shotcrete MAGAZINE

A quarterly publication of the American Shotcrete Association

VOLUME 27, NUMBER 1 • 1ST QUARTER | 2025

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OUTSTANDING SHOTCRETE PROJECT AWARDS

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shotcrete MAGAZINE

Volume 27, Number 1 • 1st Quarter | 2025

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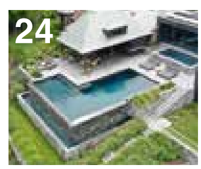

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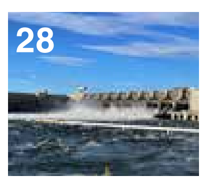

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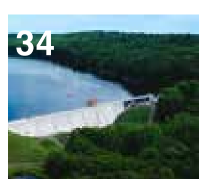

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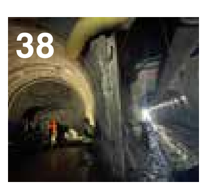

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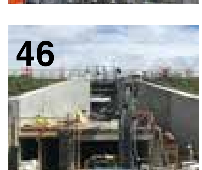

2024 Honorable Mention Project
Goose Pond Dam Improvements
By George Machikas

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

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COVER PHOTO: *Hemlock Dam downstream repair area, as featured with our 2024 Outstanding Rehabilitation & Repair Project on Pg. 34.*

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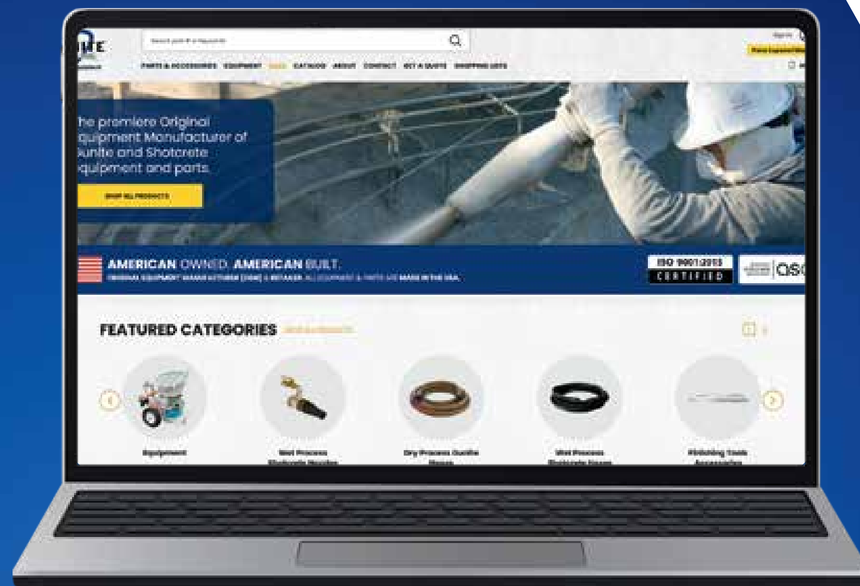

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Let's Get Started!

By Bill Geers

The American Shotcrete Association (ASA) was formed in March 1998 to increase awareness and acceptance of the shotcrete process. We are now in our 27th year, and as the incoming president of our organization — a role that has seen many giants of the industry — I am both humbled and honored to be elected to serve you for 2025.

A LITTLE BIT ABOUT ME

I first became involved in ASA nearly a dozen years ago while representing Bekaert – a leading developer and supplier of steel fiber reinforced concrete technology used in shotcrete ground support applications to replace conventional reinforcement. I have served on various committees as well as the Board of Directors and the Executive Committee of ASA, and I have found my involvement in the organization to be both personally and professionally rewarding.

As of December 2025, I retired from Bekaert as Technical and Business Development Manager for underground in North America and am currently working as an independent technical consultant in the infrastructure sector.

RECENT ENHANCEMENTS

Over our 27 years in existence, ASA has become the preeminent advocate and facilitator of the ACI Shotcreter Certification, ACI Shotcrete Inspector Certification, and our ASA Shotcrete Contractor Qualification programs. And now, thanks in large part to the efforts of our ASA members' active involvement in ACI code and standards, shotcrete is directly included in the ACI 318 Building Code as an accepted method of concrete placement!

The ACI 318 Code recognizes that the performance of the in-place material is dependent on the correct application of the material and the skill of the shotcreter. This acceptance of shotcrete opens the door for more applications to use shotcrete in construction to create more sustainable, durable, and cost-effective structures. This is in part thanks to modern day advances in technology in concrete, as well as the efforts of our industry leaders to assure the quality and durability of the in-place material.

> "The industry must continue to educate owners, engineers, and contractors, as well as recruit and educate certified shotcreters for quality shotcrete placement"
>
> **– Bill Geers**

SETTING SOME GOALS

RECRUITMENT

For the continued market growth and acceptance of this method of placement, I believe that the industry must continue to educate owners, engineers, and contractors, as well as recruit and educate certified shotcreters for quality shotcrete placement. One of my objectives this coming year is for ASA to work with our members to look at increasing the number of shotcreters coming into the market through outreach to trade schools.

POOL & SPA GROWTH

While ground support applications are one of the largest markets for shotcrete placement in the world, the single largest use of shotcrete in North America is in the building of swimming pools, spas and other water features. Another objective this year is to continue to work with our ASA Pool and Recreational Committee to increase the quality of shotcrete in the pool industry.

I encourage those involved in this industry to please consider joining us to help improve the quality of shotcrete in this application. Having ACI-certified shotcreters or being an ASA-qualified contractor provides value to your organization and sets you apart from others in your market.

INTERNATIONAL CERTIFICATION

During my tenure at Bekaert, I was involved in the increased use of shotcrete as a final lining of tunnels and underground stations around the globe. This market is expanding due to advancements in technology and the fact that using shotcrete in the final linings of these structures is cost effective and provides much lower embodied carbon than traditional cast-in-place linings, making them more sustainable.

Although hand spraying of concrete has been the primary method of application in North America, mechanized spraying is the norm in the larger tunnel and underground structures around the world. The ACI Shotcreter Certification was originally intended for hand shotcreting only. However, as remotely manipulated nozzles have become more readily available, the ACI certification can now include a mix of hand and remote nozzling. Because of the anticipated growth in underground project final lining applications, we are working

PURPOSE

AN EXCERPT FROM THE BYLAWS OF THE AMERICAN SHOTCRETE ASSOCIATION

- Educate the construction community as to the benefits of the use of Shotcrete
- Encourage and promote the use of Shotcrete by providing useful and accurate information to the concrete specifying and purchasing communities
- Support and promote the education of those in the Shotcrete industry in the proper methods, materials, and techniques to obtain high quality Shotcrete
- Serve as the primary international sponsoring group for the ACI Nozzleman Certification program (Now known as the ACI Shotcreter Certification program)
- Provide leadership, support, input and guidance to standards developing organizations (SDOs) and the engineering and architectural community to properly cover shotcrete in codes, specifications, standards and guides for concrete construction.
- Strive to maintain the highest standards of ethics and conduct for the members of the Association

to collaborate with the European group, EFNARC (the primary providers of certification and training of mechanized shotcrete equipment operators). Where EFNARC's certification focuses on the safe operation of specific mechanized shotcrete equipment, ACI's certifications focus on the safety and quality placement of shotcrete for structural integrity. ASA members are assisting ACI in bringing a remotely manipulated component to the shotcreter certification program to account for this growing method of application.

JOIN US!

I hope if you are in the shotcrete industry, or have any interest in it, that you consider joining ASA to achieve even greater success this year and the years to come. I promise to serve you to the best of my ability and focus on making an already great organization even greater.

Knowledge is Power: The Key to Advancing the Shotcrete Industry

By Derek Pay

In an industry as dynamic and technical as shotcrete, the phrase "knowledge is power" resonates deeply. Whether it's staying updated on the latest innovations, understanding evolving construction standards, or mastering the nuances of application techniques, knowledge empowers professionals to elevate their work, ensure safety, and deliver enduring structures.

THE ROLE OF KNOWLEDGE IN THE SHOTCRETE PROCESS

The shotcrete industry has seen significant advancements over the years, from enhanced material formulations to sophisticated equipment. However, technology alone does not guarantee success. It is the informed operator, engineer, or contractor who determines whether a project meets its design and durability expectations. A deep understanding of mix designs, proper nozzle techniques, curing procedures, and environmental factors ensures consistent quality and long-term performance.

For example, improper water-cement ratios or inadequate curing can compromise the structural integrity of shotcrete applications. Knowledge of these fundamental principles not only prevents costly mistakes but also demonstrates the value of skilled craftsmanship.

EDUCATION AND CERTIFICATION: EMPOWERING THE WORKFORCE

Industry knowledge grows through education and certification programs, such as those offered by the American Shotcrete Association (ASA) and similar organizations. These programs equip professionals with the technical expertise to address common challenges like rebound reduction, placement in adverse conditions, and achieving optimal compaction.

Certification also builds trust among clients and stakeholders, reflecting a commitment to quality and best practices. In today's competitive construction landscape, a knowledgeable and certified team becomes a project's greatest asset.

SHARING KNOWLEDGE TO ADVANCE THE INDUSTRY

Knowledge-sharing initiatives have the potential to uplift the entire industry. Workshops, conferences, and publications like Shotcrete magazine serve as valuable platforms for disseminating insights, innovations, and lessons learned. Collaborating and exchanging experiences can lead to breakthroughs that redefine what's possible in shotcrete applications.

Consider sustainability, for instance. As the construction industry strives to reduce its carbon footprint, leveraging knowledge about sustainable materials, energy-efficient methods, and recycling practices in shotcrete applications can lead to significant environmental benefits. Sharing such innovations ensures the industry collectively advances toward a more sustainable future.

ADAPTING TO EVOLVING CHALLENGES

Challenges such as extreme weather conditions, stricter regulations, and complex architectural

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demands require adaptability. A strong knowledge base allows professionals to embrace these challenges as opportunities for growth. Staying informed about global trends and advancements ensures the industry remains resilient and capable of delivering solutions that meet the needs of modern infrastructure.

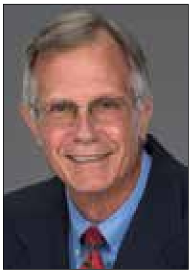
CONCLUSION

Knowledge is the foundation upon which the shotcrete industry is built. It empowers individuals to achieve excellence, drives innovation, and ensures that structures not only meet but exceed expectations. By prioritizing education, certification, and the exchange of ideas, our industry will continue to thrive and contribute to building a more sustainable and resilient future. ASA's Education and Safety Committee is committed to these goals and invites your participation in working toward that end.

As we move forward, let us remember: The power of knowledge lies not only in its acquisition but in its application. For the shotcrete industry, this is the key to long-term success.

What's Up with ASA in 2025

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



For the twentieth time, we have selected our ASA Outstanding Project Award winners. This issue of *Shotcrete* highlights all the winners, each of whom exemplifies the quality, creativity, and breadth of applications that shotcrete placement gives to modern concrete construction.

Already this year we've been a co-sponsor and exhibitor at the January World of Concrete in Las Vegas for the 25th time. It was great seeing and chatting with our members who came to the booth. We enjoyed great attendance at our educational programs and our general membership meeting (maybe the reception at the meeting helped boost attendance).

Our annual ASA Convention held at the DeSoto Hotel in Savannah, GA just wrapped up. Be sure to check out the next issue of *Shotcrete* (Q2–2025) where we will feature a recap of the sessions, meetings, and most importantly, images of the camaraderie we enjoyed.

What's ahead in 2025 for our Association? A primary thrust is to continue increasing our exposure and acceptance in the pool market. Our Pool and Recreational Committee is working with the Contractor Qualification Committee to complete an ASA Qualified Pool Shotcrete Contractor (QPSC) program. The concept is that though quality shotcrete placement requires close attention to the fundamentals of proper materials, equipment, and shotcreting technique, most pools have a more limited size and complexity than most commercial structural projects which our present ASA Qualified Shotcrete Contractors would undertake. The unique needs of shotcreters in the pool market lend themselves to a qualification specific to shotcreters who work in this market.

The goal of the new QPSC program is to focus the required education, exam, and application on aspects of shotcrete placement specifically encountered in pools. Currently, owners and pool builders who subcontract the shotcrete placement of the concrete pool shell have no proven way to confirm the quality of a pool shotcrete contractor. Though a contractor may have been shotcreting pools for 25 years, they may have been doing it wrong. The ASA qualification application evaluates the company structure, shotcrete equipment, field crews, company history, and successful project experience. The application is thoroughly reviewed and information vetted by experienced shotcrete contractors on the ASA CQ and Pool Committees.

We hope that, with the credibility of an ASA qualification program closely targeting quality in the pool shotcrete market, we can get rapid acceptance by owners and pool contractors. Owners and pool builders want a way to objectively review their pool shotcreters' credentials. ASA is essentially taking on this review process for them, backed by the exerience and reliability of the Association. We trust that pool shotcrete contractors who want to positively confirm their commitment to quality shotcrete will pursue qualification through our ASA QPSC program.

The ASA QPSC program was rolled out at the ASA Convention where a full-day education seminar and the required written exam were offered. Program information will be added to our website soon after the convention. If you're a pool builder or owner, ask your shotcrete contractor if they are pursuing the qualification and point them to the ASA website: Shotcrete.org.

We also continue to work with pool industry groups with wide exposure in the industry to present our full-day "Quality Pool Shotcrete — Know It, Demand It" seminar. This seminar is a tailored version of our Shotcrete Inspector education, geared towards pool builders who subcontract the shotcrete placement and pool shotcrete contractors. This year we already presented at the Southwest Pool Show in Houston. We also look forward to presenting at the International Pool Spa and Patio Show in Las Vegas in October. Watershape University, a premier pool educational group, has selected ASA to present shotcrete education for their classes. They have recently rolled out certifications for pool shotcrete specialists and pool shotcrete inspectors.

Wrapping up, please take some time to review the Outstanding Shotcrete Project award winners highlighted in this issue. The creativity, commitment to quality, and wide variety of shotcrete applications continues to impress me every year. 2024 was a great year for ASA, primarily due to the commitment of our members, officers, board, and staff. We expect 2025 will be just as exciting and to make further progress on advancing shotcrete acceptance around the world.

SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE

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

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2024 Outstanding International Project

Modernization of the Water Treatment Plant in Poznan

Façade after work completion

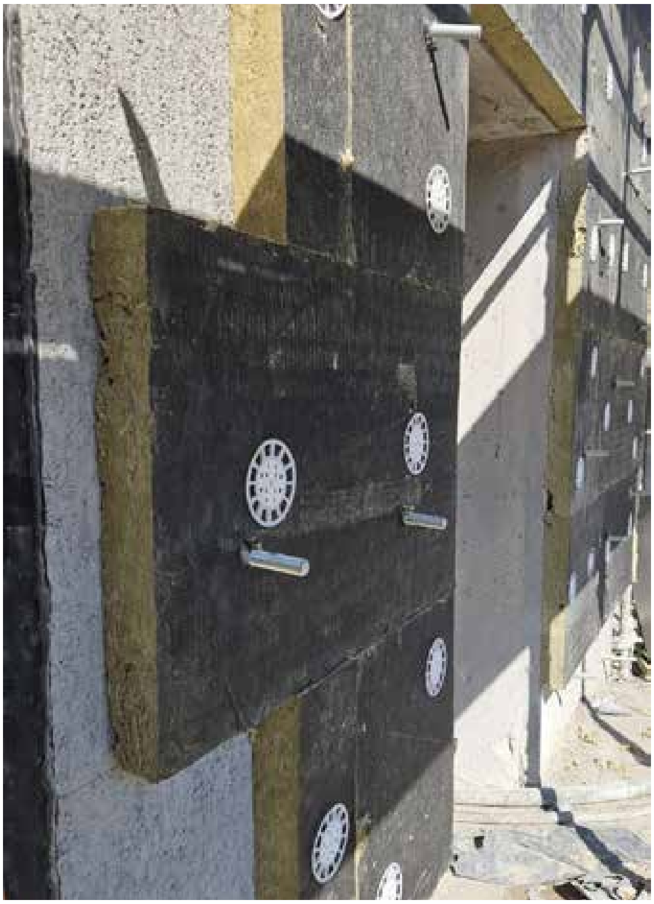
Façade of Rapid Filter Building before renovation

By Wlodzimierz Czajka

In 2022-2023, SPB TORKRET LTD repaired two buildings at the Water Treatment Plant in Poznan, Poland: The Iron Removal Building and the Rapid Filter Building. Both were constructed in the period before and during the Second World War in Poznan, which was then occupied by Nazi Germany. According to the available documentation, the Iron Removal Building and the Rapid Filter Building were both put into operation in 1943, built mainly by prisoners of war from various nations.

Constructed using reinforced concrete frames with column-and-beam structures and exterior longitudinal walls, these buildings were built using monolithic reinforced concrete technology. The gable walls had frame structures with brick infill. The buildings are under the supervision of the Municipal Conservator of Monuments in Poznan.

The contract signed with the General Contractor included the repair of the exterior walls of both buildings and the structural parts of the ceiling beams and joists of the last floor in the Iron Removal Building. The beam structure was shotcreted after being reinforced with


Installation of anchors and building insulation


Reinforcement, expansion joints, and preparation for shotcreting


Façade shotcreting

additional glued-in bars and stirrups. After chiseling and preparing the surface and installing welded wire mesh made of reinforcing bars, a 50 mm (2 in.) thick layer of shotcrete corresponding to C30/37 MPa (4400/5400 psi) concrete was applied to the exterior walls.

Initially, the General Contractor and the Designer submitted a design and mock-up for a ventilated façade, insulated with mineral wool, and clad on the exterior with fiber cement boards printed to imitate formwork, for the Conservator of Monuments' approval. The Conservator did not approve this solution.

The design of the ventilated façade, with a finish mimicking the original formwork, was intended to combine the industrial architecture of the period in which the buildings were constructed with contemporary architectural trends. As an experienced repair contractor using shotcrete technology, we proposed the construction of an insulated and ventilated façade with an external shotcrete coating with a surface finish imitating formwork. After a mock-up was made, all interested parties (Designer, General Contractor, Investor, Conservator of Monuments) agreed with our company's proposal to construct the façade using shotcrete.

It was necessary to design the repair of both buildings using shotcrete technology. The shotcrete placement solution was similar to the one used for the curvilinear walls of the POLIN Museum of the History of Polish Jews in Warsaw in 2012. The anchoring system with specially prepared reinforcement, the so-called "spider", was designed to distribute the anchoring force across the


Shotcreting

Façade after work completion

shotcrete façade. The shotcrete was sprayed on special fire-resistant impregnated boards, which had to meet the fire protection requirements of the building and, at the same time, serve as embedded formwork. An important innovation was the use of specially designed strips to act as guides and expansion joints for the shotcrete. These strips were also used to attach the film that protected the surface from both adjacent placement overspray and water evaporation in the curing process.

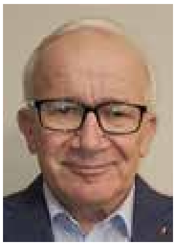
The factors that determined the choice of shotcrete placement for the construction of the façade were:

- Manual work, including producing a surface finish replicating the original building's formwork
- Rough appearance of uncolored concrete
- Natural variation in color similar to that which occurs during concrete construction

ABOVE: *Façade after work completion*
RIGHT: *Façade after work completion*
BELOW: *Final effect of formwork*

The dry-mix shotcrete used pre-packaged concrete material transported approximately 20 km (12 miles) from our company's dry-mix material plant. The composition of the shotcrete mixture was also a challenge. The shotcrete produced from this mixture had to meet the requirements for strength and freeze-thaw resistance, while remaining sufficiently plastic to allow for the imprinting of imitation formwork surface texture. The large number of windows, requiring protection and additional finishing considerations, posed technical problems which significantly slowed down the repair process. Reproducing the texture of the original formwork on the new façade, offset by approximately 110 mm (4.3 in.) from the original building wall, by stamping with the imitation formwork was another unique and innovative feature of this project.

The finished façade met the expectations of the Conservator of Monuments, the General Contractor, and the Owner of the facility (AQUANET SA). Shotcrete placement allowed us to recreate the look of the original façade with high strength and durable concrete, which could not be achieved with traditional form-and-pour methods.



__Wlodzimierz Czajka__ is the Technical Manager and a member of the Board of Directors of SPB TORKRET LTD. From the beginning of his professional career, he has been interested in the shotcrete method. He gained extensive experience by working 13 years in a large construction company where he led the Specialized Works Unit. In 1989, together with two partners, Czajka established TORKRET Company, specializing in repairs of reinforced concrete structures. For all these years, he has been a devoted promoter of the shotcrete method to designers and investors and has proactively participated in national and international symposia and conferences. He initiates innovative solutions that allow for implementing the shotcrete method on thin-walled structures in varying applications. He has 48 years of experience in the practical use of shotcrete.

