shotcrete
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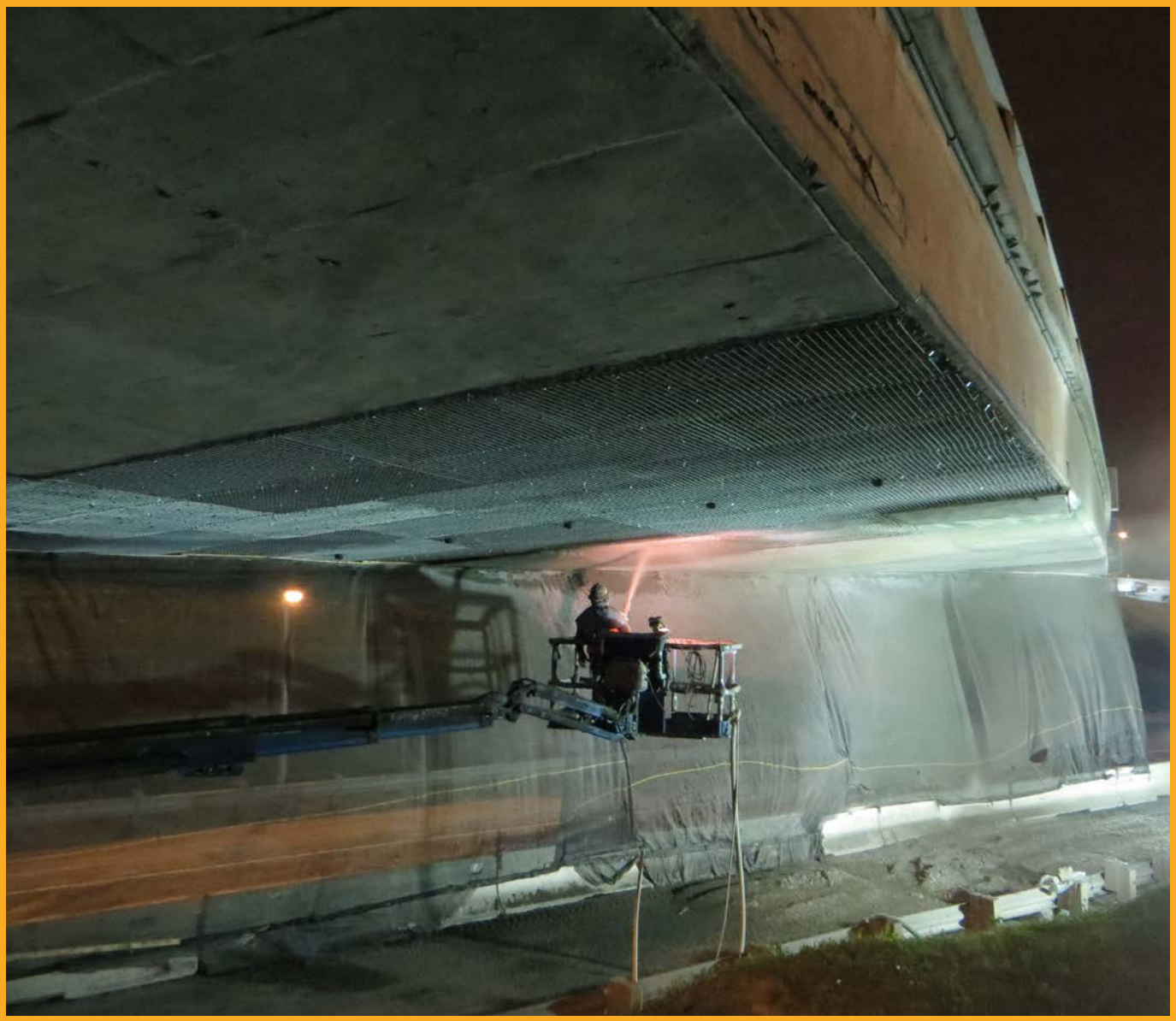
OUTSTANDING SHOTCRETE Project Awards

american shotcrete association | asa



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FEATURES

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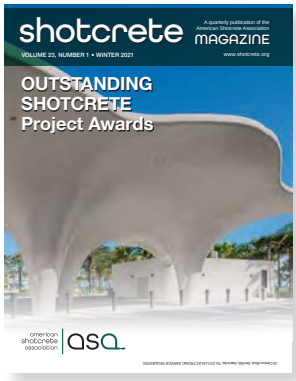
Editor's Note: Shotcrete is a placement method for concrete. However, for the sake of readability, the word "shotcrete" is often used either to identify the shotcrete process (method of placement) or the shotcrete mixture (product materials).

ALSO FEATURING

DEPARTMENTS



Los Olas Corridor Improvements – Shade Canopy – Fort Lauderdale, FL

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"We've Come a Long Way…"

By Lars Balck

2020 was quite a year. In 2019 we committed to changing our association management firm from ACI's AOE to Virtual Inc. Anytime you make a significant change you can expect glitches. We had them, but the ASA staff handled them, along with the impact from COVID-19 all in the same year. In addition to working with new systems and software, ASA staff produced ASA's first ever virtual Outstanding Shotcrete Project Awards Celebration due to COVID restrictions on meetings. The virtual Celebration featured the dynamic dual tag team of George Seegebrecht and Charles Hanskat. It was a great success, but it consumed twice as much effort as a normal banquet. Hats off to the ASA team of Tosha, Alice, and Charles. Of course, we all owe Ryan Poole a round of virtual applause for leading the Executive Committee during this difficult period.

ASA was established in 1998. Let's look at what ASA has accomplished over the past 23 years and consider our future.

Before there was an ASA, the American Concrete Institute (ACI) organized Committee 506 in 1960 to revise "Recommended Practice for the Application of Mortar by Pneumatic Pressure" produced by ACI Committee 805. By 1966 the group of shotcrete contractors, engineers, material suppliers, equipment suppliers and interested parties produced "Recommended Practice for Shotcreting" 506-66. The group, chaired by Tom Reading, consisted of well-known shotcrete legends such as Ted Crom, John Fredericks, Albert Litvin, Raymond Schutz and Stanley Zynda among others. Shortly afterwards the committee also published SP-14 a collection of early shotcrete papers and "Recommended Practice for Shotcreting." SP-14 should be in every shotcreter's library. At the time, there were widely different opinions and a scarcity of engineering data on shotcrete. In the first paper by Tom Reading titled "Shotcrete as a Construction Material," he pointed out that poor workmanship was the most frequent cause of shotcrete failures. Failures, though preventable by those contractors with proper knowledge, have haunted the shotcrete industry for years, leading many specifiers to reject the use of shotcrete.

In March of 1998, with the encouragement of Milt Collins, a group of shotcrete contractors, material suppliers, equipment suppliers and interested parties who were tired of having shotcrete rejected, came together with the goal of advancing the quality and acceptance of shotcrete. Thus, the American Shotcrete Association (ASA) was formed and the first official meeting was in October of 1998. The group consisted of Rusty Morgan, George Yoggy, Peter Tatnall, Larry Totten, Chris Breeds, Joe Hunter, Russ Ringler, Marc Jolin and Chris Zynda (son of Stanley Zynda). Whereas ACI produces technical codes and standards, ASA's goal was to promote shotcrete. Today, nearly 23 years later, ASA has over 800 members and shotcrete's use has expanded greatly. ASA's success is due to member involvement and successful programs. Below are ASA's programs.

SHOTCRETE NOZZLEMAN CERTIFICATION

The backbone program of ASA's success is administration of ACI's shotcrete nozzleman certification. Shotcrete placement quality is dependent on the craftsmanship of the nozzleman. ACI certification was developed by ASA members working with ACI to create a program that recognizes the knowledge and placement practice essential to quality concrete. ACI nozzleman certification does not guarantee quality any more than a person holding a driver's license guarantees they won't exceed the speed limit or run a red light. Craftsmen holding a current shotcrete nozzleman certification are rare, the pride of having this ACI certification drives the craftsman to deliver superior performance. ASA developed, and requires all new nozzlemen to attend, a full-day education class on the basics of concrete and shotcrete placement. There are currently 1850 ACI-certified shotcrete nozzlemen (1414 wet, 438 dry and 272 NIT's). The ACI certification program has helped give engineers the confidence to use the efficiency and quality of shotcrete placement on
their projects.

CONTRACTOR QUALIFICATION

This is a relatively new program for ASA. A nozzleman is not the only essential person on a job. Projects require a shotcrete team, with proper equipment that are well maintained, appropriate materials, and project coordination. All this is only done by a financially sound contractor dedicated to quality shotcrete placement, day in and day out. ASA began a program of qualifying shotcrete contractors so specifiers would feel comfortable allowing contractors vetted by ASA to bid. To date, since the program launched in 2018, ASA has vetted 7 Qualified Shotcrete Contractors.

SHOTCRETE INSPECTORS

Most concrete inspectors are not familiar with shotcrete placement. They often are quite familiar with concrete but

don't know the details required for quality shotcrete placement. As with the ACI nozzleman certification program, many ASA members worked with ACI certification to create an ACI Shotcrete Inspector certification. As with the nozzleman program, ASA believes education is essential to build the knowledge base of the shotcrete inspector so that inspectors can recognize quality shotcrete placement. The ASA full-day education is offered to inspectors who may also find it helpful in preparing for the ACI Shotcrete Inspector certification written exam. ACI certified shotcrete inspectors are more knowledgeable in inspecting shotcrete work and contractors have the advantage of working with an inspector that can recognize the aspects of quality shotcrete placement. This seminar is also valuable to general contractors or pool builders who sub-contract out for their shotcrete work. Recognizing quality shotcrete is essential where shotcrete plays a role in the project. To date ASA has educated well over 400 individuals with this seminar.

OUTREACH

Educating the design and construction community about shotcrete's creativity and quality is another active ASA program. ASA has developed and presented our Introduction to Shotcrete program to nearly 4000 individuals including engineers, architects, specifiers, inspectors, and engineering students. These complimentary seminars have increased awareness for what shotcrete can do for a project from students just starting out in the industry, to "hardened" veterans who have had negative experiences with poorly placed shotcrete. In many cases, reopening doors where shotcrete had been dismissed as an option due to previously developed poor reputations.

Another form of outreach is ASA's yearly Outstanding Shotcrete Project Awards that are given for shotcrete projects that highlight and exemplify the cost saving and versatility of shotcrete. This is an opportunity for ASA and the construction community to give credit to deserving shotcrete contractors and see the amazing possibilities of shotcrete for their next project. Despite COVID, we had a great assortment of winners this year!

Three years ago, ASA held our first Shotcrete Convention and Technology Conference to promote shotcrete education and provide an opportunity for leaders in the shotcrete market to interact in a conference dedicated to shotcrete. Our next convention will be held February 27 through March 1, 2022 at Hilton Head Island in South Carolina. Our leaders are passionate about their work and generous with knowledge – both in learning and sharing.

SHOTCRETE MAGAZINE

From year one ASA has published a quarterly magazine dedicated to shotcrete. Articles range from safety, equipment, projects, materials, research, case studies, FAQs, and upcoming events. Subscriptions have always been offered for

free and, as a result, is read by nearly everyone interested in shotcrete. Our readers include contractors, engineers, architects, owners, project managers, educators, researchers, suppliers, and field crew members. ASA has produced 88 issues of Shotcrete magazines and it is distributed to roughly 13,000 people around the world.

SAFETY

ASA is dedicated to safety. Oscar Duckworth initiated and guided the important Shotcrete Safety Guidelines publication. The Education & Safety Committee is currently updating this publication while looking to provide additional safety resources to our members and the industry.

RESEARCH AND DEVELOPMENT

Shotcrete research through the efforts of Dr. Marc Jolin (Laval University) has made great strides. Marc has guided many graduate students to conduct important shotcrete research, advancing an understanding of nearly every aspect of shotcrete placement. Dr. Rusty Morgan and Dr. John Zang have contributed to shotcrete knowledge by conducting shotcrete field testing of new materials and publishing results.

ASA'S WORK HORSES

Shotcrete's acceptance and ASA's success is due to the above programs which were achieved only by the hard work of many ASA volunteers and ASA staff over the past 23 years.

Charles Hanskat became our Executive Director in 2015. He soon initiated an outreach program to anyone interested in learning about shotcrete, oversees the shotcrete nozzleman education and certification program and is now also educating inspectors. He worked with the members of ACI 318 to include the use of shotcrete in the Code, and saw it successfully first included in the ACI 318-19 Code. Having ACI 318's seal of approval is a big deal. More engineers and building officials will allow shotcrete placement of structural concrete because it is directly included in the Code.

Twenty-two presidents have guided the organization for the past 23 years. ASA has administered over 800 nozzleman certification sessions. We currently have a pool of 16 ACI-Approved Examiners who travel wherever and whenever needed to conduct sessions. ASA's competency in managing what ACI considers to be its most complicated certification program, has helped ensure standards are met at each certification session. Internal reviews and audits look for continuous improvement as ASA seeks to keep raising the bar for quality shotcrete placement especially with the nozzlemen.

Marcus von der Hoffen is guiding the new Contractor Qualification program. Pool and spa builders place a lot of shotcrete yet there is little oversight or design/construction requirements. Bill Drakeley is spearheading an effort to encourage shotcrete pool builders to join ASA and improve their quality thus improving the image of shotcrete. Towards this end, at the initiation of ASA, ACI has approved the new ACI 322 Concrete Pool and Watershape Code Committee, to which Hanskat has been assigned Chair.

Although a lot has been accomplished, we still have a lot to do. Going forward we need to continue to focus on improving shotcrete quality. To focus us, the Board and Committee Chairs hopes to conduct a new ASA strategic planning session in the Fall to update what Charles Hanskat (as ASA President) started 7 years ago and Scott Rand refined in our 2017 update.

Cathy Burkert, in one of her President's Messages two years ago, recounted her experience of being rejected by an Owner/Engineer who was afraid of shotcrete. Many shotcrete contractors have similar experiences. Rejection is what started ACI 506 and ultimately ASA. Even with all our advancements, programs, and acceptance in the concrete construction industry, we still have more work to do.

The pandemic has been devastating to most of the country this past year. Fortunately, most shotcrete projects were spared as part of "essential businesses." The emphasis on improving infrastructure makes the future looks bright. Fewer shotcrete contractors are being rejected and owners are gaining the time and cost savings shotcrete can provide. Just look at the projects highlighted in the recent Outstanding Shotcrete Project Awards and ACI 318's acceptance of shotcrete in the Building Code.

"We have come a long way baby." The future of shotcrete is bright. I ask you to get involved with ASA and continue to improve shotcrete. Stay safe.

Sustaining Corporate Members

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

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Marketing Committee

By Dennis Bittner, Chair

One of the main objectives of the ASA is to promote the use of shotcrete and its proper application. This objective lines up perfectly with the objective of the Marketing Committee. To that end, the Committee has multiple initiatives in the works.

Despite the challenges presented by COVID-19, the Marketing Committee remained busy and turned to innovative technology options to stay connected with our members and the shotcrete industry. Although in-person seminars and meetings were put on hold, ASA made the most of virtual presentations. In 2021 we delivered 15 presentations as of mid- March to over 350 people. Of those presentations 12 were delivered online. Presentations were made to various audiences, including state agencies, specifiers, contractors and owners.

New for 2021, ASA's Town Hall meetings provided an opportunity to connect with members and guests of the Association once a month. These gatherings were a place for everyone to come together from coast to coast and listen in to topics pertaining to the shotcrete industry. A few of the topics we have previously hosted were ASA's Annual Membership Meeting, Meet the Outstanding Shotcrete Project Awards Winners, and Shooting Pools – It's Not Just Point and Shoot! The Town Halls offered a great place to learn about various shotcrete topics, ask questions and get answers. The Town Halls will take a break over the summer months to not compete with the height of construction and vacation schedules.

Typically, we recognize outstanding shotcrete projects from the past year at our Annual Outstanding Shotcrete Project Awards Banquet. This year, we recognized our 2020 winners by hosting a virtual Awards Celebration to over a hundred attendees! The 16th Annual Awards Celebration can be viewed on demand at www.shotcrete.org/projectawards and the winning projects are also featured in this edition of *Shotcrete* magazine.

Our Shotcrete Convention and Technology Conference has been rescheduled to February 27 – March 1, 2022, and will be held at the Sonesta Resort at Hilton Head in South Carolina. The call for convention abstract presentations is currently open and will remain open until August 1, 2021. I encourage you to submit the title of the proposed presentation, speaker information and a short (less than 100 word) abstract to be reviewed by the ASA Technical Committee. Submissions and/or questions should be directed to Charles Hanskat: 248.983.1701 or Charles.Hanskat@Shotcrete.org. The convention provides a great opportunity to learn and connect with leaders in the industry. I hope you will be able to join us.

World of Concrete was rescheduled to June 7 -10, 2021 and ASA was there to support the concrete industry by exhibiting and offering shotcrete education. Attendees had the opportunity to attend three sessions: Shotcrete Nozzleman Education Class, Recognizing Quality Shotcrete, and Shotcrete Contractor Education. It was great to be a part of this first major convention in the industry (and in Las Vegas) since the start of the pandemic.

2020 OUTSTANDING SHOTCRETE PROJECT AWARD WINNERS

CATEGORY	PROJECT
Architecture | New Construction	**Las Olas Corridor Improvements**
Infrastructure	**Davis Barracks Chiller Plant Wall**
International	**The Kaitif Skatepark**
Pool & Recreational	**Barges, Golf Carts and Shotcrete**
Rehabilitation & Repair	**Park Avenue Tunnel Rehabilitation**
Underground	**Poe Tunnel**
Honorable Mention	**The Sherwood Residence**
Honorable Mention	**Chihuahuan Desert, El Paso Zoo**
Honorable Mention	**Hale Park Skatepark**
Honorable Mention	**Grotto Pool**
Honorable Mention	**South Wastewater Treatment Plant Influent Vault Rehabilitation**

Our marketing campaign has expanded its Instagram presence, hosting a quarterly competition called The Art of Shotcrete. We understand that shotcrete is not only a structural and durable part of the construction industry, and recognize it takes a true craftsperson for quality shotcrete placement. Artful photos that you or your company post can be entered into the competition by adding #artofshotcrete to your Instagram post. The top photos of the past quarter will be selected and featured in Shotcrete Magazine. It's a great way to gain exposure for your company and your work. Don't hesitate, post and tag those pictures -- we might just make you Instagram Famous!

Our doors are always open; if you're interested in becoming a part of the Marketing Committee, or any other committee, corporate members can connect with our committee through ASA's new Online Community on the ASA website under the ASA Membership tab or send an email to info@shotcrete.org. Joining a committee is a great way to get more involved in the American Shotcrete Association and network with some of the leaders of the shotcrete industry.

MARKETING COMMITTEE

Dennis Bittner, Chair | The Quikrete Companies
Ashley Cruz, Secretary | Cruz Concrete & Guniting Repair Inc

Joseph Munch | Pullman SST, Inc
Ryan Poole | Consultant
Patrick Bridger | Sika Shotcrete, Tunneling & Mining
Randle Emmrich | Coastal Gunite Construction Company
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Ted Sofis | Sofis Company Inc
Cathy Burkert | American Concrete Restorations Inc
Ed Brennan | US Concrete Products LLC
Kevin Robertson | Sika Shotcrete, Tunneling & Mining
Marcus von der Hofen | Coastal Gunite Construction Company

Shotcrete is…

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

Every year I have the privilege to see the many shotcrete projects submitted for our annual ASA Outstanding Shotcrete Project Awards. And every year I am heartened and proud to see the quality and creativity our shotcrete contractors provide. We are an industry that knows we can accomplish things that are simply not doable without our knowledge and our attention to quality in designing, planning, and construction. ASA's Awards program provides a forum to highlight and celebrate these accomplishments as we promote and market these winners throughout the industry!

As a segment of the concrete industry, shotcrete, is truly unique. We turn architect's most creative visions into strong, durable concrete structures that will last for generations to come. We take on projects where shotcrete is the clear, and often only, choice to meet and beat challenging access, producing high quality concrete structures in remote locations or where conventional formwork may be difficult, if not impossible. We create concrete that looks like a natural rock or stone face to the unsuspecting passersby but will likely be more durable and structurally sound than real rock may have ever been. We give skaters the ideal environment to learn and advance their skills on concrete shapes that are curved in so many ways that the flat sections are the exception not the majority. Only shotcrete allows watershape builders to mold with high strength, watertight shotcrete what an Owner or designer imagined.

All the project winners you see in this issue represent the creativity, resourcefulness, experience, and attention to detail that our shotcrete contractors provide. However, this recognition of our top projects is really just the tip of the iceberg. Without a doubt 2020 was an extremely challenging year, with many of our members seeing record demand, yet still meeting the obstacles of working in a pandemic with new restrictions, requirements, and supply chain issues on our jobs. Many truly outstanding projects likely never got submitted for the awards program as our shotcrete teams strived to keep up with their work and unfortunately just could not find the time to write or capture the images to make an award nomination. Hopefully in 2021 as the world returns to some sense of normality all of you with great projects will submit them for this year's award program.

I certainly congratulate all our ASA Outstanding Shotcrete Project winners. By these exemplary examples of what we can do with shotcrete, we spark the imagination and visions of many architects, engineers and designers who now know - "Well yes, we CAN do that with shotcrete". However, I also want to congratulate ALL our shotcrete designers, suppliers, educators, and contractors who maintained the quality of shotcrete placement and adapted to the most challenging working environment we have seen in generations. To all, a job well done! Our future in the shotcrete industry is bright because of the quality work we've done, even in these most challenging of times.

We have made great strides in acceptance by engineers and architects in the last two decades of ASA's existence.

Many specifiers have recognized the efficiency and flexibility of shotcrete, and they trust that the materials, equipment, and placement techniques we routinely use create high strength, low permeability, durable concrete structures. However, what drives acceptance to an even larger degree is the confidence engineers and architects who specify shotcrete have in our ability to consistently place high-quality concrete. Confidence that their designs can be fully and properly built with quality shotcrete is crucial.

The pandemic has brought sharp increases in some of our shotcrete markets. The pool industry is reported to have seen an overall 30% increase in demand and backlogs, in some cases over a year. Highway infrastructure repair was accelerated when traffic levels were decreased from the "work from home" changes in the workforce. With these sharp increases, demand for skilled shotcrete crew is higher than ever.

I have concerns that some contractors may increase production to meet the demand and have difficulty in maintaining the quality. ASA members recognize the necessity for quality in all our shotcrete work to advance the industry. Unfortunately, other companies may not have the appreciation for how poor-quality placement resulting from prioritizing production over quality can hurt us as an industry. With careful attention to details, higher production can be achieved with quality placement, but it takes a conscious effort by all those involved in the shotcrete work.

With our gains in acceptance, we must also accept that we have a responsibility. A responsibility as shotcrete companies, crew members, equipment and material suppliers, researchers, educators, and in many ways, us as an Association, to maintain and ultimately strive to increase the quality of shotcrete placement. Engineers writing codes and standards, specifiers including shotcrete in their specifications and owners asking for shotcrete on their projects have placed their trust in our ability to consistently place quality concrete. We must keep quality as a priority, for we can lose our reputation again in a heartbeat. If their trust is lost, we lose decades of work by ASA and our members in building acceptance. Further, once lost, rebuilding that reputation and trust of shotcrete placement can take decades. We must press on and not let the pressure of demand allow us to cut corners which will have more far-reaching consequences than just the current production schedule. Let's remember lessons learned from the past and continue to strive for greater quality in our shotcrete placement.

The American Shotcrete Association sincerely thanks our Sponsors for their role in supporting the Awards Program!

asa

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US Concrete Products

THANK YOU!

