City, QC, Canada where he is studying and developing shotcrete mixtures with cellulose nanofibers. Prior to this, he obtained his bachelor's degree in civil engineering from the Instituto Tecnologico de Durango, Mexico in 2018, after which he worked 3 ½ years in mining and tunneling with a large contractor, Fresnillo PLC Corporation. Aimerick is from Haiti. He worked for a few years in the mining business and decided to pursue an M.Sc. in shotcrete technology recently at Université Laval. He is highly determined, very curious, and rigorous in his work. His M.Sc. project explores the use of micro and nano natural fibres in shotcrete, hoping to further control rebound and early-age cracking.*

MASTER'S RESEARCH PROJECT
Use of cellulose nanofibers in shotcrete

Shotcrete is well known and well placed in the current context of construction; in fact, the technique, by its versatility, has made it possible to carry out a rapid and economic intervention in the construction and repair of large and small structures. Like almost every other technique used in construction, shotcrete is constantly evolving.

The great characteristics of versatility and high productivity of this placement technique can unfortunately make it vulnerable to plastic shrinkage cracking, particularly when large surface areas are placed. Therefore, to find solutions to this challenge and to improve robustness of mixture designs, numerous scientific and technological research studies have attempted to develop new mix designs to incorporate fibres to better resist cracking. At Université Laval, research has also focused on the problem of cracking and the performance of concrete[1,2,3]. Moreover, solutions are increasingly seeking to address the ecological and sustainable aspect of cementitious materials by using natural resources available locally throughout the world.

Thus, several researchers have worked on natural microfibres and nanofibers in cast concrete[4,5,6]. These studies demonstrated the potential to significantly improve the mechanical performance of concrete. Hence, natural fibres became an interesting ecological alternative in mixture designs in order to generate a more durable and economical material. However, there is still not much research on this subject, especially in shotcrete[7]. It is therefore necessary to advance our understanding of shotcrete reinforcement with cellulose nanofibers, particularly in the current context of sustainable development.

This sparked the interest and focus on this innovative study to discover the potential of adding natural nanofibers in shotcrete. The objective is to develop shotcrete mixes with natural nanofibers that offer better pumpability and placement characteristics while at the same time improving mechanical performance and durability. The objectives for this research project include:

- Develop a mixture design for both dry-mix and wet-mix shotcrete that incorporates cellulose nanofibers.
- Establish/adapt a mixing procedure for incorporating cellulose nanofibers in both shotcrete processes.

- Evaluate and study the characteristics of wet-mix and dry-mix shotcrete developed with cellulose nanofibers.
- Formulate recommendations for their use on site.

To test the contribution of natural fibres in shotcrete, several concrete spraying experiments will be performed in the Shotcrete Laboratory at Université Laval with existing measuring instruments and analysis tools and according to corresponding ASTM (American Society for Testing and Materials) standards.

This project is directly linked to the sustainable development issues of today's society. Indeed, it has a huge potential for improving shotcrete placement, especially regarding the risks of cracking, but also on the durability and mechanical properties. In this sense, the mixtures to be developed will improve the efficiency of shotcrete used in construction, which will lead to more durable and economical applications, thus reducing additional costs in the long term.

RESEARCH SIGNIFICANCE

A new rebound model will provide a better understanding of the behavior of shotcrete and therefore offer more parameters to define the rules of shotcrete mixture design. This will make it possible to allow the shotcrete mixture design to be optimized.

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Highline Garibaldi Springs Rockscape Retaining Wall

By Jesse Ebenal

Fig. 1

This retaining wall was contracted for a new townhouse development project in Squamish, BC, Canada. Vancouver Shotcrete & Shoring Inc. has serviced many municipalities and private companies over the past 30 years in the fields of shotcrete shoring, pools, and custom rockscapes.

The shotcrete retaining wall was designed to be anchored by Titan 40 self-drilling anchors with a test load capacity of 52,000 lbs (24,000 kg) each, spaced every 6 ft (2 m) on center. The temporary 4 in. (100 mm) shotcrete was reinforced with 4 x 4 x 1 in. (100 x 100 x 25 mm) welded wire mesh, with a 0.8 in. (20 mm) continuous whaler lining to span the load between each anchor. The engineer specified a 5800 psi (40 MPa) shotcrete mix for this purpose.

The permanent, structural shotcrete layer was designed to be reinforced with one layer of 0.6 in. (15 mm) rebar placed 12 in. (300 mm) apart, in order to span the load between anchors and bridge the joint between the temporary shotcrete and bedrock.

The shotcrete shoring contractor faced numerous challenges due to poor ground conditions, including loose rock and sand backfill, blasting of adjacent bedrock, running sands, and underground water. After excavating the slope with the approved shoring sequence, a 4 in. structurally reinforced shotcrete coat was applied against the vertical excavation and the Delta-Drain strip drainage system. This procedure was time sensitive as shotcrete had to be applied on the same day as the excavated panels. Our team

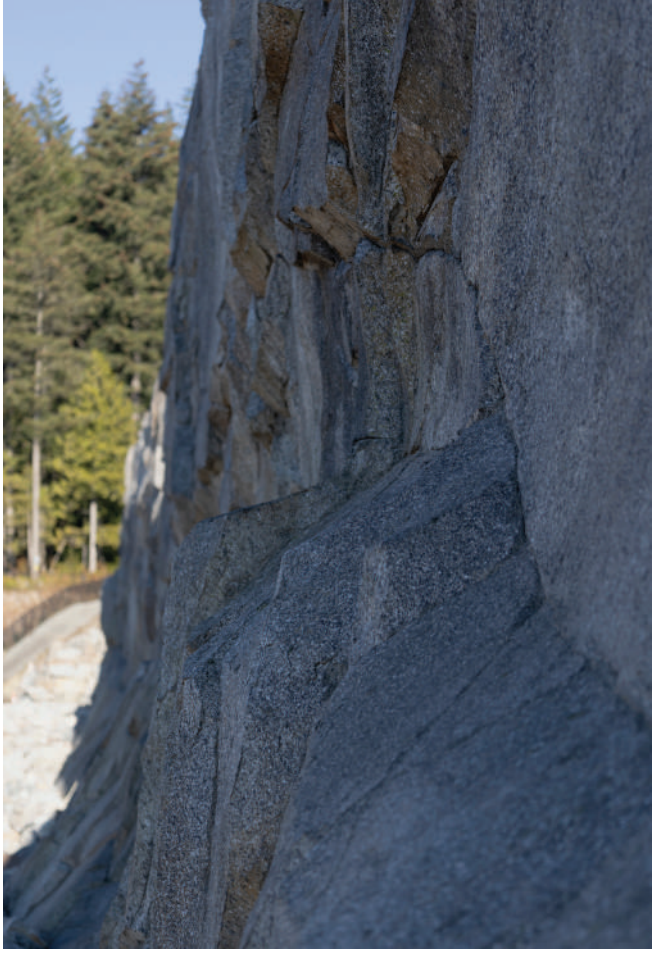

Fig. 2

Fig. 3

experienced panels sloughing into the excavation due to the poor ground conditions and had to employ measures to fill the voids. Consequently, the base coat had many undulations, which our carving team utilized in conjunction with the finished coat to give the rockscape a more defined shape.

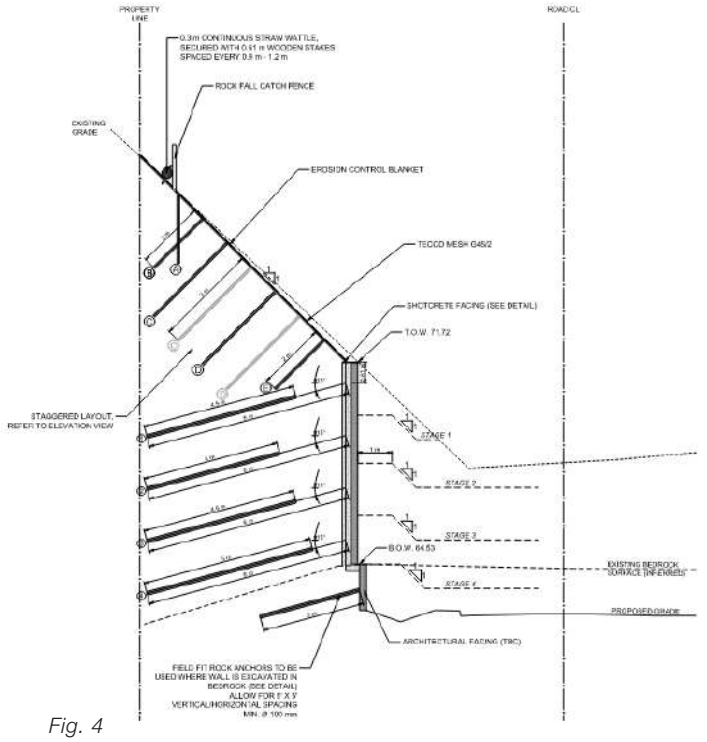

Fig. 4

Once the temporary shotcrete was complete, our next challenge was bending the 0.6 in. reinforcing for the 6 in. (150 mm) finished layer around the contours of the temporary shotcrete and exposed bedrock while working from manlifts. Our Rockscape crew successfully achieved these tight tolerances by using handheld hydraulic benders.

Given the nature of the shotcrete wall and the exposed bedrock, the second layer had to be applied along a narrow, in-use site access road, necessitating extensive coordination with other site trades. Subsequently, a 6 in. decorative rockscape finish was applied, hand-shaped, and carved by our in-house finishing crew. The shotcrete utilized MasterSure Z-60 and Master fibre F-100 fibres to aid in sculpting the shotcrete.

PROJECT DETAILS:

- 350 ft (100 m) Rock Catchment Fence
- 500 ft (150 m) Soil and rock anchored retaining wall
- 13,000 ft^2 (1200 m^2) Tecco Mesh and Coco Matting
- 5800 ft (1800 m) R32N Anchor Bar
- 8000 ft (2400 m) T40N Anchor Bar
- 4 in. Shotcrete - 6500 ft^2 (600 m^2)
- 6 in. Rockscape Finish - 9200 ft^2 (850 m^2)
- Over 450 yd^3 (350 m^3) of 5000 psi shotcrete

Upon reviewing the site, the engineer determined a grade difference of approximately 50 ft (15 m) along the northeast boundary of the property for the main access road of the new subdivision. This required a slope cut of 25 ft (8 m) from the property line at a 45-degree angle to the top of the retaining walls, with a maximum finished height of 25 ft. Due to the proximity to the property line, it was determined that a top-down, permanent shotcrete soil nailed system was the only viable option for the retaining wall.

Upon completion of the work, the contractor was not only satisfied with the wall's functionality but also considered it a significant aesthetic feature of the project. The client was so pleased, they chose to incorporate a 40 ft (12m) backlit landmark signage on the wall.

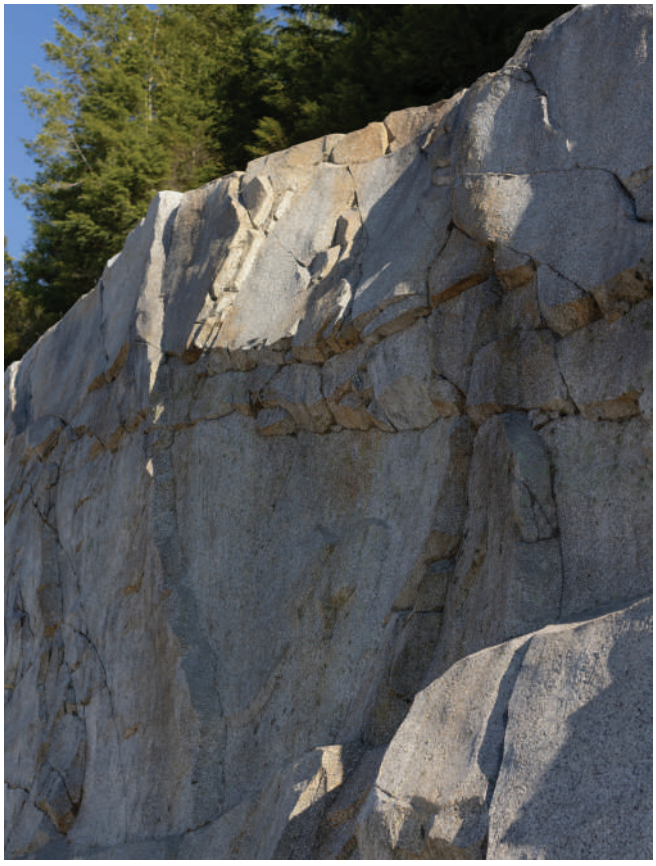

Fig. 5

Fig. 6

Fig. 7

2022 OUTSTANDING ARCHITECTURE | NEW CONSTRUCTION PROJECT

Project Name
Highline Garibaldi Springs Rockscape Retaining Wall | British Columbia, Canada

Shotcrete Contractor
Vancouver Shotcrete and Shoring Inc.

Architect/Engineer
Fontera Geotechnical Engineers

Material Supplier/Manufacturer
Cardinal Concrete

Equipment Manufacturer
REED Concrete Pumps

General Contactor
Polygon Highland Homes Ltd.

Project Owner
Polygon Highland Homes Ltd.

Jesse Ebenal *is a General Manager and has been at Vancouver Shotcrete and Shoring Inc. for 14 years. Over those 14 years, Jesse has obtained experience as a construction manager with expertise in contract negotiation, project management, and planning. His exceptional leadership and attention to detail ensure projects are executed within budget and on schedule. With a proven track record in delivering high-quality results, Jesse is a trusted professional in the industry.*

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2022 Outstanding Infrastructure Project

Shotcrete at Mount Pleasant Station on the Eglinton Crosstown LRT Project in Toronto, Canada

By Shaun Radomski, Lloyd Keller, Daniel Sanchez, and Dudley R. (Rusty) Morgan

Fig. 1: Finished Shotcrete wall at Mount Pleasant Station

Multi-million dollar underground stations are currently under construction on Metro and LRT lines in Toronto, Ontario, Canada. Traditionally, the thick, heavily reinforced structural concrete station walls have been constructed using the conventional form-and-pour concrete construction method. This construction method, while widely used, is not without its challenges. Many of the underground station sites are in congested urban areas with limited spaces for laydown of concrete formwork, and crane access time for handling and installation of formwork is often on a critical path for completion of station construction. In addition, in conventional ground-up forming, scheduling and logistics has necessitated that construction in a top-down method be employed. This method of construction, and the requirement for a series of transverse large wall supporting struts, makes setting and moving the formwork wall panels cumbersome and impractical using traditional crane hoisting methods. Recognizing these difficulties, the Joint Venture Design and Build companies constructing these underground stations have asked the following question: "Can wet-mix structural shotcrete be used in lieu of conventional form-and-pour concrete to construct these thick, often 1.0 m (39 in.) to 1.5 m (4.9 ft), heavily-reinforced mass concrete walls with embedments (electrical conduits, steel plates, grouting

tubes, and PVC water stops at vertical and horizontal construction joints) and thus largely eliminate the need for the use of formwork?"

Initially, there was skepticism in the industry in Ontario as to whether this was feasible. Reasons cited for not using shotcrete included the following:

- The heat of hydration in high-paste content concrete for the thick walls could cause thermal cracking
- There was no experience using 70% slag mixes to control heat of hydration in thick concrete sections
- Concern for increased drying shrinkage cracking due to shotcrete's higher paste content
- Proper consolidation with shotcrete placement in thick, heavily congested walls with large diameter, closely spaced reinforcing steel
- Lack of experienced, qualified structural shotcrete inspectors in Ontario

However, engineers with decades of experience in

Fig. 4: Compressed air blow pipe working in tandem with nozzleman during bench shooting.

Fig. 2: Shotcrete wall construction at tunnel openings

Fig. 3: Green Line G783-200 Fabric Concrete Placement Hose with an inner diameter of 50 mm (2 in.) connected to a nozzle assembly utilizing a unique pipe extension between the rubber nozzle tip and the nozzle air ring. Rubber nozzle tip is wrapped tight with grey duct tape.

