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A quarterly publication of the American Shotcrete Association

VOLUME 20, NUMBER 1 • WINTER 2018

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Volume 20, Number 1 • Winter 2018

FEATURES

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

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

DEPARTMENTS

On the cover: Revolution Gunite crew
Photo courtesy of Ryan Oakes

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Step Up to the Front Row

By Scott Rand

As I look forward to attending the 20th anniversary celebration at ASA's First Shotcrete Convention and Technology Conference in Napa, CA, March 11-13, 2018, I am reminded that I am coming to the end of my 1-year term as your President. It is a responsibility that I feel very fortunate to have experienced and I would challenge those who have a passionate interest in our shotcrete industry to either become involved in our Association or, if you are already involved, to pursue a committee or Board-level commitment.

Our association owes a debt of gratitude to so many unselfish people who have contributed their time and expertise during the past year and during the preceding 20 years of ASA's existence. Any organization is only as strong as its leadership and ASA has been blessed with some great leaders over the years, most of whom have proven themselves in our industry as contractors, consultants, materials manufacturers, or equipment suppliers. Many of today's shotcrete industry leaders work tirelessly as members of the ASA Board and Executive Committee. Others volunteer their time as committee chairs or participate on the many task groups that that are so critical to the success of the American Shotcrete Association.

It is difficult to affect change while sitting in the back row. Those aforementioned volunteers understand this, and their time, effort, and contributions have not gone unnoticed. I have had the pleasure to serve on this year's Executive Committee with some hard working and talented people (Burkert, Drakeley, Hanskat, Poole, and Zhang). Working together, this leadership group has developed and driven a strategic plan that will increase the acceptance of the shotcrete process as a concrete placement method and improve and enhance the value of an ASA membership.

As I previously stated, however, it is difficult to affect change while sitting in the back row. Among the many members who pay their annual membership fee, participate in our spring and fall meetings, and attend our annual awards banquet, we need more to step up to the front row and take a leadership role within ASA. Some of ASA's committee chairs and Board members have been active in their role since the first year of our association's existence, and expecting these individuals to continue to carry the load is unrealistic. It is now time for those individuals to pass the torch on to the next generation of shotcrete industry leaders. ASA needs the active participation of these new leaders and the new ideas that they bring with them.

Our ability as an Association to afford the benefit of a full-time Executive Director has definitely been a game changer. Charles Hanskat has been the ultimate ambassador for our Association and due to his efforts, we have had a stronger outreach program over the past year than ever before. Either through formal presentations, lunch-and-learns, webinars, or interaction through industry committee involvement, Charles has covered more ground than what was previously possible.

ACI Nozzleman Certification participation was higher in 2017 than any other previous year and the completion of so many certification sessions would never have been possible without the administrative support provided by Alice McComas. Alice worked very closely with the ASA membership and our roster of ASA examiners to complete the record number of ACI Nozzleman Certifications.

I would also like to acknowledge those who headed to Farmington Hills, MI, early last spring prior to The ACI Concrete Convention and Exposition to attend our 1-day Strategic Planning session. The end result was a renewed commitment to our annual objectives and a refined vision heading into the next few years. The work on our Underground Presentation was completed and delivered via webcast for the SME. Our Safety Presentation was reformatted and will be available to the market shortly. Our Shotcrete Inspector's Education program has been delivered to several Departments of Transportation with tremendous feedback. Our Contractor Qualification program was finalized recently thanks to a dedicated few and will be unveiled at our upcoming spring meeting. Our many accomplishments are written about often in this magazine and each and every one of them should be celebrated.

Heading into our 20th year, I was asked to write an article about our Association's history. I have been involved since the early days of ASA, and it has proved to be a valuable personal experience. It was not only a pleasant reminder of all the people who have passed through our doors over the years, but also a summary of the many achievements that the Association has realized. Additionally, it reminded me that the earliest members of our Association came together, setting aside their personal and professional agendas for the benefit of the industry. That spirit is truly what gave this Association its initial momentum and that same sentiment is required today. If we are to continue to accomplish our strategic objectives and be relevant 20 years into the future, we must continue to be diligent about the mindset of wearing one collective logo at our Association meetings.

One of the objectives that came out of our Farmington Hills' Strategic Planning session was to break with our World of Concrete tradition and host ASA's First Shotcrete Convention and Technology Conference—including our annual Awards Banquet—in California, March 11-13. It should provide an opportune occasion to mix pleasure and business in the company of our industry's leaders. Mark your calendar and come take a seat at our table in Napa!

ASA Technical Committee

By Lihe (John) Zhang

The ASA Technical Committee was established in 2015 to "oversee the technical activities of ASA, including the review and evaluation of technical presentations, publications, handouts, etc., and the appraisal of research projects under consideration for ASA sponsorship." Committee members have been actively working on publication reviews, technical inquiries, presentations, and many other activities.

Since 2015, ASA has provided funding support for a research project evaluating the durability of shotcrete-placed versus poured concrete. Research was completed and several papers have been published in various journals and conference proceedings. Details of this research project can be found in Reference 1.

...the Technical Committee has proposed several research projects and two of them have been approved and funded by ASA

In ASA's Strategic Plan, research is one of the main goals for the Technical Committee. Fulfilling this goal, the Technical Committee has proposed several research projects and two of them have been approved and funded by ASA.

The first shotcrete research project underway, funded by ASA, is the comparison of the shotcrete process with a low-velocity sprayed mortar system. This research project studies the in-place properties of materials placed by the low-velocity spray system that are often promoted as providing similar quality concrete as the shotcrete process. Several types of low-velocity spray equipment including the plaster gun are used in the repair and rehabilitation industry. Unfortunately, some owners and specifiers in the repair industry have confused low-velocity sprayed mortar as equivalent to shotcrete, essentially only because it applies the mortar by pneumatic projection. It is important for ASA to conduct proper research and identify and evaluate this equipment, as well as the application process. ASA is sponsoring this research project with principal investigator Marc Jolin conducting the work in the Shotcrete Laboratory at the Department of Civil Engineering of Laval University, Quebec City, QC, Canada.

Another ASA-funded research project is related to the air content of shotcrete. During the shotcrete process, the air content of the in-place (as shot) concrete can be significantly less than the as-batched air content. We have found in past studies that in-place air content will be below 5 to 6% regardless of how high the as-batched air content may be. However, current test methods for field measurement of air content only evaluate the total air content—that is, the combination of the entrained air for freezing-and-thawing durability and entrapped air. A recently developed concrete air content field test, called the Super Air Meter, will be used to evaluate the distribution of entrained air and entrapped air during concrete mixing and after shooting. If the Super Air Meter is able to reliably determine the percentage of the entrained air content and entrapped air content, this could be a valuable field test to establish that shotcrete provides good freezing-and-thawing durability of in-place concrete, despite losing much entrapped air through high-velocity impact.

Shotcrete is seeing increased use in a wide variety of concrete applications, including structural concrete, swimming pools, foundations, retaining walls, concrete repair and rehabilitation, slope stabilization, and ground support for tunnels and mines. Contractors, equipment and material suppliers, engineers, and architects will need to work together to produce quality shotcrete structures. Research on shotcrete materials, application processes, field and lab testing, and other aspects are needed. ASA has committed to sponsoring more research projects so that we may prove to the industry the quality, durability, and serviceability of shotcrete. If you have a research need or know of a research facility interested in shotcrete-related projects, please contact ASA.

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1. Zhang, L.; Morgan, D.; and Mindess, S., "Comparative Evaluation of Transport Properties of Shotcrete Compared to Cast-in-Place Concrete," *ACI Materials Journal*, V. 113, No. 3, May-June 2016, pp. 373-384.

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2017—A "Vintage" Year for ASA

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

As we enter our 20th anniversary year, we can look back proudly at how far we've come since our inception in 1998. The Fall 2017 *Shotcrete* magazine included a wide variety of articles detailing the history of ASA and the century-long history of our industry. As we enter 2018, using the retrospect of our past successes (and failures), we can also see more clearly where we're heading as an Association and becoming a more vital part of the concrete construction industry.

So, let's look back at our "vintage" 2017.

WORLD OF CONCRETE—OUTSTANDING AWARDS BANQUET

In January, ASA was once again a co-sponsor of World of Concrete (WOC). We also held our annual Outstanding Shotcrete Project Awards dinner on the Tuesday evening of WOC week, with a fabulous reception and dinner at the upscale Vdara hotel. We presented a full-day Shotcrete Nozzleman Education class and then conducted an ACI Shotcrete Nozzleman certification in Henderson, NV, with HydroArch hosting the session.

SPRING STRATEGIC PLAN REFRESH AND COMMITTEE MEETINGS

On March 24, a task group of ASA leadership gathered at ACI's headquarters building in Farmington Hills, MI, to review and revise our ASA Strategic Plan. Led by President Scott Rand, we took a detailed look at what our Association had accomplished from the initial plan. We then identified and prioritized goals and tasks for our standing committees, Board, and staff.

The updated strategic plan was shared with our committees, who met the next day at ACI's offices. The committee meetings went well, and there was a distinct sense of excitement when we explored the plan and looked to where it could take us in the future. We also decided to investigate holding our first "Shotcrete Convention and Technical Conference." Task groups were assigned to investigate venues, schedules, funding, and marketing.

Many of our members went on to attend the The ACI Concrete Convention and Exposition, held in downtown Detroit, MI, immediately after our meetings. ASA members are heavily involved in ACI Committee 506, Shotcreting, as well as certification committees C660, Shotcrete Nozzleman, and C601-I, Shotcrete Inspector.

ASA SHOTCRETE INSPECTOR EDUCATION PROGRAM

Between our Spring and Fall Committee meetings, the Board reviewed and approved the final version of the ASA Shotcrete Inspector full-day Education Seminar. Our program covers critical elements of shotcrete placement that on-site inspectors must know to properly evaluate and sign-off on acceptance documents, including an overview on materials, placement techniques, finishing, curing, testing, equipment, and safety as it relates to the building official or inspector.

In 2017, we presented the full-day Inspector Education to over 175 attendees from three state departments of transportation (DOTs) and a testing laboratory. Attendees included top state-level materials engineers, structures group, construction, and maintenance. Feedback from the group was highly positive, and all commented it was a great resource to fill the void that existed between general concrete knowledge and what is required for quality shotcrete placement. As we enter 2018, we're coordinating with two other state DOTs to present the Shotcrete Inspector program. We're also looking at how to best reach the shotcrete inspectors outside the DOTs, and considering regional seminars to attract a number of firms in a geographic area.

ASA/ACI NOZZLEMAN CERTIFICATION

Whew, 2017 was a very busy year for shotcrete nozzleman certification. We conducted 78 sessions, with 230 new certifications, 77 nozzlemen-in-training (NIT), 139 recertifications, and 36 retests. This totaled 482 overall and was a 33% increase over our previous high year of 2015. Our sessions were spread all around the United States and Canada, and even included a certification in Sydney, Australia, in cooperation with the Concrete Pumping Association of Australia. Looking at 2018, we have quoted sessions again in Australia, and—new this year—Mexico. More than ever, ASA is looked to as THE ACI sponsoring group for shotcrete nozzleman certification. Kudos to Alice McComas, who is our program coordinator for the nozzleman sessions. Her tireless efforts and attention to detail are unmatched.

ASA 20TH ANNIVERSARY EVENT AND SHOTCRETE CONFERENCE

At the Spring Committee meetings, the ASA Board decided to celebrate our 20th anniversary in style. Thus was born ASA's first full Shotcrete Convention and Technical Confer-

ence, to be held in Napa, CA, March 11-13, 2018. The planning has involved many of our officers and members, who have helped provide the overview of the event. However, there's a lot of work done behind the scenes. We've worked hard to: get the Convention and Awards dinner venues booked; solicit and approve speakers; set fees and budgets; identify the variety of events offered; develop marketing strategies and resources; solicit sponsors; coordinate exhibits; plan the awards dinner at a separate facility; coordinate transportation for the dinner; produce a web page for accepting registrations; coordinate reminders to encourage registrations; and more.

It's been a lot of additional work, often accomplishing tasks we haven't done before that always take longer than one expects, but we see the light at the end of the tunnel. Despite some worry (well, actually lots of worry) and some sleepless nights, we are confident this 20th Anniversary event will be a great opportunity for all our attendees. Hopefully we find it a valuable networking and outreach event, and consider other conventions in the future.

ASA CONTRACTOR QUALIFICATION PROGRAM

You'll find an article by Past President and Board member Marcus von der Hofen about the Contractor Qualification Program in this issue. We've finalized the details in 2017 and early 2018, and look forward to the rollout at our Napa event. It's clear that an ACI Certified Nozzleman alone does not assure quality shotcrete placement, and that quality shotcrete depends on the proper materials, equipment, trained crew, and shotcrete knowledge for a consistently quality shotcrete product.

FALL ASA COMMITTEE MEETINGS

Our ASA committees and Board met on Saturday, October 14, before The ACI Concrete Convention and Exposition at the Disneyland Hotel and Conference Center. We had good attendance in the Land of Mickey, and saw the finalization of our new 1-hour seminar on underground shotcrete. This presentation helps to explain ACI 506.5R-09, "Guide to Specifying Underground Shotcrete," to engineers and specifiers. It is offered free of charge to specifying groups upon request.

ASA 2017 MEMBERSHIP

This year, ASA reached a record number of members. ASA Corporate membership increased 6% to 239 members. Individual memberships rose 9% to 59, and nozzleman membership rose 10% to 241. Public Authority members rose by 36% to 19. These are reasonable growth numbers,

and are representative of the increase of shotcrete placement in the concrete world.

OUTREACH

One of my primary responsibilities is "spreading the word" about shotcrete. This year, we saw our outreach and support of revisions to codes and standard increase. We are working with ACI Committees 318, 301, 562, and 563 to directly incorporate shotcrete coverage in their documents. This is an important first step because the International Building Code, as well as countries around the world, use these ACI standards in their codes. We are working with the International Concrete Repair Institute (ICRI) to get revised coverage of shotcrete in their repair standards. We actively participate in ASTM and work to keep the seven ASTM standards specific to shotcrete up-to-date and relevant. We are active with the American Railroad Engineers and Right-of-way Association (AREMA) to get appropriate coverage of shotcrete for new construction and repair in their "Manual of Railway Engineering." We are also active members of ACI's Strategic Development Council (SDC) and the industry-specific Concrete and Masonry-Related Associations (CAMRA).

As mentioned before, we've presented several day-long seminars to DOTs and engineers. Additionally, we've presented talks to several ACI chapters in the United States and Canada. At WOC, two of our members presented a 90-minute talk on shotcrete, and one of our nozzleman examiners presented the first technical session on shotcrete in Spanish. We presented a 2-hour seminar on architectural shotcrete at ConAg/ConExpo 2017. A half-day seminar was presented to the ACI Student Chapter in Quebec, QC, Canada, and an hour-long introduction to shotcrete at Colorado State University, Fort Collins, CO. We also presented a shotcrete session to the annual PCA Professor's Workshop, a week-long event held in Skokie, IL, every summer.

We exhibited at WOC in Las Vegas, NV (January), Railway Interchange 2017 in Indianapolis, IN (September), and the International Pool, Spa and Patio show in Orlando, FL (November).

WRAP-UP

We're fortunate to have a great team to help run ASA on a day-to-day basis. This year, with the increased volume of certifications, programs, and events, we added a part-time position in the office and brought Beth Hinman on board. She jumped into her job feet first, and I think she's found ASA, and the wealth of things we do with our small team, challenging, yet exciting. Alice McComas' attention to detail, knowledge of everything we do at ASA, and willingness to accept and accomplish any task laid before her is astonishing. And she always does it with a smile! ACI support staff constantly help with our graphics, magazine development, website, accounting, and shipping through the ACI association management company, AOE. Alice, Beth, and I are the only fully-assigned staff, and I can assure you we never run out of things that need to get done on a given day!

Overall, we had a tremendously busy year in 2017. It was a year with many milestones. However, we look forward to 2018 and beyond to move the visibility and acceptance of shotcrete even higher. We certainly couldn't have achieved this level of progress without the diligent efforts of our Executive Committee led by President Scott Rand, our Committee Chairs, Committee Members, and Task Group Members. My sincere thanks to everyone who's been actively involved in moving ASA and our shotcrete industry to new heights.

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Responding to an OSHA Inspection

By Richard D. Alaniz

Whether an OSHA inspection of your workplace or construction site is triggered by a workplace injury, a formal complaint, a programmed wall-to-wall inspection, or just a spot decision while OSHA happens to drive by your construction site, being prepared beforehand will help limit exposure and help defend against any citations that may be issued. A very basic first step is to review and update as necessary the written safety plan for your facility or project. Such plans have been long mandated in some states, and are clearly a necessity in today's workplace, no matter the industry. In conjunction with updating the plan, it is important to develop a protocol for responding to a potential OSHA inspection. Make sure that your receptionist, front office, or construction site office knows who to contact when that OSHA Compliance Officer appears. If you do not have a Safety Director, designate a specific manager(s) to take the lead and make sure that they know exactly how you expect the inspection to proceed from the company's perspective. Be sure to confirm that OSHA 300 logs are up to date and posted as required. They will be reviewed as part of any inspection. Likewise, have Safety Committee minutes organized and readily available for review as well. If the inspection is in response to a recent workplace accident, you should also have the incident investigation notes and related material readily available.