2020-2021 Awardee

***Florent Pastorelli** is currently completing his master's degree in mechanical engineering at Université Laval in Québec City, QC,Canada. Originally from France, where he trained as a mechanical engineer at the Arts & Métiers school, Florent decided to pursue his education in Québec City in the field of robotic engineering. His research project focuses on the automation and optimization of shotcrete placement by the use of a computer controlled robotic arm. This project is part of a larger project developed by Marc Jolin's Shotcrete Research Team, the SPARO project (Shotcrete Placement Automated by Robot).*

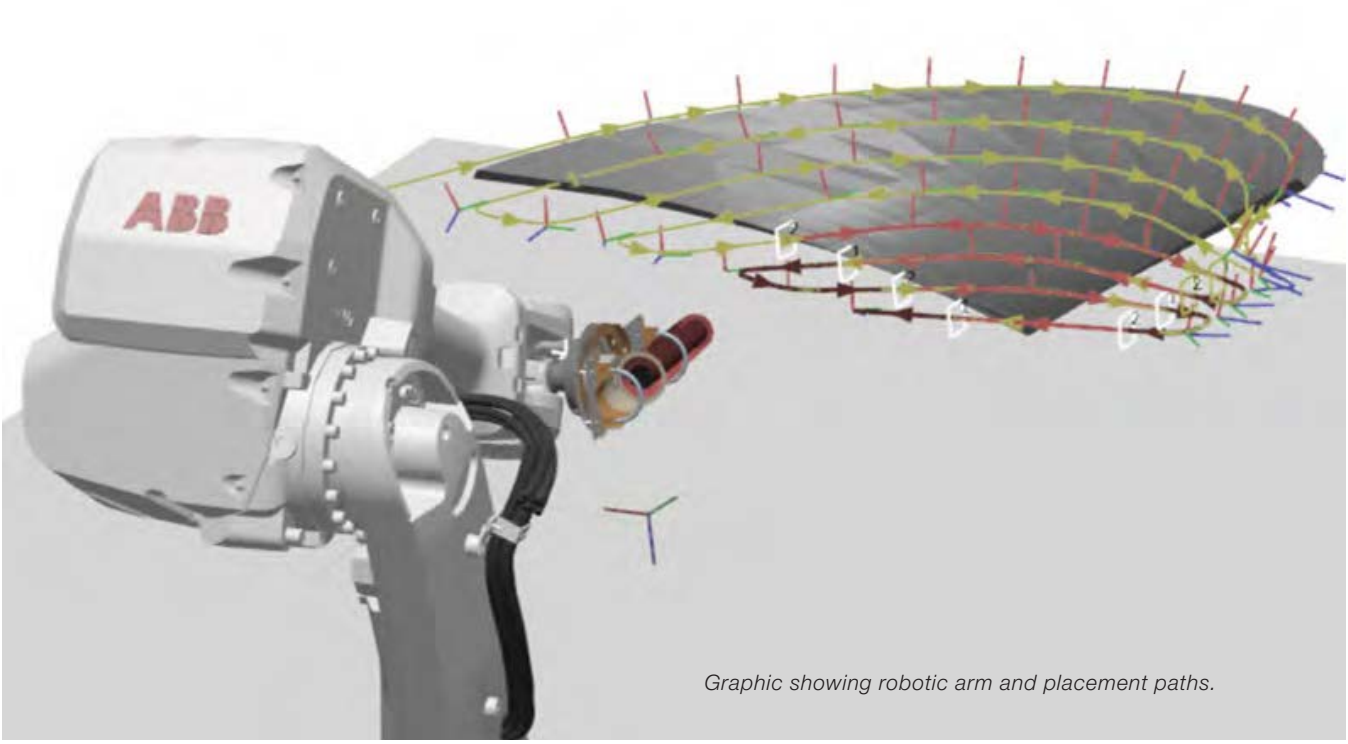
PASTORELLIE'S M.SC. RESEARCH PROJECT

Automation and Optimization of Shotcrete Placement by the Use of a Computer Controlled Robotic Arm

Civil engineering, and particularly construction, is experiencing technological advances with the advent of the so-called Industry 4.0, and shotcrete should be no exception. In many ways, shotcrete is the pioneering process of 3D-concrete printing and fits perfectly in this technological revolution, which is why it is clearly obvious to us to advance the automation of this process. Moreover, the development of automation in shotcrete will allow for a more thorough understanding of pneumatic placement of fresh concrete, and thus open the door to further optimization.

From an environmental and economic perspective, the reduction of rebound (and therefore concrete material loss) is one of the main challenges of process optimization. The knowledge acquired in the Shotcrete Laboratory at Université Laval over the years has shown that the placement technique has a great influence on rebound. We therefore conducted various tests using a robotic arm, enabling us to observe highly precise adjustments repeatedly. This showed us that optimal values of spraying parameters can be found for trajectories, angles or speeds to reduce the quantity of rebound and improve the quality of the production-placed concrete, fulfilling one objective to determine the best possible set of spraying parameters. However, this also led us to relevant interpretations of the placement process to better understand and describe the mechanisms involved in quality pneumatic placement of concrete.

This particular M.Sc. project implemented automation procedures to fill a conventional ACI nozzleman certification panel using the robotic arm. This task choice provided



Graphic showing robotic arm and placement paths.

an opportunity to address complex elements such as the presence of reinforcing bars and panel boundaries. Trajectory and handling techniques will be manipulated to ensure encapsulation of the reinforcement bars and fill the corners and edges of the panel. This allowed us to learn more about optimal spraying techniques.

An associated aspect of this project focused on 3D mapping methods. The goal is for the system to resolve all aspects of its specific working area, and develop a prototype for a visual digital system specifically for sprayed concrete applications. The robot should be able to evaluate the position of the certification panel and its reinforcing bars to automatically generate the required spraying trajectories.

Finally, the increasing complexity of shapes and optimally designed structures in architecture is pushing manufacturing methods to improve their technology. This project hopes to highlight the advantages of automated shotcrete, especially when compared to conventional 3D-concrete printing techniques. Indeed, shotcrete has tremendous advantages as it allows the use of conventional reinforcement with proven concrete design and facilitates the production of double-curvature elements. Moreover, shotcrete is a method particularly well adapted for high-performance concrete materials.

Robotic arm with shotcrete nozzle in the lab

This master's project therefore strives to optimize the efficiency of fresh concrete placement by optimizing the spraying parameters and automating these spraying methods. To do so, it relies on the development of a robotic arm system integrating 3D visualization technologies. The performance of automated sprayed concrete is opening up exciting prospects for the future in terms of reducing the use of materials and facilitating complex architectural possibilities.

2020 Outstanding Architecture | New Construction Project

Los Olas Corridor Improvements – Shade Canopy

By Douglas Wood and Christopher Foster

INTRODUCTION

Near the corner of Las Olas Boulevard and route A1A in Ft. Lauderdale, FL a contemporary architectural pavilion has recently opened to the public. This pavilion is a new landmark and focal point for a famous, urban beach. The pavilion functions as a location-orientating feature, shade shelter, outdoor performance venue, and passenger drop-off and pick-up point. The pavilion includes a shade canopy, public restrooms, and a police substation. The pavilion and its park are the eastern anchor of a larger set of civic improvements designed to provide greater beach access and an enhanced beach-going experience.

The shade canopy is 24 ft (7.3 m) high and has a footprint of 77 ft (24 m) by 64 ft (20 m). The visually striking shade canopy is supported on two corners of the conventionally constructed flanking buildings and on three large, gracefully flared columns. The canopy roof, with its wave-like undulations, cantilevers up to 29 ft (8.8 m) from the columns. The sumptuously curved, 3-dimensional, shade canopy was constructed using wet-mix shotcrete placement, applied by ACI-certified nozzlemen.

PROJECT TEAM

The shade pavilion was designed by Arquitectonica, as the architect, and Douglas Wood Associates, Inc., as the structural engineer. EDSA, Inc. was the landscape architect and prime consultant for the project for the City of Fort Lauderdale. Skanska USA Building Inc. was the general contractor for the project and COST of Wisconsin, Inc. (COST) was the sub-contractor for the shade canopy section of the project.

Douglas Wood Associate, Inc. (DWA) was founded in 1992 and has developed a reputation for innovative solutions and technical excellence in the full range of structural engineering services. Their award-winning projects include repair and restoration of existing and historical buildings, engineering of artwork and sculptures, as well as new building constructions of all types. DWA has been involved in

shotcrete projects for decades and has specified shotcrete to be used both to perform repairs on existing structures and to construct new structures with challenging geometries. Some examples include artwork, structures with curved walls and roofs and repair work for concrete restoration.

COST began using shotcrete for decorative purposes in 1957 developing naturalistic zoological habitats. Today, the COST team utilizes shotcrete in several ways to deliver both organic finishes like simulated rockwork, earthen textures, coral reefs, and even artificial trees to architectural finishes such as the Las Olas structure. Examples of their award-winning shotcrete work can be visited at zoos, aquariums, theme parks, casinos, resorts, museums, botanical gardens, golf courses, theme retail stores, and restaurants throughout the world. COST's integration of technology during design phases through construction has streamlined construction processes and improved efficiencies at all organizational levels.

DEVELOPMENT

The architect, Arquitectonica, designed the shade canopy with 3-dimensional, wave-like curvatures. The 3-dimensional curves and large cantilevers presented a challenge for engineering and construction.

During the schematic design phase, the design team and the contractor held multiple brainstorming sessions, to evaluate engineering and construction issues and solutions. DWA explored a number of options to achieve the desired shapes and meet all performance requirements while also meeting the construction cost budget. For cast-in-place concrete to achieve the desired shapes, it would have been necessary to surround the concrete in forms of carved expanded polystyrene. Forming top and bottom surfaces in this way would have been logistically difficult and expensive, and the thick, expanded polystyrene forms would have trapped the heat of hydration in the concrete during curing, potentially degrading the quality of the concrete. It was also determined that if cast solidly, the concrete volume was excessive, thus adding cost and exacerbating the problem of the heat of hydration. DWA explored other options such as a concrete shell with embedded steel spines and a concrete shell with concrete spines. After multiple engineering design iterations, it was determined that a 5 in. (125 mm) concrete shell with 12 in. (300 mm) deep and upturned concrete spines at spacings of approximately 6 ft (1.8 m) would meet all the design, performance, and budgetary criteria. The structural engineer used a 3-D computer model to develop the structural design model, which was then analyzed using sophisticated finite-element software. In addition to the usual gravity loads, the subtropical, beachfront location also required high hurricane wind resistance.

Due to environmental exposure to windblown chloride ions in the pavilion's beachfront location, all reinforcement was decided to be galvanized. The low water content used for shotcrete reduced concrete shrinkage cracking, thus providing additional resistance to chloride ion penetration.

IMPLEMENTATION

The bottom surface of the pavilion was formed with carved expanded polystyrene (using CNC equipment), coated to provide a smooth, clean surface to receive the shotcrete. The forms were sculpted by robotic routers, guided by the 3-D computer model.

Steel reinforcement was laid out over the forms and shotcrete was applied from above to create the shell and the spines. COST artisans were responsible for delivering the smooth, almost fluid-like, character. Upon completion, an anti-graffiti coating was applied to the surface, providing a brilliant white coloration and sheen. The form and finish blend seamlessly with the bookend buildings and the serpentine walls that separate the beach from the boulevard. The elements together form a consistent architectural theme.

SUSTAINABILITY BENEFITS AND CONSIDERATIONS

- The structural design, utilizing a 5 in. shotcrete shell with 12 in. deep shotcrete spines, greatly reduced the volume of concrete, thus reducing the volume of cement.
- The durability of the structure contributes to its sustainability. The pavilion's subtropical, hurricane-prone, beachfront location presented durability challenges. These challenges were met by:
  - Thoughtful and thorough structural analysis and design to meet all hurricane wind loading criteria,
  - Use of dense, high-quality, shotcrete to resist water and chloride ion intrusion,
  - Use of galvanized reinforcement to guard against future corrosion, and
  - Night-time placement of shotcrete to prevent any negative effects to the fresh concrete due to the heat of the subtropical, August afternoon.
- The use of shotcrete eliminated the need for topside formwork. Therefore, the amount of material used in forming was substantially reduced. Additionally, support structures for the topside formwork were eliminated.
- Speed of construction was improved by elimination of the topside formwork and use of shotcrete process compared to conventional form and cast method.
- The pavilion provides much-desired urban shade while using ocean breezes to provide comfort, without the use of mechanical ventilation or cooling.
- To reduce urban "heat island effect," all surfaces of the pavilion, its flanking buildings and park hardscape are high-reflectance white.
- To guard against potential hurricane tidal surge and future sea-level rise, the pavilion and building floor elevations are set at least 12 in. above the FEMA-designated Base Flood Elevation.

2020 OUTSTANDING ARCHITECTURE | NEW CONSTRUCTION PROJECT

Project Name
Shade Canopy

Location
Fort Lauderdale, FL

Shotcrete Contractor
COST of Wisconsin, Inc*

Architect
Arquitectonica

Landscape Architect
EDSA

Material Supplier
CEMEX USA

Equipment Manufacturer
REED Concrete Pumps & Shotcrete Equipment*

General Contractor
Skanska USA Building, Inc

***ASA Sustaining Corporate or Corporate Member**

Douglas Wood, P.E., SECB *has over forty-two years of experience providing structural engineering in South Florida. He is the founder and has been the president of Douglas Wood Associates since 1992. Mr. Wood's reputation for thoughtful consideration, creative solutions, thorough analysis, detailed design, and client-responsive service is unsurpassed.*

Christopher Foster *is the Vice President of Sales and Marketing for COST of Wisconsin, Inc. He has been actively involved in shotcrete theme and specialty construction throughout his 27-year tenure. Chris and the COST team's solution-driven approach has proven to be successful when delivering truly unique and iconic shotcrete structures, attractions, exhibits, and visitor experiences.*

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2020 Outstanding Infrastructure Project

Davis Barracks Sculpted Wall

By Jeff Bacon

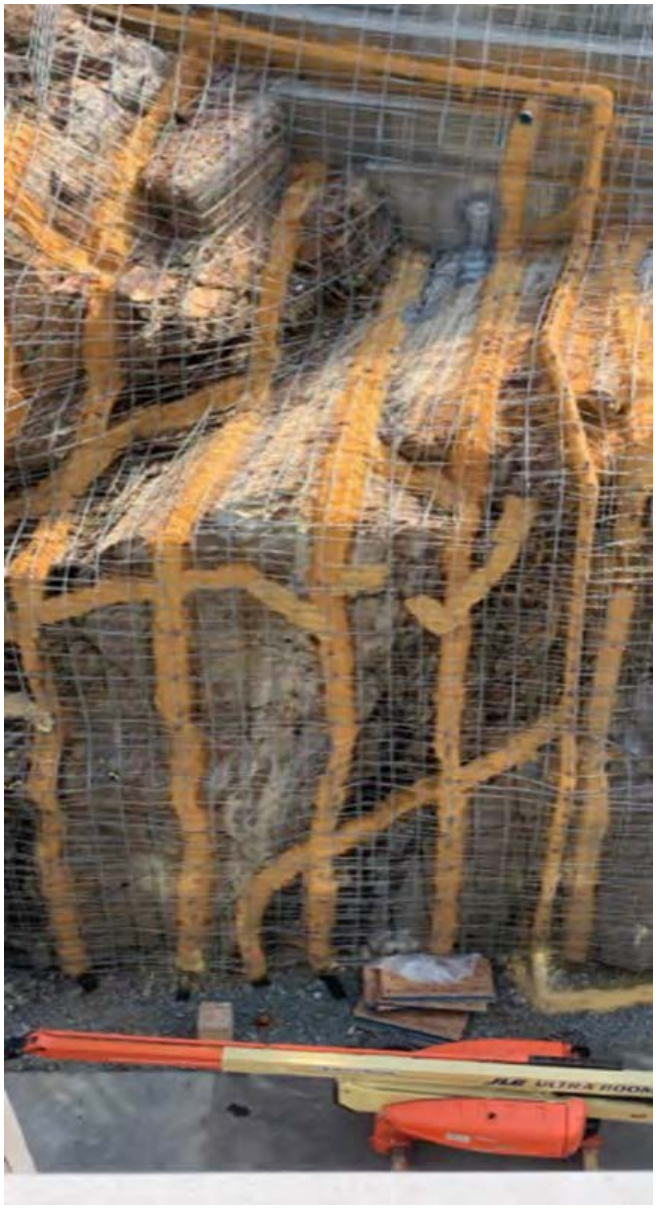
In 2015, the U.S. Army Corps of Engineering began construction on the Davis Barracks at West Point, NY. The 172 million dollar barracks became a state-of-the-art facility. The new barracks was built to house 650 cadets, three in each room, consisting of 297,392 ft^2 (27,629 m^2). The barracks building is located on the side of a mountain, below the cadet chapel, which in of itself is a famous landmark. The site for the barracks posed numerous challenges which included the removal of 285,000 tons (259,000 metric tons) of granite for the building's foundation. Between 2015 and 2017, during the construction, over 60 ft (18 m) of granite from the mountain side were removed.

The wall behind the barracks, which was exposed to a combination of exposure to the sun, as well as freezing and thawing, caused the rock to become weathered and brittle. This created the need for our work, because without an engineered solution the exposure would continue to erode the mountain side. The US Army Corps of Engineers (USACE) were tasked to provide a solution for this extensive exposed rock wall face. An elaborate sculpted shotcrete system was the answer.

Thorcon Shotcrete and Shoring LLC was awarded the opportunity to secure the wall as specified by the USACE. The multi-million-dollar project created many challenges, here are only a few:

- 110 ft. (34 m) or more working heights
- Tree and shrub removal
- Drilling into the granite
- Placing and securing two layers of reinforcing bar mats
- Ground water coming through the wall at an abnormal rate
- Shotcrete on the wall
- Detailed sculpted shotcrete finish

The wall was extremely large, approximately 825 ft (251 m) long, 100+ ft (30+ m) tall. The work was done with 125-ft



(38 m) articulating manlifts and personnel secured on ropes from topside for work operations. Specialized safety and training was required for this part of the project.

To start the project, the wall was cleaned of dirt, debris and shrubbery with several power washers, chainsaws, and miscellaneous hand tools. Due to the size of the wall, it took over a month to accomplish. Rock bars were also used to mechanically scale and remove loose rock and fragments from the wall.

Drain board was installed every 10 ft (3 m) to catch the ground water seeping through or coming over the edge of the wall. Because of the hardness of the granite, fasteners had to be drilled and epoxied to hold the drain board tight to the wall.

The specification called for a large amount of reinforcing bar to be attached to the wall. To achieve this Thorcon installed over 4000 L-shaped epoxy-set dowels every 4 ft (1.2 m) each way. While drilling into the granite, drill bits were burning up and becoming dull at an astonishing rate. Hilti Manufacturing Company recommended using specialized drill bits that helped eliminate these issues, allowing more productive installation of the dowels.

20 ft (6 m) mats using #4 (#13M) reinforcing bar spaced at a 12 in. by 12 in. (300 mm by 300 mm) spacing each way were formed on the ground. Then a large telehandler was used to raise the prefabricated reinforcing bar mats onto the wall. Because of the difficulty of bending the reinforcing bars around the ledges and curvature of the wall, personnel in manlifts were used to support the mat to the epoxied dowels. This was done twice in each location since a double layer of reinforcing was required by the design.

Due to the abnormal amount of water coming through the wall, there was major concern about the shotcrete bonding to the wall and water delaminating or coming through the shotcrete. A liquid rapid-set accelerator was introduced into the shotcrete mixture at the nozzle. This did several things in our favor. It reduced the amount of rebound to about 5 percent. It provided greater workability and final strength, and greatly enhanced the adhesion. To address the water flow issues, permeability reducing admixture called Xypex, a crystalline waterproofing chemical, was added into the concrete mixture design to help stop the water from coming through the shotcrete.

Two crews with concrete pumps placed shotcrete pneumatically in thicknesses from 12 to 16 in. (300 to 400 mm), shooting anywhere from 60 to 100 yd^3

(46 to 80 m³) per day. When the last architectural layer was placed, six artists sculpted the wall by hand with trowels and other small miscellaneous carving tools using manlifts and ropes for ready access to the face of the wall. The intent of the sculpturing was to mimic the natural rockscapes of the surrounding New York region. Then, to make the sculpting look extremely natural, several different colors of acid-based mineral stain were applied to the wall surface completing the natural appearance sought by the designers.

The overall challenges of this project tested our talents, equipment, suppliers and team at every turn. Thorcon is proud to have been a part of this successful project and holds the values, lessons, skills and team building education we received from this project in high regard. It was a great honor to deliver this amazing piece of shotcrete art to the men and women that serve this great country.

Jeff Bacon *is a Project Manager with over 16 years' experience in the geotechnical industry. Currently he is working alongside the executive team for Thorcon Shotcrete and Shoring. Jeff specializes in innovative designs for infrastructures of exterior walls.*

2020 OUTSTANDING INFRASTRUCTURE PROJECT

Location
Davis Barracks Chiller Plant Wall

Location
West Point, NY

Shotcrete Contractor
Thorcon Shotcrete Shoring*

Materials Supplier
Cranesville Block Company, United Rentals, HD Supply

Equipment Manufacturer
Putzmeister*, JLG Man Lifts
General Contractor
Kokolakis Contracting

Architect/Engineer & Project Owner
Army Corp of Engineers

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2020 Outstanding International Project

Skateboarding in Barbados

A Concrete Vision that became a Shotcrete Reality.

By Andy Duck

DEDICATION AND PERSISTENCE

People have been traveling to the small Caribbean island of Barbados to surf the ever-present waves arriving across the Atlantic for as long as humans have pursued wave riding. The same can be said about skateboarding as the parish of Christ Church now boasts a regional concrete skatepark! This was a long and thorough process shepherded by a consortium of firms and associations, all working to provide the Bajans a modern concrete skatepark through proper planning and processes. This all began with one phone call from Paul Wilson, a local skateboarding advocate with the tireless passion to bring proper skateboarding to the youth (of all ages) of Barbados.

After several years of dedicated advocacy on behalf of Paul and his growing number of associates, peers, and local skaters, he and his group created the Skateboarding Association of Barbados and became recognized by the Ministry of Sports. Now they were organized!!

Through several more years of dedicated work, including a couple of site review trips and feasibility studies, the team to design and construct the first skatepark in Barbados was in place. Our frequent partner in the design/build process, Pillar Design Studios, LLC was selected as lead designer for the skatepark aspects of the project. Pillar developed the construction documentation with the aid of a local civil and structural engineering firm, Spencer Thorne. Once funding had been secured by the Maria Holder Trust, the firm of Cooper Kaufman was tasked with managing the project and securing the bid for the general contracting portion of the project. Godson Builders was awarded the contract and Artisan Skateparks was selected as the specialty skatepark contractors. Now it was on!

As is the norm for concrete skatepark construction, shotcrete was specified as the preferred method of concrete placement for much of the new skatepark. Shotcrete has long been the go-to method for skatepark construction. The ability to provide great compaction and full reinforcement encapsulation during placement lends itself well to the typical undulating surfaces a modern skatepark encompasses.

THE PLAN

Working towards a great shotcrete experience takes a fair bit of planning when working in North America. Working towards a great shotcrete experience in a foreign land is another level. Aside from the obvious metric to US standard conversions and any potential language and cultural interpretations required, working abroad can create a variety of challenges. These challenges are best met through extensive research into the locally available materials, environmental conditions (and seasons), batching procedures, mixing capacities, hauling volumes, typical traffic, relative transit times, and who is the best local plant to supply the precious cargo. Lucky for us, this was not our first international project…

Ready Mix of Barbados was selected as the project concrete supplier. The many planning elements were handled via a wealth of email, phone calls, and even text messaging

(the most popular method of communication in Barbados). We knew it was going to be a hot weather shotcrete application and we worked diligently with Ready Mix to find a concrete mixture design as the foundation for our final shotcrete recipe. The specifications called for a mixture with a 4000 lb/in^2 (28 MPa) 28-day compressive strength requirement that required using a water reducing admixture and hydration stabilizer to facilitate the hot weather applications.