Fig. 5: A long 40 mm (1.5 in.) diameter stiff rod vibrator provided the placed shotcrete with supplementary consolidation. Credit: Jimmy Wang.

shotcrete confirmed wet-mix shotcrete was a viable construction method. Using shotcrete placement provided a high-quality end product for the owners with valuable time and cost savings for the projects.

Based on successfully addressing all the concerns in a detailed study, the joint venture consortium, Crosslinx Transit Solutions (CTS), and the designers and constructors of the Mount Pleasant Station on the Eglinton Crosstown Light Rapid Transit Line in Toronto, elected to proceed using a low carbon, low heat of hydration 70% slag concrete mixture for construction of the structural mass shotcrete perimeter walls at this station.

CTS designers required the concrete mix to meet the following design performance requirements:

- Compressive strength of 35 MPa (5000 psi) within 56 days
- Maximum water to cementitious materials ratio of 0.40
- Rapid chloride ion penetration of 1500 coulombs within 91 days

- "As-batched" plastic air content of 7-10% at discharge into the pump and "As-shot" plastic air content of 5+/- 1.5% after shooting in-place
- Slump of 90 mm +/- 20 mm (3.5 in. ± 0.8 in.) at discharge into the pump
- Maximum heat of hydration in the center of the mass shotcrete walls to not exceed 70°C (158 °F), and the temperature differential between the near surface and the center of the mass shotcrete walls not to exceed 20°C (68 °F)

The concrete mixture was designed with 30% GUbSF Portland cement and 70% slag cement. A natural cellulose fibre at 0.45 kg/m^3 (1.14 lb/yd^3) dosage was incorporated into the mix to enhance pumpability, shootability, adhesion/cohesion, stackability, and finishability. It also helped mitigate plastic and drying shrinkage cracking.

Shotcrete equipment was typical for wet-mix shotcrete. The nozzle assemblies were modified to address the thicker walls. The custom nozzle assembly used the following:

- A unique pipe extension to reduce the shooting distance to the receiving surface at the back of the wall (Fig. 3)
- A rubber nozzle tip wrapped with duct tape to reduce bulging of the nozzle tip during bench shooting, which provided a more concentrated shotcrete stream and a "rifling" type action
- In thick sections, supplemental consolidation around the back-reinforcing steel bars to the outer wall face was provided by a stiff-rod vibrator (Fig. 5) with a 40 mm (1.5 in.) diameter.

Each ACI-certified wet-mix nozzleman underwent prequalification by shooting a section of a full scale 1.3 m (4.3 ft) thick heavily reinforced mockup representing a perimeter station wall at Mount Pleasant Station (Fig. 7). After shooting the mockup, several block sections were cut open with a wire saw, and upon close evaluation, the quality of shotcrete around the reinforcing steel and to the outer membrane was observed to be excellent. (Fig. 8 and Fig. 9)

Construction began (Fig. 10) following the first wave of COVID-19, continued during the Delta variant wave, and ended at the onset of the Omicron variant wave. Not to

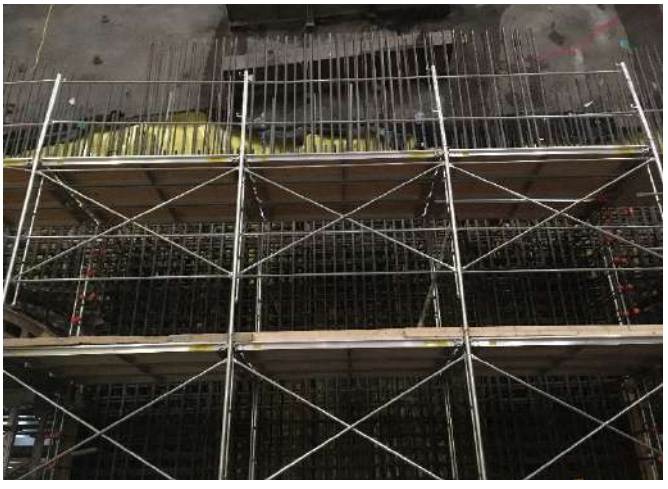

Fig. 6: Multi-level scaffolds were used to provide nozzleman with clear and safe access to the work

Fig. 7: Full-scale 1.3 m thick station wall mock-up

Fig. 8: A wire saw cut section of mockup showing excellent consolidation of shotcrete around the three layers of #35M (#11) rebar at the back of the work and to the outer membrane next to the embedded plastic water stop. Credit: Jimmy Wang.

Fig. 9: Another example of a wire saw cut section of mockup showing excellent quality of shotcrete at the transition between the shotcrete and the self-consolidating poured concrete

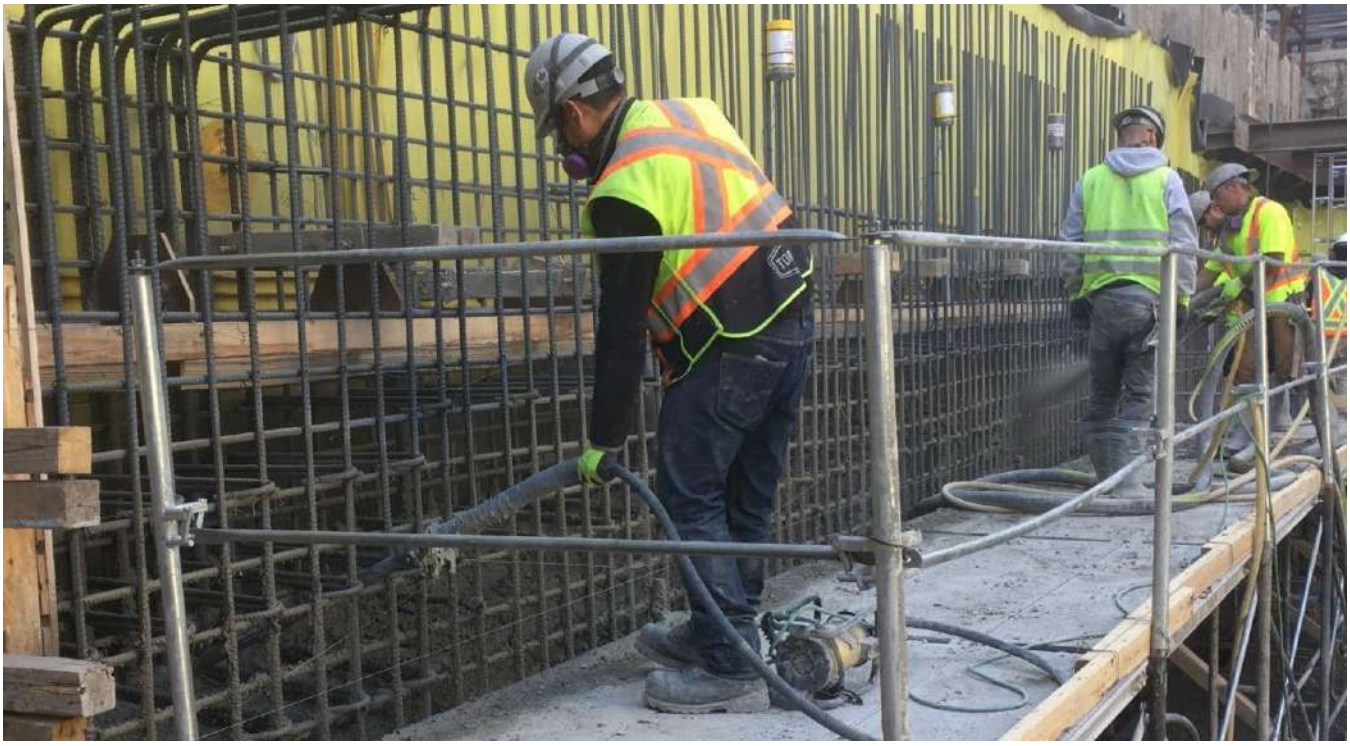

Fig. 10: A close-up view of the shotcrete contactor's nozzleman bench shooting (background) followed by an operator of a long stiff rod vibrator (foreground) being inserted into the work to "lay down the bench" and provide the shotcrete with supplementary consolidation around the back reinforcing steel.

overstate the issue, but this posed many challenges to CTS to stay on schedule while keeping all personnel safe. Very strict safety protocols were implemented onsite by CTS.

A total of 7200 m^3 (9400 yd^3) of concrete was supplied to the project and routinely met the plastic shotcrete properties of 90 mm +/- 20 mm slump at discharge into the pump and 7- 10% plastic air content at discharge into the pump. Compressive strength satisfied the specified minimum compressive strength of 35 MPa (5000 psi) at 56 days. Thermal monitoring data revealed the temperature rise in the center of the mass shotcrete walls satisfied the 70°C (158 °F) limit and the temperature differential between the near surface and the center of the mass shotcrete walls satisfied the 20°C (68 °F) limit.

Final coat was shot, cut and finished to the specified line and grade of shooting wires. The specified final finish was provided using floats and trowels. The finished surfaces were free of voids, sags, tears, or plastic shrinkage cracks. All shotcrete rebound, overspray, and cuttings were removed from the work and disposed of in an environmentally acceptable way. All shotcrete was cured to minimize drying shrinkage cracking for at least 7 days from time of shotcrete placement.

This project has elevated the knowledge and acceptance in the Toronto construction community on the use of shotcrete to construct thick (up to 1.5 m), heavily reinforced metro or LRT underground station structural walls using the "hybrid" (shoot and vibrate) shotcrete construction method, with high-volume slag concrete mixtures (up to 70% slag). Success required careful planning, control of the concrete mixture design, appropriate preconstruction mockups, qualified ACI-certified nozzlemen, attention to consolidation throughout the thick wall sections, testing, and qualified inspectors.

2022 OUTSTANDING INFRASTRUCTURE PROJECT

Project Name
Eglinton Crosstown LRT Project at Mt Pleasant Station | Toronto, Canada

Shotcrete Contractor
Torrent Shotcrete Structures Ltd.

Architect/Engineer
SNC-Lavalin

Material Supplier/Manufacturer
Innocon Ready Mix & Canada Building Materials

Equipment Manufacturer
REED Concrete Pumps

General Contractor
Crosslinx Transit Solutions

Shotcrete Consultants and Quality Inspections
WSP E&I Canada Ltd.

Project Owner
Metrolinx & Infrastructures Ontario

Shaun M. Radomski *is a Civil Materials Engineer specializing in concrete and shotcrete technology and the evaluation and rehabilitation of infrastructure. He has over 17 years of civil materials engineering, inspection, and testing experience in Canada and the United States. He is a member of ACI Committees 506, Shotcreting; and 661 Shotcrete Inspector Certification. Based in Calgary, AB, Canada, Mr. Radomski has extensive shotcrete consulting, inspection, and testing experience across North America, all with WSP and its predecessor companies. He has experience with both wet-mix and dry-mix shotcrete, vertical and overhead shotcrete, mass shotcrete, shotcrete underground, alkali-free-accelerator addition at the nozzle, and incorporating steel fiber, polypropylene fiber, natural hemp, and cellulose-based fibers in shotcrete mixes for added toughness, enhancing adhesion/cohesion, finishability, curing, and for controlling shrinkage cracking. Radomski received a Master's Degree in Civil Engineering from Ryerson University, Toronto, ON, Canada, where he conducted research on using SCM's to enhance the durability of concrete against sulphate attack and alkali aggregate reactivity.*

Lloyd Keller *is the founder of Research and Development and Quality Control for EllisDon Construction in Mississauga, ON, Canada. He is a Fellow with ACI and participates in numerous committees for ACI and CSA in Canada. He was educated at BCIT in Canada specializing in Civil and Structural Engineering Technology. His research efforts over the last number of years have focused on Self Consolidation Concrete (ACI 237) and the prediction of formwork pressure. Other areas of his research over the last few years have been the use of shotcrete for structural installations and the control of exothermic heat generation with the utilization of high-volume supplementary cementing materials.*

Daniel Sanchez *is a Professional Engineer with over two decades of experience in the heavy civil infrastructure construction industry. Highly experienced in the lifecycle of the project from conceptual design through development and delivery, he has participated in numerous underground projects in Spain and Canada, including Metro Line 9 in Barcelona, the Eglinton Crosstown LRT in Toronto, and the Scarborough Subway Extension. Daniel holds a Master's Degree in civil engineering from the University of Granada, Spain.*

Dudley R. (Rusty) Morgan, *FACI, is a Civil Engineer with over 50 years of experience in the concrete and shotcrete industries. He served as a member and Secretary of ACI Committee 506, Shotcreting, for over 25 years. He is a past member of ACI Committees 365, Service Life Prediction, and 544, Fiber-Reinforced Concrete. Morgan is a founding member and Past President of ASA. He is an ASA/ACI C660-approved Shotcrete Nozzleman Examiner. Morgan is a past member of the Canadian Standards Association Concrete Steering Committee and was a Canadian Representative on the International Tunneling and Underground Space Association Committee, Shotcrete Use. He has worked on over 1200 concrete and shotcrete projects around the world during his consulting career, he has edited seven books, and he has published over 165 papers on various aspects of concrete and shotcrete technology. In 2001, Morgan was elected as a Fellow of the Canadian Academy of Engineering.*

Editor's note: *Watch future issues of Shotcrete magazine for a two-part series of articles with more detailed insight into the pre-construction and construction phases of this project.*

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2022 Outstanding International Project

South East Asia Jungle Track | Auckland Zoo, New Zealand

By Darin A. Brenner and Monica Lake

Fig. 1

Aqua-Environs Construction was subcontracted to provide shotcrete installations as a part of our broader scope of work: construction services to create a naturalistically themed terrestrial and aquatic habitats for Auckland Zoo's new South East Asia Jungle Track (SEAJT), the Zoo's most ambitious project in its 99-year history. Our company utilized shotcrete to help create natural, realistic animal habitat areas as well as public spaces to achieve engaging natural environments for animals and fish in the zoo's care and for the zoo's visitors. Due to unique structural and theming capabilities, we chose to use wet-mix shotcrete in many key areas as both a finished surface as well as the structural form to help us create these remarkable habitats; this will ensure their long-term durability and function as Auckland Zoo's South East Asia Jungle Track. The habitats created include Lowlands (Sumatran tigers), Lowlands (Asian small-clawed otters), and Swamp Forest (Sunda gharial/crocodile).

LOWLANDS (SUMATRAN TIGERS)/ZONE 3

The Lowlands habitat consists of a series of interconnected tiger areas; each area is linked by an arched steel bridge that enables the tigers to pass over the visitor pathways. The experience is an up-close (and safe) encounter with tigers

looking down on visitors. The stunning Lowlands habitat features the use of shotcrete to create realistic dens, earth embankments, waterfalls and pools, and rock outcroppings where tigers occupy high rock plateaus while visitors sit on themed rock escarpments and walk alongside gravel and mud embankments. Sumatran tigers are endangered, and the hope of this facility is to provide additional support to genetic stock being preserved by conservation-minded ethical zoos around the world (such as the Auckland Zoo) whilst providing enriching habitats and quality welfare and care to the tigers as well as the hope for future cubs.

Our team performed all shotcrete theming work within the tiger habitat areas. We used various underlying forms over a steel reinforcement support system that was established for shotcrete placement. The purpose was to create artificial environments sculpted and textured for often hyper-realistic artificial earthen embankments. Additionally, we focused on crafting life-like rock features, including waterfalls, pools, and rock outcroppings. The Lowlands Sumatran tiger exhibit includes a large, covered public viewing shelter where several significant artificial rock forms were fabricated to provide visitors and tigers a shared safe experience on the same rock. These shelters are safely divided by large glass viewing windows that are seamlessly integrated throughout the rock outcroppings; this provides comfort and access for all for up close encounters and views. Great visitor experiences are enhanced by the shelter's rock elements which allow visitors to sit, climb, and stand adjacent to a tiger. The appearance of the shotcrete rock was designed to look like the basalt prevalent in Auckland, New Zealand. In addition, local basalt rock, scree, and boulders were utilized to hem in the shotcrete rock formations to more organically integrate with other sculpted shotcrete formations before finishing with scenic staining, coloring, and aging; all of this was done before the addition of soil and plantings to soften up these hard elements.

