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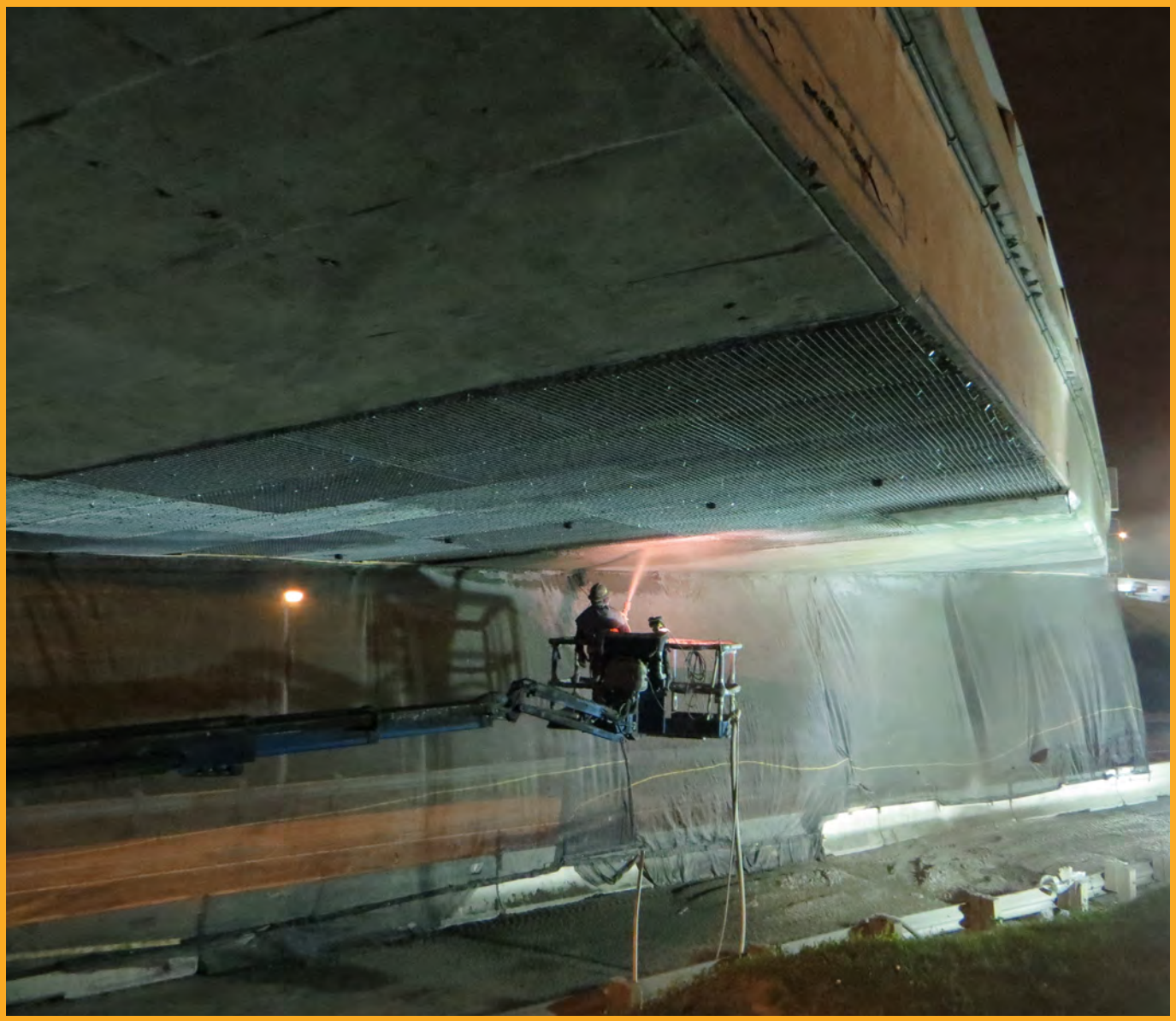

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FEATURES

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

DEPARTMENTS

Cementing a Legacy: Mark Bradford and Aaron Spohn present a guide to understanding municipal skatepark development. Pictured is skater Colton Woods. Photographer: Gage Thompson. Read about this Spohn Ranch Skateparks project on page 14.

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Learn from the Past, Create the Future

By Frank Townsend

One of shotcrete's great ambassadors was a man named George Yoggy. He did a three-part piece on shotcrete almost 20 years ago; if you haven't read it, it is worth the read, so I would recommend it. This article is going to be a CliffsNotes version of his work with some additional context from the present day. This is a fire hose of information, so take it slow.

At the beginning of the 20th century, the Lehigh Portland Cement Company was founded in Allentown, PA in 1897. Later, the American Concrete Institute (ACI) was established in 1904 to create standards for the concrete industry throughout the United States, followed by the Portland Cement Association which was formed in 1916. During this time, pneumatically placed concrete was needed and invented by Carl E. Akeley. The first machine was introduced at the Cement Show in New York in December 1910. In 1911, the construction industry trade journal, Engineering News-Record (ENR), created a list of construction applications using shotcrete which is still valid today. The term, "gunite," was trademarked by the Cement Gun Company in 1912.

By 1915, The Cement Gun Company had grown to become a large contracting organization, and their numerous application projects included the construction and repair of buildings, bridges, reservoirs, and dams; tunnels for sewer, rail, and water; and repair of furnace linings in steel production and other high-temperature process facilities. In the 1920s, the process spread through Europe, Asia, and Africa. After this, it caught fire on the West Coast in California.

Another figure was Pascal Paddock, an engineer and World War I veteran. He built dams and reservoirs and designed his first pool in the 1930s. Paddock of California became a national name with branch offices across the country, primarily in the warmer, pool-building climates. Paddock pools used the dry gunite method (now called dry-mix shotcrete) utilizing the cement gun and its components. Paddock is the father of all pool contractors.

The 1950s saw the introduction of dry-mix guns designed to shoot concrete mixtures containing coarse aggregate; wet-mix shotcrete equipment; and the rotary dry-mix gun—a continuous feed device. Machines were built to better place material from guns like the MiCon rig, which was introduced by Jack Ridley; the Meyco GM 57 rotor type machine in 1957; the Jetcrete gun; and the Bowl-type gun developed by Frank Reed in the 1960s. Also, during this timeframe, the development of the New Austrian Tunneling Method (NATM) in the late 1950s was established using shotcrete as a primary component. In 1950, ACI adopted the term "shotcrete" to describe the dry-mix process that had previously been called by the lengthy name "pneumatically-placed mortar" which was a major point in our timeline. The wet-mix process gained widespread acceptance in the United States and around the world. Shotcrete was then formalized by ACI assigning a new technical committee, ACI 506, to deal with all shotcrete-related topics around 1955. This was another major milestone in our timeline.

These new production methods and acceptance criteria spawned the grandfather companies of today's leaders: E.L. Culver of Indiana Gunite, Pressure Concrete, Crom Corp, and Superior Gunite, from which most companies today have lineage to. In the 1960s, they started making wet-mix shotcrete machines to handle the addition of aggregate up to 5/8 in (17 mm). in concrete mixtures. In the 1970s, the Army Corps of Engineers added to their specifications, and in 1982, ACI 506.3 Guide to Certification of Shotcrete Nozzlemen was published. This was the start of the brain trust which gathered requirements for certification.

In 1997, ACI C660 Shotcrete Nozzleman Certification Committee was formed, recognizing the need for standards in the growing use of shotcrete placement. Many members of ACI 506 and C660 committees, along with other industry leaders, saw a need for a trade association dedicated to shotcrete and formed the American Shotcrete Association (ASA) in 1998. The mission was to educate and train people in quality shotcrete. In 1999, the ASA Shotcrete Nozzleman Training Program was developed and implemented in 2001 with the formation of ACI C660 Shotcrete Nozzleman Certification Program; this was then followed by CP-60 Craftsman Workbook for ACI Certification of Shotcrete Nozzleman. Early in the 2000s, getting shotcrete accepted for structural concrete projects was a chore as most specifiers would only reference ACI 318 Building Code Requirements for Structural Concrete and Commentary, which was silent on the use of shotcrete placement. Shotcrete was covered in ACI 506 documents, but without reference in ACI

318, shotcrete placement was often boxed out of building construction.

Also in the early 2000s, under the tutelage of Marc Jolin at Université Laval in Quebec City, Canada started to include shotcrete in their Civil Engineering program. Jolin and associates took on several research projects to investigate and categorize shotcrete. This research found its way into ACI 506 standards, as well as into many ASA magazine articles. Though Université Laval is still the primary focus of shotcrete research, interest is building to find a United States counterpart to conduct shotcrete-specific research. Some schools that now have interest include Texas Tech, University of Kentucky, Texas A&M, and Western University.

2010 ASTM Standards established the testing methods for shotcrete. Nationwide ACI Certification took flight in the early 2000s with the acceptance of the ACI Shotcrete Nozzleman Certification program. There was a need for ACI-certified shotcrete nozzleman, as specifications started to require, but how do you get the hours needed to take the exams? A Nozzleman-in-Training program was added to the ACI Shotcrete Nozzleman Certification program and rolled out to help educate and usher in new nozzlemen, with a minimum of 25 hours on the nozzle, ensuring quality and safe shotcrete placement.

In the early 2000s, concrete mixture designs for shotcreting became highly refined using specialty admixtures like hydration control, rapid-set accelerators, and a wide variety of supplementary cementitious materials such as silica fume, fly ash, and slag. New generations of fibers, both steel and synthetic, were finding increased application in shotcrete. Synthetic macro fibers continue to evolve and can reach the same flexural toughness capabilities as steel fibers in heavy civil, tunneling, and mining applications. Techniques for successful shotcrete placement encasing large reinforcement in thick walls originated in California and are found today in almost all high-rise building foundations north of Los Angeles. Dust reduction technology for materials used in dry-mix shotcrete has seen recent advances and provides more use of shotcrete in environments that are sensitive to dust. Current ACI Codes and Specifications allow shotcrete placement to be used for critical infrastructure projects instead of form-and-pour.

Rapid-set, dry-mix shotcrete materials for mining and civil applications reaching 20 MPa (2900 psi) in 2 hours are now possible. They are changing the way shotcrete is used in mining cycles, when shooting against frozen ground conditions, in tunneling, and in emergency repairs. High-paste content and use of high-range water reducing admixtures allow for pumpability while maintaining low w/cm for enhanced strength and low permeability.

In 2019, shotcrete placement was directly included in ACI 318-19. Finally! Though, in many ways, shotcrete is cast-in-place concrete, it is definitely not form-and-pour. It took a lot of interaction with the ACI 318 committees and subcommittees by Charles Hanskat, as well as other ASA and ACI 506 members, to prove that shotcrete deserved to be included based on proven quality and long experience in successful

structural placements. With coverage in ACI 318-19, we saw more diverse structural concrete projects in the US and internationally where shotcrete's inherent benefits could be used.

Until 2021 shotcrete was included in the International Building Code (IBC), but in a very limited way. The 2021 IBC Code removed their shotcrete provisions and adopted the ACI 318-19 Code to cover shotcrete. This also opened more opportunities for shotcrete in building structures. The ASA Shotcrete Contractor Qualification program was introduced and is currently on the rise. This is a great tool for engineers and specifiers who don't know as much about shotcrete to have a system to vet contractors in advance.

ASA Shotcrete Inspector education and ACI certification rolled out in Fall 2019 and are catching on with DOTs, engineers, and testing labs nationwide. Watch the growth over the next 5 years. Expansion of certifications and education globally boomed in and around 2020.

2023 is seeing the name change in our ACI committees from Nozzleman to Shotcreter. Yes, it hurts the old school mentality people, but today, we have women who are ACI-Certified Nozzlemen, which is great! This will take time to roll out, but it is reflective of progress.

The future in front of us holds the advancement of UHPC (Ultra High-Performance Concrete), ACI pool shotcreter certification, and shotcreter certification for remotely manipulated applications widely used in tunneling and ground support. As shotcrete is used around the world, ASA and ACI are working to coordinate with EFNARC to create a certification for operators of remotely manipulated nozzling equipment with attention to the quality of placement as well as to safety.

Today, our industry is often faced with challenges by the engineering community to provide data that supports the quality and properties of the shotcrete process. There is a generous history in ASCE Proceedings, and in project case studies beginning in 1912 and continuing into the 1930s. What we call shotcrete today is perhaps the most unique and technologically advanced concrete construction method available to us. It is now our job to carry the torch and advance.

George was one of many great ambassadors in this industry. Look through time, and you'll see champions advancing this industry in every era; today we have Charles Hanskat, our Executive Director and Technical Director. I may be dating myself but watch Charlie's Angels —our Charles is the box that has the answers and focuses the team on its missions. We just won a huge mission—being directly included in ACI 318-19. Who is the next champion for advancing shotcrete broadly throughout the concrete construction marketplace? And the one after that? Our mission is to educate and promote good shotcrete. That means advancing and improving with the times. The point is this — getting involved and active in ASA is crucial. ASA's work in harnessing the experience and expertise of all those with a common interest in advancing the use of shotcrete continues to raise the bar for quality shotcrete placement. Your investment of time and resources is an investment in the growth of the industry and your business. If you're not involved, sign up NOW! What is the next great invention or advancement in our shotcrete world? It is up to you.

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Underground Shotcrete Short Course at RETC 2023

By Christoph Goss, Ph.D., PE, PMP, F.ASCE, ASA Underground Committee Chair

As one of the ASA/ACI Examiners for Shotcrete Nozzlemen Certification, I have been amazed with all the different kinds of projects that shotcrete is used for. I have met contractors that specialize in pools, skate parks, mining, tunneling, foundations, domes, soil nail walls, structural walls, bridge repair, building repair, rock facades, hydraulic structures, and more. I have also realized that, while many topics apply across the board, many others are market specific. For example, remotely manipulated nozzle shotcrete placement and rapid-set accelerator are common in underground applications, but rarely used anywhere else. High performance dry-mix materials are critical for bridge repair but often irrelevant for soil nail walls. Smoothness and finishing are really important in pools but not in slope repair. You get the idea.

Outreach and education are strategic goals for ASA and for each of our committees. How to do it best is always a question. There have been 2 to 3 day short courses covering all aspects of underground shotcrete. In the last decade, these have been put on by the Colorado School of Mines and more recently the Deep Foundations Institute. Attendance had been decent, but many companies have struggled to justify sending employees away for that long when only some portion of the courses were relevant.

In the summer of 2023, the ASA Underground Committee held a one-day, short course at the start of the SME Rapid Excavation and Tunneling Conference. The topic was shotcrete use in tunneling and underground work. The target audiences for each session were conference attendees who were interested and could easily justify arriving a day early.

Session	Presenter
Welcome	Christoph Goss
Overview of Shotcrete	Charles Hanskat
Mix Design	Charles Hanskat
Fiber Reinforced Shotcrete	Bill Geers
Equipment	Lauro Lacerda
Placement: Hand & Mechanical	Frank Townsend & Lauro Lacerda
Water Proofing & Shooting Layers	Frank Townsend
Surface Preparation	Christoph Goss
Safety	Andy Thompson
Quality Assurance/ Quality Control	Christoph Goss
Repair and Rehabilitation	Kevin Robertson
Case Study	Norbert Fuegenschuh
Q&A Panel Discussion	All

Fig. 1: Christoph Goss presenting at RETC 2023

Fig. 2: Frank Townsend presenting at RETC 2023

Feedback, both during the short course and afterwards, was very positive. I would like to thank our excellent presenters and encourage other ASA committees to consider doing a one-day, focused course at a conference or event that matches your area of interest.

Our Underground Committee is still actively maintaining our position statements, as well as developing new ones. If you are interested and want to get involved in helping ASA improve the knowledge and use of shotcrete in the wide variety of underground applications, please consider joining our committee. We always welcome new members, and we would especially like to get more of our younger professionals involved.

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Kevin Robertson | Sika STM- Shotcrete, Tunneling, & Mining (USA)
Marcus von der Hofen | Coastal Gunite Construction Company

Shooting Ahead – Where Did the Year Go?

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

First, as this issue is coming out in December, if you plan to attend the World of Concrete (WOC) in January, please use our code, A17, when you register. ASA has been a co-sponsor of WOC for over two decades, and we enjoy seeing our members there. Using our A17 Code provides us with a bigger revenue share with the show organizer, Informa. This non-dues revenue helps extend your membership dollars, supporting the programs we run today and the plans we have for the future of ASA in the shotcrete marketplace. We'll have a booth in the South Hall as well as two, full-day seminars: shotcrete nozzleman and inspector education. There will also be an opportunity for ACI Shotcrete Nozzleman Wet-Mix Certification. We will also hold our General Membership meeting followed by an informal reception late Tuesday afternoon and into the early evening at the Las Vegas Convention Center. Go to **shotcrete.org/WOC** for more details.

Second, our ASA 2024 Shotcrete Convention and Technology Conference registration is open. Go to **shotcrete.org/convention** and register today. We've packed 3 full days (March 3 - 5, 2024) with 22 speakers presenting shotcrete-specific sessions, committee meetings, table-top exhibits, and best of all, there will be networking opportunities with the movers and shakers of the shotcrete world. We'll have a diverse collection of shotcrete contractors, material and equipment suppliers, engineers, educators, and students attending. The culmination of the convention is our Annual Outstanding Shotcrete Projects Awards Banquet to be held Tuesday evening.

On the first day of the convention, Sunday, March 3, we're offering two full-day seminars. One is the ASA Shotcrete Contractor education seminar. This seminar is geared towards existing shotcrete contractors who want to enhance their knowledge of shotcrete contracting and concrete contractors who want to know more about what it takes to be a successful shotcrete contractor. This is also a prerequisite for submitting an application to our ASA Contractor Qualification program.

Our other seminar will be our Quality Shotcrete – Know It When You See It. This seminar is geared towards pool builders who may have used shotcrete contractors for years on their projects but don't really know what to look for to confirm they're getting the best quality for their money. Though shotcrete is a placement method for concrete, the process has fundamentally different equipment, material selection, crew responsibilities, application techniques, testing, curing, and protection that need to be considered for producing high-quality and durable shotcrete pool shells. We'll be offering a Pool Shotcrete Education certificate for those who attend and take the exam at the end of the class.

We'll be at the Lakeway Resort, just outside Austin, TX right on the shoreline of Lake Travis. For those who may be still stuck in cold, winter weather in early March, this may be a great opportunity to warm up and enjoy the camaraderie our conventions are known for in a small resort setting.

Finally, we just wrapped up our Fall ASA Committee and Board meetings. We were hosted at the conference center of our association management firm, Virtual Inc., located in Wakefield, MA. At the committee meetings, we discussed the updated strategic plan, current and future ASA programs, member engagement, mentorship, education, magazine articles, and student/faculty outreach.

Significant actions of the Board included:

- Reviewed and approved a new Pool Shotcrete Contractor Qualification program jointly developed by the Pool & Recreational and Contractor Qualification committees. You should see this program roll out early next year. Please check out the article in this issue by Ryan Oakes and Marcus von der Hofen with more details of the program.
- Confirmed our Slate of Officers and Board Members for 2024. Notice of the election has gone out to all our voting members. The deadline to vote is January 19, 2024.
- Previewed our new ASA website. The updated website will go live in mid-January 2024! It's designed to make our shotcrete content more application and program specific in various "portals" and thus easier to reach. It will also be mobile friendly.
- Discussed staff succession planning to ensure that ASA, as an association, continues to run smoothly and without interruption after important people move on to new opportunities, retire, or pass away.

As you can see, we're busy as staff juggling all our existing and new programs and activities. Just some of the things we do: planning for the 2024 convention; planning and attending WOC; evaluating and selecting the 2025 convention venue; planning and supporting committees and Board meetings; monthly Executive Committee meetings; organizing and administering nearly two shotcrete certification and qualification sessions each week; collecting and editing content for *Shotcrete* magazine with multiple reviews ranging from raw content to published pages; working with advertisers for *Shotcrete* magazine; running an international awards program; publishing a monthly email newsletter; enhancing our online social media engagement; organizing outreach seminars; securing convention sponsors; answering inquiries; and more. Believe me; there is even more.

As we wrap up the year, with Thanksgiving just behind us, I offer my sincere thanks to you, our members. We wouldn't be the strong association that has the recognition, credibility, dedication, and vision for advancing our shotcrete industry without you. I especially want to recognize our members who go the extra step and actively participate in one or more of our committees or sponsor our convention. You are the ones who give ASA the perspective on the shotcrete market today and what's needed in the future.

But even more, I want to offer my thanks to our small, tightly focused staff of three: Alice McComas, Tosha Holden, and Cindy Spires. It is a pleasure and honor for me every day to see their dedication to ASA, to our members, and to advancing the shotcrete industry. We all owe each of them hearty thanks for everything they do for us and for shotcrete.