WARRANT OR WARRANTLESS INSPECTION

Since at least 1978, the U.S. Supreme Court has held that an employer may require OSHA, or its state counterpart, to obtain a warrant to conduct an inspection of an employer's premises.[1] Whether to insist upon a warrant is a significant decision that has, as one might expect, serious pros and cons. Among the more significant pros is the possibility of limiting the scope of the inspection and possible dismissal of citations unrelated to the specifics of the warrant. A frequently cited con is the potential that an irritated Compliance Officer, forced to seek a warrant, will strive even more to find violations. While such conduct is clearly contrary to OSHA's inspection procedures, human nature may prevail. Unless unique circumstances are present, most employers do not insist upon a warrant and seek to be as cooperative as possible. Maintaining a cordial relationship with OSHA is always preferable. You and the Compliance Officer share the same goal: a safe workplace for all employees.

Have your response checklist ready before you get hit with an OSHA inspection!

CONTROLLING THE WALKAROUND

After reviewing your OSHA 300 logs, the Compliance Officer will normally begin the tour of your facility or construction site. An employee representative is generally requested to participate. Compliance Officers are permitted to ask questions of both employees and supervisors/managers as they inspect your facility or construction site. Some employers, in hopes of avoiding an inadvertent but unsafe act by an employee that is observed by the OSHA representative, sometimes require all work operations to cease. It has become common practice for some construction contractors. This is an option you may want to consider.

Your designated management representative should carefully note all comments and questions from the Compliance Officer during the walkaround. You may have more than one management representative participating if you so choose, and many employers do so, especially on construction sites involving several employers. If any photographs or video are taken, your management representative should take the same photographs or video. They should also exercise as much control as possible regarding the scope of the inspection without creating a confrontation. Unless it is a scheduled wall-to-wall inspection, it should be an inspection of limited scope focusing on the equipment or area that prompted the complaint or the accident that caused the visit. Permitting the Compliance Officer to have unrestricted access to inspect all work-related areas and observe uninvolved equipment merely increases the potential for finding violations.

CONDUCTING INTERVIEWS

As part of any OSHA inspection, the Compliance Officer has the right to, and generally will, interview both employees and management representatives. Employers have a right to be present or have their attorney present at any management interviews. There is no right to be present at employee interviews. However, employees are not obligated to participate in any interviews and the employer can so inform them. While OSHA could seek a subpoena to compel employee participation, they generally do not go to that next step unless a serious injury, death, or other significant issue is involved. It is important that any manager or supervisor interviewed be truthful, but not volunteer information unrelated to the matter at issue. They should respond to questions as succinctly as possible. They should also request a copy of any statement that they are asked to acknowledge or sign. You should also ask any employees interviewed to request a copy of any statement they provide to the Compliance Officer.

MEDICAL MARIJUANA, WORKPLACE INJURIES, OSHA, AND POSITIVE DRUG TESTS

A potential new concern is that in a routine OSHA inspection, your drug testing policy may become an issue. Last year, OSHA, in comments regarding new reporting requirements, suggested that employers are prohibited from enforcing a blanket policy that requires employees to submit to drug testing after an accident because the policy may discourage employees from reporting injuries.[2] Currently, OSHA does not permit employers to have a policy requiring drug tests after every accident unless the employer is required to drug test employees due to some other federal or state law (such as regulations for drivers from the Department of Transportation). It does not appear that the rule is being enforced. Additionally, in June 2017, the Department of Labor issued a notice of proposed rulemaking to revise, reconsider, or remove portions of the rule. Therefore, the Trump administration may eventually revise OSHA's current policies forbidding employers from conducting post-accident drug tests anytime there is an accident.

On a related note, employers should be aware that four states (Connecticut, Massachusetts, Maine, and Rhode Island) have found that an employer could not fire or discipline an employee for a positive drug test for marijuana when the employee uses medical marijuana and the state prohibits discrimination based on this medical marijuana use. This is a significant change that will affect many workplaces. It is likely that more states will adopt this or similar policies. If there is a workplace accident in these states (or others, as the policy becomes more widespread), then OSHA and state law may prohibit a blanket policy of drug testing after an accident, or may prevent an employer from concluding that an employee was impaired during the accident, even if they have a positive drug test.

If there is an OSHA investigation, then employers may be liable for accidents caused by employees that failed drug tests because they use medical marijuana off-duty. Currently, drug tests for marijuana cannot gauge whether an employee was under the influence of marijuana at work because marijuana can stay in someone's system for days or even weeks. Employers that conduct drug tests after an accident should be aware that unless the Obama-era rule is rescinded, OSHA might determine that the drug testing is retaliatory if the employer has a blanket drug testing policy and are not required to drug test by federal or other law.

SILICA RULE

Of at least equal concern, at least to certain employers, is the fact that on September 23, 2017, OSHA began enforcing its new rule on respirable crystalline silica (silica dust). A 30-day compliance assistance period was provided for employers to take necessary action for complying with the new rule. It is now fully in effect. The rule reduces the Permissible Exposure Limit (PEL) for work at construction projects from 250 to 50 micrograms of silica per cubic meter of air, averaged over an 8-hour day.[3] Silica dust is recognized as a workplace hazard, causing silicosis, lung cancer, chronic obstructive pulmonary disease (COPD), as well as other illnesses. Employees are exposed to silica dust in several industries, including foundries, fracking operations, and especially in the construction industry where stone and sand products are present and certain tasks involve the use of crystalline silica.

The rule is the result of years of study by OSHA and has been challenged by the Chamber of Commerce and trade groups from a variety of industries. One study by the Construction Industry Safety Coalition suggests that the costs of the rule were underestimated by as much as several billion dollars.[4]

The U.S. Court of Appeals for the D.C. Circuit recently rejected all of the issues raised by industry groups concerning the rule. However, the Court remanded for review by a lower court an issue raised by labor unions concerning the absence of medical removal protection for workers. Medical removal protection generally requires employers to protect workers from exposure when recommended by a medical

It is dusty!

determination. Employees are also usually entitled to "normal earnings as well as all other employee rights and benefits" during this period.[5]

The rule creates two sets of requirements for reducing employee exposure to silica dust. One is for the construction industry and the other for general industry and maritime employers. The rule provides an exception for construction industry employers who can demonstrate that employee exposure will remain below 25 micrograms per cubic meter of air, averaged over an 8-hour work shift.[3] For construction industry employers, virtually all the requirements of the rule (discussed in the following) are already applicable. Employers subject to the general industry and maritime standards are not required to comply until June 23, 2018.

In addition to the primary requirement of reducing the acceptable level of employee exposure to silica dust by the implementation of proactive measures, the rule requires significant specific measures by construction industry employers. They are required to: assess the actual exposure of all employees who are, or may reasonably be, expected to be exposed to silica dust at or above an "action level" of 25 micrograms; post signage near and limit access to regulated areas where silica dust exposure occurs; implement a respiratory protection program and provide respirators to all employees entering any regulated areas; implement engineering and work proactive controls, as well as housekeeping measures to reduce employee exposure; create and update as needed on an annual basis a written exposure control plan; offer free medical surveillance to any employee exposed to silica dust at or above 25 micrograms per cubic meter of air "action level" for 30 or more days per year; include silica dust in the employer's hazard communication program; and implement recordkeeping requirements to track all of the obligations referenced earlier.[3]

The most essential part of the new rule, and the best guidance for construction industry employers, is OSHA Table 1 (**https://www.osha.gov/silica/SilicaConstruction-RegText.pdf**), which matches routine construction tasks with effective dust control methods. The table sets out three separate columns that provide the specific guidance. The first column lists the task or equipment being used. The second column lists the method for controlling dust. The third column lists the type of respiratory protection needed when performing the task. Unfortunately, Table 1 does not directly cover shotcrete placement equipment or operations.

EFFECTIVE CLOSING CONFERENCE

At the end of the inspection process, a closing conference is routinely held. The Compliance Officer normally will reference any standards that they feel have been violated, as well as possible abatement measures that could or should be taken. The management team representative should take the opportunity to obtain as much detailed information as possible, including all possible violations that may result from the inspection as well as the specific OSHA standards involved. If there are any unique problems with abatement, those should also be thoroughly discussed, including any efforts already taken to abate the condition and eliminate any employee exposure to a hazard.

You'll want to miss this conference, but attendance is required!

OSHA inspections do not have to be the traumatizing experience generally envisioned by most employers. Proper planning and preparation, as well as reasonable efforts to control the scope of the inspection as it is occurring, will greatly increase the employer's opportunity to limit or even avoid costly OSHA citations.

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ASA's Contractor Qualification Program

By Marcus von der Hofen

As 2018 begins, the ASA Contractor Qualification Committee is putting the final touches on the Contractor Qualification program slated to premier this spring. After years in the making, fulfilling the goal of creating a program is just the first step. Implementation can proceed down various paths, but the focus should always be on strengthening the shotcrete industry as a whole.

In 1998, the American Shotcrete Association (ASA) was formed by a group of shotcrete industry leaders with the mission of promoting the use of shotcrete. As part of this endeavor, it laid the educational foundation for a functioning Nozzleman Certification program. In 2000, the American Concrete Institute (ACI) established a formal Nozzleman Certification program through its Committee C660, which is regulated through ACI's Certification Programs Committee's standard procedures. ASA now is the primary sponsoring group conducting ACI nozzleman certifications and continues to increase the quality of the education process.

The ACI certification program was designed to be at a "baseline" level. The nozzleman receives his certificate for each process and orientation if he succeeds in the written and the performance exam. The ACI certification was not intended to be the most rigorous possible exam to cover all possible types of shotcrete placement. There exists a wide spectrum of shotcrete applications, construction practices, shotcrete processes, performance requirements, and geographic differences. Correspondingly, there exists a wide range of project needs from basic shotcrete to more complex needs requiring more sophisticated experience and workmanship. No certification program can address all potential variables.

The ACI nozzleman program is focused on certain and specific key elements (knowledge, skills, and abilities) deemed by knowledgeable committee and industry members to be the most essential for common applications. It consists of a general knowledge written examination and a performance examination that includes shooting an actual test panel containing reinforcing steel. The test panel is 30 in. square by 3.5 in. deep (750 x 750 x 90 mm) and contains a single layer of different sizes and varyingly spaced reinforcing steel. The panel is "basic"—it does not simulate deep sections, or multiple layers of reinforcement or obstructions. The nozzleman candidates are graded on their application techniques during the shooting of the panels. After hardening, the panel is cored for further evaluation of nozzleman skill based on the quality of encapsulation of the reinforcement. Thus, the program verifies that every certified nozzleman knows the basics of both general knowledge and performance technique and, therefore, has the potential for doing a satisfactory job.

Many specifiers have mistakenly relied upon nozzleman certification as an all-encompassing credential that equates to the nozzleman to being competent to shoot ALL types of shotcrete applications. This is not the case. Though nozzlemen must have a minimum of 500 hours of nozzling experience before applying for certification, many nozzlemen's base experience may be quite different from that required for specific projects. For example, a nozzleman might be extremely competent in dry-mix overhead work on parking garage repair (very difficult) but have little experience in bench gunning or water feature work (many are misled to believe this work is easier but it is not). The similarity of the work makes a big difference.

The qualifications of the shotcrete contractor by previous performance on similar projects should be specified in the contract documents. Because the role of quality control is typically the responsibility of the contractor, their knowledge, experience, and support of the nozzlemen and shotcrete crew is vital to the success of the project. Contractors with limited experience in specific applications may not afford the support necessary, and have difficulty achieving the overall concrete quality required. The specification should consider the length of time the contractor has been in business, the quantity and magnitude of past projects, and the current level of expertise of the management and crews.

Specifiers may find it difficult to delineate the necessary components of a shotcrete qualification requirement. As a result, the specifier may be hesitant to try to thoroughly evaluate the shotcrete contractor's equipment, crews, and resources. This may lead some specifiers to simply accept

a contractor's submittal for experience without looking at it critically.

The ASA Contractor Qualification program allows ASA to do the "heavy lifting" for the specifier in evaluating these checklist items that help to quantify a contractor's shotcrete experience. ASA has shotcrete experts (contractors, engineers, suppliers, and educators) who will review and verify contractor submittals in all these checklist areas. Members of the ASA Contractor Qualification Committee (CQC) will also talk with the contractor and key personnel to verify the provided information, as well as check with all the supplied project references.

ASA provides Shotcrete Contractor Qualification as a service for shotcrete contractors, owners, and specifiers. The CQC receives submittals from contractors wishing to be evaluated. The contractor must specify what level of qualification (basic or advanced) in which they desire to be qualified. The CQC reviews the contractor submittals that detail the contractor's shotcrete experience. Upon completion of the review, the CQC would provide the contractor a certificate of qualification in either the Basic or Advanced categories. Specifiers are encouraged to require the ASA Shotcrete Contractor Qualification for their specific projects, selecting the appropriate level of qualification based on the difficulty of application.

TWO LEVELS OF QUALIFICATION

There are two levels of qualification: Basic and Advanced. Each level is established by the type and scope of shotcrete work the contractor has previously successfully executed. The contractor must specify in their application the level (basic or advanced) that best describes their work. The contractor will be evaluated based on the level the applicant submits.

- **Shotcrete Contractor (Basic)**: A company that has attended an ASA sponsored 1-day seminar on basic requirements for the shotcrete contractor and can document successful completion of at least 15 projects in the last 3 years that qualify as basic projects.
- **Shotcrete Contractor (Advanced)**: A company that meets all the requirements of the basic level and can document successful completion of at least 15 projects in the last 5 years that qualify as advanced projects.

As with the Nozzleman Certification, the two classes are considered "baseline" to their level. As before with the Nozzleman Certification, it cannot and should not be used as a replacement for documentation of previous projects of similar size and scope in a project specification, such as tunnels, pools, or foundations. Its purpose is to establish minimum levels of contractor requirements for those pursuing work in the shotcrete field.

As with all programs, whether they are educational programs, sports programs, or community programs, they are never perfect from the start. Our program will undoubtedly need adjustments, and will evolve over time. I believe complementing the ACI Nozzleman Certification with baseline ASA Contractor Qualifications will be greatly beneficial to the shotcrete industry in the long run.

***Marcus von der Hofen**, Vice President of Coastal Gunite Construction, has nearly two decades of experience in the shotcrete industry as both a Project and Area Manager. He is an active member of American Concrete Institute (ACI) Committees 506, Shotcreting, and C660, Shotcrete Nozzleman Certification. He is a charter member of ASA, joining in 1998, and currently serves as Past President to the ASA Executive Committee.*

Contractor Setup Considerations for New Construction

By Ross King

The use of structural shotcrete in lieu of "form-and-pour" is growing rapidly in the urban concrete building construction and civil infrastructure sectors throughout North America. Although this method of casting concrete has been used successfully for over 25 years, the process is still relatively new and not yet totally understood by many seasoned concrete professionals from all disciplines.

By far, the biggest challenges/considerations when setting up a project for structural shotcrete are whether the structural and architectural specifications include provisions for shotcrete, and whether the owner/builder is already on board and has included shooting as part of the overall structure plan.

Structural shotcrete mockup

The following contractor setup considerations for structural shotcrete in new construction follow the initial decision to shoot:

- Consultant approval and mockup;
- Site-specific shoot plan;
- Shotcrete mixture design and delivery;
- Site logistics;
- Weather and environment;
- Reinforcing, formwork, and waterproofing; and
- Shoot and finish.

CONSULTANT APPROVAL AND MOCKUP

Regardless of whether a project is specified as structural shotcrete or approved as an alternate, a structural shotcrete specification is necessary but not always provided by the design team. When a shotcrete specification is not available, it is wise to work with the structural engineer to help develop a specification. Having a specification helps to confirm the engineer and contractor have the same expectations for quality shotcrete on the project. This extra effort helps to alleviate misunderstandings, and to teach the consultants the shotcrete process prior to construction.

Mockups for structural shotcrete are required for certain projects and special applications. When it comes to construction and design team members unfamiliar with structural shotcrete or a ready mix supplier without shotcrete mixture design performance history, a mockup is common. Once construction team players are familiar with shotcrete and the shotcrete contractor has past proven successful results, a mockup at times can be waived and grandfathered from previous projects subject to the same nozzlemen, equipment, and concrete supplier. When special structural situations arise like congested reinforcing bars, section thickness, odd shapes, and higher concrete strength, a mockup is highly recommended.

SITE-SPECIFIC SHOOT PLAN

One of the first things I push for is to call an individual structural shotcrete application a "shoot" versus a "pour" (the term used when using typical form-and-pour). What this does is to alert all involved that the wall we are casting is similar to a

pour, but is a shoot and has different factors that must be considered when planning the setup for structural shotcrete.

One of the most important first steps is to identify the specific locations to be shot versus form-and-pour. These shotcrete locations usually have been approved and agreed to structurally along with the mockup results. The combined overall concrete forming plan shows where shotcrete placement or traditional form-and-pour is best suited.

Once the specific structural shotcrete locations are identified, it is important to check for the following:

1. Required concrete strengths that may vary by location;
2. Concrete additives: rust inhibitor, C-1 silica fume, and integral waterproofing, all of which may vary by location; and
3. Reinforcing bar densities and clearances from formwork and the finished face of wall.

From all this information, an actual shoot drawing can be created showing individual locations and the proposed sequence of shooting. This is the perfect time to control and plan the size of each shoot so as to be not too big or small.

SHOTCRETE MIXTURE DESIGN AND DELIVERY

A proper shotcrete mixture design is key to a successful shoot for both in-place concrete quality and crew productivity. Identifying the proper mixture design for a specific application can depend on many factors. Many past *Shotcrete* magazine articles address this topic.