LOWLANDS (ASIAN SMALL-CLAWED OTTERS)/ZONE 3

Located adjacent to the Lowlands habitat for tigers is the Lowlands habitat for small-clawed otters. The shotcrete used in this area consists of two forks of a gurgling stream, sandy pebbly riverside beaches, massive hollowed out logs, and a waterfall spillway through a rock crevice creating a series of clear, sandy pools and shaded, mossy banks. Most of the habitat's forms, features, and surfaces were reliant on elaborate shotcrete artistry. In some cases, we incorporated bits of real rock, pebble and sand substrates which were carefully and strategically embedded directly into the outer surfaces of the shotcrete matrix. This technique was used to re-create natural streambeds or landscape embankments typical of a small stream where alluvial rock and sedimentary layering is present in differing amounts. In this habitat, our team's ultimate challenge was to provide an endless variety of enrichment opportunities throughout the habitat for the inquisitive and energetic small-clawed otters, including two artificial logs/tree snags. One of the trees

Fig. 2

was fabricated to form a natural den that was large enough to accommodate a family of otters. This fully structurally-formed shotcrete den, was hollowed out by adopting other products and techniques to create many entrances carefully hand carved by our artisan team prior to final scenic painting, staining, and aging with lichens and moss.

SWAMP FOREST (SUNDA GHARIAL/ CROCODILE)/ZONE 2

The Swamp Forest habitat is an immersive, hot house indoor dome structure. It encompasses a series of independent and interconnected pools, each with varying depths, that enables visitors to follow along a clear, tropical river filled with hundreds of fish including the rare Arawana species. The larger river pool within the habitat is home to the Sunda gharials, also known as Tomistoma crocodiles, which can grow up to 4m (13 ft) long or more. All the subcontractors called this area the "Tomidome" throughout the construction phases. This unique and unusual habitat was created within a large, circular pre-cast concrete building capped by a 30m (98 ft) high transparent ethylene tetrafluoroethylene (ETFE) dome structure. The greenhouse environment is a light filled,

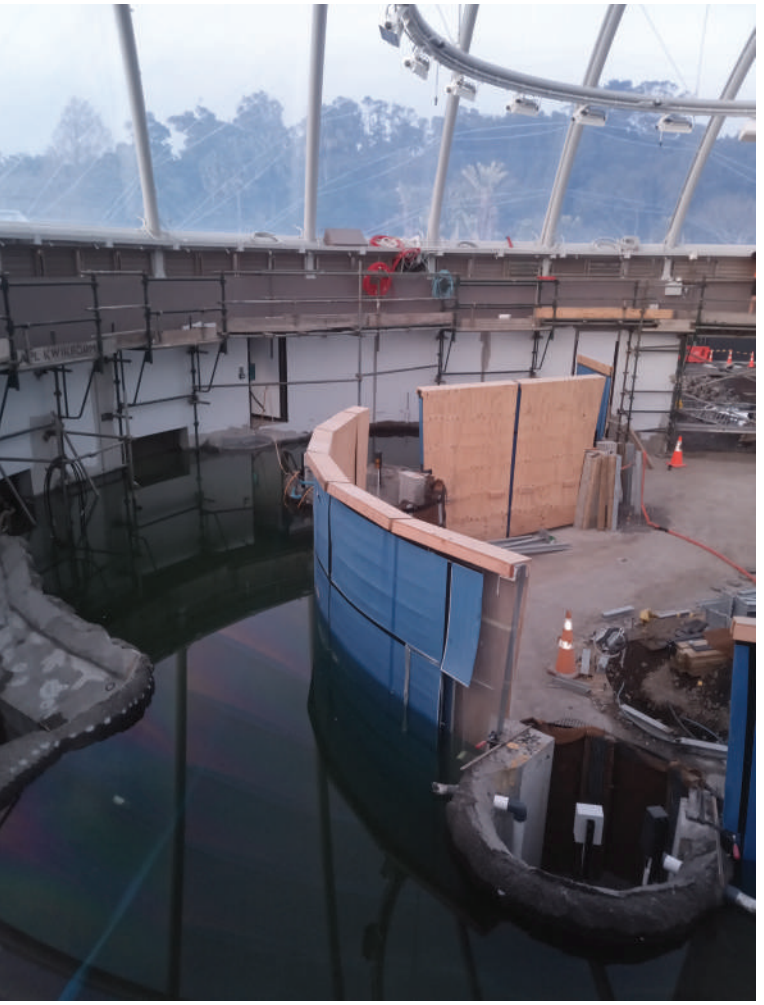

Fig. 3

temperature-controlled space with high humidity to simulate a swamp forest in South East Asia with a halogen "light clock" keeping tropical/equatorial time periods during winter months. A high degree of realism for the riverbanks and beds was achieved by utilizing the application of shotcrete, which was initially used as the reliant form for the structure and the prevalent shapes as well as to accommodate the complex, free-form design layout of high-density 12 mm (0.5 in.) diameter steel reinforcement at 200 mm (8 in.) on center. The steel reinforcements were shaped in natural, obtuse formations making the tasks of engineering, installation, waterproofing, and final shotcrete application challenging to achieve reliable structural integrity whilst authenticating the perceived environmental eco-type. Very specific animal husbandry items were crucial to the life science team and needed to be achieved by allowing these large crocodilians the opportunity to rest comfortably beneath undercut, dark shadowed ledges. It also needed to allow them to bask in the sun's UV rays while laying on water ledges and beaches and not injuring their bodies and feet while allowing them unabated movement in the habitat, mimicking their natural behaviors in these environments in the wild.

These forms and shotcrete applications had to also meet the stringent, functional water containment and waterproofing purposes as they are essentially large aquariums. These aquariums incorporated numerous large acrylic viewing panels up to 80 mm (3 in.) thick and 7 m (23 ft) placed along the visitor pathway and pools. The entirety of this habitat is quite similar to a large-scale terrarium or palladium but one that visitors can actually walk in and through. The entire immersive habitat is indoors and was completed with diverse and unusual tropical plant flora for a truly unique and rare botanical landscape. The transparent (ETFE) domed-ceiling habitat also boasts a durable greenhouse, and contains land-based, in-water, and shore-based soft-scaping plants as well as large, towering trees. A rain curtain set above and throughout the dome structure provides an authentic overhead rain effect for visitors, plants, and wildlife. A Bornean swamp forest environs soundtrack playing through a speaker system completes the experience by immersing visitors in forest and river sounds as they experience the habitat. Visitors are encouraged to bring their umbrellas and be prepared to listen to the rain and fauna!

Shotcrete enabled our team to utilize their artistry and technical skills to create the South East Asia Jungle Track, a world-class, highly immersive experience that brings people together to build a future for wildlife. Our client, The Auckland Zoo, located on the North Island of Aotearoa, New Zealand, enlisted the expertise of both local and renowned international zoo design and construction experts. Ignite Architects, a local firm, worked in partnership with SHR/Studio Hanson Roberts from Bainbridge Island, WA, USA, and various zoo staff on this project. Their collective goal was to plan, design, and construct a revitalized series of habitats for the South East Asian animals and fish in the Zoo's care, encompassing approximately one-fifth of the total acreage of the zoo. Particular zoo staff focus and coordination was led and conducted by Auckland Zoo's Capital Infrastructure Zoo Director, Monica Lake. Assisting here were team leads including Lauren Booth from the carnivore team; Richard Gibson, Head of Animal Care and Conservation; and Don McFarland, lead of the Ectotherm team. Aqua-Environs was invited to invent and create new concepts and methods for many themed construction elements both prior and in-situ thanks to the zoo staff, architect teams, and an open-minded prime contractor and project manager working together, making all these unique outcomes possible.

The project was completed and open to the public in October 2022, and the new track is a must-see destination for New Zealanders and visiting international tourists as they join the Zoo in celebrating its upcoming centenary. As a result of their familiarity with our work, Aqua-Environs Construction was selected to lead this immersive habitat creation by the prime contractor, NZ Strong of Auckland, New Zealand and Auckland Zoo staff. In particular, NZ Strong Project Manager, Garyth Jones, was instrumental in helping select Aqua-Environs due to his long history and experience with zoo construction projects; this allowed for a great deal of collaboration and ease of progress on new ideas and solved a myriad of construction buildability problems within the entirety of the SEAJT.

While visitors will be amazed and delighted by the natural feel of the South East Asia Jungle Track, few will realize that over 100 m^3 (130 yd^3) of shotcrete was applied throughout all habitats/zones. Much of it consisted of outer-detailed artificial rock or other environment simulations whilst many significant areas served structural only or a combination of purposes as well. On time, properly mixed concrete deliveries by Atlas Concrete of Auckland proved critical to our success. Close to 70 m^3 (90 yd^3) of shotcrete was designed and applied with a special mixture for the Swamp Forest pools. The special mixture met not only the engineers' and architects' standards, but our own higher standards as well. We had wished to have a shotcrete mix which would inhibit the transfer of concrete minerals and chemicals into the Swamp Forest aquariums and pool water both immediately and over time. This was especially important as the Swamp Forest habitat portrays and behaves both aesthetically and chemically similar to the water conditions of South East Asia lowland peat bog rivers which typically have a pH range that is slightly acidic and are soft waters. We decided to utilize a product known to have gelling, swelling, and sealing attributes within the concrete matrix. Aquron, distributed by a New Zealand vendor, Markham NZ Ltd., mitigated the possibility of too much mineral transfer once in contact with the aquarium pool water. Supplemental complete "system" surface waterproofing coatings and layers were then applied by a certified team from Markham NZ Ltd. once shotcrete placement was completed and in the curing phase, prior to any water filling. A specialized, low-swelling synthetic water-bar joint tape compound, provided by Markham NZ Ltd., was part of the waterproofing system and sealed the many construction joints required by the design engineers to eliminate potential cold-joint concrete leakage. The shotcrete mixture design consisted of a 30 MPa (4500 psi) low-slump mix, utilizing synthetic short poly fibers fly ash to help hold and aid the creation of the unusual shapes and overhangs found throughout the pools whilst providing a good matrix for the desired waterproofing compatibility. The use of other products made of crystallizing waterproofing products or silica fume would likely have proven disadvantageous in this instance due to the unique and sensitive nature and qualities of the environments attempting to be replicated and the ultimate water conditions sought by the zoo's ectotherm team. To minimize shrinkage in the pool shotcrete, we incorporated a shrinkage-reducing admixture and conducted regular laboratory tests for compressive strength and shrinkage. We also installed remote temperature monitors within the shotcrete matrix to track and record curing temperature changes. This meticulous approach ensured optimal strength, durability, and quality for the pools' shotcrete, meeting required standards for long-lasting durability.

In the Lowlands/Zone 3, throughout the rock and earthen environments where artistic shotcrete was placed, we often elected to incorporate various pigments directly into the concrete mixes in varying amounts. We incorporated these pigments at the batch plant. The pigment was comprised of select oxides from our two, quality New Zealand suppliers: Permacolour and Peter Fell, both of which aided and directed us with selection and use.

SUMMARY CONCLUSION:

What typifies this project for our entire team is our ability to find ways to work through the often sudden and extreme challenges that occurred throughout nearly this entire project due to COVID and because of the New Zealand government's very strict regulatory system. The government successfully implemented measures to keep COVID out of the country, and to stamp out domestic outbreaks, which they achieved for most of the project's duration. All around the world, all nations and people were impacted to one degree or another by COVID. However, in New Zealand, to keep COVID out of the country, and to stamp out domestic outbreaks, the lockdown meant that for certain periods, individuals were unable to go to work at all. Thus, we had several long and short delays with some full stops for up to six weeks on two separate occasions. These interruptions greatly affected our progress and ability to stay ahead and earn a living, creating a mystery of when we would be able to resume work.

Fig. 4

Fig. 5

Additionally, the New Zealand government had created a series of strict COVID levels which most people followed throughout the duration of the main COVID period and were obediently followed by the prime contractor and all sub-contractors on this project. Initially, I had personal concerns on this project because I was working far from home and my family was living in California, USA. COVID came up just two months into the project in early 2020, which made for a "Twilight Zone" feel when New Zealand's country-wide lockdown began in late March 2020. Thankfully, I had the opportunity to make it home to see my family in the U.S. twice during the entire SEAJT project despite the challenges posed by restrictive border regulations, which were open only to citizens and permanent residents. This involved special air ticket bookings, mandatory quarantine in New Zealand's government-run hotels upon return, and multiple mandatory COVID tests at these facilities, as well as pre-departure flight requirements and COVID tests. New Zealand was one of the first nations to initiate these requirements in early-to-mid 2020, and they continued to a lesser extent until June 2022.

We began Aqua-Environs Construction in late 2006 to early 2007 when our family lived in New Zealand. However, our very first two projects were done in Le Clede, Idaho, in early-mid 2006 for friends with a keen passion for the streams and waterfalls of the mountains.

In 2017, we decidedly moved to California to be near extended family and provide better schools and universities for our children. We will continue returning to New Zealand/Oceania for these sorts of special and exciting projects if they suit our family and the personal and business relationships we have built over the years within New Zealand.

The Auckland Zoo will always be a special place for us for many reasons. The staff treated us like family which made the experience much more bearable and comfortable given its unusual 100-year ironic circumstances on two fronts - a centennial and a pandemic! We hope the Auckland Zoo's South East Asian Jungle Track is enriching for the wildlife and truly a centerpiece for the community and the country of New Zealand for years to come. This project also created a special memory to earmark the Zoo's first Centennial celebration.

We are grateful to also be able to share it with the ASA, Shotcrete magazine, and its readership.

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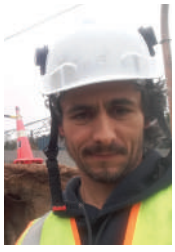

Darin A. Brenner *is a Co-Director, with Ora B. Brenner, of Aqua-Environs, a family-owned, specialized landscape, aquatic, and theming construction business of over 15 years. Darin is passionate about exploring new ideas as a landscape artist and as a builder of natural features and elements. Both Darin and Ora have run the operation from Auckland, New Zealand since its founding and will continue to do so as the "roots" of the business foundation. They recently moved and now base themselves out of Sacramento, California as Aqua~Environs Construction LLC and will be looking to a future in North America assisting zoos, aquariums, civil infrastructure, commercial, and a variety of unique, private client projects.*

***Monica Lake**, Capital Infrastructure Director, Auckland Zoo, New Zealand, has more than 30 years of experience in the management of design and construction for public projects and good, modern zoos. She is Head of Zoo Environment, Design & Construction at Auckland Zoo. She has recently completed the South East Asia Jungle Track, the largest project in the Auckland Zoo's hundred year history, and the winner of numerous design and construction awards. Before taking up her role at Auckland Zoo, she was Director of Projects at Woodland Park Zoo in Seattle, Washington, USA where her work included a Humboldt Penguin habitat which received AZA's 2010 Exhibit Award top honors. Before her work in zoos, she managed a wide range of projects for the City of Seattle, including Seattle's New City Hall and plaza. Monica grew up in Pasadena, California, USA, and from an early age, was inspired by plants and landscapes. She earned a B.A. in Economics at the University of California, Santa Cruz and attended a Master of Architecture program at the University of Washington.*

2022 OUTSTANDING INTERNATIONAL PROJECT

Project
South East Asia Jungle Track
Auckland Zoo, New Zealand

Shotcrete Contractor
Aqua-Environs Construction

Architect-Engineer
Studio Hanson Roberts

Material Supplier/Manufacturer
Atlas Concrete

Equipment Manufacturer
Concrete Pumping Equipment NZ Ltd. & Putzmeister Products

General Contractor
NZ STRONG

Project Owner
Auckland Zoo – Tātaki Auckland Unlimite

2022 Outstanding Pool & Recreational Project

Thunderbird Falls

By Dan Pitts

Fig. 1

Building a swimming pool on the edge of a cliff can be an exciting and challenging project, especially when using shotcrete as the main building material. Shotcrete is chosen for its strength, durability, and ability to create complex shapes, which is essential for a pool in such a unique location.