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- **RECOGNIZING QUALITY SHOTCRETE – (Shotcrete Inspector Education) - January 24** Registration Code: ASAWE (seminar only); ASAWEX (seminar with exam)
- **ASA SHOTCRETE NOZZLEMAN CERTIFICATION – Wet Mix - January 25 – 26**

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Cementing a Legacy: A Concrete Understanding of Municipal Skatepark Development

By Mark Bradford and Aaron Spohn

Fig. 1: Concrete Wave—After flowing over double rising swells, local skater Dave hits the over-vert lip of a skatable sculpture in Dublin, OH (2017). Project: Dublin Skatepark. Photographer: Nick Adams.

Skateparks have soared in popularity as public facilities. Globally, cities are embracing the once-deemed risky activity and shedding any previous notions of skateparks being mere passing trends. As many municipalities embark on constructing their first—and possibly only—skatepark, city staff members find themselves in a position where they must rapidly acquire knowledge about what constitutes a skatepark and how to successfully develop one. This article provides a comprehensive overview of skateparks, their enthusiasts, the expert builders, the development process, materials, and essential insights to aid governmental bodies in making informed decisions. Given that concrete is a lasting material, getting it right from the outset is crucial.

THE RISE OF THE SKATEPARK

Skateparks have emerged as a curious anomaly within the domain of public recreational facilities. Consider the design of a typical playground structure: it is heavily engineered with safety as a priority, often resulting in relatively simple challenges and limited opportunity to play outside of the box. We're sure their manufacturers would argue differently,

Fig. 2: Aerial Mastery—Skater Colton Woods blasts a soaring air out of a seamless, flowy bowl in Lehi, UT (2017). Project: Lehi Skatepark. Photographer: Gage Thompson.

but the rigorous application of railings, restrictions on height, and the use of cushioned, rubberized surfaces are all measures to minimize potential risks, which also trends toward the implementation of homogenized play.

Contrast this with skateparks —which are intricate, flowing concrete mazes characterized by deep bowls, hips, gaps, stairs, ledges, and drop-offs. These all-concrete courses are purposely designed to generate speed and momentum and enable soaring airs that provide a rider with ample time to perform difficult tricks only to then land on the unyielding concrete landscape below. Skateparks are conceived to challenge and excite with a focus on high performance and fun, but they come with an implicit warning: ride at your own risk.

At first glance, the sometimes-daunting features of skateparks may seem like a legal risk, particularly when compared to the safety-first aspect of playgrounds. However, the reality is quite the contrary. Cities experience a higher frequency of legal claims and disputes stemming from playground accidents compared to skatepark-related incidents. While playgrounds outnumber skateparks, a clear dynamic prevails: skaters acknowledge the inherent risks and generally accept responsibility for their actions, injuries included.

There's a profound sense of community exhibited by skateboarders and bikers, which encompasses both fledgling riders and seasoned veterans or pros. These stakeholders, whether they are young people hanging with their friends or even vigilant parents giving permission to go to the park, understand the inherent risks. Rather than casting blame in the unfortunate event of an accident, they recognize every fall is a well-earned learning experience and part of the game. This isn't just an individual realization; it's a collective sentiment. Any claim against the municipality jeopardizes the entire facility, and by extension, the broader bike and boarder community. In a world where many traditional sports participants are artificially formed into seasonal teams, the fellowship found in skateboarding organically forms a long-lasting, diverse collective that transcends age, race, or economics.

Beyond the thrill and camaraderie, skateparks serve as vital community assets. They provide safe havens for enthusiasts to perfect their craft, thereby reducing wear on public structures and keeping skateboarders off busy streets. These parks cultivate community, promote physical activity, reduce risk, and offer platforms for self-expression. With skateboarding and BMX now recognized as Olympic sports, skateparks have evolved into legitimate training grounds for budding athletes; this elevates their significance beyond mere recreation. Recognizing these benefits, and the fact that these young people are not engaging in traditional sports, municipalities are progressively viewing skateparks as invaluable.

Another distinct characteristic of skateparks is the user community's unparalleled commitment. A significant portion of these parks only come to fruition due to community-driven initiatives via organizing, advocacy, or fundraising. Such grassroots efforts often result in local businesses, particularly concrete suppliers, being approached for in-kind donations or sponsorships. When possible, business support not only bolsters resources but also generates vital momentum and demonstrates widespread community backing. This broad-based support is critical to qualify for state and federal grants, which frequently cover a substantial portion, if not a majority, of a project's funding.

Another hallmark of skateboard culture is the specialized community of skatepark builders who have become the foundation of park development. Born from riders-turned-craftsmen who eventually became entrepreneurs, these companies emerged to fulfill the need for dedicated skate

spaces despite early skepticism regarding the need or the sport's risks. What began as small businesses driven by passion has grown into highly respected, sought-after enterprises with national and international operations. Their teams of creative designers, engineers, and concrete artisans, most of whom are riders themselves, bring a wealth of expertise.

These pioneers are now indispensable to municipalities that prioritize quality, safety, and expertise in their projects, especially for those aiming to avoid the costly errors and common pitfalls that can occur with inexperienced or first-time builders.

THE ROLE OF MUNICIPAL PROCESSES IN SKATEPARK DEVELOPMENT

This recognition has prompted cities to tailor their procurement strategies accordingly. The crafting of RFPs and bid documents now frequently features strict provisions, including securing the expertise of veteran skatepark specialists. Translating a skatepark from concept to concrete demands a nuanced approach of aligning design objectives with budgetary constraints, ensuring efficient execution, and maintaining rigorous quality standards all while navigating the intricate matrix of municipal rules and regulations. Within this complex process, practical experience is indispensable.

Fig. 3: A Cresting Vert Wall—SR Crew Lead and ACI-certified Nozzleman, Kelly Malobovich, sprays colored shotcrete onto an over-vert, free-standing concrete wall in La Puente, CA (2020). Project: Central Park Skatepark. Photographer: @Mikendo.

Initial Advocacy and Support: The journey of skatepark development typically begins with the local community—skateboarders, parents, and community leaders—all advocating for a space dedicated to skating. Advocates play a crucial role in underscoring the tangible benefits such as improved public health and safety as well as the potential boost to local businesses. Additionally, skateparks have been recognized for their ability to transform underutilized areas and contribute to crime reduction.

Stakeholder Engagement: Effective integration of a skatepark into the community hinges on awareness and comprehensive feedback. It's essential to engage a diverse group of stakeholders, including skateboarders, BMX riders, local residents, business owners, and municipal park architects and planners.

Conceptual Design Development: The project visualization stage is crucial. Public input is instrumental in crafting a preliminary concept and rendering of the design. Catering to future users' desires is vital, but the project's trajectory should also be shaped by practical considerations such as the allotted space's dimensions and landscape. An experienced skatepark designer is key to utilizing available space to its fullest potential especially when dealing with undulating topography or elevation changes. The conceptual design acts as a goal that adds project context in the form of size, visual representation, and a budget range. However, there's a direct correlation between the size, scope, and aesthetic of the project and the exact budget; most often, the budget dictates the project's scale and complexity, but a clever designer can make subtle adjustments to maintain a balance. Early discussions between designers and clients help establish a provisional financial target. There are also analytical tools to help gauge the appropriate size of the park based on community size.

Site Considerations and Budget Impact: When planning a skatepark, understanding the native soil conditions of the proposed site and its stormwater management capabilities is crucial. These factors, while invisible to the casual observer, are fundamental and can have significant budgetary implications.

Understanding the Soil: The ideal soil conditions for a stable substrate are non-expansive and those that can achieve a compaction density between 95 to 98%, which is the typical standard for structural support and integrity. Should an otherwise suitable site have inadequate soil, it may necessitate additional geotechnical work, such as employing soil stabilization techniques or incorporating engineered fill material to reach the required compaction density and bearing capacity. These measures are crucial

Fig. 4: Homage to Upland—OG skateboard legend, Lance Mountain, drifts above the elliptically shaped, blue-tiled, pool-coping-ensconced walls of a combi-styled bowl in La Quinta, CA (2022). Project: La Quinta Skatepark. Photographer: @Mikendo.

Fig. 5: Velvety Fresh—The sweeping shotcrete curves of a clover bowl in Crowley Lake, CA begin to take shape (2017). Pictured: Spohn Ranch Build Team. Project: Lake Crowley Skatepark. Photographer: Mark Bradford.

Fig. 6: Nose Pick—Skater Vincent Luevanos carves to a nose pick along the protruding edge of a sculptural vert wall in La Puente, CA (2022). Project: Central Park Skatepark. Photographer: @Mikendo.

not only for a skatepark's solid foundation but also to minimize the risks of heaving or future subsidence that could endanger the park's safety and durability. An engineer's estimate of construction costs should not be deemed accurate unless it is based on a soils test and includes recommendations from a geotechnical engineer's report.

Managing the Water: Constructing a skatepark essentially seals the ground with a concrete cap, altering the natural infiltration of precipitation. Consequently, a comprehensive Stormwater Management Plan (SWMP), often mandated by regulations, becomes a critical component of the project. The plan must address the redirection of rain or snowmelt that will collect on impervious concrete surfaces.

For above-ground style skateparks with minimal topographic variation and a uniform grade—typically sloping between 1% and 2%—sheet drainage can effectively redirect water runoff off the edges, allowing adjacent soils to absorb it. However, in areas with low soil percolation rates, this runoff may necessitate the construction of engineered bio-swales or the implementation of riprap xeriscapes, which are landscaped areas designed to collect and filter stormwater.

In contrast, skateparks with substantial undulation and deep bowls require more elaborate drainage solutions. Strategic placement of drains at the lowest points, and connected to a network of drain lines, is essential. These lines may lead to pre-existing stormwater systems, or alternatively, they can channel water through filtration systems into engineered

drywells—excavated pits filled with crushed rock. This eco-friendly solution permits the temporary storage of water, allowing it to gradually percolate into the soil and mimic natural processes.

Budgeting and Funding: Financial planning is pivotal when considering the development of skateparks. Although certain municipalities have the luxury of allocating funds directly, many search for alternative funding methods. These can range from applying for governmental or private grants, to seeking sponsorships or in-kind donations from local businesses, to launching crowdfunded campaigns that engage the community in pooling resources. Whatever the source, clarity in budgeting ensures that every phase of the project—design, construction, and maintenance—is properly financed.

Fig. 7: Working the Wall—SR Crew Lead and ACI-certified Nozzleman Kelly Malobovich applies concrete to a crucial consolidation area beneath the steel coping of a new skate spot feature at the Redondo Beach Pier in California (2023). Project: Redondo Beach Pier Skatespot. Photographer: @Mikendo.

Navigating Procurement Rules: The procurement process can often feel like a balancing act. Municipalities that draft detailed RFPs or RFQs that reflect the unique challenges and intricacies of skatepark construction tend to achieve the most successful outcomes.

It is essential to attract contractors and designers with experience in skatepark creation to manifest the community's vision, but there is also a role for local general contractors. Depending on the size of your project, you might look to bring in a specialty builder that's also licensed in your area, or if it's a larger project with multiple aspects, a more collaborative approach may be more to your benefit. An astute procurement process incorporates an experience component that is usually predicated on a demonstrated history of successful skatepark completions. This enables qualified contractors to bid directly or to partner with the best local contractors. In such collaborations, the general contractor typically prepares the site to rough grade, installs drain lines, and handles ancillary scope, such as landscaping, while the specialist handles the fine grading, steel reinforcement, edging, and concrete placement. This division not only protects the community's interests but also safeguards inexperienced contractors from potentially underestimating the meticulous effort required to achieve the desired quality of the final product.

Ensuring Quality and Expertise: A crucial component in the procurement process, particularly when determining the expertise of specialty builders, is mandating the ACI Shotcrete Nozzleman Certification. While standardization and certification serve as markers of quality and safety, not all contractors prioritize continuing education, training, or maintaining their certifications. However, those committed to honing their skills not only deliver exemplary skateparks but also contribute significantly to fostering a safer and more resilient industry ecosystem.

Regulatory Compliance: The excellence of a design is only part of the equation. Ensuring alignment with local construction codes, environmental standards, and accessibility criteria is vital to sidestepping challenges. Prompt inspections and acquiring essential permits are indispensable. Further, seasoned professionals are adept at navigating local regulations, encompassing aspects like permitting, bonding, prevailing wage, and certified payroll.

ADA Accessibility and WCMX in Skateparks: The Americans with Disabilities Act (ADA) champions inclusivity, ensuring everyone can access and enjoy public spaces. This vision aligns seamlessly with California's Senate Bill 1003

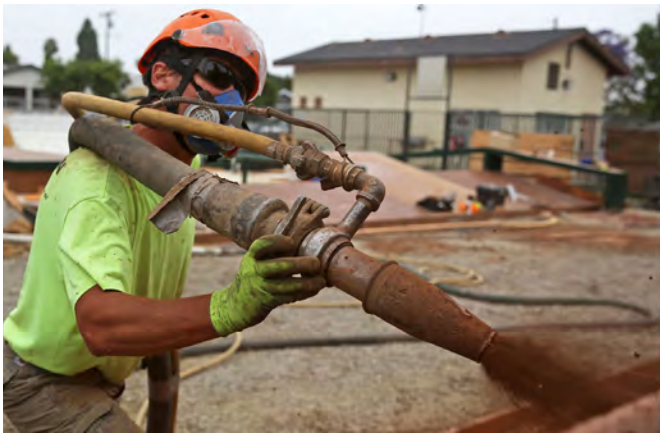

Fig. 8: ACI-certified Nozzleman, and article co-author, Mark Bradford, in his element in Hawaiian Gardens, CA. Project: Clarkdale Skatepark. Photographer: @Mikendo.

(CA SB 1003), which emphasizes the importance of skateparks being open to all non-motorized wheeled activities. The bill specifically cites skateboarding, BMX biking, roller skating, scooter riding, and wheelchair motocross (WCMX) as intended activities for these spaces.

When designing skateparks with ADA standards and the directives of CA SB 1003 in mind (or the equivalent laws in your state), the objective should not merely be regulatory compliance. Designers should envision an environment where every enthusiast, regardless of their choice of wheels, can relish the full skatepark experience. This includes creating accessible pathways to skatepark entries and retaining the challenging design features that make the park a haven for enthusiasts.

In embracing WCMX and the broad spectrum of non-motorized wheeled activities, skateparks answer a universal call for genuine inclusivity, balancing both challenge and accessibility.

Inauguration and Community Engagement: The skatepark's opening is an important community-building activity. Launch events, workshops, or even skate clinics can solidify the bond between the facility and its users.

While skateparks often dazzle with their design and functionality, it's the ability to navigate sometimes complex municipal processes that ensures a successful project. And it is an adherence to contractor quality standards (experience, nozzleman certification, etc.) that ensures a skatepark will continue to be a well-used community asset for years to come.

SHOTCRETE: ESSENTIAL IN SKATEPARK CONSTRUCTION

Understanding the mechanics and nuances of skatepark development is integral, and one of the core components of this is the role of shotcrete. It is an irreplaceable method for placing concrete that is vital in shaping today's modern skateparks.

Traditional concrete pours are suitable for basic, even terrains. However, skateparks, with their curvilinear surfaces, intricate bowls, and daring over-vertical features, require more adaptability. Enter shotcrete with its capability to mold and convey almost any shape imaginable. The method's adaptability is its hallmark. Spraying concrete allows for precision and adherence to ensure the absolute integrity and close tolerances of the concrete surface.

Beyond application, the beauty of shotcrete lies in the robust consolidation it achieves. Delivering concrete at high speed ensures proper encapsulation and consolidation, which yields sturdy skatepark structures that are built to last. The use of shotcrete often results in reduced formwork, keeping costs contained while promoting sustainability. Additionally, the efficiency of shotcrete placement means faster build timelines.

Once the shotcrete is placed, the finishing work begins. Achieving the right texture is paramount–it needs to be smooth and as free of deviations as possible while providing optimal grip for hard polyurethane wheels. This balance is central to delivering that buttery skating experience.

INNOVATION IN SHOTCRETE FOR SKATEPARK CONSTRUCTION

Skateboarding itself is in a constant quest for progression, new tricks, new methods, and new terrain. This ever-evolving ethos necessitates increasingly creative designs with complex features and pushes the boundaries of conventional construction. Shotcrete, as a preferred method for these builds, hasn't remained static either. There have been important innovations within shotcrete applications that have been tailored specifically for skateparks.

Fig. 9: Sunrise Silhouette—In the early morning light, Mark Bradford casts a shadow while he skillfully shoots a spray of concrete. Placement and consolidation are crucial. Project: Lake Crowley Skatepark, Lake Crowley, CA.

Specialized Mixture Designs: The concrete blend used for skateparks isn't your run-of-the-mill shotcrete mixture. Tailored-mixture designs have emerged, which consider factors like the skatepark's geographical location, soil conditions, and the expected footfall. Even within a single day's application, the optimal mixture may change. A savvy project coordinator may choose to make adjustments based on changing temperatures, lengthening load travel times, and other impacts. This ensures the final structure has the requisite strength and longevity.

Use of Admixtures: Admixtures to resist shrinkage, enhance workability, or delay setting times are being strategically used. These not only ensure that the shotcrete retains its desired properties during application, but they also guarantee the long-term durability of the skatepark structures.

Aggregate Types: A local or regional contractor may only encounter a single type of aggregate for the duration of their projects, but a specialty contractor, potentially working in all 50 states, will continuously encounter different materials. Type of rock, shape, and moisture content can all vary based on location and season. Considering the surface finish is paramount; understanding aggregates is essential.

Equipment Evolution: As the demand for more complex and larger skateparks grows, the equipment used for shotcreting has adapted. Enhanced nozzle designs for better

Fig. 10: The Builder's Reward—Spohn Ranch's own Jacob Welch carves high on the over-vert wall of the full-pipe he helped construct (2022). Project: Newark Skatepark, Newark, OH. Photographer: @Mikendo.

Fig. 11: During a night time ride, Spohn Ranch's SR Crew member, Jacob Welch, carves high on the over-vert wall of the full pipe he helped construct (2022). Project: Newark Skatepark, Newark, OH. Photographer: @Mikendo.

spray patterns, air lances designed for specific tasks, and custom-made, adjustable trowels for finishing are a few of the evolutions.

Sustainability Initiatives: With environmental concerns at the forefront, efforts are underway to make shotcrete mixes more eco-friendly. This includes the utilization of recycled materials and reducing waste during the application process.

Incorporating Artistic Elements: Modern skateparks are as much about aesthetics as they are about functionality. Innovations in shotcrete allow the inclusion of artistic elements, from colored concrete, textured surfaces, custom sculpted rock faces, and even embedding or acid etching designs and logos into the concrete itself; these innovations continue to make skateparks incredible landscapes.

CONCLUSION

Skateparks have transcended their initial purpose of merely being recreational spaces. Today, they symbolize a fusion of community, athleticism, art, and innovation. Their strategic design and construction, particularly with the expert application of shotcrete, have transformed them into cutting-edge infrastructures that stand the test of time and cater to evolving skateboarding styles.

Furthermore, these spaces represent the heart and soul of skateboarding culture. As hubs of creativity, they bear witness to the ever-evolving nature of the sport – from the pioneering tricks of yesteryear to the revolutionary techniques of today. Every grind, ollie, and kickflip contributes to a larger narrative of progress, resilience, and passion.

Municipalities play a vital role in this progression. Their understanding and support in facilitating these community canvases are crucial. By adhering to meticulous planning, fostering partnerships, and embracing innovative construction techniques, they ensure that skateparks are not just functional sporting arenas but also vibrant community assets.

In essence, the journey of skatepark development is a shared one—a collaboration between skateboarders, municipalities, designers, and construction professionals. The result is a living testament to the power of unity, passion, and innovation—a space that resonates with the beats of skateboarding and the pulse of the community. As the world of skateboarding continues to evolve, these spaces are a reminder of its rich history and a beacon of its promising future.