The raw material aspects went pretty simply. Once we learned we would be working with an all portland cement mix (pozzolans often comprise a 15-20% proportion in the States), and that all the aggregate to be found was a form of crushed limestone (marl), we knew we were going to be looking at a "thirsty" and rapid setting material. We were looking at historical temperature ranges from 76 °F (24.4 °C) in the morning to as high as 89 °F (32 °C) in the afternoon with maximum humidity on any given day.

Once we factored the generally windy conditions onsite coupled with how close the sun feels so near to the equator, we knew we needed to consult with some admixture gurus to make this project successful. We chose Sika, as we have a history of using several Sika products for long-haul shotcrete applications at home. Sika also has good representation in the Caribbean. After several discussions about conditions on the project, we selected appropriate ratios of hydration stabilizer and water reducing admixtures, and then we put the admixture drums onto our shipping container along with our tools, and other equipment.

Before we started this project, we were told there were about three previous uses of shotcrete on the island. Unfortunately, no one remembered what types of projects or or even when they occurred. We were about to embark on 260 yd^3 (200 m^3) of shotcrete with a plant and crew that had never

rough grading plan were comprised of crushed marl. It had been placed in layers, moistened, compacted, and was waiting for us to move forward. Just like normal.

After moving in, and moving forward those first few days, we learned a lot about marl. One, it compacts so densely that we had to literally drill holes in the ground for pins, stakes, or anything, including nails. Secondly, it dries intensely quickly. This sounds good considering it rains hard at some point every single day (if not more), but considering how quickly it was going to draw water from the concrete mixture was a major concern. Skatepark shotcrete receives a Class-A steel trowel finish (typically with 10 in. (250 mm) peanut trowels). Finishing takes place after hand shaping the finished contours and details in the freshly placed shotcrete. The third and most unexpected aspect of working with marl relates to sunburn. Yes, our families made sure we had all the applicable sun protections one would expect to need in the lower Caribbean. But the sun reflects off marl and sunburn under one's chin and under sunglasses and bottoms of ears were not at all expected nor prepared for (Ouch!)

For a litany of reasons, the decision was made to use a tented area for each shotcrete placement, and shade became our mantra.

THE WORK

As the final excavations were completed, we installed the formwork and subsequent reinforcing steel throughout the shotcrete portions of the project. We selected a sequential order to the shotcrete that began with a simple smaller placement to work out the process with the batch plant and to put the new concrete mixture design to the test. We ordered a 7 yd^3 (5.4 m^3) load with what we had calculated necessary for the Sika 440 Hydration Stabilizer to give us 2 hours to experienced it previously. Luckily for us, Godson Builders invested in a new REED A30 HP concrete pump. We have used this type of pump for over 10 years. This allowed us to easily teach their crew how to operate the machine and also gave us the confidence in the pumping equipment to get the job done. Time to head to Barbados.

THE ENVIRONMENT

The humidity strikes you the second you leave the the plane. Lush greenery and palm trees abound, showing the fairly constant wind patterns. Different cloud sets, high and low, move graciously throughout the abundant blue canopy of the sky. The concrete around the airport showed that it had rained not too long before we arrived, adding to the humidity… "Glad we packed those big tarps on the shipping container" was all I could think of in the back of my mind.

Later that day, we visited the job site, met all the local workforce, and took in the site-specific environmental conditions. The entire site had been stripped of organic materials down to what we would refer to as ledge. From there, the contours that made up the

transport, shoot, and shape the placement. We set up the tent structure from available lumber and draped our poly blue tarp over the wood frame to achieve the needed shade.

The shotcrete application went according to plan. The pump was delivered, the ACI-certified nozzleman placed the material, the shapers shaped the placed concrete, and then we waited for hours for the final set to stiffen up for the final troweling passes. Aside from too much of the 440 Hydration Stabilizer, we felt like we were on the right road to complete the tasks at hand.

At the end of each placement, we laid out relief cuts that were made with a Medusaw (wet process worm drive 7¼ in. (184 mm) saw with diamond blades). We would complete the saw cuts with mini grinders, moisten the slabs, cover with plastic to seal in the moisture for hydration, and drop our tarp on top of everything to secure the plastic from the windy conditions. The day after the placement, we would remove the plastic and apply

a Sika curing compound and re-cover the slabs with plastic to try and seal as much moisture in the slabs as possible for curing.

Each subsequent day, we increased our output, while making incremental changes in the chemical admixture volumes and slump, etc. By the end of the first week, we had achieved confidence in the mixture, the batch plant, and our new shotcrete team (local pump operator in training and a local finisher/helper – Paul Wilson – the main advocate for the project). It was time to jump into the bowl!

The Bowl was completed in four shotcrete placements and included a deep end section (8 ft [2.4 m]) that was designed to receive the pool coping and tile. We created an indentation in the shotcrete of approximately 6 in. (150 mm) from the top of the beam so that we could set the impending tile flush with the finished shotcrete surface. Daltile ceramic tile, rated for exterior use, was sourced and shipped over in our original container, along with the Federal Stone pool coping and Laticrete setting materials. We collectively chose the Barbadian Blue and Yellow colors from the Barbados national flag for the tile band underneath the white pool coping.

2020 OUTSTANDING INTERNATIONAL PROJECT

Project Name
The Kaitif Skatepark

Location
Christ Church, Barbados

Shotcrete Contractor
Artisan Concrete Services Inc.*

Architect/Engineer
Pillar Design Studios, LLC

Materials Supplier
Ready Mix of Barbados

Equipment Manufacturer
REED Concrete Pumps*

General Contractor
Godson Builders

Engineering
Spencer-Thorne

Project Managment
Cooper-Kaufman

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COMPLETION

We completed the entire project, from arrival to final flatwork and subsequent joint sealing, etc. in four months. The shotcrete process took approximately 5 weeks and went pretty smoothly for one, if not the only, shotcrete project on the island of Barbados. Luckily, this was not our first venture to international shotcrete. We spent a great deal of time planning what we needed to ship in for the project. If you don't bring it with you or you cannot fabricate whatever tool or accessory that you need for the job, you will be going without. Adapting to the environment and using good communication skills with all the various suppliers, trades, and craftsmen was crucial to the success of the project. We planned ahead, brought two of everything we would need, and relied on our skilled crew members to shape the future of skateboarding in the island paradise of Barbados.

Andy Duck: *The Artisan Group, Ltd.; Artisan Pools NC, Inc.; Artisan Concrete Services, Inc.; and Artisan Skateparks*

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2020 Outstanding Pool & Recreational Project

Barges, Golf Carts and Shotcrete

By Ryan Oakes

THE ISLAND

Bald Head Island, off the southern shores of North Carolina is a 6 mi^2 (16 km^2) island, accessed only by ferry, for guests, and by barge, for construction. It is steeped in history, playing a part in both the American Revolution and the Civil War. Feared by seamen, it is well protected by 30 mi (48 km) of shoals right off the cape into the Atlantic Ocean, known as the Frying Pan Shoals.

North Carolina is famous for its barrier islands that border the entire coastal region, giving hundreds of miles of nature preserves and island fun to its residents. Many of its islands are accessed by bridge but a few, like Bald Head, are only accessed by boat. So, when we got a call to shoot three pools at the Bald Head Island Club for Miracle Pools, a local commercial pool builder, the first thing we said was, "how on earth do we do that?"

It did not take long for us to work out a strategy for how that would go down. It seemed simple at first glance: put materials on barge; cross over to island; drop materials off; and get to work. As we learned more about the process, we quickly realized this would be no small feat.

We would be given one week to shoot all three pools, less than a week to mobilize on site and less than a month to prepare for the effort. The first thing we would need to do is estimate all materials needed for the job, so we could ship them over. Then we had to schedule all shipments on one cargo barge. "Simple enough," we thought.

THE BARGE

As it turns out, barge trips are made by appointment, months in advance. Thankfully, working for the island itself, we were able to fit in our loads with their rigorous schedule. The Bald Head Island Transportation department is a very

professional outfit and maintains a very rigid schedule. If you are late, you lose your appointment and you do not get another. If the wind blows more than 14 knots (29 km/hr) or if the waves are rough, they close down the barge, you lose your appointment and do not get another. So, the trick it turns out, is to book a few extra trips in anticipation of failure.

We had to deliver 400 tons (360 metric tons) of sand in advance and stockpile it for protection. It did not need to be dried since we had already stockpiled it at the sand pit and covered it with tarps. Ideal moisture content for the dry-mix shotcrete process is 2% to 5% depending on aggregate, and most sand deliveries come in between 8% and 15% moisture.

Additionally, we delivered a portable cement silo, and our first of four tanker loads of cement. We staged two full tankers on the island so that we could float back to the mainland for a reload during the shoot, while having some material onsite to load into our silo. This required two road tractors, one with a blower to convey cement and one just for delivery back and forth to the mainland.

Finally, just before game day, we brought over fuel tanks, two volumetric mixer concrete trucks for batching on site, two compressor trucks (one for back up) and support vehicles. Since we were literally on an island, we also brought additional staff, like our fleet manager and mechanics, along with welding supplies and other mechanical support items. There was no way to be over prepared for this job.

THE GOLF CARTS AND BEACH HOUSES

One of the more fun aspects of the trip, was the fact that other than our equipment, vehicles were not allowed on the island, so to get to the port and back, or to the rental house and back at the end of the day, we used golf carts! One can imagine, a shotcrete crew rolling into work on golf carts…

Accommodations were great. A rental beach house was complete with all amenities. Groceries from the mainland to meet the needs of the crew and good times all around.

THE POOLS

The pools themselves were freeform and had a tight rebar schedule, anywhere from 4 in. (100 mm) on center to 6 in. (150 mm) on center with multiple curtains of reinforcing. The forming could be minimally braced on one side due to the lack of hydraulic pressure that one experiences in form-and-pour concrete construction. A curved guide bar was placed with surveying equipment on the freeform walls so that the pre-ordered coping would fit the walls we shot.

Miracle Pools had done an excellent job in setting the forms and placing the reinforcing steel which helps make for

a successful shoot. As with any type of construction, each step is essential to the success of the next step and shotcrete is no exception.

We were given only a few days to stage materials and only one week to shoot the pools. This deadline was not arbitrary and had severe consequences to the builder and club owners. There was no room for error and there was only one barge to service the entire island, so we had to walk a tightwire in our project execution. Predicting that regular winds could cause daily shutdowns on the only barge available we decided that the risk would be best mitigated by on-site batching, even though the job was smaller than one which would typically justify onsite batching. There would be no room for a wet-mix mobile batch plant so not only was a dry-mix shotcrete operation the better choice, but it also really became the only good choice.

Being a multiple day shoot for the larger pool, we benched all material on the leading edge at a 45° angle and prepped the surface for the following day's shoot. The next day we would prepare the surfaces to a saturated surface dry (SSD) condition and shot at a 90° angle to the previous day's work. We used a blow pipe (air lance) to keep the surface free of rebound, overspray, dust and debris. This allowed us to create a monolithic watertight shell with properly prepared construction joints over a multiple day shoot.

Form-and-pour or even using wet-mix shotcrete would have been extremely difficult due to the barge times and the unpredictable nature of the barges. Our barges were shut down on more than a couple trips over, which would have been impractical if transporting fresh ready-mix concrete over. Local firms have brought ready-mix concrete to the island in the past, but on smaller scale projects and with fewer time constraints that eliminated undue stress to the contractors.

Using the dry-mix shotcrete process is advantageous to allow for starts and stops without worrying about ready-mixed material setting before shooting. Here, that ability to hit the pause button seemed not only essential but took one more stressor out of the equation.

In conclusion, we only had a few days to stage everything, and one week to do the job. So, with hundreds of phone calls, to over 50 different people, within 10 different organizations, carrying over 60 vehicle trips on 30 barge runs a mile (1.6 km) across the water, we were able to send our crew to a remote barrier island and shoot over 300 yd^3 (230 m^3) and create three beautiful swimming pools.

2020 OUTSTANDING POOL & RECREATIONAL PROJECT

Project Name
Barges Golf Carts and Shotcrete

Location
Bald Head Island, NC, USA

Shotcrete Contractor
Revolution Gunite*

Architect/Engineer & General Contractor
Miracle Pools

Materials Supplier
Roanoke Cement

Equipment Manufacturer
Gunite Supply & Equipment Company*

Project Owner
Bald Head Island Club

***ASA Sustaining Corporate or Corporate Member**

Ryan Oakes *is a Professional Watershape Designer and President of Clearwater Construction Group, Inc., Revolution Gunite, and Revolution Pool Finishes, all of which are award-winning firms in their respective trade. Oakes is a faculty member at Watershape University, where he continually aims to raise the bar in the swimming pool and the watershape construction industry. As a member of the leadership team for the International Watershape Institute (IWI) and through educational outreach to a vast pool builder network throughout the United States, he aims to improve the building techniques and methods of constructing swimming pools. Oakes is a member of ACI Committee 506, Shotcreting, and ACI Subcommittee 506-H, Shotcreting Pools. He serves on the ASA Board of Directors and also serves as Vice Chair of both the ASA Pool & Recreational Shotcrete Committee and the ASA Contractor Qualification Committee.*

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2020 Outstanding Repair & Rehabilitation Project

Park Avenue Tunnel Rehabilitation

By Ashley Cruz

The Park Avenue Tunnel, formerly known as the Murray Hill Tunnel, is a 1,393-foot-long (425 m), 16-foot-wide (5 m), 9-foot-tall (3 m) thoroughfare traversing six New York City blocks. The tunnel was originally constructed in 1837 as an open rock-cut, with a brick arch constructed over the cut in 1854 to create the tunnel profile. For the next 150 years, the tunnel would be plagued with issues ranging from mechanical system failures to liner wall leakage due to the soil volume above, which is where the idea of shotcrete stabilization was introduced within the project scope.

The structural scope using shotcrete as the roof liner, was first discussed at the beginning of the design phase due to the imperfect curves of the original brick archway. Cruz Concrete was brought in by the general contractor once the project was released for bid and worked closely with the design team. In this effort, Cruz's dedicated team developed the shotcrete installation sequencing and assisted with the development of the final concrete mixture design.

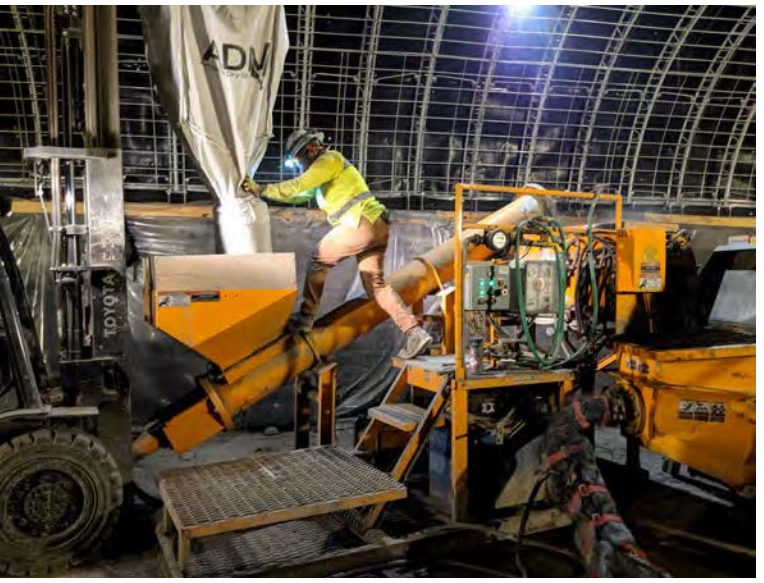
Cruz Concrete was ultimately awarded the sub-contract to perform shotcrete repairs at the original stone parapet walls and to furnish and install the 12 in. thick (300 mm) shotcrete liner spanning the entire arched roof of the tunnel. These scope items utilized 40 yd^3 (31 m^3) for concrete repair and 1600 yd^3 (1200 m^3) for the finished shotcrete liner.

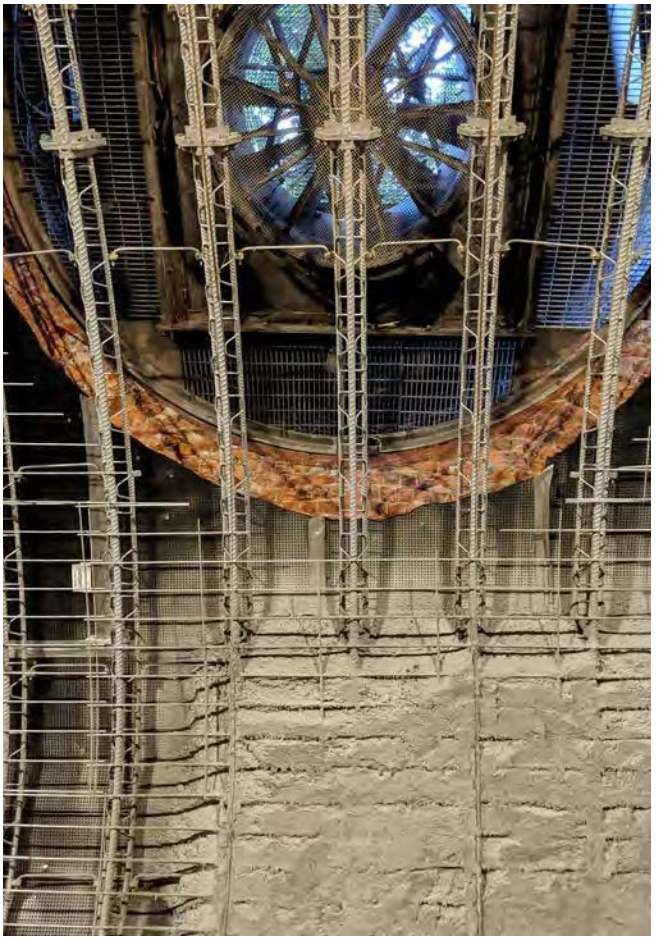
A HISTORIC ARCHED CEILING IN A MODERN TIME

The design specification required the use of 6,000 lb/in^2 (41 MPa), pre-blended single component specially formulated Portland cement mixture with shrinkage reducing admixture, fibers, silica fume and carefully graded aggregate. This concrete mixture produced a high build, low absorption, machine-applied mortar. A crystalline permeability reducing admixture was also specified in the mixture design to decrease the overall permeability of the final product. All product testing yielded results that exceeded the material specification requirements.

The structural design of the new roof liner required building outward from the existing brick utilizing a waterproofing mat fastened to the brick, and structural steel reinforcement. lattice girders, comprised of two #11 (#36M) rebars and one #13 (#44M) rebar were placed 2 ft (0.6 m) on center and rested on top of the existing stone wall ledge. Sheets of wire mesh were also installed as additional support for the shotcrete placement.

The typical progression of this project was based on both the shotcrete technique and inspector approval. Each day, the crew applied shotcrete to the overhead arch in two lifts, progressing 25 ft (8 m) along the corridor. The base lift was approximately 6 in. (150 mm) to 9 in. (225 mm) deep, enough to fill in the lattice girders. The remaining thickness was applied to the previous day's work. This served as the finishing lift, allowing for the use of less set-accelerating admixture, meaning the crew had more time to perfect the sponge float finish. Cruz mixed, applied, and finished approximately 25 to 30 yd^3 (19 to 23 m^3) of 3 in. (75 mm) slump concrete material per day.





Given the spatial limitations within a 16 ft (wide tunnel, Cruz was able to utilize a 3-team system: one nozzleman crew, one scratch and finish crew, and one pump and hose-maintenance crew.

MIXING SHOTCRETE ONSITE

Shotcrete was the major structural element, and determined the critical path of the project. The other three main elements being Road surfacing, repointing of the historic stone walls, and installation of new electrical and fire protection equipment comprised the remaining three main elements.

To successfully provide the specified shotcrete mix, which eliminated the use of ready-mix delivery trucks, Cruz was tasked with mixing the concrete materials on-site. To conquer this challenge, Cruz utilized a continuous mixer, brought in on a trailer and a pick-up truck, mounted on a skid for easy mobility via forklift. This allowed the team to move the set-up along the corridor each shift. Pre-bagged, dry concrete material came in the form of super-sacks (3,000 lb [1400 kg]), that were positioned over the dry-hopper of the mixer. Tractor-trailers delivered and off-loaded the 30 pallets of material every other week through the south entrance of the tunnel, which had a marginally taller clearance. These deliveries were strategically placed within the tunnel to mitigate any interference with other construction operations.

When working with shotcrete, it is imperative that the water-cementitious material ratio (w/cm) be properly maintained. When shooting overhead shotcrete, the precision of the w/cm becomes an even greater priority. Cruz's on-site concrete mix operator and inspector, were constantly monitoring the amount of water used for each batch of concrete. The slump was kept within +/- 1 in. (25 mm) of a 3 in. slump. As progress was made down the corridor, the water pressure

dropped, as the main source of pressurized water came from a fire hydrant located at street level, up to six city blocks away. To alleviate this problem, all but 100 ft (30 m) of the ¾ in. (19 mm) hose was replaced with a 2 in. (50 mm) water line, and other trades were only allowed to use this water source when there was no concrete mixing underway. A rapid set-accelerating admixture was also added at the nozzle throughout the project to ensure the adhesion of the concrete material once applied.

THE DESIGN CHALLENGE

Another factor adding to the complexity of the project was the inclusion of work around 8 overhead exhaust fans. The fans ranged from 8 ft (2.5 m) to 10 ft (3 m) in diameter. During construction, the exhaust system required an upgrade, and with that, a redesign of the ceiling profile at those locations. The contract documents showed a roof design with a compression ring built inside each fan well. A change order was issued to construct the compression ring to hang outside of the fan. This added material to the original design with a compression ring that would protrude downward from the ceiling approximately 14 in. (350 mm) and 24 in. (600 mm) wide.

During the fan redesign process, Cruz continued to install shotcrete, forcing the crew to leave gaps in the archway around the exhaust fans, that were required to fully operate during construction. Shotcrete proved to be invaluable in the success of the compression ring work, as shotcrete does do not require formed construction joints, ultimately allowing the gaps to be placed with ease. The final approval of this redesign came as Cruz neared the end of the tunnel. The general contractor constructed a one-sided bulkhead at the inside diameter of each fan well to act as the limits of the shotcrete. This allowed the team to continue the systematic installation of shotcrete lifts. This ultimately added to the project timeline, however, the project was still completed ahead of the team's originally anticipated completion date.

Shotcrete was also extremely important to the overall aesthetic of the finished product as the engineer and architect required the finished concrete surface to follow the profile of the existing brickwork, which was far from perfectly level. The brickwork was built in 1857, and Cruz strived to conserve as much of the historical appearance as possible for future generations to experience.

ENVIRONMENTAL AND ECONOMICAL SUSTAINABILITY

Given the efficiency of the shotcrete placement method, Cruz's team determined that shotcrete was 35 to 50% more time-efficient than the form-and-pour method would have

2020 OUTSTANDING REPAIR & REHABILITATION PROJECT

Project Name
Park Avenue tunnel Rehabilitation

Location
New York, NY

Shotcrete Contractor
Cruz Concrete & Guniting Repair, Inc*

Architect/Engineer
The LiRo Group

Materials Supplier
US Concrete Products*, Euclid Chemical Company*, & Penetron

Equipment Manufacturer
REED*, CANUSA*

General Contractor
Tully Construction Company, Inc

Project Owner
New York City Dept. of Transportation

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been. Since shotcrete placement eliminated the need for erection and removal of complicated formwork, the owner enjoyed significant cost savings due to reduction of both labor and materials. Additionally, the elimination of formwork reduced the overall embodied carbons consumed throughout the project's lifespan.