For this specific project, the pool was constructed on bedrock at the edge of a cliff in the coastal mountain range. The engineering specifications called for a double mat of 12 in. (300 mm) thick shotcrete, with footings that were 28 in. (700 mm) thick and reinforced with three layers of rebar. The grotto, an oddly shaped suspended slab, was also constructed using a double mat of rebar. To form the roof of the grotto, panel castings were created by shotcreting into a mold made from previously created art rock. These castings were then used as part of the grotto's structure.

Due to the pool's free-form shape and its location on the side of a cliff, traditional form-and-pour concrete methods were not feasible. Instead, one-sided forms made of foam were used and left in place to provide insulation (R-value) for the above-ground walls, considering the cold Canadian winter. The use of foam as a backer form raised concerns about the heat of hydration, but careful monitoring of temperatures and continuous wet curing for ten

Fig. 2. Grotto roof and suspended slab finish.

days after the shotcrete was initially set helped mitigate these concerns.

The rockwork's rough shape was achieved by skillfully shaping the shotcrete during the shooting process. Separate shots were performed for the structural columns of the grotto with foam once again utilized as a form to expedite the construction process.

Before embarking on such a project, several important factors had to be considered. First and foremost, the structural stability of the cliff was assessed by geotechnical experts, confirming the suitability of the bedrock. Designing the pool to blend seamlessly with the surrounding landscape was crucial, with specialized shotcrete rock artists

Fig. 3. Bird's-eye views of pool on the cliff edge.

Fig. 4. Sculpted rock dry entry to grotto.

ensuring an authentic ocean rock appearance. Excavation required careful planning to avoid destabilizing the cliff, and precautions such as anchoring rebar and chains were taken to secure loose boulders.

Shotcrete, with its strength and versatility, was used to construct the pool. The combination of foam and rock castings served as the forming materials with the foam left in place to provide insulation. Steel reinforcement played a vital role, enhancing the pool's strength and stability. The grotto lid, for example, was constructed using panel castings made from molds of sculpted rock, providing both structure and aesthetic appeal.

Fig. 5. Grotto swim through with "rock" columns.

The design of the underwater portion of the pool drew inspiration from swimming experiences in gorged river spots around Squamish, BC, Canada. The shotcrete rockwork was integrated into the pool structure, saving time, materials, and labor. A skilled nozzleman's expertise was essential in shaping the rockwork to be functional, realistic, and cost-effective. Adequate reinforcing steel coverage and consolidation were prioritized to ensure strength and durability. The placement of shotcrete and the nozzleman's experience played a significant role in delivering high-quality results, which are the hallmark of Oceanrock's reputation.

Dan Pitts *Owner/Operator of Oceanrock Art Ltd. (Oceanrock), Squamish, British Columbia, Canada. Oceanrock specializes in artisanal concrete rock environments. Everything we do is custom-designed and hand-crafted to ensure the perfect fit for your landscaping or construction project. With years of experience and top-notch concrete artists, Oceanrock is ready to build the rock environment of your dreams.*

2022 OUTSTANDING POOL & RECREATIONAL PROJECT

Project Name
Thunderbird Falls, British Columbia, Canada

Shotcrete Contractor
Oceanrock Art Ltd.

Architect/Engineer
CA Boom Engineering

Material Supplier/Manufacturer
Cardinal Concrete

Equipment Manufacturer
CanCrete/Putzmeister Canada

General Contractor
Oceanrock Art Ltd.

Project Owner
Guy & Jaime Morum

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2022 Outstanding Repair & Rehabilitation Project

Shotcrete versus Fire and Water

Replacement of Flume 4/5/6 and 30

By Jason Myers

Fig. 1: Before shotcreting of the flume

On August 14, 2021, the Caldor Fire started in Northern California near Pollock Pines, CA. The fire ended up consuming almost 222,000 acres (90,000 hectares) and seriously threatened South Lake Tahoe. Besides the over 1000 structures that were lost, the fire also burned along a major portion of the El Dorado Irrigation District's Canal (EID) which provides drinking and irrigation water to numerous communities throughout the area. EID found that four of their flumes were destroyed and lost in the fire. Once the area was designated as safe, EID brought Syblon Reid (SRCO) onto the site to determine what repairs were needed to get the water flowing again. Syblon Reid and Dees Hennessey Inc. (DHI) have worked on many different projects in the area in partnership with the EID, and we were put on notice before the fire was even out that shotcrete was going to be needed on the project.

The first set of challenges were these: how to get to a canal that you have no direct access to; how to get the nearest supply of concrete when it is three hours away; and how to complete the work over the winter. In the end, shotcrete was able to answer all of these questions in concert with our fellow partners working together. Three of the sites required pumping over 1000 ft (305 m) just to get to the work location, with an elevation drop of up to 500 ft (152 m) from the

Fig. 2: Streambed

Fig. 3: Canal before shotcrete

Fig. 4: Canal transition

Fig. 5: Look at Flume

pump to the jobsite. The fourth location required a new access road to get to the site, and once the access road was completed, it turned into a relatively normal project of pumping over 500 ft (150 m) to get to the end of the canal. Concrete was also properly dosed to retard the concrete for up to four hours in order to reach a high enough slump to pump the distance, but it was also accelerated so that it would be able to be stacked vertically on the canal walls. The nearest highway was visually only about a ¼ mile (.04 km) from the jobsite, but a canyon and river laid in between. It was always good to see or hear your concrete truck drive by, knowing that it would take at least another hour because of the time it took to cross the nearest undamaged bridge and to drive up and over the mountain above you, all the while hoping the driver did not get lost on the remaining 9 miles (14.5 km) of mountain roads to the jobsite.

The total scope resulted in over 1100 ft (335 m) of canal replacement, over four locations, with almost 1000 yd^3 (760 m^3) installed on the project. Shotcrete was integral to the project because it was able to adapt to any of the work situations. SRCO only had to form the outside of the canal walls which, once heavy plastic was placed over the top, created its own shelter for everyone to work in and allowed shotcrete to be installed as long as the weather permitted truck delivery to the site. Additionally, shotcrete could easily be adapted to either the horizontal or vertical positions because adjustments made were in shotcrete procedures and not in the material. Since there was minimal formwork, the location of joints, waterstops, and sequencing was changed several times without rework of the forms. Shotcrete placement easily adapted to varying conditions like the waterstops and warped wing walls. Since shotcrete placement always has an exposed face, it is easy to verify proper consolidation, workmanship, and finishes immediately after shooting.

Fig. 6: Shotcrete walls

A challenge at the first site exemplified a key advantage of shotcrete on the project — the ability to place shotcrete wherever we could get the hose to reach. A road to the site was required for access before any of the canal reconstruction could begin. However, while this access work was in progress, a retaining wall was required at the canal site for access to the other side of a stream, so a bridge could be constructed and the demolition and removal of the old canal could continue. The question arose of how to install shotcrete in a location you had virtually no access to. The versatility of shotcrete allowed us to switch to a premixed bag mixture which we batched on site. This allowed us to shotcrete the wall, permitting the project to continue until we were needed for the main canal work a couple of months later.

Shotcrete's versatility continued to shine throughout this project. DHI's crews were familiar with many different applications of shotcrete and had the opportunity to utilize their skills including concrete lining in a new stream bed with hand-stacked rocks; providing a rat slab for the coming rain

2022 OUTSTANDING REPAIR & REHABILITATION PROJECT

Project Name
Replacement of Flume 4/5/6 and 30
Pollock Pines, CA

Shotcrete Contractor
Dees Hennessey Inc.

Architect/Engineer
GHD Inc.

Materials Supplier
Folsom Ready Mix & The Quikrete Company

Equipment Manufacturer
REED Concrete Pumps

General Contractor
Syblon Reid

Project Owner
El Dorado Irrigation District

and snow; shotcreting the invert and walls of the new canal; and armoring a hillside against erosion — sometimes from the same truck! SRCO tried to pump a couple of times with a local pumper but then got frustrated cleaning out clogged and broken hoses along the hillside. Meanwhile, having an experienced shotcrete crew and team, we were able to work around the same issues with no difficulties and made improvements along the way. After we proved what our team was capable of doing, we ended up providing most of the pumping and concrete services for the difficult sections of the project. In the end, we were able to continuously pump through over 1000 ft of line pump, with over 500 ft of drop, without any major difficulties; we did this just to get material to the different work locations.

Each of the sites had its own challenges, but we were able to devise a successful game plan around each situation. For example, on three of the sites, we needed to shotcrete the invert of the canal and then the sides of the canal monolithically without getting the rebound from the walls into the freshly shot invert. We also worked with SRCO to forge a plan to work through concrete placement during winter temperatures, keeping within ACI guidelines and moving the project forward. This included sometimes working for only a couple of days between rain and snow storms in order to shotcrete sections to protect against saturation of the soil that would require replacement of all the invert excavations. There is nothing better, or worse, than getting the call that the bladder dams on a section did not hold and the section of shotcrete that you placed a couple of days before is under numerous feet of water — at least it would get a good water cure.

This was a very complex project, which required us to work under emergency conditions. Shotcrete was critical to its success. The combination of shotcrete's flexibility and DHI's experienced crews allowed shotcrete to be utilized for all the concrete needs on this project. Unlike conventional projects with a footing crew, slab crew, and wall crew, a shotcrete crew was able to bounce between all of these items, sometimes doing all three at once. By preplanning and appropriately using available admixtures, concrete mixes were able to be adapted for these applications as well. Shotcrete was indeed the success factor on this project!

Jason Myers *graduated from California Polytechnic University at San Luis Obispo in 1995 with a bachelor's degree in civil engineering and from Golden Gate University in 2015 with a master's in business administration with an emphasis in Project Management. Jason started out his professional career working for an earth retention subcontractor where he learned the importance of budgeting, scheduling, and client relationships. Also, during this time, he was introduced to the use of shotcrete and its applications. After working for a General Contractor for a couple of years, he realized that he enjoyed the tighter knit of working for a subcontractor and the ability to construct projects on a tighter time frame with several going at once. Jason also enjoys the process of handling most of the procedures that go into constructing a project rather than seeing only a small portion of the process. Jason joined Dees Hennessey Inc. in 2004 and has been a part owner of the company since 2007. Jason became President of Dees Hennessey Inc. at the beginning of 2023.*

Exchange Place Station – 9 Car Program West Corridor

By George Machikas

Fig. 1: Excavated tunnel

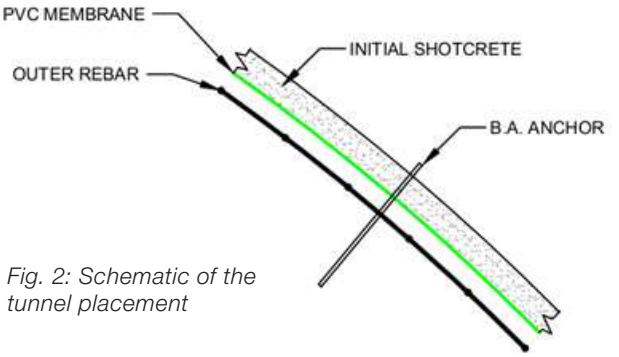


Fig. 2: Schematic of the tunnel placement

Fig. 3: Preconstruction mockup

Fig. 4: Concrete being pumped down from the street plus 100 ft to the work zone.

Exchange Place Station 9-Car Program is a vital part of the $1 billion PATH system improvement plan unveiled in 2019. The improvements to the 111-year-old system will allow for longer 9-car trains on the Newark/World Trade Center Line. The objective was to add capacity and reduce delays.

The work under this contract generally consisted of excavating a cross-corridor passage, including the installation of structural supports and architectural finishes for the PATH Exchange Place Station. Patriot Shotcrete's involvement was in constructing the lining for the cross-corridor, connecting the eastbound and westbound train platforms.

First, we had to prove to the NY Port Authority that shooting shotcrete in layers is effective and best practice for this project. This was done in the arch mockup, as this is how the project would be performed. A back mat of reinforcement was installed and shot, and then the second layer was installed and shot.

Eastern Materials, a US Concrete Company, provided the 5000 psi concrete mix. Patriot Shotcrete pumped the concrete from the street above. The placement line was routed through a drop tube to the corridor located 70 ft (21 m) below.

The corridor is 10 ft (3 m) tall and 16 ft (5 m) wide, extending 80 ft (24 m) between the station platforms with end beams and columns. Timing was of the essence as this is an active station. The corridor was tunneled through rock and

Fig. 5: Smoothening coat being applied

Fig. 6: Structural placement underway

then stabilized with an initial layer of shotcrete performed in 2 shifts. The final layer is 15 in. (380 mm) thick with a double mat of reinforcing, waterproofing, and grout tubes. The congested reinforcing of a double mat of #9 (#29M) and #6 (#19M) bars at 6 in. (150 mm) on center made it necessary to encase the outside mat prior to setting the inside mat.

The final finish was a flat and straight cut rod finish to be covered with tile. The final lining consisted of 2291 ft^2 (213 m^2) of finish area and 183 yd^3 (140 m^3). Shotcrete allowed us to meet the tight work windows available at this active station. Additional challenges included the limited access for forming, materials, and equipment; congested workspace; and a thick overhead placement. Working closely as one team with Walsh, the General Contractor, made this project very successful.

Fig. 7: Final tunnel

***George Machikas** is the Director of Operations for Patriot Shotcrete LLC, and has over 40 years of concrete construction experience. He has previous experience with Superior Gunite, Island Concrete, and C.M. Tec Inc. He has been with Patriot Shotcrete since its inception. George is experienced in poured concrete and shotcrete and graduated from Lehigh University in 1981.*

2022 OUTSTANDING UNDERGROUND PROJECT

Project Name
Exchange Place Station – 9 Car Program West Corridor

Location
Jersey City, NJ

Shotcrete Contractor
Patriot Shotcrete

General Contractor
Walsh Construction Company

Architect/Engineer
WSP USA Inc.

Material Supplier
Eastern Concrete Materials

2022 Honorable Mention

Taking Tuscarora into another Century

By Kristina Smith

This article is reprinted/reproduced courtesy of Tunnelling Journal.

Fig. 1: Pennsylvania Turnpike's Tuscarora Tunnels

Pennsylvania Turnpike's Tuscarora Tunnels are undergoing a $110m rehabilitation, aimed to deliver the 'wow' factor to its users. Kristina Smith reports.

The Tuscarora Mountain Tunnels in Pennsylvania have a fascinating history. The older of the two tunnels, built between 1938 and 1940, was designed to carry a railroad that never came into service. Industrialists of the day, William Henry Vanderbilt and Andrew Carnegie, were backers of the scheme which was halted when they struck a deal with rival railroad owners.

From 1940, the 5326 ft (1.6 km) tunnel and later its twin, which was built from 1962 to 1968, have carried a different mode of transport: motor vehicles. They are part of the Pennsylvania Turnpike, a 360-mile (580 km) toll road that runs east to west between state borders, passing through the Appalachian Mountains. When it opened, the toll road was remarkable because of its seven single tube tunnels; three of these were later bypassed to deal with bottle necks while the remaining four were twinned.

Now the operators of the Turnpike are looking to the future with a $110M rehabilitation of the Tuscarora Tunnels which aims to extend their lives for another century. The older tunnel will receive the most attention with the construction of an additional internal waterproofing layer and shotcrete skin to fight the ingress of groundwater, which has earned the tunnel the loving nickname of 'Lake Tuscarora.'

"Groundwater is a tunnel owner's worst nightmare," says Jim Stump, bridge engineer manager at the Pennsylvania Turnpike Commission. "You can try to control the water, but it always finds the weakest point."

The younger tunnel will have more modest waterproofing repairs with both tunnels receiving new electrical systems,

lighting, and ventilation; new signage and CCTV; and upgrades to the tunnel entrances and portal building.