Even with the perfect mixture design, many onsite factors can affect mixture performance and must be considered in the shotcrete contractor setup plan before the shoot. These include:

1. Slump control, meaning what is the delivered slump and slump retention during discharge, versus the mixture design specifications;
2. What are the provisions for adjusting the load for too low or too high of a slump needed for proper shotcrete application?;
3. Temperature control by monitoring temperatures on arrival and at the end of each load, and giving feedback to quality control at the ready-mix supplier; and
4. Provisions for accelerators and hot water in cold weather conditions, and retarder and chilled water or ice in hot weather conditions.

Once the right shotcrete mixture is determined for the right location and is adjusted to suit the weather, it will all come down to the ready-mix truck delivery and service. Potentially waiting for delayed concrete trucks really needs to be addressed in the shotcrete setup plan. Concrete in the shotcrete pump, pipelines, and hoses becomes old while waiting and causes an increased risk of plugged lines or blowing out the line, slowing down the shotcrete operation, reducing productivity, and potentially taking away from a quality installation. We have found most clients and parties involved in the structural shotcrete operation do not take into consideration how important it is to maintain concrete delivery as per the order. Concrete delivery trucks arriving too fast or early can also result in trucks waiting for an extended time. This can allow the concrete to get too old and potentially result in line blockage issues.

SITE LOGISTICS

Site logistics is primarily about the concrete pump location; the closer to the shoot, the better. Concrete delivery truck access to the concrete pump hopper is critical, and room for two trucks to the hopper is preferred for smooth transitions between trucks. Part of the pre-shoot setup plan that needs close attention is making sure that the pumping location is clear of other jobsite deliveries at the agreed start time, and prior to the scheduled concrete delivery time to allow for pump setup.

Having a clear, safe workspace zone in front of the wall to be shot needs to be part of the setup plan, and monitored for every mobilization. A plan for waste management and disposal bins is always a preconstruction setup plan item that needs to be considered.

WEATHER AND ENVIRONMENT

The weather, both hot and cold, affects structural shotcrete in a similar manner as casting concrete floors. Standards for

Wall tarping/hoarding

hot and cold weather are covered in several ACI documents, as well as by many past shotcrete-specific ASA articles. Setup planning should make clear which methods have been selected for each weather condition, and who is responsible for all material and equipment to be onsite prior to shooting. With inexperienced contractors, often the basic steps for weather protection are not planned for, so at the end of the day, nothing is done to protect the exposed shotcrete wall. This leads to questions of what happened to the exposed surfaces in the morning.

Curing for a shotcrete wall should follow the same specifications as for cast concrete floors and vertical elements. The same advance planning for material and equipment as required for hot or cold weather protection also applies to curing.

Protection from the rain is a common problem and again must be discussed and planned for ahead of time. This should be a part of the shotcrete contractor setup plan and should include:

1. A decision on what method of tarping will be used and how to secure against the wind;
2. Quantity of tarping that must be onsite prior to shooting, and allocated for the shotcrete operation;
3. A jobsite understanding of who is responsible to install; and
4. Use of clear tarps or opaque tarps (if supplemental lighting is available) to not restrict the ability to clearly see all the locations being shotcreted under the tarps.

REINFORCING, FORMWORK, AND WATERPROOFING

A big consideration for the shotcrete contractor setup plan is that the work done by others can have a very negative affect on the quality of the finished structural shotcrete application. If this work is not planned correctly and checked prior to shotcreting, there is a potential for poor-quality work that is often blamed on bad nozzle technique when, in fact, the nozzleman is hindered by poorly installed reinforcing bar, formwork, or waterproofing.

Reinforcing bar spacing and splices should be done per ACI 506.2, "Specification for Shotcrete." But if the reinforcing bar is irregularly spaced or bunched up in certain locations, it can create the risk of shadowing and should be covered in the shotcrete setup plan and site kick-off meeting. Proper clearance of the reinforcing bar from the back form, bulkheads, and finished face is a very common issue and needs to be addressed ahead of time in the shotcrete setup meeting and continuously monitored during all shotcrete operations. Reinforcing bar must also be tied securely and anchored to prevent movement during shotcrete placement.

Formwork, when used with shotcrete, requires less strength as compared to form-and-pour. Setup planning should consider the lighter requirements for shotcrete, but care must be taken that this reduced strength is understood and not taken too far where formwork is unstable in the wind, or moves and vibrates during shotcrete placement. Formwork should also be constructed to give the nozzlemen full access to the shot surfaces. This usually requires keeping formwork bracing away from the shot face.

Formwork should extend a minimum of 2 ft (0.6 m) and preferably 4 ft (1.2 m) beyond the ends and top of the wall to protect from the hazard and messiness created by overspray.

Waterproofing that is a part of the receiving surface needs to be securely fastened to the primary substrate (commonly the excavation shoring or a blindside application). The setup plan should detail the waterproofing fastener type and spacing to properly restrain the sheet-type material from moving in and out during shotcrete placement, which could result in shotcrete fallouts or voids.

Gauge or shooting wires to define the final surface need to be included in the setup plan along with provisions for scaffolding where a wall height is over the reach of nozzlemen from the floor.

SHOOT AND FINISH

The last step in the structural shotcrete setup plan is the shoot itself. A checklist of items included in the nozzling and

Properly installed reinforcing bar, formwork, and waterproofing

finishing setup plan should include:

1. ACI-certified nozzlemen and supervisors present with all site-specific shoot plan information in hand;
2. Proper equipment sizing, including air compressor, air and delivery hoses, nozzles, piping, and inventory of all finishing tools;
3. Clear understanding of the expected level of finish and control joint depth and spacing required;
4. Tailgate meeting with shotcrete crew to review safety, shotcrete nozzle plan, and sequence, including weather protection and curing;
5. Preshoot check of reinforcing bar rigidity and clearances;
6. Establish communication with the concrete supplier to control service and confirm mixture;
7. Monitor concrete temperature, initial set time, and cohesion characteristics of the mixture to control shotcrete benching heights and timing for subsequent lifts and finishing time;
8. Clean up and waste management process with next day provision to complete if necessary; and
9. Next-day formwork removal inspection to review and critique the mixture performance, reinforcing bar clearances, and nozzling results.

CONCLUSIONS

The final consideration, and the best test of the structural shotcrete setup plan, is the client and consultant feedback. This feedback will certainly point to the necessity and hopefully success of a good setup plan. The feedback should also help to identify where any refinements or additional procedures need to be included in the next project shotcrete setup plan. Shotcrete construction can produce high-quality, durable structural concrete. Thoughtful pre-planning can make the shotcrete placement smoother in the wide variety of weather and field conditions we routinely experience on our job sites.

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ACI Nozzleman Certification—Why, Who, When, and How

By Charles Hanskat

ASA is the largest ACI sponsoring group offering ACI Shotcrete Nozzleman Certification in the world. Since I came on board as the ASA Executive Director 3 years ago, the certification program has evolved and improved in many ways. Yet, as ACI readily admits, the nozzleman certification program is one of the most complicated certifications programs they offer. Although I was an ACI examiner for shotcrete certification several years before becoming ASA Executive Director, learning all the ins and outs of the program has been a distinct challenge. Fortunately, I've had our in-house expert on the certification process, Alice McComas, to help guide me along the way. In this article, I hope to translate some of the policy requirements into a more readable format, as well as give an insight into the finer details of the current ASA/ACI nozzleman session process and requirements.

ASA Holds Initial Shotcrete Nozzleman Certification

George Yoggy stands the field orientation for the first certification course

Streetsboro, Ohio, a small town just southeast of Cleveland, recently became the site for a landmark occasion in the shotcrete industry. For six days in September, 1999, the back lot of the Master Builders' manufacturing plant and a local hotel in Streetsboro became the venues for the first shotcrete nozzleman certification held by an industry association in North America.

The first three days were comprised of intensive training, peer-review, and curriculum development by a dedicated group of acknowledged industry experts. Working day and night, and even into the wee hours of the morning, they completed the necessary documentation, test procedures, and examination questions to enable the first class of nozzleman candidates to take a two-day instructional course and complete their certification examination on the last day. A total of 15 nozzlemen were enrolled, and all were certified in some or all of the configurations on which they were tested.

Neil McArkill (left) and Lars Balck collaborate on one portion of the training presentation

Pierre LaCombe, Ken Bradshaw, Pat Bridget, and George Yoggy pass over slides for inclusion in the training program

Personnel

Before the program was undertaken, an initial Certification Board was named to oversee this pilot offering. Chairing this first Board was Dr. D.R. "Rusty" Morgan of AGRA Earth and Environmental, Ltd. The other members were George Yoggy, Allentown Shotcrete Equipment Co.; Lars Balck, The Crom Corporation; Marc Jolin, SEM Engineers; and Larry Totten, Johnson Western Gunite Company. These and several others were invited to participate in the planning sessions which were held from Sunday through Tuesday preceding the classes and certification testing. Joining Morgan, Yoggy, Balck, and Jolin were Neil McArkill, AGRA Earth and Environmental LTD; Ray Schulhen, RCS Consulting and Construction, Inc.; Jean Francois Dufour, King Packaged Materials Co.; Pierre Lacombe, SEM Engineers; and Pat Bridget, Allentown Shotcrete Equipment. Observing for future program participation were Roland Heere, AGRA Earth and Environmental LTD.; and Ray Bradshaw, BFK Inc.

Also participating in the planning sessions was Merle Isaak, Chairman of ACI Committee C 660-Shotcrete Nozzleman Certification, who acted as both contributor and observer to assure that the ASA program was developed in accordance with both current ACI documents and also with the plans for the future ACI Shotcrete Nozzleman Certification program.

Preparation

In addition to working diligently on the classroom presentation and the written exam, all these future trainers and examiners spent many hours in actual nozzling and also in observing and critiquing each other. A wide variety of equipment and materials was used in these sessions to assure that each person was familiar with all the situations on which the candidates would be tested. Both wet and dry mix shotcretes were used, as well as different combinations of nozzles and hose sizes.

Each afternoon, after the shooting sessions were over, work started again on the documentation portion of the program. The

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Shotcrete *magazine article from November 1999*

At ASA, we recognize the importance of nozzleman certification to the shotcrete industry, and strive to provide a consistent, high-quality, and relevant experience for the session hosts and the nozzlemen participants. In 2017, we conducted 78 sessions, with 260 new certifications, 139 recertifications of existing nozzlemen, and 77 nozzlemen-in-training (NIT). Those sessions were spread primarily across the United States and Canada, but also included a session in Australia.

Checking the ACI website shows we have a total of 1713 certified nozzlemen worldwide, so adding 337 is nearly a 20% gain. In a time where attracting young people to enter construction careers is an industry challenge, it is encouraging to see this kind growth, in what is admittedly a tough, physically demanding, and often dirty job.

Over the years, we've printed several articles about the ACI Nozzleman Certification. The first, in the November 1999 *Shotcrete* issue, "ASA Holds Initial Shotcrete Nozzlemen Certification," documented the first shotcrete nozzleman certification session.

This was a pilot run put together by a collection of ASA members with extensive shotcrete experience, and was the model for the formal ACI Nozzleman Certification program that followed, established in 2001. A Summer 2013 *Shotcrete* article by J. F. Dufour, Marc Jolin, and Randle Emmrich, "Shotcrete Nozzlemen: ASA Educates-ACI Certifies," presented the then-current policies of the ACI Shotcrete Nozzleman program and identified ASA's role as an ACI Sponsoring Group. That article also described the ASA full-day nozzleman education course for all nozzlemen seeking new certification. Another article in the Summer 2013 issue, "ACI Nozzleman Certification Sessions: What Not to Do," by Bill Drakeley, was directed to the potential ASA/ACI nozzleman session hosts. It covered the do's and don'ts, with a lot of great tips for a company hosting a session. You can find all these articles in our magazine archive (**www.shotcrete.org/ArchiveSearch**).

So where are we with the ASA/ACI Nozzleman Certification program today? To help explain our comprehensive, but complicated program, I'll break it into more manageable chunks: Why, Who, When, and How.

WHY

Before ACI Nozzleman Certification was available starting in 2001, specifiers were often hesitant to specify shotcrete

because they were not familiar with the details required for quality shotcrete placement. Some had problems when they did try to allow shotcrete on a project, and an inexperienced contractor did a poor-quality job. ASA was formed in 1998 to help raise the visibility and quality of shotcrete in the concrete construction industry. Outreach seminars, trade shows, and active ACI committee involvement were ways we worked towards the goal, but we also saw that getting an ACI nozzleman certification in place would give us a tool for specifiers to more confidently start including shotcrete in their specifications.

ACI is an international organization that has produced codes and standards used by engineers and contractors globally for nearly a century. Their certification programs for individuals, such as Field Testing Technician, or Flatwork Finisher and Concrete Special Inspector, are internationally recognized and accepted as setting the standard for concrete-related certifications.

Thus, ASA identified the nozzleman certification process as a key to getting better specifier recognition of shotcrete. We also felt that by quantifying the experience, knowledge, and performance of a nozzleman, we could ultimately increase the quality of shotcrete placement. ASA members developed the initial program and pilot session along with ACI Committee C660, Shotcrete Nozzleman Certification, and then actively participated on Committee C660 to get the formal policy to match the needs of the industry.

That said, we firmly feel that simply specifying a certified nozzleman does not guarantee a properly executed shotcrete project. Yes, the nozzleman directly controls the actual placement of concrete and is a key member of the shotcrete team. However, true quality comes from a shotcrete contractor who gets the correct concrete mixture; provides proper, well-maintained equipment; has a trained crew, from the pump or gun operator through the finishers; and recognizes the importance of curing and protection of freshly shotcreted work.

The nozzleman certification is in many ways like a driver's license. You know how to drive a car, and the rules of the road, but you have not in any way experienced all the potential situations that may arise when driving. The nozzleman certification establishes you know the basics of shotcrete, can successfully pass a written exam to confirm that knowledge, and then prove to an examiner you can shoot a panel that has a few reinforcing bars. It doesn't mean you can successfully shoot a very thick section with congested reinforcing. It doesn't mean you can shoot around large embeds or in limited access areas. The ability to properly and consistently shoot more complicated work comes with experience. Often, an engineer on a complicated project will require the certified nozzleman to shoot a mockup panel to prove they have the ability to place quality shotcrete and fully encase the reinforcement.

Nozzleman certification also gives the nozzleman benefits. Through our ASA Education program, they learn more about the shotcrete process and the theory and practice for safety, selecting materials, equipment, placement, curing, and protection. It is also an achievement, a "status" level they've achieved as a shotcrete craftsman.

WHO

Nozzleman applicants must have verifiable work experience shooting shotcrete. This is not time preparing substrates, building forms, shoveling rebound, operating the pump or gun, finishing, or curing. This is time the nozzleman is on the nozzle and placing concrete. For those workers looking to become nozzlemen, operating the blowpipe (air lance) adjacent to a nozzleman can give good experience on identifying good placement techniques.

Full Nozzleman Certification

The full nozzleman certification is in the shotcrete process (dry- or wet-mix) and orientation (vertical or overhead), and requires a minimum of 500 hours of shooting overall, and at least 100 hours in the specific process and orientation being pursued. These shooting hours can be from any project before the certification. As an example, if a nozzleman has 500 hours in wet- and dry-mix and wants to be certified in both vertical and overhead for both processes, they would need to show at least 100 hours in each of the wet-mix vertical, wet-mix overhead, dry-mix vertical, and dry-mix overhead categories.

Nozzleman-in-Training (NIT)

In 2015, ACI Committee C660, which oversees the ACI Nozzleman program, added a new category of "Nozzleman-in-Training" to applicants seeking certification. The NIT requires a minimum of only 25 hours of shooting experience in the process being pursued for certification. The NIT is limited to certification in the vertical orientation in the process where they have documented their shooting hours. If a NIT wants to pursue both wet- and dry-mix, they would need to show 25 hours of shooting experience in each process.

The thought behind adding the NIT was to help answer the question, "How do I get my 500 hours of shooting experience?" The NIT program, with the ASA education and CP-60 Craftsmen Workbook, introduces the entry-level nozzleman to the basics of the shotcrete process that they may not get from just on-the-job shooting. The 25 hours gives a measure of confidence that the NIT had seen and could safely handle a shotcrete nozzle during placement.

The NIT must attend the full-day ASA Nozzleman Education class, take the ACI written exam on the process they are pursuing, and take the ACI performance exam. Upon successfully passing the exams, they will be given a NIT certification. The NIT then documents their shooting hours on a project-oriented weekly form after passing the exams. When they reach the minimum of 500 hours, their revised work experience is then reviewed by an ASA examiner for upgrade to a full nozzleman certification. Thus, the NIT is not a full nozzleman certification, but provides a clear path for those seeking the full certification.

We've also found the NIT program is popular with companies hosting sessions. It allows hosts to maximize

the value of the sessions for new or recertifying nozzlemen by including the "up and coming" nozzlemen who look to full certification in the future.

Recertification

A certified nozzleman can recertify at any point in their 5-year certification period. If a nozzleman recertifies before his certification expires, their new certification extends from the time they took and passed the performance exam for the recertification. If the nozzleman's certification expires, they have 1 year from the expiration date to recertify under the same rules as a nozzleman in good standing.