Using the required on-site batching, Cruz was able to reduce the carbon footprint of concrete mixing and transport by over 50%, with the utilization of one 29 hp diesel engine with 430-running hours and 100 deliveries of material, as opposed to concrete batch plant operations and ready-mix delivery trucks in the Manhattan traffic. All storm drains in the tunnel were lined with filter socks to prevent sediment and lessen the slurry entering the sewer system, thereby reducing the pollutant load on the site's stormwater infrastructure.

Cruz Concrete completed the project, turning 1600 yd^3 of dry prepackaged concrete material into wet-mix shotcrete that was placed, finished and cured, in 70 working days. Water leaks have subsided and the archway still holds much of its 1800's character.

ABOUT CRUZ CONCRETE & GUNITING REPAIR

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

Cruz has been a corporate member of the American Shotcrete Association since 2010. Working on this project were two ACI-certified nozzlemen who both worked on portions of the overhead shotcrete contract. They also could not have successfully done the job without their team of finishers, laborers, and operators.

Ashley Cruz *is an operating engineer and has been with the family-owned and operated business for three years. Ashley was both the project manager and concrete mixing operator for the Park Avenue Tunnel. Her attention to detail and understanding of concrete assured the mixed shotcrete was as specified. Ashley is the Director of Operations and aims to take Cruz Concrete to the next level in sustainability standards and blending creative design decisions with quality construction and bringing the foresight of our ecosystem into the spectrum.*

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2020 Outstanding Underground Project

Poe Tunnel

By Jason Myers

When you are faced with a project with limited access, material delivery by helicopter, the nearest personnel access is 5 miles (8 km) away, and the closest outside access to the shotcrete placement location is a half mile away, the only solution to handle all of these issues is shotcrete. The Poe Tunnel is a 15 mile (24 km) long tunnel in the foothills of the Sierra Nevada Mountains and is in an area of steep canyons. The tunnel transports water from a forebay on the North Fork of the American River to the Poe Powerhouse where electrical power is generated. The tunnel is almost 20 ft (6 m) in diameter and was constructed in the 1950's.

The owner, Pacific Gas & Electric (PG&E) regularly inspects their tunnel and during the 2016 inspection found several cracks in the tunnel shotcrete that was cause for concern. In 2016, the General Contractor performed some emergency repairs while a permanent fix was designed and approved. Dees Hennessey, Inc (DHI) was contracted by the General Contractor, Syblon Reid (SRCO) to perform the shotcrete placement for the final repair work. The scope consisted of a new tunnel lining for a length of 90 ft (28 m). Once the SRCO was able to mobilize on the project for the 2019 season it was decided to increase the scope and perform a shotcrete tunnel lining for 180 ft (55 m) of tunnel. This decision was made two weeks before the shotcrete was

scheduled to begin. The tunnel design thickness was 10 in. (250 mm) thick, not including overbreak and other repair work. The final shotcrete volume installed was over 500 yd^3 (380 m^3).

The difficulties to overcome on the project revolved around access to the site. The location of shotcrete work was 2,300 ft (700 m) from the nearest adit into the tunnel. Also, there was no access to that adit by vehicles or pedestrians due to the canyon, a large river at the bottom of the canyon, and a very active railroad in between. The nearest concrete plant is also two hours away.

We devised a plan for the shotcrete pumps and shotcrete material to be flown in by helicopter, across the canyon. Then the fresh shotcrete material would be pumped 2,300 ft (700 m) to the work location. One of the scheduling challenges to work with on the project was the weight limit for the helicopter. The most economical and functional way to transport the shotcrete was to use a helicopter that could carry around 0.5 yd^3 (0.4 m^3) per flight across the canyon. This proved to be the right balance to provide enough shotcrete to the shotcrete pump, without overloading it, while also allowing the truck to be emptied within an acceptable duration. This also allowed the helicopter to land and refuel after every other truck was emptied. The crew would take a 5 mi buggy ride from the nearest vehicle access point to and from the work location each day.

We used a highly retarded shotcrete mix to allow for the batching and delivery time, the transportation time of the helicopter, and the pumping of the shotcrete mixture. We also used a high slump on the mixture so that the shotcrete could be pumped 2,300 lf (700 m) from outside the adit to the work location. Once we got to the overhead portion of the shotcrete installation, we used MAPEI Mapequick AFK 888 shotcrete accelerator to provide rapid set and allow placement of the shotcrete.

The greatest advantage of shotcrete for the project was its flexibility. It provided flexibility in the work sequence, flexibility in the scope of the work, and flexibility to stop and start as needed in response to external factors. By using shotcrete, all formwork was eliminated, and the work sequence could be modified anytime the circumstances changed. This project was done during the winter months, so keeping an eye on the weather was always essential and at times the helicopter would fly up to the point that the rain or wind would start. By using shotcrete, the location of construction joints could be adjusted easily and restarted the next day or whenever the conditions changed.

This flexibility also allowed for last minute adjustments to the shooting sequence. The drawings did not show the engineer wanted the invert of the tunnel to be shot in horizontal strips along the tunnel up to the spring line and from the spring line from one side through the overhead portion of shotcrete to the other side - remember this is a 20 ft (6 m) diameter tunnel. Because of the flexibility of shotcrete, we were able to modify our placement sequences to match the engineer's needs with no additional costs or schedule constraints. Only the flexibility of shotcrete, needing no formwork, allowed us to double the scope, and meet the weather challenges and project resequencing, while still completing before the original completion deadline for the original scope of only 90 ft.!

The Poe Tunnel Project was a unique project with unique problems. Shotcrete was able to provide unique solutions. There were many challenges to overcome but with proper planning and execution, shotcrete provided the answer to each of the challenges that occurred.

2020 OUTSTANDING UNDERGROUND PROJECT

Project Name
Poe Tunnel

Location
Parkhill, CA

Shotcrete Contractor
Dees Hennessey, Inc*

Architect/Engineer
Sage Engineers

Material Supplier
A&A Concrete

Equipment Manufacturer
REED Concrete Pumps & Shotcrete Equipment*

General Contractor
Syblon Reid

Project Owner
PG&E

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

2020 Honorable Mention

Chihuahuan Desert, El Paso Zoo

By Steve Kanoza

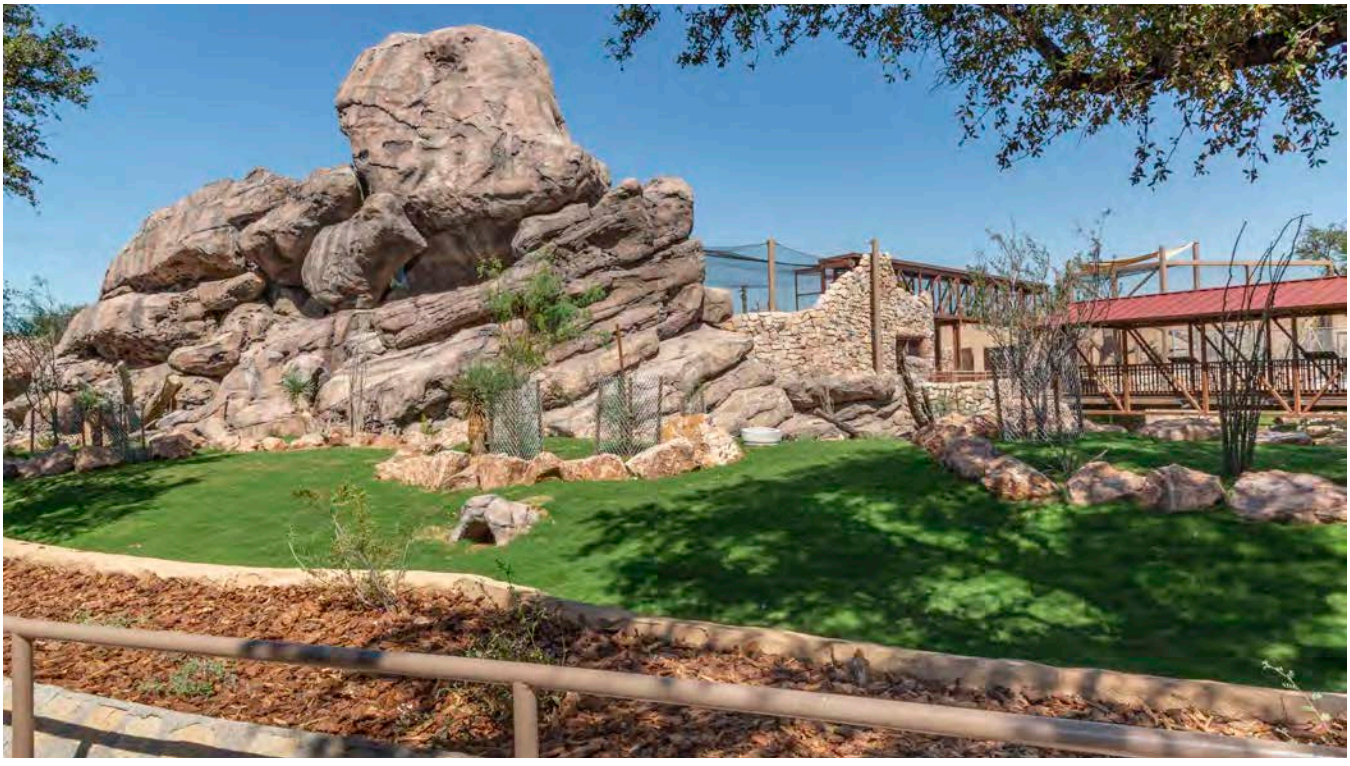

Fig. 1: Back of 45ft Rock Mountain and theming

Located in El Paso, TX, the El Paso Zoo sits on 35 acres (1400 m^2) of land and houses over 220 animal species from around the world. Accredited by the Association of Zoos & Aquariums (AZA), the El Paso Zoo's mission is *to celebrate the value of animals and natural resources and create opportunities for people to rediscover their connection to nature.* Locally recognized as the "Best Place to Take Your Kiddos," the El Paso Zoo features family favorite attractions like African Star Train, Foster Tree House Playground, and now home to the award winning Chihuahuan Desert exhibit.

The Chihuahuan Desert project is a state of the art, 2.3 acre (9300 m^2) development that is part of the El Paso Zoo's 15 year Bigger and Better than Ever master plan campaign. Cemrock's goal for the project was to create artificial rockwork and theming that represented the true geology and landscape of the region surrounding El Paso. A large, 45 ft (14 m) tall rock mountain (Fig. 1) with monsoon flood water crashing through a railroad track to simulate a desert arroyo (Fig. 2), is the center piece of this magnificent design. Artificial boulders, fallen tree trunks (Fig. 3), rustic rock walls (Fig. 4) and other features of the Chihuahuan Desert are weaved throughout the exhibits for Mexican grey wolves, mountain lions, jaguars, and other animals who call North America's largest desert, home.

DESIGN & CONSTRUCTION

To ensure the recreation of the desert's organic realism, Cemrock's project superintendent, artisan, and team traveled to southwest Texas to study the colors, shapes, textures, and beauty of the Chihuahuan Desert to incorporate into the final design. The resulting artistic rendering, physical clay 3-D model, and construction documents were used as specifications and guidelines for this project.

Production of the artificial Chihuahuan exhibition started with shaping reinforced steel armature, i.e. the application of the backing material and the rough shaping of the shotcrete structure coat. Without the realistic shaping of the reinforcing bars and proper application of the structure coat, the final naturalistic outcome would not be achievable. Design intent and structural aspects of all formations needed to be engineered with frequent inspections. The finished product may be artistic in nature, but the requirements for foundations, reinforcing steel schedules and shotcrete mixture designs are as arduous as any concrete building or bridge foundation. Full encasement of the reinforcing steel, per calculations, must be followed at this stage to achieve specified structural strength.

SHOTCRETE SOLUTIONS

When a rockwork contractor, like Cemrock, is brought in to build a project like the Chihuahuan Desert, only artisans with many combined years of hands-on experience and expertise can make the design come to life. The intimate knowledge about how shotcrete is made, transported, pumped, placed, worked, and cured is key to creating an excellent product. The Chihuahuan Desert project took more than a year for Cemrock to complete onsite. In that time, our team experienced extreme heat and freezing wet weather. With these

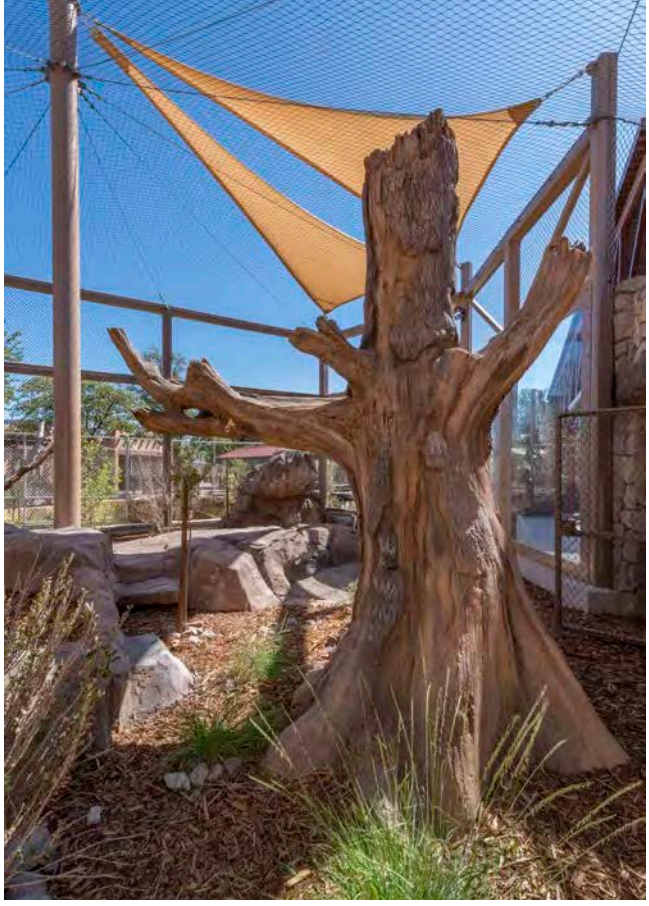

Fig. 3: Chihuahuan Desert Arroyo

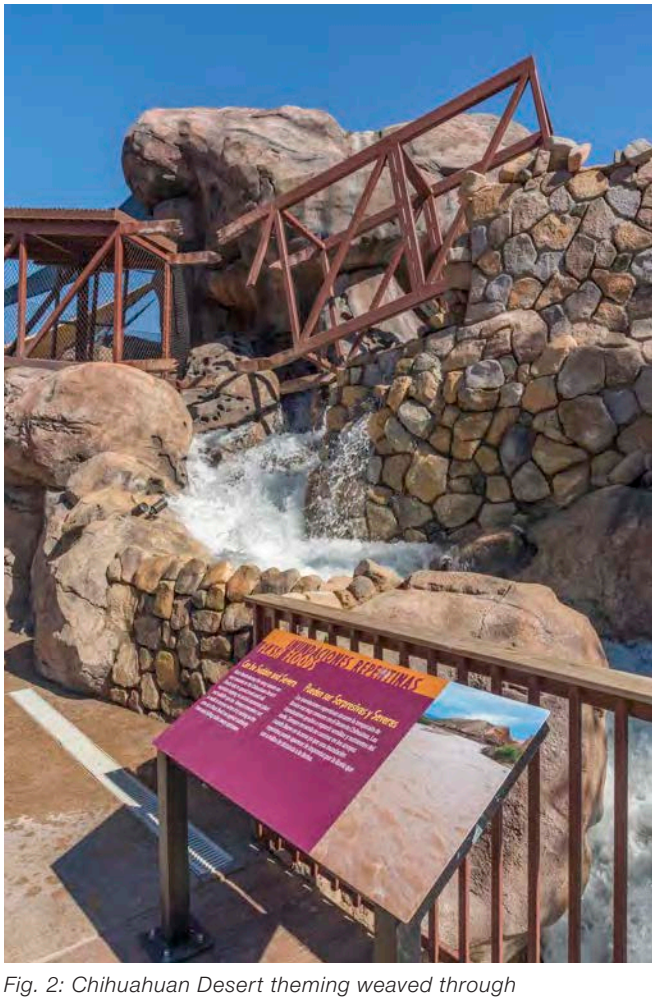

Fig. 2: Chihuahuan Desert theming weaved through animal exhibits

Fig. 4: Rustic Rock Wall and animal exhibit theming

Fig. 5: Cemrock's Chihuahuan Desert Team

Fig. 6: Chihuahuan Entry Way

Fig. 7: Rock Exhibit and Chihuahuan Desert Theming

2020 HONORABLE MENTION

Project Name
Chihuahuan Desert, El Paso Zoo

Location
El Paso, TX

Shotcrete Contractor
Cemrock Landscapes, Inc.

Architect/Engineer
PGAV Destinations Peckham Guyton Albers & Viets, Inc

Material Supplier
GCC Ready Mix

Equipment Manufacturer
REED Concrete Pumps* and Sunbelt Rentals

General Contractor
Jordan Foster Construction, LLC

Project Owner
City of El Paso - El Paso Zoo

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varying conditions, we knew that an adaptable material like shotcrete would provide the strength and durability needed to withstand harsh desert conditions. Depending on the weather, additives were used to lengthen the workable life, accelerate the cure time, as well as cool off or heat up the concrete mixture. Each ready-mix delivery truck was checked for temperature and slump before and during pumping.

SHOTCRETE EXPERTISE

Another key factor in the overall success of the project was the utilization of ACI-certified nozzlemen. With a project like this, the structures are organic in shape. It takes an expert nozzleman (Fig. 5) with specialized training to operate a shotcrete nozzle that shoots material that is both thick enough to trowel, yet thin enough to hang, without sagging. The ACI certification process and ASA education that our nozzlemen receive enhances their ability to perform this task efficiently and creatively. Present during the Chihuahuan Desert project were our fully ACI-certified nozzlemen, as well as ACI nozzlemen-in -training. The training and expertise of each nozzlemen ensured that the outcome of our project mirrored that of the designer's renderings, Zoo Executive desires and truly showcased the natural beauty of the Chihuahuan Desert (Fig. 6 & 7)

Steve Kanoza *is a Project Manager for Cemrock Landscapes, Inc. based in Tucson, AZ. With over 21 years of industry knowledge and expertise, Kanoza is highly skilled in estimating, field management and shop project execution. Kanoza is a member of the American Shotcrete Association (ASA) and earned his BAA in Outdoor Environmental Education from Central Michigan University.*

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2020 Honorable Mention

Hale Park Skatepark

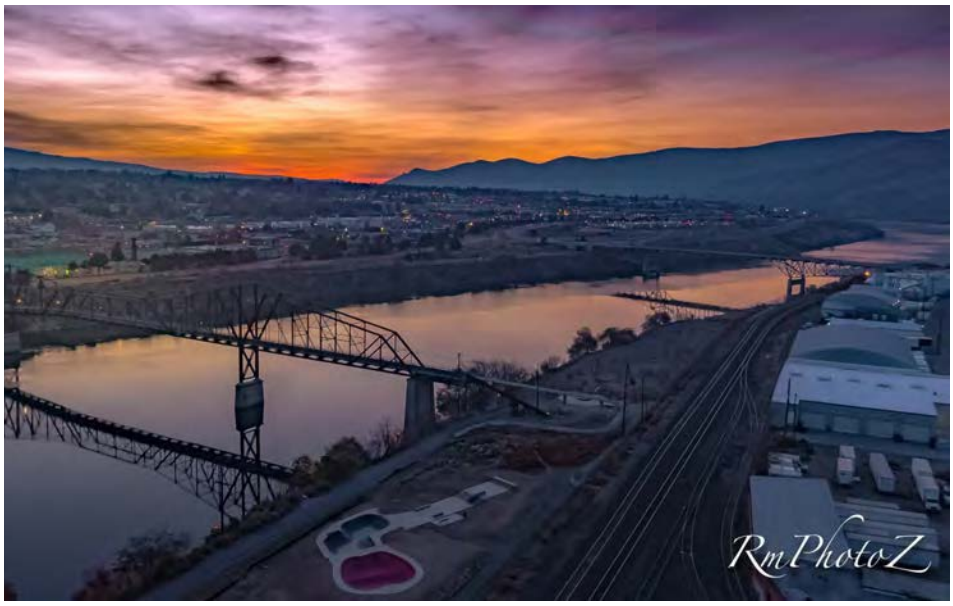
By Ryan "Peabody" McWhirter

Shotcrete was essential to create the smooth flowing transitions, curves, and blends required in the construction of the Hale Park Skatepark in Wenatchee, WA. All of our skateparks, including Hale Park, are constructed of steel reinforced shotcrete with a minimum 28-day compressive strength of 4000 lb/in^2 (28 MPa) – often breaking over 5000 lb/in^2 (34 MPa) in just 7 days. Using proprietary techniques and products, developed over the years, we can form and sculpt shotcrete into virtually any shape imaginable. This gives us the ability to produce any skate feature requested or imagined by the project stakeholders.

Concrete also provides an opportunity to add color concrete stains. A red stain was used to create the Apple

Bowl, paying tribute to the rich, world famous apple producing community of the Wenatchee Valley. Black stains were used in other areas of the skatepark to give the park a modern look. The concrete and shotcrete were hand troweled to a buttery smooth finish that our craftsmen are well known for.

All of the skateable transitions and banks used a 4000 lb/in^2 shotcrete mix. Approximately 132 yd^3 (101 m^3) of shotcrete were placed during the construction of this project. This project was designed with shotcrete from the beginning and thus allowed the designers to have more freedom in the design

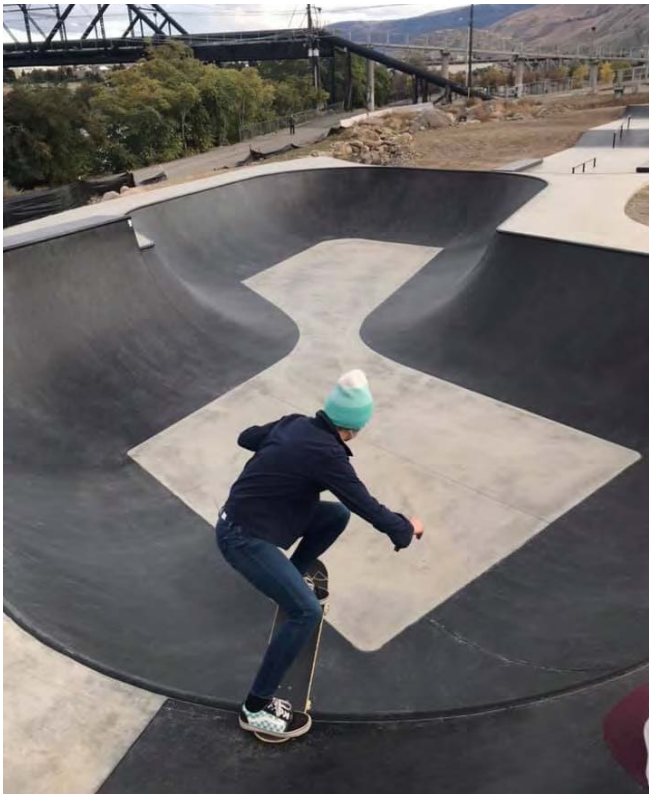


process because of shotcrete's versatility. Using shotcrete allows us to sculpt any shape, including an apple.