For contractor Mosites Construction, which has worked on most of the Turnpike's seven sets of tunnels over the years, this waterproofing method is new. Specialist contractor Schneider-Moran will install the PVC membrane, but Mosites' own crews will be performing the shotcreting.

"Due to the quantity of shotcrete on the project and the weekly productions that must be maintained due to traffic requirements, the installation of the shotcrete lining and accompanying waterproofing activities will be one of the biggest challenges on the project," says Mosites' director of heavy operations Derrick Jeannerette. "We will make sure our crews are appropriately prepared prior to production shooting."

There have been several attempts over the years to stem the flow of water from the mountain, which is made up of sandstone and quartzite, into the tunnels. The most recent major intervention was in 2005 using grout injections. "That worked well for a while, but after 15 years, the water was back," says Stump.

"The ingress of water not only causes the tunnel's fabric to deteriorate, it also leads to the build-up of ice in the winter. Maintenance crews would have to stop traffic or divert it to the other tunnel in order to knock the ice off the walls a couple of times each day," says Stump, "and knock down the icicles using paddles."

Gall Zeidler – subconsultant to the main consultant Gannet Flemming – proposed several different solutions to tackle the incoming water. "We presented the Turnpike with a bunch of options that ranged from a Pontiac used car all the way through to a Rolls Royce: a really robust design with a 100-year design life," says senior tunnel engineer Thomas Martin of Gall Zeidler.

The Commission decided on the Rolls Royce. "We have not done anything to these tunnels for a long time," says Stump. "We are looking for the 'wow' factor, so that people who use the Turnpike really know we have done something to these tunnels."

WATERPROOFING SOLUTIONS

It isn't just age that causes the eastbound tunnel to leak more than the westbound one. Over the 30 years between the construction of the two tunnels, concrete technology has advanced; the younger tunnel was constructed from air-entrained concrete, whereas the older one wasn't.

"Air-entrained concrete contains little bubbles which means that when the water infiltrates the concrete and then freezes, there is space for it to expand into," explains Thomas Leckrone, project manager for Gannett Fleming.

"As a consequence of the action of freeze-thaw in the older, eastbound tunnel, the tunnel's extensively cracked ceiling has been totally removed. The ceiling in the westbound tunnel will remain in place. It is still sound and will prevent water from dripping onto traffic if more leakages appear in the arch above it in the future," says Martin.

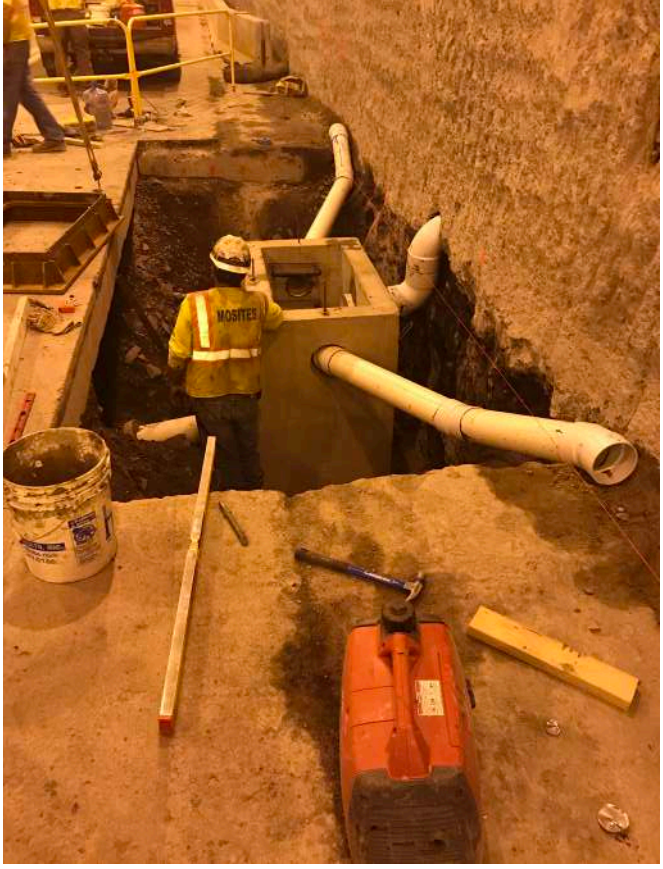


Fig. 2: Drainage installation - The new 'umbrella' waterproofing in the eastbound tunnel will be directed into the existing system beneath the tunnel.

The eastbound tunnel, with its 18 in. (450 mm) thick concrete walls and construction joints every 30 ft (9 m), has been leaking significantly through its arch area and its walls. The tunnel did have a copper water stop, but this has worn out over the years.

"There were the options of patching and curtain grouting, but that just means that the water could pop up in another area," says Martin. Unlike an urban tunnel, where rainwater is directed from impervious surfaces such as concrete and asphalt into drainage networks, in a rural area all the rainwater just permeates down to the tunnel, points out Stump.

"Rather than trying to fight the water, we are creating an umbrella system here," explains Martin. "Water will run down the back of the PVC membrane into the existing drainage system." (Fig. 2)

"At the construction joints, the design calls for three drainage relief holes to be drilled with a 1 ft wide (300 mm) J-drain – a dimpled plastic sheeting – placed over the joint to convey water down to the side wall drains at the base of the tunnel walls. The relief holes will also be packed with filter material to prevent large solids flowing into the system," adds Martin.

"Having prepared the existing tunnel walls, Mosites will install a 0.75 in. (20 mm) geotextile fleece. Preparation of the walls involves filling in any holes to create a flatter surface, although – having installed the first few sections – it seems that the geotextile itself does a good job of smoothing things out," says Jeannerette.

The PVC waterproofing layer also incorporates water barriers welded horizontally and longitudinally to create

compartments. Grout tubes installed for each area will protrude through the shotcrete layer so that grout can be pumped into these in the event of a leak in that zone.

Once the membrane is in place, Mosites will install lattice girders at 5 ft (1.5 m) spacings with two layers of welded wire mesh supported by the lattice girders. "We hate anchors!" says Martin, who goes on to explain that, by using stainless steel channels to hang the lighting from the lattice girders, the design has avoided thousands of anchors through the new shotcrete liner of the tunnel. The shotcrete and mesh will be installed in two layers to a total thickness of 8 in. (100 mm).

Mosites expects to spend around three years in the eastbound tunnel and just a year in the westbound one. Waterproofing work in the westbound tunnel will comprise patching work in the arch area, drilling relief holes at the construction joints, and directing the water to the drainage system in the tunnel through PVC pipes located at the construction joints.

"It's definitely a less involved version of what we are doing in the eastbound, but the idea is similar," says Martin. "The difference here is that we are not having the same level of infiltration, so we are only addressing the primary infiltration spots."

The design team has walked the plenum of the westbound tunnel several times to assess the water infiltration levels, most latterly in late 2019. "We noted that there was not extreme infiltration at the joints, but there was some infiltration at the shoulders," says Martin. One of the surprise observations was that some areas of spalling were also leaking; these will be treated in a similar way to the cracks.

Crack repairs are mapped out for the arch of the tunnel and the upper and lower surfaces of the ceiling slab. Gannett Fleming has prescribed three different forms of repair using grout injection, resin, or polyurethane grout if there is water in the cracks.

WORK WELL UNDERWAY

The Pennsylvania Turnpike Commission awarded the rehabilitation contract to Mosites in July 2019. Mosites was the lowest bidder with a cost just shy of $110M and only $4M below the next lowest bid.

Work started on site in August 2019 with Mosites preparing the westbound tunnel to take bi-directional traffic. The operation included additional lighting at entrance areas, directional arrow signs above the roadway, and directional arrows in the pavements themselves.

The rehabilitation contract allows Mosites to work only during weekdays in the eastbound tunnel. From Friday morning to Sunday evening, both tunnels must be open to traffic. Urban tunnels tend to have daily rush hours, but the Turnpike's tunnels have peaks at weekend and during holiday periods due to their rural locations.

"People don't want to sit there for an hour in traffic and then pay money to get off the toll road," says Stump. "That means that there are tighter restrictions than for a normal

Fig. 3a: Work underway in Eastbound - Mosites has removed the ceiling and the barriers at either side of the tunnel. Each weekend, the tunnel must be reopened to traffic.

Fig. 3b: Ceiling removed in Eastbound - The concrete in the older, eastbound tunnel was not air-entrained so the cracking of the ceiling was far more extensive; here we see the tunnel with its ceiling removed.

DOT (Department of Transportation) job. That has extended the contract because we can only work here at certain times."

Mosites must also be ready to move swiftly out of the eastbound tunnel if there is an incident in the westbound one. "To enable fast mobilisation and de-mobilisation, the contractor keeps as many materials as possible on trailers," explains Jeannerette, "with temporary barriers always to hand inside the tunnel."

Work started in the eastbound tunnel in February 2020 with the removal of the cracked ceiling. Mosites then moved on to demolishing the barriers that run along either side of the tunnel, followed by additions to the drainage at the base of each wall. (Fig. 3a and Fig. 3b)

Currently, Mosites is working on the left side of the tunnel installing drainage angles and porous concrete, and working with Schneider-Moran to install the PVC waterproofing to a level just above the height of the new barriers, with the construction of the barrier following on behind.

Fig. 4: Demolition 1 - The barriers at the side of the eastbound tunnel were removed so that the new waterproofing system could be installed.

Fig. 5: PVC membrane installation - Specialist contractor Schneider-Moran is installing the first sections of waterproofing in the eastbound tunnel on the lower sections of tunnel wall.

Mosites proposed some changes to the phasing of the barrier reconstruction. Rather than pouring short sections of each side, they suggested demolishing both sides during the same phase and using temporary precast barriers for the entire tunnel length on both sides, shifting the traffic lanes over by a couple of feet to give more working room. They also proposed slipforming for the barriers rather than consecutive pours, striking, and resetting the formwork.

"We think this particular project lends itself to slipform well," says Jeannerette. "We discussed this with the owner and their designer, and they were receptive to the idea."

The crack and spalling repair will be a precise business. "The Turnpike and their consultants have done a good job in mapping out where these repairs are. The tunnels are broken down into construction joints every 30 ft or 50 ft (15 m) (depending on the tunnel), which are all numbered so you can get a feel for where you are, how many repairs there are, and what kind of repair," says Jeannerette. "It does require a lot of coordination between us and the inspection crews so that everybody is on the same page." (Fig. 4)

"Having a crew that is made up of over 70% of Mosites' own people makes a huge difference here," says Jeannerette. All the repairs are unit price items which means that the foremen must record carefully what they have done each week. "They all understand how important it is to keep good records because we get paid for every foot they put in," he says. "They are diligent."

"An experienced and loyal workforce will also be vital for achieving the right quality and productivity for the shotcrete application," says Jeanerrette. "I have full confidence that the people we have will learn quickly and make a good job of it." Mosites has employed a craft nozzleman with direct experience in the wet-mix process, since Mosites' team usually works with the dry process, as well as a shotcrete consultant who can advise on any issues or concerns.

"The contract calls for every nozzleman to have a certain amount of experience and for each to produce mock panels which are 40 ft by 10 ft (12 m by 3 m), which is important to ensure quality," says Dominic Reda, a partner at Gall Zeidler. "With the mock-up panels, we can physically observe them, cut the panels so that we can see how the concrete has been applied, and test the material," says Reda. "And during construction, we will have very experienced inspectors, as part of the owner's representatives, to physically observe that they are doing everything we have agreed."

The shotcreting operation is complicated by the fact that it must follow right behind the PVC waterproofing application. Though it is self-extinguishing, the PVC would off-gas certain chemicals in a fire, so covering it up as quickly as possible protects road users as well as limiting the risk of damage to the membrane.

Mosites did apply for a change in the shotcreting process, to replace the mesh reinforcement with fibres, in order to speed up the whole process by cutting out the mesh fixing step – and save the owner money – but the Turnpike and its designers decided not to go with this option due to concerns about the finished surface which will be coated with a sprayed epoxy.

"The waterproofing and shotcreting process must be like a well-oiled machine," says Jeannerette. Schneider-Moran will be working two shifts – day and night – to install the geotextile and membrane, with Mosites' teams spraying concrete on one shift and fixing lattice and mesh on the other, as well as removing the temporary lighting from the next section before the waterproofing work can begin.

"Achieving the required production may take time," says Jeannerette. "Welding on the water barriers, for instance, is a time-consuming process, so any ideas which lead to savings there would be welcome."

"It's a very involved process. It will have to be just like clockwork every week for a year straight," says Jeannerette. "That will be the biggest challenge." (Fig. 5)

MULTI-DISCIPLINARY

For the owner and its designer, this tunnel rehabilitation project involves a jigsaw of stakeholders and regulations. "There are so many different disciplines involved, so many moving parts, so many different departments," says Stump. "There are restrictions with traffic, on the available working hours, and a lot of things in each phase that have to be buttoned up before you can open traffic up."

"Though Mosites has multiple subcontractor interfaces to handle, long relationships and related experience will help counter any issues here," says Jeanerette. "For instance, the electrical contractor, which has a big role to play on this project, has worked with Mosites many times before.

"They are from the Pittsburgh area, so we have worked with them a bunch," he says. "We have a good level of comfort with these guys."

The mechanical contractor, which will be installing Saccardo nozzles for ventilation to replace the existing slot ones, is new to Mosites, but the scope of works isn't.

And at the heart of all this is Mosites' supervisor, Mike Rhoads. "We have a very experienced superintendent who has a good, open line of communication with all the subcontractors," says Jeannerette.

The location of the project, however, has proved somewhat challenging. Since it is in the middle of the countryside, there's no popping to the local hardware shop to top up supplies. "If a lorry is heading out to site, you'd better check and double check that everything it's supposed to have on it is there," says Jeannerette.

The COVID 19 pandemic has put the project a little behind schedule. "Unlike some other states, Pennsylvania shut down all its construction sites which meant that Mosites was off the job for five-to-six weeks, all of which was used to plan a safe return," says Jeannerette. "On the flip side, some of the summer restrictions on working periods have been relaxed a little."

There are now protocols in place for working at a safe distance, where possible, and wearing extra PPE where it is not; hand washing stations on site; and increased cleaning regimes for offices and communal areas. Thankfully, no one working on the project has tested positive for the virus.

"Materials deliveries have been affected by outbreaks further afield. Some items coming from California were delayed by around six weeks, and waterproofing materials from Germany also arrived late. However, Mosites had allowed enough lead time to be able to absorb those delays," says Jeannerette. Pandemic allowing, the rehabilitation of both tunnels should be complete by late summer 2023.

MORE TO COME

Although Mosites' workload is largely rehabilitation projects — whether roads, bridges, or tunnels — the 'umbrella' waterproofing design for the eastbound Tuscarora Tunnel is a first for the contractor. That is also true for main designer Gannett Fleming. "When we were reviewing the proposals for design, we wanted to put together a good team," says Stump, who will have spent 10 years working on the design and delivery of the rehab by the time it's done. "We wanted Gannett Fleming due to their experience with our tunnels and Gall Zeidler on the team because they had the waterproofing experience and had done it before."

With many tunnels in the US reaching the ends of their serviceable lives, and groundwater almost always one of the issues to be tackled, this most certainly won't be the last time such a system is employed. Gannett Flemming and Gall Zeidler, both separately and together, are working on the design of several tunnel rehabilitation projects in other states.

2022 HONORABLE MENTION

Project Name
Pennsylvania Turnpike Commission – Tuscarora Tunnel Rehabilitation

Location
Burnt Cabins, PA

Shotcrete Contractor
Mosites Construction Company

Architect/Engineer
Gannett Fleming Inc.

Material Supplier
New Enterprise Stone & Lime Company Inc.

Equipment Manufacturer
King Shotcrete Equipment Inc.