2024 OUTSTANDING INTERNATIONAL PROJECT

Project
Modernization of the Water Treatment Plant in Poznan

Project Location
Poznan, Poland

Shotcrete Contractor
SPB TORKRET Ltd*

Architect/Engineer
Sweco Poland

Equipment Manufacturer
Sika* - Aliva, Atlas Copco

Materials Supplier
SPB TORKRET Ltd*

General Contractor
TERLAN/HYDRO-MARKO

Owner
Aquanet S.A.

**ASA Sustaining Corporate or Corporate Member*

Wybitny projekt międzynarodowy 2024

Modernizacja Stacji Uzdatniania Wody w Poznaniu

Elewacja po zakończeniu prac

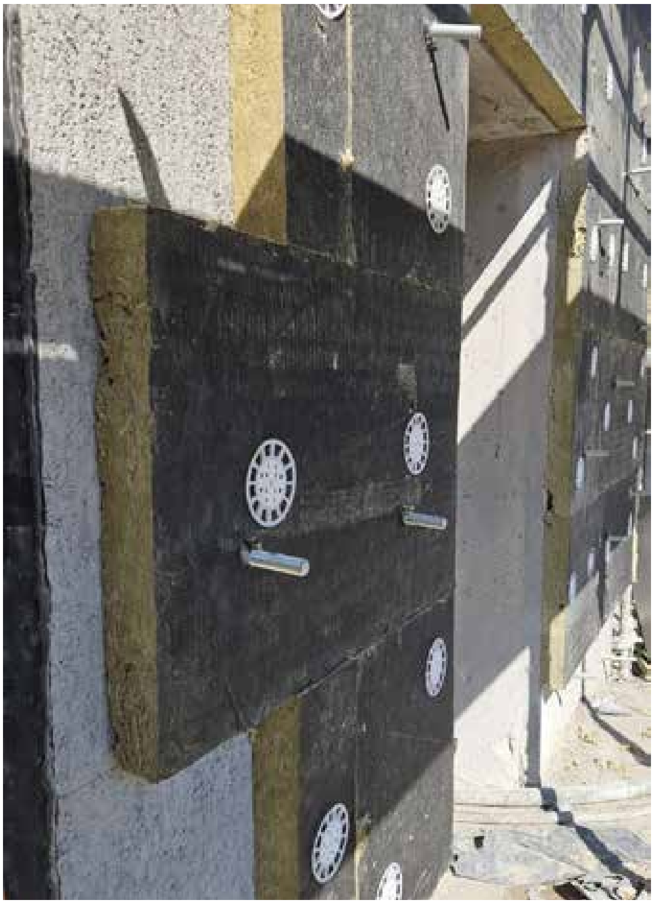
Elewacja budynku Filtrów Pospiesznych przed remontem

Napisał Włodzimierz Czajka

W latach 2022-2023 nasze przedsiębiorstwo SPB TORKRET sp. z o.o. spółka komandytowa zrealizowało naprawę dwóch budynków w Stacji Uzdatniania Wody w Poznaniu, w Polsce. Były to: Budynek Odżelaziacza oraz Budynek Filtrów Pośpiesznych. Budynki zostały wzniesione w okresie poprzedzającym II Wojnę Światową oraz w czasie jej trwania, w okupowanym wówczas przez hitlerowskie Niemcy Poznaniu. Według dostępnej dokumentacji Budynki Odżelaziacza i Filtrów Pośpiesznych były oddane do użytku w 1943r. i przy ich budowie w znacznej mierze wykorzystywano jeńców różnych narodowości.

Obydwa budynki zostały wykonane w technologii szkieletu żelbetowego o układzie słupowo-ryglowym ze ścianami zewnętrznymi podłużnymi wykonanymi w technologii monolitycznej żelbetowej. Ściany szczytowe wykonane w konstrukcji szkieletowej z wypełnieniem ceglanym. Budynki są objęte nadzorem Miejskiego Konserwatora Zabytków w Poznaniu.

Zawarta umowa z Generalnym Wykonawcą obejmowała naprawę ścian zewnętrznych budynków



Osadzenie kotew i montaż ocieplenia budynku

i części konstrukcyjnej belek i podciągów stropu ostatniej kondygnacji odżelaziacza. Konstrukcja belek po wzmocnieniu wklejanymi dodatkowymi prętami i strzemionami została natryśnięta torkretem. Na ściany zewnętrzne, po odkuciu i przygotowaniu podłoża, montażu zgrzewanych siatek z prętów zbrojeniowych, nałożono warstwę torkretu grubości 5cm odpowiadającemu betonowi C30/37.

Pierwotnie Generalny Wykonawca wraz z Projektantem przedłożyli do akceptacji Konserwatora Zabytków projekt i mockup ocieplonej wełną mineralną wentylowanej elewacji obłożonej z zewnątrz płytami włókno-cementowymi z nadrukiem imitującym deski szalunkowe. Na tego typu rozwiązanie nie zgodził się Konserwator Zabytków. Zaprojektowanie elewacji w technologii fasady wentylowanej z wykończeniem imitującym pierwotne deskowanie miało połączyć przemysłową architekturę z okresu, w którym powstały budynki ze współczesnymi trendami architektury. Jako doświadczony wykonawca napraw w technologii torkretu zaproponowaliśmy wykonanie ocieplonej i wentylowanej elewacji z zewnętrzną powłoką torkretową z imitacją szalowania. Po wykonaniu mockup'u wszystkie zainteresowane strony (Projektant, Generalny Wykonawca, Inwestor, Konserwator Zabytków) zgodziły się na propozycję naszego przedsiębiorstwa aby elewację wykonać w torkrecie. Powstała konieczność zaprojektowania obydwu budynków z zastosowaniem technologii torkretowania. Udało się to osiągnąć stosując podobne rozwiązanie jak w przypadku ścian krzywoliniowych w Muzeum Historii

Zbrojenie, dylatacje i przygotowanie do torkretowania

Torkretowanie elewacji

Torkretowanie

Elewacja po zakończeniu prac

Żydów Polskich POLIN w 2012r., w Warszawie. System kotew wraz ze specjalnie przygotowanym zbrojeniem tzw. „pajączkiem" został zaprojektowany tak aby rozłożyć siłę kotwy w płaszczyźnie elewacji z torkretu. Torkret był natryskiwany na specjalne impregnowane ognioodpornie płyty, które miały spełniać wymagania p.poż. budynku a zarazem stanowiły szalunek tracony. Istotnym innowacyjnym rozwiązaniem było zastosowanie specjalnie zaprojektowanych do wykonania torkretu listew spełniających rolę prowadnic i dylatacji. Jednocześnie listwy te posiadały funkcję montażu folii jako ochrony przed pyłem z natryskiwanego obok pola i zabezpieczenia przed odparowywaniem wody do pielęgnacji.

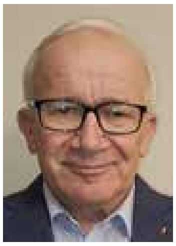
Czynnikami, które zdecydowały o wyborze technologii torkretowania do wykonania elewacji były:

POWYŻEJ: *Elewacja po zakończeniu prac*
PRAWIDŁOWY: *Elewacja po zakończeniu prac*
PONIŻEJ: *Finalny efekt deskowania*

- Praca ręczna wraz z wykonaniem imitacji deskowania pierwotnego
- Surowa barwa torkretu niebarwionego w masie
- Naturalne przebarwienia podobne do przebarwień powstających w cyklach betonowania

Torkret był wykonany w technologii suchej a konfekcjonowany materiał był przywożony ok. 20km z wytwórni suchych mieszanek naszego przedsiębiorstwa. Wyzwaniem był również skład mieszanki torkretowej. Torkret wykonany z tej mieszanki musiał spełnić wymogi wytrzymałościowe i mrozoodporności a jednocześnie musiał być plastyczny, umożliwiając wykonanie imitacji deskowania techniką odcisku. Technicznym problemem była duża liczba okien, która zdecydowanie spowalniała przebieg naprawy. Innowacyjną cechą tego projektu było odwzorowanie pierwotnego rysunku deskowania na nowej elewacji odsuniętej od pierwotnej ściany budynku o ok. 11 cm.

Wykonana elewacja spełniła oczekiwania Konserwatora Zabytków, Generalnego Wykonawcy oraz Właściciela obiektu (AQUANET SA). Technologia torkretu pomogła odtworzyć oryginalną elewację, której nie można było wykonać tradycyjnymi metodami.



***Włodzimierz Czajka** jest Dyrektorem Technicznym i członkiem Zarządu SPB TORKRET LTD. Od początku swojej kariery zawodowej interesuje się metodą torkretową. Bogate doświadczenie zdobył pracując 13 lat w dużej firmie budowlanej, gdzie kierował Działem Robót Specjalistycznych. W 1989 roku wraz z dwoma wspólnikami Czajka założył firmę TORKRET, specjalizującą się w remontach konstrukcji żelbetowych. Przez te wszystkie lata był oddanym propagatorem metody betonu natryskowego wśród projektantów i inwestorów oraz aktywnie uczestniczył w krajowych i międzynarodowych sympozjach i konferencjach. Inicjuje innowacyjne rozwiązania, które pozwalają na wdrożenie metody torkretowania na konstrukcjach cienkościennych w różnorodnych zastosowaniach. Posiada 48-letnie doświadczenie w praktycznym zastosowaniu betonu natryskowego.*

2024 WYJĄTKOWY PROJEKT MIĘDZYNARODOWY

Projekt
Modernizacja Zakładu Uzdatniania Wody w Poznaniu

Lokalizacja
Poznań, Polska

Wykonawca Natrysku Betonowego
SPB TORKRET Sp. z o.o.*

Architekt/Inżynier
Sweco Polska

Producent Sprzętu
Sika* - Aliva, Atlas Copco

Dostawca Materiałów
SPB TORKRET Sp. z o.o.*

Generalny Wykonawca
TERLAN/HYDRO-MARKO

Właściciel
Aquanet S.A.

**ASA Stały członek korporacyjny lub korporacyjny*

2024 Outstanding Architecture | New Construction Project

Math, Science & Shotcrete

By Ryan Oakes

We had just finished shooting some mockup panels for a column repair at NC State University on the Civil Engineering building where we had to prove that we could shoot around reinforcing bars between #11 and #18 (#36M and #57M) in size with very little clearance between bars. The mockups went well, and the general contractor (GC) realized that the shotcrete process might help them with a completely different problem on another project — one that would prove to be most unusual.

It took me a minute to wrap my head around what they were asking: It was challenging to understand what they were describing on the phone because it seemed so unlikely. Though the shotcrete process of placing concrete is extremely versatile and well suited for many applications, it seems we get called for the more interesting projects as well. A site visit proved necessary.

The repair was at a Middle School in Holly Springs, NC. Summer break had already started, so the situation was urgent: They needed a solution before school started back up, as one of the challenges included repair locations not just on campus but directly adjacent to class rooms. If the work fell into the school year, students would be trying to

ABOVE:
Fig. 1: Maintaining a clean surface with an air lance

RIGHT:
Fig. 2: Spraying and finishing from man lifts

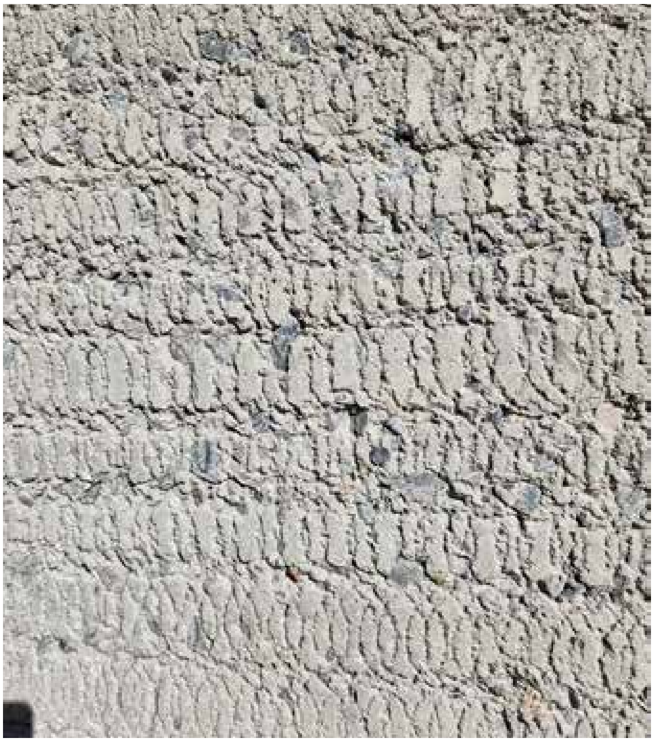


Fig. 3 Surface profile of tilt-up panel concrete after water jetting

focus on learning while contractors were outside trying to complete repairs. To aggravate the timeline further, proposals were needed, meetings scheduled, and approvals granted before any work could take place.

The building was a 40 ft (12 m) high tilt-up concrete structure clad with brick panels that had cracked and would soon begin falling off — not ideal for students walking underneath — and they had already started the demolition.

Once they started demolishing the structure, the GC and engineering team realized that the proposed brick panel system would not work on the existing tilt-up walls as the walls were not plumb or straight in any direction. In fact, they were trying to figure out why the walls were wavy and how on earth they could correct the situation. The walls were anywhere from 0.5 in. to 2.5 in. (13 mm to 63 mm) out of plumb both vertically and horizontally, sometimes over the whole 40 ft, and sometimes over just a few feet. The tolerance for the new cladding was 0.25 in. in 10 ft (6 mm in 3 m). It seems the original tilt-ups were cast on uneven ground. They needed to make the wall plumb and the leveling material needed enough strength to support the anchors for the brick cladding, as the anchors weren't long enough to reach the parent material in many locations.

Some options they were considering were polymer-modified hand-applied mortars which would be both cost and time prohibitive considering the areas and thicknesses needing rehab. With that approach, they could have likely completed the demolition before the start of school, however, all subsequent work would have to be completed during the school year and between classes.

We offered using dry-mix shotcrete placement to efficiently place varying thicknesses of concrete to create a plumb wall that met the requirements for placement of the brick panel product that would follow. Given that the tilt-up walls were extremely smooth and hard from being cast on foam boards, and because of foam being embedded in the near surface of the walls, they needed to be mechanically roughened. We tried a few surface preparation tools and ultimately went with hydro-demolition using a 40,000 psi (275 MPa) water jet. This provided an excellent rough bonding plane for the shotcreted concrete to adhere to.

Once all demolition and surface prep were complete, we used a grid pattern of piano wire to establish a finished plane in both the vertical and horizontal directions. This step was critical in ensuring the finished shotcreted surfaces would align with existing dimensions of the building. The piano wire was secured with fiberglass rebar that was doweled into the tilt-up panel concrete and epoxied in place. Since everything would be covered with the brick panels later, and because fiberglass is non-corrosive, we simply cut the bars flush with the finished shotcrete surface upon completion.

The vertical piano wires were set at slightly under 4 ft (1.2 m) widths. Our finishers then followed the wires with their finishing rods to assure the wall tolerances were maintained. Experienced shotcrete finishers can cut to a wire without pushing the wire into the freshly placed shotcrete material. The horizontal wires were run behind the vertical wires to help support them, as they were 40 ft long. The horizontal wires also allowed us to gauge the left to right tolerances of the structure.

It sounds simple on the surface, but the undulation of the substrate was substantial. Imagine floating 100 4 ft x 8 ft (1.2 m x 2.4 m) panels of insulating foam boards on a

Fig. 4: Highly tensioned piano wire used as thickness guides. Wires are held in place with fiberglass rebar, doweled into tilt-up panel concrete and left in place but cut flush with the finished surface.

Fig. 5: Wavy foam molded tilt-up concrete substrate, undulating up to 2.5 in. in any direction.

lake with boats driving all around and being able to freeze them in place with the push of a button. Then pour concrete on top of that. You can imagine the undulation we were up against: Any given area of 4 ft x 8 ft was tilted at some degree differently than the adjacent 4 ft x 8 ft spaces. This highly irregular pattern encompassed the entire length of the building. Though I was never told the source of the original cladding failure, I can imagine that it began with something as simple as the anchors not reaching far enough into the tilt-up panel substrate because of the undulation.

Overall, there were approximately 6000 ft^2 (560 m^2) of walls to correct, while working entirely from man lifts. All walls were 40 ft high and had windows and doors which could not be removed, presenting even more unique dimensional challenges regarding our finish tolerances. The window and door openings had been cast in the original wall panels so their flanges matched the adjacent surfaces prior to demolition. We had to 'cheat' the lines and 'bend' the shotcrete placement to match while honoring the allowable 0.25 in. in 10 ft tolerances mandated by the brick cladding company. To add insult to injury, the brick plinths at the bottom of the wall were staying and the top of the walls were as much as 2.5 in. out of plane left to right or out of plumb top to bottom. It was quite the puzzle, but we managed to provide the desired 0.25 in. tolerance over 40 ft for the majority of the project, much better than the 10 ft requirement.

Fig. 6: Smooth steel trowel and sponge float used to finish concrete beams for a precast look and feel.

Having areas with as little coverage as 0.5 in. and as much as 2.5 in., we could not include any wire or steel reinforcement. Instead, natural jute fibers were included in the dry-mix concrete mixture which was produced by our volumetric concrete trucks. These fibers helped to reduce rebound and provide internal curing of the thin sections because of their hydrophilic nature. They also helped 'hang' the extensive areas of concrete we were spraying.

The aggregate choice was a blend of a coarse natural sand and a washed granite screening. It met an ACI 506 gradation No. 1, with the largest aggregate passing a 0.375 in. (10 mm) by 100% and 2% retained on a #4 screen with 12% retained on a #8 screen. This made for a smooth wood float finish as prescribed by the coating company that would follow our work.

Another unique challenge presented was in dealing with the precast decorative concrete beams left in place at the top of the walls. It was clear upon close evaluation that not only did they make alignment of the finished surfaces difficult, but they could soon crack and fall down. Replacing them with new precast units would delay the project by 6 months or more, so we offered to remove them and replace them with shot-in-place, hand carved beams in a fraction of the time and for a fraction of the cost compared the precast

Fig. 7: Removing the decorative concrete beams, with equalized anchor points, by crane. Once under tension, the workers could pry the cracked beam off the safety bolts. The beams were then lowered into a dumpster with minimal effort. No pieces were dropped to the ground below.

alternative. The availability of this option for the distressed beams exemplifies the true flexibility of shotcrete.

The first obstacle in replacing the beams was to remove them. We were not contracted for demolition, but found ourselves jumping in to help meet deadlines. The existing beams were fragile, 40 ft in the air and had apparently been bolted in place by the demolition crew to stay in place. It was clear that any wrong move could cause these 20 ft (6 m) long beams to fall to the ground. We had to remove them between classes and surgically, so we employed techniques used in high-angle mountaineering and rescue to secure the beams as whole structures, then carefully cut the bolts and released them to a crane, where they were placed in a dumpster to be hauled off. The whole process went so well that it left little more to tell.

Working with the engineer on the project, we then proposed doweling the substrate with fiberglass rebar and reinforcing the ornamental elements with fiberglass rebar. The bottom of these elements were formed to provide us a beveled edge to shoot to and minimize fallout waste on the newly shot walls. The beams were shotcreted in place and carved to the finished tolerances. Finishers using a steel trowel and sponge float created a more refined, smooth finish to closely emulate a pre-cast product.

Though all parties made a valiant effort to get the project done by the original deadline, invariably, delays prevented us from starting prep or shotcrete until after the start of the school year. This created a most interesting element of the project, in working around young children, parents in school pick-up lines, teachers, and after school sporting events. It was a dance, to say the least. We would find ourselves moderating noise levels between math and science classes, stopping work for children to walk from indoors to an outdoor classroom, and managing safety during children being dropped off and picked up, which was right where we were working. Anyone who lives near a school or has small children knows what that looks like!

With all these obstacles, we finished on budget and within our extended allowed time, even with the added scope of the concrete beam replacement.

We completed the shotcrete work in 9 days, considerably faster than any other option. This project truly highlights so many of the virtues of the shotcrete process: We can adapt to non-uniform shapes while creating unique shapes of our own, work with little or no formwork, and adhere to vertical surfaces with nothing to help hold the fresh concrete in place. We can start and stop while working around various obstacles or for adverse weather. We can use basic concrete materials that are equal or superior to factory-created features and at a fraction of the cost. And we can do all that really fast!