Mark Bradford *is a Partner and Expert in Construction and Concrete at Spohn Ranch Skateparks in Los Angeles, California. Mark is the most respected and in-demand construction superintendent in the skatepark industry. He has spent his entire adult life eating and breathing wheeled sports, developing an unparalleled breadth of experience. Mark is highly skilled in all facets of construction, from steel fab to mass grading, but is considered a concrete virtuoso with multiple certifications from the American Shotcrete Association and expert analysis featured in industry publications. As the primary leader of Spohn Ranch's major builds, Mark is often on the road over 300 days per year – flying from critical shotcrete placement to Mountain Dew Tour arena set-up to supervising coping fabrication at Spohn Ranch's shop. He is Spohn Ranch's Superman. And as Co-Owner of Spohn Ranch, Mark has the authority and responsibility to make sure that every park is perfect. He calls the shots and holds both sub-contractors and Spohn Ranch's veteran crew to his industry-defining standards.*

Aaron Spohn *is the Founder and President of Spohn Ranch Skateparks in Los Angeles, California. Aaron harnessed a passion for skating and hands-on craftsmanship to establish Spohn Ranch, a beacon in skatepark innovation. From a homemade backyard skate haven, his vision and relentless entrepreneurship propelled him to influence the industry significantly, playing a key role in the early development of ESPN's X-Games. His company has now masterminded over a thousand cutting-edge skateparks around the globe. Aaron remains at the forefront by partnering with communities nationwide, guiding a new generation to realize their skatepark dreams, and forging enduring spaces where passion and community converge.*

Why We Need a Design Code for Concrete Pools

By Charles Hanskat, PE, F.ACI, F.ASCE, ASA Executive Director

The swimming pool design and construction industry is not highly regulated, and in some cases, it is simply not regulated. Some states and municipalities require licensed professional engineers to design all pools. Some jurisdictions require only commercial pools to have a set of plans and specifications that are produced and sealed by a licensed design engineer. Unfortunately, they have no requirements for a licensed engineer to design a residential pool.

Residential pools can far exceed $100,000 in cost depending on the complexity. They have pumping and piping systems, drains, sumps, filters, electrical, and water treatment equipment. Today's pools are no longer just rectangular concrete swimming ponds in the backyard (Fig. 1).

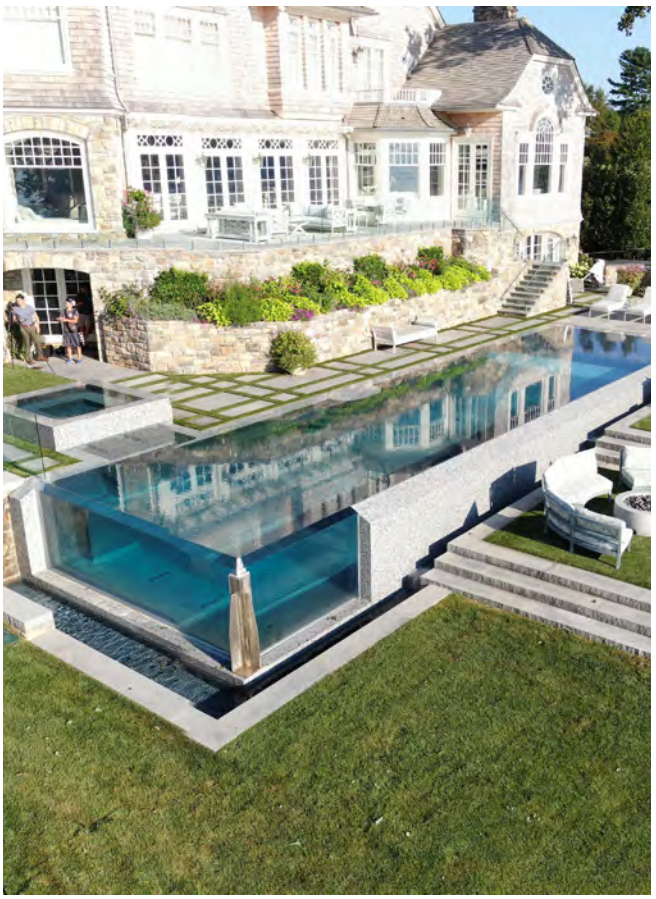

Fig. 1: Partially buried, embedded window, infinity edge residential pool. Not just a basic backyard swimming hole (Photo courtesy of Drakeley Pools).

ASA POOL POSITION STATEMENTS
(SHOTCRETE.ORG/RESOURCES)

- **Compressive Strength Values of Pool Shotcrete**
- **Shotcrete Terminology**
- **Sustainability of Shotcrete in the Pool Industry**
- **Watertight Shotcrete for Swimming Pools**
- **Monolithic Shotcrete for Swimming Pools (No Cold Joints)**
- **Forming and Substrates in Pool Shotcrete**
- **Curing of Shotcrete for Swimming Pools**

Thus, though the industry is large, the pool designers have free rein to do whatever. Many are not licensed professional engineers and have no requirements to seal a set of drawings or specifications. Some designers sell typical pool designs that take no account of the local site conditions or environmental exposures. The pool industry is totally unregulated in many states. Where some states do require designs which are signed and sealed, they still rely on the engineer's various degrees of experience or selection preferences from existing codes that do not directly relate to pool design and construction. This isn't necessarily the fault of the designer as there is not a well-established industry standard to set minimum requirements in the pool industry.

ASA has established a set of position statements for the pool industry. They address issues including Compressive Strength Values of Pool Shotcrete, Shotcrete Terminology, Sustainability of Shotcrete in the Pool Industry, Watertight Shotcrete for Swimming Pools, Monolithic Shotcrete for Swimming Pools (No Cold Joints), Forming and Substrates in Pool Shotcrete, and Curing of Shotcrete for Swimming Pools.

The ASA position statements are valuable to convey the expectations of good practices in the pool marketplace. Perhaps they will even start to set an industry standard. But these are short, non-mandatory documents meant to provide guidance. ASA is not a standards-developing organization (SDO) like ACI or ASTM.

A code is a mandatory language document that provides minimum requirements for design and some construction aspects of the structure within its scope. For example, when engineers design buildings, it is clear they use ACI 318

Building Code Requirements for Structural Concrete and Commentary. Proper use of ACI 318 is taught throughout their college education and widely used in the industry in many parts of the world.

So, where are we in the pool industry? The current International Swimming Pool and Spa Code (ISPS) has a minimal basis for concrete pool design. Here are the current ISPSC provisions for structural design:

> *802.1 Materials of components and accessories.*
> "The materials of components and accessories used for permanent inground residential swimming pools shall be suitable for the environment in which they are installed. The materials shall be capable of fulfilling the design, installation, and the intended use requirements in the International Residential Code."
> *802.2 Structural design.*
> "The structural design and materials shall be in accordance with the International Residential Code."
> *SECTION 803*
> CONSTRUCTION TOLERANCES
> *803.1 Construction tolerances.*
> "The construction tolerance for dimensions for the overall length, width, and depth of the pool shall be + 3 inches (76 mm). The construction tolerance for all other dimensions shall be + 2 inches (51 mm), unless otherwise specified by the design engineer."

These three short sections don't even fill a full page. That's it for the ISPSC on concrete pool structural design. The requirement is to just use the International Residential Code (IRC) for structural design.

Let's turn to the Introduction of the International Residential Code (IRC) where we find:

> "The International Residential Code (IRC) establishes minimum requirements for one- and two-family dwellings and townhouses using prescriptive provisions. It is founded on broad-based principles that make possible the use of new materials and new building designs."

But what chapter of the IRC addresses pool structural design? Maybe Chapter 6, *Walls*? Looking at R608.2 in Chapter 6, it appears that likely pools would only be covered by the following provision: "Buildings that are not within the scope of this section shall be designed in accordance with PCA 100 or ACI 318." There is Chapter 42, *Swimming Pools*, of the IRC, but it only covers the requirements for protection of occupants from electrical shock.

Both ACI 350, *Code Requirements for Environmental Engineering Concrete Structures and Commentary,* and ACI 318 are comprehensive concrete design codes accepted in jurisdictions around the world. ACI 350 is based on the ACI 318 Code, but it includes specific enhancements for designing liquid-tight concrete structures that are routinely exposed to water. ACI 318 is written to address concrete buildings. In comparison to ISPSC provisions for concrete pool structural design at less than one page, ACI 350-20 is 545 pages.

Swimming pools are constantly filled with water and hopefully intended to be watertight. Thus, of the two codes, ACI 350 is the more appropriate code. The ACI 350 Code has design provisions intended to limit crack widths and provide long-term serviceability and durability for the water-containing structure. Many designers of large commercial pools use ACI 350 for their designs. However, there has been much discussion in the pool industry that ACI 350 is not specifically geared towards pools and has too high a requirement for some on the various industry committees.

But in thinking about the issue – how do you design a pool for long life and watertightness? — ACI 318 isn't appropriate because it doesn't deal with crack control, watertightness, or continuous exposure to water with wetting and drying. On the other hand, ACI 350 has a massive scope to cover all types of liquid-containing structures in water, wastewater, and industrial process applications. There are many provisions that have no direct application in pools (like shear walls, roofs, beams, torsion members, prestressing, precast, etc). But concrete pools have become increasingly complex (Fig. 2), and designers need much more specific guidance. In evaluating the currently available codes, it is clear we need a pool-specific ACI Code.

Fig. 2: Complex reinforcing with integral spa and embedded piping. Not a simple design or construction (Photo courtesy of Drakeley Pools).

Recognizing the need for specific design guidance in the pool marketplace, I proposed to the ACI Technical Activities Committee (TAC) that they establish a new technical committee charged with developing a code specifically for pools. And they did by establishing the ACI 322 Concrete Pool and Watershape Code committee in late 2021.

The committee has had four in-person meetings since its inception. We are currently looking at a subset of the ACI 350-20 Code provisions dealing with structural issues but gearing it towards just the structural requirements needed

ACI 322 – PRELIMINARY TOPICS FOR CONSIDERATION IN THE NEW ACI CODE FOR POOLS AND WATERSHAPES

- **Compressive strength – 2500 psi vs 4000 psi minimum**
- **Engineer of record requirement (licensed design professional)**
- **Dry-mix shotcrete versus wet-mix shotcrete**
- **Cover requirements for various finishes**
- **Loading: Water – internal, Backfill, Differential backfill, Groundwater, Seismic, External structures, rock work, grottos, Flood/storm surge, Wind, Vertical loads from external structures, Cantilever**
- **Connections: Pool deck, ancillary structures**
- **Finishes**
- **Damp-proofing**
- **Formwork: Placing against earth, Over excavation, Stay-in-place form, Rigidity**
- **Reinforcing: Design, Chairs, Laps, Epoxy-coated, Glass-fiber reinforced plastic (GFRP)**
- **Tolerances: Shelves, Benches, Vanishing edge, Control of wall thickness**
- **Pool floors: Slab-on-grade, Pile supported for vertical & lateral loads, Thickness, Reinforcing, Sumps, Pressure-relief valves (PRV) or weep holes during construction, Buoyancy, Floor/wall**
- **Soils and Subgrade: Backfill, Subgrade prep or capability, Control of the depth of excavation, dewatering, Frost heave in shallow water sections, Swelling/shrinking soils**
- **Footings**
- **Walls: Embedded pipe - Loss of section, Placement – back vs middle**
- **Penetrations: Tied off to steel, Details for full encasement**
- **Embeds**
- **Joints**
- **Multiple layers**
- **Integral spa/pool wall**
- **Over excavation: Mass concrete concerns**
- **Trimmings (Consolidation) and Rebound**
- **Weather**
- **Curing: 24/7 – Duration, Impact of wetting/drying**
- **Functionally watertight –**
- **Shrinkage & temperature steel: ACI 350 vs 318**
- **Temperature differential through the wall**
- **Exposures: Salt water, Minerals, Acid, Cyanuric acid, Chlorine**
- **ASR, ACR**
- **Coatings: Chemical exposure before plaster or finishes (acid), Additional protection – sealer, colloidal silicas**
- **Low concrete strength/acceptance**
- **Nozzleman & Inspector certification**
- **Conductivity for pool water equipotential bonding NEC**
- **Special cases: Indoor pools, Elevated pools, Lazy rivers, Diving wells**

for the pool industry. The ACI 322 committee is producing the new 322 Code in a member-based format as introduced in ACI 318-14. Unfortunately, ACI 350-20 is based on the earlier format in ACI 318-11, so we are expecting quite a bit of work to reorganize the content.

One of our first challenges was creating a list of what we, as a group of experienced pool designers, needed to cover in the code. The following list of topics we discussed at the committee shows how comprehensive we expect the code to be. (Sidebar left.)

Where ACI 350 and ACI 318 are very broad in scope and fine for all types of concrete tanks and buildings, the design requirements are quite detailed and somewhat onerous if one is designing more limited pools and watershapes. Thus, the new ACI 322 Code for Pools and Watershapes committee was approved by ACI.

It will take us several years to complete the first version of the ACI 322 Code. Our goal, once it is complete, is to have the ISPSC adopt the ACI 322 Code for concrete pool design, as the International Building Code (IBC) adopted ACI 318 for buildings.

Our ACI 322 committee membership is still open. If you have expertise in pool design or construction and would like to help develop the design standard for the pool industry, you can apply online at **www.concrete.org/committees/joinacommittee.aspx.**

The current design methodology for the concrete pool industry is kind of like the “Wild West.” It’s time to tame it!

Charles Hanskat *is the current ASA Executive Director. He received his BS and MS in civil engineering from the University of Florida, Gainesville, FL. Hanskat is a licensed professional engineer in several states. He has been involved in the design, construction, and evaluation of environmental concrete and shotcrete structures for over 35 years. Hanskat is the chair of ACI 322, and is also a member of ACI Committees 301, Specifications for Structural Concrete; 350, Environmental Engineering Concrete Structures; 371, Elevated Tanks with Concrete Pedestals; 372, Tanks Wrapped with Wire or Strand; 376, Concrete Structures for Refrigerated Liquefied Gas Containment; 506, Shotcreting; and Joint ACI-ASCE Committee 334, Concrete Shell Design and Construction. Hanskat’s service to the American Society of Civil Engineers (ASCE), the National Society of Professional Engineers (NSPE), and the Florida Engineering Society (FES) in over 50 committee and officer positions at the national, state, and local levels was highlighted when he served as State President of FES and then as National Director of NSPE. He served as a District Director of Tau Beta Pi from 1977 to 2002. He is a Fellow of ACI, ASCE, and FES and a member of ACI, NSPE, ASTM International, AREMA, ICRI, and ASCC.*

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ASA Pool Shotcrete Contractor's Qualification Program

By Ryan Oakes & Marcus von der Hofen

It's been a wild few years in the pool industry with growth in some areas of the industry estimated to be up over 500%, and it's not all good unfortunately. The COVID Pandemic brought pool buyers out by the hundreds of thousands, and new pool builders were popping up like baby rabbits in the Spring. The pre-pandemic market had a poor balance of shotcrete contractors to pool builders with there being slightly more demand for shotcrete contractors than supply. That is probably due to the highly specialized nature of the shotcrete process, the cost of entry into the market, and the overall gritty nature of being a shotcreter. Once the demand swung high enough, however, the scales tipped and those barriers of entry to the market fell down.

School teachers became pool contractors and sales people became shotcreters. Everyone wanted in on the wave of action. Established shotcrete companies already had a real struggle finding labor in such a demanding market, and the new demand drove wages up dramatically within the industry. But shotcreters can't just appear overnight. It takes years of specialized training to become good at the process. It also takes a great deal of knowledge in the process to be a successful contractor that specializes in shotcrete. Established shotcrete contractors had to either grow or lose market share to inexperienced shotcrete contractors that didn't know how to price their work, or worse, perform the work in a quality way. So many variables were popping up that the pool industry fell into a chaotic spin. Cement shortages and reduced allocations from building industry growth tempered the problem a touch as did manufacturing shortages across the industry. Swimming pool pumps and filters had lead times of over one year in some cases.

Somehow the pressure remained, and new shotcrete contractors were showing up every day. I personally fielded weekly calls from individuals wanting to start their own shotcrete company–mostly pool contractors who were frustrated that their shotcrete contractor couldn't keep up with their growth.

So why tell this story? It is important to understand because it has happened before. The results of rapid construction growth are not isolated to the pool industry, and they aren't new. For decades, construction growth has ebbed and flowed with the economy in general, and labor, accordingly, has had to rise to the occasion each time or be let go to find more stable work. Booms in the economy and advances in technology have spurred the use of shotcrete placement in the past and the misuse of the process as well.

To that end, 25 years ago, a group of highly skilled shotcrete industry leaders, comprised of contractors, university researchers, engineers, and manufacturing companies joined together to create the American Shotcrete Association (ASA). Shortly thereafter, the ASA and the American Concrete Institute (ACI) jointly developed the Certified Nozzleman program for Shotcrete Nozzlemen. The effort became a valuable resource for an industry that needed education, training, and certification so that owners and specifiers could feel comfortable with the benefits of the shotcrete process, which are numerous when held against form-and-pour concrete construction. Over the past 25 years, ASA and ACI have taught and certified thousands of nozzlemen (soon that be called shotcreters in ACI and ASA documents)!

Unfortunately, most of the certified shotcreters are busy shooting tunnels, bridges, slope support, marine structures, etc. There are too few ACI-Certified Nozzlemen in the swimming pool industry today.

Stepping back just a moment – over the last decade, members of ASA realized that we also needed a qualification for the shotcrete contractor, not just a nozzleman certification. After all, it is the shotcrete contractor that is hired to do the work, not typically the nozzleman. There was, and still is, a problem wherein a contractor, that is not familiar with the nuances of the shotcrete process, decides to buy or rent a pump, hire a nozzleman from someone else, and call themselves a shotcrete contractor. This practice often results in poor quality work. It takes a complete, experienced shotcrete team from owner, project manager, maintenance, equipment operators, finishers as well as a nozzleman for quality shotcrete placement.

The ASA Contractor Qualification Committee was created to help provide quality assurance to prospective specifiers and owners that the shotcrete contractor they were hiring was a peer-reviewed and industry-vetted contractor that had not only the technical credentials but also the experience, personnel, equipment, and financial stability to perform the work they were being hired for.

Programa de calificación para contratistas de concreto lanzado para piscinas de ASA

Por Ryan Oakes y Marcus von der Hofen (Raúl Bracamontes, Editor de Traducción)

Han sido unos años salvajes en la industria de las piscinas, con un crecimiento en algunas áreas de la industria estimado en más del 500% y desafortunadamente no todo es bueno. La pandemia por el COVID 19 atrajo a cientos de miles de clientes de piscinas, y en la primavera aparecían nuevos constructores de piscinas como conejos. El mercado antes de la pandemia tenía un equilibrio entre contratistas de concreto lanzado y constructores de piscinas, con una demanda ligeramente mayor de contratistas de concreto lanzado que la oferta. Probablemente esto se deba a la naturaleza altamente especializada del proceso del concreto lanzado, el costo de entrada al mercado y la naturaleza generalmente arenosa del concreto lanzado. Sin embargo, una vez que la demanda subió lo suficiente, la balanza se inclinó y las barreras de entrada al mercado cayeron.

Los maestros de escuela se convirtieron en contratistas de piscinas y los vendedores en lanzadores. Todos querían sumarse a la ola de acción. Las empresas de concreto lanzado ya establecidas ya tenían verdaderas dificultades para encontrar mano de obra en un mercado tan exigente, y la nueva demanda hizo subir dramáticamente los salarios dentro de la industria. Pero los lanzadores no se hacen de la noche a la mañana. Se necesitan años de formación especializada para llegar a ser bueno en el lanzado. También se necesita una gran cantidad de conocimiento en el proceso para ser un contratista exitoso que se especialice en concreto lanzado. Los contratistas de concreto lanzado establecidos tuvieron que crecer o perder participación de mercado frente a contratistas de concreto lanzado sin experiencia que no sabían cómo fijar el precio de su trabajo o, peor aún, realizar un trabajo con calidad. Surgieron tantas variables que la industria de las piscinas cayó en un giro caótico. La escasez de cemento y la falta de piezas provenientes del crecimiento de la industria de la construcción atenuaron un poco el problema, al igual que la escasez de partes en toda la industria. Las bombas y filtros de piscinas tenían en algunos casos plazos de entrega de más de un año.

De alguna manera, la presión se mantuvo y todos los días aparecían nuevos contratistas de concreto lanzado. Personalmente, recibí llamadas semanales de personas que querían iniciar su propia empresa de concreto lanzado, en su mayoría constructores de piscinas que estaban frustrados porque su contratista de concreto lanzado no podía seguir el ritmo de su crecimiento.

Entonces, ¿por qué contar esta historia? Es importante entenderlo porque ya ha sucedido antes. Los resultados del rápido crecimiento de la construcción no se limitan a la industria de las piscinas y no son nuevos. Durante décadas, el crecimiento de la construcción ha tenido altibajos con la economía en general y, en consecuencia, la mano de obra ha tenido que estar a la altura de las circunstancias cada vez o ser despedida para encontrar un trabajo más estable. Los auges económicos y los avances tecnológicos han fomentado el uso de la colocación de concreto lanzado en el pasado y también el mal uso del proceso.