The required work experience hours (shooting on the nozzle) for recertification are a little more complicated. The policy requires:

1. At least 1000 hours over the last two (2) years immediately prior to seeking recertification, with at least 200 hours in the process for which recertification is sought; or
2. At least 2500 hours over the last five (5) years immediately prior to seeking recertification, with at least 500 hours in the process for which certification is sought.

When a nozzleman recertifies by documenting their shooting hours and taking the performance exam, an expanded oral examination by the ACI examiner (usually about 20 to 30 minutes long) will be given to verify they have retained the basic knowledge about concrete and shotcrete in the written exam. They will not need to take the written exam.

Optionally, the nozzleman seeking recertification can elect to take a written exam instead of the oral exam, and will NOT have to document any hours. In effect, their minimum 500 verified shooting hours from the original certification are still valid. We find this is useful when a nozzleman advances to a supervisory position, and may not be shooting regularly, but still wants to maintain their certification status. This option is also available to nozzlemen seeking recertification whose certification expired for less than 1 year.

Session Hosts

Our certification sessions are normally "hosted" by a shotcrete company that has a number of nozzlemen needing certification. We refer to these as the "Hosts." We need a contact assigned from the Host to help the coordination of the session. The Host is fully responsible for providing a facility for the education if we have new nozzlemen certifications, and a quiet area for taking the written exam. The Host also needs to provide a site for shooting the shotcrete performance panels and all materials, equipment, and setup of panels for the performance exams.

Often, a Host will open their session to participants outside their company to help defray the cost of the overall session. ASA keeps a list of individuals or smaller companies who can't afford a session on their own. If a Host decides to accept outside participants, ASA will connect the two, and allow them to contact the Host directly for full information on the session. The Host is responsible for providing the outside participants a price, information on timing and location of the session, and collecting payment for their inclusion in the session. ASA looks to only the Host for full payment for all aspects of the session.

Occasionally, ASA has a Host conduct an "open session." This is a session where more than half the participants are not employed by the Host. To help assure the open session is well organized and can give the nozzlemen a good opportunity to demonstrate their skill, ASA staff will interview the Host on the specifics they intend to provide for the session, and make recommendations on any improvements that may be needed.

ASA/ACI Examiners

ASA has 16 ACI examiners who have been vetted by ACI Committee C660 to conduct the ACI shotcrete nozzleman certifications. Our examiners all have extensive experience in placing or evaluating shotcrete in field conditions. Examiners must undergo a training program that includes working with existing examiners on at least two sessions, plus taking the written exams for the process they are qualified to conduct. They are also reviewed and approved by ASA to professionally present the ASA nozzleman education program. We have four examiners in Canada, one in Mexico, and 11 in the United States. Our Mexican examiner is fluent in Spanish, and one of our Canadian examiners is fluent in French.

WHEN

When should you get your nozzlemen certified? Sooner than later. Getting your nozzlemen certified gives you as a shotcrete contractor the opportunity to show owners or specifiers, that you have made the commitment to pursue quality shotcrete work. A certified nozzleman does not assure the shotcrete project is executed properly, but it is certainly an important step in establishing your shotcrete credibility.

Bidding work that requires a certified nozzleman and waiting until the job is awarded to you is often too late. The fastest a session can be scheduled without a substantial rush fee is 3 weeks, and we prefer at least 4 weeks. We have ASA/ACI examiners spread across North America. However, this is not a full-time job for them, and on occasion, we run into scheduling conflicts that can make a quick session difficult or impossible to schedule on your timetable.

Our normal sessions are 3 days long, with 1 day for the ASA education, 1 day for taking the written exam and shooting the performance exam panel, and then on the third day, coring the panel for evaluation of the cores and quality of reinforcement encasement. If the session includes a larger group of nozzleman candidates where we'd need to shoot more than 14 performance panels, we will often require an additional day or provide a supplemental examiner to allow for the shooting and coring times. If a session runs into problems with weather, equipment failure, or material issues, the session Host can coordinate with the examiner to extend the session by a day.

We conduct sessions based on the session Host's schedule. When needed, our examiners can conduct portions of the sessions on weekend days to reduce the impact on your job schedule. You should plan on full days for the session. The education is a full day of content, and unless shooting and coring goes very smoothly, those two operations can easily extend to later in the afternoon.

HOW

Book a Session

First, contact us! E-mail to info@shotcrete.org, call us at (248) 848-3780, or go to our Education page on the ASA website (**www.shotcrete.org/Education**). After contacting us, our Program Coordinator, Alice McComas, will coordinate producing a quote for the session, assigning an examiner, collecting payment and the work experience forms before the session, and then verifying the paperwork from the examiner upon completion of the session.

Before you call or fill out the online request, you should have this information handy:

- The number of nozzlemen to be certified:
  - How many are full, new certifications?
  - How many are NITs?
  - How many are recertifications?
    - Do they have the required hours, or will they be taking the written exam?
- What are the processes (wet or dry) and orientations (vertical or overhead) to be shot?
- What time frame (days) are you thinking of holding the session?
- Will any of the nozzlemen need a Spanish version of the workbook or exam?
- Will any of the nozzlemen require oral administration of the written exam?
- Contact information for the individual assigned as the Host contact for the session.

We have many certification session resources on our Education web page, including:

- Typical timeline for Certification and or Education Session;
- ASA Certification and Education Fees Price List;
- ASA-Sponsored ACI Shotcrete Nozzleman Certification Policy for Hosts and Participants;
- Nozzleman-In-Training Program Overview;
- Nozzleman Work Experience Form for Certification;
- Nozzleman Work Experience Form for Nozzleman-in-Training (right click to save file);
- Test Panel Configuration for Shotcrete Nozzleman Certification;
- Certification User's Manual;
- Order the latest Annual Nozzleman Compilation;
- Certification/Education Session Quote Request Form (for both wet-mix and dry-mix);
- ACI Shotcrete Nozzleman and Nozzleman-in-Training Dry-Mix Program Description;
- ACI Shotcrete Nozzleman and Nozzleman-in-Training Wet-Mix Program Description; and
- ACI Shotcrete Nozzleman Certification Policy.

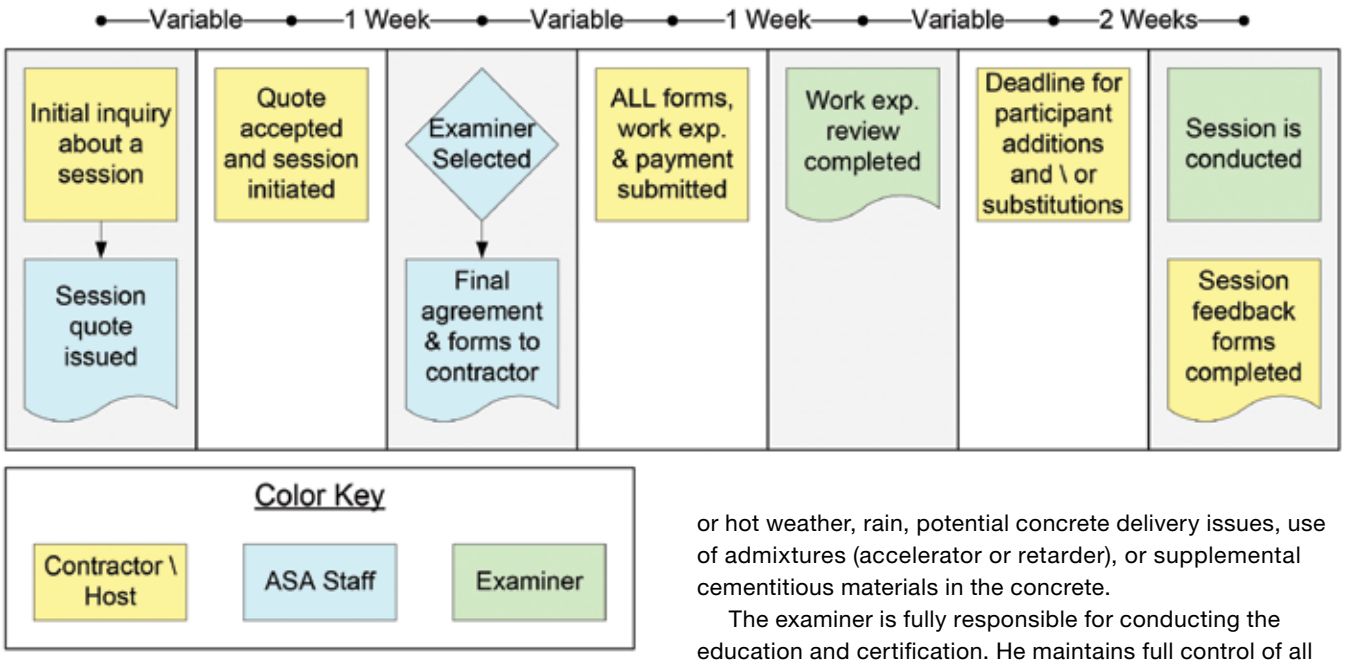
Our certification sessions are generally held at a Host Contractor site. The host location should provide a classroom (when there are new nozzlemen certifications) and panel-shooting facilities. Often, the session is at a company shop where there may be a training room and outside facilities for shooting the panels. However, we have conducted sessions on job sites or other facilities. I even did one on the owner's farm (complete with roosters and goats in the barn).

Unions can be Hosts for the sessions. However, ACI requires that the ACI certification cannot take place on union property. Thus, though the ASA day-long education can be presented at a union facility, the written and performance exams need to be conducted elsewhere. Often, we recommend the union look for a local shotcrete contractor and coordinate the session at their facilities, and with their equipment and proven materials.

When filling out the required work experience forms, we often see applicants correctly list the project, dates, employer, and contact, but in the "Wet or Dry Mix," and "Vertical or Overhead" fields list "Both." This is not acceptable, and requires staff or the ACI examiner to contact the host or nozzleman to get the breakdown of the hours shooting for each process and orientation. It is also important on the work experience to provide enough detail in the "Scope of Work" section so the examiner can establish the type of work (repair, soil nail, structural wall, and so on), the volume or area of concrete placed overall, and a range of thicknesses being shot on the project. We do check the shooting hours against the volume or area shot to confirm the stated numbers make sense from a practical field perspective.

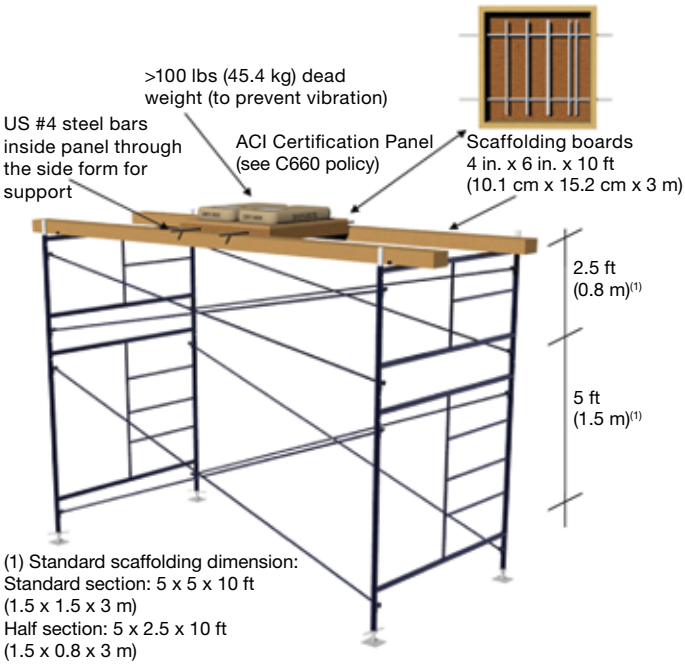
Host the Session

As mentioned previously, we need confirmation of the session at least 3 weeks (and preferrably 4 weeks) before the session start date to allow assignment of an examiner, review of work experience forms, securing necessary exams from ACI, and arranging examiner travel. The following is a typical timeline for our session process.



ASA Certification Session Process and Timeline

Once the session is booked, we assign an examiner to the session. The examiner is responsible for reviewing the work experience forms and contacting the Host well before the session. This pre-session contact gives the Host an opportunity to ask questions about the required facilities, daily schedule, materials, shotcrete equipment, and setup. In the pre-session contact, the examiner can get details on the location (or locations—sometimes the classroom session is at a different facility from the shooting location), equipment and materials to be used, safety, and overall setup. There may also be discussions on provisions for cold or hot weather, rain, potential concrete delivery issues, use of admixtures (accelerator or retarder), or supplemental cementitious materials in the concrete.



Overhead standard setup—ACI Shotcrete Nozzleman Certification

The examiner is fully responsible for conducting the education and certification. He maintains full control of all exam materials, and conducts the session in a professional manner. With the years of field experience our examiners have, they usually establish a good relationship with the nozzlemen during the session, because most were nozzlemen at some point in their career and thus understand what a nozzleman must accomplish in the field. The examiner should not be there to promote any particular products, but present a neutral, unbiased viewpoint on proper shotcrete placement.

Written exams are all graded by ACI after they are returned to ACI headquarters by the Examiner. The performance exams are graded by the Examiner. The results of the performance exam (pass or fail) can be shared with the nozzlemen at the end of the session. Nozzlemen do not have to be present for the coring, but many examiners enjoy the opportunity to review the cores with the nozzlemen that shot them on the last day of the session.

The nozzlemen are informed of their certification status after all exams are returned for the session, and the written exams are graded by ACI. ACI can normally grade the exams and when they pass, post the nozzleman's certification on the certification website for verification (**www.concrete.org/certification/verifyacertification.aspx**) within 2 weeks after receipt. The nozzleman's printed credentials are mailed to the address given in the session. If the Host wants to have the credentials mailed to the company first, they need to tell the nozzleman applicants to fill out the company address, rather than their home address, on the information form for the exams.

IN SUMMARY

Whew, that's a lot of information, isn't it? The biggest recent change is the new shotcrete NIT certification that gives shotcrete contractors a good option for exposing their nozzleman trainees to the comprehensive shotcrete knowledge our full-day ASA Shotcrete Education class

More than one core drilling rig with crews who have experience in the operation

provides. It also allows the NITs to take the written and performance exams, and if successful on the exams, be upgraded to the full certification status upon reaching the required 500 hours. The other relatively new provision is clarifying the need for at least 100 hours work experience in the process AND orientation.

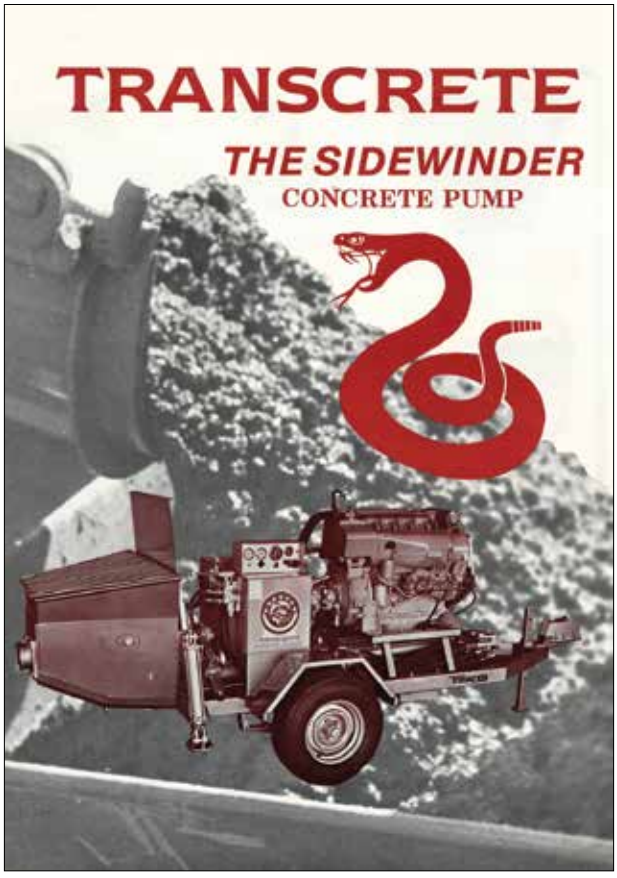
ASA constantly strives to improve the consistency, quality, and relevance of our shotcrete nozzleman sessions. We have several examiners-in-training to increase the size of our Examiner pool and allow us to be more responsive to our Host's requests for session dates. Our Education committee has a standing task to update and refine the education presentation. We work closely with ACI Certification to resolve issues that need clarification in the policy or procedures. We also closely review our process to streamline our administration and if needed suggest refinements to ACI Certification. If you have any questions about sessions, please contact Alice McComas at (248) 848-3780 or e-mail her at info@shotcrete.org. Also, if you have feedback for me on a past session, feel free to contact me directly at (248) 848-3742 or e-mail charles.hanskat@shotcrete.org.

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

The History of Shotcrete Equipment

Part II: Sidewinder—Why So Great with Shotcrete Mixtures?

By Ian Hay



Transcrete specialized in building pumps for high-rise buildings and large concrete placements. The concrete used on these projects was normally low-slump, high-strength mixtures. Transcrete's formula required diesel engines developing 2 hp/yd^3 (2.6 hp/m^3) output with a hydraulic ratio of 4:1 between the hydraulic and concrete cylinders. The Sidewinder was designed to pump low-slump mixtures for small construction projects. As the Sidewinder was to have 6 in. (150 mm) bore concrete cylinders, we required 3 in. (75 mm) hydraulic cylinders to maintain a 4:1 ratio. However, we could not source 3 in. (75 mm) cast iron piston rings; the closest were 3.250 in. (82 mm). By sheer luck, not engineering skills, we ended up with a higher-pressure pump with a 3.41:1 ratio. Using the air-cooled 80 hp diesel and vane pump that would run at 3500 psi (24 MPa), we turned the Sidewinder into a powerhouse developing 1000 psi (7 MPa)—a higher line pressure than most concrete pumps on the market at that time. That's why the Sidewinder could handle the low-slump shotcrete mixtures.