Fig. 8: Finished walls after cladding

2024 OUTSTANDING ARCHITECTURE | NEW CONSTRUCTION PROJECT

Project
Math, Science & Shotcrete

Project Location
Holly Springs, NC

Shotcrete Contractor
Revolution Gunite*

Architect/Engineer
Dewberry Engineering

Materials Supplier
Revolution Gunite*

General Contractor
Progressive Contracting

Owner
Wake County Public Schools

**ASA Sustaining Corporate or Corporate Member*

***Ryan Oakes** is President of Clearwater Construction Group, Inc., Revolution Gunite, and Revolution Pool Finishes, all of which are award-winning firms in their respective trade. As Technical Director for Revolution Gunite, he continually aims to raise the bar in the shotcrete and construction industry. Oakes is a member of ACI Committee 506-Shotcreting, and ACI Subcommittee 506-H-Shotcreting Pools. He also serves as Secretary to ACI Committee 322-Concrete Pool & Watershape Code. Oakes serves as Chair of the ASA Pool & Recreational Shotcrete Committee, a voting member of the ASA Contractor Qualification Committee, and former Board of Directors for ASA.*

2024 Outstanding Pool & Recreational Project

Boundless Waters

Fig. 1: Vanishing edge overflow with continuous edge viewing of lower property to and beyond the Hudson River

By Bill Drakeley & Anna Drakeley

The Boundless Waters pool project is a contracted water feature that draws its contemporary design from the architecture of the new house installation. The house is a modern version of the old costal mansions once built and adorned on the Hudson River by the Rockefellers, Morgans, and Vanderbilts. The house and surrounding architecture and landscape architecture incorporate a contemporary strict linear version of the old-world construction. The modernist house, complete with the pool and other features, connects directly to the Hudson River. The pool is a reflection of the house with a 3-tiered open space pool and spa incorporating a vanishing edge detail (Figs. 1 and 2). Edge water spills over the edges into a shotcreted basin and surge tank.

Fig. 2: Multiple Edge/Water in Transit

Fig. 3: Original soils and elevations to form and to work up to

Fig. 4: Poured foundation formed for on grade support of shotcreted pool

Fig. 5: Forming, plumbing out steel installation on top of cast foundation support for the wet-mix shotcrete methodology

CONSTRUCTION PHASING

Construction phasing started with forming and reinforcing bar installation. Our first concrete installation was poured concrete for the pool and wall structures surrounding the pools (see construction photos) to meet the pool heights and elevations, as we needed to base the foundation on solid ground (Fig. 3), not on fill. The poured concrete footing and wall supports would be the locking mechanisms, along with our reinforcing connections, for our shotcrete installation (Fig. 4). With proper shotcrete placement, the entire monolithic pool structure would be mechanically and physically connected to the cast concrete foundations and walls. Unlike the cast concrete substructure, our shotcrete forms were one-sided, rough-sawed lumber, 2 x 4 x 1.5 in. (50 x 100 x 38 mm) thick as well as 0.75 in. (19 mm) sheets of plywood. The entire pool installation was out of ground and some intricate forming was required. The steel reinforcement was Grade 60, #4 and #5 bars (#13 M and #16 M), 10 and 6 in. (250 and 150 mm) on centers, double, and triple cage. All reinforcing steel was installed to ensure rigidity and was free of oil and contaminants that could affect performance. A total of 20,000 lb (9100 kg) of reinforcing steel was used.

SHOTCRETE PROCESS

Shotcrete placement took place over a 3-day period. The first two days were for the bulk of the main pool shooting and some of the thicker wall to floor joints, including full thickness bench shooting of seats and benches (Fig. 5). The last day focused on the intricate detail and close tolerances of the vanishing edge. After the wet-mix shotcrete placement, the concrete was water-cured to ensure not only strength gain but to also improve watertightness and ultimately the durability of the pool (Fig. 6). Compressive values after 28-day wet cure were between 6000 and 7500 psi (41 and 52 MPa). A construction challenge at this site was the wind. We needed windbreaks as well as extra plywood during shotcrete placement to help mitigate evaporation moisture loss from the freshly shotcreted concrete surface.

Completion of the pool included these different finish materials:

- Native stone veneer matching the existing house foundational colors
- Pennsylvania Select Bluestone treads and caps
- Italian Porcelain Tile & Specialty Edge Stone
- Pool plaster, aggregate finish

SIGNIFICANCE OF SHOTCRETE

The significance of shotcrete placement on this project as well as the pool industry as a whole, is a successful installation, structural integrity and watertightness of the two connected water retaining structures. The success of this water feature is proof positive that shotcrete placement not only creates a watertight bond to support vastly different surfaces but can creatively and efficiently recreate architecture and design that mirrors world-renowned

Fig. 6: Form removal, quality concrete example of the wet-mix shotcretes with soaker hoses for curing in place

architectural works. The pool and spa sit in sight of the New Tappan Zee Bridge, which spans the Hudson River. Soil conditions, moisture, concrete placement, formwork, elevations, and final views were all similar with both the home, pool and spa projects considering their close proximity. Placement techniques in this neighborhood have a very high standard. We used two ACI-Certified Shotcreters for the shotcrete placement. Drakeley Pools is an ASA-Qualified Shotcrete Contractor.

SHOTCRETE SEGMENT OF THE PROJECT

The shotcrete segment of this project was one week's worth of shotcrete into the pre-existing form and reinforcement curtains for the pool, edge, and spa. Although the shotcrete took three days to complete, the shotcrete process prevents any cold joints. All interconnecting pools are monolithic concrete exhibiting complete watertightness. There is no expansion joint, waterstop or bonding agent used between the concrete connections. All next-day shooting and connecting joints were roughened, cleaned, and brought to an SSD condition to provide maximum bond.

Total Concrete Used
130 yd^3 for pool and vanishing edge
30 yd^3 for spa

Mix Design was as follows:
Cement (ASTM C150 Type I/II) – 750 lbs (340 kg)
Fly Ash (ASTM C618 Class C) – 50 lbs (23 kg)
Sand (ASTM C-33) SSD – 2020 lbs (920 kg)
ASTM No. 8 rock – 600 lbs (270 kg)
Water – 358 lbs (162 kg)
Air Mix 250 – 1.0 to 2.0 oz (30 to 60 ml)
Water Reducer – 2.0 oz
Entrained Air Content – 8% to 10%
Slump – 1 to 3 in. (25 to 75 mm)
W/C Ratio – 0.45

Equipment Used: Schwing BP500 Shotcrete Pump, Ingersoll Rand 375 CFM Air Compressor

SUSTAINABLE BENEFITS REALIZED ON THE PROJECT RESULTING FROM SHOTCRETE

Sustainability benefits on this project were as follows:

- Approximately 50% labor and material savings over conventional form-and-pour work.
- Our form work did not need to be designed for internal pressures and only needed one-sided forming. Unlike our form-and-pour work, which required two-sided forming.
- The speed of construction increased by almost 50% because of the reduced shotcrete formwork.
- The restricted work site and its elevated accessibility could not have been completed economically or efficiently by any other means than shotcrete placement.
- The cost savings with shotcrete materials and labor was clear when compared with the form-and-poured concrete foundation on this same job.

CONCLUSIONS:

Figs. 7 and 8 show the water surface to be clean and without any part of the structure protruding up and above the clean-glass-looking pool surface. This architectural look was a high priority with the clients. Building water features or swimming pools with multiple layers of water in transit edges and elevations requires quality shotcrete installation. Tight tolerances, material bond ability to a structure, and clean water flow at a minimum energy usage all rely on quality shotcrete and close attention to detail. Durability of a swimming pool is contingent on how well the structure was built. The top component of a well-built swimming pool is the shotcrete pool shell. Clearly, this water's edge placement of watertight concrete via the wet-mix shotcrete process is designed to be more than a pool. The water feature's intent is to be part of the architecture in both look and structural integrity. We take pride in our ability to marry the two together.

Fig. 7: Finished project providing view verification of the Hudson River

Fig. 8: Drone footage showing line and grade balance and symmetry

2024 OUTSTANDING POOL & RECREATIONAL PROJECT

Project
Boundless Waters

Project Location
Hudson River, NY

Shotcrete Contractor
Drakeley Pool Company*

Architect/Engineer
Hollander Landscape Architects

Equipment Manufacturer
Schwing Concrete Pumps

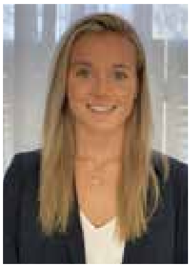
Materials Supplier
Brewster Transit

General Contractor
Yankee Custom Builders

Owner
Yankee Custom Builders

**ASA Sustaining Corporate or Corporate Member*

***William "Bill" Drakeley** is an award-winning shotcrete technologist specializing in concrete science and construction, particularly shotcrete applications, techniques, and standards. He has 30-plus years of experience in shotcrete installation, water feature and geotechnical design, and construction. He is co-founder of Watershape University.*



***Anna Drakeley** has followed in her father's footsteps by joining the pool industry first on the educational side as the Marketing Manager for Watershape University and now on the sales and marketing side for Drakeley Pool Company. She holds two bachelor's degrees in business and marketing from Saint Anselm College, where she also played on the Field Hockey Team for five years, earning the titles of First-Team All-American and Division II Defensive Player of the Year.*

Ice Harbor Lock and Dam

2024 Outstanding Infrastructure Project

Ice Harbor Dam Rewinds and Turbine Runner Replacement

Shaft for a turbine unit

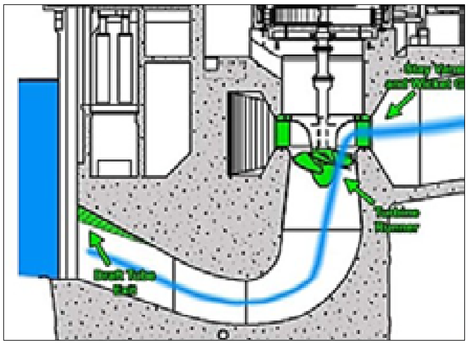


Illustration of the draft tube modification

By David Graham

Ice Harbor Lock and Dam was authorized by the River and Harbor Act of 1945. Constructed in 1956, the project includes a dam, a powerhouse, a navigation lock, two fish ladders, a removable spillway weir, and a juvenile fish bypass facility. It provides navigation, hydropower, flood risk management, fish and wildlife habitat, recreation, and incidental irrigation. The dam, located on the Snake River near the confluence with the Columbia River in Burbank, WA., is 2822 ft (860 m) long with an effective height of 100 ft (30 m). It is a concrete gravity-type dam with an earth-fill embankment section.

In 2016, the owner awarded a contract to rebuild three generating units to improve hydraulic conditions for fish passage and improved turbine electrical generating efficiency. This Contract included draft tube ceiling structural modifications, requiring the application of an accelerated wet-mix shotcrete with 100 lb/yd^3 (59 kg/m^3) of steel fiber, up to 6.25 ft (1.9 m) thick overhead. As overhead application of shotcrete to such thickness is seldom done, this posed a challenge for the designer and contractor.

PRECONSTRUCTION MOCK-UP / PROCESS AND SHOTCRETER QUALIFICATION

To qualify the shotcrete mixture design, accelerator type and addition rate, and the shotcrete application procedures by the ACI-certified shotcreters, several full-scale overhead mock-up sections were constructed with a thickness of up to 6.25 ft. These mockup sections replicated field conditions

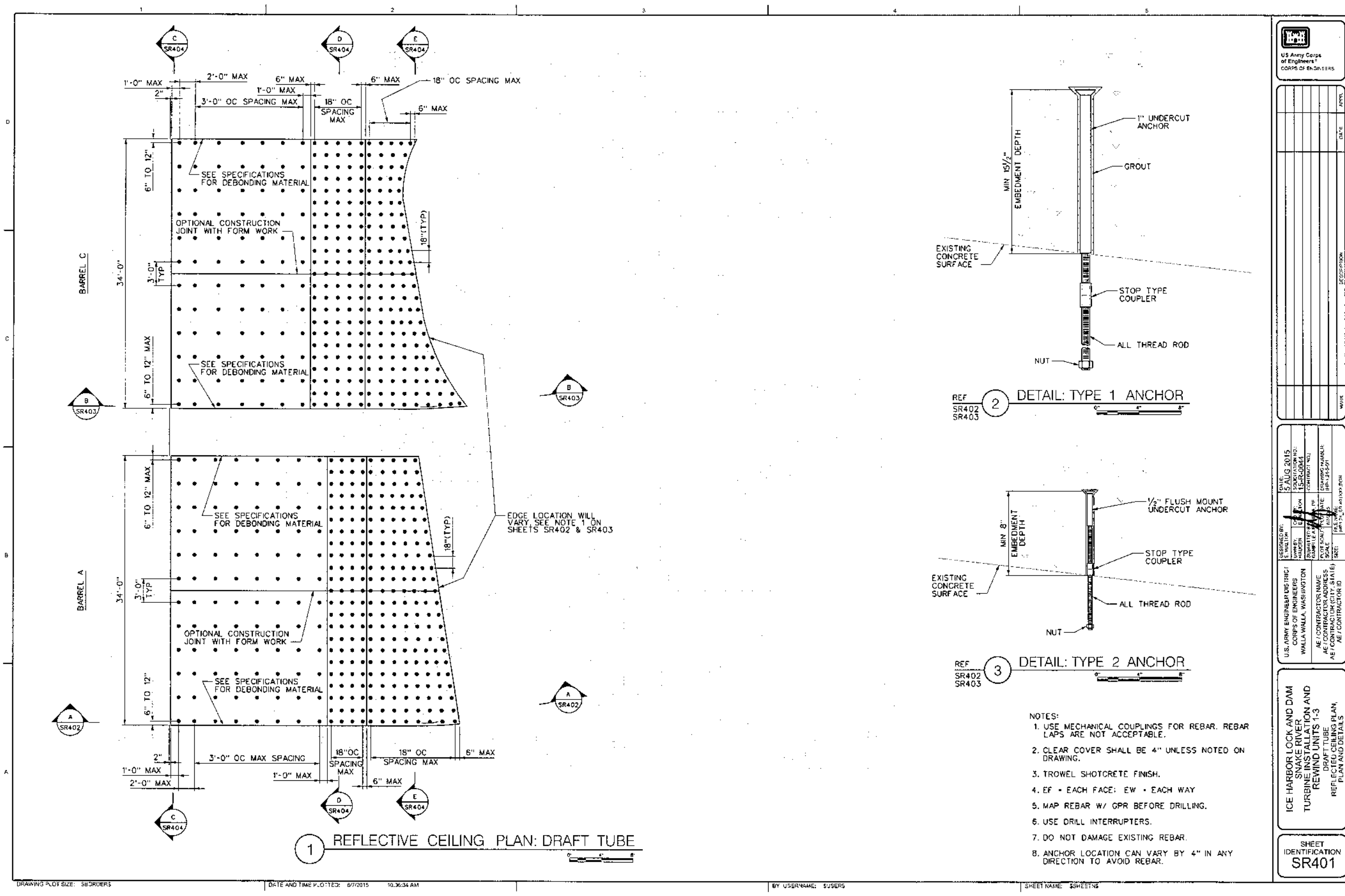


Fig. 1: Reflective ceiling plan for reinforced shotcrete modifications to draft tube

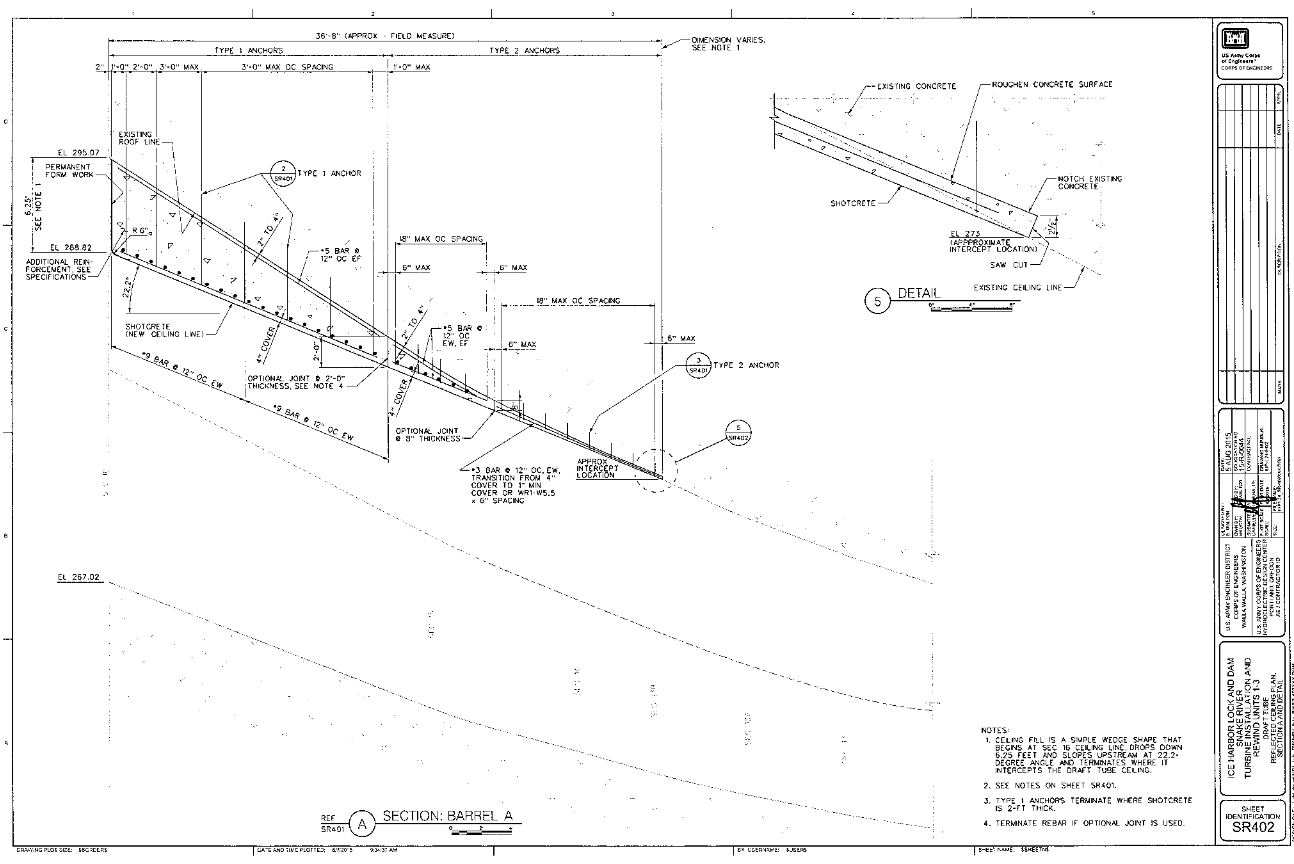


Fig. 2: Sectional view of reinforced shotcrete modifications to draft tube

Shotcreter shooting the full-scale mock-up

Mock-up block stripped and lowered to the ground for evaluation

A diamond wire cut section of a full-scale mock-up showing excellent shotcrete consolidation around rebar and saw cut prisms for bond testing

Permanent steel form, one-inch diameter anchors, and #5 reinforcing steel mat installed, secure and ready for shotcrete

Layer thickness was controlled to a maximum of 4" using steel piano wire

including 1 in. (25 mm) diameter undercut anchors, #9 (#29M) and #5 (#13M) reinforcing steel mat sections, and final finish. Each shotcreter qualified for use on this project was required to complete an acceptable preconstruction mock-up prior to jobsite shotcrete placement. After construction of the preconstruction mockup, each block was sawed in half to allow the design engineer to conduct a visual inspection of the cut sections and observe the quality of reinforcement steel encasement and consolidation of the multiple shotcrete layers placed overhead.

WORK AREA ACCESS

Sectional scaffolding was installed within the draft tube area from floor elevation to ceiling. The work platform elevation was lowered as required during construction as overhead shotcrete placement progressed.

SURFACE PREPARATION-REINFORCING STEEL-SUPPLEMENTAL ANCHORS

Prior to shotcrete placement, all existing concrete surfaces to receive shotcrete were prepared using an abrasive blasting technique to ICRI CSP 7. The leading edge was sawcut and concrete removed to provide a minimum of 2.5 in. (63 mm) thick shotcrete section. A 6.25 ft high permanent steel form was installed straight and plumb providing 2 in. (50 mm) spacing from the temporary stoplog bulkhead. Supplemental anchors were installed that included 0.5 in. (13 mm) and 1 in. diameter undercut anchors. The #5 and #9 reinforcing steel mats were installed per plan.

