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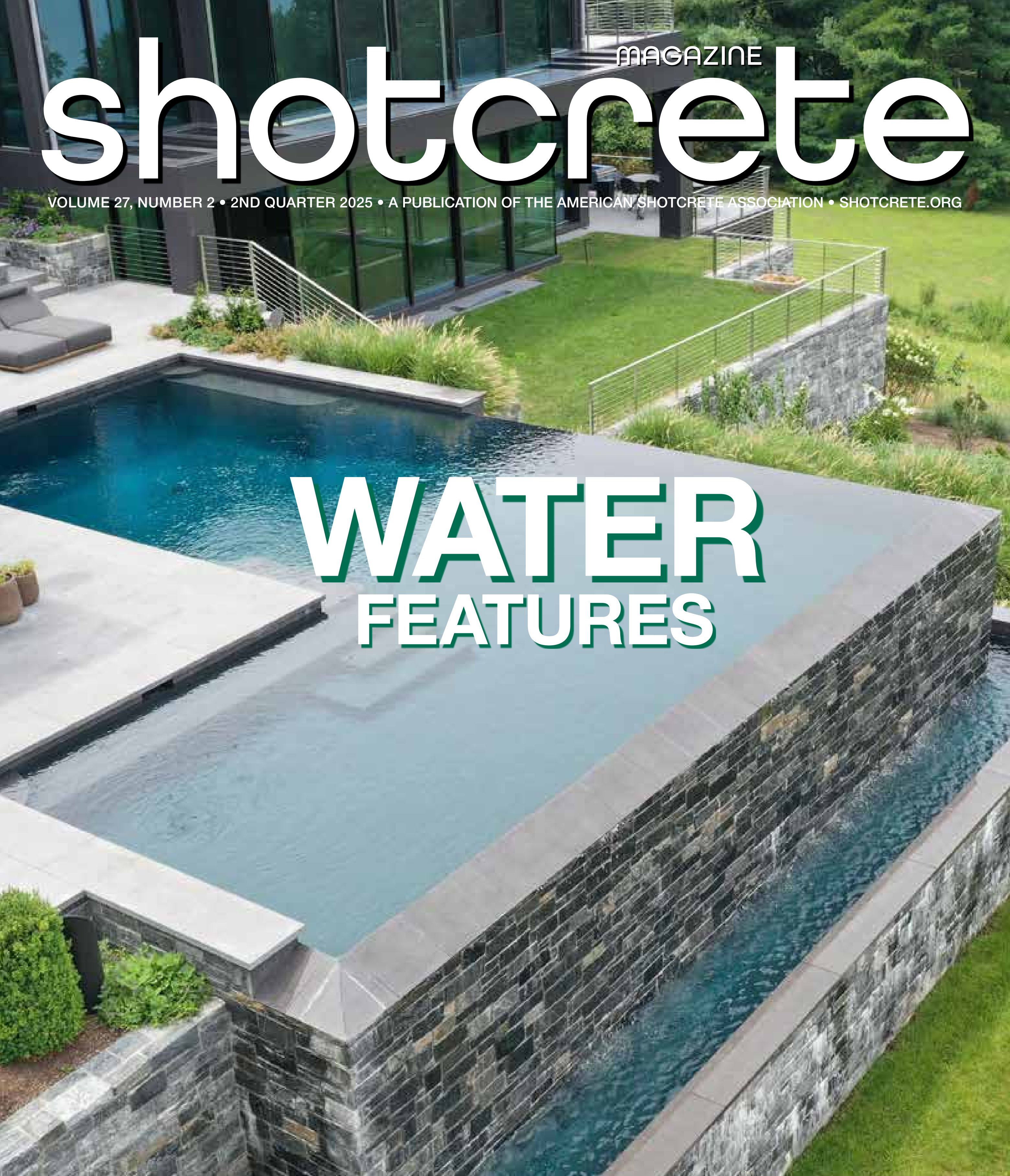

WATER FEATURES

american shotcrete association | asa

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shotcrete MAGAZINE

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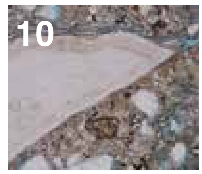

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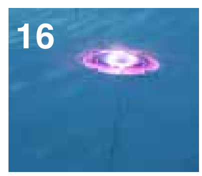

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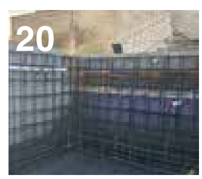

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Shotcrete is a quarterly publication of the American Shotcrete Association. For information about this publication or about membership of the American Shotcrete Association, please contact ASA Headquarters at:

American Shotcrete Association
401 Edgewater Place, Suite 600
Wakefield, MA 01880
Phone: 248.963.0210
E-mail: info@shotcrete.org
Website: **www.shotcrete.org**

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).

Editor-in-Chief
Charles Hanskat

Senior Editor
Alice McComas

Marketing & Advertising Sales
Tosha Holden
tosha.holden@shotcrete.org

Managing Editor & Graphic Design
Cara Baker
cara.baker@shotcrete.org

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COVER PHOTO: *As featured in the 2025 Q1 Awards issue, the 2024 Outstanding Pool & Recreational Project, Boundless Waters, features a vanishing edge overflow with continuous edge viewing of lower property to and beyond the Hudson River.*

Get Pool-Qualified with ASA QSC

By Bill Geers

Welcome to the 2nd Quarter, 2025 Issue of *Shotcrete* Magazine, which is focused on the single largest use of shotcrete in North America: Water features!

ACI SHOTCRETER CERTIFICATION PROGRAMS

The ACI Shotcrete Nozzleman certification program, now known as ACI Shotcreter Certification program, was developed over two decades ago by the American Shotcrete Association (ASA) and the American Concrete Institute (ACI). Using certified shotcreters is essential to ensuring quality in-place material is achieved on a project. This certification for shotcreters is now mandated by the ACI 318 code for shotcrete used in all structural applications — including pools!

ASA QUALIFIED SHOTCRETE CONTRACTOR CERTIFICATION PROGRAM

Over the last decade, ASA recognized the need for a shotcrete contractor qualification designation beyond individual shotcreter certification. The shotcrete contractor is typically hired to do the work; not the certified shotcreter. Problems arise when contractors who are unfamiliar with shotcrete nuances elect to buy or rent pumps, hire shotcreters from others, and claim to be shotcrete contractors, often resulting in poor quality work. Quality shotcrete requires a complete, experienced team, including owners, project managers, maintenance staff, equipment operators, finishers, and shotcreters.

In February 2022, ASA launched the Qualified Shotcrete Contractor Program, aligned with the ASA Board's paper on "Qualifications of the Shotcrete Construction Team." Contractors who pass the review are designated as ASA Qualified Shotcrete Contractor (QSC), Level I or II. ASA informs specifiers about this program to identify contractors who consistently deliver high-quality shotcrete work. The ASA Contractor Qualification Committee ensures specifiers and owners hire peer-reviewed and industry-vetted contractors with technical credentials, experience, personnel, equipment, and financial stability. This qualification program provides credibility for shotcrete contractors around the world just as the ACI-Certified Shotcreter Program has done for shotcreters.

NEW ASA POOL SHOTCRETE CONTRACTOR'S QUALIFICATION PROGRAM

The original ASA QSC was primarily applicable to structural shotcrete applications, not specifically taking in the unique requirements of swimming pool construction. To address this gap, the ASA Pool and Recreation Committee partnered with the ASA Qualified Contractor Committee to develop a pool-specific Qualified Shotcrete Contractor Program. This new program was approved in Spring 2024 and mirrors the original QSC program, but is specifically for the pool industry. This required adapting the ASA education presentations such as "Quality Shotcrete — Know It When You See It", along with modifying the application, and exams to be pertinent to pool-specific requirements.

"Achieving the qualification by ASA as a qualified pool contractor shows your company is an organization dedicated to quality in the pool building industry."

– Bill Geers

WHY BECOME AN ASA QUALIFIED POOL CONTRACTOR?

This program was developed by ASA members that are leaders in the North American pool industry. Achieving the qualification by ASA as a qualified pool contractor shows your company is an organization dedicated to quality in the pool building industry. This qualification provides a tool for you to promote your company and gives you an edge over the many less qualified, self-performing pool contractors in North America! Visit our **ASA Qualified Shotcrete Contractor – Pool webpage** for more information on requirements and how to apply!

These are just some of the programs ASA has developed to provide the concrete construction market with educated, quality-oriented shotcrete contractors for shotcrete projects worldwide. Apply, and join us to continue raising the bar for quality shotcrete placement on all types of projects, affirming that shotcrete placement is an excellent option for your next project.

Exciting Updates!

By Ryan Oakes

It has been a tumultuous few years for the pool industry. The onslaught of "COVID Pools" has brought the joy of swimming and being around water to thousands. Unfortunately, the lure of building pools in a time of high demand brought with it an ever-increasing need for better building standards in the pool industry.

In a time when demand exceeded supply, people with no construction experience sold pools and then found themselves responsible for managing pool construction where applicable design codes and construction standards weren't widely adopted. Salespeople were taking up the trades, from excavation to shotcrete, to keep up with demand and with an eye on what seemed like an easy profit.

To that end, the higher failure rate of COVID Pools has brought more attention to the need for guidance in the design and construction of pools, whether from building codes or the industry trade groups and pool industry education platforms like Genesis/Pool & Hot Tub Alliance and Watershape University.

From its inception in 1998, the American Shotcrete Association (ASA) has actively participated in promoting standards in the shotcrete industry. Many of its members are actively involved with the American Concrete Institute (ACI) as well and have played a key role in the development of the ACI-Certified Shotcreter program, formerly known as the Certified Shotcrete Nozzleman program. Another key program from ACI that has been developed with the help of ASA is the ACI-Certified Shotcrete Inspector.

ASA has provided educational seminars for the ACI certification programs in a supporting role for the last 27 years, but our existence as an independent industry trade association has other purposes.

ASA provides a number of benefits to various industries, all of which can benefit from using shotcrete as a placement method for quality concrete for so many purposes. From new construction to repair and rehabilitation of existing concrete structures, swimming pools to bridges and tunnels and other major civil projects, and even to the most alluring projects like Olympic luge tracks, shotcrete placement has proven to be a cost effective, sustainable, highly functional and time-sensitive method of placing quality concrete.

The swimming pool industry is no exception and is one of the primary beneficiaries of the shotcrete process. In fact, it was the advent of the shotcrete process, many decades ago, that brought swimming pools to the masses.

In recent years, the ASA Pool & Recreation Committee has offered community and guidance to its members in both the swimming pool and skate park industries. Through the publication of various position statements, the committee has helped shotcreters, engineers, architects, contractors and owners have a better understanding of the shotcrete process. Our position statements help to dispel myths and provide guidance. They are created and maintained by active members on our committees willing to share their extensive experience and supported by research from the most prestigious labs and researchers around the world.

Besides our position statements, our members contribute to our *Shotcrete* magazine with technical and project articles on topics ranging from multi-day projects creating monolithic shells to skin care in shotcrete.

Most recently, we are excited to announce our Position

ASA POOL & RECREATION COMMITTEE

Ryan Oakes, Chair | Revolution Gunite

Andy Duck, Secretary | Artisan Skateparks

Benjamin Lasseter | Design Ecology

Edgar Sanchez | Modern Method Gunite Inc.

Frank Townsend | Patriot Shotcrete LLC

George Frederick | Vue Custom Pools

Greg McFadden | Prestige Gunite and Shotcrete Inc.

Joey Bell | Active Minerals International, LLC

Juanjose Armenta-Aguirre | Texan Gunite

Marcus von der Hofen | Coastal Gunite Construction Company

Raymond Schallom | RCS Consulting & Construction Co Inc.

Rocky Wisley | Serenity Hardscapes LLC

William Drakeley | Drakeley Pool Company LLC

Statement #8, *Steel Reinforcement for Shotcrete Pools*, published in this issue of Shotcrete magazine on page 38.

This long-awaited paper has taken a great deal of energy and thought to put together. We pooled resources from our members as well as a few engineers who donated their time to the benefit of our industry. This paper will be an invaluable resource for professional engineers, architects, contractors and owners of pool projects around the world.

This position statement is a guide for all parties involved in pool design and construction, to help create lasting pools that can be passed down to future generations to enjoy enhanced health and well-being. The paper also dispels many of the misconceptions that lead to sub-standard building practices just because that was all the designers and builders knew. Further, it sheds light on the existing knowledge base within our professional design institutions and expands that knowledge base to those who are interested in creating a better product — to those who want to create a legacy, who want their products to last for not just years, but many decades.

In other exciting news, the Pool & Recreation committee has, with the Contractor Qualification Committee (CQ), launched the ASA Qualified Shotcrete Contractor - Pool (QSC – Pool) program at the 2025 ASA Convention in Savannah, Georgia this past March. Several pool shotcrete contractors showed up to attend the prerequisite education session and take the written exam.

The goal of the QSC - Pool program is to establish a peer reviewed qualification process that sets the stage for a shotcrete contractor who specializes in pools and other watershapes to prove that they have met the highest standards of our industry after being scrutinized by shotcrete experts to have met the required standards. This newly launched program stands to be regarded as highly as the ASA Qualified Shotcrete Contractor (Levels 1 and 2) for other structural concrete work and the ACI-Certified Shotcreter program.

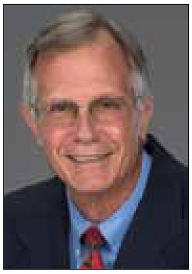
As a final note, our Committee Secretary, Andy Duck, has spearheaded an effort to raise awareness and standards in the skate park industry. More news to come on that in coming issues of *Shotcrete* magazine!

To summarize, we in ASA and the Pool & Recreation Committee have been busy digging deep, working hard with our heads down to manage our businesses and contribute to our industry with every effort we can muster. We look forward to seeing the fruits of our labors in the years to come and hope to see new faces join our ranks in service of our industry.

EXECUTIVE DIRECTOR UPDATE

This is What We Do

By Charles S. Hanskat, Executive Director and Alice McComas, Assistant Executive Director



Much of the work that ASA accomplishes is through the volunteer efforts of our active membership. ASA's five active committees normally meet in person twice a year – Spring meetings at ASA's annual Convention (this March we met in Savannah, GA), and again in the Fall, normally the Saturday before ACI's Fall Concrete Convention. Seeing a decline in attendance at our Fall meetings, the Board of Directors voted this Spring to move to a single in-person meeting each year (at ASA's Annual Convention). ASA's Committee Chairs were then charged to meet virtually every 2 to 3 months for the remainder of the year to ensure advancement of the committee work. The Board will monitor this new initiative and adjust accordingly.

ASA Committees are open to all, but voting members must be ASA members in good standing, at least at the individual level. Meetings will be posted on ASA's website calendar (shotcrete.org/calendar) and announced via ASA's monthly eNewsletter, "What's in the Mix". If you wish to join a committee, active participation and attendance at most of each year's meetings are required.

At this year's Spring meetings, a number of initiatives and action items were discussed. Here's a snapshot of the work in progress on these committees.

CONTRACTOR QUALIFICATION COMMITTEE

The Qualified Shotcrete Contractor – Pool (QSC – Pool) qualification program was launched at ASA's 2025 Convention in Savannah, GA. The policies, website, and applications have been updated, the renewal process vetted, and the committee is looking forward to another chapter in its work. The CQ Committee plans to spend more energy to better support qualified contractors. A task group was assigned to review ASA's current FAQs to update, tag by market segment, and re-present in a more user-friendly format for contractors. The committee also aims to develop best practice ideas, to be a resource for value creation for our contractors, and perhaps spark some future articles in *Shotcrete* magazine.

EDUCATION & SAFETY COMMITTEE

The *Safety Guidelines for Shotcrete* (SGS) has gone through a review and update process. Final comments were submitted just prior to the meeting and were mostly editorial. A request for additional information on underground safety concerns was made and the ASA Underground Chair, Christoph Goss, offered to submit additional information for a future revision. It was agreed that staff would incorporate all updates and edits, sending out a clean version for a no protest consent ballot. Barring any objections, we hope to get full consent and move forward to publish the updates to ASA's updated SGS. This document is included as a reference document in ACI's CP-61 Shotcrete Inspector Reference Package. We trust that ACI will use the revised SGS in the upcoming revisions to the CP-61 package along with newer versions of the pertinent ACI documents.

The committee also discussed ASA Shotcreter education in depth. Previously, ASA's Education Committee championed all efforts to update and maintain the ASA Shotcreter education provided at ASA-sponsored ACI-Shotcreter Certification sessions. ASA takes our role seriously in providing up-to-date education for shotcreters. ASA education has always been a requirement for those pursuing ACI Shotcreter certification under ASA, but not for those recertifying. The committee voted and was affirmed by the ASA Board of Directors to require attendance at the ASA education for recertification candidates at sessions as well. The ASA-Sponsored ACI Shotcreter Certification policy has been updated to reflect this decision.

COMMITTEE CHAIRS

Contractor Qualification | Marcus von der Hofen
Education & Safety | Derek Pay
Membership & Marketing | Jason Myers
Pool & Recreational Shotcrete | Ryan Oakes
Underground | Christoph Goss

MEMBERSHIP & MARKETING COMMITTEE

The Membership & Marketing Committee has been working to develop a Membership Journey survey. This survey, distributed for comment at the meeting, was designed to help ASA better understand the needs and interests of our membership. The full survey will be issued to the membership via email: Please look for it and complete it so your voice can be heard!

ASA continues to expand our outreach efforts to offer complementary seminars to universities, specifiers, local ACI/ICRI/PHTA chapter meetings and conventions, DOTs, and other interested groups. These have been both in-person or online webinars. Members of the committee were encouraged to look for new opportunities to have ASA present about the state-of-the-art of shotcrete. Questions about our outreach opportunities can be directed to **info@shotcrete.org** for details.

Members are ASA's best marketers. A few members asked for small postcard or business card-sized marketing items for them to distribute to clients or other contractors who are not yet members: This is in progress. ASA currently has business cards with QR codes pointing to both our resources and technical inquiry pages, available for marketing purposes. If you would like a supply to keep on hand, please email **info@shotcrete.org**. Additionally, ASA staff are working on other small promotional items for member use in your marketing efforts. Thank you to all who share in this desire to grow ASA membership, get out the word about quality shotcrete, and pass on ASA's resources!

Our Convention Task Group was tasked to meet shortly after the Savannah convention to review search parameters for upcoming ASA Convention venues, including ASA's 30th Anniversary convention venue for 2028! Several requests were made to explore a more unique location for this milestone event.

POOL & RECREATIONAL SHOTCRETE COMMITTEE

Pool Position Statement #8: *Steel Reinforcement for Shotcrete in the Pool Industry*, a paper long in the making, had final comments reviewed and addressed at this meeting. The Committee voted to approve the paper pending modifications submitted, and it appears in this issue of *Shotcrete* magazine on page 38! A very big thank you to all involved!

A new subcommittee task group was formed to look at skateparks, another shotcrete market with limited coverage by codes and standards. This task group is charged with identifying areas of concern for the skatepark market and looking at how to adapt some of the topics of our existing pool position statements for the skatepark market as well.

UNDERGROUND COMMITTEE

Recommendations of tests for evaluation of early strength of concrete were a topic for a proposed Position Statement from the Underground Committee. An article on the topic was published in the 4th Quarter, 2024 issue of *Shotcrete* magazine. After much discussion, the Committee thanked the authors for their work on the article and decided not to complete a Position Statement on the topic, as the feeling was the article could serve as a great reference as well. Final comments on this issue will appear in the next Underground Committee Chair memo and in an upcoming article from Andy Thompson, due out in the 3rd Quarter 2025 issue of *Shotcrete*.