Concrete was the main construction material used in this project and shotcreting was the preferred method of placement. For the flat sections we cast a small rock mix very similar to our shotcrete mix. We pumped this castable flat section mix with our Putzmeister TK-50 pump. This ensured that our flat bottom sections have the same high quality concrete as our shotcreted transitions, banks and walls.

Grindline was also the designer for this project. We included shotcrete in our plans and specifications and also require all shotcrete be placed and finished by a qualified skatepark contractor, with an ACI-certified shotcrete nozzleman. The skatepark company's qualifications and ACI-nozzleman certifications were required to be submitted at time of bidding, Grindline has been using shotcrete as our main means of concrete placement even before we were incorporated in 2002. Shotcrete was the required placement method for concrete in the construction documents for the majority of the skatepark.

Without shotcrete and experienced skatepark craftsmen, this project would not have been possible. Shotcrete was the only way we were able to achieve the smooth flowing transitions, curves, and blends mandatory in quality skatepark construction.



Since 2002, the Grindline team has designed, sculpted, and skated millions of tons of shotcrete across the United States and around the World. Our expertise is translating the needs of local skaters into skatepark designs that will propel them into the future. On every project we consider the environment, topography, safety, skill development, budget, accessibility, and user volume in the designs for our clients. We have designed and constructed over 250 skateparks, from Orcas Island in Washington State to the Holy Lands of Israel, giving us an intimate understanding of building community through skateboarding.

Ryan "Peabody" McWhirter *became interested in shotcrete through his former career as a professional skateboarder. Ryan started skateboarding when he was 11 and at the age of 16, he became a professional skateboarder. Traveling the world as a skateboarding professional piqued Ryan's interest in the unique shapes and forms that could be created with shotcrete. Ryan started working with Grindline Skateparks and Johnson Western Gunite 15 years ago and has been working with concrete and shotcrete ever since. He is a certified shotcrete nozzleman and also an accomplished wireman and concrete finisher. Ryan currently is the shotcrete nozzleman on the Seattle Center Skatepark project for Grindline Skateparks.*

2020 HONORABLE MENTION

Project Name
Hale Park Skatepark

Location
Wenatchee, WA

Shotcrete Contractor, Architect/Engineer, and General Contractor
Grindline Skateparks*

Materials Supplier
Wenatchee Sand & Gravel/ Central Washington Concrete

Project Owner
City of Wenatchee

*ASA Sustaining Corporate or Corporate Member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2020 Honorable Mention

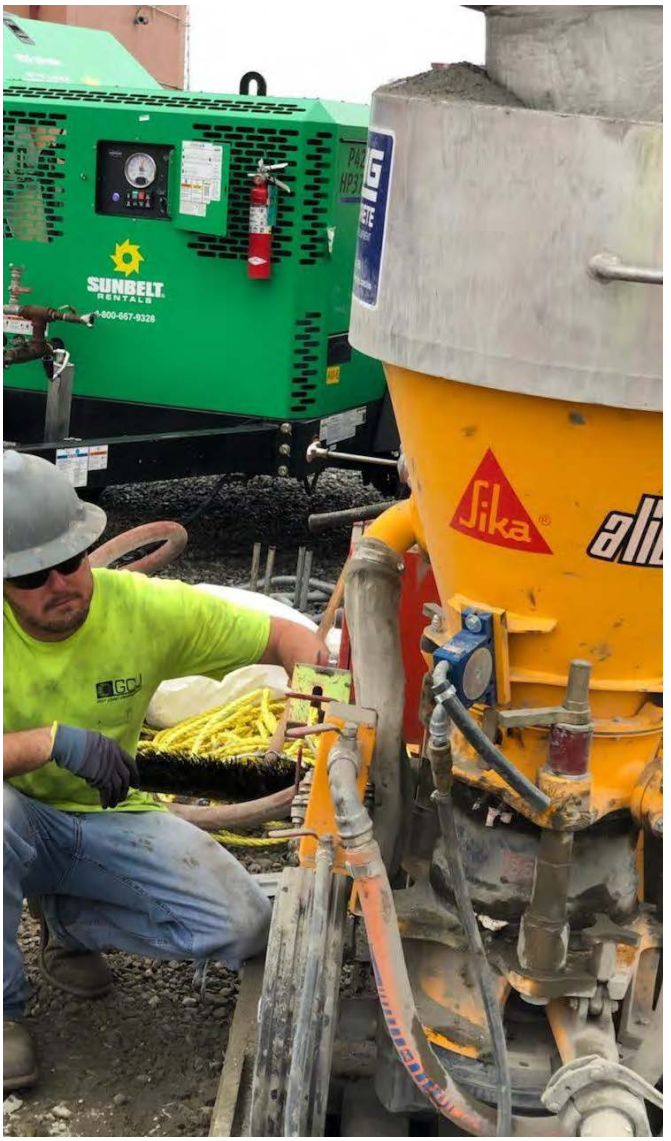
South Wastewater Treatment Plant

Junction Box Rehabilitation, Baton Rouge, LA

By Spencer Tuell

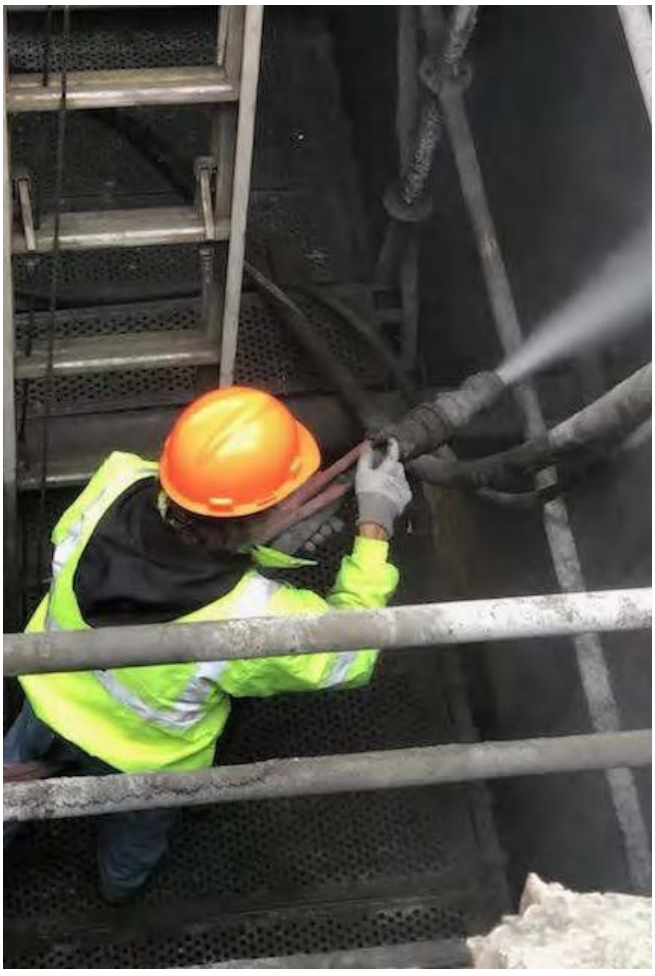
In early September of 2019, Gulf Coast Underground (GCU) received a call from the City of Baton Rouge and their construction manager, Jacobs Engineering Group (JEG). There was an issue at the South Wastewater Treatment Plant that would require a unique contractor skillset to properly repair. The problem was that the cast-in-place influent structures receiving 65 million gallons (246 ML) of sewer flow daily, were corroding and needed to be repaired quickly.

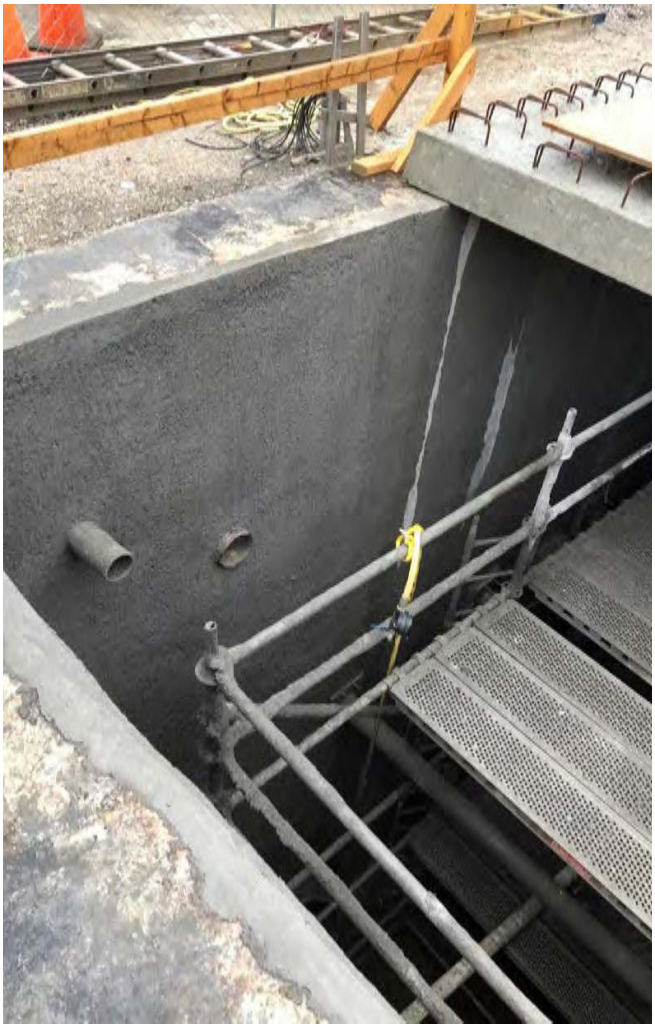
Jacob's structural sub-consultant on the project was Ragland Alderman and Associates (RAA) based in Baton Rouge. Since this project was fast-tracked and design-build in nature, the initial rehabilitation recommendations began with the structures still in service, which limited the feasibility of a full structural assessment. The assumption was



made that the walls had minor structural deficiencies and needed basic shotcrete repair to be followed by the application of an inert coating system, which would prevent future corrosion concerns. As is the case in some rehabilitation projects, once the surface prep hydro-blasting began, the designers and builders realized the structure was in much worse condition than originally assumed.

Better Pumps and Solutions (BPS) handled the bypass for the owner, plugging and transferring all 65 MGD to the headworks. Once this was done, it was time for the team to get to work as the cost of running such a bypass is massive. At the beginning of the 40,000 lb/in2 (276 MPa) hydro-blasting, GCU, RAA and JEG convened for a meeting onsite to climb into the structure and assess the degree of degradation. It was found that the majority of the inner mat of reinforcing was compromised from years of corrosion in the harsh wastewater environment. RAA quickly revised the structural design to call for the installation of lateral shoring braces to support the compromised walls, followed by full removal of the inner mat of rebar, then replacement with #6





(#19M) bars at 6 in. (150 mm), an application of shotcrete (KPM Industries MS-D1) to restore the wall profile to original thickness, and lastly the application of the protective polyurea coating system.

GCU's management team for this project had collectively over 70 years of shotcrete experience. Mockup test panels were shot to ensure good encasement practices, and

cores were taken to verify physical properties of the dry-mix material. The commitment was made to work a significant amount of overtime and weekends to ensure the overall project time was kept to a minimum. Every day the bypass was running created a huge impact on the owner's bottom line, and in the end, it was the collaborative effort of all parties involved for a successful final product.

Spencer Tuell *is a Partner and President of Gulf Coast Underground and has been involved with water and wastewater design and construction since 2005. Spencer is a licensed Professional Engineer in FL, GA, LA, SC, NC and TN, and is an active member in numerous ASCE and WEF organizations throughout the Southeast. Spencer is a graduate of the University of Florida with a Bachelor's Degree in Civil Engineering and a Master's Degree in Civil Engineering with a Construction focus.*

2020 HONORABLE MENTION

Project Name
South Wastewater Treatment

Location
Baton Rouge, LA

Shotcrete Contractor & General Contractor
Gulf Coast Underground, LLC*

Architect/Engineer
Jacobs Engineering

Materials Supplier
Sika (KING)*

Equipment Manufacturer
Sika*

Project Owner
City of Baton Rouge

*ASA Sustaining Corporate or Corporate Member

2020 Honorable Mention

Grotto Pool Project

By Andy Duck

When one of our core builders called us to announce their prospective client's desire to completely redo their beach house on the Sound in Corolla, NC, they mentioned that a new concrete pool would be part of the project. Steve Daniels, of Renaissance Construction Company, Inc., had his designer, Paul Gilbertson, send us preliminary information on the prospective property and the client's wish list for the backyard. To call it a transformation is a significant understatement.

Renaissance had been contracted to completely renovate the entire house, top to bottom, inside and out. The client wanted an exterior transformation that included a mini resort themed backyard. At this point we became keenly aware that the existing concrete pool and everything else in the rear of the property was slated for complete demolition. While we understood we would be starting from scratch to transform this Sound front property into an active area that encompassed much more than just the pool, we didn't quite grasp the overall complexity of the project. That is, until our first meeting with the client.

Being an executive of one of the largest home building firms in North America lends itself to inherent knowledge of the construction process. From materials and applications to cost elements, Steve Daniels came up from field residential framing to corporate executive over the course of his career, which gave him confidence in what he was about to ask for.

Our client sent the builder a bar and kitchen conceptual design that is reminiscent of a restaurant in Baltimore, MD. Open aired, sleek, and semi-modern, he was interested in having the bar lower than the kitchen galley, and to also serve as a swim up bar from the pool. His other wish list items included a large party spa integrated with some water sports capabilities and, oh yeah…a rock grotto with a slide. "No problem," we told him, "Sounds fun! Let's start designing!"

We immediately integrated the extremely angular aspects of the bar/kitchen area with a free form shaped pool. We thought the radial lines of the pool would transition smoothly to what we predicted would be a rather, free form grotto element. We also thought that adding random boulders here and there would create a good transition between the three contrasting elements. Sitting and jumping rocks were discussed and the concept was born.

Being based in a coastal beach community on the Outer Banks of North Carolina, we do not have a lot of rock in our

immediate area, so the decision to use shotcrete to create the rock and boulder aspects of the grotto was a no brainer. Being veterans to the shotcrete field, we knew it was a great fit for both the structural and subsequent carving and final finish. However, we also knew that we did not possess the experience in the stone and rock carving to pull this off on our own.

After some research, we contacted a few subcontractors that specialize in faux boulder and rock work, as well as one of our allies and friends who had just completed an ASA award winning project that specialized in the artistic shotcrete approach to creating faux rock. We fleshed out some basic budgetary ideas from all the providers, along with some photographs of finished projects and set up our first face-to-face meeting with the client.

We were pleased the client was very happy with our design direction regarding the pool, spa, and bar. He understood and agreed that shotcrete for the impending grotto was the right direction to pursue. With that, we laid out our idea for a simulated cave with exterior rock steps up to a sitting vista that had a slide to reenter the pool without the walk of shame (back down the stairs). He loved it and we moved on to presenting the completed project photos we had received from the shotcrete carved rock vendors, along with the proposed budget for the size and scope we were anticipating to fit the space. Afterwards, it was time to pick a shotcrete contractor for the grotto element.

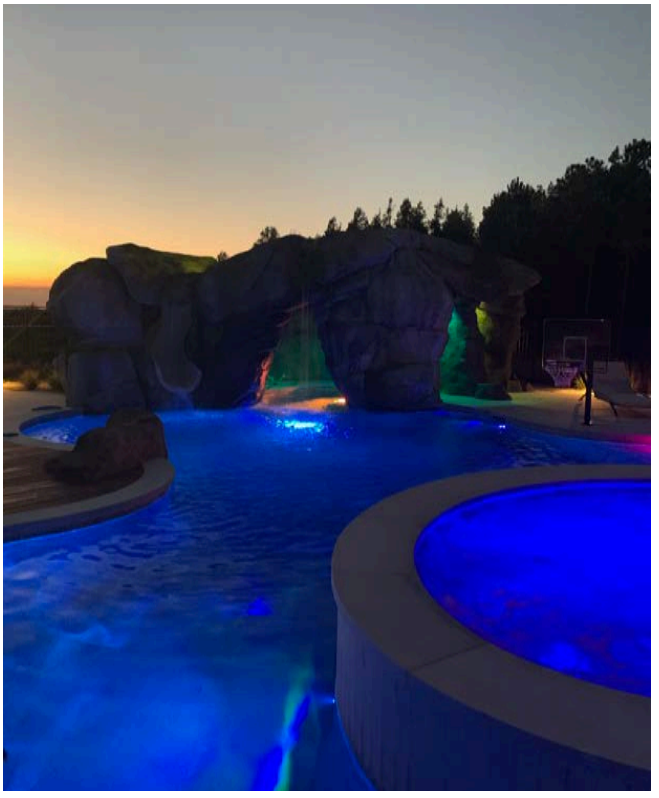
Overwhelmingly, the client chose to work with our associates at Clearwater Construction Group in Chapel Hill to design and develop the grotto and cave concept we had envisioned. Ryan Oakes took the lead on the conceptual idea and process, and we enlisted Dan Pitts from Ocean Rock Industries to consult on the design and shotcrete work, as they had previously worked together on a larger project in Purlear Creek, NC (project winner of the 2019 ASA Outstanding Pool and Recreational Project Award Recipients). Ryan Oakes, Anna Ploghoft, and their associates jumped in to create a

GROTTO POOL PROJECT - MARRYING CAST IN PLACE CONCRETE WITH SHOTCRETE, BOTH WET AND DRY MIX APPLICATIONS

three-dimensional (3D) rendering of our concept for the grotto while the rest of the pool construction got underway.

Very early in the process, after reviewing the site conditions and a geotechnical subsurface conditions report, it was determined that the entire structure would need to be pile and grade beam supported. Varying degrees of layered peat and unsuitable soils, coupled with groundwater and storm surge potentials all played into the decision to support the more than 750 tons (680 tonnes) of concrete, steel, and water that were designed for the backyard construction. Kitty Hawk Engineering handled the structural engineering for the entire pool project and specified wooden 8 in. (200 mm) piles driven to a minimum depth of 20 ft (6.1 m) below the concrete grade beams. After Millstone Marine completed the piling installation, we planned to build the 18 in. (450 mm) by 24 in. (600 mm) concrete grades beams by forming and pouring in place. However, working with Kitty Hawk Engineering, we decided to use the form-and-pour method only for the bottom half of the structural grade beams. The upper half of the beams would be shotcreted with the floor of the pool. By placing the concrete pneumatically, it allowed us to achieve good consolidation around all the steel reinforcement engineering in the beams as well as a good bond to the form-and-pour grade beams. We self-performed this part of the work using wet-mix shotcrete.

Once the initial grade beams were completed and we had finished backfilling and installing the gravel subbase to compaction specifications, we began forming the pool and spa. We called upon Revolution Gunite from Burlington, NC to provide and complete the dry-mix shotcrete process for these



aspects of the project. Being over 120 yd^3 (92 m^3), and with reload access almost two hours away, the decision was made to complete the floor on one day and the walls with ancillary features the next day. The floor casting had keyways cut into the transition where the subsequent vertical shotcrete would take place the next day and all reinforcing bars and forms were cleaned with the air lance before shotcreting.

After the pool and spa shotcrete was completed, we removed the formwork, backfilled partially to plumbing elevations, and began water curing the pool shell. Once we had completed the remainder of the plumbing, lighting conduit and piping runs, we began backfilling with the pipes under pressure. Also, being in a sandy soil, the water from flooding the pool for water curing was reused to provide "flood" consolidation of the sand, intermittent with vibratory plate compaction. This provided a sturdy subgrade for all the subsequent marble pavers selected by the client.

As mentioned, during all the pool shell construction, Clearwater Construction Group had been busy finalizing the 3D design for the grotto. They put together some sectional views with dimensions highlighted so we could finalize the proposed footprint and subsequent layout parameters for the entire cave structure. Kitty Hawk Engineering once again crafted a piling design to support the grotto structure and Millstone Marine remobilized for the piling installation. We basically repeated the grade beam process we used for the main pool shell. Once the grade beams were complete, we line pumped a spread footing under the entire cave feature.

At this point, it became an art project considering we were working from a 3D model as the main plan. We broke the structure into 48 in. (1200 mm) grids on the slab, completed a basic layout plan, and installed the slide to the manufacturer's specifications. We then turned the 3D concept into reality by hot-wire carving EPS geofoam and gluing the pieces together and to the slab with spray foam adhesive. Clearwater and Revolution Gunite once again stepped up to the plate to assist us in crafting the final look of the foam "boulders,". Considering our main consultant Dan Pitts from Ocean Rock Industries in Squamish, BC, Canada had been barred from participating in the project due to COVID-19, the Revolution and Clearwater guys were essential to this project moving forward. Ryan Oakes and Peter Oakley (renowned stone sculptor, artist, and rock climber) moved into the area for the duration and really helped us understand the creative process, as they had previously worked with Dan Pitts on other projects. Specially crafted reinforcing bar tools were used to create the metal framework for the faux rock with lathe and mesh. Ryan showed us how to create reinforcing bar trusses to arch over the dome of the cave. These would support the weight of the concrete and water that would be on top of the cave feature. After installing all the applicable plumbing and lighting runs, as well as ensuring that all the steel was properly bonded for safety and to meet code, it was time for the structural shotcrete application.

We decided to use the dry-mix shotcrete process for the majority of the structural concrete and the wet-mix process for the structural coating over the free standing dome structure. Each method of shotcrete placement was a good fit for the respective applications. The dry-mix process allowed us to stop and start at our leisure and insured a good consolidation of materials around the reinforcing bars. However, we knew the velocity of the dry process would surely pass through the lathe and reinforcing bar shell over the dome structure. The wet-mix process allowed us to shoot the dome from the topside onto the lathe with the plan to shoot the interior of the cave with the dry-mix process as overhead shotcrete.

Of course, after the structural shotcrete was complete, the carve coat shotcrete began. Again, we selected the dry-mix process for the stopping and starting aspects, as well as shooting hard enough against the already installed structural work to ensure a good bond. As always, the air lance was critical to control rebound and overspray, and all concrete surfaces were clean and brought to a saturated surface dry (SSD) condition before shotcrete placement. There were many man hours spent on pressure washers cleaning the surfaces to remove any overspray, rebound, etc. Getting a good bond on the final carve coats were crucial for a strong durable concrete section. Once the fresh dry-mix was applied to the carve coats, Ryan, Peter, and whomever was allocated as "carve helpers of the day" went to work putting the final details in place. This was truly an artform. Creating shadows, overhangs, changes of plane, and everything that makes the end product look real were meticulously labored over.

After all the shotcrete was completed, we began the staining and painting processes. A multitude of colors were base coated on the new concrete structures. So much detail was put into this aspect of the project, it is difficult to express. The application of thousands of "dots" and even creating lichen patches on the Northern faces all lent to the final product looking like it was natural and always there, despite being located on a barrier island that was mostly a sandbar. Our goal was to make the pool seem like it was created around the existing rockwork cave as a transition to the bar area and rest of the hardscaping. Landscaping plans had been drafted by Joseph Richardson, the landscape architect.

The results of this 10 month process were the epitome of design build. Having the trust of the general contractor and the client allowed us to make the necessary changes along the process. By harnessing the strengths and benefits from the various concrete installation and shotcrete placement methodologies, we were able to complete this one-of-a-kind watershape in monolithic concrete. The flexibility of the shotcrete applications was essential to the construction and produced the highest quality finished product. We will most certainly be integrating both wet-mix and dry-mix applications in our projects for the foreseeable future.