SHOTCRETE PLACEMENT AND FINAL FINISH

Accelerated wet-mix steel fiber reinforced and silica fume modified shotcrete placement started after all surface preparation, supplemental anchors, and reinforcing steel were installed and passed inspection. Shotcrete was placed in consecutive layers up to a maximum of 4 in. (100 mm) thick until the full section was complete. Steel piano wire was used for grade control between layers. Material for the final 2 in. layer was constructed using ACI 506R gradation #2 aggregate, silica fume, and polypropylene fiber dry-mix shotcrete. The final finish was light broom with a tolerance of 0.25 in. (6 mm) in 10 ft (3 m).

PRODUCTION QUALITY CONTROL AND QUALITY ASSURANCE

The work was monitored full time by qualified inspectors. After each days' production, inspectors filled out inspection checklist reports which were submitted daily. Field testing was conducted to record the ambient temperature, concrete delivery temperature, as-batched and as-shot air contents, and initial and final set times. Beam molds were shot to determine early-age compressive strength development using an end beam tester.

The contractor shot one production shotcrete test panel for every 50 yd^3 (38 m^3) of shotcrete placed, or one per day, whichever occurred more frequently. Cores were extracted from the test panels to determine:

- Compressive strength at 7, 28, and 56 days
- Boiled absorption and volume of permeable voids to ASTM C642 at 28 days

Shotcreter shooting overhead on a scaffold platform in an upright position to the No. 5 rebar and the one-inch anchors

Excellent quality of encasement of the No. 9 rebar was observed by the shotcrete inspector

Final broom finish of the draft tube ceiling modification

Beam molds shot for determination of early age compressive strength using end beam tester

Bond pull-off testing was performed to determine shotcrete bond strength to the prepared concrete substrate. Bond strength testing was conducted after the shotcrete applied to the original prepared concrete substrate had cured for a minimum of 7 days. Bond strength tests were also performed to evaluate the bond between shotcrete layers.

PROJECT CHALLENGES

- Difficult access due to the work location being deep within the dam structure
- Overhead crane limitations and shared use requirements
- Waste material removal
- Leaking stoplog seals
- Weather: Hot summer and cool winter conditions
- Multi-year contract, 2016-2024
- Construction activity delays, eight-month COVID shutdown
- Portland cement changed from Type I to Type IL in 2023
- Fly ash source change in 2021 proved detrimental to the concrete mixture design strength development; as a result, fly ash was removed from the mixture design during the 2024 phase
- Confined space, temporary ventilation, dust/vapor controls, lighting

SUMMARY

Construction of Unit No. 2 (2017), Unit No. 3 (2020), and Unit No. 1 (2024) proved that a high quality, accelerated, wet-mix, steel fiber reinforced, silica fume modified shotcrete up to 6.25 ft thick overhead can be applied successfully. The structural modification to the draft tubes was completed using wet-mix shotcrete, except for the final 2 to 4 in. (50 to 100 mm) finishing shotcrete layer, which was constructed using dry-mix shotcrete.

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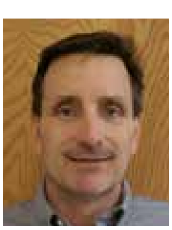
2. Zhang L., Radomski S., Morgan D.R., Graham D., Structural Modifications of Draft Tubes Using Overhead Wet-Mix Steel Fiber Reinforced Shotcrete, Concrete Repair Bulletin, International Concrete Repair Institute, Inc. July/August 2022, pp 20-28.



***David Graham**, Project Manager/Estimator for PCiRoads, LLC. With over 40 years of experience in the shotcrete industry, he has managed numerous projects nationwide that include the use of shotcrete on buildings, bridges, tunnels, dams, silos, tanks, and soil stabilization.*

2024 OUTSTANDING INFRASTRUCTURE PROJECT

Project
Ice Harbor Dam Draft Tube Modification

Project Location
Burbank, WA

Shotcrete Contractor
PCiRoads, LLC*

Architect/Engineer
U.S. Army Corps of Engineers, Walla Walla District

Equipment Manufacturer
Gary Carlson Equipment* / Putzmeister*

Materials Supplier
Master Builders Solutions*

General Contractor
Voith Hydro

Owner
U.S. Army Corps of Engineers, Walla Walla District

Other Project Members
LZhang Consulting & Testing, Ltd. / WSP Canada, Inc.

**ASA Sustaining Corporate or Corporate Member*

2024 Outstanding Rehabilitation & Repair Project

Hemlock Reservoir Dam Improvements

Fig. 1: Hemlock Dam downstream repair area

By George Machikas

The Aquarian Water Company of CT authorized the repair and resurfacing of the Hemlock Dam. The dam, commissioned in 1928, is about 2 mi (3.2 km) from Fairfield, CT. Size is approximately 1100 ft (340 m) long and 75 ft (23 m) high (Fig. 1). Shotcrete work was comprised of deep spall repairs and a continuous shotcrete coating to the upstream and downstream faces of the dam. Additional spall repairs and coatings were performed on the spillway, upper gate house, and training walls (Fig. 2).

The concrete repair material specified for the shotcrete placement was a prepackaged one component, cementitious, ready-to-use, silica fume enhanced, fiber reinforced, high strength, shrinkage compensated repair

Fig. 2: Hemlock Dam upstream and gate house repair area

mortar (SikaRepair®-224). In total, over 26,000 bags were mixed on site and shot using a wet-mix shotcrete pump with an attached mixer (Fig. 3). The finished shotcrete work included over 30,000 ft^2 (2800 m^2) of repaired and coated dam surfaces.

Workers accessed the downstream face and training walls using aerial man lifts (Fig. 4 and 5). A barge was used to access the upstream faces and spillway. The barge working deck elevations were controlled as needed by adjusting the reservoir water level.

The reservoir is a drinking water supply and has a pristine and thriving ecosystem, which is home to many species of wildlife, including largemouth bass, chain pickerel, and rainbow trout. To protect the reservoir's water, workers placed turbidity curtains on the upstream face on both sides of the gatehouse.

Fig. 3: Wet-mix pump with mixer using prepackaged repair mortar

Fig. 4: Shotcrete application from 80 ft (24 m) man lift

Fig. 5: Downstream shotcrete application

2024 OUTSTANDING REHABILITATION & REPAIR PROJECT

Project
Hemlock Reservoir Dam Improvements

Project Location
Fairfield, CT

Shotcrete Contractor
Patriot Shotcrete, LLC*

Architect/Engineer
Tighe & Bond, Inc.

Equipment Manufacturer
Putzmeister America*

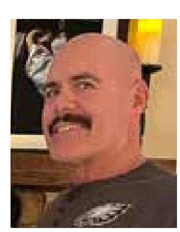
Materials Supplier
Sika Corporation*

General Contractor
Blakeslee Arpaia Chapman Inc.

Owner
Aquarion Water Company of Connecticut

**ASA Sustaining Corporate or Corporate Member*

Shotcrete was the obvious choice for the repairs because of the access challenges and time requirements of the project. Shotcrete placement eliminated the need for scaffolding, hand placement of repair materials, and complicated form work. Using shotcrete eliminated extensive hand work and avoided the complications of difficult access, yielding tremendous savings in time and cost as a result.

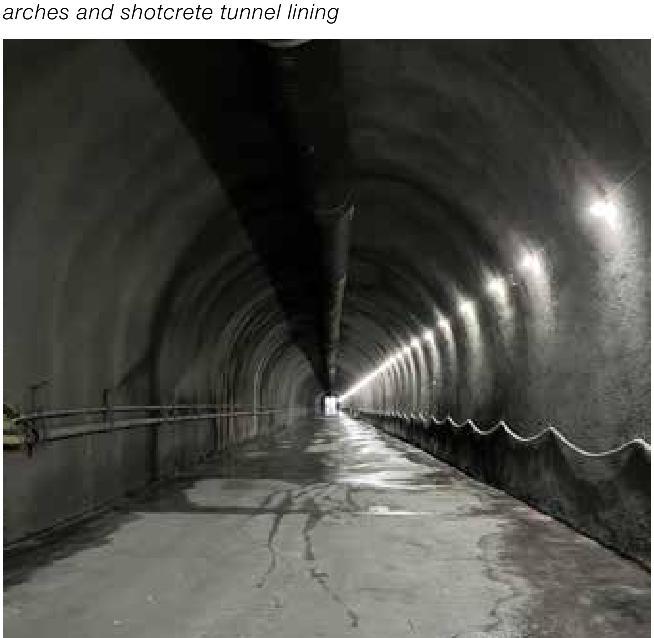


__George Machikas__ is the Director of Operations for Patriot Shotcrete LLC located in Somerset, NJ with over 40 years of experience in the concrete and shotcrete industries following graduating from Lehigh University. More recent endeavors over the last ten years have been focused on structural shotcrete work in the Northeast, providing shotcrete work for tunnels, bridges, dams, building foundations, building retrofits, and support of excavation.

2024 Outstanding Underground Project

Anderson Dam Tunnel

Two-boom jumbo installing pre-support spiles over steel set arches and shotcrete tunnel lining



Smoothing shotcrete interior surface complete looking out of tunnel toward the portal

By Brian Harris, PE, and Alex Folchi, PE

Drill Tech Drilling & Shoring, Inc. performed Sequential Excavation Method (SEM) tunnel construction with geometric cross sections consisting of 19 ft to 24 ft (5.6 to 7.3 m) diameter tunnels (including wide span intersections) for the Anderson Dam Tunnel Project. This Project is the first phase of the dam's seismic retrofit that establishes new water supply tunnels, drop shafts, and lake intake structures required prior to rebuilding the dam itself in subsequent phases. Nestled in the foothills of Morgan Hill, California, work was completed in highly unstable and variable Santa Clara and Franciscan formations, which included regional faults notorious for seismic activity and varied significantly in rock quality. The tunnel alignment traversed through these native formations and around the existing dam abutment to ultimately provide future water supply around the reconstruction of Anderson Dam. Drill Tech safely overcame the challenges of difficult mixed-faced ground conditions (soil and rock intermixed with heavily faulted zones) and

Tunnel excavation progressing ahead of steel arch set and shotcrete liner

LEFT: *Looking up into the 9 in. thick shotcrete lined 105 ft deep variable shaped shaft*

BELOW: *Looking down into the 9 in. (230 mm) thick shotcrete lined 105 ft (32 m) deep variable shaped shaft*

successfully completed the critical underground excavation and support required for the infrastructure upgrades.

As an integral component to the geostructural support mechanisms applied on this project, Drill Tech used shotcrete placement for excavation shoring on features including tunnel portal slopes, underground tunnel structural linings, and vertical shaft liners. Shotcrete primarily provided ground support immediately after excavation, thus stabilizing the open ground mined for the tunnel alignment. Following this initial application, shotcrete thickness was gradually built up to the full design thickness required by the engineer of record and acted as a portion of the composite liner that also included steel beam arch sets. The project required tight tolerances of shotcrete applications and stringent interior smoothness criteria for the finish of interior surfaces.

Over the course of 18 months, Drill Tech performed reinforced slope shoring and tunnel lining that consisted of 1800 yd^3 (1400 m^3) for slope stability and 5100 yd^3 (3900 m^3) for tunnel / shaft linings. Drill Tech set a company record for most single shift shotcrete volume placement at the tunnel portal with 220 yd^3 (168 m^3) sprayed in just 9 hours of work through a single nozzle. The applications of shotcrete at the project are included in the following table:

Project Element	Length / Depth / Area	Shotcrete Section Thickness	Shotcrete Type	Shotcrete Volume Placed
Tunnel Portal Shoring	48,000 ft^2	12 in.	Double Mat Rebar Reinforced Shotcrete	1,800 yd^3
Tunnel Underground Structural Liner	1,600 ft long of 19 ft – 24 ft diameter tunnel	8 in. – 14 in.	Steel Fiber Reinforced Shotcrete	4,450 yd^3
Shaft Underground Structural Liner	105 ft depth of minimum 23 ft-diameter shaft (variable cross sections for pipe elbows)	9 in. – 11 in.	Welded Wire Fabric Reinforced Plain Shotcrete with Lattice Girders	300 yd^3
Tunnel Interior Surface Waterproofing Membrane Preparation	1600 ft long tunnel	2 in.	Plain Sanded Shotcrete for Smoothing Purposes	350 yd^3

24/7 underground excavation operations required custom onsite batching and transportation logistics to utilize Quikrete Wet Process Shotcrete. Drill Tech designed the onsite batching and loading facilities to fill specialty, low profile, underground mining remixer trucks for transfer of shotcrete from the outside plant to application points nearly 1600 ft (490 m) into the tunnel. Using prepackaged concrete material ensured the safety and reliability of excavation activities for advancing the underground components of the project. This high quality pre-blended shotcrete product excelled in high-early strength development for rapid ground support while achieving specified compressive strength values for long-term strength. The combination of this quality concrete mixture design and its inherent performance qualities paved the way for project success.

Photo taken viewing tunnel bifurcation/intersection area, shotcrete liner visible in both tunnels

2024 OUTSTANDING UNDERGROUND PROJECT

Project
Anderson Dam Tunnel

Project Location
Morgan Hill, CA

Shotcrete Contractor
Drill Tech Drilling & Shoring, Inc.*

Architect/Engineer
AECOM

Equipment Manufacturer
Schwing Concrete Pumping

Materials Supplier
The Quikrete Companies*
Bekaert Corporation (Fibers)*

General Contractor
Flatiron West Inc.

Owner
Santa Clara Valley Water District

Tunnel Ground Support Supplier
Jennmar Civil

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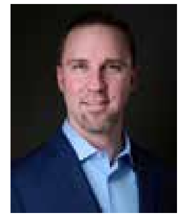
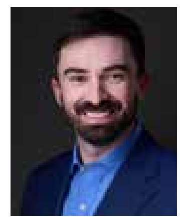
Tunnel Shotcrete placement via manlift and hand nozzle in 24 ft diameter tunnel

Looking into the Transition Zone bifurcation/intersection; comparison of complete smoothing shotcrete on left side and the in-progress right side which had yet to be completed

Aerial view of the 48,000 ft² (4500 m²) soil nail & reinforced shotcrete portal and the beginning of tunnel excavation



***Brian Harris**, PE (Drill Tech Project Sponsor for Anderson Dam) has 15 years of SEM tunneling experience, leading and overseeing operations on complex, high-profile projects. His expertise spans new construction and rehabilitation, open-face tunnel excavation, and the use of various ground support techniques such as shotcrete, steel elements, rock bolts, face support, and excavation sequencing.*



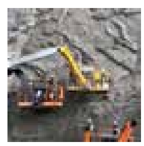
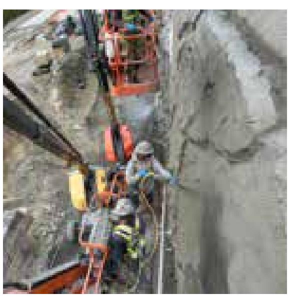
***Alex Folchi**, PE (Drill Tech Project Manager for Anderson Dam) has 12 years of experience in the heavy civil construction industry, with field management encompassing scheduling, quality control, and coordination for projects including foundation piles, shoring systems, and tunneling operations.*

2024 Honorable Mention Project

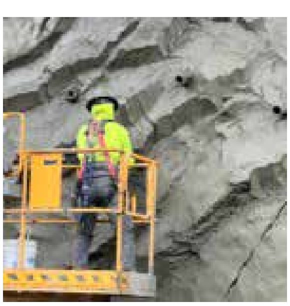
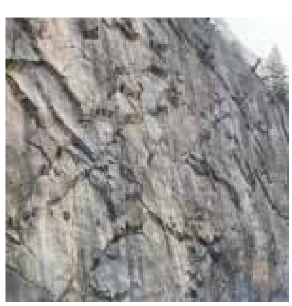
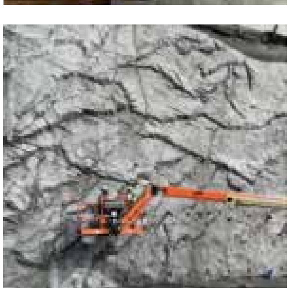
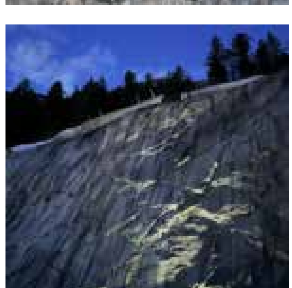
Slope Stabilization in Kicking Horse Canyon







By Dan Pitts

The Kicking Horse Canyon Highway, part of the Trans-Canada Highway near Golden, British Columbia, has a rich history tied to the region's rugged geography and vital transportation needs. Originally a narrow and winding route carved into the steep canyon walls, it was built in the early 1900s to connect the mountainous interior of British Columbia with the rest of Canada. The route follows the historic Kicking Horse Pass, named by James Hector during the Palliser Expedition in 1858.

Over the decades, the highway has undergone significant upgrades to improve safety and efficiency. Major projects have included realignments, the construction of bridges, and the widening of the highway to meet modern transportation standards. Today, the Kicking Horse Canyon Project continues this work, transforming the route into a safer, four-lane highway while preserving the stunning natural surroundings of the canyon. This shotcrete project was a joint venture between LRutt Contracting Ltd, Ocean Rock Art Ltd, and Kicking Horse Canyon Constructors Ltd.

The Kicking Horse Canyon Highway Improvement Project is one of the most ambitious highway projects in Canada, designed to improve both safety and capacity along the Trans-Canada Highway. This challenging terrain features steep slopes, deep canyons, and rocky outcrops that stand above one of the busiest railway routes. This project required advanced engineering techniques to ensure slope stability and prevent rockfalls. To secure these slopes and create a natural-looking environment, one of the key methods used in this project is shotcrete placement and sculpting it to resemble rock faces.

SLOPE STABILIZATION

Shotcrete is a critical technique for slope stabilization in areas like the Kicking Horse Canyon. The steep slopes of the canyon, coupled with the region's unpredictable weather, make traditional methods of slope stabilization challenging. Shotcrete offers an efficient, durable, and cost-effective solution to mitigate the risks of rockfall and erosion.

For the Kicking Horse Canyon Highway project, shotcrete placement reinforced and stabilized the exposed rock faces. The fast application process allows it to bond immediately with the surface, effectively securing loose material and preventing further rock movement.

MANLIFTS IN APPLICATION

One of the distinctive features of this project was the extensive use of manlifts to facilitate shotcrete placement. Given the rugged and often vertical nature of the slopes, traditional scaffolding or other forms of access would have been impractical. Manlifts, or mobile elevated work platforms , were used to provide workers with safe, efficient access to the most challenging areas.

The manlifts allowed teams of workers to reach a maximum working height of 56 ft (17 m), maneuvering around tight corners and narrow ledges. This mobility was essential for applying shotcrete in an precise manner, particularly on steep and uneven surfaces. The platforms also ensured that workers could stay safely away from the edge of the slopes, reducing the risk of accidents during the application process.

As the shotcrete was sprayed onto the slopes, the workers carefully monitored the consistency and thickness of the application. Manlifts played a crucial role in allowing workers to adjust their position quickly to ensure even coverage, which is vital for the integrity of the slope stabilization.

SCULPTING A NATURAL ROCK FINISH

While a given thickness of shotcrete alone is effective for slope stabilization, the Kicking Horse Canyon Highway project required an added aesthetic challenge: Creating a natural rock appearance to blend with the surrounding environment. The design team ensured the stabilization efforts would not detract from the natural beauty of the canyon, a significant concern in such a visually sensitive area. The total amount of shotcrete placed was approximately 1100 yd^3 (875 m^3) and included 29,800 ft^2 (90,800 m^2) of rock carved finish.

To achieve the desired aesthetics, the shotcrete was sculpted into a realistic rock texture. After applying the initial coat of shotcrete, our workers used specialized tools to carve and shape the surface to mimic the appearance of natural rock formations. This sculpting process is an art in itself, requiring skilled craftsmen to replicate the random patterns and intricate details found in the canyon's geology.

The sculpting process was meticulous, with workers using a combination of manual tools, trowels, brushes, and stamps to form natural seams, fissures, and textures that resemble the jagged edges and weathered look of the local rock. The finished surface was treated to enhance its durability and weather resistance, ensuring that the sculpted finish would endure the harsh environmental conditions of Kicking Horse Canyon.

ADVANTAGES OF SHOTCRETE AND SCULPTING

Using shotcrete placement combined with sculpting offers several advantages for slope stabilization, particularly in such a dynamic and challenging environment as Kicking Horse Canyon:

- **Speed and Efficiency:** Shotcrete is quick to apply, reducing the time required for stabilization compared to traditional methods like rock bolting or mesh installation.
- **Flexibility:** Shotcrete placement can adapt to various surface types, surface profiles and slopes, making it ideal for the irregular terrain of Kicking Horse Canyon.