As you can see, our ASA committees are in many ways the lifeblood of our Association. They help set directions, identify new areas to help our members and the industry, and then produce the deliverables that move our industry forward. There is always a lot to do. That's how we progress! All our engaged committee members who routinely share their time and experience to better the shotcrete community are our unsung heroes. Would you like to play a part? We would love to hear your thoughts and hope to see you as a future contributor to one (or more) of our ASA Committees!

ASA MEMBERS! READY TO JOIN A COMMITTEE?

Here's the easiest way to do that! Visit **shotcrete.org***, click My ASA in the top-right navigation bar, and log in with your username and password. Once you have logged in, you will see a list of committees; click the 'Request' button to notify the committee chair that you're interested in becoming a member of their committee. You will be contacted by the chair once they have reviewed your request.*

My ASA

Understanding AAR in Watertight Structures

By Paolo Benedetti & Charles Hanskat

Although Alkali Aggregate Reactions (AAR) have probably been around since the Romans first used concrete, they were not formally identified until the 1930s by California DOT engineer Thomas Stanton. Stanton published the first comprehensive study of ASR (one form of AAR) in the 1940s, and countless studies on AAR have been published in the 85 years since. The Federal DOT published a series of studies from 2006-2013 as guidance to the state DOTs. Additionally, numerous state DOTs, universities, and trade associations have studied AARs.

There are two primary forms of AAR; Alkali Silica Reaction (ASR) which forms as a reaction with silica-based minerals, and Alkali Carbonate Reaction (ACR) caused by carbonate or dolomite minerals. A less common concrete defect is Delayed Ettringite Formation (DEF), which is caused by a reaction of sulfates with aluminates in the cement. In this article, I will use the generic term AAR to broadly discuss these destructive chemical reactions. Essentially, each form of AAR is a chemical reaction that creates a substance that expands when exposed to moisture or by the chemical reaction. The expansion of the material within the concrete matrix results in fine cracking which compromises the structural integrity of concrete leading to a more rapid deterioration and reduced lifespan of the structure. The destructive forces are so prevalent, it is sometimes referred to as “concrete cancer.”

Everyone who works with concrete should understand basic concrete chemistry. When designers use ACI Codes for design of pools they must address the potential for AAR in concrete exposed to water. ACI 318-19 Section 26.4.2 Concrete mixture requirements, subsection (12) requires all concrete for sections with W1 or W2 exposures must be evaluated for potential for alkali-aggregate reactivity. ACI 350-20 Chapter 4 has extensive requirements for considering AAR potential in liquid-containing structures.

However, in areas where a licensed professional engineer is not required or even retained for a pool design and there is no competent engineering support, the burden for using proper concrete materials for the project falls on the pool builder or the owner.

Aggregates are usually sourced and consumed locally due to their high transportation costs. Quarries are generally not highly sophisticated operations, so the purchaser may need to investigate the quality and specific chemical composition of their locally sourced aggregates and the impact on their use in concrete for a project.

REACTIVE AGGREGATES

ASR

ASR is a reaction between the alkali components of cement and aggregates containing amorphous silica. According to the Portland Cement Association: “Aggregates containing certain forms of silica will react with alkali hydroxide in concrete to form a gel that swells as it absorbs water from the surrounding cement paste or the environment. These gels can induce enough expansive pressure to damage concrete.” ASR is the most common form of AAR, due to the high percentage of silica present in most aggregates.

ACR

ACR is a chemical reaction between dolomite in carbonate aggregates and the alkali components of the cement. The soluble salts, calcite, and brucite formed by this reaction can also induce enough pressure to damage the concrete. The reaction will continue until the dolomite is consumed.

DEF

DEF is caused when the sulfate ions attack the aluminate compounds in the cement, and the resulting ettringite crystals can exert sufficient pressures to damage concrete. The sulfate ions can be present in the cement paste, supplementary cementitious materials (SCM), some admixtures and high sulfate aggregates High internal concrete temperatures above 160°F (70°C), as often found in mass concrete structures, are the most common reason that DEF forms in concrete.

Each of these destructive chemical reactions can be prevented with a thorough understanding of the reaction causes, as well as the limitations of material testing protocols, careful selection of raw materials, utilization of supplemental cementitious materials (SCMs), competent concrete mixture designs, and specification of competent prophylactic measures.

MATERIAL TESTING LIMITATIONS

Because of the many factors and extensive time required to aggravate AAR conditions, numerous testing standards are generally inconclusive or inaccurate. Two generally accepted tests, ASTM C 1260: *Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)* and ASTM C 1293: *Standard Test Method for Concrete Aggregates by Determination of Length Change of Concrete Due to Alkali-Silica Reaction*, stand out as the industry standards.

The ASTM 1260 test is an accelerated testing method that can produce significant false negative results. As such, the DOT only recommends that it be utilized to reject aggregates.[1]

While the ASTM C 1293 concrete prism test provides a higher level of accuracy and confidence, it requires a minimum of one year to complete the test. “When testing SCMs or lithium compounds, the test typically is carried out for two years. This relatively long period for conducting ASTM C 1293, either one or two years, has been the major drawback for the test and has somewhat limited its use.”[1]

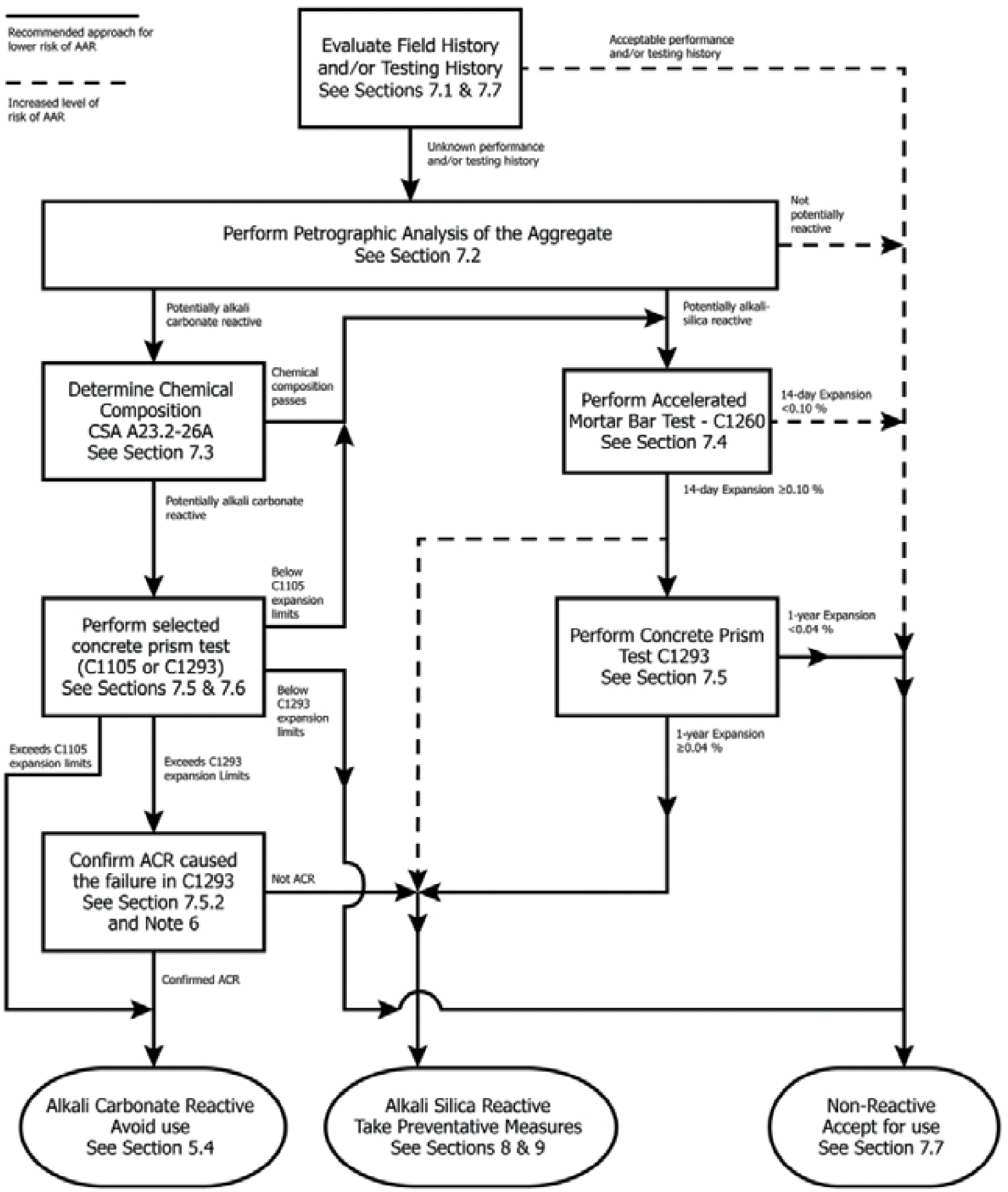


Fig. 1 Sequence of Laboratory Tests for Evaluating Aggregate Reactivity (ASTM C1778-22).

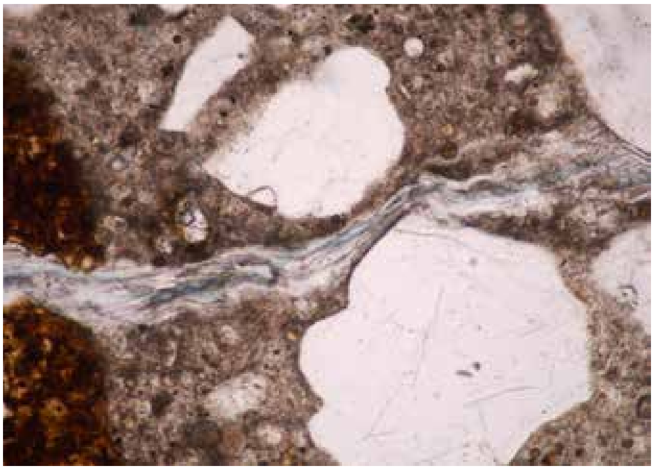
MITIGATION

Per ASTM 1778-22 Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete, "There are no proven measures for effectively preventing damaging expansion with alkali carbonate reactive rocks in concrete and such materials."[2] So the most obvious means to avoid AAR is to steer clear of reactive minerals. This is often easier said than done due to the economy and ease of using locally sourced aggregates. Knowing the chemical composition of the aggregates is paramount in mitigating the risks of these destructive forces. One must have a high level of confidence in their testing protocol to rely solely upon the test results identifying an aggregate as non-reactive.

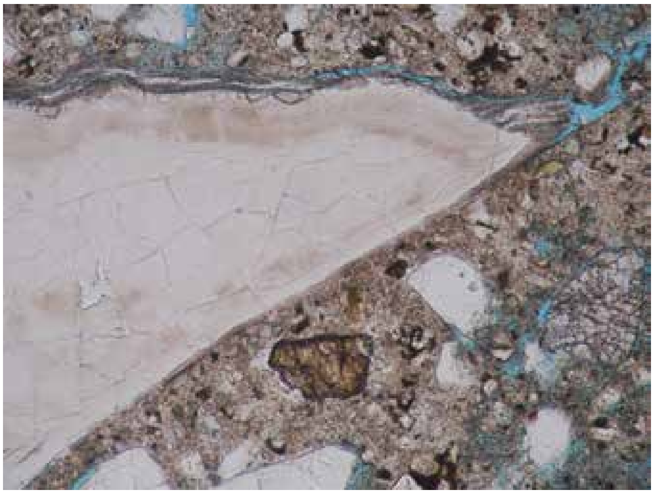
When avoiding using AAR-susceptible aggregates is not practical, other measures can be implemented to help mitigate the impact of AAR. This includes use of low alkali cements, supplementary cementitious materials like fly ash, silica fume and slag, and lithium admixtures.

ASTM C1778 is a key reference in designing concrete mixtures that can help mitigate the impact of AAR in concrete structures. The standard delineates a prescriptive approach in four steps:

1. Classify the aggregates reactivity using ASTM C1293 or ASTM C1260 (Fig. 1). Aggregates are classified as non-reactive (R0), moderately reactive (R1), highly reactive (R2) or very highly reactive R3).
2. Decide on the level of ASR risk. Pools will always fall into the category "All concrete exposed to humid air, buried or immersed and have a Risk Level from 3 to 5 with increasing reactivity of the aggregate (R1, R2 and R3).
3. Assign a structure classification. Generally pools would fall into an SC3 classification where a minor risk of ASR is acceptable though service life may reduce to 40 to 74 years. An SC4 classification is generally used for lifeline structures but may be used if the owner desires a service life of greater than 75 years.



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. Photo courtesy of Mark Lukkarila, F.ACI.



Thin section photomicrograph of an ASR in a chalcedonic chert. Photo courtesy of Mark Lukkarila, F.ACI.

4. Decide on the level of prevention. This varies from V (no prevention needed) to W, X, Y, Z and ZZ (with increasing levels of mitigation. Most pools would fall between the X and ZZ level.

Once a level of prevention (X-ZZ) is selected C1778 provides Table 1 that lists the minimum levels of SCM required to replace the portland cement in the concrete mixture to achieve the desired level of prevention. The CSA guidelines for controlling ASR, shown in ASTM C1778, also provide an alternative method for performance testing that may be useful if using SCMs that are not included the standard.

There are currently no ASTM standards that address the use of lithium to mitigate AAR. However, several government agencies including the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and Canadian Standards Association (CSA) have testing procedures that can be used to evaluate the effects of lithium admixtures on AAR.

SUPPLEMENTARY CEMENTITIOUS MATERIALS

SCMs have proven to be the most cost effective alternative means of preventing AAR in concrete. Lower lime content fly ash has proven to be the most effective in controlling AAR, due to its improved alkali binding ability.[3] Class-F fly ash is better at mitigating AAR than Class-C fly ash. Though less fly ash is being produced by coal-fired power plants, supplemental processing of waste fly ash for concrete is helping to maintain availability. However, the extra processing adds to the cost of fly ash processed for use in concrete.

CONTROL OF AAR IN NEW CONCRETE

ASR CAN BE CONTROLLED BY:

- Use of low alkali reactive aggregates (both coarse and fine)
- Low alkali cement (reduces the potential for alkali-silica reactions)
- High compressive value concrete (decreased permeability)

Type of SCM	Total Alkali Content of SCM (% Na_20_e)*	Chemical Composition Requirement (% oxides)	Cement Replacement Level (% by mass)[a]		
			Prevention Level W (mild)	Prevention Level X (moderate)	Prevention Levels Y and Z (strong-Y) (exceptional-Z)
Fly Ash	< 3.0	CaO < 8%	≥ 15	≥ 20	≥ 25
		CaO = 8% - 20%	≥ 20	≥ 25	≥ 30
		CaO > 20%	See note *b*	See note *b*	See note *b*
	3.0 - 4.5	CaO < 8%	≥ 20	≥ 25	≥ 30
		CaO = 8% - 20%	≥ 25	≥ 30	≥ 35
		CaO > 20%	See note *b*	See note *b*	See note *b*
	> 4.5			See note *b*	
Blast Furnace Slag	< 1.0[b]	None	≥ 25	≥ 35	≥ 50
Silica Fume	< 1.0[b]	SiO_2	2.0 alkali content[c]	2.5 alkali content[c]	3.0 alkali content[c]
Natural Pozzolans	Natural pozzolans that meet the requirements of CSA A23.5 may be used provided thtat their effectiveness in controlling expansion due to ASR is demonstrated according to CSA Recommended Practice A23.2-28A.				
Ternary Blends	When two or more SCMs are used together to control ASR, the minimum replcement levels given in Table 5 of CSA, 2004 for the individual SCMs may be reduced partially, provided that the sum of the parts of each SCM is 1. For example, when silica fume and slag are combined, the silica fume level may be reduced to one-third of the minimum silica fume level given in Table 5, provided that the slag level is at least two-thirds of the minimum slag level given in Table 5.				

*Na_2O_e = socium oxide content = $Na_2O + 0.658 * K_2O$

Table 1: Interim Recommendations for the Use of Lithium to Mitigate or Prevent Alkali-Silica Reaction (ASR), Publication Number: FHWA-HRT-06-073, Date: July 2006 Table 3.

- Mitigating concrete mixture designs:
  - SCMs
  - Lithium compounds
- Improved site drainage (negative side water)

ACR CAN BE CONTROLLED BY:

- Use of silica-free dolomite aggregates
- Low alkali cement (reduces the potential for alkali-silica reactions)
- High compressive value concrete (decreased porosity)
- Mitigating concrete mixture designs:
  - SCMs
  - Lithium compounds
- Improved site drainage (negative side water)

DEF CAN BE CONTROLLED BY:[4]

- Controlling the heat of hydration (excessive heat over 160°F (70°C) during the early stages of hydration accelerates DEF formation)
- Use of low-sulfate aggregates
- Lower aluminum content concrete
- Controlled cooling after concrete placement
- Low alkali cement

SHOTCRETE WORKMANSHIP

Poor shotcrete placement practices can result in reduced compressive strength and increased permeability, even when placing high-quality concrete. Insufficient air volumes resulting in low velocity, utilization of unconsolidated trimmings and rebound, over working placed concrete, or improper curing and temperature control can impact the in-place properties of the concrete and the watertightness. The primary benefit of proper shotcrete placement of concrete for reducing the potential for AAR is the higher strength and lower permeability of the hardened concrete keeping water from permeating the concrete as easily.

REINFORCING STEEL

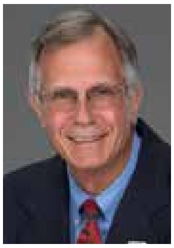
Water migration into structures containing reactive aggregates is also a contributing factor to the formation of AARs. The reinforcing steel for swimming pools is usually specified solely for structural purposes. Per ACI 318-19(22), the minimum concrete/steel ratios are 0.18 - 0.20%. Yet this quantity of steel is rarely sufficient to prevent drying shrinkage cracks. Per ACI PRC 224-01 Control of Cracking of Concrete Structures, “To control cracks to a more acceptable level, the percentage requirement needs to exceed about 0.60%.” Note that this recommendation is THREE times the minimum steel required by ACI 318. If the pool shell does not contain enough reinforcing steel to control drying shrinkage cracks, these through wall cracks can allow water to more easily reach deeper and more extensive sections of the concrete and promote additional AAR damage.

SUMMARY

In existing concrete containing AAR reactive-aggregates, only by keeping the concrete dry can AAR damage be fully mitigated. Unfortunately, this is impractical in most pools and watershapes. Thus, the best solution is addressing the potential for AAR when the concrete mixture design is developed. A knowledgeable pool builder should investigate the concrete supplier's attention to the potential of AAR in their aggregates and methods that may be implemented to mitigate potential damage in their pools.

Potential AAR damage can be mitigated by selecting appropriate concrete materials for the fresh concrete. Understanding the contributing factors and careful attention to materials used in the mixture design, proper reinforcement and skilled shotcrete placement can all play a role in controlling, if not preventing, AAR harm.

Paolo Benedetti *is a CA licensed general contractor and swimming pool contractor. As the principal of Aquatic Technology Pool & Spa, Morgan Hill, CA, he has designed, consulted, and built swimming pool projects internationally. He is a nationally recognized expert witness in swimming pool construction defects, sits on the ACI 506H Shotcrete Swimming Pool and ASA 322 Pool & Watershape Code Committees, and is an ASA member and primary instructor for Watershape University.*



Charles Hanskat*, P.E., is a Fellow member of the American Concrete Institute, American Society of Civil Engineers, and the Florida Engineering Society. He is Executive Director and Technical Director for the American Shotcrete Association and holds a bachelor's and master's degree in civil engineering from the University of Florida. He has been a licensed professional engineer for over 40 years.*

Hanskat has been involved in the design, construction, evaluation, and repair of environmental concrete, marine, building, and shotcrete structures throughout his career. He is active in developing codes and standards from many professional and technical engineering societies, including ACI, ASTM, AREMA, and ICRI.