Con ese fin, hace 25 años, un grupo de líderes de la industria del concreto lanzado altamente calificados, compuesto por contratistas, investigadores universitarios, ingenieros y empresas, se unieron para crear la Asociación americana del Concreto lanzado (ASA). Poco tiempo después, la ASA y el instituto americano del concreto (ACI) desarrollaron conjuntamente el programa de certificación de lanzadores. El esfuerzo se convirtió en un recurso valioso para una industria que necesitaba educación, capacitación y certificación para que los propietarios y especificadores pudieran sentirse cómodos con los beneficios del proceso de concreto lanzado, que son numerosos cuando se comparan contra la construcción tradicional de concreto cimbrado y colado. ¡Durante los últimos 25 años, ASA y ACI han enseñado y certificado a miles de lanzadores (que pronto se llamarán concreto shotcreter en los documentos de ACI y ASA)!

Desafortunadamente, la mayoría de los lanzadores certificados están ocupados lanzando túneles, muros, puentes, taludes, estructuras marinas, etc. Hoy en día, hay muy pocos lanzadores certificados por ACI en la industria de las piscinas.

Retrocediendo un momento, durante la última década, los miembros de ASA se dieron cuenta de que también necesitábamos una calificación para el contratista de concreto lanzado, no solo una certificación de lanzador.

While in its early stages, this qualification program stands to provide credibility for shotcrete contractors around the world just as the ACI-Certified Nozzleman Program has done for nozzlemen.

The ASA Qualified Contractor (CQ) program, however, is geared very much toward commercial shotcrete uses and not so much toward swimming pool construction using shotcrete placement. To that end, the ASA Pool and Recreation Committee has worked closely with the Qualified Contractor Committee to create a Pool Shotcrete Qualified Contractor Program.

This program will be very similar to the existing CQ program but tailored to the pool industry. We are leveraging presentations we already use, such as Quality Shotcrete—Know It When you See It, and modifying everything from the contractor presentation to the required application and exams to be very swimming pool specific.

This program will provide pool builders, owners, and specifiers the confidence that the pool shotcrete contractor they hire is not a fly-by-night contractor; rather, they are industry-vetted, peer-reviewed, and financially stable; additionally, they will employ certified nozzlemen for placement and will have received education in the subject matter as well as passed a rigorous test. Past project success will be reviewed over the course of the past 3 years to ensure that longevity is a component of their existence.

This is not an easy program to enter, but neither is the shotcrete business as a whole. Owners spend hundreds of thousands of dollars on their backyard improvements with a swimming pool installation, and the shotcreted pool shell is the backbone of that process. It is essential to the success of the pool construction that a qualified shotcrete contractor is utilized for this process, and now we have a program to provide that assurance to the client. This program will launch in the Spring of 2024 with several members of the community and industry leaders already in line to apply for the program.

This program will be a tool for pool contractors as well, so they may leverage the quality of an industry-vetted shotcrete contractor to promote the quality of their overall pool construction.

Like the QC Program, the Pool Shotcrete Qualified Contractor Program will take time to become what the ACI-Certified Nozzleman Program has become, but industry leaders in pool education, such as Watershape University, have already expressed support for the program and will aid in its launch. We are excited to see this program begin, and we look forward to it ensuring quality shotcrete placement around the world.

For more information on the program, including how to apply for the program, please don't hesitate to contact ASA at www.shotcrete.org.

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 secretary for ACI 322 Concrete Pool & Watershape Code, a member of ACI Committee 506, Shotcreting, and ACI Subcommittee 506-H, Shotcreting Pools. He serves on the ASA Board of Directors and as Chair of the ASA Pool & Recreational Shotcrete Committee and Vice-Chair of the ASA Contractor Qualification Committee.*

Marcus von der Hofen *is the Chief Operating Officer of Coastal Gunite Construction Co. and has nearly three decades of experience in the shotcrete industry. He is an active member of American Concrete Institute (ACI) Committees 506, Shotcreting, and C660, Shotcrete Nozzleman Certification. He is a charter member of ASA, joining in 1998; he currently serves as the Chair of the ASA Contractor Qualification Committee.*

Después de todo, es la empresa de concreto lanzado la que se contrata para hacer el trabajo, no al lanzador. Existía, y todavía existe, un problema en el que un contratista, que no está familiarizado con los procesos del concreto lanzado, decide comprar o alquilar una bomba, contratar a un lanzador de otra compañía y llamarse a sí mismo contratista de concreto lanzado. Esta práctica a menudo resulta en un trabajo de mala calidad. Se necesita un equipo completo y experimentado de concreto lanzado, compuesto por el propietario, el gerente de proyecto, el de mantenimiento, los operadores de equipos, los acabadores y un lanzador para una colocación de concreto lanzado de calidad.

El Comité de Calificación de Contratistas de ASA se creó para ayudar a brindar garantía de calidad a los posibles especificadores y propietarios de que el contratista de concreto lanzado que estaban contratando era un contratista revisado por pares y examinado por la industria que no solo tenía las credenciales técnicas sino también la experiencia, el personal, el equipo y estabilidad financiera para realizar el trabajo para el que fueron contratados.

Si bien se encuentra en sus primeras etapas, este programa de calificación brindará credibilidad a los contratistas de concreto lanzado en todo el mundo, tal como lo ha hecho el Programa de lanzador certificado por ACI.

Sin embargo, el programa de Contratista Calificado (CQ) de la ASA está más orientado a usos comerciales de concreto lanzado y no tanto a la construcción de piscinas mediante la colocación de concreto lanzado. Con ese fin, el Comité de Recreación y Piscinas de ASA ha trabajado estrechamente con el Comité de Contratistas Calificados para crear un Programa de Contratistas Calificados de piscinas de concreto lanzado.

Este programa será muy similar al programa CQ existente pero adaptado a la industria de las piscinas. Estamos aprovechando las presentaciones que ya utilizamos, como concreto lanzado de calidad: Reconózcalo cuando lo vea, y modificando todo, desde la presentación del contratista hasta la aplicación y los exámenes requeridos, para que sean muy específicos para piscinas.

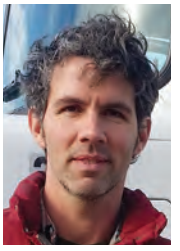
Este programa brindará a los constructores, propietarios y especificadores de piscinas la confianza de que el contratista de concreto lanzado para piscinas que contratan no es un contratista hecho de la noche a la mañana; más bien, son examinados por la industria, revisados por pares y financieramente estables; Además, emplearán lanzadores certificadas para la colocación y habrán recibido educación en el tema y habrán aprobado un examen riguroso. Se revisará los últimos 3 años para garantizar que la experiencia es parte de la compañía.

Este no es un programa fácil, pero tampoco lo es el negocio del concreto lanzado en su conjunto. Los propietarios gastan cientos de miles de dólares en mejorar en su propiedad con la instalación de una piscina, y la estructura de la piscina con concreto lanzado es la columna vertebral de ese proceso. Es esencial para el éxito de la construcción de la piscina que se utilice un contratista de concreto lanzado calificado para ello, y ahora tenemos un programa para brindar esa seguridad al cliente. Este programa se lanzará en la primavera de 2024 y varios miembros de la comunidad y líderes de la industria ya están en fila para postularse para el programa.

Este programa también será una herramienta para los contratistas de piscinas, de modo que puedan aprovechar la calidad de un contratista de concreto lanzado aprobado por la industria para promover la calidad de la construcción general de su piscina.

Al igual que el Programa de Control de Calidad, el Programa de Contratistas Calificados de albercas de Concreto lanzado tardará en convertirse en lo que se ha convertido el Programa de lanzador Certificado por ACI, pero los líderes de la industria sobre piscinas, como la Universidad Watershape , ya han expresado su apoyo al programa y ayudarán en su implementación y lanzamiento. Estamos entusiasmados de ver comenzar este programa y esperamos que garantice la colocación de concreto lanzado de calidad en todo el mundo.

Para obtener más información sobre el programa o cómo solicitar el programa, no dude en comunicarse con ASA en www.shotcrete.org.



Ryan Oakes *es un diseñador profesional de formas de agua y presidente de Clearwater Construction Group, Inc., Revolution Gunite y Revolution Pool Finishes, todas ellas empresas galardonadas en sus respectivos sectores. Oakes es miembro del cuerpo docente de la Universidad Watershape , donde continuamente busca elevar el nivel en la industria de las piscinas y la construcción Watershape . Como miembro del equipo de liderazgo del Instituto Internacional Watershape (IWI) y a través de la extensión educativa a una vasta red de constructores de piscinas en todo Estados Unidos, su objetivo es mejorar las técnicas y métodos de construcción de piscinas. Oakes es secretario del Código de forma del agua y piscinas de concreto ACI 322, miembro del Comité 506 de ACI, concreto lanzado y del Subcomité 506-H de Concreto lanzado en Piscinas. Es miembro de la junta directiva de ASA y como presidente del Comité de concreto lanzado recreativo y para piscinas de ASA y vicepresidente del Comité de calificación de contratistas de ASA.*

Marcus von der Hofen *es el director de operaciones de Coastal Gunite Construction Co y tiene casi tres décadas de experiencia en la industria del concreto lanzado. Es miembro activo de los Comités 506, concreto lanzado y C660, certificacion de lanzadores de concreto lanzado del Instituto Americano del Concreto (ACI). Es miembro fundador de ASA, incorporándose en 1998; Actualmente se desempeña como Presidente del Comité de Calificación de Contratistas de ASA.*

Can Shotcrete be Affected by Alkali Silica Reaction?

By Mark Lukkarila, F.ACI

The American Concrete Institute (ACI) defines alkali-silica reaction (ASR) in ACI CT-23: ACI Concrete Terminology as "the reaction between the alkalies (sodium and potassium) in portland cement and certain siliceous rocks or minerals, such as opaline chert, strained quartz, and acidic volcanic glass, present in some aggregates."

Outward signs of ASR include pattern cracking (either longitudinal or map-type depending on restraint in the structure), closed or spalled joints, displacement, or popouts. The product of ASR is a gel that has a strong affinity for moisture and will increase in volume when it absorbs moisture, causing expansive pressures that will crack the concrete. The amount of expansion is also dependent on the ASR gel chemistry. There are three requirements for ASR to cause damage:

- A reactive form of silica
- The availability of alkali (contributed by cement, external alkali source, or some aggregates)
- Sufficient moisture. Moisture not only provides for expansion of the gel but also sustains the chemical reaction

If any one of these are missing, ASR will not occur. Cracks initiated by ASR mainly affect serviceability and may promote other modes of deterioration such as freeze-thaw damage. For instance, a concrete pool shell experiencing deleterious expansion due to ASR will likely leak over time.

Petrographic examination of concrete samples conducted in accordance with ASTM C856, Standard Practice for Petrographic Examination, will reveal evidence confirming that the concrete is experiencing ASR. Evidence from a petrographic examination, together with a thin section examination, would include fractured aggregates that disrupt the paste, gel plugs within the reactive aggregate at the interface between the reactive aggregates and the paste, copious quantities of gel exuding into cracks and into voids, and gel-soaked paste directly adjacent to the reactive aggregates. Reaction rims may also be present but must not be confused with weathering rinds, which can be common in natural gravel deposits.

Scanning electron microscopy (SEM) is a very useful tool when looking at concrete that has experienced some form of distress. A SEM uses an electron beam instead of light to produce an image. When the electron beam hits the sample, x-rays as well as primary backscatter and secondary electrons are ejected from the sample. Detectors collect the x-rays along with backscatter and secondary electrons to produce an image. Backscatter electron images display contrast produced by different elements. Energy dispersive spectroscopy (EDS) identifies the different elements present and determines quantities of individual elements. With respect to ASR, scanning electron microscopy with EDS provides a more detailed view of the gel microstructure and, more importantly, its composition.

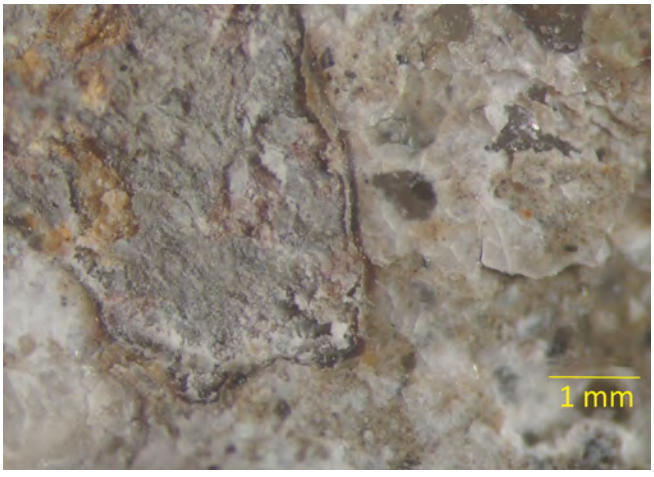


Fig. 1: Photomicrograph of a fresh fracture surface showing a reacted volcanic aggregate with rim development and ASR gel adjacent to the particle.

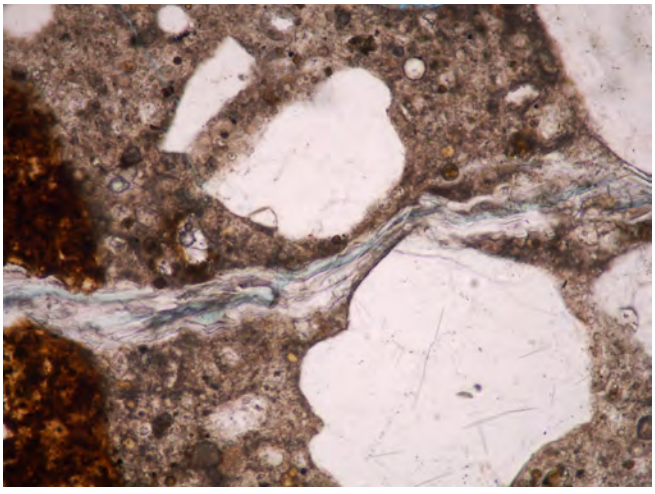


Fig. 2: Thin section photomicrograph of alkali-silica reaction of a glassy volcanic rock (on the left) with copious quantities of ASR gel completely filling the fracture that propagates through the paste.

There are several ways of reducing the impact of ASR. ASTM C1778, Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete, provides guidance on identifying the potential for ASR such as the evaluation of field history of an aggregate source. Additional guidance on evaluation of ASR potential is found in ASTM C295, Standard Guide for Petrographic Examination of Aggregates for Concrete; ASTM C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method); and ASTM C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction. ASTM C1778 also provides guidance on how to prevent ASR, such as ASTM 1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method); ASTM C1293 run for 2 years to show mitigation of different combinations of cementitious materials and aggregates. One preventative measure would be to use an aggregate source that does not contain alkali-reactive rock types. However, this could be cost prohibitive because such aggregate sources would likely need to be shipped in from another geographic region. The more popular approach would be to use supplementary cementitious materials (SCMs). Testing, as outlined in ASTM C1778, should be conducted to identify the level of SCMs needed to mitigate ASR expansions.

Now let's look at ACI's definition of shotcrete. Shotcrete is defined in ACI CT-23: ACI Concrete Terminology as "concrete placed by a high-velocity pneumatic projection from a nozzle." This definition shows that shotcrete is simply a placement method of concrete. Therefore, concrete placed pneumatically at high velocity, or shotcrete, is susceptible to the same concrete deterioration mechanisms as form-and-pour concrete. This includes, but is not limited to, alkali-aggregate reaction (ASR and alkali-carbonate reaction), sulfate attack, and freeze-thaw distress.

ASR damages the internal microstructure of concrete. Microphotographs of concrete sections provide visual evidence of the impact of ASR. Below are several microphotographs of ASR in various concrete materials.

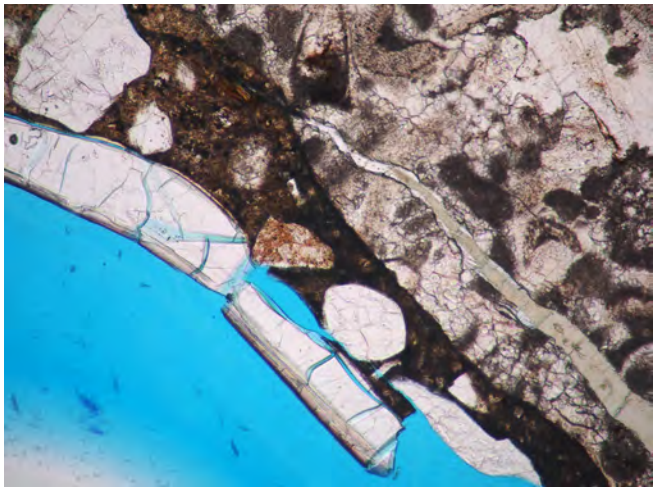


Fig. 3: Thin section photomicrograph of ASR gel lining an air void and filling a fracture within a siliceous limestone coarse aggregate particle.

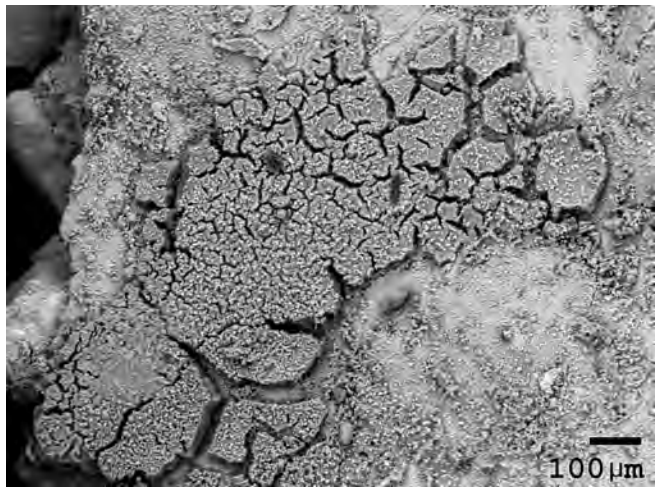


Fig. 5: Scanning electron image of ASR gel in an exposed fracture.

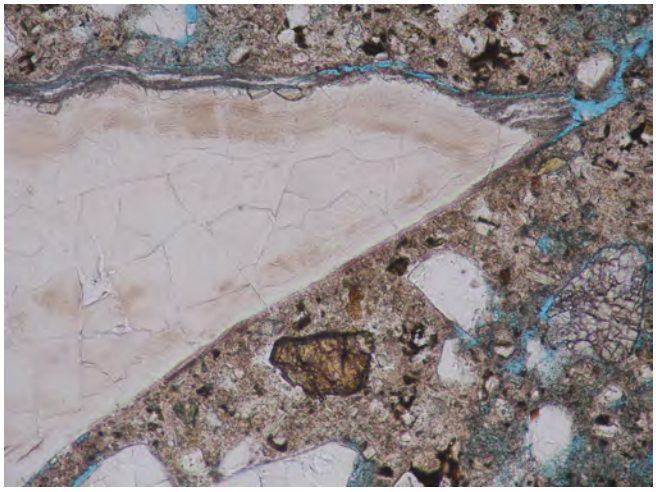


Fig. 4: Thin section photomicrograph of an ASR in a chalcedonic chert.

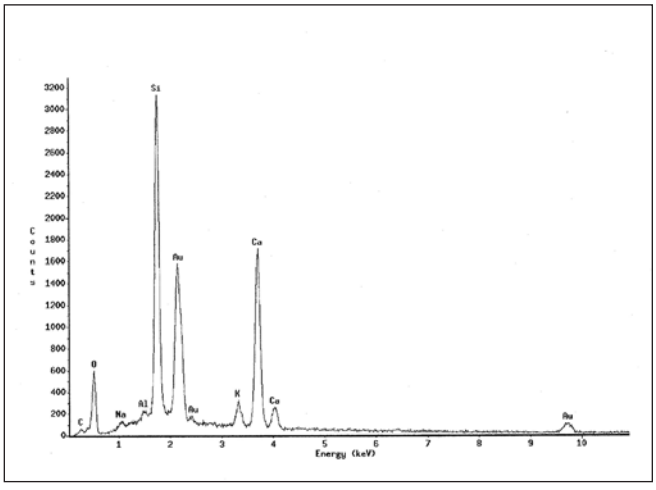


Fig. 6: Energy dispersive spectroscopy spectrum of the ASR gel shown in Fig. 5.

There are many potential causes for concrete deterioration. Often, there is more than a single factor contributing to deterioration. Internal concrete damage due to ASR has been widespread, affecting concrete in pools, tanks, and even nuclear storage casks. Conferring with a ready-mix supplier before casting concrete, and asking about ASR aggregate testing, is always recommended. Beton Consulting Engineers LLC can help identify the causes of distress and provide solutions to prevent distress for future projects.