2020 HONORABLE MENTION

Project Name
Grotto Pool

Location
Corolla, NC

Shotcrete Contractor
Revolution Gunite* & Artisan Pools NC, Inc.*

Architect/Engineer
Artisan Pools NC, Inc.*, Pillar Design Studios, LLC, Clearwater Construction Group

Materials Supplier
Revolution Gunite* and C&L Concrete

Equipment Manufacturer
REED*

General Contractor
Renaissance Construction

Project Owner
Keith Neiman

**ASA Sustaining Corporate or Corporate Member*

Andy Duck: *The Artisan Group, Ltd.; Artisan Pools NC, Inc.; Artisan Concrete Services, Inc.; and Artisan Skateparks*

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2. Use only QUALIFIED CONTRACTORS with relevant project experience
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2020 Carl E. Akeley Award


Gagnon


Jolin


Lemay

The 15th annual Carl E. Akeley Award was presented to Antoine Gagnon, Marc Jolin, and Jean-Daniel Lemay from Université Laval, for their article, "Performance of Synthetic Sheet Waterproofing Membranes Sprayed with Steel Fiber-Reinforced Shotcrete Testing for Waterproofing Membrane Integrity After Spraying," published in *Shotcrete* magazine, Fall issue of 2019. This article is aimed at evaluating the potential damage and performance reduction of synthetic sheet waterproofing membrane when using steel fiber-reinforced shotcrete.

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

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

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

PAST AKELEY AWARD RECIPIENTS

- 2006— Dufour, Reny, and Vézina, "State-of-the-Art Specification for Shotcrete Rehabilitation Projects"
- 2007—K. F. Garshol, "Watertight Permanent Shotcrete Linings in Tunneling and Underground Construction"
- 2008—E. S. Bernard, "Embrittlement of Fiber-Reinforced Shotcrete"
- 2009—Dufour, Lacroix, Morin, and Reny, "The Effects of Liquid Corrosion Inhibitor in Air-Entrained Dry-Mix Shotcrete"
- 2010—Dr. L. Zhang, "Is Shotcrete Sustainable?"
- 2011—C. S. Hanskat, "Shotcrete Testing—Who, Why, When, and How"
- 2012—R. Curtis White Jr., "Pineda Causeway Bridge Rehabilitation"
- 2013—Jolin, Nokken, and Sawoszczuk, "Sustainable Shotcrete Using Blast-Furnace Slag"
- 2014—Dr. L. Zhang, "Variability of Compressive Strength of Shotcrete in a Tunnel-Lining Project"
- 2015—E. Yurdakul and K.-A. Rieder, "Effect of Pozzolanic-Based Rheology Control Agent as a Replacement for Silica Fume"
- 2016—M. von der Hofen, "East End Crossing"
- 2017—Axel Nitschke, "Modeling of Load-Bearing Behavior of Fiber-Reinforced Concrete Tunnel Linings"
- 2018—Kyong-Ku Yun, "Cellular Sprayed Concrete"
- 2019 – William Clements and Kevin Robertson, "Compatible Shotcrete Specifications and Repair Materials,"

References

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

2020 ASA President's Award

The ASA President's Award was established in 2005 to recognize a person or organization that has made exceptional contributions to the shotcrete industry. It is the sole responsibility of the immediate outgoing President of ASA to select the recipient of this award. Since 2006, 14 well-deserving individuals and one organization have been awarded the ASA President's Award, all of whom dedicated their time and energy to advancing the shotcrete industry. For 2020, at the virtual Sixteenth Annual ASA Awards Celebration, the immediate outgoing President of ASA, Ryan Poole, presented this award to Lars Balck, for his exemplary leadership in the shotcrete industry, advancing and facilitating the mission of ASA.

"This year's President's Award is given to one of the founding members of ASA. His long service with ASA has built the foundation of our Association that has given people like me and many others the opportunity to serve as officers, Board members and active participants in our programs and activities. He was involved in the original establishment as an Association of members with a common goal of advancing the quality and breadth of application of shotcrete.

My choice for the President's Award is a retired business owner in a company that depended on quality and productivity of shotcrete placement for their product. He was always at the forefront in the firm for shotcrete quality, through training of nozzlemen, establishment of standards, and evaluating new and innovative methods and equipment, while keeping safety and quality at the top of all the field crew members' minds.

Finally, my selected recipient has had a long history of giving back to our industry not only with ASA through the years, but also in ACI. In ACI he has provided leadership to the ACI 506 Shotcrete Technical Committee, as chair of both the main committee and subcommittees, as well as being an active voting member for decades. In his roles with ACI, he has exhibited the proven ability to get the volunteer members to work together and reach a consensus as new documents are created, or older documents revised.

My choice for recipient of the President's Award is Lars Balck. Lars is incoming president of ASA for 2021, and our first president back in 1998. I'm sure we will see him very active in leading ASA…again. Please join me in congratulating and thanking Lars for the time, effort, and commitment he's given us, both as an Association and as an industry advancing in quality and breath of applications over the last two decades."

—Ryan Poole

Slump - The Most Misunderstood Characteristic of Wet-Mix Shotcrete

By Oscar Duckworth

If asked, could you accurately explain why the choice of slump is so important to a wet-mix shotcrete material's hardened properties?

Many current slump specifications are derived from historical beliefs that may no longer be valid. It is widely accepted that slump is a rough measure of concrete consistency - a general term meaning fluidity or stiffness. Using slump to describe an important characteristic of concrete's plastic properties dates back nearly a century.

In the 1920s, Duff Abrams, a young engineer, proved that a plastic concrete mixture's consistency, from the addition of water, had a strong influence on the development of its strength and other hardened properties.

Initially known as the Abrams Cone test, the slump test was created to correlate a mixture's consistency, to a uniform numerical value. At a time when concrete was simply a mixture of Portland cement, water, and aggregates, it became evident that allowing a higher slump could diminish hardened strength. The slump test and correlating numerical value system was quickly adopted as one of the most commonly specified values of a then modern reinforced concrete industry. "Abrams Law:" *Concrete strength development is inversely proportionate to the water content of the mixture*, was coined. Abrams Law remains a primary design parameter for nearly all concrete produced today.

Historically, project specifications determined the allowable slump that could be used for specific concrete placement operations. Since a higher slump was a potential indicator of lower concrete strengths, specifying a slump range was an important tool to help prevent the placement of low strength concrete. An increase of slump, from using excessive water added during batching, or by workers in the field, was (at the time) a major cause of low-quality concrete.

If asked, could you accurately explain why the choice of slump is so important to a wet-mix shotcrete material's hardened properties?

Beginning with the initial patent by Edward W Scripture Jr for a primitive water-reducing admixture in 1934, US patent 2,081,642 described a thick dispersing liquor derived from waste sulphite pulp, added to concrete so that the material will flow more readily. Unknown to Mr. Scripture his patent for a chemical admixture would forever change how we place concrete.

With continuous admixture advancements, especially water-reducing admixtures, the innovations of the last 90 years have dramatically increased the strength and durability of concrete by eliminating the use of water as the primary means to alter the material's plastic consistency. Modern admixture technology can now provide nearly any slump without changing the mixture's water content (w/cm ratio). Because of this, today's admixtures have greatly diminished the choice of slump as having a meaningful relationship to a mixture's strength development.

Nowhere in the concrete Industry is the choice of slump more critical than with shotcrete. Seemingly minor variations in placement slump can affect shotcrete's hardened properties in very major ways. The nozzleman's control of slump is one of the most important concrete mixture characteristics (if not the most important) that can influence the in-place quality. The importance of slump control may not be well understood by those not intimately familiar with the shotcrete process. The need for precise control of slump is no longer due to water content's correlation to strength development, rather it is due to the slump's critical, but largely unseen role of flowability and consolidation.

SHOTCRETE IS A UNIQUE PLACEMENT METHOD FOR CONCRETE

Shotcrete differs substantially from other concrete placement methods in how the material is consolidated. Since proper consolidation is critical to the strength and durability of any reinforced concrete element, consolidation is an essential component of placement. Generally, conventional concrete is placed in a process requiring two individual steps. First, concrete material is placed into a form utilizing generally accepted methods to prevent excessive segrega-

El revenimiento - La Característica Más Incomprendida Del concreto lanzado vía Húmeda

By Oscar Duckworth

Si se le pregunta, ¿podría explicar con precisión por qué la elección del revenimiento es tan importante para las propiedades endurecidas del concreto lanzado vía húmeda?

Muchas de las especificaciones actuales del revenimiento se derivan de creencias históricas que pueden no ser válidas en la actualidad. Es ampliamente aceptado que el revenimiento es una medida burda de la consistencia del concreto - un término general que significa fluidez o rigidez. El uso del revenimiento para describir una característica importante de las propiedades plásticas del concreto, data de casi un siglo.

En el 1920s, Duff Abrams, un joven ingeniero, demostró que la consistencia de una mezcla de concreto plástico, por la adición de agua, tenía una fuerte influencia en el desarrollo de su resistencia y otras propiedades endurecidas. Inicialmente conocida como la prueba del cono de Abrams, la prueba de revenimiento se creó para correlacionar la consistencia de una mezcla con un valor numérico uniforme. En un momento en que el concreto era simplemente una mezcla de cemento Portland, agua y agregados, se hizo evidente que permitir un mayor revenimiento podría disminuir la resistencia final. La prueba de revenimiento y el sistema de valor numérico correlacionado se adoptó rápidamente como uno de los valores más comúnmente especificados en la industria de concreto armado moderno. "Ley Abrams" El desarrollo de la resistencia del concreto es inversamente proporcional al contenido de agua de la mezcla. La ley de Abrams sigue siendo un parámetro de diseño principal para casi todo el concreto producido hoy en día.

Históricamente, las especificaciones del proyecto determinaron el revenimiento permisible que podría usarse para operaciones específicas de colocación de concreto. Dado que un revenimiento mayor era un indicador potencial de resistencias más bajas del concreto, especificar un rango de revenimiento era una herramienta importante para ayudar a prevenir la colocación de concreto de baja resistencia. Un aumento del revenimiento, debido al uso excesivo de agua agregada durante el mezclado, o por los trabajadores en el campo, era (en ese momento) una causa importante de concreto de baja calidad. Comenzando con la patente inicial de Edward W Scripture Jr. para un aditivo reductor de agua primitivo en 1934, la patente estadounidense 2.081.642 describió un espeso licor de dispersión derivado del residuo de la pulpa de sulfito, agregado al concreto para que el material fluya más fácilmente. Desconocido para el Sr. Scripture Jr. su patente para un aditivo químico cambiaría para siempre cómo colocamos el concreto.

Si se le pregunta, ¿podría explicar con precisión por qué la elección del revenimiento es tan importante para las propiedades endurecidas del concreto lanzado vía húmeda?

Con los continuos avances en los aditivos, especialmente en los reductores de agua, las innovaciones de los últimos 90 años han aumentado drásticamente la resistencia y durabilidad del concreto al eliminar el uso del agua como medio principal para alterar la consistencia plástica del material. Con la moderna tecnología de los aditivos hoy en día se puede diseñar casi cualquier revenimiento sin cambiar el contenido de agua de la mezcla (relación a/mc). Debido a esto, las mezclas de hoy en día han disminuido en gran medida la elección del revenimiento como una relación significativa del desarrollo de la resistencia de una mezcla.

En ninguna parte de la industria del concreto es la elección del revenimiento más crítica que con el concreto lanzado. Variaciones aparentemente menores en el revenimiento pueden afectar las propiedades endurecidas del concreto lanzado de manera muy importantes. El control del revenimiento por parte del lanzador es una de las características más importantes de la mezcla de concreto (si no la más importante) que puede influir en la calidad de la colocación. La importancia del control del revenimiento puede no ser bien entendida por aquellos que no están íntimamente familiarizados con el proceso de lanzado. La necesidad de un control preciso del revenimiento ya no se debe a la correlación del contenido de agua con el desarrollo de la resistencia, sino que se debe al papel crítico, pero en gran medida invisible, de los efectos en la fluidez y la consolidación.

EL CONCRETO LANZADO ES UN MÉTODO ÚNICO DE COLOCACIÓN DE CONCRETO

La colocación de concreto lanzado difiere sustancialmente la forma en que se consolida el material comparado con otros métodos de colocación de concreto. Dado que la consolidación adecuada es crítica para la resistencia y durabilidad de cualquier elemento de concreto armado, la consolidación es un componente esencial de la colocación. Generalmente, el

tion. Following placement, consolidation, using mechanical vibration or other means is an essential second step.

Mechanical vibration, utilizing the correct pace, equipment, and methodology, is a necessary and well proven method to achieve acceptable consolidation during conventional placement. Shotcrete, however, does not utilize the second step of consolidation through vibration. Shotcrete must be placed and properly consolidated within a nearly instantaneous single high velocity placement step. Because of this, the proper choice of a mixture's consistency is a powerful factor in consolidation success. Unfortunately, few realize the importance of material consistency in this process. The importance of understanding the critical correlation between material consistency to shotcrete consolidation might be compared to the importance of understanding "Abrams Law" to the early days of reinforced concrete.

To understand the immense role shotcrete slump plays in this process, it is important to understand what occurs at the exact moment of placement. To see this, we must look deeply into the nozzle stream, an area that only the nozzleman might ever actually see. It is within this violent agitation zone, where high velocity materials collide with an un-moving receiving surface, where the importance of consistency becomes apparent. A slow-motion analysis of shotcrete placement exposes distinct functions that are ultimately responsible for shotcrete consolidation success. Concrete enters the nozzle as a homogeneous mixture, but becomes both diffused and rapidly accelerated by power-

Fig. 1: Modern nozzle designs diffuse and accelerate the incoming mixture into thousands of individual particles moving within a high velocity nozzle stream.

ful opposing forces within the nozzle body. The mixture's components will not exit the nozzle as a concrete mixture, but more akin to a shotgun blast pattern of thousands of individuals, unconsolidated paste and aggregate particles moving within a focused, high velocity stream. (Fig. 1).

Upon impact, each particle will behave differently. Some of the larger particles may strike the receiving surface and ricochet or rebound away rather than stick to the surface. However, the mixture's most cohesive component, the paste, tends to stick and remain in place. As a paste layer begins to thicken at the receiving surface, incoming particles begin to collide with other particles trapped within the puddle. Strong agitations, especially those caused by the collisions of the larger, heavier aggregates, cause vigorous high frequency oscillations within the impact zone's developing puddle. These temporary, impact-derived oscillations have the same effect on consolidation within the puddle as the oscillations caused by mechanical vibration.

With shotcrete, temporary viscous flow, caused by impact-derived oscillations will be responsible for the consolidation of all materials directly exposed to the high velocity nozzle stream and the consolidation of materials within the shadow areas not directly exposed to the material stream. Unfortunately, if a mixture's paste is excessively stiff, critically important viscous flow within the impact zone's puddle is greatly diminished. Impact-derived viscous flow may properly consolidate areas directly exposed to the strong nozzle stream, but the puddle may lack adequate flow to completely consolidate materials in the shadow areas. With no second consolidation step, un-filled shadow areas will remain as voids. (Fig. 2)

Fig. 2: This core specimen's major flaw is evidence of inadequate flow during placement.

To a degree, nozzle orientation, and higher velocity can increase impact-derived oscillations and viscous flow within the shadow areas somewhat but will not be sufficient to overcome an excessively stiff paste that lacks flowability. It is important to understand that the placement of excessively stiff mixtures must be avoided due to its strong negative affect on full encapsulation of embedded reinforcing and consolidation quality. A skilled nozzleman must "see" the material flow readily into shadow areas and watch for important visual cues to help maintain the material's proper

concreto convencional se coloca en un proceso que requiere dos pasos principales. En primer lugar, el concreto se coloca en una cimbra utilizando métodos generalmente aceptados para prevenir la segregación excesiva. El segundo paso esencial es la consolidación, generalmente con el uso de vibradores mecánicos u otros medios.

La vibración mecánica, utilizando el ritmo, el equipo y la metodología correctos, es un método necesario y bien probado para lograr una consolidación aceptable durante la colocación convencional. En el lanzado, sin embargo, no utiliza el segundo paso de consolidación a través de la vibración. El concreto lanzado debe colocarse y consolidarse correctamente en un solo paso, colocándolo a alta velocidad casi instantáneamente. Debido a esto, la elección adecuada de la consistencia de una mezcla es un factor poderoso en el éxito de la consolidación. Desafortunadamente, pocos se dan cuenta de la importancia de la consistencia material en este proceso. La importancia de comprender la correlación crítica entre la consistencia material y la consolidación podría compararse con la importancia de entender la Ley Abrams a los primeros días del concreto armado.

Fig. 1: Los diseños modernos de boquillas difuminan y aceleran la mezcla en miles de partículas individuales que se mueven alta velocidad en forma de una corriente saliendo de la boquilla.

Para entender el inmenso papel que desempeña el revenimiento en este proceso, es importante entender lo que ocurre en el momento exacto de la colocación. Para ver esto, debemos mirar profundamente en la corriente de la boquilla, un área que sólo el lanzador podría realmente ver. Es dentro de esta zona de agitación violenta, donde los materiales a alta velocidad chocan con una superficie receptora que no se mueve, donde la importancia de la consistencia se hace evidente. Un análisis a cámara lenta de la colocación del concreto lanzado expone funciones distintas que son en última instancia responsables del éxito de la consolidación del lanzado. El concreto entra en la boquilla como una mezcla homogénea, pero se disgrega y acelera rápidamente por fuerzas opuestas dentro del cuerpo de la boquilla. Los componentes de la mezcla no saltarán de la boquilla como una mezcla de concreto, sino más parecidos a un disparo de escopeta lanzado de miles de partículas individuales, no consolidadas de pasta y agregados que se mueven dentro de un flujo a alta velocidad (Fig. 1).

En el impacto, cada partícula se comportará de forma diferente. Algunas de las partículas más grandes pueden golpear la superficie receptora y rebotar en lugar de pegarse a la superficie. Sin embargo, el componente más cohesivo de la mezcla, la pasta, tiende a pegarse y permanecer en su lugar. A medida que una capa de pasta comienza a espesarse en la superficie receptora, las partículas entrantes comienzan a colisionar con otras partículas atrapadas dentro del mortero. Las agitaciones fuertes, especialmente las causadas por las colisiones de los agregados más grandes y pesados, causan oscilaciones vigorosas de alta frecuencia dentro del mortero en la zona de impacto. Estas oscilaciones temporales derivadas del impacto tienen el mismo efecto en la consolidación dentro del mortero que las oscilaciones causadas por la vibración mecánica. Con el concreto lanzado, el flujo viscoso temporal, causado por oscilaciones derivadas del impacto, será responsable de la consolidación de todos los materiales directamente expuestos al flujo de boquilla a alta velocidad y la consolidación de

Fig. 2: El principal defecto de este núcleo es evidencia de un flujo inadecuado durante la colocación.

materiales dentro de las áreas de sombra que no estén directamente expuestas al flujo de material. Desafortunadamente, si la pasta de una mezcla es excesivamente rígida, el flujo viscoso críticamente importante dentro del mortero de la zona de impacto se reduce grandemente. El flujo viscoso derivado del impacto puede consolidar correctamente las áreas expuestas directamente al flujo directo de boquilla, pero el mortero puede carecer del flujo adecuado para consolidar completamente los materiales en las áreas no impactadas por el (áreas de sombras). Sin un segundo paso de consolidación, las zonas de sombra sin rellenar permanecerán como vacíos (Fig. 2).

En cierto grado, la orientación de la boquilla y una velocidad mayor pueden aumentar las oscilaciones derivadas del impacto y el flujo viscoso dentro de las zonas de sombra, pero no serán suficientes para colocar una pasta excesivamente rígida que carece de fluidez. Es importante comprender que la colocación de mezclas excesivamente rígidas debe evitarse debido a su efecto negativo en la calidad de la consolidación y el recubrimiento del refuerzo. Un lanzador experto debe "ver" el flujo del material fácilmente en las áreas de sombra y observar las señales visuales importantes para ayudar a mantener la consistencia apropiada del material a medida que ocurre

consistency as placement occurs. Within any given reinforcement configuration, there is a suitable consistency where proper shotcrete placement techniques can achieve acceptable consolidation. For example, more congested elements require a higher slump to achieve proper consolidation (Fig. 3a and 3b). Visual cues, continuously monitored by a skilled nozzleman, rather than a strength-based slump value from a prescriptive specification is the correct way to determine the ideal placement consistency for a given reinforcement configuration.

Fig. 3a & 3b: Different reinforcement configurations require different material consistencies.

Fig. 4: Void beneath reinforcement in saw cut specimen occurred from downward movement.

VISUAL CUES NOZZLEMEN NEED TO KNOW

During placement, a nozzleman must rely on certain visual cues to help maintain an ideal consistency. As impact energy agitates the developing puddle, experienced nozzlemen study the point of impact. If the slump is too high, temporary viscous flow from agitation will cause the puddle to move excessively. The puddle will flow outward and downward excessively, creating a noticeable sag. This visual indicator is plainly visible to the nozzleman. Any attempt to continue, results in more downward flow. Since reinforcements are firmly tied, downward movement of the puddle (sags or sloughs) leads to the potential creation of voids developing beneath horizontally oriented reinforcement bars (Fig. 4). Once created, lacking secondary consolidation, these voids become permanent structural deficiencies within the work. Fortunately, nozzlemen rarely attempt to place excessively fluid mixtures since they lack the cohesive properties required to remain in place or stack on a vertical surface. If the nozzleman attempts to shoot a slump that is too high, placement is either very inefficient, or simply not possible due to the inherent higher flowability of the material. It is the author's observation that shotcrete nozzlemen rarely attempt to place materials with too high of slump for the reasons stated above. Rather, some nozzlemen, especially those less experienced, tend to place materials that are too stiff. There is a natural tendency for less experienced nozzlemen to select a lower slump to help facilitate stacking the materials. Unfortunately, they may be entirely ignoring obvious visual cues within the puddle indicating that proper consolidation may not be occurring due to an improper choice of slump. It is important to understand that the primary goal of an experienced nozzleman is not to stack material to its final height in as few lifts as possible. Rather, it is to place and properly consolidate the materials simultaneously.

RED FLAG VISUAL CUES THAT EVERYONE SHOULD KNOW

Fortunately, using materials at both the right and wrong consistency will always display clear visual cues. If the mixture is too stiff, several easy to identify visual cues immediately become plainly visible not only to the nozzleman, but anyone who can see the placement in progress. To achieve acceptable compaction and consolidation, the mixture must readily flow around all embedded reinforce-

la colocación. Dentro de cualquier configuración de refuerzo dada, hay una consistencia adecuada donde las técnicas de colocación de concreto adecuadas pueden lograr una consolidación aceptable. Por ejemplo, los elementos más congestionados requieren un mayor revenimiento para lograr una consolidación adecuada (Fig. 3a y 3b). Las señales visuales, monitoreadas continuamente por un lanzador experto, en lugar de un valor de revenimiento basado en la resistencia de una especificación prescriptiva, es la forma correcta de determinar la consistencia de colocación ideal para una configuración de refuerzo dada.

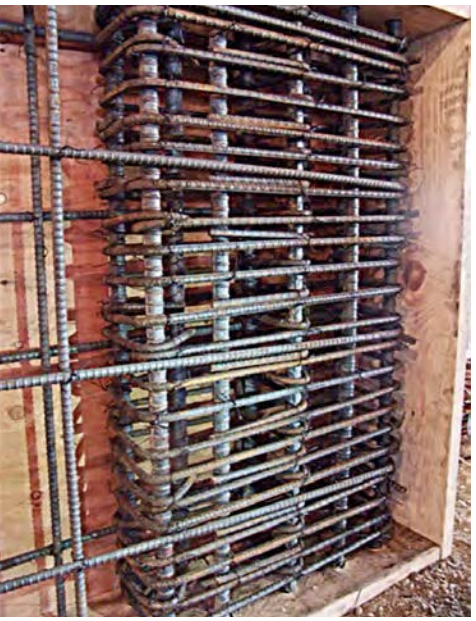


Fig. 3 & 3a: Las diferentes configuraciones de refuerzo requieren diferentes consistencias de la mezcla.