BEYOND ARIZONA

Anthony Pools, through an Arizona contact, found out that Bennett Brothers was selling a hydraulic-powered shotcrete pump. In the Los Angeles, CA, area, Anthony Pools was using dry-mix shotcrete (gunite) because the local ready-mix producers would not supply concrete to pool builders, as they disrupted their delivery schedules due to the unreliable mechanical ball valve pumps they used. Dick Bennett and I arranged to meet Anthony Pools management on a site in Beverly Hills, CA, where they were shooting a pool at an existing multi-million-dollar home.

It was quite a circus. Bulk piles of sand and bags of cement were dumped on the grass in front of the home. A

One of Anthony Pools' shotcrete rigs with proportional mixer, Sidewinder pump, diesel generator to run the mixer, hydraulic power to run the concrete pump, and a 350 CFM compressor

huge Ridley chamber dry-mix gun machine and 600 ft³/min (17 m³/min) air compressor were parked at the curb. Dust covered the whole area. The Anthony site supervisor called me to one side and quietly confessed that due to cement shortages at the time he was losing money with dry-mix; he had a special "cleanup" crew that followed up the next day to collect any sand left on the job as well as cement bags. "Are you sure your pump will handle wet-mix without breaking down? If so, you will save my backside!" I told him to let us know his next job location and we would provide a Sidewinder pump and the concrete supply. He seemed quite scared about the proposal so I told him we would pay for the concrete should the Sidewinder not perform.

I also added a "kicker"—if we perform, they would place an order for a Sidewinder. Several days later, Dick and I turned up to the next pool job with a Sidewinder hooked to a small pickup truck and a 120 ft (37 m) of 2 in. (50 mm) hose. The Anthony Pools crew set up the hoses and operated the pump with their own crew. The Sidewinder discharged the transit mixers in 30 minutes and the pool was shot and cut in a little over 2 hours. We were given a purchase order before we left the site. In addition, management wanted a meeting with Bennett Brothers to discuss building special volumetric mix rigs for all their operations country-wide.

MIXTURE DESIGN PROBLEMS

Bennett Brothers, in a joint venture with Bob Morgan, an Orange County manufacturer of volumetric mixers, built the first of many custom Anthony rigs mounted on "lowboy" trailers. There was a huge diesel generator and hydraulic power pack to provide electric power for the mixer and hydraulic power for the Sidewinder pumping module. The rig also had dry cement and aggregate boxes that were hoisted over the mixer hopper. We found that electric-powered mixers held their output settings much better than hydraulic systems that could vary as the oil heated up.

A week before the Thanksgiving holiday, Dick Bennett called to say, "Ian, the Anthony Pools' rig is using extra-high pumping pressures and getting as hot as a pistol." My response was, "Dick, it sounds to me like a mixture problem." He seemed very worried, so I jumped on the next plane to Los Angeles. Upon arrival, Dick and I met up with Anthony Pool's supervisor to discuss the mixture problem. I checked the material they had in their bins and asked the supervisor to take me around to his sand supplier, where he replied, "What is the point in that? Sand is sand." I replied, "Not exactly. It may not matter with gunite mixtures but with wet-mix, sand is very important! Your sand in the yard can contain a large amount of rock and coarse sand. Sand suppliers have a wide range of sands: plaster sand, masonry sand, concrete sand, stucco sand, and even sand for cats to pee in."

We went to the sand supplier and I gathered bags of different sands and aggregates. Next, we purchased a set of material grading screens. Back at Bennett's yard, I spread out the different sands in the sun to dry out and then made up

Close-up of the Anthony Pools rig used in Los Angeles and some in Texas

Gunite machine used in Beverly Hills by Anthony Pools when we were invited to inspect their operation. These machines were "dust producers." In today's market, the EPA would fine any company using such machines

cardboard boxes so I could get specific weights. I selected what I felt were the two correct gradations of sand and then issued the highly technical blending process that follows:

- When the supplier loads your sand in his dump truck, he must put two scoops of the No. 1 sand followed by one scoop of the No. 2 sand...then repeat until he has a full load. I knew that between loading, delivery to Anthony Pools' stock pile, then reloading into the mixer boxes, the sand would be mixed enough.
- The secret sand was the one that passed the No. 100 screen. You need 3 to 5% of that sand in your total amount.

As it was coming up to the long weekend holiday period, I flew back to Australia. The following week, Dick called to tell me that the mixture was great, pump pressures were very low, and the mixture would "stack well" in vertical placements. I had also increased the rock content to 2000 lb (900 kg) to reduce pressure and decrease build up in the Sidewinder S-tube.

FLY ASH

Australia had an abundance of coal-fired power plants close to major cities that were producing a large amount of coal ash that was difficult to dispose of. However, in the early 1960s, an American by the name of Peabody had a bright idea to "help" the power plants solve their waste ash problem. Peabody entered into long-term disposal contracts with the power plants to remove their waste ash free of charge. At the same time, he had his daughter packing pozzolanic cement (fly ash) into plastic bags and sending off sample bags to all the ready-mix producers.

It turned out that by using a 75% portland cement and 25% fly ash blend in a concrete mixture it would improve long-term strength and reduce their costs, plus it made our concrete pump mixture designs in Australia much more pumpable. I kept telling everyone in the United States, "you should be using a fly ash blend rather than neat portland cement for shotcrete and pumping mixtures." At that time, they all called me crazy! I later found out that it would be another 4 to 5 years before fly ash blends were accepted in the United States.

Sidewinder exported to Bennet Brothers in starting their dealership

SIDEWINDER SALES TAKE OFF

By late 1980, Action Equipment salesman, Dave Rudin, was selling five Sidewinders per week in Arizona. Marion Ryder sold pumps to Shasta Pools and Sylvan Pools in Pennsylvania. Anthony Pools was running their special rigs in Texas. Haines Gunite and Superior Gunite were running Sidewinders. The Sidewinder became the "pump of choice" for shotcrete applications. We were air freighting one Sidewinder per day to Bennett Brothers in Los Angeles. Every month, a Sidewinder would be air freighted direct to dealers in New York or Pennsylvania. Air freight cost 46 cents per pound, Australia to Los Angeles, and an extra 18 cents to the East Coast. It turned out that the additional air freight cost was about the same as road freight for shipping a Sidewinder from Los Angeles to the East Coast.

SIDEWINDER DISAPPEARS

Around late 1981, Dick Bennett was approached by Jim Leach, President of Pacific Alloy Foundries, with a "buyout" proposal. Dick wanted to know if I had any problems with such a proposal, adding a "kicker" that if the deal goes through, Bennett Brothers would be able to settle all outstanding monies owed to Transcrete. Bennett Brothers was only a startup business when they became the lead dealership for Sidewinder pumps. Once Sidewinder sales took off, it was difficult for the Bennetts to have adequate cash flow for the operation. Their bank would not commit to funding such a new operation. As a result, Transcrete provided funding for new Sidewinders, with end buyer and distributor financing. Bennett Brothers' outstanding account was well over $500K US, so naturally I agreed to the sale.

Pacific Alloy's manufacturing skills were first class, so we agreed that they would only buy the Sidewinder pumping cell from Transcrete and do the rest on their premises. Money was never an issue, but their marketing ability was not that great. Thomsen Division, once the top pump manufacturer in the United States, had some difficulties with a management buyout, so we created a deal where Pacific Alloys would supply Sidewinder pumps to Thomsen, which in turn would be sold as "Thomsen Sidewinders." I felt that Transcrete should apply for trademark protection. We applied for and were granted the Sidewinder "snake" trademark. We found out from the U.S. Patent and Trademark Office that the Thomsen lawyers had also applied for the Sidewinder trademark. Fortunately, our application was lodged several hours before Thomsen. So much for "straight shooters." Thomsen was doing a great job; however, I could not see how a $25,000 trailer pump could solve Thomsen's financial issues. Then, we found out that Pacific Alloy Management was developing their own clone of our Sidewinder. Needless to say, Transcrete and Pacific Alloys parted company.

SIDEWINDER CLONES APPEAR

Transcrete attended the Atlanta World of Concrete to market Sidewinder pumps under the Transcrete brand. At the show, I was approached by the President of Security Pacific, the financiers of the Thomsen management buyout. Security Pacific wanted to dispose of Thomsen, and they presented me with a proposal that appealed to me. A handshake deal was made on the amount and terms. A week after the show, I received a Telex from Security Pacific Management advising me that Putzmeister had made an offer far higher than Transcrete was willing to pay and Putzmeister would be the successful bidder. As a matter of interest, Security Pacific would be providing funds to Putzmeister so they could buy Pacific Alloy as well. Under the Transcrete/ Pacific Alloy venture, the manufacturing agreement was not transferrable to another concrete pump manufacturer. A legal action was to follow.

I attended a meeting with Putzmeister and Pacific Alloy's "legal eagles" in Los Angeles. The theme was that the Pacific Alloy agreement should stand without the "not transferrable" clause, as my lawyer should not have included the clause. I explained that Pacific Alloy's team of three lawyers presented me with the Bennett Brothers buyout agreement 45 minutes from my air flight from Australia.

I read the agreement and asked if I could go up to the diner, to have a cup of coffee, and closely study the agreement. As I reviewed the proposed agreement, I made a few amendments. I returned 40 minutes later and presented the lawyers with my amendments. Jim Leach, Dick Bennett, and the three lawyers all agreed to my amendments. My reason for not wanting to change the legal document was I was not a lawyer and Jim Leach's three legal people should have advised their client(s) as to what they were signing.

Putzmeister accepted the document and proceeded with development of the Sidewinder copy they were to market as Putzmeister "Thom-Katt." It was many years before most Sidewinder parts were designed out of the Thom-Katt.

THEY BURY SIDEWINDER

In 1984, just prior to the LA Olympic Games, Transcrete sold a Sidewinder license to the Japanese manufacturer Suguie Ltd. In 1983, I purchased a home in the San Diego area and leased an office in La Jolla, CA. Dave Stoner, Vice President of Reed Manufacturing, contacted my office and was seeking a meeting to discuss the Sidewinder. I drove up to Reed's office in Walnut, CA, to meet with Dave. Reed was manufacturing the Reed dry-mix gun machine and could see the increased popularity of wet-mix shotcrete. Reed was a division of the Shea Construction group, so I felt comfortable with their capacity to manufacture the Sidewinder. A license agreement and the sale of the Sidewinder trademark was reached on the same terms as the Japanese deal. For tax purposes, we agreed to a monthly payment rather than a lump sum. We transferred Bruck Buckner and his partner Lisa to assist Reed's manufacturing program. Bruck and Lisa stayed on the Transcrete payroll for several years and finally transferred to Reed. For reasons best known to Reed, they proceeded to manufacture concrete pumps but dropped the use of the Sidewinder brand.

Back in Australia in 1987, Jacon Industries Pty Ltd., a Transcrete subcontractor, made an offer to buy the Sidewinder trademark and the rights to manufacture pumps. They started manufacturing pumps but did not use the Sidewinder brand. Jacon now specializes in manufacturing robotic shotcrete rigs for underground mining and tunnel applications that they sell worldwide under their own brand name.

Transcrete agreed to vacate the North American market for 5 years (and we did). Transcrete established a joint venture manufacturing plant in Los Angeles in 2002. Transcrete America Inc. moved into a larger factory in Pomona, CA, in mid-2016 and still manufactures the Trojan shotcrete pumps for the North American market. Dave Stoner asked Transcrete to design a new small, lower-cost trailer pump to tackle Mayco and Putzmeister models. In 1989, a production model Trojan was delivered to Reed. Stoner did not want to commit to ordering Trojans in large numbers. Transcrete, based on early discussions with Stoner, had tooled up to manufacture a batch of 100 Trojans for Reed and other markets. The Trojan is now the best-selling shotcrete pump in the Australian market. The North American market is very competitive with Sidewinder clones produced by Putzmeister, Warrior, Reed, Mayco, Airplaco, Schwing (S-tube model), and Olin—all with a touch of Sidewinder DNA.

THE PEOPLE BEHIND THE SIDEWINDER SUCCESS

The Sidewinder success was due to a large group of skilled people who made it their mission to sell the features and benefits of the Sidewinder for shotcrete applications: The Bennett Brothers, Al Connors and Dave Rudin in Arizona; Marion Ryder with his wide-ranging United States contacts; Fran Wilson; Bill Erwin, who attended a demo in Los Angeles whilst on Thomsen's payroll (Bill lent us a set of Allen wrenches when we had a minor hiccup during the demo); Michael Wilkman, the Northern Californian Sidewinder dealer; Pat Ingles, President of Pioneer Pumping Group who had the vision to buy a stock unit at Marion Ryder's suggestion; and finally all the dry-mix guys who switched to wet-mix. Today, it would be nearly impossible to assemble another group of people with the capacity to pull off what these gentlemen achieved in such a short time.

Born in Australia in 1941, ***Ian Hay*** *has spent a lifetime in widely diverse careers, including as a butcher, selling neon and outdoor signage, concrete placement, real estate, and eventually selling the Sidewinder S-tube pump for shotcrete placement.*

Overhead Shooting against PVC Membrane

By Frank E. Townsend III and Dennis Rubi

Overhead shotcrete application against any substrate is challenging. Shooting against a polyvinyl chloride (PVC) membrane waterproofing system increases the difficulty and danger of the process. This requires the use of alkali-free liquid set accelerator introduced to the mixture at the nozzle to provide rapid accelerated hydration, thus allowing increased layer thickness and reduced sagging. The PVC membrane is a flexible PVC sheeting that can be easily welded and repaired and can be applied efficiently on most wet and uneven substrates.

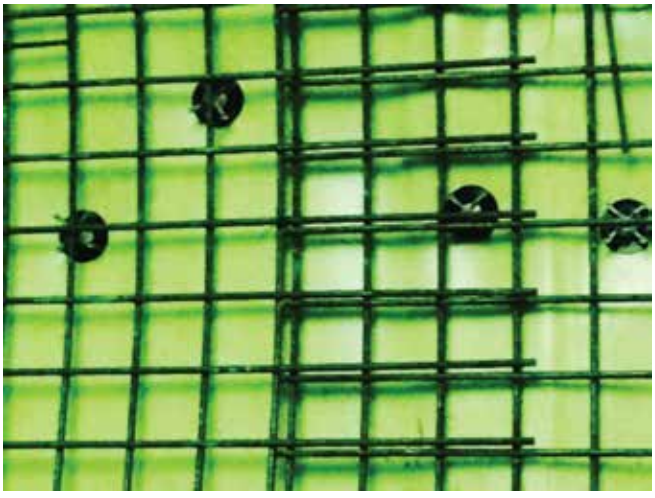
PVC membrane waterproofing system

Anchorage system

Creating the overhead shotcrete section starts with the substrate and anchoring system. A combination of rock-bolts, BA anchors, and reinforcement mats greatly assists as an anchorage system to support freshly applied concrete in place. It is critical that the reinforcing bar mats are rigid and adequately spaced. Also, the spacing of the reinforcement is important because if it is too tight, other means of form-and-pour should be used. If the reinforcement is not supported adequately, the shotcrete may collapse after placement as the reinforcement flexes with the weight of the concrete. Rigidity impacts the ability to properly encase the reinforcing steel because if the steel is loose, it will vibrate, leading to poor encapsulation.

The malleable nature of the PVC membrane against uneven surfaces, coupled with large BA anchor spacing, causes the sheeting to pillow in areas not tight against the substrate. More anchors in a tighter pattern will help hold the membrane closer to the substrate and thus create less pillowing. Shotcrete against the combination of this pillowing effect and the smooth surface of the PVC sheeting exacerbates the difficulty of shooting overhead. Plastic-tipped reinforcing bar slab bolsters are often used to put pressure on the areas of PVC membrane that sag.

The overhead shotcrete application against the PVC waterproofing membrane is undertaken on scaffold or lifts



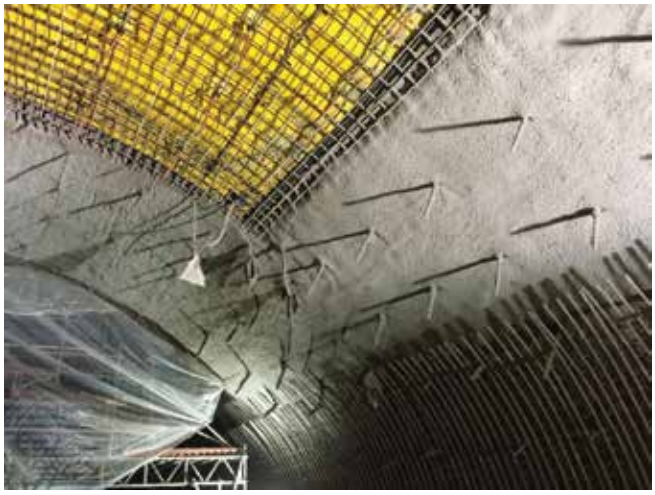
Reinforcing bar spacers

Shotcrete application building up from wall

Scratch finish between layers

to provide proper access for the nozzle to ensure it is within effective range for good encapsulation. With the nozzle pointed perpendicular to the receiving surface, and rotating to assure you get slightly different angles within 3.2 ft (1 m) of the back surface. The concrete material is applied in thin layers building up from the more vertical section of the walls to the overhead arch. Doing so minimizes the rebound as you approach the overhead sections. As you build up the concrete, focus is placed on building around the rock bolts to act as a bridge to support the load of the final lining. Reinforcing steel is encased by a combination of the workability of the material, distance of the nozzle, and high impact velocity, causing the concrete to flow around the bar, creating full encasement of the reinforcing bar and compaction of the concrete.