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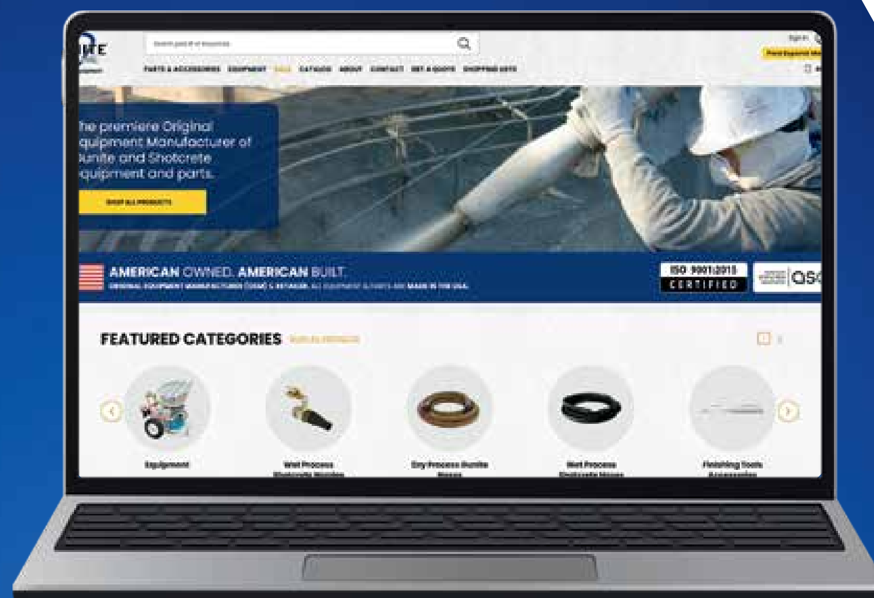

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Why is My Pool Cracked?

By Philip Cowles

Introduction

Swimming pools are intended to improve quality of life and be visually appealing, so no pool owner is happy to find a crack running through their investment. For liquid-containing structures like swimming pools, cracks are more than just an aesthetic nuisance. Crack control is critical to maintaining the durability and function of the structure. So why does a concrete pool crack?

The simple answer is that concrete cracks when its tensile capacity is exceeded. However, as multiple factors can contribute to this condition, this article discusses some of the reasons why concrete pools crack.

External Loads

Swimming pools must resist a variety of external loads. With in-ground pools, while the primary external loads are earth and water pressures, the pool may also provide support for attached or adjacent structures such as shade canopies, grottos, and waterslides. External loads can change in magnitude during the lifetime of a pool as well — heaving or settling subgrades may increase earth pressures or reduce pool support, leading to increased stresses within the concrete (Fig. 1).

When the stresses imposed on the pool shell by external loads exceed the concrete's tensile strength, the concrete cracks. Steel reinforcement in the concrete works to resist the tension. If external loads in excess of the pool shell's resisting capacity are continually applied, the structure deflects and eventually fails.

Fig. 1: Cracks due to heavy rock structure and subgrade settlement.

Freeze-Thaw Cycling

Concrete pools exposed to freezing temperatures may experience freeze-thaw cycling. Water absorbed by the concrete creates internal pressures when it freezes and expands. Repeated freezing and thawing cycles may cause internal pressure that causes spalling and pop-offs on the surface of the concrete and can worsen existing cracks (Fig. 2). Tile and coping are particularly vulnerable to freeze-thaw cycling since they are often exposed to the elements and become saturated. Note that cracks and pop-offs observed in these elements may be because of a failure of the mortar bed and not the underlying concrete shell.

The freeze-thaw resistance of concrete may be improved by including air entrainment, reducing the water to cement (w/cm) ratio and increasing the compressive strength. Air entrainment provides space in the concrete matrix for water to freeze. A lower w/cm ratio provides a higher compressive strength and decreases moisture ingress by reducing the permeability of the concrete.

Fig. 2: Shrinkage crack worsened by freeze-thaw cycling.

ALKALI-AGGREGATE REACTION

Alkali-aggregate reaction (AAR) refers to the reaction of alkalis and reactive aggregates in concrete. Moisture in the concrete is needed for this process to occur. AAR creates expansive forces within the concrete that cause cracking and spalling. The two forms of AAR, alkali-silica reaction (ASR) and alkali-carbonate reaction (ACR), are named after the reactive minerals found in some aggregates. ASR is more common than ACR. In general, microscopic analysis of concrete samples is required to confirm the presence of AAR.

AAR tends to be a regional issue and is not a concern for every pool. The reaction will not occur if reactive aggregates are not used. ASR may be mitigated through the use of supplementary cementitious materials (SCMs) and lithium-based admixtures. ACR cannot be mitigated so the use of reactive carbonate aggregates should be avoided.

DELAYED ETTRINGITE FORMATION

Delayed ettringite formation (DEF) refers to the crystallization of ettringite (a byproduct of portland cement hydration) in substantially hardened concrete. DEF occurs in part because ettringite was not allowed to form normally during the early stages of cement hydration due to elevated concrete temperatures. There are similarities between AAR and DEF, and the two processes may occur simultaneously. DEF requires a source of moisture and creates internal swelling pressures within the concrete. Like AAR, DEF is usually identified in a laboratory.

DEF may be prevented by limiting the maximum internal temperature of the concrete during the curing period. Concrete generates heat as it cures. The thicker the concrete section, the greater the heat increases. It is not uncommon for stairs and tanning ledges in pools to be shotcreted solid. These large concrete elements may experience elevated internal concrete temperatures that create a favorable environment for DEF. Structural foam, gravel bags, and earth forms may be used to reduce the thickness of the pool shell in these areas. A thermal control plan may be needed when large concrete sections are unavoidable.

POOR CONSTRUCTION PRACTICES

A poor but not uncommon construction practice in the swimming pool industry is the incorporation of shotcrete rebound, trimmings and overspray into the pool shell. Rebound is sometimes left in pool floors, coves, and corners. It also may be hand packed to form benches and stairs, or other elements that may lack reinforcing steel. It is no surprise then to observe cracks in these areas. Rebound is not a structural material and should be removed from the pool. Trimmings are unconsolidated concrete and likewise should not be used in the pool shell unless supplemental internal vibration is used. Tamping with a trowel or floating the surface does not consolidate the concrete.

Cracks may also occur at the interface of the pool coping and bond beam or along the waterline tile. Again, this is a location where shotcrete rebound or trimmings are hand placed to level up or correct the bond beam elevation. A better practice is to use grade stakes, wires, and forms to establish the proper shotcrete elevation and alignment and eliminate hand packing or excessively thick mortar beds.

Bricks, rocks, trash, and other construction debris should also not be incorporated into the pool shell. These materials create weakened areas within the concrete that are more susceptible to cracking. Clay bricks, rocks, and concrete masonry units (CMUs) are frequently used to support reinforcement in pool shells (Fig. 3). These supports are irregularly shaped and have a lower compressive strength than the concrete. Manufactured reinforcement supports should be used instead of bricks, rocks, and CMUs to ensure reinforcement is installed at the correct elevations and spacing.

CONCRETE SHRINKAGE

There are multiple types of concrete cracks that could be labeled as shrinkage cracks. Of primary concern for swimming pools are drying shrinkage cracks and temperature shrinkage cracks. This is because these cracks typically extend through the full depth of the pool shell (Fig. 4). If the

ABOVE
Fig. 3: Clay bricks used as bar support.

LEFT
Fig. 4: Shrinkage crack through full depth of pool shell.

LEFT
Fig. 5: Shrinkage cracks at reentrant corner.

ABOVE
Fig. 6: Shrinkage cracks in wall caused by horizontal restraint from floor.

cracks expand in width, they begin to allow water to pass through the concrete, and the structure is no longer watertight.

As concrete dries it loses moisture and experiences volume changes (shrinkage). Similar shrinkage occurs when concrete cools and contracts. This shrinkage may be restrained by a variety of factors including subgrade friction and the geometry of the structure itself. Any restraint creates tensile stresses in the concrete. As noted earlier, concrete cracks when its tensile strength is exceeded. Steel reinforcement is provided to resist the tension and keep the crack tightly closed. If the reinforcement is also overstressed, it yields (elongates) and the crack in the concrete increases in width. For many pools, the amount of reinforcement required to resist external loads may be less than that required to resist stresses from restrained drying and temperature shrinkage.

Measures may be taken during the design and installation phases to reduce restraint and shrinkage. The pool shape should be evaluated to determine areas of high restraint. It is not uncommon to observe diagonal shrinkage cracks at reentrant corners where shrinkage is restrained in perpendicular directions (Fig. 5). Providing a radius at corners may help decrease stress concentrations in these areas. A wall connected to a previously placed concrete floor is restrained horizontally by the floor (Fig. 6). Additional reinforcement may be needed near the wall-to-floor connection to control crack widths.

Installation practices and the pool environment should be assessed as well. Hot, dry, and windy conditions during concrete installation and curing lead to rapid moisture loss. This can lead to early-age plastic shrinkage cracks at the concrete surface. Proper curing is critical to delaying shrinkage until the concrete has gained strength. ASA and ACI recommend a minimum of 7 days of curing for concrete pool shells. Some conditions are unavoidable, but careful thought and planning will improve control of shrinkage cracks.

THERMAL STRESSES

The restrained temperature shrinkage noted above is a type of thermal stress, but there are other types of thermal stresses in swimming pools. Concrete exposed to large temperature gradients through the thickness of the concrete section may develop thermal stresses due to external or internal restraint of concrete contraction and expansion. Thick sections and extreme ambient temperatures increase the potential for thermal differential stresses.

Consider a wall separating a pool and spa. If the spa is heated during the winter, but the pool is not, a significant temperature differential could develop between the two sides of the wall. The conditions discussed earlier that are favorable for DEF can also create thermal stresses. For thick concrete sections, the surface of the concrete may be considerably cooler than the core of the section. Again, a thermal control plan may be needed to manage temperature gradients for thick concrete sections.

EMBEDMENTS AND OPENINGS

From skimmers to main drains to light niches to pipe, swimming pools are full of embedments and openings. Sometimes it seems the only thing in short supply is the concrete itself! Cracks are often observed around embedments and openings. Stress concentrations develop around these features due to multiple factors.

Embedments and openings interrupt the reinforcing steel and reduce the overall cross-sectional area of the concrete. If the interrupted reinforcing steel is not replaced with trim bars on either side of the opening, a weakened plane is created in the concrete (Figs. 8, and 9). This condition is worsened when multiple embedments or openings are aligned. The resulting concrete section may not have sufficient strength to resist external loads. Openings also create reentrant corners that are susceptible to shrinkage cracks (Fig. 7). Pipe embedded in and oriented parallel to the plane of the concrete member reduces the section thickness. The thinner concrete has less capacity to resist stresses due to external loads and restrained shrinkage.

Conclusion

To review, the following measures may be taken to reduce and control cracks in swimming pools:

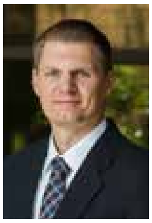
- Provide adequate reinforcement to resist stresses from external loads and restrained shrinkage. Keep in mind that the maximum stress may come from restrained shrinkage rather than external loads.
- Use concrete with air entrainment, a low w/cm ratio, and a high compressive strength.
- Avoid using reactive aggregates or develop a plan for mitigation.
- Avoid using concrete as fill for stairs and tanning ledges.
- Implement a thermal control plan for thick concrete sections.
- Do not incorporate rebound, trimmings, and overspray into the pool structure.
- Use manufactured reinforcement supports instead of bricks, rocks, and CMUs.
- Evaluate the proposed pool layout to determine areas of shrinkage restraint that may be reduced or eliminated.
- Wet cure the concrete for a minimum of 7 days.
- Maintain section thicknesses around embedments and openings.
- Add trim bars to replace reinforcement interrupted by embedments and openings.

An old adage says, there are two kinds of concrete: Concrete that has cracked and concrete that is going to crack. As can be seen, there are multiple reasons a concrete pool shell may crack. Often, a combination of factors contributes to the development and worsening of cracks. Consequently, it is perhaps unrealistic to expect a totally crack-free pool. It is reasonable, however, with proper design and construction to expect a pool to be watertight and durable. For existing pools with cracks, a design professional may help identify the causes of the cracks and make recommendations for their repair.

Fig. 7: Shrinkage crack at skimmer throat.

ABOVE
Fig. 8: Shrinkage crack at underwater light.

LEFT
Fig. 9: Pool shell distress at recessed steps.



__Philip Cowles__ is a project manager for The C.T. Brannon Corporation. He is a licensed professional engineer in seven states and specializes in the design of aquatic features. He is also a member of ACI Committee 322 - Concrete Pool and Watershape Code.

The Solid Foundation:

Cast-in-Place Concrete Floors with Shotcrete Walls for Swimming Pools

By Benjamin Lasseter

Residential swimming pools have evolved significantly beyond simple rectangular or kidney forms to a wide array of complex shapes, features, and designs. Design trends, technological advancements, and shifting consumer preferences to outdoor living have helped to fuel this transformation, and today's pools often integrate intricate elements like infinity edges, perimeter overflows, custom lighting systems, automated controls, and elaborate water features. Additionally, advances in technology have brought us "smart pool" systems that monitor and adjust water chemistry and temperature automatically. This increased complexity reflects a desire for personalized, luxurious outdoor living spaces, but also demands greater expertise in design, construction, and maintenance.

The fast-paced and largely unregulated expansion of the pool industry over the past 40 years — accelerated even further during the COVID-19 pandemic — has driven high demand for labor in a market where most consumers prioritize low cost over quality and durability. The industry is now flooded with so-called professionals who are untrained, unskilled, and clueless when it comes to spotting poor installation of reinforcing bars, plumbing, and shotcreted concrete; the core components of a pool shell. The American Shotcrete Association (ASA) and American Concrete Institute (ACI) are making tremendous progress with programs like the ACI Shotcreter Certification and the ASA Qualified Pool Contractor Qualification, but the demand for pools still outpaces the training available.

In my experience as a builder, shotcrete inspector, and construction defect expert, I get to observe the process and examine the results of numerous pool projects. My observations have revealed countless concrete issues stemming from poor workmanship, many of which occur in the pool floor and cove (transition from the floor to the wall) and include poor consolidation, loosely compacted materials, continuous excessive voids, and delaminated layering. Another common issue I have observed is the pool shotcrete has an extremely high w/cm ratio, which happens when the contractor adds excessive amounts of water to the concrete mixture when they are placing the floors to get the concrete to a more workable consistency. It is not uncommon to find a combination of all of these issues in the floor of a pool.

But why is this an issue with swimming pools? Shotcrete placement is a process that works best for vertical and overhead concrete construction, but in the pool business, we use it for the floors because it speeds up the process, allowing the entire shell to be placed in one day. Most pool shotcreters will start with the walls, building up from the cove, then finish by spraying the floor as they work their way out of the pool. This leaves the pool floor exposed to overspray, rebound, and trimmings for several hours while the walls are being placed and finished. Additionally, a full day of foot and hose traffic can shift the reinforcing steel off its supporting chairs or drive the chairs into the gravel bed under the floor. This typical process essentially makes the floor of the pool the trash can for the finishers that they can easily spray over to avoid having to remove the trimmings and rebound from under the reinforcing steel.

Fig. 1: Core sample taken through the floor of a pool near the cove showing unconsolidated layering.

Fig. 2: Concrete placement in the floor of a pool with a boom pump.

While concrete floors can be placed with the shotcrete method, it's not the most ideal or preferred solution. Shotcrete placement is slower than poured concrete: Using volumetric trucks, a shotcrete pump with a 2-in. (50 mm) hose, and wet-mix shotcrete, we average about 10 yd^3 (7.6 m^3) an hour. When using a ready-mix truck, boom pump, and a concrete mixture designed for a minimum of 4000 psi (28 MPa), we can pump about 10 yd^3 in less than 15 minutes.

My average pool floor is about 40 yd^3; this includes a 12-in. (300 mm) thick floor and grade beams, spa floor, and any other features that can be considered part of the floor or foundation. If I use a boom pump or large line pump and cast these features, I can have all the concrete placed in about an hour, leaving my finishers free to work in the cooler part of the day to trowel and broom the pool floor. At that pace, I can have concrete stiff enough to walk on before lunch, allowing me to begin the curing process and protect it from the warmer afternoon temperatures. The boom pump also drastically reduces the amount of foot traffic over our reinforcing steel. The pump operator remotely controls the overhead boom from outside of the pool while a crew of 3 to 5 finishers can place and finish without the potential for rebound and trimmings to be trapped and encapsulated below the reinforcing steel and with minimal foot traffic on the reinforcing steel.

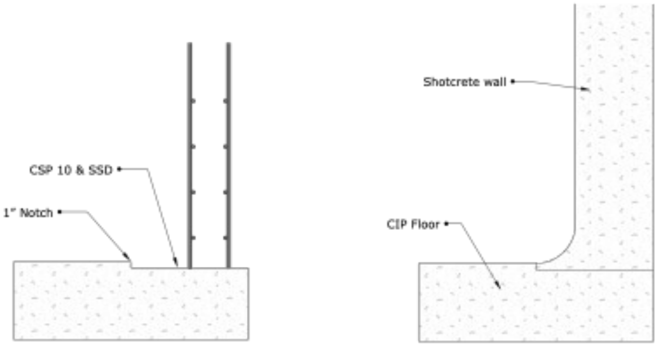


Fig. 3

While finishing our floors, we will typically carve a notch about 1 in. (25 mm) deep in the surface of the floor to allow for our walls to taper into the floor into a prepared cut. This is done by the finishers when they are brooming the surface with a screed or 2 in. by 4 in. (50 by 100 mm) trowel. At that time, we also make sure the bond plane where the wall meets the floor has a concrete surface profile (CSP) of 10 (Fig. 3). We normally use a heavy broom to create a stipple surface and high CSP.

Shotcreting the walls can commence once the floor has gained sufficient strength to support foot traffic without damaging the concrete. While this could potentially happen on the same day as the floor pour, we typically begin the wall shotcrete placement 2 to 3 days later. The time elapsed between floor placement and wall shotcrete placement is not critical, provided the receiving concrete surface at the base of the wall is properly prepared.

Our preparation process involves pressure washing the floor with a 4000 psi turbo nozzle (minimum 3000 psi [21 MPa]). I prefer to pressure wash in the afternoon before shotcrete placement to pre-saturate the concrete. This pressure washing removes loose debris and laitance, and also saturates the concrete as outlined in ACI 506-22 and 506.8-24.

On the day of shotcreting, the floor surface is soaked again while the crew prepares the site for the application. Just before shotcrete placement begins, we confirm that the receiving surface is clean and saturated with a saturated surface dry (SSD) condition. During the shotcrete placement for the walls, an air lance is used ahead of the nozzle to ensure that rebound and overspray are blown clear.

At this point we proceed just like a normal swimming pool, except we are working on a concrete surface instead of a reinforcing bar grid. The finished concrete floor offers a safer and more comfortable workspace compared to having to walk on an open grid of reinforcing bars, making it easier to move around and drag hoses throughout the day. Additionally, this solid surface provides a convenient area for collection of rebound and trimmings, which are later shoveled out of the pool. We also occasionally use a concrete washout bag to collect the rebound and trimmings, allowing for efficient removal from the pool later using a telehandler or skid steer.

Having successfully completed the construction of the walls, we now have a full concrete pool shell. The specific construction methodologies employed in this project were instrumental in significantly minimizing the potential for structural imperfections and flaws, all while contributing only a marginal increase to the overall project timeline. The financial considerations associated with casting the floor are largely confined to the expense of a second day of mobilizing the necessary pumping equipment and the associated crew. Nevertheless, it is important to note that, depending on the total volume of concrete required for the floor, these incremental costs may be substantially mitigated, if not entirely counterbalanced, by the inherent cost-effectiveness of using poured concrete for the floor, where the concrete mixture can have a reduced volume of cement and uses larger coarse aggregate materials.