Fig. 4: El vacío debajo del refuerzo en el espécimen cortado con sierra se produjo a partir del movimiento hacia abajo.

SEÑALES VISUALES QUE EL LANZADOR NECESITA SABER

Durante la colocación, un lanzador debe observar ciertas señales visuales para ayudar a mantener una consistencia ideal. A medida que la energía de impacto agita el mortero durante la colocación, los lanzadores expertos analizan el punto de impacto. Si el revenimiento es demasiado alto, el flujo viscoso temporal de la agitación hará que el mortero se mueva excesivamente. El mortero fluirá excesivamente hacia fuera y hacia abajo, creando un escurrimiento. Este indicador visual es claramente visible para el lanzador. Cualquier intento de continuar, resultara en un mayor escurrimiento. Dado que el acero de refuerzo está firmemente amarrado, el movimiento hacia abajo del mortero (escurrimientos o desprendimientos) conduce a la creación potencial de vacíos que se desarrollan debajo de las barras de refuerzo colocadas horizontalmente (Fig. 4). Una vez creados estos vacíos, y sin una consolidación secundaria, estos vacíos se convierten en deficiencias estructurales permanentes dentro del trabajo. Afortunadamente, los lanzadores rara vez intentan colocar mezclas excesivamente fluidas, ya que carecen de las propiedades cohesivas necesarias para permanecer en su lugar o apilarse en una superficie vertical. Si el lanzador intenta colocar un revenimiento demasiado alto, la colocación es o muy ineficiente, o simplemente no es posible debido a la mayor fluidez inherente del material. La observación del autor es que los lanzadores rara vez intentan colocar materiales con un revenimiento demasiado alto por las razones mencionadas anteriormente. Más bien, algunos lanzadores, especialmente los menos experimentados, tienden a colocar materiales que son demasiado rígidos. Existe una tendencia natural para los lanzadores menos experimentados a seleccionar un revenimiento más bajo para ayudar a facilitar el apilamiento de los materiales. Desafortunadamente, pueden estar ignorando completamente las señales visuales obvias dentro del mortero indicando que la consolidación apropiada puede no estar ocurriendo debido a una elección incorrecta del revenimiento. Es importante entender que el objetivo principal de un lanzador experimentado es no apilar material a su altura final en tan pocos ascensores como sea posible. Más bien, es colocar y consolidar adecuadamente los materiales simultáneamente.

BANDERA ROJA INDICADORES VISUALES QUE TODO EL MUNDO DEBE CONOCER

Afortunadamente, el uso de materiales con una consistencia correcta e incorrecta siempre mostrará indicaciones visuales claras. Si la mezcla es demasiado rígida, varias señales visuales fáciles de identificar inmediatamente se vuelven claramente visibles no sólo para el lanzador, sino cualquiera que

ment. A clear visual cue that the mixture lacks flow is material sticking, or building up on the front of reinforcement within the nozzle stream. Bars should remain clean, with deformations clearly visible until they have become fully encased. If buildup occurs, nozzlemen must immediately stop and make the necessary adjustments to the mixture's consistency. Buildup developing on the face of reinforcements is an obvious visual cue that a mixture is too stiff (Fig. 5).

Other plainly visible cues of excessively stiff material are also evident to those who know what to look for. The receiving surface within shadow areas must fill through viscous flow within the impact zone's puddle. During placement, nozzlemen should train their eyes to study the shadow areas. Watch for complete filling

Fig. 5. Visual evidence of buildup on the reinforcement was ignored by the nozzleman. Note the massive voids that have formed behind the bars.

Fig. 6a. Tracking occurring within the shadow area is easy to see. Tracking behind reinforcements is visual evidence that the mixture is far too stiff.

Fig. 6b. Further evidence of tracking visible from the formed side.

of shadow areas as material is applied. If a visible valley or void line forms (identified as "tracking" by the author) directly behind reinforcements within the shadow area, this is clear evidence that the mixture's paste is too stiff and is not completely flowing into the shadow areas. The nozzleman must stop and adjust the mixture's consistency before continuing (Fig. 6a and 6b).

The easiest visual cue to proper consistency should be considered as the nozzleman and other workers most basic visual cue that the mixture's consistency is, or is not within the correct range. This easy to identify visible indicator within the freshly applied shotcrete surface will reveal proof of exactly what occurs as high velocity materials collide within the developing puddle. Generally, large and small aggregates make up 70-80% of a shotcrete mixture's volume. The paste is a far smaller fraction of the total volume. Though less abundant, the paste is the mixture's most cohesive element, and adheres readily upon impact. Since actions within the nozzle cause the mixture's aggregate particles to become diffused from the paste, at the moment of impact, the consistency of the paste will have the most influence on the activities of aggregates as they strike the puddle. When the consistency of the paste is correct, the freshly applied shotcrete surface will appear primarily as a glossy or shiny paste layer. Although aggregates are far more plentiful than the paste, very few will be visible on the puddle's surface.

Why would this be the case? A paste with the proper consistency will be sufficiently fluid to allow the fast-moving aggregates to enter and deeply embed within the paste layer leaving a glossy paste surface (Fig. 7). If the paste's consistency lacks fluidity, only the fastest moving aggregates may enter the puddle. Aggregates moving at a slower velocity will only slightly embed or stick to the puddle's surface. Worse,

pueda ver la colocación en progreso. Para lograr una compactación y consolidación aceptables, la mezcla debe fluir fácilmente alrededor de todo el refuerzo colocado. Una clara señal visual de que la mezcla carece de flujo es la adherencia del material o la acumulación en la parte delantera del refuerzo dentro del chorro de la boquilla. Las barras deben permanecer limpias, con deformaciones claramente visibles hasta que hayan quedado completamente cubiertas por el concreto. Si se produce acumulación, los lanzadores deben detenerse inmediatamente y realizar los ajustes necesarios a la consistencia de la mezcla. La acumulación de concreto en la cara del refuerzo es una señal visual obvia de que una mezcla es demasiado rígida (Fig. 5).

Otras señales claramente visibles de material excesivamente rígido son también evidentes para aquellos que saben qué

Fig. 5: La evidencia visual de la acumulación de concreto en el refuerzo fue ignorada por el lanzador. Nótese los enormes vacíos que se han formado detrás del acero.

Fig. 6a: El valle que ocurre dentro del área de sombra es fácil de ver. El valle detrás del refuerzo es evidencia visual de que la mezcla es demasiado rígida.

Fig. 6b: Evidencia adicional de valles visible desde el lado cimbrado.

buscar. La superficie receptora dentro de las áreas de sombra debe llenarse a través del flujo viscoso dentro del mortero de la zona de impacto. Durante la colocación, los lanzadores deben entrenar sus ojos para estudiar las áreas de sombra. Observe el relleno completo de las áreas de sombra a medida que se aplica el material. Si se forma un valle visible o una línea vacía (identificada como "camino" por el autor) directamente detrás del refuerzo dentro del área de sombra, esto es evidencia clara de que la pasta de la mezcla es demasiado rígida y no está fluyendo completamente en las áreas de sombra. El lanzador debe detenerse y ajustar la consistencia de la mezcla antes de continuar
(Fig. 6a y 6b).

La señal visual más fácil para la consistencia adecuada debe considerarse como la señal visual más básica del lanzador y otros trabajadores de que la consistencia de la mezcla está, o no, dentro del rango correcto. Este indicador visible fácil de identificar dentro de la superficie de concreto recién aplicada revelará la prueba exacta de lo que ocurre cuando los materiales a alta velocidad chocan dentro del mortero en desarrollo. En general, los agregados grandes y pequeños constituyen entre el 70 y el 80% del volumen de una mezcla de concreto lanzado. La pasta es una fracción mucho menor del volumen total. Aunque menos abundante, la pasta es el elemento más cohesivo de la mezcla y se adhiere fácilmente al impacto. Puesto que las acciones dentro de la boquilla hacen que las partículas de los agregados de la mezcla se separen de la pasta, en el momento del impacto, la consistencia de la pasta tendrá la mayor influencia en las actividades de los agregados cuando golpeen el mortero. Cuando la consistencia de la pasta es correcta, la superficie de concreto lanzado recién aplicada aparecerá principalmente como una capa de pasta brillante. Aunque los agregados son mucho más abundantes que la pasta, muy pocos serán visibles en la superficie del mortero.

¿Por qué sería así? Una pasta con la consistencia adecuada será lo suficientemente fluida como para permitir que los agregados moviéndose rápidamente entren e incrusten profun-

Fig, 7. The ideal slump allows incoming aggregates to deeply embed within the puddle rather than remaining on the surface.

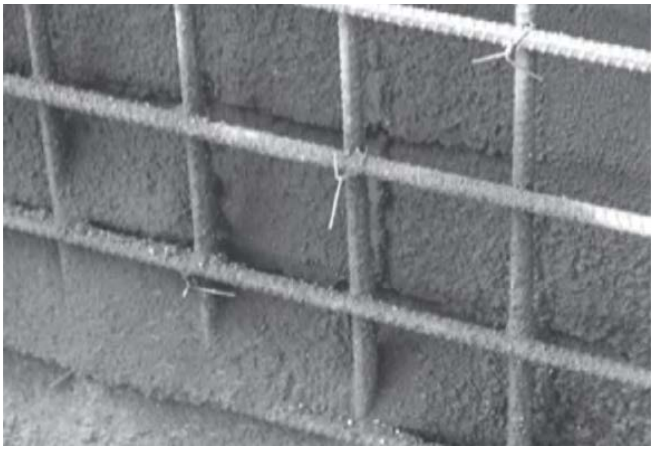


Fig.8. Freshly applied materials with a dull, rocky, or sandy surface is evidence of a mixture that is too stiff.

Fig. 9. Freshly applied materials with few visible aggregates at the surface is the visual indicator of a well-chosen slump.

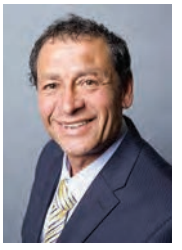
NOZZLEMAN CHECKLIST:

- Important visual cues help the Nozzleman select the correct placement consistency.
- Remember, YOU are in charge of the proper selection of slump.
- Study the impact area's puddle during placement.
- Visually validate that materials are flowing into shadow areas.
- Monitor the area behind the reinforcements for signs of tracking.
- Stop and immediately increase the slump if materials build upon the face of reinforcements.
- Work within a slump range that results in a glossy paste surface (not dull, sandy, or rocky) on the puddle.
- A glossy paste surface is evidence that the paste is both sufficiently fluid to allow the aggregate particles to embed, and flows into the shadow areas.

many incoming aggregates will bounce off the stiff surface, causing excessive rebound. Using a mixture that is too stiff will always result in a surface that appears rocky or sandy rather than glossy.

During application, a dull, sandy, or rocky surface is evidence that the mixture lacks fluidity, and may not reliably flow into shadow areas. A freshly applied shotcrete surface lacking a glossy or shiny paste layer is a powerful visual indicator that temporary viscous flow, caused by impact-derived oscillations is not occurring. Nozzlemen must stop immediately and increase the slump or attaining acceptable consolidation will not be possible (Fig. 8).

Currently, many contract documents still specify a maximum slump or slump range. However, we are starting to see specifications recognize slump's diminished role in strength development and have relaxed or eliminated slump ranges for shotcrete placement. Be aware that some shotcrete specifications citing a slump range as a strength indicator still exist. It is important to remember that proper shotcrete consistency can only be properly chosen through understanding and identifying the important visual cues of the correct slump.



*ACI Certified Nozzleman **Oscar Duckworth** is an ASA and American Concrete Institute (ACI) member with over 25,000 hours of nozzle time. He has worked as a nozzleman on over 2500 projects. Duckworth is currently an ACI Examiner for the wet- and dry-mix processes. He was a former member of ASA's Board and is Chair of ASA's Education & Safety Committee. He continues to work as a shotcrete consultant and certified nozzleman.*

Fig. 7: el revenimiento ideal permite que los agregados entrantes se incrusten profundamente dentro del mortero en lugar de permanecer en la superficie.

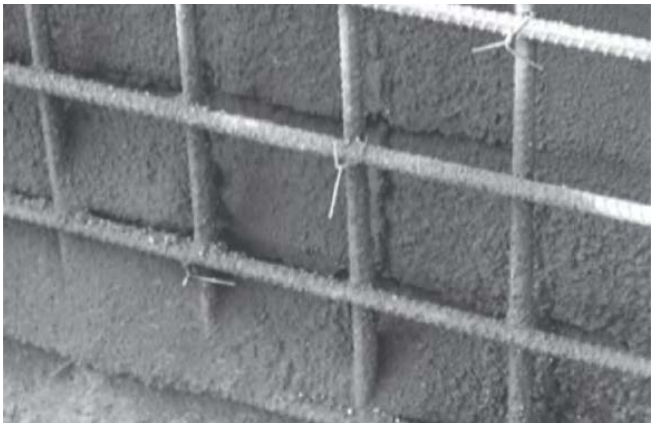


Fig.8: Los materiales recién aplicados con una superficie opaca, rocosa o arenosa son evidencia de una mezcla que es demasiado rígida.

Fig. 9: Los materiales recién aplicados con pocos agregados visibles en la superficie son el indicador visual de un revenimiento bien elegido.

LISTA DE VERIFICACIÓN DEL LANZADOR:

- Las indicaciones visuales importantes ayudan a Lanzador a seleccionar la consistencia de colocación correcta.
- Recuerde que está a cargo de la selección adecuada del revenimiento.
- Estudie el mortero del área de impacto durante la colocación.
- Validar visualmente que los materiales están fluyendo hacia áreas de sombra.
- Controle el área detrás del refuerzo en busca de señales caminos o valles
- Detenga y aumente inmediatamente el revenimiento si los materiales se acumulan sobre la superficie del refuerzo.
- Trabaje dentro de un rango de revenimiento que dé como resultado una superficie de pasta brillante (no opaca, arenosa o rocosa) en el mortero.
- Una superficie de pasta brillante es evidencia de que la pasta es lo suficientemente fluida como para permitir que las partículas agregadas se incrusten y fluya hacia las áreas de sombra.

damente dentro de la capa de pasta dejando una superficie de pasta brillante (Fig. 7). Si la consistencia de la pasta carece de fluidez, sólo los agregados que se mueven más rápido pueden entrar en el mortero. Los agregados que se mueven a una velocidad más lenta sólo se incrustarán ligeramente o se pegarán a la superficie del mortero. Peor aún, muchos agregados entrantes saltarán de la superficie rígida, causando un rebote excesivo. El uso de una mezcla demasiado rígida siempre dará como resultado una superficie opaca rocosa o arenosa en lugar de brillante.

Durante la aplicación, una superficie opaca, arenosa o rocosa es evidencia de que la mezcla carece de fluidez, y puede no fluir confiablemente en áreas de sombra. Una superficie de concreto lanzado recién aplicada que carece de una capa de pasta brillante es un indicador visual potente de que no se produce un flujo viscoso temporal, causado por oscilaciones derivadas del impacto. El lanzador debe detenerse inmediatamente y aumentar el revenimiento o no será posible alcanzar una consolidación aceptable (Fig. 8).

Actualmente, muchos documentos de contrato todavía especifican un rango máximo de revenimiento. Sin embargo, estamos empezando a ver las especificaciones reconocer el papel disminuido del revenimiento en el desarrollo de la resistencia y han relajado o eliminado los rangos del revenimiento para la colocación de concreto lanzado. Tenga en cuenta que todavía existen algunas especificaciones que citan un rango de caída como indicador de resistencia. Es importante recordar que la consistencia apropiada del concreto lanzado sólo puede ser escogida apropiadamente a través de la comprensión e identificación de las señales visuales importantes del revenimiento correcto.

*Certificado por CI Nozzleman **Oscar Duckworth** es miembro del Instituto de Concreto (ACI) ASA y Americancon más de 25.000 horas de tiempo de boquilla. Ha trabajado como noble en más de 2500 proyectos. Duckworth es actualmente un examinador ACI para los procesos de mezcla húmeda y seca. Es miembro de la Junta Directiva de ASA y Presidente del Comité de Educación de ASA. Continúa trabajando como consultor de escopeta y como nozzleman certificado.*

Eden Innovations LLC

Eden Innovations is dedicated to clean technology solutions that make life better and the planet more sustainable. In 2015, Eden Innovations launched a revolutionary chemical admixture named EdenCrete®, designed to improve shotcrete placement, performance, and durability. At the core of EdenCrete® are carbon nanotubes (CNT) produced by Eden and their performance in shotcrete is staggering. EdenCrete® improves fresh and hardened properties of shotcrete.

In fresh shotcrete, EdenCrete® creates a creamier paste that moves more easily through the pump, hose, and nozzle. Segregation and sand packing are mitigated, and shotcrete pumping pressure can reduce from approximately 3800 lb/in^2 (26 MPa) to 2400 lb/in^2 (17 MPa). Using EdenCrete® in shotcrete with lower pumping pressure has allowed contractors to continue using pump equipment with more than 7000 service hours. This allows contractors to delay investing in newer equipment. Because pumps can be operated at lower hydraulic pressure, safety and fuel efficiency are improved, allowing more shotcrete to be applied for a fixed amount of fuel.

Out of the nozzle, EdenCrete® improves the concrete's rheology, increasing adhesion and stacking very well, thus significantly reducing dust and waste from rebound. Nozzlemen have commented on how little rebound is on their boots and the ground when they finish shooting with EdenCrete®. Jobsite efficiency is improved since there is little to no downtime necessary to disconnect and clear clogged hose lines. The reduced level of dust improves jobsite safety and air quality. For indoor or enclosed spaces, the reduced level of dust accelerates project schedules because two pumps and nozzlemen may operate simultaneously within the same space.

Since shotcrete with EdenCrete® adheres extremely well, nozzlemen find they can cover soil nails, bolts, and steel plates without having to stack from the ground upward. Additionally, the freshly shot material can be screeded or cut more easily without sagging, allowing for thicker joint patterns and transitions for stamped or aesthetically finished applications.

Shotcrete mixtures can be optimized to use a lower w/cm while still achieving design strength. Customers can potentially use a single shotcrete mixture design with EdenCrete® for both architectural and structural applications, eliminating the need for two mixture designs on a project.

For the Colorado Dept. of Transportation's (CDOT's) Central-70 project, EdenCrete® was specified for a 12-mile (19 km) rehabilitation of the highway and bridges north of Denver. Thorcon Shotcrete & Shoring is the contractor for the project and Kiewit is the general contractor.

For the Central-70 project alone, EdenCrete® was used to optimize the originally specified 5000 lb/in^2 (35 MPa)

shotcrete mix to use 152 lbs/yd^3 less cement. Across the entire 6000 yd^3 (4600 m^3) of shotcrete applied on project, the EdenCrete® shotcrete mix saved the producer 500 tons (450 tonnes) of cement and 32 fewer tankerloads of cement delivered. Overall, the use of the EdenCrete® enhanced shotcrete mixture saved 400 tons (360 tonnes) of carbon dioxide from the environment and the project footprint. Mike Klemp (Thorcon – Owner) now uses EdenCrete® on all Thorcon Colorado projects since using the admixture during the Central-70 project.

EdenCrete® is used in a variety of shotcrete applications, from DOT to residential and commercial, for shoring, soil-nailed walls, and underground expansions, as well as for pools, hardscapes, and more aesthetically pleasing architectural jobs. The EdenCrete® liquid admixture is added to the shotcrete during the batching process. Dosed like other admixtures, EdenCrete® can be used in dry batch, central plant, and volumetric batching processes.

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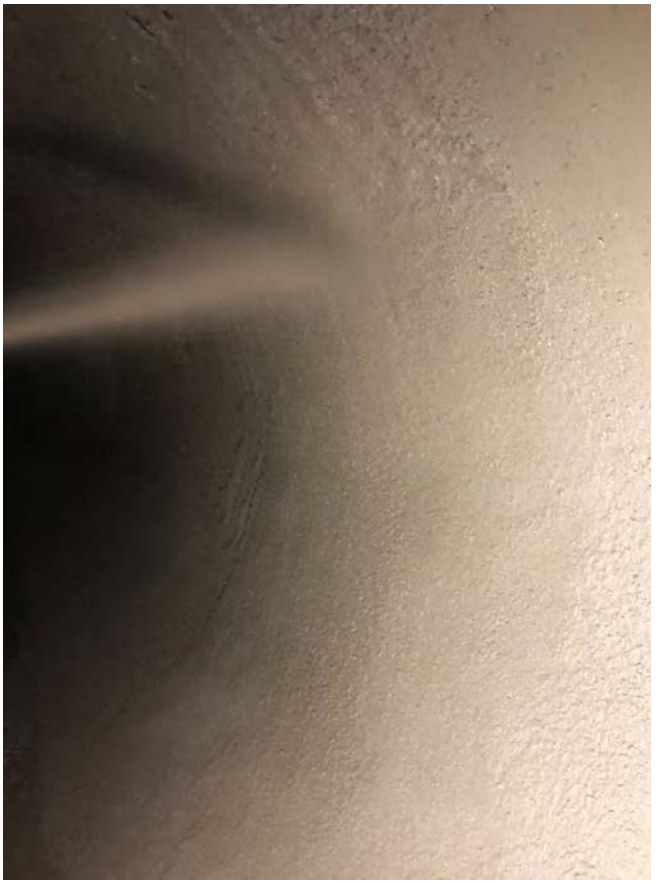
SPINIELLO

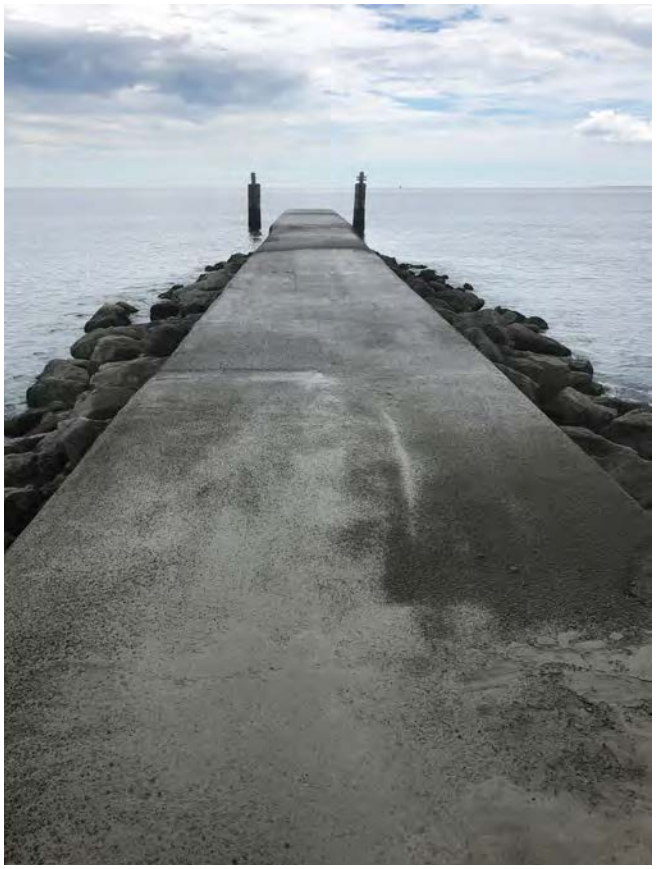
APPROACHING 100

Spiniello Companies has excelled in developing infrastructure in North America and around the world since 1922. Virgil Spiniello founded the company and began providing utility and heavy construction services in New Jersey and the surrounding states. The company expanded its operations to include cleaning, repairing, and replacing underground pipelines during the construction boom of the mid-1940s. The first pipeline Spiniello rehabilitated with cement mortar lining remains in service today! In the 1980s, Spiniello continued to expand its trenchless focus across the United States and Canada and introduced cured-in-place lining (CIPP) and slip lining into its repertoire. In 1998 Emil Solimine acquired the company, and more recently, his son EJ Solimine took on the role of President in 2015. The Solimine family has continued to evolve Spiniello's offerings, focusing on shotcrete solutions. Our pipeline rehabilitation technologies and replacement processes may have expanded and changed; however, our mission of renewing the past and building the future remains the same as our firm nears its 100th year in business.