2024 HONORABLE MENTION PROJECT

Project
Kicking Horse Canyon Mountain Stabilization

Project Location
Golden BC

Shotcrete Contractor
LRutt Contracting Ltd* / Ocean Rock Art Ltd*

Architect/Engineer
Aecon/Emil Anderson

Equipment Manufacturer
REED*

Materials Supplier
Golden Concrete Ltd

General Contractor
Kicking Horse Canyon Constructors

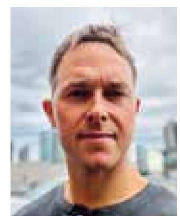
Owner
Government of Canada

*ASA Sustaining Corporate or Corporate Member

- **Aesthetic Integration:** Sculpting the shotcrete into a natural-looking rock face allows the project to blend seamlessly into the canyon's landscape, preserving the natural beauty while ensuring safety.
- **Durability:** Shotcrete provides a robust, long-lasting barrier against rockfalls, erosion, and weathering, ensuring that the slopes remain stable for decades to come.
- **Safety:** The use of manlifts reduces the risks to workers by providing safe access to difficult-to-reach areas, minimizing the need for dangerous climbing or scaffolding.

Conclusion

The Kicking Horse Canyon Highway Improvement Project stands as a testament to the effectiveness of modern engineering techniques in preserving both safety and aesthetics in difficult terrains. Using shotcrete for slope stabilization, combined with the intricate process of sculpting the shotcrete to resemble natural rock, has not only ensured the long-term stability of the slopes but has also allowed the project to blend harmoniously with its surroundings. The extensive use of manlifts for shotcrete placement and subsequent sculpting of the rock finish allowed a high level of precision placement while maintaining a safe work environment. Using shotcrete placement ensured this project will provide lasting benefits to travelers on the Trans-Canada Highway for decades to come.



***Dan Pitts** is President of Ocean Rock Art Ltd. and Partner in Ocean Rock Art US LLC. He is a Certified ACI Shotcreter and proudly serves as a corporate member of the American Shotcrete Association (ASA).*

2024 Honorable Mention Project

Goose Pond Dam Improvements

By George Machikas

The rehabilitation of the Goose Pond Dam was initiated by the New Hampshire Department of Environmental Services to address significant leaking of the dam that threatened multiple downstream towns. Improvements included flattening the downstream slope, updating and improving the seepage collection system along the downstream toe of the dam, installing relief wells along the toe of the dam, installing an underdrain system below a new spillway apron, installing a cutoff sheet pile wall, installing a new concrete bridge over the spillway to accommodate vehicular traffic, replacing the gates, rehabilitating the concrete spillway, and repairing existing concrete.

Patriot Shotcrete was tasked with performing several aspects of the rehabilitation. Lining the box culvert running from the weirs to the outlet spreader presented a difficult situation due to both access and forming limitations. The 80 ft (24 m) long culvert's dimensions varied in both width and height and included both vertical and overhead linings. Shotcrete remedied the access problem and eliminated difficult forming which saved time and reduced costs.

The existing training walls were segmented and with varying heights. Using shotcrete to line the existing training walls eliminated formwork and extensive bracing. The weirs at the top of the spillway were placed with shotcrete to eliminate the need for a complex forming shape. The additional structural wing walls were an extremely difficult shape, which would have been difficult to form. Both wing walls required an 18 in. (450 mm) thickness at the top of the wall with a 1:12 batter. Since the top of the wall sloped, the bottom thickness varied continuously with the wall height. Shotcrete eliminated complicated formwork and bracing that otherwise would have been necessary. The stoplog wall was shotcreted as it had a variable thickness and was inaccessible by scaffold, plus there were no points to secure any formwork braces.

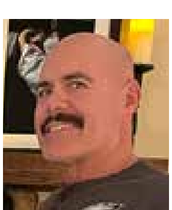
In every portion of the project where shotcrete was used, complex formwork and access problems were eliminated. The elimination of setting and stripping formwork saved approximately 66% of the time needed to complete the tasks assigned to Patriot Shotcrete. The time savings directly resulted in a proportional reduction in cost. Additionally, the elimination of formwork meant that no forming materials needed to be disposed of after the project, thus enhancing the environmental benefits of selecting shotcrete placement.

Shotcrete for box culvert lining walls

Shotcrete for box culvert lining ceiling

Segmented training walls, structural lining with a top cantilever

Downstream dam elevation revealing the culvert below and the training wall detail



***George Machikas** is the Director of Operations for Patriot Shotcrete LLC located in Somerset, NJ with over 40 years of experience in the concrete and shotcrete industries following graduating from Lehigh University. More recent endeavors over the last ten years have been focused on structural shotcrete work in the Northeast, providing shotcrete work for tunnels, bridges, dams, building foundations, building retrofits, and support of excavation.*

2024 HONORABLE MENTION PROJECT

Project
Goose Pond Dam Improvements

Project Location
Canaan, NH

Shotcrete Contractor
Patriot Shotcrete, LLC*

Architect/Engineer
Gannett Fleming, Inc

Equipment Manufacturer
Western Shotcrete Equipment, Inc.*

Materials Supplier
Carroll Concrete

General Contractor
Michels Construction, Inc.

Owner
New Hampshire Department of Environmental Services

**ASA Sustaining Corporate or Corporate Member*

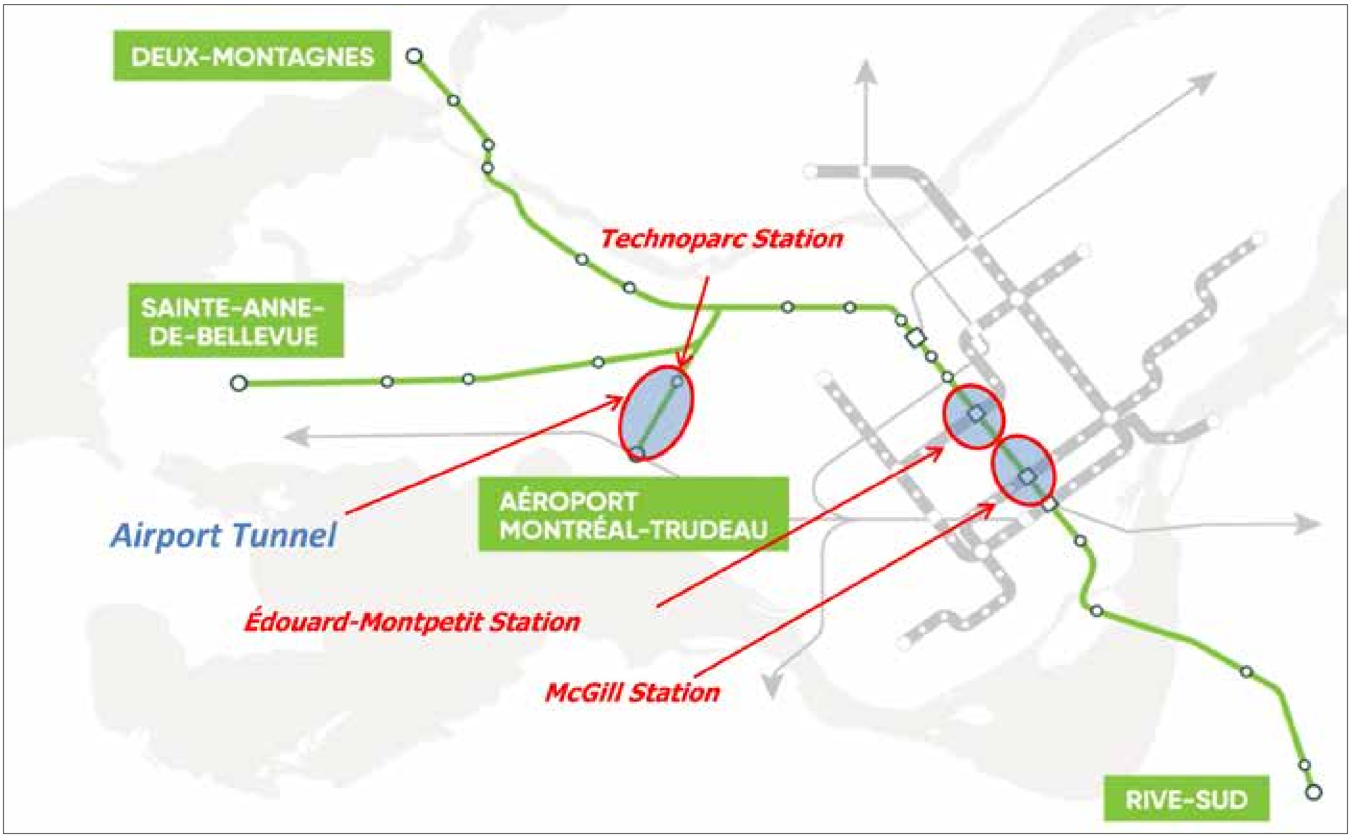


Fig. 1: Overall map of REM project

2024 Honorable Mention Project

Initial and Final Shotcrete Linings for Edouard Montpetit Station of REM Project

By Verya Nasri

Réseau Express Métropolitain (REM) is an automated (driverless) light-rail transit (LRT) system in Montreal, Canada. It features 67 km (42 mi) of double tracks and 26 stations. Once completed, it will be the 4th longest automated LRT transportation system in the world. REM consists of three Branches: The Saint-Anne Bellevue Branch, the Deux-Montagnes Branch, and the Airport Branch (Fig. 1). There are two underground tunnels included in the project. One is a new bored tunnel in the Airport Branch and the other is the Mont-Royal tunnel, which is a 100-year-old existing tunnel that is being repaired and rehabilitated. The project also has three underground stations. McGill Station and Edouard-Montpetit Station, which are in the Deux-Montagnes Branch and Technoparc Station, which is in the airport tunnel branch. Édouard-Montpetit is connected to McGill station through the existing Mont-Royal Tunnel. The REM project is currently under construction by a joint venture of SNC Lavalin, AECON, Dragados, EBC, and Pomerleau and the final design was performed by a joint venture of SNC Lavalin and AECOM. Workers have already completed the excavation, support, and internal structure of the Edouard-Montpetit Station.

Edouard-Montpetit Station (EMP) connects with the existing Mont-Royal tunnel, and thus connects to Montreal's subway blue line station of the same name, linking the University campus with the network at the intersection of Vincent D'Indy Avenue and Édouard-Montpetit Boulevard. At this intersection, the REM tracks are at an approximate depth of 70 m (230 ft) below surface, making Edouard-Montpetit Station the deepest major train station in Canada. This article discusses the various aspects of design and construction of the station, including its excavation, spaceproofing, architecture, and structural design, and how innovative engineering solutions were utilized to design and construct this station.

GEOLOGY

Based on the borehole logs, the overburden around the station is defined as a compact to dense gravely sand of brown color. The thickness of overburden can be considered to vary between 1.5 and 2 m (5 and 6.5 ft) in the shaft area. The geology of Montreal includes a variety of sedimentary rock formations dating from the Precambrian, Cambrian and Ordovician. The main rock types encountered are limestone and shale. Intrusions from the Mesozoic – Cretaceous period can be also observed intruding into these sedimentary deposits. The layers are generally subhorizontal. The main fault system is oriented East-West, although for this project, they are considered inactive. The fault lines feature thin zones of fractured rock.

As previously mentioned, the lithology is defined as strata of grey crystalline limestone interbedded with argillaceous limestone and shaly limestone horizons. The lithology will be referred to as interbedded limestone. The interbedded limestone is also randomly intersected by a significant number of aphanitic igneous dikes and sills of thickness that is less than 2 m. This is due to the fact that the station is located in the vicinity of the Montreal Intrusion. The EMP shaft is located in the Trenton Group, specifically in the Rosemont and Saint-Michel members and the Deschambault Formation. The EMP auxiliary tunnels and platform are located almost entirely in the Deschambault formation. The rock in this area has very good quality, with a minimum GSI of 70 for most of the depth of the shaft and has an intact uniaxial compressive strength that is higher than 126 MPa (18,200 psi).

GENERAL STATION CHARACTERISTICS

Edouard Montpetit is the deepest Metro station in Canada and the second deepest station in North America. It is built in the middle of a busy area in Montreal, near many sensitive buildings for the University of Montreal. It connects to the old existing Mont-Royal tunnel. The station is designed for a service life of 125 years and for a passenger load superior to 6000 passengers during the 3-hour peak period. For the design of such an important station, it is crucial to carry out the design using Building Information Modeling (BIM) (Fig. 2). 3D BIM models allow for clash detection between the different disciplines (Structural, Mechanical, Plumbing, Electrical), for efficient spaceproofing, quantity take-off, and construction simulation.

The REM project was divided into multiple architectural styles, depending on the surroundings of the station being built. Since the station is located in the middle of a university campus and a busy area, it was classified in the "Urbain Mixte" category. Therefore, the design of Edouard Montpetit was based on three aspects. The first one is a transparent design. The building entrance is covered with windows to bring maximum natural light into the elevator hall, located below, at the same level as the access to the adjacent metro station. The second aspect is the stations were separated into separate units and volumes, each having a different identity. Most of the mechanical and electrical units are located underground, and the above ground units are grouped together to minimize their impact on the architecture of the building. The third one is the seamless movement between these units, the station and the nearby transit systems.

The station is composed of a main shaft that has 16 levels that is approximately 70 m deep with high-speed elevators. At the bottom of the shaft are two enlarged caverns, one of which opens to the mezzanine level of station. The mezzanine level contains a passenger tunnel and several other tunnels and adits that are related to utilities and connect to the platform level. This station connects to the existing MRT at the platform level (Fig. 3). The existing tunnel is expanded, and new platforms are constructed. One of the special aspects of the architectural design of the platform

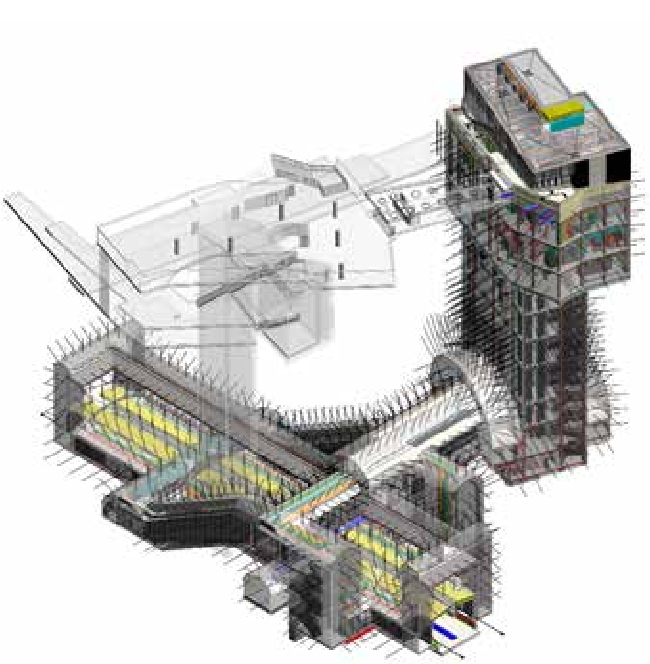


Fig. 2: 3D BIM model of Edouard-Montpetit Station

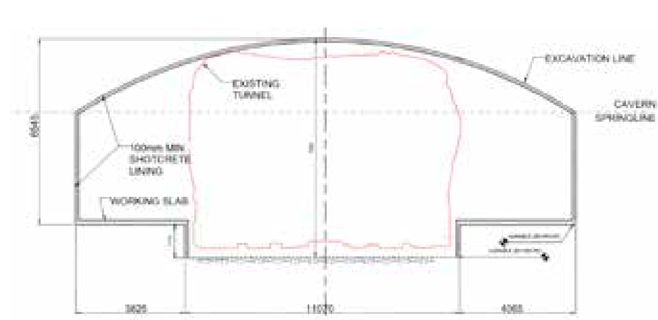


Fig. 3: Typical cross-section of EMP Station at platform level

ABOVE/BELOW: *Figs. 4a & b: Architectural design of the station*

level (Fig. 4) is the presence of multiple areas of exposed rock in the station where commuters can admire the geology and rock around the station.

INITIAL AND FINAL SUPPORT

The shotcrete lining of the EMP cavern and tunnels is 100 mm (4 in.) thick. It was applied on all the walls in the upper and lower part of the shaft in rock, as well as the caverns, in addition to the rock bolts. This shotcrete was applied in two layers of 50 mm (2 in.) each with a 4 mm (160 mils) thick layer of spray-on waterproofing membrane sandwiched between them. The first/primary layer of fiber-reinforced shotcrete 50 mm thick will be used as initial support. It will help to keep rock wedges in place and to prepare rock surface to receive waterproofing membrane, and the second layer of fiber reinforced shotcrete (50 mm thick) will be used to protect the waterproofing membrane. The system is design as a drained system. The waterproofing membrane will be applied between the primary and the secondary layers of shotcrete. As shown in Fig. 5, the bolts are installed after the first layer of shotcrete. Delta Strip Drains were installed before shotcrete layers in locations where water inflow is seen from open joints in the rock. If large water inflow was observed before the installation of shotcrete, then the problematic joints and rock areas were grouted.

Multiple degradation mechanisms (including chloride and carbonite induced corrosion, acid and sulfate attack, alkali-aggregate reactions, freezing and thawing, and stray current corrosion) were studied for the lifespan of 125 years of the structure. Using codes and standards, the minimum characteristics of the concrete mixture are:

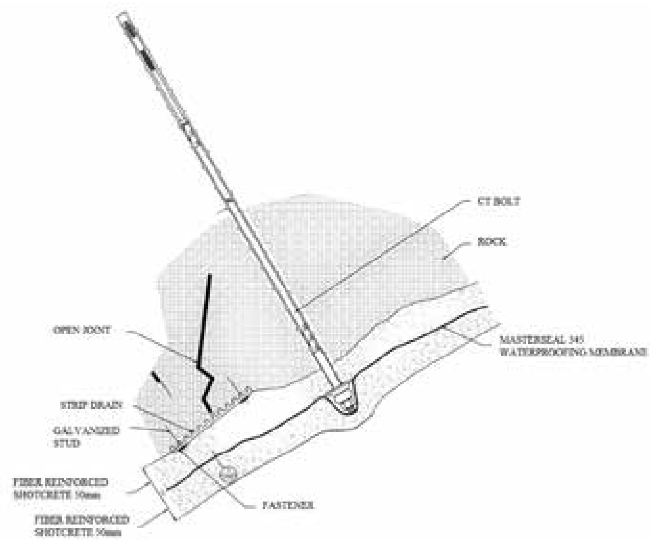


Fig. 5. Typical shotcrete detail at the station

- Minimum compressive strength
  a. At 10 hours: 7 MPa (1000 psi)
  b. At 24 hours: 18 MPa (2600 psi)
  c. At 7 days: 28 MPa (4000 psi)
  d. At 28 days: 42 MPa (6000 psi)
- Maximum water-cement ratio: 0.38
- Unit Weight: 2300 kg/m³ (144 lb/ft³)
- Minimum total cementitious materials: 475 kg/m³ (810 lb/yd³)
- Silica fume: 5% of cementitious materials weight
- Ground granulated blast-furnace slag: 22% of cementitious materials weight
- Maximum aggregate size: 10 mm (0.375 in.)
- Minimum air content: 5% as shot (10-15% immediately before pumping)
- Minimum slump: 100 mm (4 in.)
- Chloride ion penetrability at 56 days: < 1,000 coulombs
- Maximum chloride ion diffusivity (NT Build 492-91): 2.6 x 10^{-12} m²/s at 56 days
- Maximum carbonation resistance (CEN/TS 12390-10): 7.6 mm (0.3 in) after 28 days exposure to CO_2

The durability of the Delta drains, the sprayed waterproofing membrane and the rock bolts is estimated to be for 125 years. The durability of the bolts based on the corrosivity of the exposure environments is due to the protective properties of CombiCoat bolts, i.e. a coating system consisting of:

- Hot dip galvanizing, >65 µm (2.6 mils) zinc coating
- Phosphating
- Epoxy powder coating, >55 µm (2.2 mils)

The sprayed waterproofing layer, Masterseal 345, is designed to be spray-applied in a sandwich system between layers of shotcrete or cast-in-place concrete. This composite system is the key to its optimum durability. For example, in most applications, this system should limit the temperatures to which the membrane is exposed during its life and prevent exposure to UV radiation. Because of the nature of the bond between the polymer and water, unlike other polymers such as PVC, over time, the ethylene-vinyl acetate copolymer does not become increasingly brittle.