For the initial layer against the water barrier, shotcrete placement must be applied from joint to joint. The layout for the water barrier joints are identified and approved by the



Adjacent surfaces cleaned of debris

Second-layer reinforcement mat

engineer and laid out on the contract drawings. With exception of final linings, the initial layer and subsequent layers can be shot at a thickness of up to 12 in. (300 mm), given a rough, scratched finish, and will not be treated with curing compound. Curing compounds and bonding agents impair the bond between shotcrete layers.

Prior to application of the subsequent initial layer, placement must be cleaned by employing jet-wash cleaning to remove loose and foreign materials, as well as fume condensates, and to bring the surface to a saturated surface-dry condition (SSD).

Upon completion of an initial layer, another layer of prefabricated reinforcement mats will be installed to complete either a second layer or the final lining.

With exception of being restricted to placing shotcrete from joint-to-joint, required by the water barrier, subsequent layers can be stopped wherever it is necessary. These subsequent layers are completed in a similar fashion described in the sequence for the initial layer, and because shotcrete does not have cold joints produces a monolithic concrete section.

Once the liner is complete and finished, grouting must be performed to fully fill the back surface, especially in arch applications. The pillowing waterproofing-created air pockets must be filled with a thorough grout program between the PVC waterproofing membrane and shotcrete liner.

Final product

Frank E. Townsend III *is the East Coast Region Manager for Superior Gunite. He is a civil engineering graduate of Worcester Polytechnic Institute, Worcester, MA, and received his master's degree from the University of Missouri, Columbia, MO. Townsend comes from the U.S. Army Corps of Engineers and his diverse military background has led to him being deployed around the world. He is a member of ACI Committee 506, Shotcreting, and an ASA Board member. Townsend has been awarded the U.S. Army Corps of Engineers deFluery Medal and* Engineering News-Record *New York's "Top 20 under 40" design and construction leaders in 2016.*

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Dry-Mix Gun with Mobile Volumetric Batching Equipment

By Michael Reeves

Within any construction site, there are hazards that need to be recognized to produce a safe work environment. Working with dry-mix shotcrete is no different. There are a multitude of activities going on at one time that not only the person working directly with the equipment needs to know, but everyone working on the crew or around the site should also know. Here are a few things to look out for and help make for a safer and more productive work area.

BE SEEN. For starters, when working around heavy, moving equipment, you always want to be seen. Wearing a bright-colored safety vest or bright clothing will help you stand out to truck drivers and operators. This is important, especially with dry-mix volumetric batch trucks because they discharge from the rear of the truck. Each truck needs to be backed into the work area and up to the shotcrete gun. It can be difficult enough backing into a tight access in a large truck, so letting the driver know you are there and helping guide him in will only help.

DON'T GET CAUGHT. While on the topic of clothing, wearing form-fitting shirts and gloves is also important and easily overlooked. There are many moving parts on each of these volumetric batching trucks, between the sprockets and chain that connect to the sand and cement augers, the material mixing auger itself, and the rotating bowl agitator on the dry-mix shotcrete gun. As a gunman, you work close to these moving parts and you want to make sure no loose or torn clothing can get caught in any of these components.

USE YOUR SENSES. Like any construction site, you need to be aware of dust, dirt, and falling objects. The gunman should wear eye protection, ear protection, respirators, and hard hats. When operating a dry-mix batch truck, there are vibrators on the truck body to keep the cement and aggregate discharging into the auger. The dry-mix gun can also produce a lot of noise. As a result, this environment can get very loud for the gunman, so a quality set of ear protection is a good item to have that many new people often overlook.

Example of dry-mix crew working safely in an active environment | Crew: Revolution Gunite | Photo: Ryan Oakes

PROPER SAFETY COVERS. On the back of a dry-mix batch truck, there is a chain and two sprockets that should have a safety cover over them whenever the truck is running. One sprocket is attached to the sand auger and the other to the cement auger. Both augers are located inside the housing. However, the sprockets need to be accessible for maintenance and adjusting the cement ratio. The main sand auger runs off a hydraulic motor and a chain then connects to the cement auger. These hydraulic motors and augers are extremely strong and will not stop if something (such as fingers, loose clothing, or tools) get stuck in them.

HYDRAULIC ARMS ARE A MUST. This caution is more applicable to older-style mobile batching rigs, but is still a very important upgrade. Dry-mix batch trucks have a mixing auger on the back of the truck that is hinged at the bottom of the truck and adjusted downward by what should be a hydraulic arm connected from the top of the mixing auger to the back of the truck. Older-style trucks used a cable winch system to lower the auger. A cable winch system doesn't have the inherent stiffness of a hydraulic arm and it becomes much easier to allow the heavy mixing auger to swing loose and out of control. This can be a very dangerous hazard to crew around the auger discharge.

CONNECT YOUR HOSE. Dry-mix shotcrete requires a large air compressor to convey material to the nozzle. The air hose that is connected from the air compressor to the shotcrete gun is under the maximum pressure the compressor produces. You must have a whip check to connect the air hose to the dry-mix gun. Without this safety device, an air hose that accidentally becomes disconnected could whip around wildly, and potentially strike and injure someone.

MAINTAIN IT. Unfortunately, there is no way to see into the future. Things always seem to go wrong when you least expect it, so it is best to be prepared. Preventative maintenance is a must with any heavy equipment, including your shotcrete equipment. Check all your equipment daily. There are a lot of moving parts and catching something that is worn out before it breaks is the best way to create a safe and efficient work area.

Michael Reeves *is the Vice President of GSI Pool Finishes and Gunite Specialists, serving the industry in Pennsylvania and surrounding states. He grew up in the profession and is a second-generation guniter. Reeves is a member of ASA, ACI, NESPA, and APSP.*

Tips for Maintaining High- and Low-Pressure Concrete Pumps

By Tripp Farrell

Cleaning and maintenance is one of those "necessary evils." It takes time away from shotcrete placement on the project but skipping it can be even more time consuming, as well as costly. Concrete pumps are no exception. Consider these tips for cleaning and maintaining high- and low-pressure concrete pumps.

Hydraulic hopper lifts provide easy access to the pump kit for maintenance

Cup seals, or piston cups, attach to the end of the hydraulic rams and are the most common wear parts on swing tube piston pumps

HIGH-PRESSURE HYDRAULIC SWING TUBE PISTON PUMPS

It's essential that hydraulic swing tube pumps are kept in working order at all times. These pumps, commonly used for low-slump concrete and pumping mixtures extreme distances, can generate more than 2000 psi (14 MPa) of line pressure for working in the most demanding concrete pumping and shotcrete applications.

Keeping the hydraulic pumping pressure as low as possible can help to prevent premature wear. Routinely conduct preventative maintenance on the primary wear parts. Cup seals, or piston cups, attach to the end of the pump's hydraulic rams and are the most common wear parts on swing tube piston pumps. Also, regularly check poly packs, the wear plate, and wear ring.

Clean the pumping system properly after each use to avoid premature wear on the cup seals and material pumping cylinders. A swing out or hydraulic lift hopper offers easy and quick access for cleaning and maintenance.

Generously grease the outgoing housing, swing tube shaft, and swing tube cylinders each hour during operation. Consider automatic lubrication systems for swing tube pumps, as this drastically reduces maintenance costs and as a result increases return on investment.

Swing-out hoppers give users easy access to the pump kit for maintenance

LOW-PRESSURE PERISTALTIC (SQUEEZE) PUMPS

Hydraulic peristaltic pumps are used for lower-pressure concrete pumping, grouting, shotcrete, plastering, and cellular concrete applications. These pumps generate in excess of 450 psi (3.10 MPa) of line pressure and cannot pump material extremely long distances. However, they have a niche when pumping materials within 250 ft (76 m) horizontally and 50 ft (15 m) vertically. Peristaltic pumps are extremely simple and safe to operate. These units can run in reverse to remove blockages or obstructions without damaging the pump. They also can be operated as a skidsteer work tool or by other equipment equipped with auxiliary hydraulics.

There's only one wear part on these squeeze pumps: the rubber pumping tube, which makes them an economical concrete pump. Maintenance costs are typically less than $1 per yd^3 (m^3) of pumped material. To ensure maximum longevity of the pumping tube and reduce maintenance costs, keep a log of the amount of material pumped through each pumping tube. After noticeable wear, remove the tube, flip it 180 degrees and install it back inthe pump.

Operators can easily clean peristaltic pumps with a round sponge ball because no concrete comes in contact with the pump's moving parts. Concrete is pumped out of the hopper and the sponge ball is sucked into the pump's inlet pipe. Next, flood the hopper with clean water. The sponge serves as a dam between the concrete being pumped and the cleanup water. Engage the pump in forward and the water pushes the ball through the pump and delivery system for a quick and simple cleanup.

Both high- and low-pressure concrete pumps have advantages and disadvantages. Work with an experienced pump manufacturer to help determine the best pump for the application. This ensures minimal maintenance and downtime.

There's only one primary wear part on peristaltic pumps—the rubber pumping tube—which makes these the most simple/ economical concrete pumps to own

Consider automatic lubrication systems for swing tube pumps, as these drastically reduce maintenance costs and increase return on investment

***Tripp Farrell** joined Blastcrete Equipment, LLC, in 2000 and serves as President. In addition to his responsibilities in sales, he works in product design and conducts product demonstrations and training. He is also involved in advertising and marketing of the Blastcrete product line, as well as research and development and, most importantly, customer service.*

2018 Winter Olympics Sliding Track Mockup Test

By Kyong-Ku Yun, Yong-Gon Kim, and Dudley R. (Rusty) Morgan

On June 4, 2014, a mockup of the 2018 Winter Olympics sliding track was constructed by Daesang E&C Co. Ltd., constructors of the track, with the help of Kyong-Ku Yun, Professor of Civil Engineering at Kangwong National University, Chuncheon, Gangwon-do, South Korea, and with consultation by D. R. (Rusty) Morgan, PEng, FACI. Morgan had previously communicated with Yun about shotcrete construction of the track; on the day of the mockup construction, provided advice to Yun and, through him, to the Daesang construction team regarding optimal means and methods for the mockup construction. This article provides observations and evaluation on construction of the mockup, together with insight on opportunities for improvement.

TRACK MOCKUP CHALLENGES

Mockup Procedures

Figure 1 shows a general view of the track mockup prior to shotcrete placement with the reinforcing steel and cooling pipes installed in the track. Also note the open edge forms used at the top of the lower wall section (low wall) and the plastic screed pipes used to control final finish line and grade. Figure 2 shows an end view of the cooling pipes and reinforcing steel in the higher wall section of the track (high wall). Also note the stay-in-place form installed at the back of the wall.

Fig. 1: General view of track mockup prior to shotcrete construction

The mockup was constructed in accordance with the project design drawings and specifications. The cooling pipes and reinforcing steel were installed as specified, except for one small area in the invert, where some of the reinforcing steel intruded into the "covercrete" zone of the mockup. The contractor acknowledged this item will be corrected during construction of the actual track. It was also noted that the stay-in-place form installed at the back of the structure had V-ribs that were only 0.3 in. (8 mm) high. As a result, the stay-in-place form will be chaired only 0.3 in. (8 mm) off the back row of vertical reinforcing steel. This is less than the 0.4 in. (10 mm) diameter of the vertical bars. While not a major concern for the "coved" areas of the track, where the shotcrete can be further consolidated by

Fig. 2: End view of reinforcing steel, cooling pipes, and Stay-Form in high wall

use of immersion vibrators after shotcrete application, it is a concern for the high wall and shotcreted portion of the low wall, where it becomes difficult for the shotcrete material to wrap behind the back row of bars and fully encase them during shooting. A stay-in-place form, similar to the AMICO product, with a taller 0.8 in. (20 mm) high V-rib (as used in the Canadian Whistler 2010 Winter Olympics track) should be used in future shotcreted tracks. This should make it easier to consolidate the shotcrete around the back row of bars and at the contact area with the stay-in-place form.

Another issue was noted: while the plastic screed pipe used to control line and grade in the high wall and the adjacent side of the invert was suitable for its intended purpose, the screed pipe extending from the low wall to the invert was too flexible. The result is that the screed guide had some bumps in it as installed and did not properly control line and grade. The product used for the screed pipe in the high wall was too stiff to bend to the radius of the low wall without kinking. It is recommended that another screed pipe product with a stiffness between the current mockup high wall and low wall screed pipes be identified and used in the actual track construction.

Shotcrete Mixture Design and Performance

Details of the shotcrete mixture design used for the mockup construction are provided in Table 1. The blended cement contained 93% portland cement and 7% condensed silica fume by mass. The mixture was air entrained to provide the shotcrete with resistance to freezing and thawing. The measured plastic air content at the point of discharge into the shotcrete pump was over 10% and the slump was 5.5 in. (140 mm). After shooting, the as-shot air content reduced to 4% and the as-shot slump reduced to 1.2 in. (30 mm). This demonstrates the beneficial "slump-killing" effect of using high air entrainment to improve pumpability in the concrete mixture. The residual air content of 4% is expected to provide the shotcrete with good freezing-and-thawing resistance. The aggregate gradation meets ACI 506 Gradation No. 2 (coarse aggregate gradation) for shotcrete.

The shotcrete mixture shot quite well, with no significant sloughing or fall-out on vertical surfaces. In Morgan's opinion, it was, however, a bit "sticky." The ability of the mixture to wrap around the reinforcing steel and cooling pipes and provide full consolidation could be enhanced by making the mixture a bit less sticky. It is suggested that smaller-scale trials be conducted on vertical test panels to assess the shooting characteristics of a mixture with the silica fume content reduced to 5% by mass of cement and a second mixture with 15% fly ash by mass of cement and no silica fume. Such mixtures would be less sticky than the mixture used in the mockup and would be expected to provide better encasement of the reinforcing bar and cooling pipes and be a bit friendlier for finishing operations—that is, be less stiff and thus less susceptible to "tearing" during troweling and finishing operations.

Shotcrete Supply

Shotcrete was batched and mixed using the mobile mixer unit shown in Fig. 3. The shotcrete was discharged from the mixing auger on the mobile mixer into an Allentown P20 shotcrete pump, as shown in Fig. 3. This was an excellent system for shotcrete batching, mixing, and supply for the track construction. Mobile batching units enable the production of shotcrete that is always "fresh" and facilitates fine tuning of the workability (slump) of the shotcrete to optimize it for shooting the different parts of the track. Control of workability of the shotcrete during construction of the mockup was generally good, indicating that the mobile batcher unit and pump were operated by an experienced and competent crew.

Fig. 3: Bench gun shooting shotcrete in high wall

Shotcrete Installation

The shotcrete was placed in a sequence generally consistent with that the process recommended for the construction of bobsleigh/luge tracks. More specifically, the mockup track was constructed in this sequence:

1. Shotcrete placed in the coved area of the low wall;

Table 1: Mockup Construction Mixture Design

Design strength	Max. size of coarse aggregate	Targeted slump	Air content as shotcrete	W/B	S/a	Unit content (kg/m)					
MPa	mm	mm	%		%	water	Pre-blended cement	Sand	Gravel	WR	AE
35	10	80 ± 20	10	0.40	75	184	460	1099	380	2.300	0.181

2. Shotcrete applied to the coved area of the high wall (Fig. 4);
3. Shotcrete placed in the track invert;
4. Shotcrete placed in the high wall using a “bench” shooting method;
5. Shotcrete placed in the formed low-wall head beam;
6. Shotcrete placed in the high-wall head beams;
7. After a suitable delay period to allow the shotcrete in the low-wall head beam to set sufficiently, the inside form boards were removed in preparation for application of the final lift of shotcrete;
8. The inner form board in the high wall was removed in preparation for the application of the final lift of covercrete shotcrete;
9. The finish “flash” coat of shotcrete, approximately 1.2 in. (30 mm) thick, was applied to the high wall;
10. After completion of troweling, the plastic screed pipes were released by cutting the steel wires securing them to the reinforcing steel and removed;
11. After a suitable delay period, the final shotcrete surface was given a light hand-applied broom finish;
12. The form board was removed from the low-wall header beam and the shotcrete trimmed in the same way as the high wall in preparation for application of the final lift of covercrete shotcrete;
13. After cutting with the cutting screed to the screed pipes, the shotcrete was finished with hand floats and special tools. Figure 5 shows finishing of the radius edge of the low wall using a tool custom built for this purpose;
14. After setting, the shotcrete was covered with a plastic sheet; and
15. Finally, it is recommended that, prior to applying shotcrete to the back side of the stay-in-place form, the back side should be high-pressure water-blasted (minimum 5000 psi [35 MPa]) to remove any loose or porous shotcrete “dribble” and open the screen.

Figure 6 shows the completed mockup after application of the broom texture finish. Figure 7 shows members of the mockup engineering design, inspection, and construction team.