Fig. 4: Layer of shotcrete in place over the cast floor.

***Benjamin Lasseter** is a graduate of Texas A&M University and Co-Founder and President of Operations of the award-winning international Landscape Architecture Firm, Design Ecology. He oversees all construction projects from planning to completion while managing a skilled team of craftsmen to provide unparalleled attention to detail. Benjamin is a member of ACI Subcommittee 506-H-Shotcreting Pools, ACI Committee 322-Concrete Pool & Watershape Code, and ASA Pool & Recreational Shotcrete Committee.*

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La Base Sólida:

Pisos de Concreto Colado en Sitio con Muros de Concreto Lanzado para Albercas

Por Benjamin Lasseter

Fig. 1: Muestra de núcleo tomada en el piso de una alberca cerca del cove, mostrando capas sin consolidar.

Las albercas residenciales han evolucionado significativamente más allá de las formas rectangulares o en forma de riñón, hacia una amplia variedad de formas, características y diseños complejos. Las tendencias de diseño, los avances tecnológicos y las preferencias cambiantes de los consumidores hacia la vida al aire libre han impulsado esta transformación. Hoy en día, las albercas integran elementos intrincados como bordes infinitos, rebosaderos perimetrales, sistemas de iluminación personalizados, controles automatizados y elaboradas fuentes de agua. Además, los avances tecnológicos han dado lugar a sistemas de "alberca inteligente" que monitorean y ajustan automáticamente la química y temperatura del agua. Esta complejidad creciente refleja un deseo por espacios exteriores personalizados y lujosos, pero también exige una mayor experiencia en diseño, construcción y mantenimiento.

La rápida y, en gran medida, no regulada expansión de la industria de albercas en los últimos 40 años —acelerada aún más durante la pandemia de COVID-19— ha generado una alta demanda de mano de obra en un mercado donde la mayoría de los consumidores prioriza el bajo costo por encima de la calidad y durabilidad. Actualmente, la industria está saturada de supuestos profesionales sin capacitación, sin habilidades y sin conocimientos sobre cómo identificar una mala instalación de barras de refuerzo, plomería y concreto lanzado, que son componentes esenciales de la estructura de una alberca. La American Shotcrete Association (ASA) y el American Concrete Institute (ACI) están logrando avances significativos con programas como la Certificación de Lanzadores de ACI y la Calificación de Contratistas de Albercas de ASA, pero la demanda de albercas aún supera a la oferta de formación disponible.

En mi experiencia como constructor, inspector de concreto lanzado y perito en defectos de construcción, he tenido la oportunidad de observar numerosos proyectos de albercas y analizar sus resultados. Mis observaciones han revelado innumerables problemas relacionados con el concreto derivados de una mala mano de obra, muchos de los cuales ocurren en el piso y el cove (transición entre el piso y el muro) de la alberca. Entre ellos se incluyen la falta de compactación, materiales sueltos, vacíos excesivos continuos y capas delaminadas. Otro problema común que he observado es una relación agua/cemento (a/c) extremadamente alta en el concreto lanzado, que ocurre cuando el contratista añade cantidades excesivas de agua a la mezcla de concreto al colocar los pisos para lograr una consistencia más trabajable. No es raro encontrar una combinación de todos estos defectos en el piso de una alberca.

Pero, ¿por qué esto representa un problema en las albercas? La colocación de concreto lanzado es un proceso que funciona mejor para construcciones verticales y sobre cabeza. Sin embargo, en la industria de albercas se utiliza también para los pisos porque acelera el proceso, permitiendo colocar toda la estructura en un solo día. La mayoría de los lanzadores de albercas comienzan con los muros, construyendo desde el cove hacia arriba, y luego terminan aplicando el concreto en el piso mientras se retiran de la

Fig. 2: Colocación de concreto en el piso de una alberca con bomba pluma.

alberca. Esto deja el piso expuesto al rocío, rebote y recortes durante varias horas mientras se colocan y acaban los muros. Además, un día completo de tráfico de pies y mangueras puede mover el acero de refuerzo fuera de sus soportes o hundir los soportes en la base de grava del piso. Este proceso típico convierte el piso de la alberca en el “basurero” de los acabadores, quienes simplemente rocían concreto encima del material no deseado (recortes del muro y material de rebote) para evitar retirarlo de debajo del acero de refuerzo.

Si bien es posible colocar pisos de concreto con el método de concreto lanzado, no es la solución más ideal ni preferida. La colocación con concreto lanzado es más lenta que el colado convencional. Usando camiones volumétricos, una bomba de concreto lanzado con una manguera de 2 pulgadas (50 mm) y mezcla húmeda, promediamos alrededor de 10 yd^3 (7.6 m^3) por hora. Con un camión revolvedor, bomba pluma y mezcla de concreto diseñada para un mínimo de 4000 psi (28 MPa), podemos bombear alrededor de 10 yd^3 en menos de 15 minutos.

El piso promedio de mis albercas requiere aproximadamente 40 yd^3; esto incluye un piso de 12 pulgadas (300 mm) de espesor, vigas de cimentación, piso del spa y otras características consideradas parte del piso o la cimentación. Si utilizo una bomba pluma o una bomba estacionaria grande para colar estos elementos, puedo tener todo el concreto colocado en aproximadamente una hora, lo que permite a mis acabadores trabajar en la parte más fresca del día para acabar y escobillar el piso. A ese ritmo, puedo tener el concreto suficientemente firme como para caminar sobre él antes del mediodía, lo que me permite iniciar el curado y protegerlo del calor de la tarde. Además, la bomba pluma reduce drásticamente el tránsito sobre el acero de refuerzo, ya que el operador de la bomba controla el brazo remotamente desde fuera de la alberca, mientras un equipo de 3 a 5 trabajadores coloca y acaba el concreto con mínima interferencia.

Durante el acabado de nuestros pisos, normalmente tallamos una ranura de aproximadamente 1 pulgada (25 mm) de profundidad en la superficie del piso para que los muros se integren en el piso dentro de un corte preparado. Esto lo hacen los acabadores al escobillar la superficie con una regla o una llana de 2x4 pulgadas (50 x 100 mm). En ese momento, también nos aseguramos de que el plano de unión entre muro y piso tenga un perfil de superficie de concreto (CSP) de 10 (Fig. 3). Normalmente usamos una escoba pesada para crear una superficie rugosa con un CSP alto.

El lanzado de los muros puede comenzar una vez que el piso ha ganado suficiente resistencia para soportar el tráfico sin dañarse. Aunque esto podría ser el mismo día que se coló el piso, normalmente comenzamos el lanzado de muros 2 a 3 días después. El tiempo entre el colado del piso y el lanzado del muro no es crítico, siempre que la superficie del piso esté adecuadamente preparada.

Nuestro proceso de preparación consiste en lavar el piso con una hidrolavadora de 4000 psi y boquilla turbo (mínimo 3000 psi [21 MPa]). Prefiero lavar en la tarde anterior a la colocación del concreto lanzado para pre-saturar el concreto. Este lavado elimina residuos sueltos y lechada superficial, y también satura el concreto como lo indican las normas ACI 506-22 y 506.8-24.

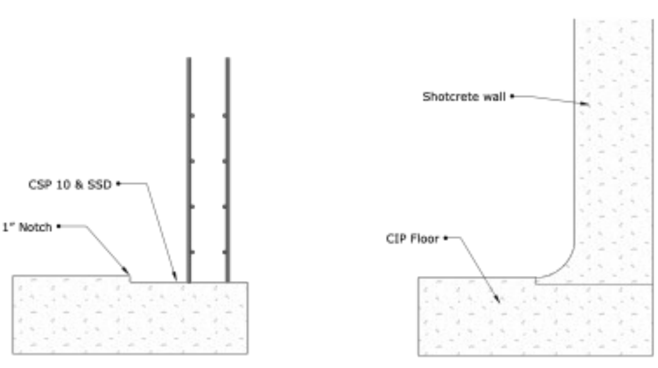


Fig. 3

El día del lanzado, la superficie del piso se vuelve a mojar mientras el equipo se prepara para la aplicación. Justo antes de comenzar el lanzado de concreto, confirmamos que la superficie esté limpia y saturada en condición SSS (saturada y superficialmente seca). Durante el lanzado de los muros, se utiliza una lanza de aire delante de la boquilla para asegurar que el rebote y el rocío sean retirados.

En este punto, continuamos como si se tratara de una alberca normal, excepto que ahora trabajamos sobre una superficie de concreto en lugar de una malla de refuerzo expuesta. El piso de concreto terminado ofrece un área de trabajo más segura y cómoda, comparado con caminar sobre una rejilla de refuerzo, facilitando el movimiento y el arrastre de mangueras durante todo el día. Además, esta superficie sólida proporciona un área conveniente para la recolección del rebote y los recortes, los cuales se recogen posteriormente con palas. Ocasionalmente usamos una bolsa de lavado de concreto para recolectar estos residuos, lo que permite su remoción eficiente del fondo de la alberca con un montacargas o minicargador.

Fig. 4: Capa de concreto lanzado colocada sobre el piso colado.

Una vez completada la construcción de los muros, obtenemos una estructura completa de concreto para la alberca. Las metodologías constructivas específicas empleadas en este proyecto fueron fundamentales para minimizar significativamente el potencial de imperfecciones estructurales, todo ello con solo un pequeño aumento en el cronograma total del proyecto. Los costos financieros asociados con el colado del piso se limitan principalmente al gasto de una segunda jornada de movilización de la bomba de concreto y el equipo asociado. Sin embargo, es importante señalar que, dependiendo del volumen total de concreto requerido para el piso, estos costos adicionales pueden ser sustancialmente compensados, o incluso eliminados, gracias a la rentabilidad del concreto colado, que puede usar una mezcla con menor contenido de cemento y agregados más gruesos.

Benjamin Lasseter *es egresado de Texas A&M University y cofundador y presidente de operaciones de la galardonada firma internacional de arquitectura de paisaje Design Ecology. Supervisa todos los proyectos de construcción desde la planificación hasta la finalización, mientras lidera un equipo especializado de artesanos para ofrecer una atención al detalle sin igual.*

Benjamin es miembro del Subcomité ACI 506-H Shotcreting Pools, del Comité ACI 322-Concrete Pool & Watershape Code, y del Comité ASA de Concreto Lanzado para Albercas y Recreación.

Dewatering in Swimming Pools:

Techniques, Benefits, and Best Practices

By Derek Pay

Dewatering is a crucial process in pool maintenance and construction that ensures the structural integrity, cleanliness, and longevity of swimming pools. Whether you're a pool owner, contractor, or maintenance professional, understanding the purpose and methods of dewatering can help prevent costly damage and maintain optimal pool conditions.

WHAT IS DEWATERING?

Dewatering refers to the process of removing groundwater from the area surrounding a swimming pool (see Fig. 1). Dewatering is commonly used during pool construction, repairs, or when draining a pool for maintenance. Without proper dewatering, excessive groundwater pressure can cause significant issues, including pool wall collapse, structural cracks, or even pool shell 'floating,' where the entire structure lifts out of place.

WHY IS DEWATERING IMPORTANT?

Groundwater pressure is a natural force that can exert immense upward pressure on an empty or partially drained pool. This is particularly common in regions with high ground water tables. Effective dewatering ensures that:

- The pool structure remains stable during draining.
- Hydrostatic pressure is managed to prevent pool 'floating' or 'pop-out'.
- Pool repairs or resurfacing projects can be conducted safely.

COMMON DEWATERING METHODS

Choosing the right dewatering method depends on factors such as soil conditions, water table levels, and pool design. Here are some commonly used techniques:

Fig. 1: A pool excavation in definite need of dewatering.

Fig. 2: Sump pump style pipe installed near pool base with pump inside removing ground water.

Fig. 3: Pool with ground water — hydrostatic relief valves in floor relieving hydrostatic pressure and allowing ground water to come up into shell.

Fig. 4: Trash pumps around pool for dewatering with well points used to successfully drain ground water during construction phase.

1. **Sump Pump Systems:** A sump pump is installed in a strategically placed pit near the pool's base to continuously remove groundwater. This method is ideal for long-term dewatering needs, especially in areas with persistent groundwater issues (see Fig. 2).
2. **Hydrostatic Relief Valves:** These pressure relief valves are installed in the pool floor during construction. When groundwater pressure rises, the valves automatically open to release excess water into the pool, preventing structural damage (see Fig. 3).
3. **Well Point Systems:** This method uses a series of small well points installed around the pool perimeter. Water is drawn out of the well points using a vacuum pump, effectively lowering the surrounding water table (see Fig. 4).

   It is important that water discharged from well points or sump pumps is directed away from the pool and into an area that can accommodate the increased volume of water (see Fig. 5).
4. **French Drains:** A French drain is a gravel-filled trench with a perforated pipe that redirects groundwater away from the pool area. It's commonly used in combination with other dewatering methods.

Fig. 5: Water discharged away from pool construction, allowing ground water levels to decrease.

BEST PRACTICES FOR SUCCESSFUL DEWATERING

To ensure effective dewatering, consider the following best practices:

- **Pre-Assessment:** As construction begins and water is encountered, or before draining a pool, assess the groundwater conditions and soil type to determine the appropriate dewatering strategy.
- **Monitor Water Levels:** Regularly check groundwater levels during the dewatering process to ensure conditions remain stable. Water can cause damage; monitoring levels is key to reducing pool damage and maintaining the safety of others during construction. Heavy rainfall may quickly increase the ground water level.
- **Install Backup Systems:** In areas with unpredictable weather or rising groundwater tables, consider installing backup pumps or additional relief valves for added protection.
- **Consult Professionals:** If you're unsure about your pool's structural risks, consulting an experienced pool contractor or geotechnical engineer can prevent costly mistakes (see Fig. 6).

CONCLUSION

Dewatering is a vital aspect of construction and pool maintenance, especially in regions with high groundwater levels. By understanding the techniques and best practices for dewatering, contractors and pool owners can safeguard their investment and ensure the longevity of their swimming pools. Whether you're preparing for a new pool, major renovation, or simply conducting routine maintenance, proper dewatering strategies are key to protecting your pool from water-related damage.

Fig. 6: Not an ideal way to effectively deal with ground water levels.

Derek Pay *is Owner of Oceanside Construction in Salt Lake City, UT. He received his BA from the University of Utah, Salt Lake City, UT, and has been in the shotcrete industry for about 20 years. He is a certified shotcreter in vertical and overhead techniques and currently installs shotcrete throughout the Intermountain west.*

Dry-Mix Shotcrete Application Using Hydro-Mix System

By Gregory McFadden

Shotcrete is a form of concrete placement using airflow to provide high velocity to the concrete material stream. This concrete placement technique allows for the creation of complex structures, particularly in areas that are difficult to reach or form using conventional casting methods. Variations on the hydro-mix system have been used for decades. Using a hydro-mix system can improve the performance and efficiency of dry-mix shotcrete, offering enhanced mixture control, reduced material waste from rebound, reduced dust, and improved placement quality.

In traditional dry-mix shotcrete application, dry concrete materials are conveyed by airflow through the delivery line to the nozzle, where water is injected immediately before the nozzle tip. The hydro-mix system simply moves the water injection point further back in the shotcrete hose. The additional exposure time of the dry concrete materials to the injected water improves the mixing of water with the dry concrete materials and reduces dust and rebound.

Pre-dampening nozzle options have been around for many decades, and through the years, dry-mix shotcreters have used and perfected the use of the hydro-mix. While the ‘correct’ spacing of the hydro-mix water injection point placement in the hose has varied from manufacturer to manufacturer, the more experienced shotcrete contractors typically elected an 8 to 10 ft (2.4 to 3.0 m) placement of the hydro-mix water body for better mixing and dust control of the concrete material. We adopted this method for our company, building on their successful experience — however in adopting the hydro-mix system, we found the ability to inject water against the air pressure in the material hose was a challenge. We overcame the challenge by developing a booster pump system to provide water pressure well in excess of the air pressure in the dry-mix hose.

One of the key advantages of using the hydro-mix system is its ability to produce a more consistent concrete mixture. With the ability to closely control the water and the resulting water-to-cement ratio, the quality of the shotcrete placement is more predictable, resulting in improved strength, low permeability, and improved overall durability of the concrete.

The well-mixed consistency of the concrete improves its flowability, allowing for smoother application, better encasement of embedded reinforcing, and easier finishing of the final surface. This is particularly beneficial for vertical or overhead applications, where proper workability is crucial to prevent sagging and material loss.

Using the hydro-mix system can provide more thorough mixing with water and ensure the concrete mixture is more fully hydrated, even in challenging environmental conditions such as extreme heat or wind. This is especially important in building concrete swimming pools, ensuring a consistent and durable finish where high-quality, crack-resistant concrete is essential to watertightness and long life of the concrete pool shell.

Using a hydro-mix system represents a significant advancement in the dry-mix shotcrete industry, providing more efficient, consistent, and environment-conscious solutions for shotcrete placement. With its ability to optimize material use, improve workability, reduce dust, and enhance the overall quality of the final structure, hydro-mix technology has become an essential tool in our quality dry-mix shotcreting.

Gregory McFadden *is the East Coast General Manager for Prestige Gunite & Shotcrete Inc. He brings over 40 years of experience in the concrete industry, with the past 15 years focused specifically on dry shotcrete construction.*

Skimmer: Ensuring the Continuity of the Bond Beam

By Nathan Delaforce

This article shares some techniques and procedures we have developed as a company — from the guys in the field to our design team — along with input from industry leaders and exceptional educators, plus years of experience (including trial and error). Commonly, not enough time and detail are spent on forming and reinforcing our bond beams, particularly around surface skimmers. Such a simple aspect is often overlooked, leading to costly results and creating failure-prone areas in our concrete structures.

First, let's start with a simple definition of what a bond beam is in a swimming pool, and what role the skimmer plays. A concrete bond beam is a thickened horizontal concrete beam that runs along the entire perimeter of the pool. It is reinforced with reinforcing bars, providing the concrete section with extra strength to help prevent cracking, and aiding the pool walls to withstand the backfill pressure from surrounding soils and backfill materials. It also helps distribute the pressure of the water inside the pool against the wall. In other words, it's like the rim on the top of a solo cup!

The skimmer is a bucket space within the bond beam that's built to hold a skimmer basket, which captures light debris floating on the surface of the filled pool. The skimmer placement in the bond beam area should be as strong as any other part of the bond beam; but unfortunately, this is not the case in most instances. That's where we began our mission: To create a skimmer box that is easy to construct and replicate, integrating well with our tried-and-true forming techniques, while conforming to American Concrete Institute (ACI) guidelines for reinforcing steel concrete coverage.

Typically, we see either large square boxes with insufficient or no reinforcing steel hanging off the back of the bond beam, or small restrictive boxes with inadequate reinforcing steel or thickness of concrete that fail to maintain the strength of the bond beam and are nearly impossible to backfill correctly. After building a mockup of our typical formed wall in our shop, we set the skimmer and reverse-engineered the form to fit the skimmer, resulting in Fig. 1.

Our typical bond beam.

A typical skimmer box, rebar placement too close, forming too tight, not enough rebar across the skimmer mouth to continue the bond beam continuity.

Fig. 1: Prefab box being installed on our mock-up wall

Fig. 2: Pre-formed skimmer boxes and rebar cages

We built out 6.5 in. (165 mm) all the way around, ensuring our steel has 2.5 to 3 in. (64 to 75 mm) of cover on either side of the reinforcing bars, while reducing excess weight by angling the sides at 45 deg.

When developing our standard wall forming system, we sought out and received constructive input from our shotcrete contractor regarding anything that could simplify their job. They suggested angling the back of our bond beam instead of having a 90-deg shelf, to ease removal of rebound. Making perfect sense, we applied this principle to the bottom of our skimmer boxes, significantly reducing the rebound in the in-place concrete. As an added benefit, it improves backfilling under the skimmers, eliminating voids and settling issues in the decking, especially in impervious areas where we cannot use a concrete base for pavers, travertine, marble, etc.