Mark Lukkarila, *of Beton Consulting Engineers LLC, has worked as a Petrographer and Materials Scientist for over 35 years. Mark has performed petrographic examinations of concrete, aggregates, and masonry, as well as petrographic examination of historic mortars and concrete. During his career in the consulting, manufacturing, and research arenas, he also served as Research Laboratory Manager and Technical Services Director in the cement industry, as well as Technical Services Manager in the masonry industry. While in the cement industry, Mark became adept at interpreting process conditions using clinker microscopy and has gained extensive knowledge of cementitious systems, cement, and hydration chemistry. Mark's practical experience and knowledge in manufacturing, as well as performance of concrete, is the reason that he is a respected forensic investigator. Mark also has extensive experience with new product development and troubleshooting product performance, as well as process-related issues.*

Mark received a Bachelor's degree in Earth Science from the University of Minnesota Duluth. Mark is a Fellow of the American Concrete Institute (ACI). He is very active in ACI and is the current Chair of Committee 225 Hydraulic Cements, and 524 Plastering. Mark is also the Past-Chair of 221, Aggregates and Committees E701, Materials for Concrete Construction. He also serves as Secretary of ACI Committees 221, Aggregates and 225, Hydraulic Cements. He is a member of Committees 710, ACI University Programs, 240, Pozzolans, 506, Shotcrete, 524, Plastering, C621 Cement Testing Certification, and an Associate Member of 201, Durability. He is also a member of ASTM and is a voting member of C01, Cement, as well as, C12, Mortars and Grouts for Unit Masonry, and he served as the Chair of Subcommittee C09.46, Shotcrete and was the past Task Group Chair of C294/295, Aggregate Petrography.

Mark is an approved educator and examiner for ACI's shotcrete certification program. He also is ACI certified as an Aggregate Testing Technician – Level 1, Concrete Strength Testing Technician, and Concrete Field Technician-Grade 1. Mark was also an instructor for MnDOT's AggregatProduction certification classes.

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Watershape University: Filling a Void

By Bill Drakeley

Swimming pools are so commonplace; it's easy to take them for granted. When we step back and consider, in specific terms, what the industry is about and what it does, however, we find a profound and even surprising need for education as well as licensing and certification.

It's a big industry. The U.S. boasts 10.7 million swimming pools, both commercial and residential. Each one is different and serves the needs of people of all ages, incomes, religions, races, and cultural origins. Pools are a place where humanity comes together for essentially the same purpose—to enjoy being on, near, or under the water.

Pools are not only popular and plentiful; they are also complex. A lot can go wrong with a pool that isn't built correctly—from structural failures to aesthetic imperfections to inefficient or unreliable operation; therefore, a swimming pool requires the work of professionals during design, engineering, construction, and service. The public deserves a means by which to decide if the investment they've made in their new pool is not only soundly designed and aesthetically pleasing, but robustly constructed for the long lifespan concrete pools are capable of.

ANSWERING THE CALL

All of that is why Watershape University (WU) exists. It is our objective to equip industry professionals with the knowledge they need to meet consumer demands—today and into the future.

Ever since the formation of WU in Fall 2019, curious minds have rightfully asked us what this organization is all about, what our goals are, and the means we've been using to achieve those ends.

Ultimately, many interested parties want to know how we are working to fill the education void and improve the shotcrete knowledge that exists within the world of pools, spas, and other forms of recreational and/or decorative bodies of water.

Here's a run-down of those important questions and our answers:

What's a "watershape?"

The creators of *WaterShapes* magazine coined the term before the magazine debuted back in February 1999. It's essentially shorthand for all forms of recreational and decorative water including pools, spas, fountains, ponds, streams, lazy rivers, waterfalls, interactive water features, water gardens, natural bodies of water, and even birdbaths.

The magazine spearheaded an educational movement that sought to redefine water in the landscape as an architectural design element and an art form—a campaign that continues to this day.

What is Watershape University?

Watershape University (WU) is a leading professional authority on quality live and online instruction for business, design, engineering, construction, repair, restoration, and service. We serve students of all levels in the pool, spa,

> Structures that contain water can be contentious beasts, and they need to be designed, built, and maintained by trained professionals – otherwise costly problems are almost certain to follow.

aquatics, and outdoor living sectors. Although recently founded by David J. Peterson and me, WU encompasses decades of teaching and practice among staff, faculty, and volunteers engaged in its educational and credentialing programs.

Why do we exist?

WU was created to ensure long-term prosperity within watershaping industries by supporting the growth of an educated, professional workforce. We also exist to raise awareness of the benefits of an aquatic lifestyle.

Our efforts first grew out of the founders' shared desire for staff training within their own companies. While other sources were either too expensive or not technical- or design-oriented enough, the WU curriculum exists to fill those voids.

What do we strive to accomplish?

We are working to create an educated class of individuals and companies dedicated to elevating the professionalism of the watershaping industries while also inspiring everyone to experience the joy and benefits of recreational and decorative water.

What means do we use to accomplish those goals?

WU's curricula are based on third-party (IACET) accreditation, providing a credentialed path for career advancement. We are financially supported by student fees as well as support from watershape manufacturers and suppliers.

WU has aligned with ASA specifically in the area of education for quality shotcrete placement in pools. Helping both pool builders and self-performing shotcrete contractors recognize the inherent requirements for quality shotcrete placement and the resulting impact on the servicability and durability of the watershapes they are building is a joint effort. Working together, WU leverages the experience of ASA members to broaden shotcrete knowledge across the pool marketplace. ASA members participate in many internationally recognized organizations that develop codes and standards, and together, we bring the shotcrete-specific knowledge to the pool industry through institutions like WU.

WU provides coaching and outreach through the International Watershape Institute, a group of our most

accomplished instructors and students. Finally, we support the Live Blue Foundation, an affiliated organization established to provide grants to organizations putting what we call the "Blue Mind" concept into action. Blue Mind is the mildly meditative state people fall into when they are near, in, under, or on water. Blue Mind illustrates ways people can use water to improve their overall well-being.

What values and benefits sustain our efforts?

As both idealists and realists, we believe that principled leadership, honesty, integrity, a supportive culture, compassion, gratitude, and altruism will inevitably result in personal growth and professional gain for the entire industry.

Who benefits from WU?

Many stakeholders benefit from WU, including our credentialed students, as well as their companies, employees, and subcontractors; faculty and coaches; associate corporations, colleagues, and partners; peers and the entire professional watershaping community; and owners and consumers.

To what end?

It's been said that swimming pools are the gateway to the world of water, and Watershape University is considered the educational authority on how best to design, build, service, and sell watershapes.

How do we define our mission?

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William "Bill" Drakeley *is an award-winning shotcrete technologist specializing in concrete science and construction, particularly shotcrete applications, techniques, and standards, with thirty-plus years of experience in shotcrete installation, waterfeature and geotech design, and construction. He is co-founder of Watershape University.*

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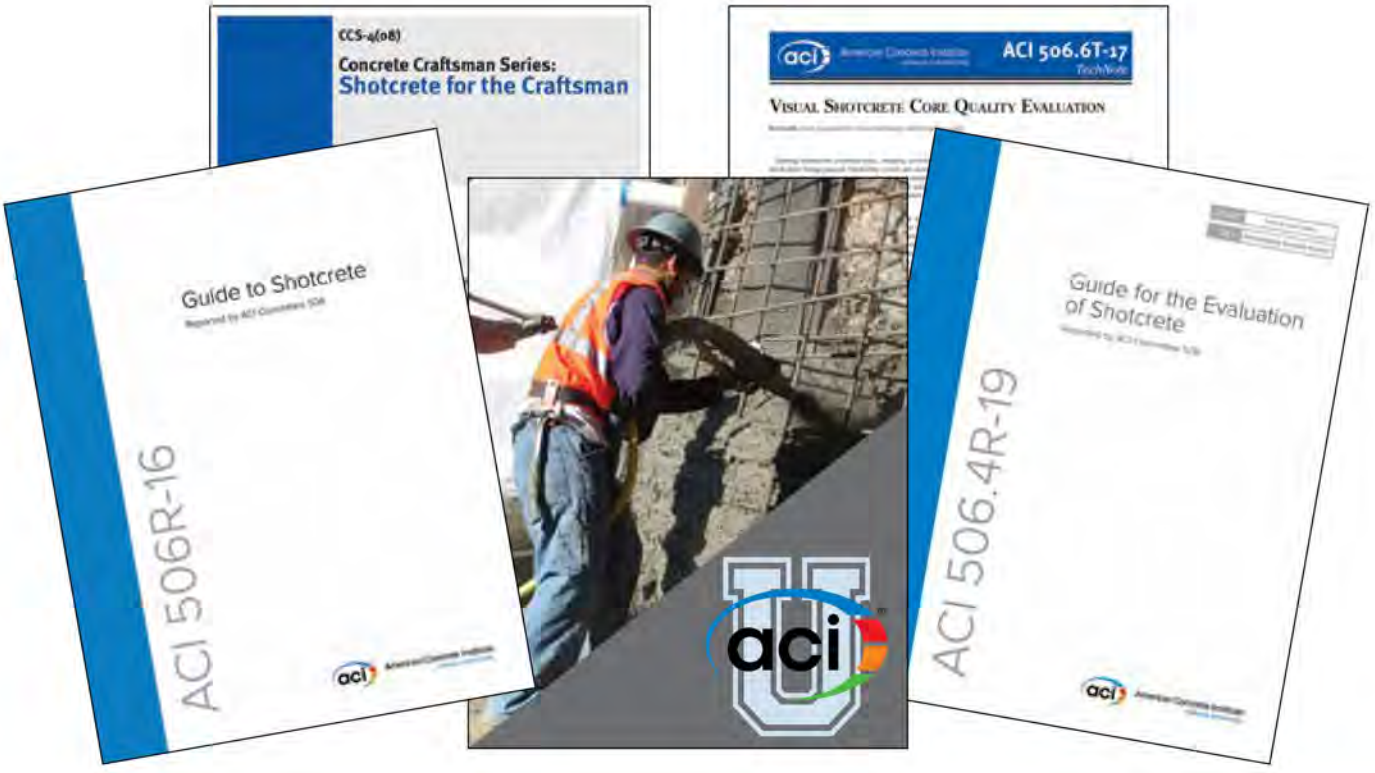

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Mount Pleasant Station, Part 1: Preconstruction Qualification for Shotcreting of Mass Concrete

By Shaun Radomski; Dudley R. (Rusty) Morgan, Ph.D., F.ACI; Lloyd Keller, F.ACI; Daniel Sanchez; & Laura Di Monte

Multi-million-dollar underground stations are currently under construction on Metro and LRT lines in Toronto, Ontario, Canada. Traditionally, the thick, heavily reinforced structural concrete station walls have been constructed using the conventional form-and-pour concrete construction method. This construction method, while widely used, is not without its challenges. Many of the underground station sites are in congested urban areas, with limited areas for laydown of concrete formwork, and with crane access time for handling and installation of formwork often on the critical path for completion of station construction. In addition, in conventional ground-up forming, scheduling and logistics have necessitated that construction in a top-down method be employed. This method of construction, and the requirement for a series of transverse, large wall supporting struts, makes setting and moving the formwork wall panels cumbersome and impractical using traditional crane hoisting methods.

Recognizing these difficulties, the Joint Venture Design and Build companies constructing these underground stations have asked the question: "Can wet-mix structural shotcrete placement be used in lieu of conventional form-and-pour concrete to construct these, often 1.0 m (3.3 ft) to 1.5 m (4.9 ft) thick heavily reinforced mass concrete walls with a variety of embedments (electrical conduits, steel plates, grouting tubes, and PVC waterstops at vertical and horizontal construction joints) and thus largely eliminate the need for the use of vertical formwork?"

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

a) The walls were too thick; given that wet-mix shotcrete typically has a high cement or paste content (around 450 kg/m^3 [750 lb/yd^3), the heat of hydration, and peak and differential shotcrete temperatures would be too great and could result in thermally induced cracking and damage in the station walls. The design of the system had taken into consideration the necessity to reduce the potential for both thermal and drying shrinkage cracking. High cement content and smaller coarse aggregate sizes in traditional shotcrete mixtures conflicts with the need to reduce and minimize shrinkage.
b) While the issue of the heat of hydration in mass form-and-pour concrete walls had been dealt with in Ontario by using 70% slag replacement of portland cement in concrete mixtures (Ref. 3), there was no precedence for the use in structural shotcrete. There was uncertainty as to whether such high percentage of slag shotcrete mixtures could be satisfactorily pumped, shot, stacked, and finished without sagging and sloughing.
c) The thickness of walls and heavy congestion of large diameter, closely spaced reinforcing steel bars (up to four and sometimes more layers of lapped 30M or 35M bars [#9 or #11]), as well as embedments, would make it impossible to get full consolidation of shotcrete around such bars and embedments.
d) There was a lack of certified and qualified shotcrete nozzlemen in Ontario with demonstrated, proven experience in the construction of such heavily reinforced structural shotcrete walls.
e) There was a lack of experienced, qualified structural shotcrete inspectors in Ontario to monitor and sign off on the acceptability of the constructed shotcrete work.

Based on decades of experience in the concrete and structural shotcrete fields, the authors in Reference 1 and Reference 2 believed that the concerns above could all be satisfactorily addressed, and that the use of wet-mix shotcrete for construction of the structural walls in these underground stations was a viable construction method, which could provide a high-quality end product for the Owners with valuable time and cost savings for the projects.

The concerns in Item a) above were addressed in a systematic study undertaken to develop a low heat of hydration mass shotcrete which would meet the CSA A23.1

requirements such that the peak temperature of the in-place shotcrete would not exceed 70°C (160°F) and with an appropriate thermal control plan that the temperature differential between the core and exposed shotcrete surface would not exceed 20°C (70°F). This was accomplished using a 70% slag shotcrete mix. A detailed thermal control plan comparing the potential strain developed versus the strain capacity of the candidate concrete mixtures (generally in compliance with methods described in CIRIA C 660 and CSA A23.1 Annex T) confirmed the compliance with the empirical temperature constraints described previously. Details of this study are provided in Reference 1. The issue of concerns regarding possible restrained shrinkage cracks were addressed by using the 70% slag mix which provides low shrinkage where both test panels and full-scale mock-ups were found to be crack-free, as detailed in Reference 2.

The concerns outlined in Item b) above were alleviated. It was demonstrated in the study detailed in Reference 1 and Reference 2 that the selected 70% slag shotcrete mix was able to be satisfactorily pumped, shot, stacked, and finished without any significant problems of excessive plugging in the delivery line or sagging and sloughing of the shotcreted material in-place.

The concerns listed in Item c) above regarding the constructability of these thick, heavily reinforced structural shotcrete walls were dealt with by adoption of a "hybrid" (shoot and vibrate) shotcrete construction method. Details of the method used are provided in Reference 2. It was shown in the construction of full-scale mockups, from which "windows" were cut out of the thick structural walls with a diamond wire saw, that both full encapsulation of reinforcing steel, as well as embedments and walls free of voids and defects could be achieved. Six shotcrete nozzlemen were qualified to shoot structural shotcrete walls for an underground station, thus addressing the concern listed in Item d) above.

Finally, with respect to Item e) above, regarding the need for qualified structural shotcrete inspectors to monitor and sign off on the acceptability of the constructed work, a comprehensive shotcrete inspector education and training program was developed and provided by the authors. It also included a detailed Shotcrete Inspection Checklist which is now being routinely used by qualified Shotcrete Inspectors on Metro station construction projects in Toronto.

Based on successfully addressing all the issues raised in the list of concerns above, the joint venture consortium, Crosslinx Transit Solutions (CTS), and the designers and constructors of the Mount Pleasant Station on the Eglinton Crosstown Light Rapid Transit Line in Toronto, elected to proceed with using this low carbon, low heat of hydration 70% slag shotcrete for construction of the structural mass shotcrete perimeter walls at this station. This paper provides details of the Mount Pleasant Station pre-construction mock-up phase of this work. More specifically, it provides details of:

- Structural wall design details for the mock-up
- Shotcrete performance requirements and shotcrete mixture design submittals
- Qualification of shotcrete mixture design and ten shotcrete nozzlemen in shooting full-scale station wall mockups
- Qualification of shotcrete inspectors

STRUCTURAL WALL DESIGN DETAILS FOR THE MOUNT PLEASANT STATION PRE-CONSTRUCTION MOCK-UP

Figures 1 and 2 show the reinforcing design details for the 1.3 m thick perimeter station wall shotcrete mock-up used to pre-qualify both the mixture design and the shotcrete nozzlemen for the Mount Pleasant Station.

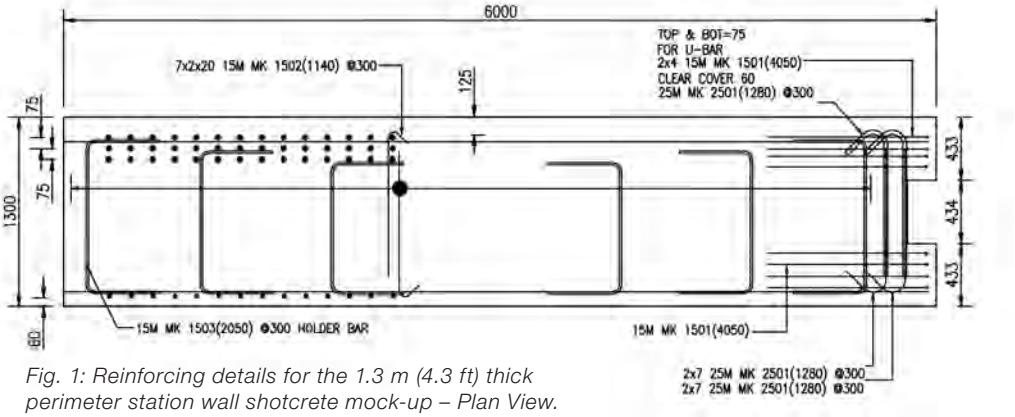

Fig. 1: Reinforcing details for the 1.3 m (4.3 ft) thick perimeter station wall shotcrete mock-up – Plan View.

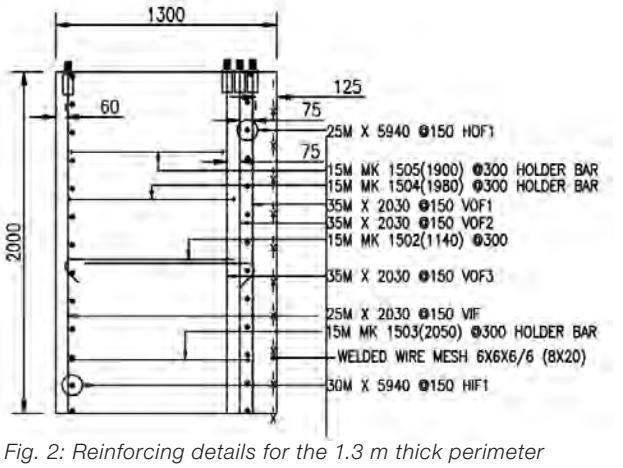

Fig. 2: Reinforcing details for the 1.3 m thick perimeter station wall shotcrete mock-up – Section View.

SHOTCRETE PERFORMANCE REQUIREMENTS AND SHOTCRETE MIXTURE DESIGN SUBMITTALS

CTS designers required the shotcrete mixture design to meet the following performance requirements:

- Compressive strength of 35 MPa (5000 psi) within 56 days
- Maximum water to cementing materials ratio of 0.40

- Rapid chloride ion penetration (CSA A2.3.-23C) of 1500 coulombs within 91 days
- "As-batched" plastic air content of 7-10% at discharge into the shotcrete pump
- "As-shot" plastic air content of 5 ±1.5% after shooting in-place
- Slump of 90 mm +/- 20 mm (3.5 in. ± 0.8 in.) at discharge into the shotcrete pump
- Maximum heat of hydration in the centre of the mass shotcrete walls to not exceed 70°C (158°F)
- The temperature differential between the near surface and the centre of the mass shotcrete walls not to exceed 20°C (68°F)

Two ready-mix concrete producers underwent pre-construction mixture design qualification to supply a wet-mix shotcrete for this work. Each mixture was designed with 30% GUbSF portland cement and with 70% slag cement. A natural cellulose fibre at 1.5 lbs/m^3 (0.7 kg/m^3) dosage was incorporated into the mixture to enhance pumpability, shootability, adhesion, cohesion, stackability, and finish-ability of the mixture. The fibre also helped mitigate plastic, autogenous, and drying shrinkage cracking.