The use of only 100 mm of shotcrete lining, along with the bolt and a sprayed waterproofing membrane as the initial and permanent rock support system, is an innovative solution which was used for the first time in a major transit project in North America for Edouard Montpetit. It offers savings in cost, time, and carbon emissions.

SHAFT EXCAVATION

Controlled blasting was used to excavate the 70 m deep shaft. Because the station is in a dense area next to many structures (such an acoustic laboratory for the university of Montreal as well as other buildings that have classes and laboratories) that are sensitive to noise and vibrations, line drilling was used to excavate the shaft. It comprises drilling closely spaced holes around the perimeter of the shaft to decouple the inside of the shaft from its surroundings, and then blasting the inside of the shaft. Here, the vertical hole drillings had a diameter of 140 mm (5.5 in.) and a clear spacing of 110 mm (4.3 in.) along the entire perimeter of the main entrance shaft. This significantly reduced the vibration from the blasts. Fig. 6 and 7 are pictures of the shaft excavation.

Overall, during the excavation of the shaft, the hydrogeological conditions observed were very favorable. The walls of the excavation were generally dry. The

ABOVE/LEFT: *Fig. 6: Photos of the shaft construction near the ground level*

BOTTOM 2: *Fig. 7: Photos of the waterproofing membrane spraying on the shaft walls*

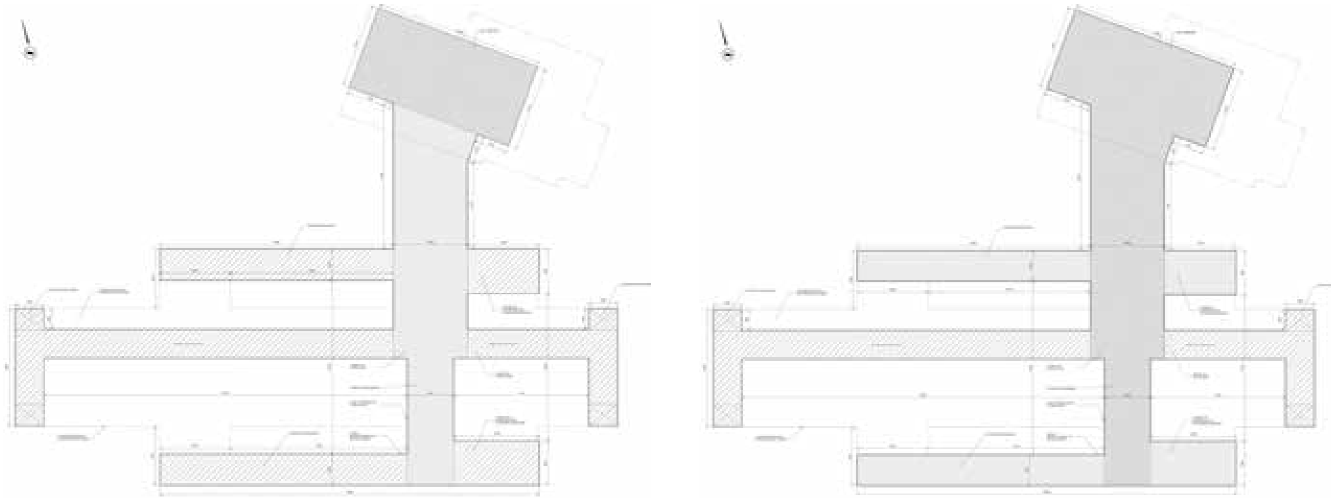


Fig. 8. Schematic of excavation of auxiliary tunnels after shaft excavation

conditions observed in the first portion of the mezzanine tunnel are similar, if not better. Convergence bolts were installed on the shaft walls every 15 m (49 ft) in depth.

The sequence of the excavation was very important because of the location and depth of the station, and other constraints such as small site area available. For the first 15 m of the shaft, the material was excavated using a long-boom excavator. For the rest of the shaft, it was excavated using a tower crane. It was very important to remove the excavated material efficiently as the excavation deepened to stay on schedule.

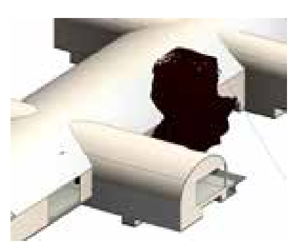
CAVERN, TUNNEL, AND PLATFORM LEVEL EXCAVATION

The large caverns at the bottom of the shaft were excavated after the shaft excavation. The auxiliary tunnels were then excavated after the excavation of the lower portion of the shaft as shown in Fig. 8. The maximum excavation drift was 3 m (10 ft). The auxiliary tunnels include one pedestrian tunnel, two escalator tunnels, two ventilation adits and 4 ventilation shafts connecting to the platform level. The excavation on the platform level included the expansion of the existing MRT tunnel to excavate the station platforms as well as the mechanical and electrical room adits (Fig. 9).

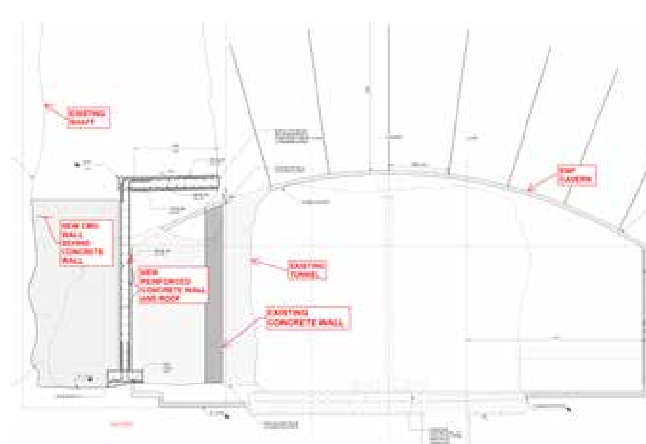
Figure 9: Excavation at the platform levelexcavation

MAIN CAVERN EXCAVATION NEAR EXISTING VENTILATION SHAFT

Surveyed point clouds of the existing shaft and the as-built station excavation were used to identify the best solution for the excavation near this shaft (Fig. 10a). At the side of a cavern, at one point of the existing Mont Royal Tunnel, the excavation of the new EMP platform intersected with an existing ventilation shaft for an existing station. The existing concrete wall at the edge of the existing tunnel was demolished, and a reinforced concrete wall and concrete roof were installed as shown in Fig. 10b. The back of this concrete wall will then be filled with CMU walls on the sides to isolate the shaft from the EMP platform level.



LEFT/BELOW: *Figs. 10a and b: Intersection with ventilation shaft at platform level*



Conclusion

Edouard-Montpetit is the deepest major railway station in Canada, and its design and construction in the middle of a university imposed a lot of challenges and constraints that required innovative and efficient engineering solutions. The design of a drained system with the shotcrete liner and CT-Bolts as both the initial and permanent lining offered a cost-effective and sustainable solution that was perfectly suited for this type of application. Deciding on the most effective construction sequence for the shaft excavation and then for two other tunnel levels played a key role in the successful construction of the station.

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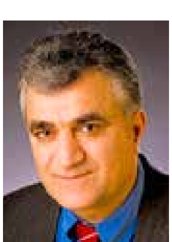

***Verya Nasri**, PhD, PE, Chief Tunnel Engineer, Senior Vice President at AECOM; PhD in Structural and Geotechnical Engineering from Ecole Centrale Paris, France; more than 220 journal and conference papers mainly in Tunneling; more than 30 years of experience in conventional and mechanized tunneling of mega projects all over the world.*

2024 Honorable Mention Project

Project
Édouard-Montpetit Station - Réseau Express Métropolitain

Project Location
Montreal, Canada

Shotcrete Contractor
NouvLR

Architect/Engineer
AECOM / AtkinsRealis

Equipment Manufacturer
Various equipment manufacturers including Shaft & Cavern

Materials Supplier
Bekaert* / Lafarge Canada

General Contractor
NouvLR (SNC-Lavalin, Dragados, Aecon, EBC, Pomerleau)

Owner
CDPQ Infra

**ASA Sustaining Corporate or Corporate Member*

2024 Honorable Mention Project

Shotcrete and Waterproofing Works Multifaceted Conference Centre at Brigade Tech Gardens

By Rajendra Pai and Manthan Pai

Brigade Tech Gardens Whitefield is a Grade A project featuring a total development of 3.3 million ft^2 (310,000 m^2) spread across 26 acres (10 hectares). The commercial project is in the middle of Bengaluru's IT corridor in Whitefields, Bengaluru, India. The master plan of the project integrates planning, landscape, and architecture in perfect harmony to create the idyllic 21st-century environment. Salient features include modern commercial development featuring a contemporary design with a responsive approach to business needs, as well as a world-class conference center situated near the entrance offering state-of-the-art facilities for events and meetings.

A CONCRETE APPLICATION WITH A COMPLEX SHAPE

Shotcrete domes need special consideration because the shape can be complex to build. Here are some of the important considerations for using shotcrete placement to build domes:

Shape and geometry: Domes are double-curved structures with some complexity in both the design and the construction. It is critical to plan for positive thickness control during shotcrete placement. Domes are structurally dependent on having an accurate geometrical shape for strength, thus maintaining uniform thickness on a properly shaped form is a key structural consideration.

Shotcrete placement facilitates construction with the ability to accurately place the required thickness of concrete material on complicated curved forms. The dome shape would be difficult to build efficiently or economically with conventional form-and-pour concrete construction methods, as form-and-pour concrete sections generally need a double-sided form to retain the liquid concrete during casting. The curved, irregular shape of a dome would be difficult and expensive to manufacture. Shotcrete can use a one-sided form and can be lighter since it doesn't need to carry the liquid forces of wet concrete.

Using shotcrete speeds up the construction process since each layer does not have to cure before applying another, thus saving time during construction. Form-and-pour concrete has a series of operations — including placing, vibrating, protection, and curing — that need to be performed sequentially and are time consuming.

Shotcrete's high velocity placement compacts the concrete against the receiving surface. This fully consolidates the concrete and typically produces higher bond strengths against old or finished surfaces, as is often found in repairs. In comparison, if form-and-pour concrete is not fully vibrated to provide full consolidation, you may get a weaker bond to an existing substrate and more potential for voids.

CONCRETE MATERIAL SELECTION FOR SHOTCRETING

Selecting a concrete mixture that is appropriate for overhead and vertical surfaces needs to provide both workability for pumping and the required structural strength. Additions to the concrete may include fiber and admixtures. Fiber is often provided as supplemental reinforcement to help control cracking. Accelerators can be helpful when placing overhead or in colder weather. Air-entraining admixtures materials may be needed in geographical regions that experience many freezing and thawing cycles.

Dome construction benefits greatly with shotcrete placement as it substantially cuts costs (by minimizing complex, expensive formwork and scaffolding) while providing equal or better strength when compared to traditional concrete methods. Custom formwork that doesn't use flat panels or plywood can be much more expensive to build and often generates a lot of waste material. Shotcrete can be used to provide the exact thickness needed within the dome structure: Thicker at edges and openings, thinner in most of the uniform shell areas.

High-velocity shotcrete placement creates a denser concrete material than many cast-in-place sections, providing improved durability, crack resistance, and environmental resistance. Form-and-pour concrete may need extra treatments or coatings to reach a similar level of durability, particularly in aggressive climate or exposure regions.

These factors all make shotcrete an attractive option for dome construction, offering efficiency, strength, and cost savings compared to form-and-pour concrete.

APPLICATION PROCESS

The embedded steel reinforcement included 8 mm and 12mm (#3 and #4) laid out on an orthogonal pattern. The reinforcement had a tensile yield strength of 550 N/mm^2 (80,000 psi) and was placed at the center of the concrete thickness. Reinforcement was secured with chairs off the form.

The wet-mix shotcrete was applied in layers so the concrete didn't sag or slough. Shotcrete placement started at the base and then worked up to the top.

The shotcreter adjusted the distance to the receiving surface as required to maintain a perpendicular angle of placement. This was usually about 1 m (3.3 ft). The shotcreter had to pay close attention to not apply thicknesses on the curved areas that were too thick or too thin. The shotcreter also needed to make sure that the compaction of shotcrete was proper, especially at intersections and edges where layers were meeting.

CURING

We start curing immediately after the shotcrete is placed, usually within a few hours of placement. An initial moist cure with a fogging nozzle on a pressure washer can help reduce early-age plastic shrinkage cracking. Wet curing using cool water is the preferred method for curing concrete. Misting the surface regularly or using concrete curing blankets are good methods for keeping water available at the surface of the concrete for curing. The shotcrete must be cured for a minimum of 7 days, and an even longer curing time will increase the strength and durability of the shotcrete. Curing is particularly critical with domes since all sections of a dome shape are carrying loads.

QUALITY CONTROL

Since the designed dome shape and thickness is critical to the structural performance, the shotcrete placement should be continuously measured to ensure that it is uniform and meeting the design requirements. Verification of the concrete hardened properties was accomplished by testing cores taken from the dome to confirm compressive strength and density. Additionally, all exposed surfaces can be inspected visually or by hammer sounding for voids, cracks, or inconsistencies in the regions of complex curvature.

SURFACE DÉCOR AND TEXTURE CONSIDERATIONS FOR DOME DESIGN

Depending on the architectural theme of the dome, an aesthetic, uniform-color plaster may be applied to the surface. If a natural concrete color finish is desired, the freshly shot concrete can be textured in a variety of ways — most common is a smooth floated finish, though a steel trowel or gun finish can be provided if desired. When the dome is tying into other elements, make sure that shotcrete transitions are tight and smooth.

SAFETY PRECAUTIONS

It is important that workers have been trained and equipped with appropriate PPE. This is particularly relevant for work at height or when working on a curved surface that may not be easy to stand or walk on. Scaffolds and manlifts are helpful in sections of the dome that are more vertical. It is important to monitor the formwork during shotcrete placement, as stability issues — especially in larger domes — can cause problems. One should monitor the formwork stability both during and after shotcrete placement.

Brigade Tech Gardens Whitefield

Aerial view of Brigade Tech Gardens Whitefield

Shotcrete placement produces dust. It is necessary to ensure proper ventilation for the work space and you may need to employ dust control techniques to increase the safety of crewmembers working in close proximity to the shotcrete placement on the dome.

In Summary

Using shotcrete placement for construction of this complex, double-curved concrete structure was, without question, the most efficient and cost-effective approach. Needing only one-sided forms cut formwork costs by more than half. Shotcrete placement also allowed us to closely control the thickness of the concrete to meet the structural design requirements while provided a strong, durable concrete section. Shotcrete placement allows architects to dream of concrete structures with curves — and a quality shotcrete contractor and experienced crew can turn those dreams into reality.

***Raj Pai** is the Founder and Director of Kasturi Projects Pvt Ltd. After completing his Master's in Physics from the University of Mumbai, he went on to pursue various courses and diplomas in management, underground construction, and civil engineering. He has 37 years of industry experience in injection, repairs and protection of concrete, underground construction, and overground construction. He has also won awards for the repair and rehabilitation of heritage structures and stormwater drains in Mumbai City from the International Concrete Repair Institute.*

***Manthan Pai** is a geotechnical engineer at ANS Geo, Austin and holds a Master's Degree in Civil Engineering with a focus on Geotechnical Engineering from Arizona State University. He has a strong background in both civil and geotechnical engineering, with experience in underground construction, tunneling, geotechnical, and mining engineering. Manthan has a proven ability to design and execute complex projects while ensuring compliance with industry standards and regulations.*

2024 Honorable Mention Project

Project
Shotcrete & Waterproofing - Brigade Tech Gardens

Project Location
Bengaluru, India

Shotcrete Contractor
Kasturi Projects Private Ltd*

Architect/Engineer
Brigade Properties Pvt Ltd

Equipment Manufacturer
Epiroc India

Materials Supplier
Prism Johnson Ltd

Owner
Brigade Properties Pvt Ltd

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President's Award 2024

A highlight of an ASA President's responsibilities is to nominate a distinguished member for ASA's President's award. Since 2005, this award has recognized 18 individuals and an organization that have made exceptional contributions to the shotcrete industry. It is among ASA's highest honors and is the responsibility and honor reserved for the immediate outgoing President. This year that mantle falls upon Oscar Duckworth.

Frank Townsend
Patriot Shotcrete LLC

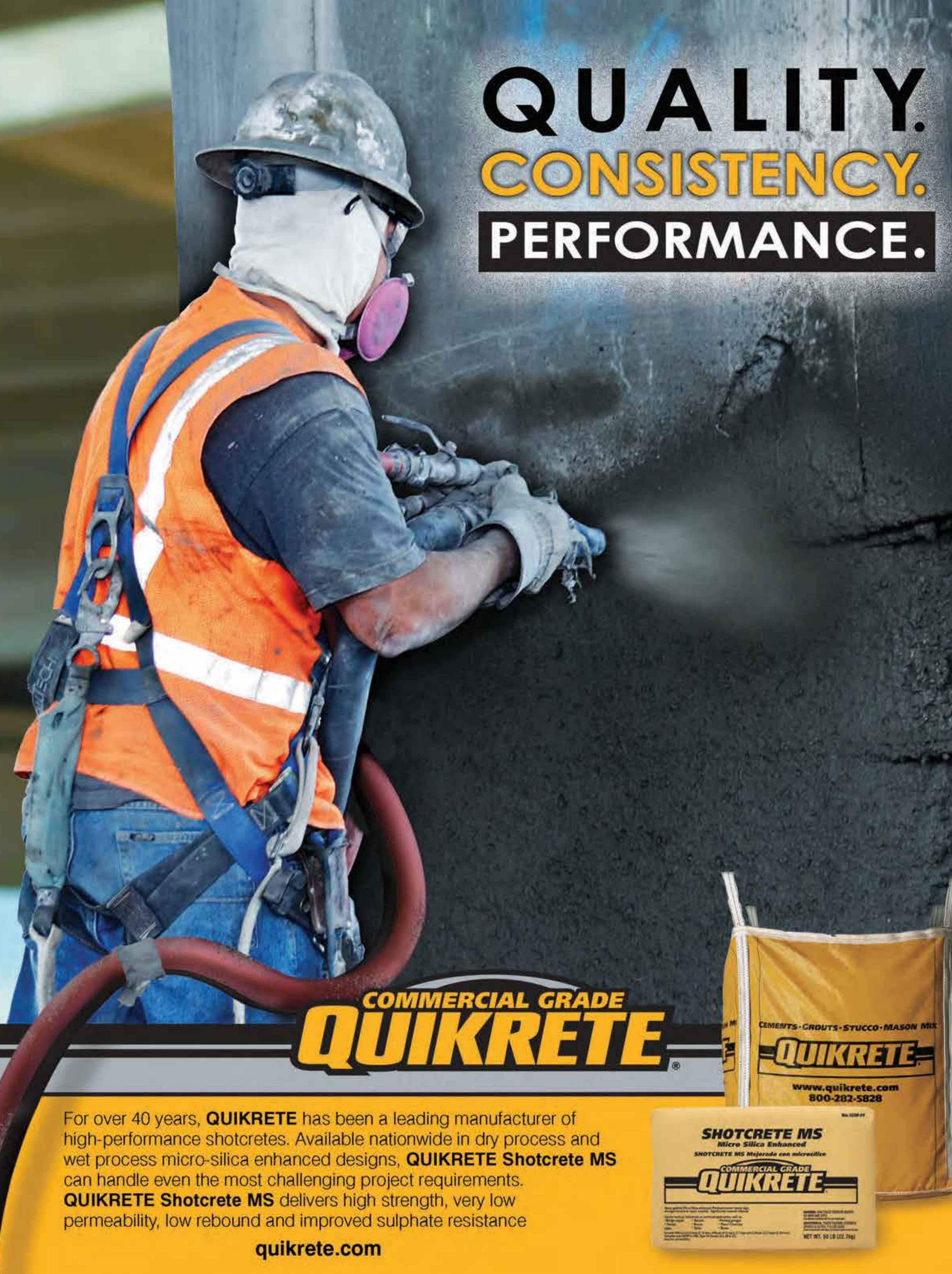
It is the sole responsibility of each year's American Shotcrete Association (ASA) President to select the recipient of the President's award as a final act before leaving office. Since 2006, numerous well-deserving individuals and one organization have been awarded the ASA President's Award, all of whom dedicated their time and energy to advance the shotcrete industry. At the completion of my tenure as President, I am honored to be presenting the ASA President's Award to a person clearly deserving of this esteemed award: I am presenting this year's President's Award to Mr. Frank Townsend for his outstanding service to the ASA and the shotcrete industry.