After establishing our basic design, we began prefabricating our boxes in the shop (Fig. 2) whenever we faced inclement weather. We now have a consistent prefabricated form that is easy to install and transport to the job site, saving us considerable time on the job — and as we all know, time is money.

Time for the reinforcing bars! Back at the mockup wall, we contacted one of our engineers for a typical structural reinforcing detail. We adapted and employed his detail to our new form (Fig. 3), ensuring all our tolerances were met.

We created a jig to represent the plastic chairs used on our walls and pre-manufactured our steel cage by spot

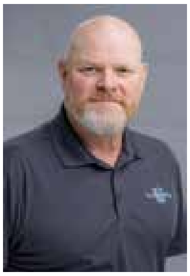
Fig. 3: Steel jig in place in mockup

Fig. 4: Ready for shotcrete placement with reinforcement bars under the skimmer mouth and extra reinforcing steel in the box to control shrinkage.

Fig. 5: After shotcrete placement during 28-day water cure.

welding the components together. Now all our skimmer steel is prefabricated in the shop on rainy days, allowing us to make good use of our downtime and keep our team busy. Back at the job site, we tie in the rest of our walls and bond beam reinforcing steel after the skimmer forms, skimmers, and reinforcing bars are set in place (Fig. 4). This makes the skimmer much stronger, less bulky, and easier to place in the bond beam with less rebound, facilitating effortless backfilling (Fig. 5).

Like anything we do in our industry, there is a constant need for improvement. When we keep an open mind and continue to educate ourselves, we can accomplish those improvements. We can all become better contractors by sharing our ideas and striving to raise the bar for our industry, which will benefit all of our customers. Hopefully, this will help builders avoid costly mistakes and encourage them to think outside the box to develop better building solutions and techniques to share as well.



Nathan Delaforce *is the Director of Construction and Renovation for Vue Custom Pools in Greensboro, NC. Nathan is also currently affiliated with Watershape University and Genesis, and is a member of the PHTA chapter of the Carolinas. A second-generation pool builder, designer, innovator, and shotcreter with over 35 years in the shotcrete pool industry, Nathan has worked on a multitude of high end residential and commercial projects.*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Steel Reinforcement for Shotcreted Pools

INTRODUCTION

Shotcrete, as defined by ACI Concrete Terminology, is "concrete placed by a high-velocity pneumatic projection from a nozzle."

Concrete is strong in compression but weak in tension. Reinforcement, typically as deformed steel bars, is embedded in concrete to create a composite section that is strong in both compression and tension and behaves in a ductile manner. A concrete swimming pool must resist a variety of loads that create both compressive and tensile stresses in the structure. The majority of concrete swimming pools contain reinforcement to help carry these loads. This paper surveys the various areas of reinforcement concerns in pool design and highlights their relevant, currently available code principles.

CODES & GUIDES

The American Concrete Institute (ACI) develops codes and standards for a wide variety of reinforced concrete design. Two codes in particular, ACI 318-25 *Building Code Requirements for Structural Concrete* and ACI 350-20 *Code Requirements for Environmental Engineering Concrete Structures*, are often used for the design of concrete swimming pools. While ACI 318 provides shotcrete placement provisions, section 1.4.9 of ACI 318 states, "This Code does not apply to the design and construction of tanks and reservoirs." ACI 350, in comparison, is intended for the design of liquid-containing concrete structures, so it is currently the more appropriate code for concrete pool design. In the absence of a pool-specific concrete design code, a licensed design professional (LDP) should use good engineering judgment in properly using portions of existing codes for the design of swimming pools.

Of special note, the LDP should look to ACI 506.2-13 (18) *Specification for Shotcrete*, for guidance on shotcrete specifications when producing their project documents. ACI PRC 506.8-24 *Shotcrete Use in Pool Construction – Guide* is also a valuable resource for the LDP.

Complete design of concrete pools is beyond the scope of this paper, but we do provide guidance on design considerations for appropriate reinforcing in pool shells.

SPACING OF REINFORCEMENT

ACI 350 includes spacing requirements for reinforcement in concrete. ACI 350 allows a maximum spacing of 12 in. (300 mm). Section 12.6.1 of ACI 350 allows a minimum spacing of the bar diameter but not less than 1 in. (25 mm). The reduced spacing of ACI 350 provides improved crack control. For a given area of reinforcement, using more smaller-diameter reinforcing bars at a closer spacing is more effective in controlling cracking than a smaller number of larger bars at a greater spacing.

Alternative spacings are permitted by the ACI codes where shotcrete mockup panels are provided to demonstrate proper reinforcement encasement.

LAP SPLICES

Lap splices are required between staggered reinforcing bars to provide a continuous load path through the structure. ACI 350 contains equations for lap splice length and requires the LDP to specify lap splice lengths and locations on the structural drawings. Lap splices may be contact or non-contact splices. Contact splices occur where overlapping bars are in direct contact with one another and wired together. Non-contact splices occur where overlapping bars have a small gap between them. For non-contact splices, ACI 350 requires the center-to-center spacing of spliced bars not to exceed the lesser of one-fifth the required lap splice length and 6 in. (150 mm).

Non-contact lap slices are preferred in some shotcrete applications since contact lap splices are more difficult to encase in shotcrete. It is important to note that ACI 506.2 section 3.1.4.2 does not allow contact lap splices in shotcrete unless the plane of the spliced bars is oriented perpendicular to the surface of the shotcrete and the splice configuration is approved by the LDP. The shotcrete-specific reinforcement spacing requirements for non-contact lap splices in ACI 506.2 require clearance between laps of at least 3 times the diameter of the bar, 3 times the largest aggregate size, or 2 in. (50 mm), whichever is least unless otherwise specified: Non-contact lap splice lengths may need to be increased above code minimums to comply with requirements for both the maximum center-to-center spacing and the minimum clear spacing between lapped bars.

REINFORCING BAR CONGESTION

In shotcrete structures, careful attention to reinforcement detailing is needed to prevent reinforcing bar congestion. Reinforcement congestion can prevent full shotcrete encasement of the reinforcement and increase rebound. Complex reinforcement layouts are sometimes needed at intersections between floors and walls for strength requirements. To complicate matters further, bars are often spliced at these locations. This can lead to congested reinforcement installations that violate the minimum clear spacing requirements described above. Licensed design professionals and installers should coordinate complex reinforcing layouts to ensure that requirements for both strength and constructability are met. The LDP should strive to maintain a 6 in. centering of reinforcing bars so that intersecting planes are not less than 3 in. (75 mm). Bundling of bars should be avoided as it makes it nearly impossible to encase all the individual reinforcing bars.

CONCRETE COVER

Steel reinforcement requires concrete cover to protect it from corrosion. The amount of concrete cover over reinforcing depends on the environmental conditions and the type of the concrete used. ACI 350 requires 3 in. of concrete cover for concrete installed against and permanently in contact with the ground. For concrete floors and walls exposed to earth, liquid, or weather, for primary reinforcing bars, ACI 350 section 12.7 requires a minimum of 2 in. of cover for this exposure condition regardless of bar size. Licensed design professionals may increase cover for future renovations, however when increasing the concrete cover, one should keep in mind that as the concrete cover increases, crack widths at the surface also increase. A maximum of 3 in. should be considered for cover.

SHRINKAGE AND TEMPERATURE REINFORCEMENT

Concrete experiences drying shrinkage as it cures and also undergoes volume changes as temperatures fluctuate. Restraint of these movements creates tension in the concrete that leads to cracks. These drying shrinkage cracks generally extend through the full depth of the concrete cross section. Drying shrinkage and temperature reinforcement is provided to limit the width of the cracks that form. Since concrete pools are intended to be watertight, it is critical that full depth crack widths are minimized. ACI PRC 224-01 *Control of Cracking in Concrete Structures*, indicates crack widths of up to 0.004 in. (0.1 mm) are reasonable for watertightness of water-retaining structures.

Section 24.4.3.2 of ACI 318 requires a minimum ratio of shrinkage and temperature reinforcement area to gross concrete area in a cross section of 0.0018. The commentary to this section indicates this ratio is not intended for leakage prevention. Structures designed to ACI 318 will allow cracks much greater than the 0.004 in. required for watertightness.

Table 12.13.2.1 of ACI 350 includes minimum shrinkage and temperature reinforcement ratios ranging from 0.0025 to 0.01, depending on the amount of restraint imposed on the concrete section. While the shrinkage and temperature reinforcement ratio of ACI 318 is too low for watertight concrete pools, the reinforcement ratio at the high end of the ACI 350 range is intended for highly restrained walls and may lead to reinforcing congestion and bar spacings that do not allow for shotcrete installation. In some cases, a lower shrinkage and temperature reinforcement ratio may be considered by removing or reducing restraint to shrinkage and temperature changes. Unless design calculations require more, a ratio of 0.005 is a good rule of thumb for liquid-containing structures without movement joints. A ratio of 0.005 creates minimal congestion for shotcrete structures while providing adequate reinforcement for control of volume change cracking and providing watertightness.

Additional consideration should be given for the inclusion of plumbing pipes found in swimming pool construction. Pipes and embedded fixtures are necessary components in swimming pool construction and often require additional design considerations. ACI 350 section 6.3.9 requires that pipes shall be placed between the top and bottom reinforcement. Section 6.3.10 requires that pipe, conduit, and fittings shall meet the minimum coverage requirements for reinforcement except where designed to intersect the surface.

ALTERNATIVES TO STEEL REINFORCEMENT

ACI 350 Commentary R10.6.4 states, "Testing has shown that inclusion of epoxy-coated reinforcement will cause an increase in the crack width of flexural members by approximately 30 percent." Additionally, the abrasive nature of the shotcrete process tends to disrupt the epoxy coatings from reinforcing bars. Epoxy-coated bars also complicate the equipotential bonding requirements for swimming pools put forth by the *National Electrical Code* (NEC). For these reasons, epoxy-coated reinforcement is not recommended for concrete swimming pools.

GFRP (Glass Fiber Reinforced Polymer) bars are not widely used in swimming pool construction at this point in time. This is perhaps due to the interpretation of the NEC, as well as the product not being able to be bent in the field. Further design considerations for the LDP are the much lower stiffness of GFRP bar compared to that of steel bar.

REINFORCEMENT SUPPORTS

In concrete pool construction, bars are frequently supported by bricks, concrete masonry, and broken pieces of old concrete. Many times, the spacing of reinforcement supports is inadequate, and bars sag between supports. These practices should be avoided as they incorporate weak material into the pool shell and do not comply with code requirements for concrete cover and reinforcement installation tolerances. In shotcrete applications, it is critical that the reinforcement be rigidly tied together and supported.

Vibration of loose reinforcing bar mats when impacted by shotcrete creates voids and sagging of plastic shotcrete. ACI 301 *Specifications for Structural Concrete* requires that reinforcement supports be furnished and installed in accordance with Concrete Reinforcing Steel Institute (CRSI) RB4.1 *Supports for Reinforcement Used in Concrete*. CRSI RB4.1 includes specifications for reinforcing bar support types and spacings.

Since concrete pools hold water and are often installed against earth forms, reinforcing bar supports should be corrosion resistant. The practice of supporting reinforcing bars by driving the bar into soil should be prohibited. The LDP should specify the proper type of supports to be used in their project.

MULTIPLE REINFORCEMENT LAYERS

Many concrete pool shells are installed with a single layer of reinforcing. This may be appropriate for concrete sections less than or equal to 8 in. (200 mm) in thickness. For these sections, it can be difficult to install multiple layers of reinforcement and still comply with requirements for concrete cover and clear spacing. As concrete sections increase in thickness beyond 8 in., additional layers of reinforcement are needed.

The LDP may also choose to require two layers of reinforcement to evenly distribute shrinkage and temperature bars to each face. For shotcrete applications, a reinforcing layer in the face of the wall nearest the nozzle can help the shotcreter 'hang' the shotcreted concrete and prevent sloughing. In this case, an additional layer may be added to the section; while it is not required by strength calculations, it improves constructability. However, care must be taken not to exceed the maximum allowable area of steel per ACI 350.

A pool is not always full of water and needs to be drained occasionally. The LDP should consider the forces that are applied when the pool is empty with hydrostatic pressure from saturated soils, as well as uplift from groundwater. Using two layers of reinforcing steel may help with serviceability when the pool is full and empty.

While not in the scope of this paper, it should be noted that pressure relief provisions or dewatering both during and after construction should be provided for when ground water is present.

FIELD BENDING

Field bending of reinforcing bars is common practice in concrete pool construction to accommodate curves and creative design elements. The problem with field bending is the lack of quality control. ACI 350 only allows field bending of reinforcing bars when it is permitted by the LDP or shown in the construction documents. The Code includes requirements for reinforcing bars' bend diameters. These requirements are derived from tests on reinforcing bars and concrete. Code equations for reinforcement hooks, ties, and stirrups assume standard bend diameters are used. Tight reinforcing bends can fracture bars and increase the likelihood of concrete crushing and splitting at the bend. Repeated cold bending of reinforcing, work hardens the material and decreases its ductility. Installers field bending reinforcement should obtain the approval of the LDP and implement a quality control program to ensure that field-bent bars conform to the requirements of ACI 350.

GRADE 40 VS GRADE 60

Reinforcing steel is graded based on its yield strength. Grades 40 and 60 reinforcement are most often used in concrete pool construction. Grade 40 reinforcement is typically requested by swimming pool installers planning to field bend the reinforcing bar. Grade 40 steel is easier to bend than Grade 60 steel due to its lower yield strength (40 ksi vs 60 ksi).

Where reinforcing steel strength requirements do not govern the concrete design, Grade 40 reinforcing may be a viable alternative for Grade 60 bar. ACI 350 requires Grade 60 steel for shrinkage and temperature reinforcement. If Grade 40 is used for shrinkage and temperature reinforcement, the LDP should consider increasing the percentages of reinforcing.

Designers need to adjust the design depending on whether Grade 40 or 60 reinforcing is to be used. Installers should not substitute Grade 40 bar for Grade 60 bar without approval from the LDP. Licensed design professionals are unlikely to allow substitution of Grade 40 reinforcement where Grade 60 reinforcement has been specified and used for concrete design calculations.

Position Statement #8

ASA Pool and Recreational Shotcrete Committee

american shotcrete association

NEW CODE DEVELOPMENT & SUMMARY

ACI has tasked ACI Technical Committee 322 with developing a Concrete Pool and Watershape Code. ACI 322 will address the concerns put forth here along with a broader range of considerations for the design of swimming pools using reinforced concrete. Until that code is released, licensed design professionals may conservatively lean on ACI 350 for guidance while considering the shotcrete provisions of ACI 506.2. This paper highlights relevant sections of each code and establishes principles that should be followed for the design and installation of reinforcement in concrete swimming pools.

REFERENCES

1. ACI CODE-318: Building Code for Structural Concrete – Code Requirements and Commentary
2. ACI CODE-350: Code Requirements for Environmental Engineering Concrete Structures and Commentary
3. ACI SPEC 506.2-13(18): Specification for Shotcrete
4. ACI PRC 224-01: Control of Cracking in Concrete Structures
5. NFPA 70 National Electrical Code – 2023
6. ACI SPEC-301: Specifications for Concrete Construction
7. CRSI RB4.1-2022 Supports Used for Reinforcement in Concrete

Position Statements

ASA has produced position statements on the best practices for proper shotcrete placement. To date, seven position statements from our Pool & Recreational Shotcrete Committee, four from our Underground Committee, and one from our Board of Direction have been issued. These statements have also been published in *Shotcrete* magazine.

Visit **http://www.shotcrete.org/resources/**

Building a Water Feature Using Shotcrete Placement

By Monte Vandeventer

Water features have become a staple in modern landscaping, offering a tranquil ambiance and a uniquely aesthetic appeal. Whether it's a serene pond, a cascading waterfall, or a dynamic fountain, the addition of water to your garden or backyard transforms the space into an inviting, peaceful retreat, and one of the best methods for constructing durable, customizable water features is with shotcrete placement — a versatile and efficient form of concrete application. In this guide, we will explore the process of building a water feature using shotcrete placement, from planning and site preparation to the final finishing touches and maintenance.

WHAT IS SHOTCRETE?

Shotcrete placement is a method of applying concrete to a surface sprayed at high velocity using specialized equipment. It is often used in situations where traditional pouring methods would be difficult or impractical, such as in creating curved or irregular shapes for water features. There are two primary shotcrete processes: wet-mix or dry-mix. In wet-mix shotcrete, the materials are pre-mixed with water before spraying, while dry-mix injects water at the nozzle during application. With proper materials, equipment and application techniques, both methods offer strong, durable, watertight results. Some water feature contractors prefer wet-mix for higher production rates.

The main benefits of shotcrete placement for water features include its flexibility in design, rapid application, and the ability to create intricate forms and shapes that traditional concrete may not accommodate.

Sketched out concept


Excavations

PLANNING YOUR WATER FEATURE

Before shotcrete placement, it is essential to plan your water feature carefully to ensure it fits seamlessly into your landscape and meets your functional and aesthetic needs.

DESIGNING THE FEATURE

Think about the style and size of the feature. Will it be a small pond, a tranquil waterfall, or a large, dynamic fountain? Consider elements such as water flow, height, and shape. You may want to create a natural, rock-like appearance, or opt for smooth, modern lines. You can sketch out your design or consult with a landscape designer to help visualize the concept.

CHOOSING THE RIGHT LOCATION

Selecting the right location for your water feature is crucial. Choose a spot where the water flow can be easily controlled and ensure that the area has adequate drainage. Consider access to water supply and electricity, as you will need a reliable water source and power for pumps and lighting.

PREPARING THE SITE

Once your design is finalized, it is time to prepare the site for the shotcrete application. This involves excavation, reinforcement, and formwork.

EXCAVATION

Depending on the size and depth of your water feature, you will need to excavate the site accordingly. For a pond, you will need to dig deep enough to accommodate the desired water depth, while ensuring the base is level. If you are creating a waterfall, ensure the slope is designed to guide the water flow smoothly.

REINFORCEMENT

To provide the shotcrete structure with the necessary strength, install a steel reinforcing bar cage or steel mesh in the excavated area. This reinforcement will help reinforce the shotcrete and prevent cracking over time. You should also plan for the placement of plumbing and electrical systems that will be used for water circulation, lighting, and pumps.

FORMWORK

If your design calls for specific shapes or ledges, such as for a waterfall or rock formations, you may need to build temporary formwork. This will guide the shotcrete into the desired shape as it is placed.

ADDING THE WATER FEATURE COMPONENTS

PLUMBING AND PUMPS:

Install the necessary plumbing and water circulation system, including a pump, filtration system, and any piping for water flow. The pump will need to be powerful enough to move water through the feature, and the filtration system will ensure the water remains clean and clear.

Reinforcement

Formwork

LIGHTING AND ELECTRICAL

Consider adding lighting to enhance the visual impact of your water feature, especially for evening use. Submersible LED lights work well in water features and can create dramatic effects when placed strategically.

SHOTCRETE PLACEMENT

With the site properly prepared, you can now move on to shotcrete placement. This is a critical stage, as the quality of the final structure will determine the final appearance and durability of the water feature.

SHOTCRETE PLACEMENT

Shotcrete placement typically uses a specialized spray nozzle connected to a delivery hose, which is fed by an air compressor. Wet-mix or dry-mix is sprayed onto the prepared surface in layers, with each layer fully bonding to the previous one as it builds up. The shotcreter will need to carefully direct the shotcrete to create the desired contours and textures while achieving full consolidation of the concrete and encasement of the reinforcing. Use of ACI-certified Shotcreters is highly recommended to help ensure a quality placement.