SHOTCRETE EQUIPMENT USED IN THE PRE-CONSTRUCTION MOCK-UP

Shotcrete equipment included a 46 m^3/hr (60 yd^3/hr). TK60HP pump and two 10.6 m^3/min (375 ft^3/min) 375H air compressors (Fig. 3). Shotcrete was pumped from the hopper into a 90° steel elbow with an initial inside diameter of 127 mm (5 in.). Following the 90° steel elbow, the inside diameter of the steel line was reduced to 100 mm (4 in.), and then gradually reduced to 75 mm (3 in.) before a 45-degree elbow clamped to a short 75 mm slick line with 10 MPa (1450 psi) pressure rating. At another reducer, a 50 mm (2 in.) slick line traveled 3 m (10 ft) before the steel line was transitioned to 15 m (50 ft) of New-Line G783-200 Fabric Concrete Placement hose with 8.5 MPa (1230 psi) pressure rating feeding shotcrete to the mock-up. All connections in the shotcrete delivery system used clamp gaskets, rubber seals, pins, and whip checks. Shotcrete was pumped a total length of approximately 30 m (100 ft) to the mock-up (Fig. 4).

The nozzle assembly (Fig. 5) utilized the following:

- A unique pipe extension to reduce the shooting distance to the receiving surface at the back of the wall
- A rubber nozzle tip wrapped with duct tape to reduce bulging of the nozzle tip during bench shooting, which provided the shotcrete with a more concentrated shotcrete stream and a "rifling" type action

Compressed air was fed to the nozzle assembly using 30 mm (1.2 in.) air delivery hoses with 2.8 MPa (400 psi) pressure rating. A separate air compressor fed compressed air to two blow pipes. The reason for the separate compressor was to avoid stealing any air from the nozzle during bench shooting and blow piping simultaneously. A long, stiff rod vibrator with a 40 mm (1.6 in.) diameter (Fig. 6) provided the shotcreted concrete with supplementary consolidation.

Fig. 3: 375CFM Air Compressor and Putzmeister TK60HP Shotcrete Pump.

Fig. 4: Steel slickline and rubber hose which fed shotcrete to the mock-up. Credit: Jimmy Wang.

Fig. 5: Nozzle assembly utilizing a unique pipe extension between the rubber nozzle tip and the nozzle air ring compressed air valve. Rubber nozzle tip is wrapped tight with grey duct tape. Credit Jimmy Wang.

Fig. 6: A long 40 mm (1.6 in.) diameter stiff rod vibrator provided the placed shotcrete with supplementary consolidation.
Photo Credit: Jimmy Wang.

QUALIFICATION OF SHOTCRETE MIXTURE DESIGN AND SHOTCRETE NOZZLEMAN BY SHOOTING FULL-SCALE STATION WALL MOCKUPS

ACI-certified shotcrete nozzlemen underwent prequalification by each shooting a section of a full scale 1.3 m (4.3 ft) thick heavily reinforced mock-up representing a perimeter station wall at Mount Pleasant Station (Fig. 7, 8, and 9). The mock-up consisted of three layers of closely spaced 35M reinforcing bars at the back of the work adjacent to a waterproofing membrane system; it also contained grout tube embedments and one layer of closely spaced 35M rebar along the front inner wall face of the mock-up. Each nozzleman was responsible to shoot a separate rectangular 2 m (6.6 ft) long, 1.0 m (3.2 ft) high, and 1.3 m thick block segment of the mock-up, as shown in Figures 7, 8, and 9.

During the mock-up construction, the mixture design underwent prequalification and was evaluated for its pumpability, shootability, stackability (adhesion and cohesion using "beehive" and "buttress" tests); its ability to consolidate and "wrap" the rebar; and its finishability characteristics.

Fig. 7: Full scale 1.3 m (51 in.) thick mockup. Photo Credit: Robert Mattes

Fig. 8: Mock-up was heavily reinforced with 4 layers of heavy rebar, including 3 layers of closely spaced 35M (#9) rebar at the back of the work adjacent to a water proofing membrane. Photo Credit: Jimmy Wang

Each nozzleman began bench shooting (Fig. 10) the first lift, starting in the left corner of the wall of segment one, using the standard bench shooting procedures recommended in ACI 506R-16 Guide to Shotcrete. The nozzleman would insert and position the nozzle with the pipe extension into the 150 mm (6 in.) square openings in the reinforcing mat (along the inner wall face) on a consistent basis to reduce the shooting distance to the three back rows of 35M reinforcing bars and to the outer face of the wall (waterproofing membrane) (Fig. 11). The shotcrete stream was observed to impact the three layers of vertical reinforcing steel and waterproofing membrane at a high-impact velocity while a blow pipe was used to continuously clean the back reinforcing steel in front of the area about to be shot.

Fig. 9: Inside mock-up showing spliced 25M vertical reinforcing (inner wall face), spliced 3-35M vertical reinforcing (outer wall face), 15M holder bars and plastic waterstop.

Fig. 10: Nozzleman bench shooting mock-up with blow pipe operator working in tandem with the nozzleman.

Fig. 11: Nozzleman inserting entire nozzle tip and extension between square openings in the front mat of reinforcing steel. Shotcrete stream impacting three layers of vertical reinforcing steel and water proofing membrane at a high impacting velocity. Blow pipe being used to continuously clean the back reinforcing steel in front of the area about to be shot.

The nozzleman would systematically insert the nozzle into several square openings up and down while moving in a left to right direction to the centre of the mock-up. Three nozzlemen shot equal-sized block segments along the bottom half of the mock-up and, similarly, three additional nozzlemen shot the top half of the mock-up. The nozzlemen would hand off the nozzle once their segment was complete.

The nozzlemen began bench shooting the first lift of segments three and six from the far-right corner of the work, instead of at the transition between segments two and three (at bottom half) and between segments five and six (at top half), working back to segments two and five, respectively, which is standard practice to avoid trapping rebound into the corners of the work. Similarly, standard bench shooting procedures recommended in ACI 506R-16 were used. During shotcrete placement, the following took place:

- Nozzlemen would shoot approximately 500 mm (20 in.) high lifts.
- A blow pipe operator worked in tandem with each of the nozzlemen, removed overspray and shotcrete build-up from the reinforcing steel and rebound from the work (Fig. 12).
- An operator of a stiff rod immersion vibrator (Fig. 12) would start behind the nozzleman inserting the rod right to the back of the work to "lay down the bench" and provide supplementary consolidation of the shotcrete around the back-reinforcing steel bars to the outer wall face.

Fig. 12: An operator of a stiff rod vibrator would start behind the nozzleman inserting the vibrator to the back of the work to "lay down the bench" and provide supplementary consolidation of the shotcrete around the back reinforcing steel. Photo Credit: Leonard Crasta.

During regular and frequent stoppages in shotcrete placement:

- One to two blow pipe operators rigorously cleaned off any buildup of shotcrete and overspray from the reinforcing bars and removed rebound from the work.

Fig. 13: Supplementary consolidation provided by insertion of a long 40 mm diameter stiff rod vibrator into the back of the work. Photo Credit: Robert Mattes.

Fig. 14: Following use of stiff rod vibrator, shotcrete was being well consolidated and wrapping around the three outer 35M reinforcing steel bars. Photo Credit: Leonard Crasta.

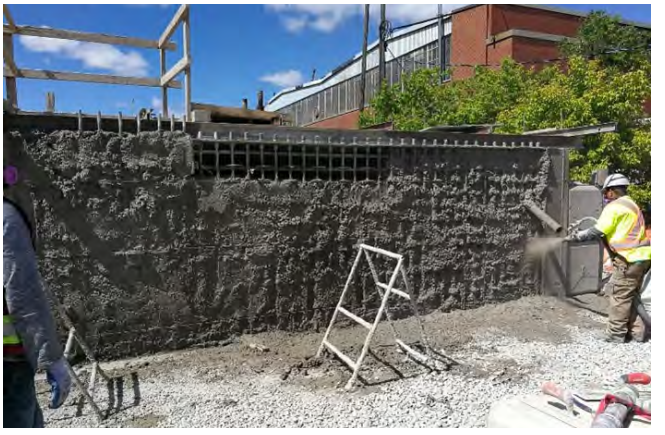

Fig. 15: Nozzleman shooting the final finish coat of the mock-up. Photo Credit: Jimmy Wang.

Fig. 16: Final finishing of mock-up. Photo Credit: Jimmy Wang.

Fig. 17: Close up view of the finished mock-up. Photo Credit: Mitchell Matais.

Fig. 18: Finished mock-up was cured using a spray on applied curing compound. Photo Credit: Jimmy Wang.

Fig. 19: Finished mock-up following stripping of the formwork after curing in air for 10-days.

- Two stiff immersion vibrators were inserted into the shotcrete to "lay down the bench" and provide supplementary consolidation to the back of the work adjacent to the waterproofing membrane and the outer vertical 35M reinforcing steel bars. Immersion vibrators were used extensively. One immersion vibrator had a curved rod to help consolidate shotcrete in previous lifts, and one immersion vibrator had a straight rod to enable reaching the outer wall formwork.
- Typically, the straight rod immersion vibrator would lay down the bench, which was followed by one or two blow pipe operators cleaning off the build-up of shotcrete and overspray on the reinforcing bars, and then the curved stiff rod immersion vibrator would provide additional shotcrete consolidation behind the blow pipe operator(s).

It was observed that by using the stiff immersion vibrators, shotcrete was well consolidated and wrapped around the three outer 35M reinforcing steel bars (Fig. 13 and 14). Final proof of the overall quality of the reinforcing steel encasement was confirmed when the work was cut open into blocks and a review of the adequacy of reinforcing steel wrap was completed.

Following bench shooting the work to the top of the mock-up and out to just cover the front reinforcing bars, a final finish coat layer was applied out to just beyond the shooting wires (Fig. 15) and then trimmed with a cutting screed to the shooting wires.

Wooden floats were used to close the surface then followed by a steel trowel finish (Fig. 16 and 17). The left half of block segment two and the left halves of block segments five, one, and four received a spray-on applied curing compound (Fig. 18), and the remainder of the mock-up surfaces were wet cured using water saturated burlap.

Upon a close-up review of the finished surfaces of the mock-up, the shotcrete mix incorporating 70% slag cement and natural cellulose fibre at 1.5 lbs/m^3 dosage displayed excellent finishability, with finished surfaces without any pulls or tears (Fig. 17). In addition, the mock-up's finished surfaces were found to be crack free (Fig. 19). These findings are attributed to using the natural cellulose fibre in the mix, which controls accumulation of bleed water near the surface and acts as a finishing aid as well as an internal curing aid due to the hydrophilic nature of the natural cellulose fibres.

Routine plastic shotcrete testing included temperature, slump ("as-batched" and "as-shot"), and plastic air content ("as-batched" and "as-shot"). The results of these plastic shotcrete tests are provided in Table 1.

The "as-batched" slump tested at discharge into the pump ranged between 75 mm and 110 mm (4.3 in.), and averaged 90 mm, which satisfied the specified slump of 90 mm +/- 20 mm at discharge into the pump. At these slumps, there did not appear to be any sloughing or sagging in the shotcrete placement. This finding was supported by the beehive test (Fig. 20), where shotcrete was applied onto a vertical plywood out to a thickness of about 220 mm (8.7 in.) before the shotcrete sagged. The "as-batched" air content tested at discharge into the pump ranged between 7.5% and 8.2%, and averaged 7.8%, which satisified the specified plastic air content of 7-10% at discharge into the pump. The as-batched slump was measured and showed that over 50% of the "as-batched" slump was lost during the shooting process as the mixture was designed with a high plastic air content, generally in the 7-10% range, to produce the "as-shot" air content ranged between 4.0% and 5.5%, and averaging 4.9%, which satisfied the specified "as-shot" air content range of 5 +/-1.5%.

Fig. 20: Beehive Test. Photo Credit: Mitchell Matias

Table 1. Plastic Shotcrete Properties

Mt. Pleasant Station Preconstruction Mock-up					
Load No.	**Temperature (°C)**	**"As-Batched" Slump (mm)**	**"As-Shot" Slump (mm)**	**"As-Batched" Plastic Air Content (%)**	**"As-shot" Plastic Air Content (%)**
1	24.0	110	20	8.0	5.0
2	21.0	85	5	7.5	5.5
3	23.5	90	40	7.6	4.0
4	23.2	75	20	8.2	5.0
Avg.	22.9	90	20	7.8	4.9
Spec.	10-25	90±20	-	7-10	5±1.5

The results of compressive strength of cores are provided in Table 2.

Table 2. Compressive Strength of Cores

Mt. Pleasant Station Preconstruction Mock-up			
Trial #	Compressive Strength of Cores (MPa)		
	7 Days	28 Days	56 Days
1	18.6	32.3	36.2
2	18.8	33.2	38.1
Avg.	**18.7**	**32.8**	**37.2**
Spec.	-	-	**35.0**

Compressive strength of cores tested at 56 days ranged between 36.2 and 38.1 MPa (5280 and 5530 psi), averaging 37.2 MPa (5400 psi), which satisfied the specified compressive strength of 35 MPa at 56 days.

The results of rapid chloride ion penetration of cores are provided in Table 3.

Table 3. Rapid Chloride Ion Permeability of Cores

Mt. Pleasant Station Preconstruction Mock-up			
Trial #	Rapid Chloride Permeability (Coulombs)		
	28 Days	56 Days	91 Days
1	1430	1059	-
Spec.	-	-	**1500**

Rapid chloride ion penetration of cores tested at 28 days and 56 days achieved 1430 coulombs and 1059 coulombs, respectively, which satisfied the specified rapid chloride ion penetration of 1500 coulombs within 91 days.

Using heat box analytics, the 70% slag shotcrete mixture's adiabatic heat development was found to reach a peak temperature of 56.2°C (133 °F) at 73 hours, which is less than the specified peak temperature in the center of the mass shotcrete walls of 70°C. B4Cast Modelling Software was then used to develop the thermal control plan by modeling the anticipated climatic environment and various boundary condition scenarios to safely dissipate the heat from these mass shotcrete walls, ensuring that the temperature differential between the near surface and the center of the mass shotcrete walls did not exceed the maximum specified temperature differential limit of 20°C. Thermal controls included limiting shotcrete placement temperatures and using three layers of R2.5 tarpaulins to cover the walls during the curing period.

Fig. 21: An example of a wire saw cut section of mockup showing excellent consolidation of shotcrete around the three layers of 35 M rebar at the back of the work and to the outer membrane.

Fig. 22: Another example of a wire saw cut section of mockup showing excellent consolidation of shotcrete around the three layers of 35 M rebar at the back of the work and to the outer membrane next to the embedded plastic water stop. Photo Credit: Jimmy Wang.

Following mock-up construction, it was cut open into several block sections using a wire saw, and upon close evaluation, the quality of shotcrete in the stripped vertical ends (Fig. 19), around the reinforcing steel, and to the outer membrane were observed to be excellent (Fig. 21, 22, and 23).

Fig. 23: An example of a wire saw cut section of mockup showing excellent quality of shotcrete at the transition between the shotcrete and the SCC using the StayForm Option 1 at the roof soffit with the keyway and plastic embedded water stop detail

An earlier study (Ref. 2) found that it was not possible to use the shotcrete process to construct the wall just below the roof soffit due to a keyway and embedded plastic water stop protruding outward along the underside of the roof. Poorly consolidated shotcrete was found, including significant voids behind the keyway and embedded plastic waterstop just below the roof soffit. Knowing that shotcrete was not an option here, CTS considered two alternative options to construct the wall just below the roof soffit behind the keyway and embedded plastic water stop. Options evaluated included the following:

1. Shoot shotcrete 300 mm (12 in.) short of the roof soffit so that there is a noticeable gap between the top of the shotcrete and the roof soffit. A 300 mm wide StayForm positioned 450 mm (18 in.) in from the front inner wall face (Fig. 24) was used to act as a receiving surface where shotcrete was applied directly to the StayForm and built out to cover the front mat of reinforcing steel. A final finish coat was then shot to the shooting wires and finished. At a later date, using a pressure pump technique, a self-consolidating concrete (SCC) mixture was pumped in behind the StayForm, filling the remaining 300 mm gap up to the roof.
2. Shoot shotcrete 300 mm short of the roof soffit so that there was a noticeable gap between the top of shotcrete and the roof soffit. At a later date, a suitable form was inserted along the front face of the wall and SCC was pumped between the top of shotcrete and the roof soffit filling the 300 mm gap along the entire wall thickness.

Upon review of the cut sections incorporating this detail, the overall quality of shotcrete at the transition between the shotcrete and the SCC was found to be excellent in Option 1 (using the StayForm) (Fig. 23). Option 2 revealed a minor, but notable cold joint observed in the cut section. CTS chose the StayForm Option 1 to construct the station walls along the underside of the roof soffit and behind the keyway and plastic embedded water stop.

QUALIFICATION OF SHOTCRETE INSPECTORS

The Mount Pleasant Station preconstruction mock-up was used as the practical component of the shotcrete inspector education and training program

[Insert Figure 24] Fig. 24: A 300 mm wide StayForm positioned 450 mm. in from the front inner wall face used to act as a receiving surface to apply shotcrete out to cover the front rebar. Credit: Carl King.

provided by the authors. The inspectors completed a review of the mock-up in advance of shotcrete application, and if there were any recommended adjustments to be made (such as fastening reinforcing steel or grout tube embedments), these were relayed to CTS for corrective action. The inspectors were each assigned to monitor a specific nozzleman during shooting. The following additional reviews were completed during construction of the mock-up:

- Shotcrete mixture behavior, such as mixture pumpability, shootability, adhesion/cohesion, reinforcing steel encapsulation, and finishability
- Equipment
- Nozzleman and crew technique

The inspectors were required to fill out and complete a detailed shotcrete inspection checklist report and provide comments on the acceptability of the work that was observed by the inspector. All inspection checklist reports were handed in and reviewed by the lead authors. At the conclusion of the mock-up phase of this work, a total of four shotcrete inspectors were qualified to provide full-time construction monitoring as part of CTS's quality control program during the construction phase of the work.

CONCLUSIONS

This article demonstrates how a total of 10 nozzlemen were prequalified to construct the station walls using the "hybrid" shoot and then vibrate shotcrete construction process. The work proceeded to construction based on the satisfactory mock-up results using the same equipment, mixture design, and qualified nozzlemen to construct the station walls. CTS was required by the designers to have the work monitored full-time by qualified third-party shotcrete inspectors. In addition, rigorous monitoring of temperature was completed by CTS as part of the thermal control plan to provide assurance that these mass shotcrete walls did not develop excessive temperature rise in the core of the element and that large temperature differentials resulting in thermal induced cracking were avoided (Ref. 4).

CTS received recognition of significantly 'decarbonizing' the construction process by using such high volumes of supplementary cementitious materials like slag cement, which are much more environmentally friendly than using more carbon-intensive General Use (GU) portland cement. Prior to extensive trials undertaken by CTS:

- Conventional low heat of hydration cast-in-place concrete mixes were typically designed with between 50-60% portland cement content
- A recent low heat of hydration shotcrete mix used in British Columbia incorporated 40% slag cement (Ref. 4)
- Conventional wet-mix shotcrete mixes were typically designed with up to 450 kg/m^3 of cementitious materials, at least 70% of which incorporated general use (GU) portland cement (i.e. portland cement production is known to have a high carbon footprint) (Ref. 3).

In summary, a considerable reduction in greenhouse gas emissions using 70% slag cement in the shotcrete mixture design can be achieved (Ref. 3). This level of cement replacement proved to be optimum, when combined with local materials, to provide performance benefits in reducing the heat of hydration, shrinkage, and permeability while minimizing short-term strength reductions.

A second paper to be published in an upcoming edition of *Shotcrete* magazine will provide details of the Mount Pleasant Station construction phase of this project.

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ACKNOWLEDGEMENTS

Owner: Metrolinx and Infrastructures Ontario

General Construction Contractor and Designers: Crosslinx Transit Solutions, a general partnership comprised of SNC-Lavalin Constructors (Pacific) Inc., Dragados Canada Inc., EllisDon Civil Ltd. and Aecon Infrastructure Management Inc.