Fig. 4: Shotcrete applied to the coved area of the high wall

Fig. 5: Finishing radius cove of low wall with a custom-built tool

Fig. 6: Completed mockup after application of broom finish texture

Fig. 7: Members of the engineering design, inspection, and construction team

EVALUATION OF MOCKUP TEST

Hardened Shotcrete Evaluation

On June 6, 2014, after the shotcrete had been able to harden and gain sufficient strength, seven cores and a 1.6 x 1.6 ft (500 x 500 mm) slab were extracted from the shotcrete mockup at locations selected by the design engineer, Uwe Deyle, President of Planungsburo Deyle GmbH, and Giacomo Dariz, Chair of the Track Committee for the FIBT.

Four of the cores were taken from the corners of the slab in the high wall to assist in extraction of this slab. A fifth core was taken from the slab cove, a sixth from the slab invert, and a seventh core from high up in the high wall. Figure 8 shows diamond-tipped core drill extracting the first core.

Condition of Extracted Cores

Figures 9 and 10 show the sides of the slab removed from the high wall.

Figure 11 shows Core No. 1. There is excellent consolidation of the shotcrete and encapsulation of the front layer of reinforcing steel and around the cooling pipe. The shotcrete is, however, porous and not well consolidated around the back layer of reinforcing steel (left side of the photo) adjacent to the stay-in-place form. This shotcrete was considered unacceptable. The likely reasons for the shotcrete around the back layer of reinforcing steel and adjacent to the stay-in-place form being porous have been discussed previously in this article in the section discussing shotcrete application.

Figure 12 shows a side view of Core No. 2. This core broke in two during core extraction at a porous zone behind

Fig. 8: Diamond drilling extraction of first core

Fig. 9: View of right side of slab removed from high wall. Note typically good encapsulation of reinforcing bar and cooling pipes

Fig. 10: View of top of slab removed from high wall. Note voids behind cooling pipe and back reinforcing bar

Fig. 11: Side view of Core No. 1. Note voids around back layer of reinforcing bar near stay-in-place form. Assigned ACI Core Grading No. 4

Fig. 12: View of middle of Core No. 2. Note porosity behind cooling pipe. Assigned ACI Core Grade No. 3

the cooling pipe. Some porosity was also noted adjacent the stay-in-place form. Shotcrete in this core would be considered marginally acceptable.

Figure 13 shows a side view of Core No. 3. While shotcrete consolidation is generally good around the reinforcing steel and cooling pipes, there are some voids in front of the cooling pipes. This was considered marginally acceptable shotcrete.

Fig. 13: Side view of Core No. 3. Note voids in front of cooling pipes. Assigned ACI Core Grade No. 3

Fig. 14: Side view of Core No. 4. Note porous shadow behind cooling pipe. Assigned ACI Core Grade No. 3

Fig. 15: Side view of Core No. 5. Core broke in two at porous zone behind cooling pipe. Assigned Core Grade No. 4

Figure 14 shows a side view of Core No. 4. The shotcrete in front of and around the cooling pipe is well consolidated. There is, however, a porous "shadow" behind the cooling pipe and, overall, this core would be considered marginally acceptable.

Figure 15 shows a side view of Core No. 5 extracted from high up in the high wall. The core broke in two at a porous zone behind the cooling pipe. This porous zone was also visible in the core hole. This core was considered unacceptable.

Figure 16 shows a side view of Core No. 6 extracted from the mockup invert. While the core fractured during extraction, the shotcrete was observed to be well consolidated and essentially void-free. This core was considered acceptable.

Finally, Fig. 17 shows a side view of Core No. 7 extracted from the shotcrete cove on the high wall. This shotcrete was observed to be generally well consolidated and was considered acceptable.

In summary, the shotcrete in Core No. 6 from the invert and Core No. 7 from the high wall cove is high quality. The shotcrete in Core No. 5 from high in the high wall is of unacceptable quality. Three of the four cores (Cores

Fig. 16: Side view of Core No. 6 from invert. Shotcrete well consolidated and assigned ACI Core Grade No. 1

Fig. 17: Side view of core No. 7 from high wall cove. Shotcrete typically well consolidated and assigned ACI Core Grade No. 2

No. 2, 3, and 4) from the slab cut out in the high wall are of marginally acceptable quality and the fourth core in this area (Core No. 1) is of unacceptable quality.

The voids observed in some of the extracted cores, as detailed earlier, are not as apparent in the sides of the saw-cut holes or in the extracted panel, as shown in Fig. 9 and 10. This is in part because raveling and washout caused by the coring operation and cracking sometimes caused by core extraction tends to exaggerate the extent of any defects in the shotcrete.

Remedial Considerations

Defects at the back of the shotcrete section, such as the voids observed behind the cooling pipes at some locations and voids around the back row of reinforcing steel bars, can be remediated by the following process before applying the back-lift of shotcrete to the stay-in-place form. Remove the stay-in-place form at areas of concern, then use hydro-milling (high-pressure water blasting, typically 29,000 to 40,000 psi [200 to 275 MPa]) to remove all porous shotcrete and open the voids to allow full encapsulation of the back layer of reinforcing steel and back of the cooling pipes when shooting in the back layer of shotcrete. The substrate shotcrete should be in a saturated surface-dry (SSD) condition at the time the back layer of shotcrete is applied. Note that in the final track construction, there will be some areas, such as at the baffle ends of the cooling pipes, where the steel congestion is so great that some back voids are likely to occur during the initial shooting. Such areas should be carefully evaluated for the need for remedial work, as described herein, and be part of the design/construction process.

Opportunities for Improvement

A summary of the "opportunities for improvement" include:

1. Care should be taken to ensure that reinforcing steel does not intrude into the "covercrete" zone;
2. Use stay-in-place form with deeper 0.8 in. (20 mm) V ribs, rather than the 0.3 in. (8 mm) deep V ribs used in the mockup, to better support the stay-in-place form off the back vertical reinforcing steel bars;
3. Use a more rigid screed pipe in the low wall;
4. Run trials with less "sticky" shotcrete mixture designs on vertical test panels. Trials with a mixture containing 5% silica fume and a second mixture with 15% fly ash are recommended;
5. Extend the shotcrete application in the coves in the low and high walls further down into the track invert;
6. The nozzleman should increase the air volume or hold the nozzle closer to the work to increase the shotcrete material impact velocity;
7. The nozzleman should systematically first shoot below and then above the horizontal cooling pipes with a sweeping motion to optimize shotcrete consolidation;
8. More systematic insertion of the immersion vibrator is required to improve concrete consolidation in the coved areas, invert and low- and high-wall header beams;
9. Consideration should be given to judicious use of stay-in-place form at the open bottom of the header beam to improve the vibration and consolidation of the shotcrete with reduced fallout;
10. The low-wall finish coat should be applied and trimmed prior to shooting the invert finish coat;
11. The finishers should use longer cutting screeds and trowels to improve productivity and the final finish grade and tolerance;
12. A wider stiff-bristle broom should be used for application of the broom finish to improve productivity and the final finish appearance; and
13. The shotcrete should be fogged/misted as soon as finishing operations have been completed and it has reached initial set. As soon as it has reached final set, it should be covered with presaturated curing fabric and then kept wet for at least 7 days using soaker hoses or a suitable equivalent.

SUMMARY

In summary, except for the long void behind the cooling pipe at the top of the saw-cut hole and porous zones in cores

Fig. 18: Sliding track under construction

Fig. 19: Overview of completed sliding track

PROJECT PARTNERS

Project Name
Pyeongchang 2018 Winter Olympic Sliding Track Mockup Test

Project Location
Pyeongchang, Korea

Shotcrete Contractor
Daesang E&C

General Contractor
Daelim Co.

Engineer
Yooshin Engineering Co.

Material Supplier
Daesang E&C

Project Owner
Gangwon-do Provincial Government, Korea

No. 1 and No. 5, the shotcrete in the mockup is considered close to being of suitable quality. It is believed that, with implementation of the "opportunities for improvement" referred to in this report, and with the increasing skills that will be developed by the nozzleman and crew as the final track construction proceeds, the owner should receive a quality track that conforms to the intent of the project specifications.

As a result of the mockup and evaluation, the entire sliding track for bobsleigh, luge, and skeleton was successfully constructed by the end of 2015 (refer to Fig. 18 and 19).

Kyong-Ku Yun *is a Professor at Kangwon National University, Chuncheon-si, Gangwon-do, South Korea. He received his PhD from Michigan State University, East Lansing, MI, in 1995. His research interests include shotcrete and concrete materials. Recently, he has been heavily involved in shotcrete research and has consulted on the shotcrete material and overall procedures for this rehabilitation project.*

Yong-Gon Kim *is CEO of Daesang E&C, a leading Korean company for shotcrete research and application. He received his PhD from Kangwon National University, Chuncheon, Gangwon-do, South Korea, in 2010, with an emphasis on latex-modified concrete and steel fiber-reinforced concrete. His research interests include shotcrete application.*

Dudley R. (Rusty) Morgan*, PhD, P.Eng, FACI, is a civil engineer with over 50 years of experience in the concrete and shotcrete industries. He is a Fellow of the American Concrete Institute and was a member and Secretary of ACI Committee 506, Shotcreting, for over 25 years. He was a member of ACI Committees 365, Service Life Prediction, and 544, Fiber-Reinforced Concrete. Morgan is a Founding Member and Past President of ASA. He is an ACI Committee C660-approved Shotcrete Nozzleman Examiner and presenter for the ASA Shotcrete Nozzleman Education course. He is a past member of the Canadian Standards Association Concrete Steering Committee and was Canadian Representative on the International Tunneling Association Committee: Shotcrete Use. Morgan has worked on over 1000 concrete and shotcrete projects around the world during his consulting career, and has edited five books and published over 150 papers on various aspects of concrete and shotcrete technology. In 2001, he was elected as a Fellow of the Canadian Academy of Engineering.*

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Hydro-Mix Nozzle Setups

By Ray Schallom III

Hydro-mix and predampening nozzle options have been around for many decades—some dating back to the original cement gun company days. Through the years, former licensees have used and perfected the use of the hydro-mix nozzle for dry-mix shotcrete.

The correct length for the hydro-mix nozzle placement in the hose before the nozzle began to vary from manufacturer to manufacturer. Older, more experienced shotcrete contractors normally would use an 8 to 10 ft (2.4 to 3.0 m) hydro-mix nozzle arrangement for better mixing of the concrete material before it passed through the nozzle tip (refer to Fig. 1). The nozzle setups made today are often only 3 to 4 ft (0.9 to 1.2 m) long; that places the nozzle body between the nozzleman's legs and does not allow ample time for material mixing before it leaves the nozzle.

Predampening raises moisture in the dry concrete materials to a 3 to 5% level to help start the hydration process, cut down on dust, and reduce wear in the gun. Predampening also reduces the potential for buildup of static electricity generated by conveying bone-dry bagged material through the hose.

Predampening is good for normal-set concrete mixtures but not accelerated or fast-set concrete mixtures, which may start setting up before reaching the receiving surface from the nozzle. Thus, hydro-mix nozzle setups are used with accelerated and fast-set concrete mixtures in place of the preferred predampening method. Hydro-mix nozzle setups are also used in refractory installations, mining, and tunnel operations where fast-setting materials are routinely gunned.

Fig. 1: A 2 in. (50 mm), 8 to 10 ft (2.4 to 3.0 m) hydro-mix nozzle and hose setup that gives good mixing action before the concrete material reaches the nozzle tip. Also, note the easy access to the water body to clean out the water ring daily

When shooting bagged, dry materials, using a hydro-mix nozzle is a better alternative than using a regular nozzle setup. Having the waterbody well before the nozzle allows the concrete materials longer exposure and mixing with the water than in a standard nozzle, where the waterbody is right at the nozzle. It is still not better than predampening material before it enters the dry shotcrete gun, but it is much better than not using it without predampening.

In my opinion, using a predampener and hydro-mix nozzle setup would be the best of both worlds because we would have a more completely mixed concrete material hitting the receiving surface. The dry material is conveyed through the hose at 60 to 80 miles/h (100 to 130 km/h) as it passes through the water-spray jets of the water ring. Without the proper concrete mixing action required before it is discharged out of the nozzle, the nozzlemen would have a difficult time trying to mix and blend the layers as they build out material.

In ACI and ASA committee meetings, there have been lengthy discussions over the use of a hydro-mix nozzle versus pre-dampening. Finally, 2 years ago, ACI Committee C660, Shotcrete Nozzlemen Certification, voted to accept the hydro-mix nozzle as an alternative to predampening. However, the nozzle setup must be at least 8 to 10 ft (2.4 to 3.0 m) back in the hose from the nozzle for proper mixing action.

Figure 2 is a picture of a prewetting nozzle setup to which I was exposed early in my career. It wasn't until 20 years into my nozzling career that I started using one. You must have great water pressure—at least 15 psi (0.1 MPa) higher than your air pressure at both water rings—and at least a 750 ft^3/min (21 m^3/min) compressor to push the concrete material through both water rings correctly. The water ring that is 8 to 10 ft (2.4 to 3.0 m) before the nozzle is for predampening the concrete materials as they pass through the hose. The water ring in the nozzle body is used for applying 90% of the mixing water as the concrete is shot from the nozzle onto the receiving surface. Both water valves need to be either needle valves or diaphragm valves to allow precise metering of the water into the concrete mixture as it passes through them.

In conclusion, after 40 years as a nozzlemen, the hydro-mix and prewetting nozzle setups do work, but it is not as

Fig. 2: A prewetting setup with two water valves and nozzle bodies with water rings

good as predampening the material prior to placing into the machine. Remember: predampening the dry material controls the dusting around the machine, reduces wear, and reduces static electricity when you convey the damp material. That's why when not predampening, the hydro-mix water body needs to be 8 to 10 ft (2.4 to 3.0 m) back in the hose to wet material before it reaches the nozzle. The material in that 8 to 10 ft (2.4 to 3.0 m) of hose is more thoroughly hydrated, thus substantially reducing the buildup of static electricity that can shock the nozzleman. Having the hydro-mix water ring 3 ft (0.9 m) back places it between the nozzleman's legs, where it is difficult to hold up due to its extra weight and with the short hose length can produce a good shock. Good shotcrete practices and common sense, with many techniques first learned back in 1909, are still applicable today. Shortcuts hurt the entire industry. There are many good resources offered by the American Shotcrete Association at **www.shotcrete.org**. Of particular interest, all the past *Shotcrete* magazine articles can be found on the website and can help educate the nozzlemen, crew, and owners about the shotcrete process for high-quality, durable concrete placement in a wide variety of concrete applications.

Ray Schallom III *is a shotcrete application specialist and President of RCS Consulting & Construction Co. Inc. He has 40 years of experience as a Project Manager, Owner, and Superintendent. Schallom works with State DOT on their shotcrete specifications and trains engineering company inspectors in the field of shotcrete. He is a Past President of the American Shotcrete Association; past Chair of the ASA Education Committee; and a member of the ASA Publications, Underground, Marketing, and Pool & Recreational Shotcrete Committees. He is also a member of ACI Committee 506, Shotcrete; C660, Shotcrete Nozzleman Certification; and various ACI 506 Subcommittees. With over 36 years of shotcrete nozzling experience in wet- and dry-mix handheld and robotic applications, Schallom is a retired ACI Certified Nozzleman in the wet- and dry-mix process for vertical and overhead applications, as well as an ASA-approved ACI Shotcrete Examiner for wet and dry applications. He is also a member of ASTM Committee C09, Concrete and Concrete Aggregates, and Subcommittee C09.46, Shotcrete.*

NEW ASA MEMBERS

american shotcrete association | asa

CORPORATE MEMBERS

ABC Polymer Industries
Helena, AL
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Air Placed Concrete
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Primary Contact: Jose G. Aguayo
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NOZZLEMEN

William A. Underwood
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STUDENTS

Asif Arshid
North Dakota State University

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

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Take the step that will help grow your organization and industry—become an ASA Corporate Member today

american shotcrete association | asa

For more information on ASA membership, visit www.Shotcrete.org/Membership

THE EUCLID GROUP

The Euclid Chemical Company has joined with several RPM International Inc. subsidiaries, including Eucomex, Toxement, Cave, Viapol, Flowcrete, RPM Belgium, and Vandex, to create The Euclid Group. Each of the operating businesses will sit equally under The Euclid Group umbrella, but will also be able to manufacture and supply additional construction chemical solutions according to local demand and production capabilities. The Euclid Group will consist of 34 manufacturing facilities in 14 countries, a sales presence in 55 countries, and over 2100 staff. The combined portfolio of the new group includes concrete admixtures, polymer and steel fibers, coatings, grouts, leveling compounds, specialty polymer flooring, and decorative concrete products. The Euclid Group will operate as part of the RPM Performance Coatings Group, a subsidiary of RPM International Inc.

KRYTON INTERNATIONAL ACQUIRES CEMENTEC INDUSTRIES

Advancement of "Smart Concrete Solutions"

Vancouver-based Kryton International Inc., which specializes in crystalline concrete waterproofing, announces its acquisition of Calgary-based Cementec Industries Inc., a manufacturer of concrete additive solutions for the construction, oil, and gas industries.

This acquisition demonstrates Kryton's commitment to innovation while complementing its existing lineup of Smart Concrete® waterproofing solutions. Hard-Cem®, the integral concrete hardening admixture developed by Cementec, is an award-winning innovation that provides concrete with unmatched resistance to abrasion and erosion. With this admixture, concrete floors and infrastructure last up to six times longer than untreated concrete. As a result, costly repairs and the inconvenience of shutdowns can be avoided.