LAYERING AND BUILDING UP

The shotcrete placement is often done in layers, allowing each layer to set before the next is added. This layering method, with proper surface preparation, ensures a monolithic, strong concrete structure. Shotcrete placement is typically completed in sections, starting from the base and moving upward or outward. The result is a solid, durable structure with the exact shape and features you designed.

FINISHING TECHNIQUES

After shotcrete placement has taken place, the concrete can be smoothed, textured, or carved to create realistic rock faces, smooth pond surfaces, or other desired effects. You can use tools like trowels, sponges, and brushes to add finishing details. Curing the concrete properly is also important to ensure it hardens correctly, reaches its full strength and minimizes cracking.

Finishing techniques

Final product

CONCLUSION

Building a water feature using shotcrete placement offers both beauty and practicality. This method provides a durable, customizable, and cost-effective way to bring your landscaping vision to life, allowing for unique designs that other materials may not accommodate. With careful planning, site preparation, and attention to detail, your shotcreted water feature will be a stunning addition to your outdoor space for years to come.

***Monte Vandeventer** began his career in 1996 in the drilling industry, working out of a Local 320 Laborers union in Portland, Oregon for Tigard Sand and Gravel. He worked drilling with air-track drills, drilling holes and helping the explosive techs load the shots with explosives to break the rock apart so it could be crushed and sold for various applications. In 1998, he began working on the geotechnical side of the industry that focused on the building of Deep Foundation Shoring Systems consisting of a variety of different drilling techniques with engineered shoring solutions — such as soldier piles, lagging, soil nails, shotcrete, micro-piles and tiebacks — to retain earth around deep excavations, especially in urban or confined sites.*

Throughout his 29-year career, Monte has found himself with a love of the industry and the joy each day brings as he gets to be a mentor and train so many young contractors coming up in the industry. Over the years he has had the opportunity to be a part of the construction of some beautiful architecture, carved shotcrete walls, and water features like those displayed in this article. He currently serves as the Director of Field Operations at Thorcon Shotcrete and Shoring LLC.

Interested in becoming a member of the American Shotcrete Association?

Read about the benefits of being a member of ASA online at:
shotcrete.org/join-asa/benefits/

Find an application at :
shotcrete.org/membership

american shotcrete association | asa

ASA Contractor Qualification – Pool: Why, Who, When, and How

By Charles Hanskat

So — you're a shotcrete contractor with a large majority of your projects shooting pools. The immense post-COVID surge in pool demand has kept you extremely busy, but it has also created an environment for less experienced shotcrete contractors to jump into the market. Is there some industry-vetted way to document your years of top-tier work and prove your ability to shoot a high quality, durable pool shell?

Or, maybe you're a pool builder subcontracting the shotcrete placement of the pool shell. How do you evaluate the qualifications of your shotcrete subcontractor? Do you dive into the details of each company's business when they give you a quote, including their organizational structure, equipment, training, and certification of their field and support staff, plus record of experience with other builders? Is there a service that can provide an industry-recognized qualification to help evaluate these potential subcontractors?

Now, yes there is!

At our ASA 2025 Annual Convention in Savannah, GA, we rolled out the newest ASA Contractor Shotcrete Qualification (QSC) category: Qualified Shotcrete Contractor – Pool (QSC – Pool). This broadens our established QSC program that addresses the more commercial, structural shotcrete market with Structural Level 1 and 2 qualifications. Though the structural qualification levels could certainly be applied to pool shotcrete placement, there was a clear need in the market for a qualification program specifically designed for pools. For more detailed information on the existing QSC Structural programs, refer to **shotcrete.org/certification-qualification**. This article focuses on the fundamental aspects to consider for whether the QSC – Pool program is appropriate for your company that focuses on the pool market.

WHY?

Before engaging a pool shotcrete contractor, any pool designer, builder, or owner (let's call them the "clients") should thoroughly review the shotcrete company's qualifications. This is critical, as the shotcrete placement of the pool shell is the heart of the pool. A quality pool shell has great serviceability and durability that may last at least 50 to 100 years in normal service.

However, many clients don't have sufficient knowledge of shotcrete placement and thus are less prepared to fully to evaluate the shotcrete contractor's equipment, crews, and resources. This may lead some clients to simply accept a contractor's shotcreting submittal based on years of experience without critical examination. But, though a shotcrete contractor may have been shotcreting for years, how does a client know whether it has been shotcreting right or wrong?

Unlike the infrastructure industry and commercial side of shotcrete construction, the swimming pool industry has very few existing programs for scrutiny. Only a few states have building codes regulating pool construction and, more specifically, the shotcrete process. Without a knowledgeable and experienced shotcrete contractor dedicated to quality shotcrete placement day in and day out, the entire success of the project and all components of the project, from the plumbing to tile and plaster, are in jeopardy.

Basically, this QSC – Pool program lets ASA do the work of vetting a pool shotcrete contractor's experience and capacity to do a quality job for the client. ASA has shotcrete experts (shotcrete contractors, engineers, researchers, suppliers, and educators) who closely review and verify a pool shotcrete contractor submittals. Members of the Contractor Qualification Committee (CQC) will also communicate with the applicant and key personnel to validate the application information, as well as verify the project references supplied.

WHO?

ASA administers the QSC - Pool program as a review service for pool shotcrete contractors. ASA expects that those contractors who pursue the QSC – Pool qualification want to quantify and fully demonstrate their commitment and knowledge of the shotcrete business and the ability to routinely shotcrete quality concrete for pools. A successful application can provide clear documentation of their years of good work and the potential to build a quality pool shell. Thus, achieving the QSC – Pool qualification can be a great tool for a pool shotcrete contractor to differentiate themselves from other non-ASA qualified contractors to their clients.

WHEN?

The QSC - Pool program allows for qualification in either wet-mix or dry-mix shotcrete, or both. The shotcrete contractor must specify which process they wish to pursue, supplying documentation to confirm their work over the last three (3) years. The shotcrete contractor must submit at least 15 projects for review in each process for which they are pursuing qualification. Applicants must submit contact information for each project's references. Further documentation of the field and support staff is also required. This includes listing the ACI-certified shotcreter for each project.

So, before submitting an application, the pool shotcrete contractor must have:

1. Documentation, including references, on at least 15 projects over the last 3 years
2. Documentation on field and support staff on the submitted projects
3. A company representative attend the ASA Shotcrete Contractor seminar
4. That representative pass the QSC – Pool written exam

HOW?

First, visit the ASA Contractor Qualification webpage at **shotcrete.org/certification-qualification**. Closely review the full policy that is linked on the "ASA Qualified Shotcrete Contractor – Pool (for self-performing)" tab. Once you decided to pursue completing the QSC – Pool qualification and have the required quantity of projects and the 3 years of experience, you should consider scheduling at least one company representative to attend the ASA Shotcrete Contractor Qualification seminar (CQ seminar). The ASA typically holds these annually at its Annual Convention, but may offer them throughout the year if demand rises. You can check our ASA Calendar (**shotcrete.org/calendar**) to see when the CQ seminars are scheduled. One of the company representatives who attend the seminar and pass the exam will be assigned as the "Qualifying Individual" for your company.

Assuming the required time and project requirements are met, and you have an assigned qualifying individual, you are ready to complete the application. The application is available on our Contractor Qualification webpage.

Besides basic information on your company structure, equipment, and field and support staff, you will need to fully document your project list. When describing each project, it is important to include the following characteristics:

- New construction or renovation? If renovation, describe the scope of the renovation
- Residential or commercial?
- Thickness of wall sections
- Reinforcement: Size and spacing of reinforcing bars, level of congestion, or complexity of geometry
- Subgrade preparation, including difficulties with excavation, access, dewatering, or other environmental requirements
- Volume of shotcrete placed per day and overall project

- Additional details, or challenges faced and measures to overcome them

Reliable contact information for each project submitted must be available to the CQC Review Team for phone interviews. Applicants must request permission from their contacts to be used as references on their application and inform the contacts that they may expect to be contacted by ASA's Review Team. A single client reference may be used for multiple projects, however a minimum of three different references must be submitted.

Alternatively, project references can provide a detailed letter of reference. The details that should be addressed in the letter of reference is covered in the ASA QSC – Pool policy.

Once the application is submitted, ASA staff (or its consultants) will initially review an application for completeness. If any portions appear incomplete or inaccurate, the application will be returned with notation on areas needing correction/additional information. After the initial staff review, the CQC will assign a review group to process the application. If a review group member has a potential conflict of interest, they must notify the chair, and a substitute assigned. The review group will review the information, check references, and fully verify the supplied information. The assigned review group will make a final recommendation that is submitted to the main CQC for comment and final approval. Note that any members of the main CQC with a potential conflict of interest must abstain from commenting or disclose any conflicts with the applicant when commenting.

The ASA QSC program requires all qualified shotcrete contractors to adhere to the following code of conduct:

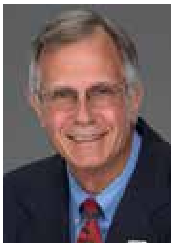
> *As an ASA Qualified Shotcrete Contractor - Pool, we agree to ongoing compliance with the requirements and standards set forth in the ASA Pool Shotcrete Contractor Qualification Program Description. We will not knowingly or purposefully violate any project specifications or requirements. We agree to maintain the required insurance coverage, staff our projects with trained and certified personnel, and strive to produce a high-quality product in a safe and professional manner.*

Failure to adhere to this code of conduct may result in disciplinary action, which may include being placed on probation or losing ASA Qualified Pool Shotcrete Contractor status.

Once approved, the ASA QSC – Pool qualification is valid for 5 years. The program policy describes the renewal process. ASA lists all the current ASA QSC on our website. Finally, the program provides a process for addressing public complaints about a QSC.

SUMMARY

This article provides the highlights of the QSC – Pool program. You can find more comprehensive details in the policy and application, both publicly available on the webpage. Overall, we trust that the ASA QSC – Pool program provides a distinct and needed service to the pool industry. With a program that highlights the pool shotcrete contractors committed to quality shotcrete placement, we continue to set a higher standard for clients to recognize capable self-performing pool shotcrete contractors available for their projects.



***Charles Hanskat**, P.E., is a Fellow member of the American Concrete Institute, American Society of Civil Engineers, and the Florida Engineering Society. He is Executive Director and Technical Director for the American Shotcrete Association and holds a bachelor's and master's degree in civil engineering from the University of Florida. He has been a licensed professional engineer for over 40 years.*

Hanskat has been involved in the design, construction, evaluation, and repair of environmental concrete, marine, building, and shotcrete structures throughout his career. He is active in developing codes and standards from many professional and technical engineering societies, including ACI, ASTM, AREMA, and ICRI.

SHOTCRETE CALENDAR

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

JUNE 22-25, 2025	**ASTM Committee Meetings - C09 Concrete & Concrete Aggregates** Sheraton Centre Toronto Hotel | Toronto, ONT Canada
AUGUST 8, 2025	**Recognizing Quality Shotcrete** Mid-Atlantic Resource Center | Columbia, MD
SEPTEMBER 10, 2025	**Recognizing Quality Shotcrete** Southern California Resource Center | San Bernardino, CA
OCTOBER 1-3, 2025	**ACI Shotcreter Certification (Wet- & Dry-Mix)** Minova | Millstadt, IL
OCTOBER 3-5, 2025	**ACI Shotcreter Certification (Wet- & Dry-Mix)** Applied Shotcrete | Sebastopol, CA
OCTOBER 10, 2025	**Recognizing Quality Shotcrete** Midwest Resource Center | Elk Grove Village, IL
OCTOBER 19-22, 2025	**2025 ICRI Fall Convention** Intercontinental Hotel | Chicago, IL
OCTOBER 19-24, 2025	**International Pool | Spa | Patio Expo 2025** Las Vegas Convention Center | Las Vegas, NV
OCTOBER 21, 2025	**WU C2241 Quality Shotcrete for Pools – Know It, Demand It | IPSP (Pre-Show)** Las Vegas Convention Center | Las Vegas, NV
OCTOBER 26-29, 2025	**ACI Concrete Convention - Fall 2025** Hilton Baltimore & Marriott Baltimore Inner Harbor | Baltimore, MD
NOVEMBER 8, 2025	**Quality Shotcrete – Know It When You See It** Hilton Garden Inn | San Mateo, CA
DECEMBER 7-10, 2025	**ASTM Committee Meetings - C09 Concrete & Concrete Aggregates** Hilton Atlanta | Atlanta, GA
MORE INFORMATION	To see a full list, current updates, and active links to each event, visit www.shotcrete.org/calendar.

The Need to Recognize Quality Shotcrete Placement

By Bill Drakeley

In my 35 years in the pool industry, I've seen many changes take place, especially in shotcrete placement for pools. This mostly unregulated market suffered from the lack of design codes and construction specifications which guide most other built concrete environments. Yet, no longer an afterthought in home construction, pools now play a vital role in creating the 'home' space of protection and relaxation; something which became especially apparent during the COVID pandemic.

> Shotcrete swimming pool construction is unique and very demanding."
>
> **– ACI PRC-506.8-24: Shotcrete Use in Pool Construction – Guide**

As poor-quality installations — which were already eroding the credibility of shotcreted pool shells — were slowly dissipating, the pandemic instigated a surge in demand for pools as an oasis at home. This surge in demand for pools couldn't be fully supported by the existing network of shotcrete contractors, thus leading to a rise of inexperienced companies who tried to step in to meet demands. Unfortunately, with improper shotcrete knowledge and little regard for quality or proper placement practices, the resulting pools were poor, causing more harm than good for the concrete pool market and leaving many with nowhere to turn.

Watershape University (WU) was founded to provide everyone in the pool industry with educational resources to succeed. With this in mind, WU developed two credentials for those involved in shotcreted pool shells:

- Certified Watership Shotcrete Specialist (CWSS) is a standard that validates a watershapers' understanding and general knowledge of shotcrete placement for pool applications.
- Certified Pool Shotcrete Inspector (CPSI) is a standard that validates a watershapers' understanding and general knowledge of shotcrete placement for pool applications, while also acknowledging that the watershaper has the field experience to inspect pool projects during shotcrete placement for concrete watershapes.

These credentials provide guidance in recognizing quality shotcrete placement, which would be helpful for:

- Homeowners or municipalities – to know that their onsite pool contractor is performing shotcrete installation correctly.
- Pool builders – to know that a knowledgeable inspector is available to help and assist during construction rather than to judge or condemn after completion.

This education helps everyone in the industry by outlining what it takes to build a better shotcreted pool shell. When you do so, it lessens the need for an 'immediate fix' or a waterproofing product in a non-watertight pool shell. After all, there is no better time to identify and correct problems in shotcrete placement than when concrete is being placed. Correctly shotcreted pools should last 50 to 100 years, or more!

THE CREDENTIALS:
A THREEFOLD APPROACH

1. Required WU certification: Certified Watershape Foreman (CWF) – complete the *Construction 2111: Essential Pool Construction* course and pass the corresponding exam. You must be an active CWF to earn the CWSS.
2. Complete the *Construction 2241: Quality Shotcrete Placement for Pools – Know It, Demand It* course (presented by ASA, hosted by WU) and pass the

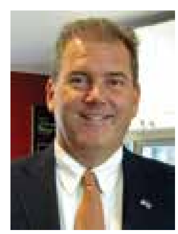
corresponding exam. Completion of Steps 1 and 2 confers the CWSS certification. A candidate must obtain the CWSS to pursue the CPSI.

3. Apply for the CPSI in a two-part application.
   a. Part One – a written application form that includes detailed descriptions of at least ten pool shotcrete placement projects completed over the course of the last five years, documenting the types of projects you were involved in and your role on the projects.
   b. Part Two – upon successful submission and review of Part One, you will be sent a link to complete an online exam, which includes videos of shotcrete placement, to verify your ability to recognize quality shotcrete placement.
   c. Successful completion of *both* parts of the application, *and* current/active CWF & CWSS credentials, confers the CPSI certification.

WU is the credentialing body. The credentials are active for a three-year period with renewal requirements of 24 continuing education units (CEs) with at least 12 CEs specifically related to shotcrete. Those who pursue these credentials demonstrate an adherence to the ASA and WU recommended line of resources, including the ASA Pool Position Statements and ACI PRC-506.8-24: *Shotcrete Use in Pool Construction – Guide*. These credentials affirm your vested interest in and commitment to building quality shotcrete pools that give owners the serviceable and durable concrete pool they expect and deserve.

ASA POOL POSITION STATEMENTS

- **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**
- **Steel Reinforcement for Shotcreted Pools** **(featured on page 38)**



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

Raising the Bar

By Ryan Oakes

I began working with concrete and water 27 years ago, the same year the American Shotcrete Association (ASA) was formed in 1998. We were form-and-pouring all projects at the time, and some years later we naturally stumbled on shotcrete as the preferred method for placing concrete for water features of all sorts — from pools and fountains to art commissions, architectural works, and heavy civil work. In the transition from fountains to pools, I noticed that our projects went from being specified with thoughtful steel reinforcement design by well-versed engineers to cocktail napkin designs by pool designers, sales people, and contractors — many of which had little or no formal education in reinforced concrete design.

To use the cliché: They didn't know what they didn't know. The pool industry had learned from its predecessors, who learned from their predecessors. 'If [the process] ain't broke, don't fix it' seemed to be the reasoning behind pool design. The problem — as we now know clearly from the boom in renovation projects in the pool industry — is that the process was broken. The means and methods of pool design and construction were, and in large part still are, inadequate.

Concrete pools have had a bad rap for decades. People chose other methods such as fiberglass or vinyl because their neighbor's concrete pool had cracked and leaked, creating problems for the owners.

To add insult to injury, there are few building codes or standards applied to the pool industry, so it's an industry that could be likened with the Wild West: Basically, there are no rules, codes, or laws governing pool construction, so anything goes, right?

Wrong. Standards do exist — just not codified in law. Yet.

A VERY BRIEF HISTORY OF POOL CONSTRUCTION

More than half a century of pool construction sits before us. Building practices have changed over time and materials have changed to some degree. For the most part, our knowledge base has improved. Over the last 70 years, pools have gone from a simple hole in the backyard to elaborate residential or municipal water parks. Even what seems like a simple pool in the backyard to the builder or homeowner may be a structure that withstands a great deal of stress and must be designed to handle the applied loads.

Some of the common features in pools that require more thoughtful design and construction are cantilevered skimmer boxes and cover boxes for automatic pool covers, spas, grottos, creeks and waterfalls, underwater benches, raised walls to support landscape gradient changes, shallow water lounging areas, and vanishing edge pools, just to name a few. Then there are pools built on slopes, built out of the ground, on second floors or higher, in seismic zones, in expansive soils, in high freeze/thaw exposure conditions or with high groundwater tables, and in coastal regions with the potential to have some or all of the soil under the pool removed by a hurricane.

FROM THE GROUND UP

Not a home or building in America goes under construction without a footing inspection, yet most pools do not get a footing inspection or a review by a geotechnical firm to ensure the soil is suitable to support the pool. With typical concrete pool construction costs ranging from $100,000 to $400,000 to several million dollars on the high end — one must wonder why there are few inspections of the soils that support these structures.

A simple geotechnical report can prevent many problems and provide solutions for soils unsuitable to support the project. A geotechnical report may provide notice that a pool may sink, float, or break because of expansive soils. Solutions for all these circumstances exist, but without professional guidance, a pool contractor is taking on this liability and the homeowner isn't even aware of the potential problems.

EXCAVATION AND FORMING

One might ask, why am I writing about soils or carpentry and excavation in a shotcrete publication? High-quality concrete work fully depends on high-quality excavation, ground support, and formwork. Inadequate forms can flex under pressure, causing sagging in the shotcrete placement that the shotcrete crew may not see. Inadequate formwork may also lead to poor finish problems and inadequate concrete cover over reinforcement steel, later leading to rust and a cracked pool. Plus, inadequate ground support or groundwater management before, during, and after construction of the shell can lead to pools that settle, float, or even slide down a hill, all of which are devastating to the pool. These are all preventable scenarios with a little education in pool construction and the use of an experienced licensed design professional (LDP).