*With a career that began on site as a graduate engineer, **Kristina Smith** has been writing about civil engineering and construction for over 20 years. Starting out as a technical writer on Construction News, she progressed to features editor before being poached by Property Week to be assistant editor. After a stint as editor on the monthly magazine, Construction Manager, Kristina began her freelance career in a bid to balance home and work commitments. Tunnelling articles are among her favourites, with every assignment offering the chance to learn something new and to talk to some of the world's most interesting engineers and experts. Kristina has been writing for Tunnelling Journal for 12 years, covering topics from tunnel linings to deep interventions, and reporting on tunnelling projects around the world.*

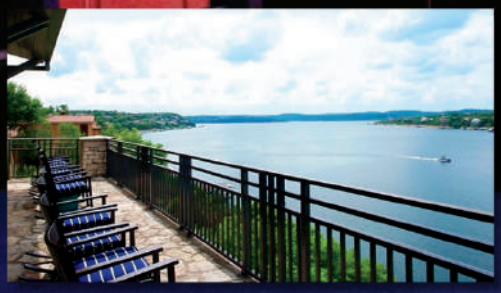
Save the Date

SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE

March 3 - 5, 2024

Lakeway Resort & Spa | Austin, TX

www.shotcrete.org/convention



american shotcrete association | asa

President's Award 2022

The ASA President's Award was established in 2005 to recognize a person or organization that has made exceptional contributions to the shotcrete industry. As one of ASA's highest honors, it is the sole responsibility of the immediate outgoing ASA President to select a recipient for this award. This year, Lars Balck had that honor and selected Bill Drakeley as his choice for the 2022 President's Award.

William T. "Bill" Drakeley, Jr., is a principal and founder of Drakeley Pool Company, a luxury swimming pool and watershape design and construction firm serving Connecticut, New York, and Massachusetts. Drakeley Pool Company designs and installs residential swimming pools, large commercial and competition structures, and interactive and decorative water features. Bill is also a managing member of Drakeley Industries, a nationwide consulting firm specializing in shotcrete applications and techniques that offers review, training, and expert witness services for shotcrete projects. Drakeley Industries has notably provided consultation and training for the NYC Metropolitan Transit Authority East Side Access subway tunnels projects. Most recently, Bill is a co-founder and instructor for Watershape University, teaching courses on shotcrete application at numerous trade shows.

Bill is a pool builder who has a passion for raising shotcrete standards at large, but particularly for the pool industry. He holds the distinction of being the first pool builder to sit as a voting member of the American Concrete Institute's (ACI) Committee 506 – Shotcrete, and he serves as secretary of the ACI C660 Nozzleman Certification Committee. Because of his efforts, ACI formed two pool committees to develop resources for the pool industry. Bill chairs ACI 506-0H Shotcreting – Pools subcommittee, and he is a voting member of ACI 322 – Concrete Pool and Watershape Code (developing and maintaining code requirements for concrete pools, spas, and other recreational watershapes). Drakeley is a valued contributor to WaterShapes, Shotcrete magazine, and other industry publications.

Bill has been a member of ASA since the early 2000s. His company won the first Outstanding Pool & Spa Project at ASA's First Annual Outstanding Shotcrete Project Awards in 2005. He helped revitalize the Pool & Recreational Shotcrete Committee during his tenure as Chair from 2011 to 2019, rallying the Committee to produce a series of Pool Position Statements to establish reference benchmarks for "bottom-line fundamentals of correct shotcrete" in an effort to raise the bar for shotcrete in the pool industry. Bill is an ACI-Examiner and certified Nozzleman for the shotcrete process. He served on ASA's Directors from 2010 – 2013; he joined the Executive Committee in 2014; and in 2016, his executive leadership culminated with his presidency.

As a member of ACI, APSP, NESPA, CONSPA, and an educator on industry standards, Bill has conducted trainings for numerous events, including the American Society of Landscape Architects (ASLA), Colorado School of Mines, Genesis 3 Construction School, World of Concrete, American Shotcrete Association, Aqua Show, NESPA, WU, and the IPSP. His technical writings have been widely published in trade magazines. He served on the Advisory Council of the Genesis 3 Design Group, is on the leadership team at Watershape University, and is a Platinum member of the Society of Watershape Designers. Bill holds a Bachelor of Science degree in Business Administration from Northeastern University.

Bill's involvement over the years in ASA, and particularly in the pool industry, illustrates his passion and commitment to quality shotcrete placement. He's learned from legends like George Yoggy and takes seriously the responsibility of passing on what he has learned. Bill's work indeed facilitates the work of ASA to provide "shotcrete leadership, knowledge, resources, qualification, certification, and education for the concrete industry." It is my honor to present Bill Drakeley as my President's Award winner this year.

Fig. 1: Susan & Bill Drakeley

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SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE
March 3 - 5, 2024 | Lakeway Resort & Spa | Austin, TX

2024 ASA SHOTCRETE CONVENTION AND TECHNOLOGY CONFERENCE

March 3 – 5, 2024

ASA will host our annual ASA Shotcrete Convention and Technology Conference at the Lakeway Resort and Spa, located in the heart of Texas Hill Country along Lake Travis. Our annual ASA convention is a unique opportunity to explore shotcrete applications and innovations as well as future advancements in the industry with 12 presentations. Attendees are also invited to attend and participate in ASA's 2024 Spring Committee meetings. Additionally, ASA will celebrate our 2023 Outstanding Shotcrete Project Award winners at our Annual Awards Banquet on Tuesday. Join us for this wonderful networking and learning experience!

Contractor Qualification Education Seminar

Sunday, March 3, 2024 - Pre-convention Seminar, additional fees apply.

One of the mandatory requirements in ASA's Contractor Qualification Program (CQP) is the attendance of a company representative (aka Qualifying Individual) at a full-day Contractor Qualification Seminar presented by ASA. The seminar focuses on the many aspects of successful shotcrete contracting and how shotcrete construction compares to more traditional form-and-pour concrete construction. The seminar is geared toward education of Contractors but may be valuable to Owners, Engineers, Architects, and Suppliers who want to learn more about the details required to consistently construct high-quality, durable concrete structures with shotcrete placement.

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, available at the conclusion of the seminar.

CALL FOR ENTRIES FOR 2023 OUTSTANDING SHOTCRETE PROJECT AWARDS PROGRAM

ASA is accepting applications for the 19th Annual Outstanding Shotcrete Project Awards program. These awards confirm and demonstrate the exceptional advantages of shotcrete placement of concrete. Awards are bestowed in the following six categories: architecture/new construction, infrastructure, international projects, pool & recreational, rehabilitation & repair, and underground. The deadline for submissions is October 2, 2023. For more information about the Outstanding Shotcrete Projects Awards, and to view past award-winning projects, visit www.shotcrete.org/ASAOutstandingProjects, or contact us at info@ shotcrete.org.

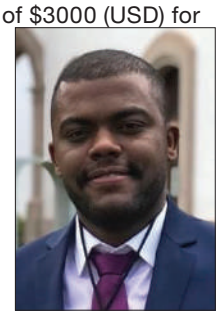
ERRATA

Acoustical Wave Wall – Winter 2022

The American Shotcrete Association sincerely apologizes for featuring the wrong image on the cover of our Winter 2022 issue of Shotcrete magazine. The Steinmetz Hall Wave Wall should have been featured on the cover. Additional updates and corrections for the article can be found online at www.shotcrete.org/back-issues.

2022-2023 ASA GRADUATE SCHOLARSHIP AWARDED

The 2022-2023 ASA Graduate Scholarship was awarded to Aimerick Vincent. He received a stipend of $3000 (USD) for tuition, residence, books, and materials. His bio and a summary of his research project can be found on page 10 of this issue. Our annual graduate scholarship provides funding to a Laval University graduate student engaged in shotcrete research. Evaluation of the entries includes a review of the relevance of the project's objectives with regard to the needs of the shotcrete industry, quality, originality and scope of the research project, and integration of sustainability elements in the project. Laval University has been a leader in shotcrete research. ASA recognizes and supports their contributions to the industry through this scholarship and through the funding of other research needs.



Aimerick Vincent

CONGRATULATIONS TO ACI'S NEW FELLOWS – ASA'S VERY OWN OSCAR DUCKWORTH AND LIHE "JOHN" ZHANG

ACI Fellow—"A Fellow shall be a person who has made outstanding contributions to the production or use of concrete materials, products, and structures in the areas of education, research, development, design, construction, or management" (Bylaws, Article III, Section 3). Created in 1973, 611 members now hold the position of Fellow. They are recommended by the Fellows Nomination Committee and elected by the Board of Direction.

Oscar Duckworth, Principal at Applied Shotcrete, was one of the first ACI Certified Shotcrete Nozzlemen in the United States. Since that time, he has devoted countless hours to the advancement of this industry, both for ASA and the American Concrete Institute (ACI).

Oscar Duckworth

He has been an active ACI member since 2006 and has assisted with critical advancement of training, education, and certification of this concrete placement method. Duckworth's work on various ACI and ASA Committees has been instrumental in the ACI Shotcrete Inspector Program, the ASA Inspector Education, and the ASA Nozzleman Education, which included work on ACI-CP 60 and CCS-4 Craftsman Workbook, the primary education documents for the shotcrete industry. He is a member of the ACI Certification Programs Committee; ACI Committees C660, Shotcrete Nozzleman Certification; C661, Shotcrete Inspector Certification; 506, Shotcreting; and ACI Subcommittee 506-C, Shotcreting-Guide. Duckworth currently serves as the Secretary of the ASA Board of Directors and chairs the ASA Education and Safety Committee. As an author of more than 20 published shotcrete articles and a speaker at major industry events, Duckworth is a leader and influencer of this industry. He received the 2016 ASA President's Award and the 2021 ASA Carl Akeley Award.

Lihe "John" Zhang, Consulting & Testing Ltd., is Chair of ASA's Technical Committee; ACI Subcommittee 506-F, Shotcreting-Underground; and a member of ACI Committees 370, Blast and Impact Load Effects; 506, Shotcreting; 544, Fiber Reinforced Concrete; and C660, Shotcrete Nozzlemen Certification. He has also served as President of the American Shotcrete Association (ASA) in 2018. Zhang has authored or co-authored over 30 technical papers and was awarded the ASA Carl Akeley Award for best paper in both 2010 and 2014. He has conducted research on fiber-reinforced shotcrete, durability of concrete and shotcrete, thermal properties of mass concrete, and low carbon-emission concrete. He received his B.Eng. in civil engineering materials from The Chongqing Jianzhu University, Chongqing, China, in 1998; his MSc. in materials science and engineering from the Tongji University, Shanghai, China, in 2001; and his PhD in civil engineering from the University of British Columbia, Vancouver, BC, in 2006. He is a licensed professional engineer in the Canadian provinces of British Columbia and Ontario.

Lihe "John" Zhang

WORLD OF CONCRETE 2024

January 23 – 25, 2024
Las Vegas Convention Center | Las Vegas, NV

Don't miss out on the savings! Use ASA's source code **A17** for the lowest-discounted, exhibit-only admission pass, and stop by to see us at booth **#S10919** in the South Hall. Registration opens in the Fall.

ASA Shotcrete Nozzleman Education
Tuesday, January 23, 2024
8:00 AM – 4:00 PM
This course is designed for shotcrete nozzlemen, individuals involved with inspection of shotcrete, and anyone interested in learning about the principles and practices that must be known and understood for a nozzleman to satisfy his or her role in the quality application of the shotcrete process.

ASA Nozzleman Education Courses present an overview on placement technique, finishing, curing, testing, equipment, and safety as it relates to the nozzleman and the shotcrete process. This course also helps to prepare individuals for participation in the ACI Nozzleman Certification program. ACI-required work experience, the written exam, the performance exam, and other program criteria will be discussed. The CP-60(15) Shotcrete Nozzleman Craftsman Workbook is included with the course registration fee.

World of Shotcrete will again be hosting an ACI Wet-Mix Shotcrete Nozzleman Certification Session January 25 - 26, 2024 in Henderson, NV. Go to www.worldofshotcrete.com for details.

ASA WOC 2024 General Membership Meeting & Shotcrete Reception
Tuesday, January 23, 2024
5:00 PM – 7:00 PM
Come hear the latest updates on ASA's activities, and network at our General Membership Meeting and Reception (no registration required).

Quality Shotcrete – Know It When You See It (Shotcrete Inspector Seminar)
Wednesday, January 24, 2024
8:00 AM – 4:00 PM (without exam; 6:00 PM with exam)
Contractors: though you may have used shotcrete contractors for years on your projects, do you know what to look for to confirm you're getting the best quality for your money? Though shotcrete is a placement method for concrete, the process has fundamentally different equipment, material selection, crew responsibilities, application techniques, testing, curing, and protection that need to be considered for producing the high-quality and durable shotcrete you as a contractor and the owner expect.

This seminar from ASA provides guidance on over 40 critical elements of shotcrete applications for those onsite to properly evaluate the overall quality of shotcrete placement. These include an overview on material selections, equipment, placement techniques, finishing, curing, protection, testing, and safety as it relates to the shotcrete process. For shotcrete contractors, this seminar will help you verify the quality of your work to your general contractors and inspectors.

Optional Reference Resource can be purchased directly from ACI: CP61 Pack is the Reference Resource for the open book exam for those pursuing ACI Shotcrete Inspector Certification. (search for CP61 at concrete.org/store)

2023 ASA OFFICERS AND BOARD OF DIRECTORS APPOINTMENTS

ASA announced its new officers and Board members, elected by the membership, during the annual convention held earlier this year. Frank Townsend, Patriot Shotcrete & Construction, will serve a 1-year term as ASA President. Lars Balck, Consultant, assumes the position of Past President. To complete the Executive Committee, the ASA membership also elected the following for 1-year terms: William "Bill" Geers, Bekaert, as Vice President; Oscar Duckworth, Applied Shotcrete, as Secretary; and Jason Myers, Dees Hennessey Inc., as Treasurer.

Newly-elected ASA Director, Jamie Curtis, CCP Shotcrete + Pumping, will serve a 2-year term, completing the position vacated by Jason Myers as he moved up to the Executive Committee. The following Directors have been elected to serve 3-year terms: Juanjose Armenta-Aguirre, Gunite Supply & Equipment Co; Mark Bradford, Spohn Ranch Skateparks; and Justin Shook, Baystate Shotcrete LLC. Lastly, we have the following returning Directors: Dennis Bittner, The Quikrete Companies; Derek Pay, Oceanside Construction; Bruce Russell, Crom LLC; Kevin Robertson, SIKA Shotcrete Tunneling & Mining; and Ryan Oakes, Revolution Gunite.

To support the mission and work of ASA, the following individuals serve as Chairs of ASA Committees: Marcus von der Hofen, Coastal Gunite Construction Company, Contractor Qualification Committee; Oscar Duckworth, Applied Shotcrete, Education & Safety Committee; Ashley Cruz, Cruz Concrete and Guniting Repair, Marketing Committee; Jason Myers, Dees-Hennessey Inc., Membership Committee; Ryan Oakes, Revolution Gunite, Pool and Recreational Committee; Lihe "John" Zhang, LZhang Consulting & Testing Ltd., Technical Committee; and Christoph Goss, Schnabel Engineering, Underground Committee. Committee meetings are open to the public and ASA welcomes and encourages the participation of all interested parties in the shotcrete industry. Upcoming committee meetings can be found online under ASA Calendar. For more information, visit www.shotcrete.org.

OFFICERS

President
Frank Townsend

Vice-President
Bill Geers

Secretary
Oscar Duckworth

Treasurer
Jason Myers

Past President
Lars Balck

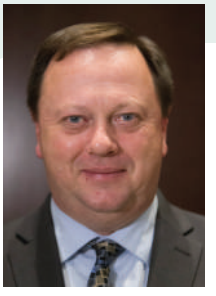
DIRECTORS

Juanjose Armenta-Aguirre
(2nd consecutive term)

Mark Bradford

Justin Shook

Jamie Curtis
(2 yrs replacing Myers)



Dennis Bittner
(2 yrs remaining)

Derek Pay
(2 yrs remaining)

Bruce Russell
(1 yr remaining)

Kevin Robertson
(1 yr remaining)

Ryan Oakes
(1 yr remaining)

ASA Committee Chairs

Marcus von der Hofen
Contractor Qualification

Oscar Duckworth
Education & Safety

Ashley Cruz
Marketing

Jason Myers
Membership

Ryan Oakes
Pool & Recreation

Lihe "John" Zhang
Technical

Christoph Goss
Underground

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AMERICAN CONCRETE INSTITUTE ANNOUNCES NEW EXECUTIVE VICE PRESIDENT

Fred Grubble

The American Concrete Institute (ACI) is pleased to announce Frederick H. Grubbe, M.B.A., C.A.E. and current President and Chief Executive Officer of the National Precast Concrete Association (NPCA), has been named Executive Vice President of ACI.