Frank has provided untold hours of his personal time and effort to help move our industry forward through his benevolent efforts and strong leadership skills. Anyone who meets Frank knows that he is certainly an original. He is a natural leader. Frank is not particularly warm and fuzzy, but his distinct personality and colorful language broadcasts each of his viewpoints to all with blunt clarity and memorable style. Frank is always entertaining. I have admired his ability to influence a group with the grace and effectiveness of a bulldozer.

Frank is currently serving as Chair of ACI C660 – Shotcreter Certification, where his natural ability to follow up with ACI staff and Task Groups on their respective responsibilities is an active testament to his leadership skills. This committee manages the ACI Shotcreter Certification program, for which ASA is the primary sponsoring group and where many ASA members actively take part to maintain and develop relevant updates.

As a tireless volunteer in the Association, Frank came up through the Board of Directors, Executive Committee roles and served as the Underground Committee Secretary and Chair. During his tenure as ASA President, he prioritized the drafting of a workable set of Standard Operating Procedures (SOPs) to document the monumental work of ASA's four person staff. He patiently kept staff accountable to bring this work product into existence. This played a key role in generating a succession strategy that helps plan for the Association's long-term growth. I have observed Frank for many years. Although we have two distinctly different personalities, viewpoints, and backgrounds, we hold one belief deeply. It is that which I admire most about Frank Townsend: His natural desire to involve the next generation. Frank seeks out and finds time to speak to universities, associations, and engineers at every opportunity — I believe he is correct that investing in the next generation of leaders is the best path toward future growth.

Frank has not only influenced us, but the entire industry through his leadership and dedication. His eye toward the future — both in documenting procedures and a sober look at succession planning for the Association, as well as broad outreach to the next generation — is not only strategic, but also visionary! It has been my pleasure to work with Frank and to present him with this year's ASA President's Award.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2024 Carl E. Akeley Award

The 19th annual Carl E. Akeley Award was presented to Christine Poulin and Marc Jolin for their article, "A Study on Low-Velocity Sprayed Mortars," which was published in Shotcrete magazine, Volume 26, Number 2, 2nd Quarter 2024.

The article discusses the use of Low-Velocity Sprayed Mortar (LVSM) as an alternative to shotcrete for structural repairs in civil engineering. Shotcrete, known for its high-velocity spraying, provides effective consolidation for concrete repairs, while LVSM uses low-velocity spraying to apply mortar, offering advantages like reduced rebound and the potential for more controlled applications. The research conducted at Université Laval explored the effectiveness of LVSM, examining material properties, durability, adhesion, and reinforcement encapsulation. The findings showed that while LVSM can produce high-quality materials with good mechanical properties, its ability to encapsulate reinforcement and handle thicker applications remains limited compared to shotcrete. Additionally, LVSM's lower spraying velocity presents challenges in certain repair conditions, particularly when dealing with reinforced structures.

Despite these limitations, LVSM offers potential benefits for non-structural repairs, where reinforcement encapsulation is not required. The study also highlighted that LVSM's minimal rebound could be advantageous, though its higher material cost compared to shotcrete limits its economic viability for larger repairs. The research calls for further industry standards and certifications for LVSM to ensure quality work, particularly given the varying experience levels of applicators. Ultimately, the study concludes that while LVSM is not a suitable replacement for shotcrete in structural repairs with reinforcing bars, its application in non-structural repairs could be promising, provided that technical guidelines and improvements in material and spraying techniques are developed.

Scan or click the QR code to read the full article.

Christine Poulin

Marc Jolin

AKELEY AWARD HISTORY

ASA established the Carl E. Akeley Award in 2005 to honor his founding of what is today referred to as the shotcrete process. This award is presented to the author(s) of the best technical article appearing in Shotcrete magazine in the past 12 months, as determined by the Akeley Award Committee of ASA.

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

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

REFERENCES

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

PAST AKELEY AWARD RECIPIENTS

- 2023—R. Bracamontes, “The Use of Rapid-Set Accelerators in Shotcrete”
- 2022—Program Paused
- 2021—O. Duckworth, “Slump—The Most Misunderstood Characteristic of Wet-Mix Shotcrete”
- 2020—A. Gagnon, M. Jolin, and J. D. Lemay, “Performance of Synthetic Sheet Waterproofing Membranes Sprayed with Steel Fiber-Reinforced Shotcrete Testing for Waterproofing Membrane Integrity After Spraying.”
- 2019 – W. Clements and K. Robertson, “Compatible Shotcrete Specifications and Repair Materials”
- 2018—K. Yun, “Cellular Sprayed Concrete”
- 2017—A. Nitschke, “Modeling of Load-Bearing Behavior of Fiber-Reinforced Concrete Tunnel Linings”
- 2016—M. von der Hofen, “East End Crossing”
- 2015—E. Yurdakul and K.-A. Rieder, “Effect of Pozzolanic-Based Rheology Control Agent as a Replacement for Silica Fume”
- 2014—L. Zhang, “Variability of Compressive Strength of Shotcrete in a Tunnel-Lining Project”
- 2013—Jolin, Nokken, and Sawoszczuk, “Sustainable Shotcrete Using Blast-Furnace Slag
- 2012—R. C. White Jr., “Pineda Causeway Bridge Rehabilitation”
- 2011—C. S. Hanskat, “Shotcrete Testing—Who, Why, When, and How”
- 2010—L. Zhang, “Is Shotcrete Sustainable?”
- 2009—Dufour, Lacroix, Morin, and Reny, “The Effects of Liquid Corrosion Inhibitor in Air-Entrained Dry-Mix Shotcrete”
- 2008—E. S. Bernard, “Embrittlement of Fiber-Reinforced Shotcrete”
- 2007—K. F. Garshol, “Watertight Permanent Shotcrete Linings in Tunneling and Underground Construction”
- 2006— Dufour, Reny, and Vézina, “State-of-the-Art Specification for Shotcrete Rehabilitation Projects”

ASA GRADUATE STUDENT SCHOLARSHIP

***Maxime Monfort** is completing his Master's degree in Mechanical Engineering at Université Laval, which brought him to the Concrete Infrastructure Research Center (CRIB) and specifically to the Université Laval Shotcrete Lab. He is a French student completing his general engineering studies from Arts & Métiers school in France. His M.Sc. thesis revolves around the challenges of implementing full robotic automation in shotcrete placement. His work focuses on implementing a 3D-depth camera to estimate, in real time, the thickness of the deposited shotcrete layer. He had the privilege to present his work twice with a fellow student, Jongbeom Kim, during the ASA 2024 conference hosted in Austin, Texas. He has been serving as the president of both the ACI and CRIB Local Student Chapters at Université Laval since June 2023.*

MONFORT'S RESEARCH PROJECT

SHOTCRETE PROCESS AUTOMATION: SUBSTRATE'S THICKNESS ESTIMATION DURING SPRAYING

For a couple of decades, automation and particularly robotization have had an increasing presence on shotcrete construction sites — in mining and tunneling especially. Currently, it can be used in several stages of a shotcrete project, from spraying of the first layer to placement of the final lining. Everyone working in the shotcrete industry knows that working conditions of shotcreters are not the easiest or cleanest, and some applications require extensive experience and skills. Existing technologies work well to spray a uniform pre-set thickness on walls, but most involve a few minutes' pause in spraying to scan the surfaces to compare a before and after spraying. Further development efforts are required to reach full automation, such as:

1. Scanning the surface to obtain the deposited shotcrete layer's thickness during spraying. This is a crucial point required for the following two.
2. Consistency of an observed thickness (as opposed to an estimated one based on concrete flow and nozzle movement) as the robot's trajectory generation algorithm becomes adaptive in real time. This allows for more precise and reliable spraying thicknesses, especially in changing ground surface conditions.
3. Finally, precise and close-range real-time observations during spraying opens the doors for specific nozzle trajectory generation where placement quality and reinforcement encapsulation (or steel sets, rock bolt plates, lattice girders, etc.) are as important as concrete thickness optimization.

Today, shotcrete automation is focusing on tunneling and mining, but these further improvements in shotcrete automation can easily expand into other parts of the shotcrete industry.

OBJECTIVES

The Shotcrete Placement Automated by Robot (SPARO) project began in 2019 under the supervision of Marc Jolin at Université Laval. Initially, the research focused on the robot's trajectory for reducing rebound (Germain[1,2], 2021; Pastorelli[3], 2021; Schaeffer[4], 2022), but now the main focus of this research work is to explore full shotcrete application automation.

The main purpose of Monfort's project is to find a method to estimate the thickness of the deposited shotcrete layer in real time, i.e. during spraying. After having set the requirements: Observation of a local area about 2 m^2 (22 ft^2) with an accuracy below 10 to 15 mm (0.4 to 0.6 in^2), spatial resolution less than 15 mm at a distance between 1 and 2 m (3.3 to 6.6 ft) from the wall, and computing time below 1s to allow real-time analysis. After estimating this local thickness area , the goal is to first display the information to the shotcreter or other crew members (for example the shotcreter assistant or a manager), and in a second phase, transfer the thickness information to the computer controlling the robot. Then the method for presenting the thickness information, especially to humans, need to be reviewed.

RESULTS

A 3D-depth camera was selected after benchmark and lab tests and became the main tool of this research. This camera uses two distinct technologies to estimate depth at 30 frames per second, which allows real-time observation and calculation. Code was developed to start acquisition of the camera to capture and display the thickness of concrete in real time via colormaps with colored gradients (see Fig. 1 below) according to the requirements introduced above.

A current limitation in the study is the requirement for

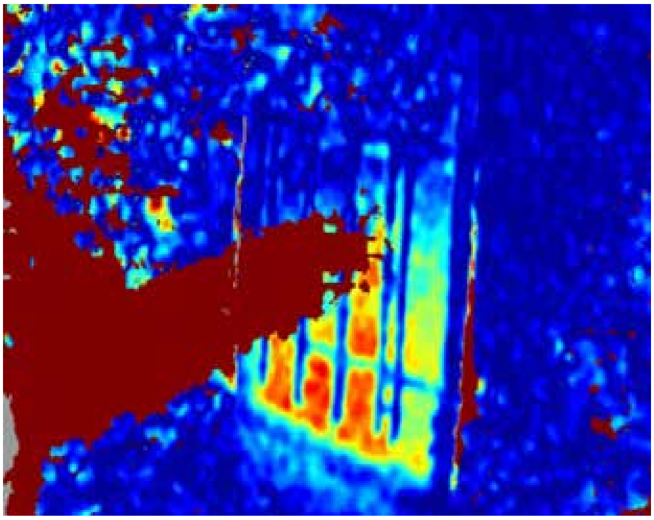


Fig. 1: Thickness observation during placement

the camera to remain fixed during placement; otherwise thickness observation is compromised. Knowing the camera's relative position and including it in the algorithm's inputs are key for the future of the SPARO project. Rest assured, another promising graduate student is already working on this topic (Florian Gayraud).

CONCLUSION & DISCUSSION

The underlying idea of acquiring local information in real time during spraying is fundamental to enabling real advances in automated shotcrete placement. Key functionality is detecting local thicknesses and reinforcing bars quickly and accurately enough to enable trajectory generation and modification based on this observation, rather than using a less precise simulation and theoretical deposition models. This opens the door to real-time spray trajectory optimization that minimizes rebound and maximizes mechanical properties while guaranteeing reinforcement embedment, thanks to AI and manual algorithm drives, for all shotcrete applications. Finally, concrete pumps could also be connected to the spraying robot. The robot could give orders to the pump to adjust its flow rate, its concrete mixture, etc. The camera equips the robot to adapt its trajectory, responding to spraying hazards.

Better still, the addition of shotcrete layer thickness acquisition to existing lidar technology is very promising. Indeed, information fusion brings confidence, precision, and redundancy, all while expanding the field of possibilities. For example, real-time monitoring and digital twin updating are becoming increasingly feasible. Thus, this research plays a contributing role in the ongoing development of automation of the shotcrete process.

REFERENCES

1. Maxime, M. and al. (2024). "Sprayed Concrete Automation: a unique and complete digital fabrication method," Digital Concrete 2024 - Supplementary Proceedings,
2. Germain, T. (2021). « Automatisation et optimisation des techniques de mise en place du béton projeté, » [M.Sc.]. Université Laval
3. Pastorelli, F. (2021) « Automatisation du procédé de béton projeté : Robotisation et optimisation, » [M. Sc.]. Université Laval
4. Schaeffer, J. (2022) « Automatisation du procédé de béton projeté : Contrôle du rebond et vision numérique, » [M.Sc.]. Université Laval

BAM Shotcrete

BAM Shotcrete, founded in 2016 by Jeff Araiza, has become a trusted name in the shotcrete industry, known for delivering exceptional results on projects across the commercial and residential sectors. From the very beginning, our mission has been clear: To deliver the highest quality finished product, on time, and at the most economical value for our clients. This mission is driven by our unwavering commitment to core values that include punctuality, transparency, professionalism, and integrity. These principles guide every project, ensuring we consistently exceed our clients' expectations.

Our services encompass a wide range of applications, including commercial shotcrete for canals, vertical walls, freeway projects, and skateparks, as well as residential shotcrete for swimming pools, custom water features, and architectural designs. We specialize in creating unique and innovative solutions tailored to the specific needs of each project. Whether shaping an intricate slope protection system or constructing a stunning dome home, BAM Shotcrete brings precision and craftsmanship to every undertaking. Over the years, we have cultivated a reputation for tackling complex challenges and delivering projects that stand the test of time.

A hallmark of BAM Shotcrete's success is our experienced and dedicated team. Under the leadership of Jeff Araiza, our team includes key players such as Zach Carlito, our lead estimator, who brings a detail-oriented approach to project planning; Mark Araiza, project manager, who oversees operations with a focus on efficiency; and Leonard Hererra, general foreman, whose decades of industry experience ensure every job is executed to the highest standard. Weekly performance reviews and job site meetings allow us to refine our processes continually, while robust safety programs and ongoing training ensure our team is always prepared to meet the demands of our industry.

Artificial River Constructed for Kevin Costner's Movie: A scenic artificial riverbed, crafted using concrete and shotcrete techniques, set against the Utah landscape for the Netflix movie, Horizon: An American Saga.

Bridge Scour Protection: Skilled BAM Shotcrete crew applying shotcrete to protect the bridge foundation from erosion and water damage, securing long-term stability.

Eastmark Skatepark in Mesa, AZ: BAM Shotcrete played a key role in constructing this modern skatepark, delivering expertly crafted concrete tracks and smooth surfaces for skaters to enjoy.

V-Ditch Shotcrete Installation: BAM Shotcrete crew installing a durable shotcrete lining in a V-ditch for enhanced water flow management and erosion resistance.

Shotcrete Oil Pit Installation for Transformer Switchgear: Workers installing a robust oil containment pit using shotcrete, designed for safety and environmental protection in industrial applications.

CONTACT INFORMATION:

BAM Shotcrete Inc.

Headquarters
36807 N. 14th Street, Phoenix, AZ 85086

Phone: 623-208-2912

bamshotcrete.com

Throughout our history, we've completed a number of high-profile and meaningful projects that showcase our versatility and dedication to excellence. One of our most notable achievements was constructing an artificial river for Kevin Costner's film Horizon: An American Saga, a project that highlighted our ability to combine creativity and technical expertise. Additionally, we've built renowned skateparks, including the Paradise Valley Skatepark in AZ, the Calvary Church Skatepark in Albuquerque, NM, and the Park City Skatepark in UT. Our work extends to large-scale infrastructure projects, such as the Coolidge Expansion Project, where we constructed eight retention ponds that play a vital role in the area's water management.

Beyond our technical achievements, we are deeply committed to giving back to the community. BAM Shotcrete partnered with the Make-A-Wish Foundation to construct Jonah's Skatepark in Ojai, CA, creating a space for joy and recreation. We've also volunteered for meaningful projects in Puerto Peñasco, Mexico, underscoring our belief that businesses have a responsibility to contribute positively to the communities they serve.

Innovation is at the heart of everything we do. By leveraging advanced equipment such as REED Shotcrete pumps and Sullivan-Palatek air compressors, we ensure every project is completed with precision and efficiency. Our commitment to quality is further supported by our industry certifications, including using ACI-Certified Shotcreters, as well as our membership in the American Shotcrete Association. These affiliations demonstrate our dedication to adhering to the highest standards of practice and continuously improving our craft.

BAM Shotcrete's ability to blend technical expertise, innovative solutions, and a passion for exceptional service sets us apart in the industry. Whether we're enhancing residential properties, constructing skateparks that inspire creativity, or undertaking large-scale commercial projects, our focus remains on delivering results that exceed expectations. As we continue to grow and take on new challenges, we remain steadfast in our commitment to quality, innovation, and community engagement.

PLEASE WELCOME OUR 2025 LEADERSHIP!

Our entire slate of American Shotcrete Association Officers, Board of Directors, and Committee Chairs was elected with no alternatives submitted.

ASA Officers
President: Bill Geers
Vice-President: Jason Myers
Secretary: Kevin Robertson
Treasurer: Bruce Russell
Past President (non-elected): Oscar Duckworth

New ASA Directors (3-year terms)
Jamie Curtis (2nd term)
Mike Klemp (2nd term)
Derek Pay (2nd term)

New ASA Director (2-year term)
Jake Wiseman (filling Bruce Russell's remaining 2 yrs)

Returning ASA Directors
Juanjose Armenta-Aguirre (1 yr remaining)
Mark Bradford (1 yr remaining)
Justin Shook (1 yr remaining)
Randle Emmrich (2 yrs remaining)
Christoph Goss (2 yrs remaining)

ASA Committee Chairs (Appointed not Elected)
Contractor Qualification – Marcus von der Hofen
Education & Safety – Derek Pay
Marketing & Membership– Jason Myers
Pool & Recreational – Ryan Oakes
Technical – Lihe "John" Zhang
Underground – Christoph Goss

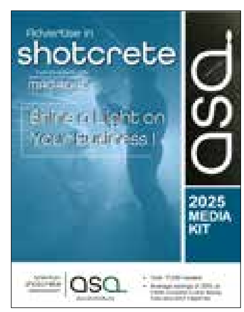
WOMEN IN SHOTCRETE: **SURVEY**

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

SUBMISSIONS NEEDED FOR SHOTCRETE SPOTLIGHT

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

JOIN OUR *SHOTCRETE* MAGAZINE ADVERTISERS!



2025 Media Kit is now online! Place your insertion orders now to ensure inclusion in your choice of Q2, Q3, and Q4 issues of *Shotcrete* magazine!

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

asa Sustaining Corporate Members

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

Geo Craft Builders
www.geocraftbuilders.com

CanCrete Equipment Ltd.
www.cancrete.ca

Curtis Concrete Pumping
www.curtisconcretepumping.com

Ashlar Structural - A Halmar International Affiliated Company
www.ashlarstructural.com

Dees-Hennessey Inc.
www.deeshenn.com

Maple Site Solutions
www.maplesitesolutions.ca

Artisan Skateparks
www.artisanskateparks.com

Consolidated Shotcrete Inc.
www.consolidatedshotcrete.ca

REED Shotcrete Equipment
www.reedpumps.com

Coastal Gunite Construction Company
www.coastalgunite.com

Construction Forms
www.ConForms.com

Imerys
www.imerys.com

Geo-Rope Ltd. (Canada)
www.geo-rope.com

A & B Gunite
www.abpoolsub.com

Ocean Rock
www.oceanrockart.ca

MAPEI Underground Technology Team
www.utt-mapei.com

COST of Wisconsin Inc.
www.costofwisconsin.com

The Quikrete Companies
www.quikrete.com

Nationwide Shotcrete Inc
www.nationwideshotcrete.com

PULLMAN
www.pullman-services.com

Lanford Brothers Company Inc.
www.lanfordbrothers.com

Buesing Corporation
www.buesingcorp.com

Master Builders
www.master-builders-solutions.com

Baystate Shotcrete LLC
www.baystateshotcrete.com

Prestige Gunite & Shotcrete Inc
www.prestigeconcrete.com

Western Shotcrete Equipment
www.wseshotcrete.com

CROM LLC
www.cromcorp.com

Kaaterskill Kahncrete
www.kahncrete.com

Sika STM - Shotcrete, Tunneling & Mining (Canada)
www.sika.com

Sika STM - Shotcrete, Tunneling & Mining (USA)
www.sika.com

Valme North America Inc.
www.valme-na.com

Joe Contri
Patriot Shotcrete

Nominated by Frank Townsend

Joe started in our shotcrete industry with me back in the days of Superior Gunite. He is a local 731 Union Laborer and Patriot Shotcrete's General Superintendent.

Joe is a husband and father to some great children whom he cherishes. He spends countless hours traveling to many states supporting them in their competitions. The definition of Joe is "make it happen." He is better than a project manager as he knows all facets of his projects and how to get them done efficiently and with quality shotcrete placement. He is a self-starter and requires minimal supervision.