SPINIELLO'S SHOTCRETE PROCESS

Perfecting shotcrete rehabilitation has allowed us to rehabilitate pipelines with maximum bonding effectiveness and durability that translates to those pipes benefiting communities for years to come. Our shotcrete process employs the traditional application of a concrete mixture pneumatically conveyed at a high velocity through a hose. Spiniello crews line pipes of various sizes, including 90 in. (2300 mm) in diameter and beyond. This unique process is also utilized for non-pipeline-related concrete restoration projects. Our coast-to-coast operations have the equipment and expertise to deliver a variety of shotcrete solutions and can also provide an array of complementary services to shotcrete applications.





GLOBAL SERVICES

Spiniello may be rooted in New Jersey, but we are committed to addressing the problem of aging infrastructure across America and beyond. Spiniello has fully operational facilities in New Jersey, Maryland, and our sister company, Spiniello Infrastructure West, Inc, is headquartered in California. Our growing reach has allowed us to not only rebuild areas from coast to coast, but internationally as we have completed projects around the globe. Spiniello looks forward to growth and future operation as a premier contractor blazing the trail of trenchless rehabilitation.

We offer a multitude of trenchless rehabilitation and replacement services to ensure challenges are overcome with the best possible solutions:

- Cured-in-Place Lining
- Slip Lining
- Bypass Pumping
- Pipe Bursting
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- Geopolymer
- Shotcrete
- Conduit Installation
- Water and Sewer Installation
- Heavy Construction

SAFETY

At Spiniello, safety is more than an obligation; it's a habit. For this reason, we stress that productivity and safety go hand in hand and ensure accident prevention is an integral part of every operation. We provide a range of safety training for our employees, open our jobsites to periodic inspections, and document our safety policies.

SPINIELLO COMPANIES

354 Eisenhower Pkwy
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www.spiniello.com

2021 ASA OFFICERS AND BOARD OF DIRECTORS APPOINTMENTS

ASA announced its new officers and Board members, elected by the membership, during the virtual Awards Celebration this past February. Lars Balck, Consultant, has graciously returned to serve another 1-year term as ASA President. Ryan Poole, Consultant, assumes the position of Past President. To complete the Executive Committee, the ASA membership also elected the following for 1-year terms: Axel Nitschke, WSP USA, as Vice President; Mason Guarino, South Shore Gunite Pools & Spas, Inc., as Secretary; and Frank Townsend, III, Patriot Shotcrete, as Treasurer.


Balk


Poole


Nitschke


Guarino


Townsend


Bittner


Geers


Robertson

Newly elected ASA Director Dennis Bittner, The Quikrete Companies, will serve a 1-year term, completing the position vacated by Frank Townsend as he moved up to the Executive Committee. The following Directors have been elected to serve 3-year terms: William "Bill" Geers, Bekaert Underground Solutions; Ryan Oakes, Clearwater Construction Group, Inc., Revolution Gunite, and Revolution Pool Finishes; and Kevin Robertson, U.S. Markets for Sika - Shotcrete, Tunneling and Mining.

To support the mission and work of ASA, the following individuals serve as Chairs of ASA Committees: Marcus von der Hofen, Coastal Gunite Construction Company, Contractor Qualification Committee; Oscar Duckworth, Valley Concrete Services, Education & Safety Committee; Dennis Bittner, The Quikrete Companies, Marketing Committee; Jason Myers, Dees-Hennessey Inc., Membership Committee; Mason Guarino, South Shore Gunite Pools & Spas, Inc., Pool and Recreational Committee; Lihe "John" Zhang, LZhang Consulting & Testing Ltd., Technical Committee; and Axel Nitschke, WSP USA, Underground Committee. Committee meetings are open to the public and ASA welcomes and encourages the participation.

2020-2021 ASA GRADUATE SCHOLARSHIP AWARDED

The 2020-2021 ASA Graduate Scholarship was awarded to Florent Pastorelli. He received a stipend of $3000 (USD) for tuition, residence, books, and materials. His bio and a summary of his research project can be found on page 14 of this issue. Our annual graduate scholarship provides a scholarship to a Laval University graduate student engaged in shotcrete research. Evaluation of the entries includes a review of the relevance of the project's objectives with regards to the needs of the shotcrete industry, quality, originality and scope of the research project, and integration of sustainability elements in the project. Laval University has been a leader in shotcrete research and ASA recognizes and supports their contributions to the industry through this scholarship and funding of other research needs.

CALL FOR PRESENTATIONS FOR ASA'S SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE

SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE

February 27 – March 1, 2022, at the Sonesta Hotel & Resorts | Hilton Head, SC. The Call for Presentations is currently open. Brief abstracts of your proposed presentation should be emailed to Charles.Hanskat@Shotcrete.org. ASA's Shotcrete Conventions provide a unique opportunity for leaders in the shotcrete industry to receive a variety of shotcrete-focused seminar options while meeting key players in the industry and learning from each other. The Convention will also host ASA's Annual Outstanding Shotcrete Project Awards Banquet, as we return to an in person celebration!

CALL FOR ENTRIES FOR 2021 OUTSTANDING SHOTCRETE PROJECT AWARDS PROGRAM

asa OUTSTANDING SHOTCRETE PROJECT Awards

ASA is accepting applications for the 17th Annual Outstanding Shotcrete Project Awards program. These awards confirm and demonstrate the exceptional advantages of shotcrete placement of concrete. Awards are bestowed in the following six categories: architecture/new construction, infrastructure, international projects, pool & recreational, rehabilitation & repair, and underground. The deadline for submissions is October 1, 2021. Visit www.shotcrete.org/ASAOutstandingProjects, or contact us at info@shotcrete.org to submit your project.

CONGRATULATIONS TO ACI'S NEW FELLOWS AND OUR VERY OWN JONATHAN DONGELL

Jonathan E. Dongell is current Director of Research and Development at Pebble Technologies Inc., Scottsdale, AZ, USA. He is the past Research Director at General Cement and Concrete Technologies, past President of Whitestone Cement Company and Universal White Cement Company, and past owner of Precision Plastering Company and Custom Precision Pools. He has worked in the cement and concrete construction industry for over 40 years.

Dongell is a member and past Chair of ACI Committee 524, Plastering, and a member of ACI Committees 201, Durability of Concrete; 225, Hydraulic Cements; 232, Fly Ash in Concrete; 308, Curing Concrete; 350, Environmental Engineering Concrete Structures; and 506, Shotcreting, as well as the Concrete Research Council. He serves as a member of the Board of Directors and as Chair of the Technical Advisory Committee of the National Plasterer's Council. He is also a member of the Board of Directors of the American Shotcrete Association (ASA) and a voting member of ASA's Pool & Recreational Shotcrete Committee. He is a voting member of ASTM Committees C01, Cement, and C09, Concrete and Concrete Aggregates, as well as numerous subcommittees of both.

CONGRATULATIONS TO MARC JOLIN - RECOGNIZED FOR OUTSTANDING LEADERSHIP OF ACI COMMITTEE 506, SHOTCRETING

Marc Jolin, FACI, has been a Professor in the Department of Civil and Water Engineering at Laval University, Québec City, QC, Canada, since 2005 and is a member of the Research Centre on Concrete Infrastructures (Centre de recheche sur les infrastructures en bétons—CRIB). He received the 2017 ACI Certification Award and the 2009 ACI Young Member Award for Professional Achievement. He became a Fellow of ACI in 2010. He is a member and past Chair of ACI Committees 506, Shotcreting, and C660, Shotcrete Nozzleman Certification. He is Secretary of ACI Committee C661, Shotcrete Inspector Certification. Jolin is also an active ACI Examiner for Shotcrete Nozzleman Certification (wet- and dry-mix processes) and an active member of the American Shotcrete Association (ASA). Jolin was a past Technical Editor and frequent contributor for Shotcrete magazine. He received his bachelor's degree and MSc from Laval University in 1994 and 1996, respectively, and his PhD in civil engineering from the University of British Columbia, Vancouver, BC, Canada, in 1999.

asa

The Art of Shotcrete WINNERS

Congratulations to our **Art of Shotcrete** winners! Thank you all for submitting photos in the 4th Quarter 2020 judging of the Art of Shotcrete.

Project: Main Street Substation Rebuild for Orange and Rockland Utilities
Cruz Concrete & Guniting
Port Jervis, NY
Email: cruzconcrete@gmail.com
Phone Number: (732) 223-2206
IG: @cruzshotcrete

Project: Descending Water
Drakeley Pool Company
Bridgewater, CT
Contact Person: Jesse McDowell
Email: info@drakeleypools.com
Phone Number: (860) 274-7903
IG: @drakeleypools

Project: Shotcrete placed and carved at soldier pile retaining walls.
TRZA
Contact Person: Travis Johnston
Email:
Phone Number:
IG: @trza

SUBMIT YOUR ENTRY TODAY! JUST ADD @ARTOFSHOTCRETE TO YOUR NEXT INSTAGRAM POST TO SUBMIT YOUR PHOTO. SUBMISSIONS CLOSE AT THE END OF EACH QUARTER.

american shotcrete association | asa

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mhackebeil@relmcoinc.com

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Primary Contact: Joshua Bentley
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Legazpi City, Phillippines

SURAJ BHOSALE
S V National Institute of Technology
Surat, Gujarat, India

INTERESTED IN BECOMING A MEMBER OF ASA?

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

EUCLID CHEMICAL PRODUCTS FEATURED IN THE NEW AMERICAN HOME'S INNOVATIVE DESIGN

Euclid Chemical, a leading manufacturer of concrete and masonry construction products, was proud to partner with the National Association of Home Builders on the 2021 New American Home to provide flooring solutions for the 37th annual project. Located in Winter Park, Florida, the New American Home showcases state-of-the-art materials in home efficiency, construction, and design.

Euclid Chemical's products have been incorporated into this year's "concrete home," offering resilience to high-wind events and fire. Its Level Top PC-AGG self-leveling overlayment was used in white throughout the first floor's main living area, office, and bathrooms as a modern, polished flooring solution with accents of charcoal for aesthetic purposes. Offering excellent adhesion and long-term durability, it features micro-fibers that prevent shrinkage and cracking.

Additionally, Euclid Chemical's Increte Granite Coat flooring system was installed in the home's three-car garage. Featuring a smooth, high-gloss appearance, this vinyl-chip epoxy coating provides a chemical- and abrasion-resistant surface that is easy to maintain.

The 2021 New American Home features a variety of trending design concepts, efficient construction methods and innovative products, representing the highest standards for residential design and construction. As the official show home of the annual International Builders' Show, this home will proudly showcase the latest products and technologies from the Leading Suppliers Council (LSC), part of the National Association of Home Builders of America.

PUTZMEISTER'S NEW MIXKRET 6 MIXER SUCCESSFULLY COMPLETES TRIALS AT CHUQUICAMATA UNDERGROUND MINE

Launched last year, the new higher capacity low-profile mixer, Mixkret 6, which offers a mixing and concrete capacity of 6 m^3 (8 yd^3) has completed a series of demanding tests at the Chuquicamata mine in Chile, the world's largest open-pit copper mine that has now been converted to underground.

Fig. 1 & 2: Mixkret 6 during tests at the Chuquicamata mine, Chile

Like the entire Mixkret family, this equipment is characterized by its robustness and maneuverability, making it ideal for tough mining projects. The Mixkret 6 has a powerful engine, that allows the unit to reach 25 km/hr (16 mi/hr). Thus, the Mixkret range of equipment is ideal for those mining projects where the demands are greater. For this trial, Polpaico, one of the main concrete suppliers in Chile, was commissioned to assist Putzmeister. Retention tests were mainly carried out on the long downhill slopes at Chuquicamata, testing different configurations, and on various slopes both with the machine loaded and empty. The Mixkret 6 mixer system has different automatic modes, due to its continuously variable hydrostatic transmission, along with an ICVD motor and electronically controlled hydraulic pump. In addition, the operator can constantly monitor the speed, slope, and operating mode of the unit on the control panel in the cab.

Fig. 3: Mixkret 6 tested at Chuquicamata together with Polpaico

The variable hydrostatic transmission system is characterized by its simple operation for optimum performance and ease of maintenance. This provides the advantages of reduced consumption, less noise, less pollutants and lower maintenance and operating costs.

During the trial, Putzmeister Mixkret 6 also performed front-end discharge to the robotic shotcrete equipment.

Fig. 4 & 5: Mixkret 6 inside the Chuquicamata underground mine discharging concrete at the front.

Fiber-Reinforced Shotcrete—Guide (ACI PRC-506.1-21)

Reported by ACI Committee 506, Shotcreting Simon Reny, Chair; James A. Ragland, * Secretary; Lars F. Black, Louis-Samuel Bolduc, Chris D. Breeds, Wern-Ping Nick Chen,* Scott R. Cumming, William T. Drakeley Jr., Randle M. Emmrich, Charles S. Hanskat,* Marc Jolin, Mark R. Lukkarila, Axel G. Nitschke,* Ryan Oakes, Ryan E. Poole, Raymond C. Schallom III,* William L. Snow Sr., Jason P. South, Lawrence J. Totten, Frank Townsend, Marcus H. von der Hofen, Ezgi Wilson, Peter T. Yen, and Lihe Zhang,* Members; Jean-François Dufour, Richard A. Kaden, Dudley R. Morgan,* H. Celik Ozyildirim, Harvey W. Parker, and Philip T. Seabrook, Consulting Members. * Subcommittee members who prepared this guide. The committee would like to thank A. Gagnon, Subcommittee Chair.

Abstract: This guide describes the technology and applications of fiber-reinforced shotcrete (FRS) with a focus on synthetic and steel macrofibers. It serves as a bridge between information given in documents reported by ACI Committee 506 and ACI Committee 544, Fiber Reinforced Concrete. Proportions of typical mixtures, batching, mixing, and application procedures are described, including modification of mixture proportions and equipment needed for FRS. General performance criteria of FRS, particularly post cracking flexural strength and toughness, are described along with other typical properties and benefits, such as increased resistance to shrinkage cracking and impact resistance.

ASCC Announces the 2020 Member Owner/Executive Safety Award

The Safety and Risk Management Council (SRMC) of the American Society of Concrete Contractors (ASCC), St. Louis, is pleased to announce that Ken Fender, Senior Vice President, Baker Concrete Construction, Washington D.C., received the ASCC Member Owner/Executive Safety Award for 2020, presented September 23 at the association's Annual Conference. The purpose is to annually recognize one owner/executive of a contractor member company who displays a clear focus and passion for safety and provides the leadership that creates a best-in-class safety culture.

In their nomination, Fender's co-workers had this to say: "He believes that absolutely no injury is acceptable to himself or his co-workers. He challenges all Baker D.C. employees, management and craft, to increase awareness of safety at home and work.

"In 2018 Fender promoted an operational excellence initiative to improve SSQP (Safety, Speed, Quality & Production). Collectively Baker supervisors underwent 8,000+ hours of safety training and immediately put that knowledge to use. Leaders became more visible and engaged in projects. The total of recordable injuries decreased by 57% and the Recordable Incident Rate decreased by 55+%, while Baker D.C. experienced record revenue and profit."

The Safety and Risk Management Council (SRMC) is a specialty council dedicated to making ASCC contractors the safest in the industry. The Council board consists of safety and insurance professionals from all aspects of the concrete contracting industry. The group meets three time a year and spends countless additional hours overseeing safety matters for the organization. Council activities include publication development, review and monitoring of ASCC events and materials for safety compliance, member education, a safety awards program, and a safety/insurance hotline.

The ASCC is a non-profit organization dedicated to enhancing the capabilities of those who build with concrete and to providing them a unified voice in the construction industry.

Members include concrete contracting firms, manufacturers, suppliers and others interested in the concrete industry, such as architects, specifiers and distributors. There are approximately 740 member companies in the United States and 13 foreign countries.

For more information, visit www.ascconline.org or call the ASCC office at (866) 788-2722.

ASCC/TCA 1st Safety Summit

The American Society of Concrete Contractors (ASCC), St. Louis, MO, and the Tilt-Up Concrete Association (TCA), Mt. Vernon, IA, have announced the first ASCC/TCA Safety Summit, postponed from 2020, will be held November 12, 2021, in Houston, TX. This new event is designed to bring together those responsible for safety in their companies for a day of information exchange. "Our hope is that safety professionals from ASCC and TCA members across the country will come together to share best practices and their most daunting challenges," says Bev Garnant, executive director, ASCC.

The summit will open with keynote speaker, Tim Manherz, operations manager, Encore Concrete Construction, Spring, TX, winner of the prestigious ASCC Owner/Executive Safety Award for 2019 and a past president of TCA. The remainder of the day will be devoted to breakout sessions, the heart of the program. Attendees will move from table to table to delve into a wide range of hard-hitting topics selected to foster spirited discussion. "The goal is for every attendee to leave armed with new ideas and contact information from fellow members, eager to continue the conversations, and with renewed energy for keeping their companies safe," says TCA executive director Mitch Bloomquist.

The ASCC is a non-profit organization dedicated to enhancing the capabilities of those who build with concrete, and to providing them with a unified voice in the construction industry. Members include concrete contracting firms, manufacturers, suppliers and others interested in the concrete industry, such as architects, specifiers and distributors. There are approximately 740 member companies in the United States and 13 foreign countries.

For more information visit the website at www.ascconline.org or call (866) 788-2722.

SHOTCRETE CALENDAR

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

AUGUST 24 – 26, 2021	**SDC Technology Forum 50** Virtual Conference **www.acifoundation.org**
SEPTEMBER 13 – 15, 2021	**MINExpo INTERNATIONAL® 2021** Las Vegas Convention Center | Las Vegas, NV **www.minexpo.com**
SEPTEMBER 13 – 15, 2021	**Breakthroughs in Tunneling** University of Denver | Denver, CO **www.tunnelingshortcourse.com**
OCTOBER 16, 2021	**ASA's Fall Committee Meetings** **www.shotcrete.org/News/Calendar** **LOCATION TBD | Atlanta, GA**
OCTOBER 17 – 21, 2021	**ACI Concrete Convention – Fall 2021** Hilton Atlanta Downtown **www.concrete.org**
NOVEMBER 16 – 18, 2021	**International Pool | Spa | Patio Expo** Kay Bailey Hutchison Convention Center | Dallas, TX **www.poolspapatio.com**
NOVEMBER 16, 2021	**ASA Shotcrete Nozzleman Education @ PSP 2021** Kay Bailey Hutchison Convention Center | Dallas, TX Required for New & Nozzlemen-in-Training pursuing ACI Certification **www.shotcrete.org/Events**
NOVEMBER 17, 2021	**Recognizing Quality Shotcrete @ PSP 2021** Kay Bailey Hutchison Convention Center | Dallas, TX **www.shotcrete.org/Events**
DECEMBER 5 – 8, 2021	**ASTM International Committee C09, Concrete and Concrete Aggregates** Atlanta Marriott Marquis | Atlanta, GA **www.astm.org**
JANUARY 18 – 20, 2022	**World of Concrete 2022** Las Vegas Convention Center | Las Vegas, NV **www.worldofconcrete.com**
JANUARY 19 – 22, 2022	**Southwest Pool & Spa Show 2022** Henry B. Gonzalez Convention Center | San Antonio, TX **www.swpsshow.com**
JANUARY 25 – 27, 2022	**2022 Pool & Spa Show in Atlantic City** Atlantic City Convention Center | Atlantic City, NJ **Thepoolspashow.com**
FEBRUARY 27 – MARCH 1, 2022	**2022 ASA Shotcrete Convention & Technology Conference** Sonesta Resort | Hilton Head, SC **www.shotcrete.org**
JUNE 17 - 24, 2022	**North American Tunneling Conference (NAT) 2022** Philadelphia, PA **www.natconference.com**
MORE INFORMATION	To see a full list, current updates, and active links to each event, visit www.shotcrete.org/calendar.

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SHOTCRETE FAQs

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

Question: *I am in the process of hiring a contractor to install a pool at my home. I have a long driveway, about 350 ft (100 m) and the pool will be constructed behind my house. The contractor wants to remove a substantial amount of plantings to allow the shotcrete truck to get closer to the pool area. How far can you reasonably pump shotcrete horizontally and what type/brand pump would be needed?*

Answer: Shotcrete placement conveys concrete materials through a delivery line that ranges from 1½ in. (38 mm) to 2½ in. (64 mm) in diameter. A 2 in. (50 mm) diameter at the nozzle is most common. Wet-mix shotcrete pumps wet concrete through the line. Dry-mix conveys dry concrete materials through the line and adds water at the nozzle to make concrete. Using proper concrete materials, equipment and placing techniques both wet-mix and dry-mix should provide high strength, durable concrete for your pool.

Wet-mix is more difficult to pump as it has more internal friction pushing the low-slump concrete through the line. Shotcrete contractors will try to minimize the delivery line length in wet-mix to make pumping easier and reduce the chance for plugs in the line. With proper planning, concrete mixture selection, and delivery line choices, wet-mix shotcrete can be pumped 500 ft (150 m) or more. The shotcrete contractor can increase the pumping distance by using steel pipe for most of the delivery line with rubber hose the last 50 to 75 ft (15 to 23 m), or using larger diameter hose or pipe and then reducing to the final size closer to the nozzle.

If the shotcrete contractor is using dry-mix (often called Gunite) they should easily be able to reach over 500 ft as the delivery hose is mostly full of air conveying the dry concrete materials. This means you don't have nearly the internal friction that would tend to cause plugging of the line, and thus allows for longer delivery lines.

Thus, if using wet-mix, check with the shotcrete contractor and see if they can make adjustments to their delivery lines to allow a greater pumping distance to accommodate your lot. If using dry-mix, they should have no problems running the hose to your back yard assuming they have enough hose.

Question: *We have shotcrete test panels, 12 by 12 by 6 in. (300 by 300 by 150 mm). My question is it OK to move the panels right after shooting to different location for initial curing or should the panels be left untouched for certain period of time at the spot of shooting?*

Answer: In normal weather conditions test panels should be undisturbed for at least 24 hours. In cold weather you must protect the panels from freezing and preferably keep the concrete surface temperature above 50 to 55 °F. That allows the young concrete to gain enough strength to tolerate movement. Also, your test panels are very small in comparison to current ACI 506.2 Specification for Shotcrete requirements that have a minimum of 16 by 16 by 5½ in. (400 by 400 by 140 mm) dimensions. When coring your smaller panels you should be sure to have the nearest edge of the core 3 in. (75 mm) from the sides to preclude the effect that rebound collection in the corners may cause.

Question: *I am working on a project that has existing tunnels made with shotcrete. I am needing to hang 12 in. (300 mm) duct and trying to figure out the best type or suggested anchors to use.*

Answer: Shotcrete is just a placement method for concrete. Shotcrete placement with proper materials and application techniques should provide monolithic concrete with a 28-day compressive strength of at least 4000 lb/in^2 (28 MPa). Thus, any systems that work in concrete should be fine. Either mechanically-fixed or epoxy-set anchors are commonly used in concrete. You should consult with the anchor suppliers for the size and type of anchor appropriate for your specific application.

DO YOU HAVE QUESTIONS ABOUT SHOTCRETE?

Submit an inquiry: ***www.shotcrete.org/products-services-information/technical-questions-submit/***

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