THE PURPOSE OF A POOL

Concrete swimming pools are constructed throughout the United States using shotcrete placement of the concrete. Both the dry-mix and the wet-mix shotcrete methods are equally adept and preferable most times to form-and-pour methods of placing concrete.

When designing a concrete structure, one must ask what the structure's purpose is and then design to that purpose. Other considerations in the design process are constructability, service life, and value.

The primary purpose of any swimming pool is to hold water. This broad definition of the purpose of a pool includes all pools within residential and commercial environments.

With the overarching purpose of holding water, the LDP must consider the best construction methodology that brings serviceability, durability and value to the owner. As the most widely used building material on Earth, concrete is affordable, quickly installed, and shaped in most any form one can imagine, especially when using the shotcrete placement method. Concrete alone, however, will perform poorly for pools as several environmental conditions can affect the structure. Reinforcing steel in the form of deformed bar is embedded in concrete to create a composite structure that combines the benefits of concrete with the benefits of steel. This allows the structure to resist a variety of loads beyond just compressive loads.

While not an exhaustive list, an LDP will consider compressive loads, shear loads, flexural loads, tensile loads among others. To do this, the LDP will use industry-standard references, including published design codes and commentary, to design the size, frequency, and location of the reinforcing bars in the concrete structure as well as to establish the hardened properties of the concrete, such as compressive strength or shrinkage potential.

An often-overlooked and extremely important design consideration for water-containing concrete structures is the need to resist thermal stresses due to seasonal or even daily temperature changes. These changes occur during initial curing of the concrete, during ongoing construction, and throughout the life of the structure. The requirements to resist these thermal stresses are different than those of the load considerations, yet they are equally important to create a watertight concrete structure.

While thermal stresses can cause cracks through the pool shell, other design considerations should not be overlooked, such as drying shrinkage in the concrete. With the wide variety of shapes in a pool such as steps, benches, skimmer boxes, cover boxes, and the like, much consideration has to be given to volume change from both thermal and shrinkage stresses. Reinforcement layout must accommodate the volume change that results from varying geometries and inclusion of accessories. Shape and size of the pool shell alone are not the only phenomenon that cause cracking from volume change: The numerous components such as pipes, skimmers, sumps, and spa fittings, to name a few, all create design concerns for the LDP when considering concrete cover and the impact of drying

shrinkage. The steel reinforcement design should take these items into consideration.

Another consideration of the LDP is that of the thermal conditions with mass concrete pours. It is not uncommon in swimming pool construction to see placement of concrete in excess of 3 x 7 x 10 ft (0.9 x 2.1 x 3.0 m). The placement of this much concrete in one pour or shoot creates significantly increased internal heat of hydrating cement, resulting in a differential thermal stress that can cause cracking if not addressed by increased reinforcing steel in the section. Thick concrete sections that exceed an internal temperature of 160°F (70°C) may also initiate a delayed ettringite formation (DEF) internal attack of the concrete. LDPs should also consider providing support for such a large quantity of concrete with reinforcement steel.

Additional considerations should be given to thermal differentials that arise from the intended use of the project. Spas, for example, can see temperature swings from 40 to 104°F (4 to 40°C) in an hour, and later returning to 40°F in a matter of minutes. These swings in temperature create a high stress within the concrete, so reinforcement must be designed to carry this tensile stress without cracking.

This all circles back to the very broad purpose of a pool, which is to hold water. If all the aforementioned items can cause tensile stress and the resultant cracks in concrete, we must design our reinforced concrete to have adequate reinforcing to minimize crack width so that the pools do indeed hold water. Generally, this is not the responsibility of a pool builder, or owner, but rather an LDP with experience in designing watertight concrete structures. However, if a pool builder chooses to forgo retaining an experienced LDP, the liability for building a pool that meets the expected loads while remaining watertight falls on the builder.

CODES

While there is not currently a design code that specifically addresses concrete swimming pools, there is one in progress. American Concrete Institute (ACI) Technical Committee 322 is developing a *Concrete Pool and Watershape Code*, that will address pools directly. Their mission is to create a code for the LDP regarding all aspects of concrete design in pools. However, while the ACI 322 Code is in development, many design professionals use ACI 350 *Code Requirements for Environmental Engineering Concrete Structures* that addresses all concrete liquid-containing structures.

The ASA Pool and Recreation Committee has just published our 8th Position Paper, *Steel Reinforcement for Shotcreted Pools*. This paper identifies many of the issues encountered in the design of shotcreted pools. Though not a mandatory document, like the ACI 350 Code, it helps to establish a standard of practice for quality pool construction so that the designer, contractor, or owner can evaluate if their project meets current standards. The ACI 506 Shotcrete Committee has recently published ACI PRC 506.8-24 *Shotcrete Use in Pool Construction-Guide*. This new document is available online at ACI or ASA. It is a comprehensive guide covering many aspects of pool construction that are required make a quality pool shell that can last 50 to 100 years.

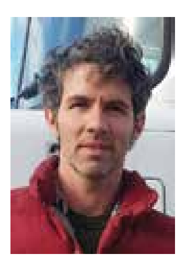
As members of the Shotcrete industry, we need to encourage the builders of pools to raise the bar. Shotcreters, pool builders, and professional designers need to become familiar with the resources mentioned above in order to create lasting shells made from concrete.

Shotcreters should be seeking ACI-certification, and pool shotcrete contractors should look to ASA for company qualification programs like *ASA Qualified Shotcrete Contractor – Pool*.

Owners, designers, and builders should all demand certification of shotcreters and qualification of your shotcrete contractors. This is a cycle that feeds itself. The more demand for shotcreter certification, the more incentive there is for shotcrete companies to seek certification of their key field staff. The more shotcrete companies that pursue company qualification and promote this level of peer review, the more likely pool builders will use their services.

We can all work together to raise awareness for better design, better construction, and better qualifications for the pool building team. Together, we can raise the bar in the pool industry and bring lasting value to millions of residential and commercial projects.

We can and should build pools that last not 10 to 20 years, but 50 to 100 years with a few changes in design and construction. It is time to raise the bar.



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

SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE

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

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VALME
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With four decades of experience and production facilities in both the United States and Italy, the Valme Group has become a prominent leader in the design and manufacturing of concrete distribution systems. Our unique strength is rooted in our extensive industry knowledge and manufacturing expertise, allowing us to develop products that perfectly meet our customers' needs.

We oversee all aspects of our product manufacturing processes, from product design and engineering to in-depth in-house manufacturing, which include the forging of couplings, casting of elbows, and heat treatment of pipes and reducers, while utilizing state-of-the-art equipment, such as automated laser cutting, welding, and robotic machining centers. All these manufacturing processes are controlled by our in-house proprietary chemistry and metallurgy lab.

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ASA Sustaining Corporate Members

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

REED Shotcrete Equipment
www.reedpumps.com

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www.cancrete.ca

Curtis Concrete Pumping
www.curtisconcretepumping.com

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

Dees-Hennessey Inc.
www.deeshenn.com

Coastal Gunite Construction Company
www.coastalgunite.com

Artisan Skateparks
www.artisanskateparks.com

Consolidated Shotcrete Inc.
www.consolidatedshotcrete.ca

Ocean Rock
www.oceanrockart.ca

Construction Forms
www.ConForms.com

Nationwide Shotcrete Inc
www.nationwideshotcrete.com

A & B Gunite
www.abpoolsub.com

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

MAPEI Underground Technology Team
www.utt-mapei.com

PULLMAN
www.pullman-services.com

Imerys
www.imerys.com

Buesing Corporation
www.buesingcorp.com

COST of Wisconsin Inc.
www.costofwisconsin.com

The Quikrete Companies
www.quikrete.com

Western Shotcrete Equipment
www.wseshotcrete.com

Prestige Gunite & Shotcrete Inc
www.prestigeconcrete.com

Baystate Shotcrete LLC
www.baystateshotcrete.com

CROM LLC
www.cromcorp.com

Kaaterskill Kahncrete
www.kahncrete.com

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

Master Builders
www.master-builders-solutions.com

William Emfinger Construction Inc.
William Emfinger Construction, Inc.
www.instagram.com/weskateparks

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

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

Higginbotham™
Insurance and Financial Services

Since 2018, the commercial insurance market in the United States has demonstrated persistent premium increases due to a hard insurance market.

WHAT IS A HARD INSURANCE MARKET?

A hard insurance market is a period of time in the insurance marketplace when the supply of insurance is decreased. Market hardening generally begins when insurance carriers take corrective actions to increase their profitability, such as implementing tighter underwriting guidelines, offering fewer coverage options and making their client base "healthy" by limiting new business writings and non-renewing current clients that are not profitable.

PAST HARD MARKETS

In the past four decades, the insurance industry has experienced three hard markets: 1985-1987, 2001-2004 and 2018-present. In 1985, a tort crisis arising from extensive liability lawsuits related to construction defect claims almost collapsed the U.S. insurance industry. In 2001, the tragic events of 9/11 triggered a hard insurance market.

Typically, hard markets are shorter in duration than soft markets. However, this has not been the case with the most recent hard market, which is expected to continue into 2025. Factors contributing to today's hard market include heightened vehicle prices, increased medical expenses, low investment yields, social inflation, and increased construction costs.

WHAT STRATEGIES CAN HELP IN A HARD MARKET?

With the current market conditions, carriers will continue to non-renew policies, increase deductibles, lower coverage limits and add limitations and exclusions. This means that now is the time to prepare and adjust strategies with your insurance advisor.

RENEWAL TIMELINE

In a hard market, waiting until the last minute to begin the renewal process can limit your options. Since carriers may require a loss control visit before offering a renewal quote, your insurance broker should begin working on your renewal at least 120 days prior to the renewal date. You should also meet with your broker to discuss renewal strategies, including ways to improve your organization's risk profile for carriers and underwriters.

LOOK OVER PAST CLAIMS

Review your company's loss runs and claims history with your insurance advisor. If your business has experienced frequent claims, you'll need to explain to underwriters what preventative measures you've taken to prevent similar claims in the future. If you've experienced a large claim, your broker will need to negotiate with underwriters to have it considered a "shock loss" and discounted from your overall loss ratio.

REVIEW RISK MANAGEMENT STRATEGIES WITH YOUR BROKER

To appear more attractive to underwriters, it's important for businesses to prove an effective, well-documented risk management program.

CHECK YOUR EXPERIENCE MODIFIERS

Make sure to ask your insurance advisor if they have confirmed paid losses and audited premiums on your workers' compensation experience modifier worksheet, since experience modifiers directly affect the cost of workers' compensation insurance.

EXPLORE ALTERNATIVE OPTIONS

Talk to your insurance broker about exploring options other than a traditional insurance plan, such as a captive program. When capacity shrinks in the insurance marketplace, a captive may be an attractive alternative for financing risk.

THE IMPORTANCE OF RISK MANAGEMENT

Insurance is just one piece of the puzzle when it comes to protecting your business; risk management is also essential. By taking actions to lower your exposure to risk, you're less likely to experience claims and hefty insurance rate increases. Examples of risk management strategies include:

SMALL CLAIMS

Frequent claims typically carry more weight than a single severe claim. In general, unless a claim is two to five times your deductible, it may be best to handle it out of pocket.

AUTOMOBILE SAFETY

Auto insurance claims are among the worst types of claims for insurance companies, so implementing strategies to monitor your fleet and drivers can have a positive impact on your auto insurance premiums. Your insurance advisor will be able to offer tailored risk management strategies for your recruitment process, driver qualifications, employee training, vehicle operation guidelines, and driver policies.

MASTER SERVICE AGREEMENTS (MSAS)

When working with contractors and vendors, MSAs are just as important as certificates of insurance (COIs). Even if the COI indicates your business is an additional insured, a contract like an MSA needs to be in place so your company has legal recourse in the event that the other party breaches the agreement. In addition to your lawyer, work with your insurance broker to make sure an MSA includes the proper hold-harmless and indemnification wording.

HOW CAN HIGGINBOTHAM HELP IN THE SHOTCRETE INDUSTRY? BY SAVING YOU MONEY.

The first thing that comes to mind Is auto insurance premiums: This is the number one concern for business owners in this ongoing hard insurance market, especially for those who have large fleets with extra heavy vehicles. We understand that it's affecting the profitability of the shotcrete industry due to the premium increases you've experienced, on the commercial auto line of business in particular.

There are many components utilized in the rating of a single commercial auto, including the gross weight of the vehicle, how far the vehicle is driven (radius), how many stops it makes in a day, five year loss history, and more — plus the rate filings available to the insurance company providing the coverage. These filings allow carriers to debit or credit their auto rates, and they can vary greatly from one carrier to the next. Any of these individual rating components can affect your auto rating and ultimately the premium you are being charged.

As insurance agents, it's our duty and responsibility to verify every single detail involved in the polices we sell our clients and prospective clients. More often than not, when reviewing prospective clients auto policies, we find errors which are producing higher rates and premiums for the insured.

To sum up, at Higginbotham we understand the critical nature of managing your business's risks, especially in today's hard insurance market. That's why we tailor our insurance programs to meet each client's unique needs and stand by those programs with our Day Two Services®, which provide proactive customer support through the life of each policy.

- **Risk Management:** Our team assesses your operations to pinpoint vulnerabilities and design a risk management program that supports your business goals, financial position, and risk tolerance.
- **Risk Technology:** We provide tools to proactively manage your exposures, access safety communications, analyze losses, and manage OSHA requirements.
- **Safety and Loss Control:** We help you implement safety measures, stay compliant, and enhance service efficiency from your insurance carrier.
- **Contract Review:** Our specialists review your contracts, MSAs, and agreements from a risk management and insurance perspective so you're covered for the liability you're assuming.
- **Claims Management:** Should you face a loss, our team will manage the claims process for you, advocating for your best interests every step of the way, so you can focus on resuming operations.

CONTACT INFORMATION:

Higginbotham Insurance & Financial Services

Jeannette Blanton
jblanton@higginbotham.net
972.776.6502

Renee Porter
rporter@higginbotham.net
972.776.6505

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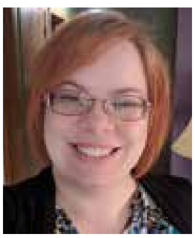
I'm Not a Shotcrete Expert—

But Here's How You Can Write Like One for *Shotcrete* Magazine

By Cara Baker, Managing Editor



Let me start with a confession: I'm not in the shotcrete industry — at least not directly. I don't spray concrete, design structures, or calculate compressive strengths for a living. I'm a writer and editor, someone who spends my days making sure other people's ideas come through clearly and professionally on the page. And guess what? You — yes, the engineers, contractors, and shotcreters out there — have some really great stories worth sharing in *Shotcrete* magazine. You just need to know how to tell them!

If you've got a cool project or technical insight you want the industry to know about, you don't need to be a professional writer. You just need to follow some clear steps to turn your expertise into a polished article.

STEP 1: START WITH WORD (AND A WORD COUNT)

First things first: Write your article in Microsoft Word. *Shotcrete* magazine prefers this format, and it keeps things simple for the editorial team. If you're writing a deep-dive feature article, aim for 1500 to 2000 words. If you're doing a project report — say, about that tricky tunnel rehab or innovative pool application — 800 to 1000 words is the sweet spot.

Don't worry about being flashy. Focus on explaining what you did, why it mattered, and how you overcame challenges. Think about what *you* would want to read in a trade magazine.

STEP 2: ILLUSTRATE YOUR STORY

Now comes the fun part — pictures, drawings, charts, and tables! You should include at least four visuals. They don't need to be fancy, just relevant and clear; maybe a site photo, a detail drawing, a material application chart — whatever helps tell the story better.

There are two helpful ways you can include these visuals in your submission:

1. **This is a must:** Email hi-resolution visuals (1MB+) as individual JPG, PNG, or PDF files. This helps us ensure your story has the best possible presentation with clear imagery and sizeable graphics. ***HOT TIP:*** *Reach out to me at cara.baker@shotcrete.org for alternatives if your attachments are too large to email all at once.*
2. **Useful, but not required:** Embed the visuals in the Word document itself as well, exactly where you want them to appear (use a caption and label like "Fig. 1"). While this helps to ensure your visuals get placed exactly where you want them, imagery placed within a Word document loses resolution and is much less likely to be of printable quality.

Reference list entry

American Shotcrete Association - American Shotcrete Association. (2025, April 1). American Shotcrete Association. https://shotcrete.org/

STEP 3: CAPTION AND CROSS-REFERENCE LIKE A PRO

Each image needs a caption — short and sweet, ideally 12 to 15 words or less. Think of it like a headline for the photo. And within the body of your article, make sure you point the reader to the illustration: Phrases like "As shown in Fig. 2…" are perfect. This kind of cross-referencing keeps things organized and professional.

STEP 4: NAIL THE TECHNICAL DETAILS

Technical accuracy is a big deal. Measurements should always appear first in U.S. customary units — like inches, feet, or pounds — followed immediately by the metric equivalent in parentheses. For example: 4 ft (1.219 m). Same goes for temperature — write it like this: 70°F (21°C).

If you refer to a code, standard, or research paper, list it in your properly formatted references section at the end of the article. If you're unsure how to cite references, there are multiple free citation generators online to make it easier, such as scribbr.com, where I created the reference above for Shotcrete.org using just the web url.

STEP 5: DON'T SKIP THE FINAL TOUCHES

Almost there! The final two things you'll need are:

- A short author biography (about 100 words). Just tell readers who you are as a professional in the industry.
- A headshot-style author photo — clear, professional, and at least 300 dpi in JPG or PNG format.

This helps humanize your article: People want to know there's a real person behind the words, not just a shotcrete nozzle or a clipboard.

So, there you have it — from someone who may not know a wet-mix from a dry-mix, but does know how to craft a clean, compelling article. If you're in the shotcrete world and have something to share, don't let the writing part hold you back. Follow these steps, be clear, be accurate, and be proud of what you've built, both in the field and on the page.

YOU KNOW SHOTCRETE

Now it's time to share it. Ready to tell your story?

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:

We are a little uncertain how to adjust our dry-mix shotcrete mixture using the new Type 1L (portland limestone cement). We have had several calls with ready-mix companies, and they do not have any experience with what we need. I have heard that 1L cement has a lower specific gravity than the old Type I/II product, and our mixture designs use weight. Should we change our mixture design? Old school, we always referenced 4:1 sand to cement by volume. Can you give me any advice on how adjust the weights of concrete materials we use in our dry-mix mixtures? ***This inquiry attached two mixture designs: DRY GUNITE with 3638 lb (1650 kg) of fine aggregate and 900 lb (408 kg) of Type 1L cement, and then DRY GUNITE - 20 with 2614 lb (1185 kg) of fine aggregate and 900 lb of Type 1L cement.***

ANSWER:

Type 1L is a new "blended" cement with up to 15% replacement of portland cement with finely ground limestone. Specific gravity varies depending on the percentage of replacement. The percentage depends on the cement manufacturer. However, the specific gravity doesn't really make any difference in concrete mixture designs since all ingredients are by weight even if just using the 'old school' 4:1. Your "Dry Gunite" mix is 4:1 by weight (as it should be). Your "Dry Gunite - 20" is just under 3:1 (very cement rich).

Type 1L cement introduces issues by replacing portland cement with limestone. We see extended set times, slower strength gains, and sometimes more chance of flash set. Thus, I recommend watching the set times closely, especially if you are shooting more than one lift in a wall. Strength gain being slower may be an issue if filling the pool for curing early or in cold weather. You should ask your design engineer about the required strength gain.

QUESTION:

I have reviewed your web site and it has some great references! The attached picture of a core shows the bottom portion with some voids but everything else looks great. What was the likely cause of the lower portion having issues but not the top? Also, would you know if the pool industry normally uses GPR or impact-echo as a standard to determine if shotcrete is good? I'm not sure what is the most popular method currently being used out there.