Joe gets out in front of the work and often joins the estimating team for site visits and assists them in scoping out the required work. He is a key leader for Patriot Shotcrete, he inspires the workforce, and creates a safe work environment. His organizational prowess is impeccable as he knows where everyone is, and what they need to accomplish each day to stay on schedule. His work ethic is Thomas the Train Engine tough; he keeps on moving forward no matter the obstacles. He gets right to work and doesn't stop, early, late, weekends… whatever it takes. His hard work contributes to our Patriot team's success.

He is a pusher and a driver who gets the job done, daily diving in to help experienced crew members complete their work or properly train new personnel. Joe is integral to the Patriot team and to our success.

SHOTCRETE SPOTLIGHT NOMINATIONS

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

Shotcrete Excellence Deserves Recognition

Get in on the Benefits of the ASA Outstanding Shotcrete Project Awards Program!

By LaTosha Holden

The ASA Outstanding Shotcrete Project Awards Program isn't just about trophies; it's about celebrating the best of the best in shotcrete! If you've been part of an amazing project, this is your chance to showcase your work, get industry credibility, and take advantage of exceptional marketing perks.

Winning, or even just nominating a project in this program, benefits your company. Projects submitted go above and beyond to highlight the quality, craftsmanship, creativity, and innovative problem-solving capabilities your company practices daily. Award-winning projects are featured annually in our first *Shotcrete* magazine of the year as well as in our monthly eNewsletters and regularly on our online platforms. This puts *your* work in front of key players in the shotcrete industry. It's an opportunity to spotlight the amazing ways shotcrete made your project shine and inspire others to explore the greater potential for using shotcrete on their next project.

> This puts *your* work in front of key players in the shotcrete industry. And don't forget the impact on your team!"
>
> **– LaTosha Holden**

Keep in mind: We do not give these awards to just anyone. Projects go through a judging process based on factors like presentation, ASA membership, ACI Shotcreter Certification, innovation, challenges, sustainability, and overall success. That means winning is more than just an honor — it's proof that you're doing outstanding work that stands out in the industry.

Beyond the award itself, taking part in the program is an amazing networking opportunity. You'll connect with top industry players, such as contractors, engineers, material and equipment suppliers, and more who can help take your business to the next level. You never know where a handshake or a shared appreciation for shotcrete might lead!

And don't forget the impact on your team in the field, at the shop, and in your office! Award recognition is a confidence boost for your crew. It recognizes their hard work throughout the concrete construction market, celebrating their dedication and showing them that their efforts don't go unnoticed. A happy and motivated team is productive, and this kind of recognition can do wonders for workplace culture. We encourage winners to bring their team to the awards banquet to share in the celebration.

Get ready to jump in on the benefits! Consider which project(s) you would like to submit this year. Take pictures during construction and of the completed project. Highlight your work's challenges and successes by gathering details on the project. Ultimately submitting a project nomination can elevate your brand to the shotcrete community. **The 2025 Outstanding Shotcrete Project Award application opens in May 2025, and we hope to showcase your achievements in this year's awards program!**

MECBO AMERICA LAUNCHES BETON CAP CONCRETE MIXER-PUMP

ANNISTON, AL (January 15, 2025) — Mecbo America, a division of **Blastcrete Equipment LLC**, announces the launch of the Beton Cap Series concrete mixer-pump to the North, Central and South American markets. Users will enjoy an efficiency boost from Mecbo's patented pump design, the convenience of a handheld radio control and the support of Blastcrete's dedicated customer service team.

The Beton Cap Series provides a range of concrete mixers with capacities of 5, 8 or 9 yd3 (4, 6, 7 m3), combined with a powerful pump capable of delivering up to 105 yd3 (80 m3) per hour at a pumping pressure of 725 or 1,015 psi (5 or 7 MPa). The patented PULSAR pump design minimizes surge and ensures fast, even distribution of concrete, making it ideal for a wide range of placement applications.

For years, Mecbo pumps have been well established and respected in European markets but lacked availability in the American markets due to the absence of a service and support structure. Blending Blastcrete's industry-leading mixing, pumping and placing expertise with Mecbo's products, the two companies teamed up to provide top-tier products backed by first-class support. The Mecbo pumps complement the Blastcrete line with units offering higher pumping volumes for structural concrete applications requiring larger aggregate material. Additionally, Blastcrete stocks a full inventory of Mecbo pump parts to help customers minimize downtime should a repair be required.

Blastcrete co-CEO Scott Knighton said that market feedback on the Beton Cap has been very positive. "The formation of Mecbo America enables us to offer customers access to a unique Italian product backed by unparalleled domestic service and parts distribution as well as Blastcrete's in-depth application knowledge," Knighton said. "We're confident that the increased efficiency and convenience of the Beton Cap, with the full benefits of the PULSAR pump design, will benefit contractors working in structural concrete throughout the Americas."

Mecbo is widely known for its patented PULSAR pump system — a rack and pinion valve control that reduces the maintenance burden and consistently facilitates smooth pouring. A long stroke allows the pump to push a greater volume of concrete with less movement, which minimizes surging. In addition, PULSAR has been shown to reduce energy consumption by 30-40% compared to other concrete pumps.

Operators of both diesel and electric models can enjoy the convenience of dedicated work and maintenance stations, as well as a user-friendly radio control. The handheld radio remote control bucks the current industry trend by featuring toggles instead of a touch screen. This design eliminates the risk of digital malfunction prevalent when working with wet concrete.

The Beton Cap offers multiple power options in the form of 115-, 160- or 210-horsepower (85-, 120-, or 157-kilowatt) diesel engine models. Customers looking to use the pump in settings where diesel exhaust would be prohibitive to the project have the option of a 200-horsepower (150-kilowatt) electric motor. Models range in weight from 9 to 19 tons. The state-of-the-art mixer-pump is seamlessly integrated onto an axle with a durable tracked undercarriage. Adaptable to various terrains, the pump can be effortlessly installed on wheels or trucks.

Factory options include soundproofing for work in densely populated urban areas, a hopper screen vibrator for harsh mixes and an automatic lubrication system.

To learn more about Mecbo America and their concrete mixer-pumps, visit **www.mecboamerica.com**.

GUNITE Supply & Equipment

GUNITE SUPPLY & EQUIPMENT PROMOTES LARRY KLEIN TO NATIONAL SALES MANAGER

JANUARY 2, 2025 — Gunite Supply & Equipment is proud to announce the promotion of Larry Klein to the position of National Sales Manager, effective January 1, 2025. Larry brings a wealth of experience to this role, having demonstrated exceptional leadership and expertise in the shotcrete industry and with large-scale construction project management. Since joining Mesa Industries, Larry has been instrumental in enhancing Gunite Supply's operations, most notably through his leadership in the successful relaunch of GuniteSupply.com in March 2024.

"Larry Klein is a highly respected figure among our customers and peers. His dedication and vision make him a natural choice for this expanded role," said General Manager, Adam Vance. "We are confident that Larry's leadership will continue to positively influence the trajectory of Gunite Supply & Equipment, and we look forward to the innovative contributions he will make as National Sales Manager."

The entire team at Gunite Supply & Equipment extends heartfelt congratulations to Larry on his well-deserved promotion. We are excited to support him as he embarks on this new chapter of leadership and growth.

RC3

Supporting Concrete Industry & Agency Collaboration

REDUCED CARBON CONCRETE CONSORTIUM SUPPORTS STATE IMPLEMENTATION OF LOW CARBON TRANSPORTATION MATERIAL GRANTS PROGRAM FOLLOWING FHWA AWARD ANNOUNCEMENT

ROSEMONT, IL — The Reduced Carbon Concrete Consortium (RC3) — a consortium created to help departments of transportation and other qualifying entities apply for and use federal Low Carbon Transportation Materials (LCTM) funds — applauds today's Federal Highway Administration (FHWA) announcement of funding. INVESTING IN AMERICA: USDOT Awards $1.2 Billion in Grants to Help State Departments of Transportation Utilize Cleaner Construction Materials provides details on the grant awards that will go to 39 state departments of transportation.

RC3 recognizes program execution will be a collaborative effort between state and federal agencies, industry partners and service providers. To assist individual states in their efforts to streamline operations and maximize the value of their award, RC3 will continue to provide support and consultation. RC3 will also act as a coordinating body, matching states who have an opportunity to collaborate and gain efficiencies of scale when using LCTM funds. Collaborative tasks can include training, Environmental Product Declaration (EPD) development, performance monitoring and more.

RC3 has partnered with states throughout the application process, making available resources including sample template proposals for both Volumes 1 and 2 of the FHWA application, informational video meetings for state highway agency representatives, and personalized technical support for individual states.

Other initiatives of the Consortium include disseminating information on reducing carbon in the construction process and facilitating contractor preparedness with critical next steps such as Environmental Product Declarations (EPDs). RC3 has released documentation to help contractors begin collection of EPD data.

RC3 leadership includes the American Concrete Pavement Association (ACPA); National Concrete Pavement Technology Center (CP Tech Center); Concrete Advancement Foundation; National Ready Mixed Concrete Association (NRMCA); MIT Concrete Sustainability Hub (CSHub); Thomas J. Van Dam, PH.D., P.E., FACI, LEED AP, Principal at Wiss, Janney, Elstner (WJE); Lawrence L. Sutter, PH.D., P.E., FASTM, FACI, Principal at Sutter Engineering LLC; and Kevin Senn, PE, Principal at NCE.

The LCTM Grants Program will make $1.2 billion available to departments of transportation and other state agencies. The funds will support activities and projects that advance the use of low carbon materials and products by reimbursing or incentivizing states who incorporate low carbon materials—including concrete—on construction projects. RC3 believes effective use of LCTM funds will help lower embodied greenhouse gas emissions associated with the production, use, and disposal of construction materials, compared to current estimated industry averages.

"With these grants, the FHWA is providing an opportunity for agencies to engage in bold programmatic initiatives. RC3 was formed by dedicated industry experts who are committed to that vision, and we offer practical tools and guidance each step of the way to help connect funding goals to measurable outcomes—we are working to make sustainability goals implementable on the grade," said Laura O'Neill Kaumo, President & CEO of ACPA.

"RC3 is thrilled to have played a part in supporting the LCTM application process and is excited this funding will advance high performing material alternatives. We will continue to provide assistance as the LCTM program moves to implementation, and welcome any questions," said Kevin Senn, Principal, NCE.

For more information, please contact Tom Van Dam (tvandam@wje.com), Larry Sutter (sutter.engineering@gmail.com) or Kevin Senn (KSenn@ncenet.com), or visit our website at **https://rc3.acpa.org/**.

SHOTCRETE CALENDAR

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

MARCH 21-23, 2025	**ACI Shotcreter Certification (Wet-Mix) | Skatepark Summit** Kaaterskill Kahncrete | Saugerties, NY
MARCH 30-APRIL 2, 2025	**ACI Concrete Convention - Spring 2025** Sheraton Centre Toronto Hotel | Toronto, ONT Canada
APRIL 9-11, 2025	**ACI Shotcreter Certification (Wet- & Dry-Mix)** Minova | Millstadt, IL
APRIL 13-16, 2025	**2025 ICRI Spring Convention** Austin Marriott Downtown | Austin, TX
APRIL 29, 2025	**Recognizing Quality Shotcrete** Midwest Resource Center | Elk Grove Village, IL
MAY 9-11, 2025	**ACI Shotcreter Certification (Wet- & Dry-Mix)** Applied Shotcrete | Sebastopol, CA
JUNE 22-25, 2025	**ASTM Committee Meetings - C09 Concrete & Concrete Aggregates** Sheraton Centre Toronto Hotel | Toronto, ONT Canada
AUGUST 8, 2025	**Recognizing Quality Shotcrete** Mid-Atlantic Resource Center | Columbia, MD
SEPTEMBER 10, 2025	**Recognizing Quality Shotcrete** Southern California Resource Center | San Bernardino, CA
OCTOBER 1-3, 2025	**ACI Shotcreter Certification (Wet- & Dry-Mix)** Minova | Millstadt, IL
OCTOBER 3-5, 2025	**ACI Shotcreter Certification (Wet- & Dry-Mix)** Applied Shotcrete | Sebastopol, CA
OCTOBER 10, 2025	**Recognizing Quality Shotcrete** Midwest Resource Center | Elk Grove Village, IL
OCTOBER 19-22, 2025	**2025 ICRI Fall Convention** Intercontinental Hotel | Chicago, IL
OCTOBER 19-24, 2025	**International Pool | Spa | Patio Expo 2025** Las Vegas Convention Center | Las Vegas, NV
OCTOBER 25, 2025	**ASA Fall Committee Meetings - 2025** TBD | Baltimore, MD
OCTOBER 26-29, 2025	**ACI Concrete Convention - Fall 2025** Hilton Baltimore & Marriott Baltimore Inner Harbor | Baltimore, MD
DECEMBER 7-10, 2025	**ASTM Committee Meetings - C09 Concrete & Concrete Aggregates** Hilton Atlanta | Atlanta, GA
MORE INFORMATION	To see a full list, current updates, and active links to each event, visit www.shotcrete.org/calendar.

CONGRATULATIONS TO OUR 2024 WINNING SUBMISSIONS!

2024 OUTSTANDING ARCHITECTURE | NEW CONSTRUCTION PROJECT

PROJECT: MATH, SCIENCE & SHOTCRETE

Project Location: Holly Springs, NC
Shotcrete Contractor: Revolution Gunite*
Architect/Engineer: Dewberry Engineering
Materials Supplier: Revolution Gunite*
General Contractor: Progressive Contracting
Owner: Wake County Public Schools

2024 OUTSTANDING INFRASTRUCTURE PROJECT

PROJECT: ICE HARBOR DAM DRAFT TUBE MODIFICATION

Project Location: Burbank, WA
Shotcrete Contractor: PCiRoads, LLC*
Architect/Engineer: U.S. Army Corps of Engineers, Walla Walla District
Equipment Manufacturer: Gary Carlson Equipment* / Putzmeister*
Materials Supplier: Master Builders Solutions*
General Contractor: Voith Hydro
Owner: U.S. Army Corps of Engineers, Walla Walla District
Other Project Members: LZhang Consulting and Testing, Ltd. / WSP Canda, Inc.

2024 OUTSTANDING INTERNATIONAL PROJECT

PROJECT: MODERNIZATION OF THE WATER TREATMENT PLANT IN POZNAN

Project Location: Poznan, Poland
Shotcrete Contractor: SPB TORKRET Ltd*
Architect/Engineer: Sweco Poland
Equipment Manufacturer: Sika - Aliva, Atlas Copco
Materials Supplier: SPB TORKRET Ltd*
General Contractor: TERLAN/HYDRO-MARKO
Owner: Aquanet S.A.

2024 OUTSTANDING POOL & RECREATIONAL PROJECT

PROJECT: BOUNDLESS WATERS

Project Location: Hudson River, NY
Shotcrete Contractor: Drakeley Pool Company*
Architect/Engineer: Hollander Landscape Architects
Equipment Manufacturer: Schwing Concrete Pumps
Materials Supplier: Brewster Transit
General Contractor: Yankee Custom Builders
Owner: Yankee Custom Builders

2024 OUTSTANDING REHABILITATION & REPAIR PROJECT

PROJECT: HEMLOCK RESERVOIR DAM IMPROVEMENTS

Project Location: Fairfield, CT
Shotcrete Contractor: Patriot Shotcrete, LLC*
Architect/Engineer: Tighe & Bond, Inc.
Equipment Manufacturer: Putzmeister America*
Materials Supplier: Sika Corporation*
General Contractor: Blakeslee Arpaia Chapman Inc.
Owner: Aquarion Water Company of Connecticut

2024 OUTSTANDING UNDERGROUND PROJECT

PROJECT: ANDERSON DAM TUNNEL

Project: Anderson Dam Tunnel
Project Location: Morgan Hill, CA
Shotcrete Contractor: Drill Tech Drilling & Shoring, Inc.*
Architect/Engineer: AECOM
Equipment Manufacturer: Schwing Concrete Pumping
Materials Supplier: The Quikrete Companies* / Bekaert Corporation (Fibers)*
General Contractor: Flatiron West Inc.
Owner: Santa Clara Valley Water District
Tunnel Ground Support Supplier: Jennmar Civil

2024 HONORABLE MENTION PROJECTS: KICKING HORSE CANYON MOUNTAIN STABILIZATION | GOOSE POND DAM IMPROVEMENTS | ÉDOUARD-MONTPETIT STATION - RÉSEAU EXPRESS MÉTROPOLITAIN | SHOTCRETE & WATERPROOFING - BRIGADE TECH GARDENS

**ASA Sustaining Corporate or Corporate Member*

NEW ASA MEMBERS

SUSTAINING CORPORATE MEMBERS

Ashlar Structural - A Halmar International Affiliated Company
Nanuet, NY
www.ashlarstructural.com
Primary Contact: Mike Munyon
mmunyon@ashlarstructural.com

PULLMAN
Trenton, MI
www.pullman-services.com
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Valme North America Inc.
Franksville, WI
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r.housman@dconstruction.com

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www.davenconsultingservices.com
Primary Contact: Fred Daven
fdaven@davenconsultingservices.com

Hall Constructors
Langley, BC, Canada
www.bdhall.ca
Primary Contact: Greg Marenick
gmarenick@bdhall.ca

R&W Shotcrete & Soil Support, LLC
Lansdale, PA
www.Forcineconcrete.com
Primary Contact: Bruce Wilson
bwilson@rwshotcrete.com

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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:

Is there a publication by your organization showing the basic symptoms of problems on pool shotcrete? Or even a class that reviews these? Currently, I have a pool with cracking. I'm not sure of the extent, but I'm trying to figure out what could've gone wrong.

ANSWER:

We have several pool position statements (**pools.shotcrete.org**). You can also do a search of our Pool FAQs on that pool portal. Try the keyword "cracking". In general, cracking is a function of too little reinforcing steel, inadequate curing, or both. You haven't mentioned the size, type, or orientation of the cracks. That can help determine the root cause. Also, concrete 28-day compressive strength should be at least 4000 psi. The stronger the concrete, the better able to handle tensile stresses that lead to cracking.

We also offer classes at national pool shows and other venues for recognizing quality shotcrete and how design and execution is critical to long-term serviceability and durability. The "Recognizing Quality Shotcrete" is offered for general shotcrete inspection that can include pools. We have a pool-specific class, "Quality Shotcrete for Pools - Know It, Demand It" that focuses on the pool industry. Check our ASA Calendar for upcoming classes at **shotcrete.org/calendar**.

QUESTION:

We are adding a waterproofing admixture to the concrete for a pool we are shooting in the cold weather. Do I need to tent and heat or can I wet the shell then lay plastic over the surface?

ANSWER:

Shotcrete is just a placement method for concrete. Concrete "waterproofing" admixtures are part of the concrete mixture. You should follow cold weather concrete procedures as documented in ACI PRC-306-16 Guide to Cold Weather Concreting or ACI SPEC-306.1-90: Standard Specification for Cold Weather Concreting (Reapproved 2002) . That generally means keeping the temperature of the shotcreted concrete over 55°F (13°C) for sections 12 in. (300 mm) or thinner. This allows the concrete to gain strength. If the concrete temperature drops below 40°F (4°C), hydration of the cement in the concrete slows substantially. Heating the concrete surface can be accomplished by tenting or covering the exposed surfaces with insulated blankets. Supplemental vented heaters should be used if the project is exposed to extended freezing weather. Non-vented heaters should not be used as they can produce carbonation and resulting weakness of the surface of the young concrete.

QUESTION:

We have a completed sculpted shotcrete project that is undergoing what appears to be efflorescence bleed. The face was sculpted and stained then controlled low-strength material (CLSM) was placed behind the wall. The wall is directly on the coast and is exposed to a harsh coastal environment. I have used a muriatic acid wash in the past to remove deposits, but not on stained surfaces. Do you have any recommendations on what we could use to remove streaks without compromising stain??

ANSWER:

Efflorescence is calcium hydroxide on the surface. It usually is noticeable below cracks in the concrete and results from ground water flowing through the cracks from the opposite face or from rainwater filling and then seeping out of the crack.

Acid will negate the alkalinity of the calcium hydroxide. Muriatic acid can be used but may be quite strong. Acetic acid (part of vinegar) can be used and may be less aggressive towards what was used to stain the concrete.

Ultimately, the efflorescence will reappear unless the source of the water is addressed. If the water source is rainwater or ocean spray flowing over the surface, a clear sealer like a silane may be worthwhile to prevent water from seeping into the crack and then leeching out the soluble calcium hydroxide.

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