Construction Project Managers: Eduardo Hernandez Arnanz, Mario Prieto Dominguez, Laura Di Monte
Construction Quality Lead: Bashir Alim | **Design Engineer:** Ken Stranks | **Shotcrete Contractor:** Torrent Shotcrete
Shotcrete Pump Equipment: Reed | **Shotcrete Ready-Mix Supplier:** Innocon CBM
Shotcrete Testing Company: Qualitylinx | **Shotcrete Construction Inspectors:** WSP E&I Canada Ltd.
Project Consultant and Senior Shotcrete Inspector: Shaun Radomski
Resident Shotcrete Inspectors: Jimmy Wang, Robert Mattes, Leonard Crasta
Technical Support: Lloyd Keller, Dr. Dudley (Rusty) Morgan, and Dr. Lihe (John) Zhang

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

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

Dudley R. (Rusty) Morgan, Ph.D., F.ACI, *is a Civil Engineer with over 50 years of experience in the concrete and shotcrete industries. He served as a member and Secretary of ACI Committee 506, Shotcreting, for over 25 years. He is a past member of ACI Committees 365, Service Life Prediction, and 544, Fiber-Reinforced Concrete. Morgan is a founding member and Past President of ASA. He is an ASA/ACI C660-approved Shotcrete Nozzleman Examiner. Morgan is a past member of the Canadian Standards Association Concrete Steering Committee and was a Canadian Representative on the International Tunneling and Underground Space Association Committee, Shotcrete Use. He has worked on over 1000 concrete and shotcrete projects around the world during his consulting career and has edited five books and published over 150 papers on various aspects of concrete and shotcrete technology. In 2001, Morgan was elected as a Fellow of the Canadian Academy of Engineering.*

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

Laura Di Monte *is a mechanical engineer with Bell in Toronto, Canada. She worked as the Technical Project Coordinator for the Mount Pleasant Station project.*

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Risk Management

By Theo Goodwell

In the world of shotcrete, we often speak about the importance of safety: how to handle the nozzle safely, how to hold the nozzle to protect your back, the importance of proper personal protective equipment (PPE), and even pump and vehicle maintenance. How all these safety measures affect your bottom line is the world of risk management, and risk management affects productivity and insurance premiums.

In this article, I will review some best practices for proactively hiring, training, and handling claims so that your Experience Modification Rating (EMR) and your risk will be low (or lowered) and your company-wide productivity will be high (or higher). I will also cover some basics of risk management, safety awareness, and handling claims.

WHAT IS RISK MANAGEMENT?

- Risk is defined as "uncertainty concerning the occurrence of a loss."[1]
- Risk is "often used in situations where the probability of possible outcomes can be estimated with some accuracy."[1]
- Risk management is "a process that identifies loss exposures faced by an organization and selects the most appropriate techniques for treating such exposures."[1]
- Steps in the risk management process include[1]:
  - Identifying loss exposures
  - Measuring and analyzing loss exposures
  - Selecting the appropriate combination of techniques for treating loss exposures
  - Implementing and monitoring the risk management program.

RISK MANAGEMENT IN THE INTERVIEWING & HIRING PROCESS

An overlooked, but potentially costly, aspect of risk management is not allowing your "next claim" through the door in the first place. No, I am not saying to make blanket generalizations based on physical appearance, demeanor, or age. What I am saying is that doing a little more work on the front end will go a long way to reducing your EMR on the back end. There are no fool-proof ways to ensure you are hiring quality employees, but effective screening can go a long way toward sifting out employees that may wreak havoc from a liability standpoint.

Many small to midsize contractors do not have an HR department; they hire based on need and experience for the industry and position. There is not a national database for nozzlemen that will tell you if your candidate is prone to accidents or does careless work, but you do need to make sure your company is covering the basics: multiple in-person interviews, job applications listing work experience, drug testing, reference checks, etc. Consider the concept of integrity testing when you are screening and interviewing candidates. This is when you evaluate a candidate based on his or her responses to integrity- or ethics-based questions.

First, draft a list of attributes that your ideal employee would have. For example, your list might have the following on it: shows up to work on time, consistently produces quality work, has a teamwork-based approach, is pleasant to work with, etc. Then write a few questions for each of those attributes that will help you screen candidates for the attributes you know work best on your team.

Here is a line of questioning you might ask to determine if the candidate produces quality work consistently: Have you ever had to start over on a project when the quality did not turn out the way you were expecting? What did you do to fix it, and how did you know the work wasn't up to standards?

> There are no fool-proof ways to ensure you are hiring quality employees, but effective screening can go a long way...

Next, to screen candidates that will not be more likely to experience consistent claims, draft some interview questions based on scenarios you've experienced with employee claims.

For example, your list of questions might have the following on it, or questions like these:

- Have you ever had a minor accident on the job? Tell me more about it.
- Have you ever had a major accident on the job? What were the circumstances and outcomes?
- How often would you say you experience minor or major accidents on the job? What do you attribute this to?

- Would you drink on the job if no one were watching?
- How many days in a week is it acceptable to show up to work slightly hungover?
- If there are three unopened lunches in the refrigerator that do not belong to you – how many can you eat without feeling guilty?

These questions may have obvious answers to you, but you will be surprised at some of the responses you will get if you just ask them during your interviews.

Screening candidates more effectively for your open positions should have a direct impact on your potential for claims.

> Claims have a direct effect on a company's risk level, productivity, and finances...

Let's circle back to the EMR. It is like a credit score that underwriters will use to help determine what rate your company will pay for workers' compensation premiums. The goal here is not to have an 800 (8.0) score! The more claims you have, the higher the score. The more serious claims you have, the higher the score. You want the lowest possible rating score.

How do we get a low score? The bad news is that there is not a magical one-step process; it will take time. Period. Part of effective risk management is claims management. Do you have claims that have been open for extended periods? Do you have a claim that drags on? Can you communicate with your insurance agent or underwriter and explain that your claims handling process is inadequate for your needs?

Claims have a direct effect on a company's risk level, productivity, and finances, so let's review some ways we can be proactive in other areas, so we minimize claims and their effects on decreased productivity in the short term and the long run.

CHANGES TO EMPLOYEE TRAINING & SAFETY AWARENESS

There are a few things to consider regarding employee training as it affects both your bottom-line productivity and your EMR rating:

- How often do your employees (field operations in particular), receive training, and how often are they tested on best safety practices?
- Do you hold daily tailgate safety meetings?
- When was the last time you updated your employee handbook, and do all employees have easy access to it (including periodic updates you might make to it)?
- Does your company have an Injury Illness Prevention Program (IIPP), and do all of your employees have easy access to a copy of it?
- Do you have an attorney to review your company's employee handbook or IIPP so you are staying up-to-date on the latest laws and regulations? (Some states like California require this annually!)
- Do you hold paid training during work hours or online paid training during off-work hours?
- Do you require employees to acknowledge safety risks daily before entering a job site, or do you require a daily short quiz before starting work in order to ensure aspects of the job are clear?

If you do not practice these already, consider which of these you might easily implement now in the short term and which could be implemented as a long-term goal.

> What is the cost, to your business, of not implementing these practices?

These are just a few considerations to help ensure that you have done your best to assess risks within your employee pool and to actively seek to minimize issues and occurrences resulting from training deficits and safety protocols.

Your response to these questions may be that you are doing all of this already, but the workers' compensation claims are still piling up. Maybe there is not enough time to get a new crew trained and tested on safety, and your exploding EMR is telling you otherwise. What is the cost, to your business, of not implementing these practices? Have you run a cost-benefit analysis? That should be next on your list, so you have a true assessment of the costs of acting or not acting on your needs.

It is not easy or cheap to train a new worker, so perhaps the cost is prohibitive to you at this time in terms of committing extensive training or re-training.

Another hurdle for your particular business could be that your state says some of these changes would constitute illegal job practices, or perhaps your most valuable employees are bucking against new training or policies that will help you reduce your risk as a business owner or manager.

Reducing your overall cost of risks can seem like a complicated and frustrating task. It does not have to be. Many of you that own your businesses or are in positions at your company to make these decisions, understand this is true. What steps can you take to improve your EMR, your new employee hiring and screening process, and your existing employees' training and safety awareness? Start small if need be.

CHANGES TO HANDLING CLAIMS

How does your company handle claims? I will use a nozzleman example to illustrate a typical scenario. If he comes into work one day and is complaining of shoulder pain, what is

the first question you ask him? More than likely, you ask this: How did you hurt your shoulder? Then, you probably ask this: When did this happen? Here is where it can get tricky. Let's say this specific nozzleman is in a basketball league and he plays every week; he is in good shape and plays often. Did the injury happen during the game or on the job site? How will you, as an Office/Operations Manager, HR Executive, or Owner know?

Remember at the beginning of this article where I mentioned not hiring your next claim and the importance of integrity testing? Integrity testing in the hiring phase, or along the way in training and safety follow-ups, comes into play here when we set expectations that our employees are open and honest in their reporting of job-related injuries. In most cases, you will not know whether the injury is work-related or not, but the approved medical facility you use, who happens to be in the approved Medical Provider Network (MPN), is surely going to find out.

How many of your claims went through a nurse triage process? By this I mean do you have a company that has nurses on staff that, through a series of questions or a quick visit, can determine if this is a work-related injury or not?

Under a nurse triage program, you would make a call from the jobsite or back at the office. Their representative would gather the information from the employee and decide what happens next. In this example, they go to a local clinic where the injury is assessed and maybe some basic medicine is provided. Since it was properly treated and documented, the employee is cleared to go back to work the next day. This happens all the time, and through this process, other claims-related issues are avoidable. In other cases where an injury causes the employee to be unable to do his or her normal duties, the nurse triage program route will open other options to consider; for instance, using a return-to-work program through a local non-profit where they can do low-impact office work.

> Timely claims reporting reduces the amount of time an employee is out of work or a vehicle is off the road.

Let us look at another example. One of your crew members cuts her finger on a piece of equipment during the workday. Most crews have a first aid kit on site, and as long as the finger is still attached to the hand, you treat it and move on. When the team gets back to the yard or office, the incident is reported according to your employee handbook. However, what happens when your employee goes home for the day because she is tired and forgoes the clinic? She treats it at home with whatever she has in her medicine cabinet, and she reports to work the next day. The finger hurts, but she needs to keep earning money, so she says nothing and keeps showing up for the rest of the week.

Eventually, she cannot drive due to the finger, so another employee graciously drives her to the emergency room or urgent care. There, it is determined that a serious infection has set in, and the employee will be sidelined for a month. You do not have an IIPP, (remember this acronym from earlier), there is not a return-to-work program, and thus there is no light-duty work for your employee to do while recovering.

If your employees are sidelined, they are missing income. Since you do not have a return-to-work program, that amount will be paid out in the form of indemnity. Take a look at your loss runs and review your claims. There will be a column labeled indemnity (to make them whole). This is a running tab of one part of what the carrier will have to pay out. Nurse-triaged accidents are 40% less likely to become claims. Doctors-on-call services prevent 90% of injuries from turning into claims. Consider taking advantage of a mobile nursing unit that will come to your jobsite and triage on the spot.

Once the claim has been opened, it is very important to close them out within an appropriate period of time because this will save you money on workers' compensation premiums in the end. What is an appropriate period for reporting and closing claims? The official answer is to READ your policy. A good rule of thumb is within 24 to 48 hours. Timely claims reporting reduces the amount of time an employee is out of work or a vehicle is off the road. Who really likes a long, drawn-out process of any kind? No one!

Along with the nurse triage program discussed earlier, what else could you do to ensure proper claims management? Here are a few suggestions:

- Provide the claims adjuster with ALL claim documentation within 3 days of injury notice.
- Implement an automated system for tracking, monitoring, and organizing claims.
- Have an Experience Modification Analysis completed each year.

CONCLUSION

We have covered a few reasons why it is important to close out claims quickly; what we have not discussed is when and how. Most business owners have no idea how or when their claims are reported and to whom. In CA, your workers' compensation carrier reports claims directly to the WCIRB (Workers Compensation Insurance Rating Bureau). In other states, the NCCI (National Council on Compensation Insurance) performs the same function as the WCIRB.

- Workers Compensation Insurance Rating Bureau-California (WCIRB): https://www.wcirb.com/
- National Council on Compensation Insurance (NCCI): https://www.ncci.com/

By knowing when the unit statistical period ends, you can formulate a plan to close out claims, have the reserves lowered, and have the claim descriptions amended. Being able to execute one, or a combination, of these steps could go a long way to reducing your company's EMR, which will in turn help to drastically reduce your annual workers' compensation premiums.

If you are already doing this at your organization, well, thank you for reading this deep into my article. If you are not, I (and your employees) do hope you consider some, if not all, of these practices and suggestions as they will help with both productivity and your bottom line. Ultimately, these are your employees, clients, and carrier relationships, all of whom are important. Over the years, I have made an observation: there are so many company websites that promote their safety culture and their employees as "family," but their actions do not match their words. It is worth the extra time and effort to help ensure the care and safety of your extended family because while you're ensuring your employees are healthy and safe, your finances and EMR ratings will be healthy too!

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Theo Goodwell *is an Associate Vice President at Champion Risk & Insurance Services LP in San Diego, California. He has been in the insurance business since 2012, providing businesses with commercial insurance products and risk assessments. Theo has been a member of the American Shotcrete Association since 2021. He joined ASA because he wanted to holistically assist his clients in the construction business and to be a source of information for an underserved market segment. Another reason Theo joined ASA was because he has always been fascinated by how concrete structures are designed and constructed.. In his spare time, he trains in Jiu-jitsu, travels, and appreciates trying new restaurants.*

New Column, "Shotcreter Spotlight," to Celebrate Nozzlemen and Crews, Support Staff, and Women in Shotcrete

By Cindy Spires, Managing Editor

The editorial staff at *Shotcrete* magazine have created a new column entitled "Shotcreter Spotlight." Its purpose is to shine a spotlight on the nozzlemen and teams who prep, shoot, sculpt, and finish the everyday jobs, the award-winning jobs, and everything in between. This new column also serves to spotlight those who work away from the nozzle as support staff and to specifically spotlight the women who make the industry thrive.

The impetus behind this column is acknowledgment and praise of team members from their own team leadership or from colleagues who value their work.

This is your opportunity—as a business owner, superintendent, director, manager, supervisor, or colleague—to tell the readers of *Shotcrete* magazine all about the wonderful things your employees are doing to make the shotcrete industry, and your business, a success.

"Shotcreter Spotlight" will celebrate the individual and the team-based achievements of your employees, as nominated by you as their leaders and colleagues.

We have three categories you can nominate an individual or a team in:

- **Nozzlemen & Field Crews**—nozzlemen, field teams, and crews.
- **Support Staff**—office staff, mechanics, shop employees, etc.
- **Women in Shotcrete**—a woman who is making her mark on the shotcrete industry in big or small ways.

CONSIDERATIONS FOR NOMINATIONS

Publication Selection: Unlike the Outstanding Shotcrete Project Awards, which celebrate holistic project success, "Shotcreter Spotlight" is not voted on by a committee or evaluated for merit. Editorial staff will review submissions as we get them, follow our normal editorial process for proofreading and formatting, and publish these praise-based pieces appropriately spaced in our upcoming issues.

Nomination frequency: You can nominate an individual or team/crew once every two years maximum. You are welcome to submit multiple nominations at any given time. For example, you may want to nominate your CFO for Women in Shotcrete, and you may also want to nominate one of your nozzlemen—that is fine! Just make sure you aren't re-nominating someone you've nominated within the 2-year timeframe. If a crew changes members, and you want to nominate the crew before the 2-year timeframe, please reach out directly to me so I can review your proposed nomination with ASA editorial staff.

Publication Frequency: As space is available in *Shotcrete* magazine, these columns will be released at a maximum of one per issue in each category at the discretion of ASA's full editorial staff. Some may also be shared via ASA's social media channels if we have a hearty influx of nominations (which we hope we do!). Unlike ASA's annual awards, no committee review is involved: submit a nomination and, as space allows, these spotlights will be published.

Pre-Publication Logistics: Leaders or colleagues who submit nominations for this column will have a chance to review a proof of the column before publication and will be asked to complete ASA's typical magazine-specific requirements, including signing a copyright form, providing photos, and responding to proofs by a deadline.

Please note, when you submit this nomination, pre-approval from the individual(s) to use their pictures and names in *Shotcrete* magazine is required. Prior to final proofing, ASA staff will need confirmation that the individual or team/crew members have approved the publication of their information.

HOW TO NOMINATE SOMEONE FOR SHOTCRETER SPOTLIGHT

We have a online form that you will use to answer some questions and to provide additional information to help us understand why this person or team should be praised for their work. We will ask you to include a photo or two as well, so be sure to give us a headshot and at least one work-based photo of this stellar employee's work (or the team of employees in action) that will showcase them!

This online form is where you will complete the nomination: **https://forms.gle/bBrNY8xJfyPqQiyq5.** Keep an eye out for announcements in our monthly newsletter, What's in the Mix, and on our social media posts. We'll share the link there as well!

The online form is the only way to nominate someone to appear in "Shotcreter Spotlight." Please reach out to me directly (cindy.spires@shotcrete.org) if you have issues with the form.

In the nomination form, in addition to some basic contact information questions, and a request to attach portrait and work-based photos, you will find these questions to answer:

1. Why are you nominating this individual/crew?
2. How has this individual/crew gone above and beyond?
3. How does the work performed by this individual/crew make it easier or more efficient for everyone else on the job site, in the company office, or in the shop?
4. When challenging conditions arise, how does this individual's/crew's reaction positively impact the company?

See your employees' names in lights in Shotcrete magazine, and nominate them for "Shotcreter Spotlight!" We look forward to celebrating their achievements with our readers!

Cindy Spires *recently joined the American Shotcrete Association (ASA) as the Managing Editor of Shotcrete magazine. Her background is in teaching writing at the university level and in developmental and copy editing for professional and academic writers. Originally from the deep south, Cindy moved to San Diego in 2000 and earned a B.A. in English from San Diego State University. She has lived in the Detroit area since 2005 when she came to Wayne State University to earn her M.A. in English. One of Cindy's greatest strengths is helping writers communicate their intended purpose through their writing.*

Fibercon International

In the late 1950s, United States Steel funded a research project at Carnegie Mellon University. The goal was to find a way to use steel fibers to increase the overall strength of concrete.

THE RESULT

Fibercon steel fiber technology has proven to increase crack stability, minimize crack propagation, and improve impact and fatigue resistance.

In 1980, the Mitchell family purchased Fibercon from US Steel. In 1981, the plant was moved to its present location in Evans City, PA. From that humble beginning, Fibercon International has emerged as one of the world's leading manufacturers of steel fiber reinforcement for the concrete construction and refractory industries.

In addition to manufacturing carbon steel and stainless-steel fibers, the operations include continuing research and development of fiber technology to improve and expand the application of steel fibers. Fibercon's research and development is continually refining its products and developing solutions to industry problems, both in the lab and in real-world conditions.

Fibercon steel reinforcing fibers used in East Side Access Tunnel, NYC

STEEL FIBERS

Fibercon steel fibers are manufactured under the slit sheet process as described in ASTM A820. The slit sheet process describes a fiber of rectangular shape. This shape was chosen due to its increased surface area when compared to a circular shape. This shape is important since the larger the surface area, the better the bond between the fiber and the concrete matrix. Bond is important in reducing crack growth. Cracks in concrete are a prime reason for using steel fibers in concrete.

THE MORE, THE MIGHTIER

Our slit sheet process allows Fibercon to manufacture steel fibers with high fiber counts. This is also important for control cracks. It has long been known that, as reinforcement is progressively sub-divided at a constant volume with a corresponding increase in specific surface area, the size and spacing of tensile cracks in concrete decreases. Decreasing crack size so they become invisible to the eye is important in steel fiber design.

PERFORMANCE

Performance includes results from the lab as well as the field. Fibercon continues research and development in the

lab to develop concepts which can be converted to improve the performance of steel fibers in the field. Taking lessons learned in the lab to the field is an important aspect in Fibercon's product development.

MIXABILITY

Performance is only one aspect of a good fiber. If you can't incorporate them into the concrete, the steel fibers will not be able to perform their intended function. Fibercon fibers are designed with this in mind. Balling of fibers was a problem with the first fibers in the 1960s. Fibercon has addressed this issue by developing fibers with the proper length and aspect ratio. Now fibers can be added to the concrete without worrying about balling. Without balling issues, you can be assured that the fibers will be well distributed in the concrete mix.

PLACABILITY

Concrete must be easily placed in many different applications. For slab-on-ground, it must be truck dumped which can be easily worked by the finisher. Composite steel decks require a mix that can be pumped to different elevations easily. In shotcrete, the fibers must go through a 1-1/2 in. (38 mm) nozzle. Fibercon has designed fibers that make placing steel fiber reinforced concrete as easy as placing conventional concrete.

FINISHABILITY

Fibers on the surface of any application were a problem in the past. Fibercon fiber takes this into account with its different designs. On slab-on-ground and composite steel decks, fibers on the exposed surface have almost disappeared when using Fibercon fibers. You can't say this about other fibers.

FIBERCON INTERNATIONAL

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SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE

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2024 ASA SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE REGISTRATION IS LIVE!