Current ACI Executive Vice President, Ronald G. Burg, will retire from ACI in August after 13 years of service to the Institute. Grubbe will join the 148-member ACI staff at its Farmington Hills, MI headquarters on August 10.

"I am very excited to join the ACI team," said Fred Grubbe. "As one of the premier global authorities on all things concrete, ACI will continue to elevate the design, construction, and most effective use of concrete worldwide. Ron Burg, in concert with the Board of Direction, has provided superb leadership over the years to educate and enrich the knowledge base of individuals and organizations committed to concrete usage," added Grubbe. "While I have some very big shoes to fill, I look forward to the challenge ahead and am anxious to get started."

Grubbe brings more than 25 years of non-profit executive leadership experience to the Institute with notable prior positions at the Appraisal Institute, American Fraternal Alliance (formerly the National Fraternal Congress of America), and the Think First Foundation. He also served as director of strategic planning and special projects at the Million Dollar Round Table along with positions at several other non-profit organizations.

ACI OFFICERS AND BOARD OF DIRECTION MEMBERS FOR 2023-2024

Nanni, Juenger, and four new Directors elected

As elected by the ACI membership, **Antonio Nanni**, FACI, Professor and Chair of the Department of Civil, Architectural, and Environmental Engineering at the University of Miami, Coral Gables, FL, USA, will serve as ACI President in 2023-2024. Nanni succeeds Charles K. Nmai, FACI, Head of Engineering at Master Builders Solutions Admixtures US LLC, Cleveland, OH, USA. Nmai's 1-year term as ACI President and Nanni's 2-year term as ACI Vice President both expired at the conclusion of the Spring 2023 ACI Board of Direction meeting.

Maria Juenger, FACI, L.B. (Preach) Meaders Professor of Engineering in the Department of Civil, Architectural, and Environmental Engineering and Associate Dean of Graduate Education Transformation in the Graduate School at The University of Texas at Austin, Austin, TX, USA, has been elected as ACI Vice President. She filled the vacant seat that Nanni previously held, and she began her 2-year term as VicePresident at the conclusion of the Spring 2023 ACI Board of Direction meeting. **Michael J. Paul**, FACI, Principal Structural Engineer, Larsen & Landis, Inc., Philadelphia, PA, USA, is the other current Vice President. His 2-year term began at the conclusion of the ACI Convention Spring 2022 and ends at the conclusion of the ACI Convention Spring 2024.

Four members have been elected to serve on the ACI Board of Direction, each for a 3-year term that commenced at the conclusion of the Spring 2023 ACI Board of Direction meeting. They are:

- **Oscar R. Antommattei**, FACI, Chief Concrete Engineer and Materials Engineering Manager, Kiewit Corporation, Lone Tree, CO, USA
- **Peter Barlow**, FACI, Founder, and now Consultant to Contech Services, Inc., Seattle, WA, USA
- **Arturo Gaytan Covarrubias**, FACI, Innovation and Sustainability Manager, CEMEX México, Mexico City, Mexico
- **Carol Hayek**, Chief Technical Officer, CCL International, Jessup, MD, USA, and Lecturer, Johns Hopkins University, Baltimore, MD, USA.

The individuals leaving the Board of Direction after 3-year terms are **Scott M. Anderson**, Vice President and General Manager, Keystone Structural Concrete LLC, Houston, TX, USA; **G. Terry Harris Sr.**, Director, Technical Services-Concrete Americas, GCP Applied Technologies, Alpharetta, GA, USA; **Kimberly E. Kurtis**, Professor and Associate Dean for Faculty Development and Scholarship in the College of Engineering, Georgia Institute of Technology, Atlanta, GA, USA; and **W. Jason Weiss**, Professor and The Miles Lowell and Margaret Watt Edwards Distinguished Chair in Engineering, Oregon State University, Corvallis, OR, USA.

ACI Board members who will continue to serve during 2023-2024 include **Michael C. Brown**, Associate Principal, Wiss, Janney, Elstner Associates, Inc., Falls Church, VA, USA; **Anthony R. DeCarlo Jr.**, Chief Operations Officer, TWC Concrete LLC, Cincinnati, OH, USA; **John W. Gajda**, Principal and Co-Founder, MJ2 Consulting PLLC, Lindenhurst, IL, USA; **Kamal H. Khayat**, Vice Chancellor for Research and Innovation Studies, Missouri S&T, Rolla, MO, USA; **Robert C. Lewis**, Technical Marketing Manager, Ferroglobe PLC, Reading, United Kingdom; **Anton K. Schindler**, Professor and HRC Director, Auburn University, Auburn, AL, USA; **Matthew R. Sherman**, Senior Principal, Simpson Gumpertz & Heger, Melrose, MA, USA; and **Lawrence L. Sutter**, Associate Dean of Research and External Engagement for the College of Engineering, Michigan Technological University, Houghton, MI, USA.

With Nmai's term as ACI President concluded, he automatically assumes a position on the ACI Board of Direction as a Past President member. In doing so, he replaces **Randall W. Poston**, ACI President in 2019-2020, who will no longer be one of the three Past Presidents of ACI serving on the Board. Nmai will serve with **Jeffrey W. Coleman**, ACI President in 2020-2021, and **Cary S. Kopczynski**, ACI President in 2021-2022, as stipulated by the Institute's Bylaws.

RETIRED PRESIDENT OF EUCLID ADMIXTURE CANADA NAMED HONORARY MEMBER OF THE AMERICAN CONCRETE INSTITUTE

Claude Bédard

Euclid Chemical, a leading manufacturer of concrete and masonry construction products, is pleased to announce that Claude Bédard, former president of Euclid Admixture Canada Inc., has been named a 2023 honorary member of the American Concrete Institute (ACI). Formal announcement of Bédard's election was made at the ACI Concrete Convention on April 2, 2023.

Being named an honorary lifetime member is ACI's highest honor. This membership was bestowed upon Bédard for his impact as a dynamic ACI ambassador, his dedication and commitment to improving relations between industry and academic researchers, and for his central role in the chairing and success of the Strategic Development Council.

Bédard has been active in the concrete industry for more than 40 years. He is currently a strategic consultant at Euclid Chemical and also serves as an ambassador for the Centre for Research on Concrete Infrastructures (CRIB). Additionally, Bédard serves as a member of the Self-Consolidating Concrete Committee, ACI Foundation Concrete Innovation Council, and Concrete Research Council.

Previously, Bédard served as a member of the Board of Direction of ACI, Standards Council of Canada and various ACI committees. He is also a former trustee and chair of the ACI Foundation, past chair of the ACI Foundation Strategic Development Council, past chair and member of the Canadian Standards Association, and two-time past president of the ACI Québec and Eastern Ontario Chapter.

In 2021, Bédard received the ACI Foundation Concrete Innovation Council Jean-Claude Roumain Innovation in Concrete Award for his lifelong contribution to innovative concrete applications. Other industry awards include the 2015 ACI Henry C. Turner Medal; the 2014 ACI Québec and Eastern Ontario Chapter ACI Chapter Recognition Award; the 2012 ACI Henry L. Kennedy Award and the ACI 10th International Conference on Superplasticizers and Other Chemical Admixtures in Concrete Award; the 2010 Québec RD-Mix Ambassador Award; and the 2002 CSA Award of Merit.

Bédard was also elected a fellow of ACI in 2008. His research interests include chemical admixtures and fibers and their use in high-performance concrete applications.

COLORADO SCHOOL OF MINES' MINING ENGINEERING PROGRAM RECEIVES HISTORIC $7.5 MILLION INVESTMENT

Steven Whisler

Colorado School of Mines' No. 1 world-ranked mining engineering program has received a historic $7.5 million investment from alumnus J. Steven Whisler and his wife Ardyce, of Whitefish, Montana, USA. It's one of the program's largest gifts since Mines was established in 1874 to support Colorado's booming mining industry.

"Mines has the best mining engineering program in the world, and Ardy and I are pleased to provide meaningful support to create an even better mining engineering educational experience for students," said Steve Whisler, a retired mining executive who earned a master's degree in mineral economics at Mines in 1984 and received an honorary doctorate in engineering in 2001.

The investment creates the J. Steven Whisler Chair for the Head of Mining Engineering, the J. Steven Whisler Professor of Practice, and the J. Steven Whisler Scholars Program, which funds scholarships for mining engineering students.

The Whislers' investment comes as the number of U.S. mining engineering students is shrinking—by nearly half from 1,449 in 2015 to 736 in 2020, according to a story in the December 2021 issue of Mining Engineering. And, fewer than 200 students on average are graduating each year.

As a result, there simply are not enough graduates with expertise to meet the rapidly escalating demand for minerals and materials used in construction, transportation, electronics, and energy production, or to address the coming onslaught of retirements across industry and academia. In the United States alone, the Bureau of Labor Statistics projects about 500 mining and geologic engineer jobs openings each year for the next decade.

"Mining companies not only have to compete among ourselves for the best talent, but with other industries such as tech firms in the Silicon Valley," Whisler said. "It's critical that we continue to create a positive reputation and work environment for the industry that will attract and retain new talent to the profession."

Mines president Dr. Paul C. Johnson said the Whislers' historic investment gives the department the resources it needs to be the exemplar and leader that all other universities will want to emulate, not only because of the quality of its graduates, but also because its expertise and education align with industry's future needs.

"The mining engineering program's world-renowned reputation reflects our graduates' capabilities and successes, the program's strong connection and relevance to industry, our

faculty's expertise and leadership, and the program's unique resources, such as the Edgar Mine," said Johnson. "The Whislers' support shines a spotlight on our program and will catalyze its evolution in a way that could not happen without it."

ICRI ELECTS 2023 OFFICERS AND BOARD MEMBERS - PIERRE HÉBERT TO SERVE AS ICRI PRESIDENT

The International Concrete Repair Institute (ICRI) announces the election by the membership of new officers and board members for calendar year 2023, and Pierre Hébert, with Sika Canada Inc. as its President. To support Hébert, the ICRI membership also elected the following officers:

- President-Elect – Brian MacNeil, Mac & Mac Hydrodemolition
- Vice President – Gerard Moulzolf, American Engineering Testing, Inc.
- Treasurer – David Karins, Karins Engineering Group Inc.
- Secretary - Dan Wald, Watson Bowman Acme Corporation

John McDougall served as 2022 President and will continue his service on the board as Immediate Past-President.

The terms began on January 1, 2023 for a one-year period.

Matthew Sherman replaces Mark Nelson, serving as an ex-officio member of the Executive Committee in the role of Chair of the Technical Activities Committee (TAC).

In addition to the president and officers, the membership voted-in the following new members who began serving three-year terms on January 1, 2023, and ending on December 31, 2025:

- Matthew Carter, Dayton Superior Corporation (Region 5)
- Ed Kluckowski, Freyssinet Inc. (At Large)
- Sarah Thaxton, Southern Paint & Waterproofing Company Inc. (At-Large)
- Jonathan Woo, Engineering Consultant (Region 8)
- Bryan Wood, University of Alabama (Region 2)

The returning board members whose terms were not up for re-election include:

Terms Ending in 2024:

- Rich Barrett, LymTal International Inc. (Region 3)
- Natalie Faber, Balco Inc. (At Large)
- Brad Rogers, Buckeye Construction & Restoration Ltd (Region 6)
- Kandace Thompson, Master Builders Solutions (MBCC Group) (At Large)

Terms Ending in 2023:

- Jason Coleman, Wiss, Janney, Elstner Associates Inc. (At Large)
- Pete Haveron, Texas Concrete Restoration Inc. (Region 7)
- Kenneth Hopfensperger, Euclid Chemical Company (At Large)
- Michelle Nobel, MAPEI Corporation (Region 1)
- Aamer Syed, Sika-USA (Region 4)

We would also like to thank Nominations Chair Mark LeMay, Vice-Chair Elena Kessi, and the Nominations Committee for their service to the association in the important task of evaluating and selecting future members of the Board of Directors and Nominations Committee.

The nominations and elections are conducted to ensure representation from varied geographic areas and industry disciplines. Those elected to this committee will serve three-year terms. The other members of the committee will be Chair Elena Kessi and Vice-Chair John McDougall. Previously elected and serving until December 31, 2023, are Marthe Brock and Thomas Donnelly, and serving until December 31, 2024, are Alessandra Bianchini and Robert Flynn.

Members elected to serve on the Nominations Committee and serving until December 31, 2025, are:

- Stephen Grelle, PE, SE, Wiss, Janney, Elstner Associates Inc.
- Tara Toren-Rudisill, Thornton Tomasetti

Congratulations to all and we thank you for your contribution and service to ICRI.

shotcrete2023

Outstanding Shotcrete Project Awards

The 2023 award application is now available! Projects must be completed between January 1, 2021, through September 1, 2023, and can be submitted in the following areas:

- Architecture | New Construction
- Infrastructure
- International Projects
- Pool & Recreational
- Rehabilitation & Repair
- Underground

Submit your winning project at **www.shotcrete.org/projectawards**

asa
OUTSTANDING
SHOTCRETE PROJECT
Awards

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: *What is the efficiency of dry-mix shotcrete? How much is over spray vs. how much sticks to the surface?*

Answer: Dry-mix shotcrete may have more rebound (coarse aggregate that bounces off the surface) than wet-mix so it may be considered a little less efficient.

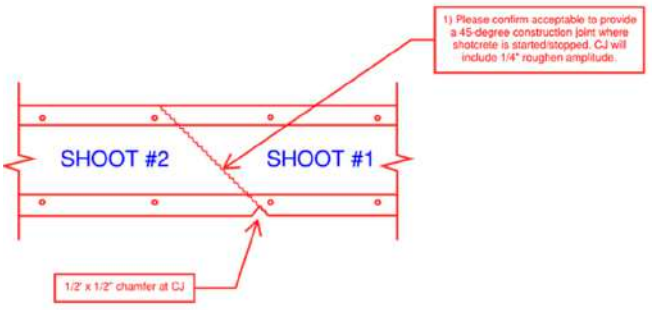
Question: *I'm about to order a new pool with gunite. My previous shotcrete pool was demolished due to ASR. I'm in Texas. I wanted to see if the psi recommendation for gunite was the same in shotcrete, and that's 4000 psi. Is it 4000 psi for gunite also? For swimming pools? Current builder specs are showing 3000 psi, but I've told them to review using 4000 psi gunite.*

Answer: Yes, ASA recommends a minimum 28-day compressive strength of 4000 psi for both dry-mix shotcrete (gunite) and wet-mix shotcrete. A 3000 psi dry-mix shotcrete would use much less cement in the mix. This results in a significantly reduced volume of paste in the concrete that would make proper encasement of reinforcement and eliminating sand lenses in the shadow area behind reinforcing much harder to achieve. More details on why can be found in our position statement, "Compressive Strength Values of Pool Shotcrete," on our Shotcrete Resources web page: https://shotcrete.org/products-services-information/resources/

Question: *Please direct me to the proper guidelines for the hydration of shotcrete.*

Answer: A minimum of 7 days of continuous wet curing is recommended. Providing extra water to hydrate the unhydrated cement in the concrete mixture will increase the concrete's strength, reduce permeability and will improve the watertightness and durability of the pool shell. The ASA Pool and Recreational Shotcrete Committee Position Statement, "Curing of Shotcrete for Swimming Pools," provides more details: https://shotcrete.org/wp-content/uploads/2022/01/218216_SCMSummer21_PS7v2.pdf

Question: *Do you have any experience with a vertical 45-degree construction joint for shotcrete? Is this a common practice? Is there anything we should watch out for? Does the ½" chamfer (shown top right) really required? I found an article saying that a properly prepared 45-degree joint is the best type of joint and will provide load transfer in flexure, but how about horizontal shear force?*



Answer: On vertical walls where we shoot horizontal lifts to build up the height of the wall, we do prefer a horizontal construction joint angled so the outer edge is lower than the back edge. This allows rebound from the shotcrete placement to roll off the surface and not be trapped in a back corner. This would not be needed on a vertical construction joint as rebound would fall downward and not be trapped.