Core image

ANSWER:

As you likely found on our website, we have several pool position statements related to pool design and construction (**pools.shotcrete.org**). You can also search our Pool FAQs on that portal. You can use the keyword "cracking" in a

DISCLAIMER

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

search to get relevant past FAQs. Substantial cracking in shotcreted sections is usually a function of too little reinforcing steel, or inadequate curing, or both. You haven't mentioned the size, type, or orientation of the cracks. That information can help determine the root cause. Also, concrete 28-day compressive strength should be at least 4000 psi (28 MPa). The stronger the concrete the better able to handle tensile stresses that lead to cracking.

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

Regarding the testing issue, pool concrete is just concrete shotcreted in place. Thus, standard concrete non-destructive evaluation (NDE) methods apply. Ground penetrating radar (GPR) is a suitable method to establish the embedded reinforcing bar layout. Other NDE methods allow better evaluation of voids, large and small. In the International Concrete Repair Institute (ICRI) document *210.4R-2021 (PDF) - Guide for Nondestructive Evaluation Methods for Condition Assessment, Repair, and Performance Monitoring of Concrete Structures*, Table 7.3 states GPR is "limited to large voids". Impulse Response, Impact Echo, and Ultrasonic methods are good for all voids. The document also has a good overview of the different methods in Appendix A.

How do you evaluate if the concrete is good or bad? Small, infrequent voids may not be a structural problem. Frequent voids showing a lack of full encasement may be an issue. It's a matter of degree. A serviceable pool needs a proper design for all pool loading conditions, including temperature and shrinkage stresses, adequate concrete strength (4000 psi or greater), shotcrete placement with full consolidation (minimal voids), and proper curing. Major voids or substantial cracking at the back of the wall as shown in your core image may result from improper shotcrete placement by the shotcreter. You should always require your shotcrete contractor to use ACI-Certified Shotcreters for the pools they shoot for you.

QUESTION:

Could you please tell me what the ACI standards are for air to the nozzle and also if you know what the drop off would be for each hose attached?

ANSWER:

ACI 506-22 Guide to Shotcrete has recommendations for air supply of the two different processes. For dry-mix shotcrete the Guide says use between 600 and 750 CFM for 1.5 to 2 in. hose. For wet-mix shotcrete 200 to 400 CFM for the 1.5 to 2 in. hose. Longer air delivery lines may need to use the higher range.

QUESTION:

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

Efflorescence

ANSWER:

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

Acid will negate the alkalinity of the calcium hydroxide. You can use muriatic acid, but it may be quite strong. Acetic acid (vinegar) is usable and may be less aggressive toward the concrete stain.

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

INDUSTRY NEWS

IN MEMORIAM

ANTHONY (TONY) FEDERICO JR.
MAY 12, 1936 - MARCH 13, 2025

We have lost another great one from the Shotcrete Industry. Tony Federico was born and raised in the Boston Area. According to Tony, he attended Northeastern University, majoring in football and minoring in business. After a brief career in professional football, he joined the Perini Corporation. Eventually he was running work on the West Coast, where he met the founder of Superior Gunite. In 1966, he joined Superior Gunite and in the 1970s ran Superior Gunite as its president. Around 1974 Superior Gunite bought Johnson Western Gunite. In 1979, Tony bought out the owner of the combined Superior/Johnson Western Gunite.

Under Tony's leadership, Superior Gunite and Johnson Western Gunite transitioned from predominantly dry-mix shotcrete to wet-mix shotcrete. This was unique as most other dry-mix contractors could not adapt to the change and eventually went out of business. Also, under his leadership, shotcrete became accepted for structural and seismic applications. Contractors successfully used shotcrete to seismically upgrade almost all the older schools in Los Angeles and San Francisco. The first major structural wet-mix shotcrete seismic upgrade was in 1976 at the California State Capitol Building. Tony's long career includes far too many significant projects to list here.

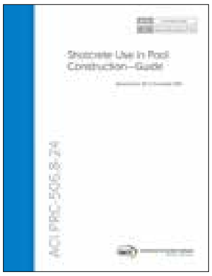
Besides his construction success, he was an accomplished golfer playing in some 150 Pro-Am tournaments. The most memorable was being paired with Tiger Woods on the Saturday of the Las Vegas Open in which Tiger got his first pro win that Sunday. This meeting started a lifelong relationship with Tiger Woods.

Tony's full obituary and well wishing options are available on the **Forest Lawn Obituaries website**.

MARIA JUENGER ELECTED PRESIDENT OF AMERICAN CONCRETE INSTITUTE

The American Concrete Institute (ACI) announces its 2025-2026 president, vice president, and four board members.

Maria Juenger has been elected to serve as president of the Institute for 2025-2026, and Matthew R. Sherman has been elected ACI vice president for a two-year term. Additionally, four members have been elected to serve on the ACI Board of Direction, each for three-year terms: Michael Ahern, Mary Beth Deisz Hueste, Xiomara Sapón-Roldán, and Kimberly Waggle Kramer.



ACI RELEASES ACI PRC-506.8-24 SHOTCRETE USE IN POOL CONSTRUCTION - GUIDE

This document is intended for use by owners and pool builders. It does not include specific design requirements. It does include recommendations for aspects of planning, design, and construction that are needed for quality shotcrete placement, with the goal of producing pools that have the long-term durability and serviceability owners should expect. With proper design, material selection, and construction, a shotcreted concrete pool should have a service life of 50 to 100 years or more. Available for purchase at **shotcrete.org/bookstore**!

ACPA ANNOUNCES NEW BOARD MEMBERS

LEWIS CENTER, OHIO – (April 11, 2025) The American Concrete Pumping Association (ACPA) is proud to announce the election of its new executive board. Selected at the ACPA Annual Meeting and Awards Presentation on Jan. 22 in Las Vegas, Nevada, during World of Concrete 2025, the board members were recently announced in the Spring issue of Concrete Pumping, the association's quarterly magazine.

The ACPA Executive Board plays a pivotal role in shaping the vision and direction of the association. The board is tasked with governance, strategic planning and ensuring adherence to the ACPA's mission of promoting safety, education and advancement within the concrete pumping industry. Through its oversight and leadership, the board guides initiatives that advocate for best practices, enhance professional standards and provide valuable resources to its members and the broader construction community. Their collective expertise ensures that the ACPA remains a trusted advocate and resource for the industry.

Elected to serve a one-year term, the 2025 ACPA Executive Board includes:

EXECUTIVE BOARD

- **President:** Nathan Germany—Tri-Way Concrete Pumping, Inc., Roanoke, Texas
- **Vice President:** Chris Pernicano—San Diego Concrete Pumping, Inc., Santee, California
- **Secretary:** Wayne Allen—DY Concrete Pumps, Inc., Alvarado, Texas
- **Treasurer:** Tyler Wood—McClure Concrete, Inc., Aurora, Colorado
- **Past President:** Gary Brown—R. L. McCoy, Inc., Indianapolis, Indiana

Also at the Jan. 22 meeting, the ACPA announced election results for the following board positions.

PUMP DIRECTORS

- Dennis Andrews—Andrews Equipment Company, Inc., Jessup, Maryland
- Clint Price—Brundage-Bone Concrete Pumping, Thornton, Colorado
- James Sederburg—AAA Concrete Pumping, LLC, Nixa, Missouri
- Scott Wilson—Concrete & Materials Placement, LLC, Pineville, North Carolina
- Tyler Wood—McClure Concrete, Inc., Aurora, Colorado

REGIONAL DIRECTORS

- **Region 1:** Lee Roy Thompson—Champion Concrete Pumping, Inc., Hauser, Idaho
- **Region 3:** Chris Avella—Modern Concrete Pumping Services, LLC, Stony Brook, New York
- **Region 5:** Carl Walker—Central Concrete Pumping, Fort Worth, Texas

DISTRIBUTOR DIRECTOR

- David Palomares—CreteSuite, Windermere, Florida

MANUFACTURING DIRECTORS

- Bill Dwyer—Putzmeister America, Inc., Sturtevant, Wisconsin
- Scott Roisum—Schwing America, Inc., White Bear, Minnesota

DENNY DOBBS SKATE PARK WINS AWARD

District 2 Commissioner Demond Mason displays the award received on behalf of the skate park at Denny Dobbs Park. Photo courtesy of Rockdalenewtoncitizen.com

COVINGTON — The skate park at Denny Dobbs Park was recently recognized with an Outstanding Achievement Award by the Georgia Chapter of the American Concrete Institute. The 1.5-acre skate park was designed by Gridline Skateparks with concrete by Thomas Concrete.

Phase 1 of the park opened in July 2021 with a ramp and handrails. The second phase was approved by the Board of Commissioners in April 2022 and included a drop pool and more street course elements connected to the first phase.

The project was funded by the 2017 Special Purpose Local Option Sales Tax approved by voters under the category of District 2 improvements. Phase 1 was funded by $189,875 of SPLOST dollars. The BOC then approved another $750,000 of unallocated collections for Phase 2.

MECBO AMERICA INTRODUCES TRACKED CONCRETE PUMPS FOR VERSATILITY

ANNISTON, Ala. (April 15, 2025) — Mecbo America, a division of Blastcrete Equipment LLC formed through a distribution agreement with Mecbo Srl, announces the launch of two products to the American market: the CARTRACK P6 and P7. These innovative concrete pumps pair a powerful electric or diesel pump with a crawler undercarriage to maximize mobility and maneuverability on the jobsite.

The 150-horsepower P6 and 180-horsepower P7 place concrete at volumes of 104 to 144 cubic yards per hour, making them an ideal solution for a wide variety of applications including continuous flight augering, drilling, tunneling and commercial construction. A simple toggle radio remote control provides smooth handling and efficient operation, eliminating the issues seen when touchscreens interact with concrete covered gloves.

"Track-mounted pumps are not new to this market, but what we've done is add Mecbo's patented PULSAR pump, which offers more power and lower maintenance demands," said Blastcrete co-CEO Scott Knighton.

Mecbo's patented PULSAR pump system features a long stroke, allowing the pump to push more concrete with less movement. That translates to greater output with less wear and tear on the pump. In addition, the smooth pump performance virtually eliminates pressure fluctuation even when pumping long distances.

"With more than 75 years in the concrete pumping business, our team understands what customers want; and we work hard to give the best functionality to ensure easy and maintenance-free operation," Knighton continued. "They don't need bells and whistles, they need a simple, rugged, efficient system."

All Mecbo America products are serviced by trained and experienced service technicians and application specialists at Blastcrete Equipment LLC. A full array of common wear parts are housed at the Blastcrete facility in Anniston, Alabama, for fast and convenient shipping anywhere in the Americas, drastically reducing downtime. When working with Mecbo America, operators benefit from reduced maintenance thanks to Mecbo's patented pump system and Blastcrete's dedicated customer support and robust spare parts program.

Both the CARTRACK P6 and P7 feature two hatches to make routine maintenance easier. The CARTRACK series can come with an optional water pump, compressor, hopper screen vibrator for harsh mixes, radio remote control and pipelines and accessories for specialized projects.

Mecbo America offers the P6 and P7 with several customization options. Both come standard with a crawler undercarriage but can also be installed on wheels or trucks. The diesel models have a soundproofing option for work at times and in areas where noise reduction is important. Safety was prioritized in designing the P6 and P7, as both feature a walkway with steps, handrails and lights.

NORMET UNVEILS NEW SPRAYING EQUIPMENT

At the World Tunnelling Congress 2025 in Stockholm, Sweden, Normet announced the launch of a new sprayer for large tunnel profiles, the Spraymec 9100, along with a new spray boom update for the established spraying manipulator Minimec, allowing for an extended spraying reach.

Spraymec 9100 – a powerful sprayer for large-scale tunnel projects

The Spraymec 9100 is a purpose-built tunnelling sprayer designed for high-output sprayed concrete applications in large-profile tunnels and caverns. It combines the most advanced features from our entire sprayer lineup—including a best-in-class low-pulsation concrete pump, onboard compressor, and a 1,500-liter accelerator tank—into one powerful machine.

Offering exceptional productivity, the Spraymec 9100 delivers an extended spraying range with a maximum vertical reach of 19.5 meters and a spraying width of up to 28 meters. To ease the spraying process, our innovative SmartSpray boom control system comes as standard, and with the optional Remote Driving System, the machine can be relocated conveniently from ground level.

Minimec – proven spraying manipulator with an extended reach

The Minimec, a proven spraying manipulator designed for maximum efficiency and ease of use in confined underground spaces, is now available with an extended boom with a reach of 8.5 m, in addition to the standard boom with 7.5 m reach. It delivers enhanced manoeuvrability and precise spraying performance. Its compact design and advanced control system ensure smooth and accurate spraying, even in the most demanding conditions. Built for reliability and durability, the Minimec is the ideal solution for boosting productivity and safety in underground construction projects.

Continuous development to meet the unique customer demands of tunnelling

"The World Tunnelling Congress is a perfect platform to launch these expansions to both ends of our sprayer offering. The Minimec update sets a benchmark for efficiency and precision in confined spaces, while the Spraymec 9100 delivers powerful, high-quality spraying in demanding large-scale tunnelling projects," states Toni Huttunen, Product Line Director of Sprayed Concrete at Normet.

With the launch of the Spraymec 9100 and longer-reach Minimec, Normet continues to expand its tunnelling equipment offering, demonstrating a strong commitment to serving customers and designing solutions that meet the evolving needs of a broader spectrum of tunnelling projects. These advancements underscore Normet's continuous development to address the unique challenges and demands of tunnelling customers globally.

PUTZMEISTER UNVEILS NEW SHOTCRETE EQUIPMENT WETKRET 3 AND UNDERGROUND CONCRETE PLANT BATCHKRET 20 AT BAUMA 2016

Leading underground mining shotcrete specialist Putzmeister is adding new products to its range of underground construction equipment at this year's world-leading construction machinery fair, bauma in Germany.

The company is extending its portfolio with the launch of the new top-of-the-range mechanised shotcrete spraying machine for small sections, WETKRET 3, and a compact shotcrete batching plant, BATCHKRET 20, specially designed for underground mines.

WETKRET 3 concrete spraying unit for small tunnel sections

WETKRET 3 is ideal for smaller tunnel sections. Perfect for the rugged, uneven terrain of the mine, the equipment is mounted on a compact rubber-coated crawler chassis to facilitate manoeuvring, even in jagged worksites.

It features a telescopic spraying arm with a vertical reach of 9m and a horizontal reach of 7m, which can be deployed in a minimum section of 2.5m. It can run both on diesel and on electricity, boosting on-site mobility away from the mains.

The unit has hydraulically-operated support legs with an optional tilting system of +/-30° that adds to its stability and safety profile on-site. For upward slopes, there is an optional rear stabiliser blade; and an optional electronically-operated 50m winch cable with a 6.803kg tractive force for downward slopes.

The engine, support legs, tilting system and the blade stabiliser can also be operated in electric or diesel mode. A proportional remote control can be used either by cable or.... **Click or scan the QR Code for the rest of the story!**

NEW ASA MEMBERS

american shotcrete association asa

SUSTAINING CORPORATE MEMBERS

William Emfinger Construction Inc.
Lafayette, Louisiana
Primary Contact: William Emfinger
weskateparks@gmail.com

INDIVIDUAL MEMBERS

Wayne Warburton
Aldea Services
Lawrenceville, Georgia

Mark Herdade
Bluewater Pools
Catoosa, Oklahoma

CORPORATE MEMBERS

T & A Rock Works Inc.
Kelowna, British Columbia, Canada
www.tarockworks.com
Primary Contact: Shay Casavant
shay@tarockworks.com

SWATcrete
Val-d'Or, Quebec, Canada
www.swatcrete.com/en/
Primary Contact: Eve-Lyne Sylvestre
esylvestre@fournier-fils.com

AAA Shotcrete Inc.
Granada Hills, California
www.aaashotcrete.com
Primary Contact: Nadia Alexandre
nadiashotcrete@gmail.com

South Industries
Menan, Idaho
www.southindustries.com
Primary Contact: Jonathan South
jon@southindustries.com

Wurster Engineering & Construction Inc.
Greenville, South Carolina
www.wursterinc.com
Primary Contact: Clyde Switzer
clyde.switzer@wursterinc.com

The Anatomy of an Award-Winning Project

By LaTosha Holden

What separates an OUTSTANDING shotcrete project from the rest? At the American Shotcrete Association (ASA), our Outstanding Shotcrete Project Awards Program recognizes the projects that embody innovation, technical excellence, sustainability, and creativity, with shotcrete placement at the heart of their success. And, like a well-built structure, a winning submission has a distinct anatomy — key components that work together to tell a complete, compelling story. Here's how to ensure your project has all the right parts in place to stand out from the competition.

THE BASICS

Every strong submission starts with a foundation of clear, complete project details. Here are some things to make sure you have or consider before you start your submission:

- Project name and location, which help identify your project.
- Determine which category best suits your project, and keep in mind that the judges reserve the right to move the project to a different category.
- Include all the companies that worked on your project, noting ASA Sustaining or Corporate Membership status where able.
- Note that the project description does NOT include company names (to keep the projects anonymous for the judges' review).
- Submit the full name of the ACI-Certified Shotcreter(s) that worked on your project.

This "skeleton" of essential facts supports everything else you will build into your application. A complete list of questions can be found online at **www.shotcrete.org/awards**, under the Submission Resources button.

THE PROJECT DETAILS

The true heart of a winning project lies in its **story**: Why the project mattered, the starring role shotcrete placement played, and what made this project different. *Your project description should bring the judges into your world.* A winning submission must also showcase the expertise and hard data behind its success, conveying the magnitude of your work. These technical details flesh out your story, demonstrating not only creativity but also technical excellence and professional execution. Each detail becomes

FINAL CHECKLIST FOR SUBMISSION

Before sending in your application, make sure you have:

- Answered all required questions fully
- Avoided using company names or individuals in project or image descriptions
- Provided at least six photos, with descriptions, to show the full project lifecycle
- Ensured that all U.S./Canadian projects are completed by an ACI-certified shotcreter (international projects that do not have a certified shotcreter may only be entered under the International category)
- Included all necessary technical and contact information

Submission Deadline: 5:00 PM EDT | October 1, 2025

Eligible projects must be completed between:
January 1, 2023 – September 1, 2025

Categories:

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

Questions?
Tosha Holden
Member Engagement and Marketing Manager
Tosha.Holden@Shotcrete.org | Call/Text: 248.983.1712

2024 ASA OUTSTANDING SHOTCRETE PROJECT AWARD WINNERS: ARE YOU NEXT?

part of the bigger picture, so avoid generic language; be specific and show the unique advantage(s) your team brought to the project.

Remember, ASA judges rely entirely on what you submit. A strong, detailed description ensures they fully appreciate the challenges you faced and the solutions you delivered with the power of shotcrete placement.

Now let's move on to the eyes of your submission: The photos. Your photos allow the judges to see how your project came to life, to visually walk through your project. We suggest that you submit at least six clear, detailed photos. This award values the process as well as the finished product, so choose images that:

- Show the project *from beginning to end*.
- Capture action shots during shotcrete application.
- Highlight technical or architectural complexity.
- Present images that show the completed work.
- Are high resolution; at least 1MB in size are preferred.

TIE IT ALL TOGETHER

Now that you have all the significant parts of the project entered, let's bring it all together as a living, breathing submission. Like the anatomy of most living organisms, every individual part of your submission must work together to become a winning one. Before you submit, make sure your submission includes:

- Strong details to create the framework.
- A compelling story to pump life into the project.
- Clear images that offer a vital perspective.
- Sharp technical data which proves precision and expertise.

Without each of these elements, a submission can feel incomplete. But when all the pieces fit, *your project comes alive for the judges*, making it easy for them to recognize and reward your outstanding work.

Now: Let's submit your project and let your achievements inspire the future of shotcrete construction!

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