Join leaders in the shotcrete industry for our annual convention, held next in Austin, Texas from March 3-5, 2024 at Lakeway Resort & Spa. It is a unique opportunity to explore the use of shotcrete materials, equipment, and applications, as well as to look ahead to future advancements in the industry. During the convention, we will have three tracks of presentations (pool, underground, and general), a welcome reception "Savor the Taste: Exploring Austin's Distilled Delights", a golf outing, meals, the ASA Spring Committee and Board meetings, and ASA's Outstanding Shotcrete Project Awards and Banquet. There are opportunities for sponsorships for this year's convention, which include high-visibility exhibition options as well.

This year, ASA offers two options for pre-convention full day seminars, on Sunday March 3, 2024:

- **Contractor Qualification Seminar** – This course provides "best practices" for the shotcrete contractor looking to grow and increase productivity and quality in their shotcrete applications. This course supports and is a prerequisite for the ASA Shotcrete Contractor Qualification program.
- **Quality Shotcrete** – Know It When You See It (Pool Certificate) – Learn how to recognize and approve quality shotcrete while it is being placed specifically for those in the pool industry. This course supports and is a prerequisite to obtain an ASA Pool Certificate.

Register by February 8, 2024 to lock in ASA's early-bird rates: **www.shotcrete.org/convention**

Make sure your company is recognized among the leaders of the shotcrete industry by sponsoring the 2024 ASA Shotcrete Convention & Technology Conference! As a sponsor, you will receive a variety of exposure opportunities:

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Themes for 2024 include:

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- Q3 2024 – Tunnels/Mining
- Q4 2024 – Why Shotcrete?

Look for the 2024 *Shotcrete* magazine media kit online at **www.shotcrete.org/mediakit**. For more information, rates, and deadlines, contact Tosha Holden, ASA Member Engagement and Marketing Manager, at t*osha.holden@shotcrete.org* or 248.983.1712.

SHOTCRETE 2024: TODAY'S STATE OF THE ART

January 7, 2024
Transportation Research Board | Washington, DC

Registration:
www.trb.org/AnnualMeeting/Registration.aspx

SCHEDULE:

Introduction to Shotcrete – Not Your Father's Gunite
Charles Hanskat, American Shotcrete Association

Shotcrete Research – Past, Present, Future
Marc Jolin, Laval University

Shotcrete Application in NY DOT Projects
Brian Carmody, New York State Department of Transportation

Shotcrete in Substructure – Infrastructure Repair – Case Studies
Marcus von der Hofen, Coastal Gunite Construction Company

Enhanced Sustainability and Efficiency of Fiber-Reinforced Shotcrete
William Geers, Bekaert Corporation

Question and Answer Session
Charles Hanskat, American Shotcrete Association

WORLD OF CONCRETE 2024

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

Don't miss out on ASA at WOC!

Registration is now open. Use ASA's source code A17, which helps financially support our association with every registration. Stop by to see us at booth **#S10919** in the South Hall, and attend our General Membership meeting and reception on Tuesday after the show.

ASA hosts a number of events at World of Concrete. Complete details can be found at **shotcrete.org/asa-at-world-of-concrete.** Events include:

ASA Shotcrete Nozzleman Education
Tuesday, January 23, 2024 | 8:00 AM – 4:00 PM
Registration code: **ASATU**

ASA WOC 2024 General Membership Meeting & Shotcrete Reception
Tuesday, January 23, 2024 | 5:00 PM – 7:00 PM
(all are welcomed)

Quality Shotcrete – Know It When You See It
Wednesday, January 24, 2024 | 8:00 AM – 4:00 PM
(without exam registration code: **ASAWE**; until 6:00 PM with exam registration code: **ASAWEX**)

ACI Shotcrete Nozzleman Certification – Wet Mix
January 25 – 26, 2024 | Henderson, NV
Register: **www.worldofshotcrete.com/**

NEW ASA MEMBERS

american shotcrete association | asa

SUSTAINING CORPORATE MEMBER

Kaaterskill Kahncrete
Saugerties, NY
www.kahncrete.com
Primary Contact: Jasper Kahn
jasperkahn@yahoo.com

CORPORATE

Axiom Foundations
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Primary Contact: Doug Rudd
drudd@goettle.com

BAM Shotcrete Inc.
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Denali Construction
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Denaliconstruction.com
Primary Contact: Adam Warren
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DN Tanks
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www.dntanks.com
Primary Contact: Colemann Johnston
colemann.johnston@dntanks.com

Elite Landscaping LLC
Omaha, NE
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Primary Contact: Jason Decker
elitelandscaping@msn.com

Precision Urethane & Machine Inc.
Hempstead, TX
www.precisionurethane.com
Primary Contact: Chris Flanagan
chris@precisionurethane.com

Takbeer Enterprises Inc.
Westbury, NY
Primary Contact: Usman Beig
usman@takbeerent.com

SUSTAINING CORPORATE ASSOCIATES

Alan Henderson
Sika STM – Shotcrete, Tunning, & Mining (USA)
South Jordan, UT

James Lee
Sika STM – Shotcrete, Tunning, & Mining (USA)
Lyndhurst, NJ

Christine Poulin
SIKA STM – Shotcrete, Tunning, & Mining (Canada)
Oakville, ON

James Schumacher
Elko, NV
Sika STM – Shotcrete, Tunning, & Mining (USA)

Jared Stanwyck
COST of Wisconsin Inc.
Jackson, WI

JJ Stanwyck
COST of Wisconsin Inc.
Jackson, WI

CORPORATE ADDITIONALS

Dan Clark
Euclid Chemical Company
Ohio, USA

INDIVIDUAL

Thomas Collison
Paco Pools & Spas
Baldwin, NY

Jarrett Hughes
Hydroscapes
Oklahoma City, OK

PUBLIC AUTHORITY

Larry Good
Dallas Area Rapid Transit (DART)
Dallas, TX

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**.

Since 1946, Gunite Supply & Equipment has been the leader in dry process shotcrete (gunite) equipment manufacturing and wet-mix shotcrete nozzles, clamps, hose, parts & accessories since the invention of the process. Gunite Supply & Equipment serves specialty contractors who spray concrete on a surface to build or repair structures such as swimming pools, tunnels, bridges, and more.

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BLASTCRETE ANNOUNCES PATRICK BRIDGER AS NEW BUSINESS DEVELOPMENT MANAGER

Blastcrete Equipment, a prominent global leader in the manufacturing of concrete pumping, gunite, and wet shotcrete equipment, announced Patrick Bridger as their newly appointed Business Development Manager: "In his role, Bridger will collaborate closely with the Blastcrete team to provide unwavering support to both new and existing customers, aiding them in finding tailored solutions for their specific concrete pumping and wet/dry process shotcrete applications."

The press release further elaborates that, "In 1998, Bridger worked with other industry professionals to create the American Shotcrete Association (ASA). He remained an active member of the organization for more than 12 years serving as ASA secretary, vice president, and president. He helped develop the first shotcrete nozzleman certification program, which consists of a guidebook, education, written exam, and performance exam for all industry professionals."

Reflecting on his extensive experience, Bridger emphasized his unwavering commitment to customers, stating "My commitment through all these years has been to the customers. The customers make our business, and I strive to keep that in mind while I'm serving the community, whether that's through my current position or in my role as a member of the ASA."

The American Shotcrete Association would like to extend a special congratulations to Patrick Bridger for his new role at Blastcrete!

For more information, visit **blastcrete.com**.

GRINDLINE SKATEPARKS AWARDED FIRST PLACE IN DECORATIVE CONCRETE AT 2023 ACI EXCELLENCE IN CONCRETE CONSTRUCTION AWARDS

Grindline Skateparks Inc. was awarded a 2023 ACI Excellence in Concrete Construction Award—First Place in Decorative Concrete—for the North Bend Torguson Skate Park in North Bend, WA, USA. According to the ACI Awards website, "Grindline collaborated with the North Bend community in Washington to design a nearly 13,000 ft² (1200 m²) concrete skatepark outfitted with exciting elements for all skill levels, as well as a central gathering area. The park consists of a one-of-a-kind flow bowl, a pool-style bowl, and a large street skate area. The ready-mixed concrete of the skatepark was applied with the shotcrete method to achieve the smooth flowing transitions, curves, and blends that were required by the design. The concrete and shotcrete were finished by hand troweling to a buttery smooth finish."

Congratulations to Grindline Skateparks Inc., and their project team members, for their win!

For more information, visit **www.grindline.com/skateparks/north-bend-torguson-skatepark-north-bend-wa/** and **www.concrete.org/aboutaci/honorsandawards/awards/projectawards.aspx.**

MATTHEW CARTER JOINS ICRI AS TECHNICAL DIRECTOR

In October 2023, ICRI announced they have hired Matthew Carter as their new Technical Director. According to a Press Release, Carter has "over 18 years of experience in product support, sales, and management in the repair industry. He also holds numerous technical credentials, including certifications from ICRI, ACI, ASTM, and OSHA."

As a volunteer at ICRI for many years, Carter has contributed to the organization in many ways, including as a Region 5 Representative on the Board of Directors, on the Awards and Publications Committees, and in multiple leadership positions for the ICRI Great Plains Chapter from 2017-2020.

As Technical Director, Carter will direct "ICRI's technical and professional development activities in close coordination with the Technical Activities Committee, individual committees, and the Professional Development Committee."

For more information, visit **www.icri.org**.

NORMET ANNOUNCES EQUITY INVESTMENT IN ELECTRIC DRIVELINE SOLUTIONS FOR UNDERGROUND MINING AND TUNNELING

Normet announced that it has invested in Swiss company, Motics, who specialize in electric driveline solutions: "Through this and other innovative investments, Normet continues to

pave the way for cleaner and more sustainable underground mining and tunnelling."

According to Ed Santamaria, President and CEO of Normet, "The investment is part of our strategy to expand our offering in electrification in mining and tunnelling. With Motics' technology expertise, Normet is expanding its knowledge and scaling up its electrification efforts."

For more information, visit **www.normet.com/en/news.**

SIKA INVESTS IN MACRO FIBERS FOR SUSTAINABLE CONCRETE IN THE U.S.

According to a recent announcement, "Sika has increased production capacities for macro fibers at its plant in Chattanooga, Tennessee, thus extending a product line of strategic importance for Region Americas. With this innovative fiber technology, Sika is further strengthening its position as the leading single-source supplier to the mining industry and a strong partner for sustainable construction projects."

According to Christoph Ganz, Regional Manager Americas: "The United States is experiencing a booming trend in the construction of new industrial and sustainable production facilities, including gigafactories and data centers. This surge in construction is driving a high demand for macro fibers, which are used in manufacturing of abrasion-resistant slabs and industrial flooring. On top of this, there is growing demand for macro fibers in the US, Canada, and Latin America in shotcrete applications to stabilize excavations in tunneling and mining. This smart investment will allow us to make further advances in our market penetration throughout Region Americas, unlocking the potential offered by strong growth markets on a targeted basis."

For more information, visit **www.sika.com**.

MAPEI CELEBRATES REMODELING & EXPANSION OF CALHOUN, GEORGIA FACILITY

In October 2023, MAPEI Corporation celebrated the expansion of its Calhoun, Georgia facility, which features state-of-the-art production capabilities in the areas of automatic mixing equipment and processes; full automation of finished-goods packaging; robotic palletization; and bulk storage capacity. Customers, employees, and members of the community attended an open house to showcase the additional production space (45,000 ft^2 / 4,200 m^2) and office space (20,000 ft^2 / 1,900 m^2).

According to a Press Release, "The high-tech equipment is housed in a linear plant layout to enhance efficiency and productivity. This design also provides the facility with the opportunity to further MAPEI's commitment to sustainability by increasing the facility's ability to source and store local materials, decreasing its carbon footprint."

"The existing facility has been such a tremendous asset, and demand has been so great, that it necessitated the addition of extra lines to increase our production;" stated Luigi Di Geso, President and CEO of MAPEI Corporation, "Now we are even better able to accommodate the needs of our clients, not only in Georgia, but in the surrounding states."

For more information, visit **www.mapei.com/us/en-us/home-page.**

SHOTCRETE CALENDAR

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

JANUARY 7 - 11, 2024	**Transportation Research Board – 103rd Annual Meeting** Washington, DC
JANUARY 7, 2024	**Shotcrete 2024: Today's State of the Art** Transportation Research Board | Washington, DC
JANUARY 13, 2024	**Quality Shotcrete – Know It When You See It (Shotcrete Inspector Seminar)** Dees-Hennessey Inc. | San Francisco Bay Area, CA
JANUARY 23 - 25, 2024	**The Pool & Spa Show 2024** Atlantic City Convention Center | Atlantic City, NJ
JANUARY 23 - 25, 2024	**World of Concrete – 50th Anniversary (Use Source Code A17)** Las Vegas Convention Center | Las Vegas, NV
JANUARY 23, 2024	**ASA Shotcrete Nozzleman Education** Las Vegas Convention Center | Las Vegas, NV | 8:00 AM - 4:00 PM
JANUARY 23, 2024	**ASA WOC 2024 General Membership Meeting & Shotcrete Reception** Las Vegas Convention Center | Las Vegas, NV | 5:00 PM - 7:00 PM
JANUARY 24, 2024	**Quality Shotcrete – Know It When You See It (Shotcrete Inspector Seminar)** Las Vegas Convention Center | Las Vegas, NV | 8:00 AM - 4:00 PM
JANUARY 25 - 26, 2024	**ACI Shotcrete Nozzleman Certification | Wet-Mix** World of Shotcrete | Henderson, NV
FEBRUARY 6, 2024	**Recognizing Quality Shotcrete** ACI MidWest Resource Center | Elk Grove, IL
FEBRUARY 21 - 22, 2024	**Everything Under the Sun – Specialty Education** **Quality Shotcrete – Know It When You See It (Shotcrete Inspector Seminar)** Orange County Convention Center – West Hall E | Orlando, FL
FEBRUARY 23 - 24, 2024	**Everything Under the Sun** Orange County Convention Center – West Hall E | Orlando, FL
FEBRUARY 25 - 28, 2024	**MINEXCHANGE – 2024 SME Annual Conference & Expo** Phoenix Convention Center | Phoenix, AZ
MARCH 3 - 5, 2024	**2024 Shotcrete Convention & Technology Conference** Lakeway Resort and Spa | Austin, TX
MARCH 3, 2024	**ASA Contractor Qualification Education** Lakeway Resort and Spa | Austin, TX | 8:00 AM - 4:00 PM
MARCH 3, 2024	**Quality Shotcrete – Know It When You See It (Pool Certificate)** Lakeway Resort and Spa | Austin, TX | 8:00 AM - 4:00 PM
MARCH 4 - 5, 2024	**ASA 2024 Spring Committee Meetings** Lakeway Resort and Spa | Austin, TX
MARCH 24, 2024	**ACI 2024 Concrete Convention** Hyatt Regency New Orleans | New Orleans, LA
MORE INFORMATION	To see a full list, current updates, and active links to each event, visit www.shotcrete.org/calendar.

SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE

March 3 – 5, 2024 | Lakeway Resort & Spa | Austin, TX

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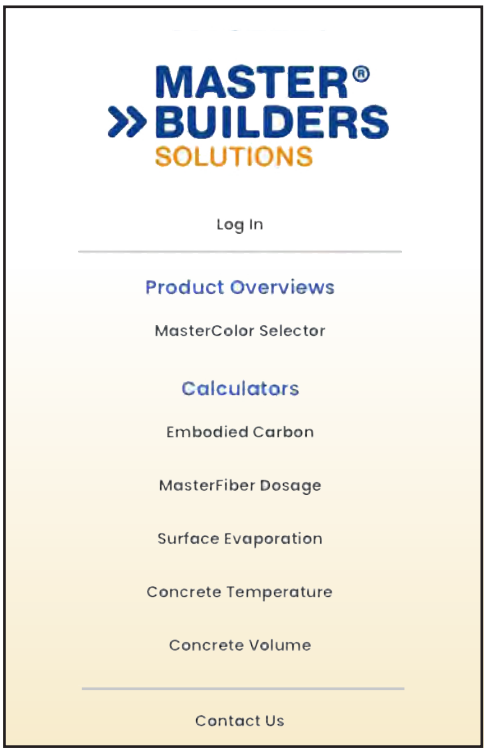
CONVENTION HIGHLIGHTS:

- 3 TRACKS: POOL, UNDERGROUND, & GENERAL
- SAVOR THE TASTE: EXPLORING AUSTIN'S DISTILLED DELIGHTS (WELCOME RECEPTION)
- INDUSTRY EXHIBITORS
- CONTRACTOR QUALIFICATION SEMINAR
- QUALITY SHOTCRETE SEMINAR (POOL CERTIFICATE)
- COMMITTEE INVOLVEMENT OPPORTUNITIES
- NETWORKING EVENTS

Register at shotcrete.org/convention



MASTER BUILDERS SOLUTIONS' CONCRETE NOW! SMARTPHONE APP

The Concrete Now! Smartphone App is available in the U.S. and Canada, and "allows for instant access to information on concrete properties." It's a helpful tool in the field or in the planning stages for your shotcrete projects.

According to their website, the Concrete Now! Smartphone App is "intended for contractors, engineers, architects, and producers…[and] serves as a channel to basic knowledge on the fundamentals of concrete use. The app includes items such as concepts and design factors, and interactive tools that provide answers related to concrete slump, air, finishability, and set time."

The Concrete Now! Smartphone App has estimators or calculators for the following categories: MasterColor Selector, Embodied Carbon, MasterFiber Dosage, Surface Evaporation, and Concrete Temperature. It also offers services and solutions with a MasterAtlas, which is a virtual assistant for project management; it has information about the Master Builders Solutions Technical Services Laboratory; and it has downloadable specifications for concrete.

Download the Concrete Now! Smartphone App from your phone's App Store or visit the desktop version at **concretenow.app/#/.**

Fig. 1: Screenshot of the Menu in the Concrete Now! App

SHOTCRETE FAQs

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

Question: *I have a project with a segmental retaining wall. The project is located in Maryland. The CMUs of the retaining wall have significantly deteriorated in several areas. The geogrid fabric appears to be in good condition in the areas where it could be observed.*

I suspect the deterioration is caused by saltwater runoff during snow events combined with the freeze/thaw cycles. There are some localized areas where the masonry units have completely disintegrated—the largest area is approximately 4 ft^2 (0.37 m^2).

Is it feasible to remove the deteriorated masonry material, down to a sound surface, and shotcrete the face to restore (or exceed) the structural integrity of masonry units?

If so, will this restore the structural integrity of the segmental retaining wall?

Answer: Shotcrete is routinely used for the repair of deteriorated concrete masonry and brick. Shotcrete should easily have a minimum compressive strength of 4000 psi (28 MPa) when properly shot and cured. According to the National Concrete Masonry Association, current CMU units have a minimum 2000 psi (14 MPa) compressive strength. Older CMU had a lower 1500 psi (10 MPa) minimum. Thus, the shotcrete placement will be significantly stronger and less permeable than the in-place CMU. This should give the wall better resistance to saltwater and freeze-thaw exposures thus extending useful life.

Depending on the depth of the new shotcrete placement, you may consider mechanically tying the shotcreted layer back to the sound CMU with epoxy or mechanically embedded anchors or j-bolts. Thicker sections may also benefit from the use of a steel wire mesh or fibers.

When shooting onto existing CMU sections, the surface must be properly prepared and then shotcreted with proper shotcrete materials, equipment, and placement techniques. Shotcrete placed onto an existing CMU surface will provide an excellent bond IF the following conditions are met:

- Make sure the surface is roughened and clean.
- The amplitude of roughness should be +/- 1/8th in. (3 mm) or more.
- A high-pressure water blaster (5000 psi [34 MPa] or more) or abrasive blasting can help to roughen and clean the surface.
- Bring the CMU surface to a saturated surface dry (SSD) condition. This means the surface feels damp, but water is not picked up on a hand.
- Make sure the shotcrete placement is properly executed with high-velocity placement and quality materials.
- The shotcrete should have a minimum 28-day compressive strength of 4000 psi (28 MPa).
- Be sure the shotcrete contractor is using an air compressor able to produce at least 185 CFM (5.2m^3/min) for wet-mix and 375 CFM (10.6 m^3/min) for dry-mix (gunite) of air flow at 100 to 120 psi (0.7 to 0.8 MPa).
- Use of an ACI-certified shotcrete nozzleman is recommended.
- No bonding agent should be used. It will interfere with the natural bonding characteristics of shotcrete placement.

Finally, without details on the loading conditions and structural details of the original construction, we cannot comment on the structural integrity of the repaired wall. You should contact a professional engineer experienced in concrete repair to evaluate the structural integrity of the wall when repaired.

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