There doesn't appear to be a need for the chamfer.

The ¼ in. amplitude is good. It is interesting they are creating it with a surface retarder. I assume they will apply the retarder then wash off the unhardened concrete. They must be sure the receiving surface is fully hardened and sound when shooting the subsequent section.

Shotcrete placement with proper materials, equipment, and placement techniques provide an excellent bond between the hardened concrete and subsequently placed fresh concrete. You should routinely expect to have a bond tensile strength at the interface of at least 150 psi. Work by PCA decades ago showed that bond shear strength of at least 200 psi allowed bonded overlays to act monolithically with the underlying concrete. Research shows that to correlate bond tensile strength to bond shear strength, multiply the tensile strength by 2 or 3. Thus, shotcrete placement should be providing at least 300 psi of bond shear strength and would act as a monolithic section.

Shotcrete placed onto an existing concrete surface or previously shot section will provide an excellent bond IF the following conditions are met:

1. Make sure the surface is roughened and clean.
   a. The amplitude the of roughness should be +/- 1/8th in. or more.
   b. If the surface was not roughened when it was chipped out, be sure to have the contractor roughen it.
   c. A high-pressure water blaster (5000 psi or more) or abrasive blasting can help to roughen and clean the surface.
2. Bring the concrete surface to saturated surface dry (SSD) condition. This means the surface feels damp, but water is not picked up on a hand.

3. Make sure the shotcrete placement is properly executed with high velocity placement and quality materials.
4. The shotcrete should have a minimum 28-day compressive strength of 4000 psi.
5. Be sure the shotcrete contractor is using an air compressor able to produce at least 185 CFM for wet-mix and 385 CFM from dry-mix (gunite) of air flow at 120 psi.
6. Use an ACI-certified shotcrete nozzleman.
7. No bonding agent should be used. It will interfere with the natural bonding characteristics of shotcrete placement.

This article on the excellent bond between shotcrete layers provides more detail: https://shotcrete.org/wp-content/uploads/2020/05/2014Spr_TechnicalTip.pdf

Question: *Is there a way to search for certified technicians in a given area?*

Answer: Your best option is to ask the pool shotcrete company to provide you with the current certification card for an ACI-certified shotcrete nozzleman who will be doing the shotcrete placement on the job. You can verify whether they are currently certified on the Verify a Certification tab at the ACI Certification website: www.concrete.org/certification.aspx.

Nozzlemen are certified in the type of shotcrete (dry-mix or wet-mix) and the orientation (vertical with an option for overhead). In the pool market, dry-mix shotcrete is often called by the old tradename "gunite," and wet-mix may just be called shotcrete. As pools don't usually have any overhead placement, just making sure they are certified for vertical work is fine. It is important you verify the nozzleman's certification is current.

You can review this article at Shotcrete.org. If you want to know more about what's involved in the certification process visit: shotcrete.org/wp-content/uploads/2020/05/2018Win_Hanskat.pdf

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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A Member of The Harco Group

Neptune Coatings has been providing waterproofing solutions to the construction industry since its founding in Northern California in the year 2000. As Pioneers of the Wetsuit® Instant-Set Liquid Applied membrane (Patented Systems), Neptune Coatings provides innovative solutions where there are none. Neptune Coatings is constantly innovating through development of new products, applications, and systems, all of which leads to delivering shorter project timelines.

WHAT IS WETSUIT®?

WetSuit® is a family of polymer-modified bitumen coatings that is cold-liquid applied, Class A self-extinguishing, hail resistant, and UV stable. It also has high-velocity wind uplift, an elongation of more than 2000%, and the ability to resist ponding water indefinitely.

WetSuit® is suitable for roofing, waterproofing (below grade, foundation, methane barrier, and shotcrete) and other specialty applications.

WHAT IS WETSUIT® 2-PART?

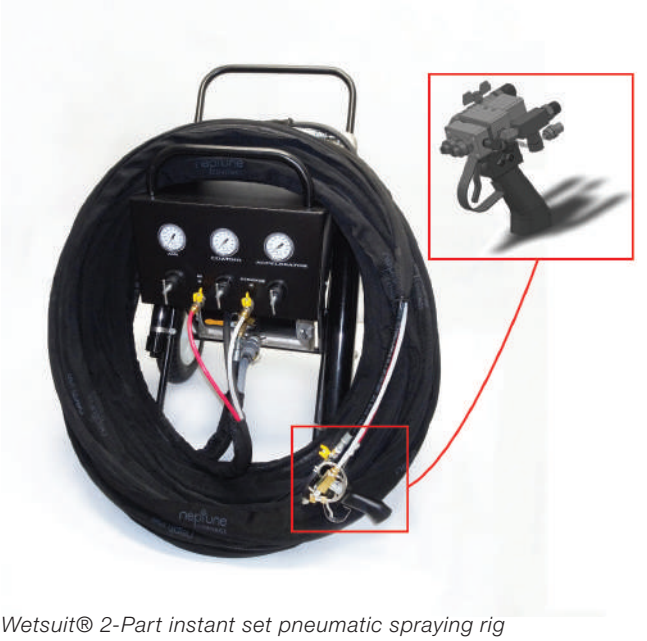
WetSuit® 2-Part, our flagship product, is a 2-component, instant-set, cold-spray-applied membrane that is 80% cured in 3 seconds and is sprayed using Neptune Coatings' proprietary 2-component Rig System.

The product and spraying equipment are covered by 3 US Patents.

WetSuit® 2-Part is a cold-spray-applied monolithic membrane that is water-based and Zero VOC. It is seamless, self-flashing, and extremely durable. With one machine, a single day application can exceed 12,000 ft^2 (1100 m^2), with the ability to build any thickness in a single pass.

WetSuit® 2-Part can be applied to horizontal, vertical, and blindside surfaces with superior adhesion, providing true waterproofing solutions (less than 0.1 US Perms/in.) as well as damp proofing.

Wetsuit® 2-Part is approved by LARR (Los Angeles Research Report), ref. RR 26190, CSI #07 14 16 for



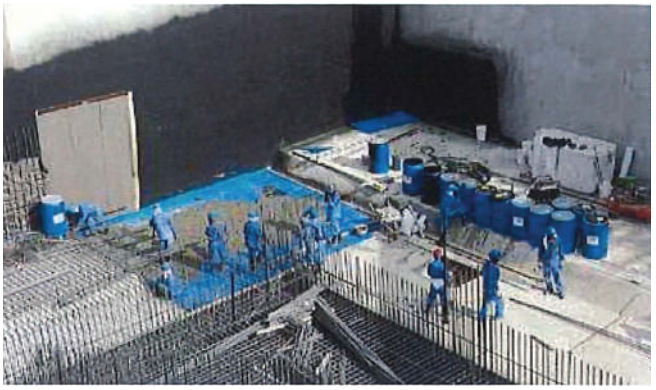
Wetsuit® 2-Part instant set pneumatic spraying rig

WetSuit® 2-Part spray applied membrane behind shotcrete

Below-Grade Waterproofing, Methane Barrier and Pneumatically Applied Concrete (Shotcrete).

Wetsuit® 2-Part is applied only by trained and certified applicators.

Shotcrete over Wetsuit® 2-Part spray applied membrane



Wetsuit® 2-Part spray applied membrane over shotcrete

Wetsuit® 2-Part spray applied membrane over shotcrete

WETSUIT® 2-PART IN SHOTCRETE

Advances in construction technology have continued to evolve. Pushes for stronger and faster solutions with less environmental impact have made shotcrete a viable choice in lieu of formed or poured-in-place systems.

Builders found out quickly that traditional waterproofing products were not the best solution because of failures that were likely due to the impact pressure on the waterproofing sheet during the shotcrete application. Furthermore, the combination of limited accessibility between the rebar and the high velocity of the actual shotcrete installation has eliminated many traditional waterproofing products.

Coupled with the fact that blindside waterproofing does not allow a second chance to get it right, contractors are reluctant in general to try new products in this PASS/FAIL type of application. However, Wetsuit® 2-Part, with its unique properties, certifications, and application method, overcomes this challenge and is the solution considering its elongation of more than 2000%, its high-impact resistance, and its monolithic membrane. WetSuit®v 2-Part eliminates the potential of failure at seams and laps compared to traditional sheet systems.

Even with a product like Wetsuit® 2-Part, proper installation is key to a successful project. That's why Neptune Coatings has developed a unique process that takes into account the entire life of the structure and how it will affect the waterproofing.

Neptune Coatings' commitment to excellence is geared towards meeting the customer's needs with the highest standards of service and product performance.

If you are interested in becoming a certified WetSuit® applicator, please contact us.

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NORMET LAUNCHES BATTERY-POWERED SHOTCRETE MACHINE

Normet said its new battery-electric Spraymec MF 050 VC SD has been specifically tailored for the needs of underground mining. The machine combines the Normet SmartDrive battery-electric architecture with state-of-the-art spraying technology. It offers unrivaled concrete spraying results, superior operator ergonomics, and excellent serviceability with zero local emissions, according to Normet.

The Spraymec MF 050 VC SD is purpose-built for small and medium-sized tunnels. It comes with a cutting-edge dosing system and a low-pulsation concrete spraying pump with a maximum theoretical concrete output capacity of 10.5 m^3/h (6 cfm) with battery-powered operation or, alternatively, 27 m^3/h (16 cfm) with electric operation.

Normet attributes these latest innovations and features to the thousands of hours spent in the field listening to miners and gathering operator feedback and improvement proposals. Concrete can be sprayed from either inside the FOPS/ROPS certified cabin with significantly improved ergonomics and control features or outside of it with a wireless remote. In addition, an advanced remote driving system enables safe and easy machine relocation.

The new cabin is fitted with features like ergonomically located spraying controls, a water spray supply system to keep the windscreen clean during spraying, and a NorSmart 3 dashboard with a touchscreen MID display.

The vehicle is equipped with a high-volume onboard compressor and the extremely durable and accurate SB 500 C spraying boom with strengthened steel structures; it also has rebound protection and high maneuverability, allowing for smooth concrete spraying operations. Furthermore, the boom's selectable vertical tracking and nozzle nutation functions ensure uniform spraying results.

Want all the benefits of the Shotcrete process?

Then don't skip any steps.

1. Start with a project-appropriate specification
2. Use only QUALIFIED CONTRACTORS with relevant project experience
3. Verify Nozzlemen are ACI Certified

aci

American Concrete Institute

www.concrete.org

www.ACICertification.org/verify to confirm that the nozzleman on your job is ACI certified

asa

www.shotcrete.org

SHOTCRETE CALENDAR

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

SEPTEMBER 29, 2023 – OCTOBER 1, 2023	**ACI Shotcrete Nozzleman Certification (Wet & Dry-Mix)** Applied Shotcrete | Sebastopol, CA
OCTOBER 1 - 4, 2023	**International Symposium on Fiber Reinforced Shotcrete for Underground Mining** PUC-Rio | Rio de Janeiro, Brazil
OCTOBER 4 - 5, 2023	**Highways USA** Kay Bailey Hutchison Convention Center | Dallas, TX
OCTOBER 4 - 6, 2023	**ACI Shotcrete Nozzleman Certification (Wet & Dry-Mix)** Minova | Millstadt, IL
OCTOBER 5, 2023	**Recognizing Quality Shotcrete** ACI SoCAL Resource Center | San Bernardino, CA
OCTOBER 16 - 18, 2023	**2023 ICRI Fall Convention** TradeWinds Island Resorts | St. Pete Beach, FL
OCTOBER 18, 2023	**Quality Shotcrete – Know It When You See It (Shotcrete Inspector Seminar)/ Shotcrete de calidad: conózcalo cuando lo vea (para la certificacion inspector de concreto lanzado)** Radisson Poliforum Leon | Leon, GTO
OCTOBER 27, 2023	**Quality Shotcrete – Know It When You See It (Shotcrete Inspector Seminar)** American Shotcrete Association | Wakefield, MA
OCTOBER 28, 2023	**ASA 2023 Fall Committee Meetings** American Shotcrete Association | Wakefield, MA
SEPTEMBER 29, 2023 – OCTOBER 1, 2023	**ACI 2023 Fall Concrete Convention** Boston Convention Center & Westin Boston Waterfront | Boston, MA
NOVEMBER 4, 2023	**Quality Shotcrete – Know It When You See It (Shotcrete Inspector Seminar)** Dees-Hennessey Inc | San Francisco Bay Area, CA
NOVEMBER 13 - 15, 2023	**International Pool | Spa | Patio Expo 2023** Las Vegas Convention Center – West Hall | Las Vegas, NV
NOVEMBER 13, 2023	**Quality Shotcrete – Know It When You See It (Shotcrete Inspector Seminar)** International Pool | Spa | Patio Expo 2023 | Las Vegas, NV
DECEMBER 3 - 6, 2023	**ASTM – C09 Concrete & Concrete Aggregates** Washington Hilton | Washington, DC

SHOTCRETE CALENDAR

JANUARY 7 - 11, 2024	**Transportation Research Board – 103rd Annual Meeting** Washington, DC
JANUARY 23 - 25, 2024	**World of Concrete – 50th Anniversary (Use Source Code A17)** Las Vegas Convention Center | Las Vegas, NV
JANUARY 23, 2024	**ASA Shotcrete Nozzleman Education** Las Vegas Convention Center | Las Vegas, NV
JANUARY 23, 2024	**ASA WOC 2024 General Membership Meeting & Shotcrete Reception** Las Vegas Convention Center | Las Vegas, NV
JANUARY 24, 2024	**Quality Shotcrete – Know It When You See It (Shotcrete Inspector Seminar)** Las Vegas Convention Center | Las Vegas, NV
JANUARY 25-26, 2024	**ACI Shotcrete Nozzleman Certification | Wet-Mix** World of Shotcrete | Henderson, NV
FEBRUARY 6, 2024	**Recognizing Quality Shotcrete** ACI MidWest Resource Center | Elk Grove, IL
FEBRUARY 25, 2024	**ASA Contractor Qualification Education** Lakeway Resort and Spa | Austin, TX
FEBRUARY 25-27, 2024	**2024 Shotcrete Convention & Technology Conference** Lakeway Resort and Spa | Austin, TX
MORE INFORMATION	To see a full list, current updates, and active links to each event, visit www.shotcrete.org/calendar.

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

506.6T-17: Visual Shotcrete Core Quality Evaluation Technote

During shotcrete construction, owners, architects, engineers, and contractors want to verify the quality of shotcrete being placed. Shotcrete cores are normally extracted from shotcrete sample panels or when needed from as-placed shotcrete for evaluation of shotcrete quality (ACI 506.4R). In addition to the routine tests such as compressive strength or other material quality tests required by project specification, visual examination of shotcrete cores by an experienced licensed design professional (LDP) is an important tool for evaluation of shotcrete quality.

Visit the ASA Bookstore to purchase today!

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ACI 506.6T-17 TechNote
VISUAL SHOTCRETE CORE QUALITY EVALUATION

NEED A SHOTCRETE CONTRACTOR OR CONSULTANT FOR A SPECIFIC PROJECT?

The American Shotcrete Association has created a free online tool to allow owners and specifiers the opportunity to distribute their bid request to all ASA Corporate Members in one easy form!

Submit your project for a bid request from ASA's outstanding Corporate Members today by visiting:

www.Shotcrete.org/ProjectBidRequest

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