Cementec also manufactures silica fume products that are used to densify and strengthen concrete. These Cementec solutions can be used in conjunction with Kryton's award-winning Krystol Internal Membrane™ (KIM®) system to provide customers with Smart Concrete solutions that will save time while providing durability.

"The breakthrough concrete solutions developed by Cementec are technically superior and innovative. Not only do they increase infrastructure's service life and eliminate exposure to harmful dust, Hard-Cem removes quality control issues and provides increased design flexibility. This will bring greater value to our customers," says Kari Yuers, CEO of Kryton.

"Hard-Cem and silica fume will extend our product offerings in integral concrete durability, erosion, and abrasion protection. We intend to be a go-to solutions provider to an industry that is increasingly concerned about protecting and extending the lifespan of concrete structures," adds Kevin Yuers, Vice-President of Product Development at Kryton.

"This is a perfect match of expertise and a shared mission in providing unique solutions, exemplary customer service and market leadership," says Farid Remtulla, President of

Cementec, adding that "Kryton will offer global exposure for Cementec products."

About Kryton

Kryton International Inc. is the inventor of the crystalline waterproofing admixture and has been waterproofing concrete structures with its proprietary Krystol® technology since 1973. It has won awards for innovation, manufacturing, and best place to work, as well as entrepreneurial awards. Kryton is an active member of the American Concrete Institute, International Concrete Repair Institute, American Shotcrete Association, and many other thought-leading organizations. Kryton exports its products to more than 50 countries globally. Further information is available at **www.kryton.com**.

About Cementec

Cementec Industries Inc. is an award-winning product developer and manufacturer of proprietary concrete products for the construction, oil and gas industries. Cementec manufactures Hard-Cem, an integral (not surface-applied) concrete hardener for increased abrasive and erosive wear resistance of ready mixed concrete, precast concrete, and shotcrete. It won the Most Innovative Product Award at the World of Concrete in 2007. Hard-Cem has been used in over 50 million square feet (46 million square meters) of concrete at work across North America in commercial, industrial, hydro, and infrastructure applications. Cementec is also the only manufacturer of silica fume products in Western Canada.

GEOSTABILIZATION INTERNATIONAL® ESTABLISHES BRIDGE DIVISION

The Bridge Division of GeoStabilization International (GSI) expands GSI's ability to deliver time-critical bridge rehabilitation and construction services by applying cutting-edge technologies and approaches developed through decades of emergency geohazard mitigation and bridge rehabilitation/construction experience.

By leveraging extensive soil nail, micropile, shotcrete, compaction grouting, and GRS construction capabilities, GSI's Bridge Division can solve budget, access, and design challenges most bridge rehabilitation or construction projects face. The innovative approach to bridge substructure rehabilitation enables GSI to reduce project cost, schedule, road closures, and environmental impacts. As with their other geohazards mitigation services, GSI Bridge Division provides 24-hour on-call response to bridge emergencies.

Over the last 15 years, GSI has amassed a considerable bridge rehabilitation resume, and GSI's founders were also instrumental in developing the Geosynthetically Reinforced Soil-Integrated Bridge System (GRS-IBS), designing and installing the first of these structures in the world. More recently, the FHWA has promoted GRS-IBS technology as one that can provide numerous benefits over conventional bridge construction. Through a newly-formalized strategic partnership with U.S. Bridge, GSI will expand its ability to provide complete, turn-key, design/build GRS-IBS solutions. Since 1930, U.S. Bridge has been a recognized leader in the design and manufacture of steel beam and truss bridges. GSI's partnership with U.S. Bridge allows them to seamlessly deliver a complete GRS-IBS solution in a fraction of the time more conventional systems or approaches would take.

For more information, go to: **www.geostabilization.com/contact-us**.

ASA SHOTCRETE CONVENTION AND TECHNOLOGY CONFERENCE

March 11-13, 2018 | Silverado Resort and Spa | Napa, CA

ASA is proud to recognize 20 years of service to the industry by providing resources, qualification, certification, education, networks, and leadership to increase the acceptance, quality, and safe practices of the shotcrete process. Come celebrate with us and attend this dynamic event specifically designed for the shotcrete industry. ASA will bring together exhibitors and speakers that exemplify the state of the art in shotcrete today, hosted in a format and venue that provides plenty of time for interaction with leaders and decision-makers from the shotcrete industry. We also have many fun and exciting activities planned, taking advantage of the unique experiences that California's Napa Valley and the Silverado Resort and Spa lend to the destination.

ASA CONTRACTOR QUALIFICATION PROGRAM (CQP) LAUNCH

Sunday, March 11, 2018 | Silverado Resort and Spa | Napa, CA

The American Shotcrete Association—a leader in informing and educating the construction industry on quality, economical, and durable shotcrete placement for a wide variety of concrete applications—introduces a program to help specifiers and project owners identify shotcrete contractors with the appropriate qualifications for shotcrete applications of varying complexity.

With qualifications in either Basic or Advanced shotcrete work categories, both contractors and owners benefit from having the ASA Contractor's Qualification Committee review company work histories, verify experience on referenced projects, and confirm shotcrete crew experience to better match contractor experience to the project requirements. Experienced shotcrete contractors are encouraged to submit their applications for the Contractor Qualification Program. Specifiers are encouraged to require an

ASA-qualified contractor for their projects, selecting the appropriate level of qualification based on the difficulty of application.

Attend the seminar and be part of the program launch!

Silverado Resort and Spa, Napa, CA

SHOTCRETE TECHNOLOGY CONFERENCE

Tuesday, March 13, 2018 | Silverado Resort and Spa | Napa, CA

Bringing together industry leaders, ASA is pleased to offer a diverse range of state-of-the-art and innovative practices in shotcrete presentations at this conference. See table at right for complete course list.

ANNUAL OUTSTANDING SHOTCRETE PROJECTS AWARDS BANQUET

Tuesday, March 13, 2018 | Inglenook Winery and Wine Caves | Napa, CA

This awards banquet is a highlight event for the industry. Normally held in conjunction with World of Concrete in Las Vegas, we are excited to host this year's celebration at this elegant and historic Napa-area winery. Look for it as an optional ticketed event when registering for the convention.

Inglenook Winery

For complete information on the activities, technology conference sessions, registration, and resort reservations, please go to: **www.shotcrete.org/20thAnniversary.**

Shotcrete Technology Conference Presenters and Topics

Speaker	Topic
Bill Allen	Equipment Safety: Prevention through Design
Chris Breeds	Architectural Aspects of Shotcrete Final Linings in Water Proofed Tunnels
Patrick Bridger	State of the Art in Shotcrete Equipment
William Clements	Innovative Shotcrete Technologies for Underground Development and Infrastructure Repairs
Bill Drakeley	State of the Art in Shotcrete Pool Design and Construction
Oscar Duckworth	Are We There Yet? Hybrid Placement Techniques
Oscar Duckworth	Thixotropy—What Does It Have to Do with Shotcrete?
Bill Geers	Advancements in Steel Fiber-Reinforced Shotcrete for Underground
Adrian Hedström	Virtual Training and Certification for Mechanized Shotcrete Spraying—New Procedures in Australia and Sweden
Marc Jolin	Shotcrete R&D in the Next 25 Years: What to Expect
Terry Lee	Why Natural is Better—Benefits of Natural Fibers in Concrete Curing Process
Axel Nitschke	Specification and Design of Shotcrete for Road Tunnels
Dominic Petrella	Recognizing and Avoiding Shotcrete Finishing Mistakes
Dominic Reda	Design and Construction Aspects of Shotcreted Final Tunnel Linings
Stephen C. Tadolini	Fiber-Reinforced Ultra-Rapid-Hardening Sprayed Concrete for Civil and Construction Applications
Sach Williams/ Rick Shone	Wine Caves of California
Kyong-Ku Yun	Cellular Sprayed Concrete: An Innovative Method for a Variety of Applications
Lihe (John) Zhang	Transport Properties of Shotcreted and Cast Concrete

ASA IS A SPONSOR AT NEW YORK BUILD 2018 CONSTRUCTION & DESIGN EXPO

March 19-20, 2018 | Javits Center | New York, NY

New York Build 2018 is the leading construction and design expo that focuses exclusively on projects across New York City and New York State. Be the first to know about the latest construction projects, plans, products, and solutions across two productive days while generating new leads and ideas for your business. Register to attend the expo for FREE today: **http://bit.ly/2Fhh2DF**.

CAM AND CCI MERGER CREATE AOE

Two leading organizations with decades of experience serving associations and companies in technical industries have merged to form AOE (Advancing Organizational Excellence), a full-service consulting firm.

AOE is the merger of Creative Association Management (CAM) of Farmington Hills, MI, and Constructive Communication, Inc., of Dublin, OH.

CAM has provided full-service association management expertise ranging from publications, electronic media and website development, certification, outsourced HR and financial services, strategic planning, event/meeting planning and execution, as well as strategic and operational planning since 1990. Clients include the Post-Tensioning Institute, the American Coal Ash Association, the American Shotcrete Association, the Slag Cement Association, and the Building Owners and Managers Association of Detroit.

Founded in 2001, Constructive Communication, Inc., is a recognized leader in marketing strategy, public relations, social media, graphic design, and communications tactics for the AEC and other industrial sectors. The firm is known for expertise in crisis communications, article and white paper development, as well as strategic planning. Representative clients include the International Grinding and Grooving Association, LORD Corporation, Stream + Wetlands Foundation, the Concrete Industry Management program, Rieck Services, O'Neal Inc., CTS Cement, D.S. Brown, and more.

"The merger of these two entities provides the industry with a one-stop resource for everything from strategic planning to operations, marketing, and management," said William E. Rushing Jr., PE, FACI, CAM Chair of the Board, Manager of Civil and Environmental Engineering at Waldemar S. Nelson & Co., Inc.

Kimberly Kayler, President and Founder of CCI, has been named as President of AOE.

Kayler

A marketing professional with extensive experience serving technical industries, Kayler served in business development and marketing communications roles at engineering firms as well as an editor at Wright-Patterson Air Force Base before she started CCI to serve the needs of professional service and business-to-business technical firms. In her role as President of CCI, she has helped clients define strategy and develop marketing action plans. CCI's client list includes more than two dozen design- and construction-related organizations and associations, as well as companies in chemical, aerospace, and industrial sectors.

A past member of the Board of Direction for the American Concrete Institute (ACI), Kayler chaired the ACI Marketing Committee and is a past member of the Construction Liaison, Membership, Convention, Financial Advisory, and Chapter Activities Committees. Past Task Group membership includes the International Conferences, 2030, Strategic Planning, Branding, convention Opening Session, as well as the Communications Platforms for Delivery of Services and Products. She also is the past Chair of the Global Marketing and Research Task Group.

Kayler is co-founder of the Women in Concrete Alliance (WICA) and leads efforts to create networking programs for women in the concrete industry. In this capacity, she represented WICA on the U.S. Secretary of Transportation's Women in Transportation Roundtable.

She has authored more than 2000 articles and is the co-author of *Leading with Marketing*, a handbook for marketing and business development professionals. She has given presentations at World of Concrete and for many industry organizations and associations during the last 20 years related to marketing, leadership, and branding. In 1999, she was the first person in Ohio and one of the first 20 in the nation to earn the Certified Professional Services Marketer designation from the Society for Marketing Professional Services and she still holds this designation.

Since 2009, Kayler has served as an Adjunct Professor in the Integrated Marketing Communications Department at Columbus State Community College, Columbus, OH. She received her BA in journalism from the University of Arizona, Tucson, AZ, and her MS in organization and management with an emphasis in leadership from Capella University, Minneapolis, MN.

AOE will operate out of CAM's existing headquarters in Farmington Hills, MI. CCI team members joining AOE are Amy Numbers, Kari Moosmann, Ashley Kizzire, Kristin Dispenza, and Lindsay Chelf. For more information, visit **www.aoeteam.com**.

SHOTCRETE CALENDAR

FEBRUARY 28 – MARCH 2, 2018	**SDC Technology Forum 43/Concrete 2029 Workshop 4** McCormick Scottsdale | Scottsdale, AZ **www.acifoundation.org/sdc/forums.aspx**
MARCH 11-13, 2018	**ASA 20th Anniversary Event: First ASA Shotcrete Convention** Silverado Resort and Spa | Napa, CA **www.shotcrete.org/20thAnniversary**
MARCH 11, 2018	**ASA Contractor's Qualification Seminar** 8:00 am–4:00 pm **ACI C660 Shotcrete Nozzleman Certification Committee Meeting** 2:00 pm–3:30 pm **ACI C601-I Shotcrete Inspector's Certification Committee Meeting** 3:30 pm–5:00 pm Silverado Resort and Spa | Napa, CA **www.shotcrete.org/20thAnniversary**
MARCH 12, 2018	**ASA Spring Committee Meetings** 8:00 am–5:00 pm Silverado Resort and Spa | Napa, CA **www.shotcrete.org/20thAnniversary**
MARCH 13, 2018	**ASA Shotcrete Technology Conference** Presentations: 8:00 am–12:00 pm and 1:00 pm–3:00 pm Silverado Resort and Spa | Napa, CA **www.shotcrete.org/20thAnniversary**
MARCH 13, 2018	**ASA Annual Outstanding Shotcrete Project Awards Banquet** 6:00 pm–10:00 pm Silverado Resort and Spa | Napa, CA **www.shotcrete.org/20thAnniversary**
MARCH 19-20, 2018	**New York Build 2018** River Pavilion, Javits Center | New York, NY **www.newyorkbuildexpo.com**
MARCH 25-29, 2018	**The ACI Concrete Convention and Exposition** Theme: "Concrete Elevated" Grand America & Little America | Salt Lake City, UT **www.concrete.org**
APRIL 11-13, 2018	**ICRI Spring Convention** Theme: "Seismic Solutions" InterContinental Mark Hopkins | San Francisco, CA **www.icri.org**
JUNE 24-27, 2018	**ASTM International Committee C09, Concrete and Concrete Aggregates** Sheraton San Diego Hotel & Marina | San Diego, CA **www.astm.org**
SEPTEMBER 6-8, 2018	**Mining Expo International** Las Vegas Convention Center | Las Vegas, NV **www.miningexpointernational.com**
WANT MORE INFORMATION?	**See a full list with active links to each event: visit www.shotcrete.org and click on the Calendar link under the News & Events tab.**

Gary Carlson Equipment Co.

Gary Carlson Equipment Co. (GCE) specializes in the rental and sale of wet- and dry-mix shotcrete and grouting equipment across North America. Founded in 2000, the company maintains a large inventory of shotcrete pumps, guns, and grout plants for immediate shipment. “We usually have 15 to 20 shotcrete pumps, a dozen or so guns and pre-dampeners, and 20 to 25 grout plants in our fleet at any time,” said Gary Carlson, company President. Their centralized location in Minnesota allows them to ship anywhere in 2 or 3 days by truck.

For wet-mix shotcrete, GCE stocks high-pressure 50 to 60 yd^3 (38 to 46 m^3) pumps, the classic Allentown version PC20 yard ultra-smooth pump, and several mixer-and-pump combinations, including large refractory style bulk bag “rig” units and the 5 yd^3 (3.8 m^3) Putzmeister MAGNUM. GCE is also adding to their fleet small, easily portable pumps for smaller repair jobs that used to be done with dry-mix shotcrete. The advent of high-pressure 1 in. (25 mm) high-velocity nozzles has opened up new ways to use small pumps for repair jobs.

On the dry-mix shotcrete side, GCE always has REED Lova and Sova bowl machines and Picolla and GRH cylinder-style guns. Electric and hydraulic-drive auger-style predampeners and a very broad range of stand-alone mixers are available from Easy Grout, Essick, and Imer to help contractors eliminate dust and reduce wear and rebound.

Grout plants and pumps range from the small CHEMGROUT hand- or air-powered piston pumps for a few gal./min (L/min) through 50 gal./min (190 L/min) colloidal plants with freestanding diesel or electric hydraulic power packs. High-pressure plunger machines for tiebacks and geotechnical jobs, low-pressure rotor stator machines for dam and tunnel grouting, and everything in between are available. Colloidal plants are available in both high- or low-pressure configuration.

GCE's rental fleet is purchased new and ranges from brand new to a few hundred hours of use. Customers seem to appreciate getting a new pump or gun for their rental job. Unlike most rental companies, GCE will sell a used machine from the rental fleet at any time. This keeps their rental fleet with very low hours of use and looking sharp on the customer’s job site. The company constantly adds new units for rental so you will never get an old rental fleet item. A like-new fleet, coupled with a dedicated crew of mechanics, parts, and rental professionals, keeps the fleet up and customer repair calls to a minimum.

REED and Piccola dry guns and predampener

New Putzmeister diesel power gun predampener combo rig

Putzmeister bulk bag mixer pump

New and rental Chemgrout pumps

Carlson continued, "I got started in the shotcrete industry in the early 1980s. Our predecessor company, Carlson Equipment, was trying to grow our air compressor business. We identified sandblast and gunite customers as high-priority air customers. That led to a request from the Minnesota DOT to supply a gunite rig for the season. No other distributor was interested in renting this equipment, so we purchased a new Airplaco 423 rig and delivered it. Next, they wanted us to train users on how to operate the equipment, so we had a lot of learning to do to get that up and running. Not long after, a repair contractor asked where to get a 'REED' gun. So, I purchased two machines and became the REED dealer; a relationship that now spans almost 40 years."

GCE is a customer-driven organization. Contractors can buy or rent equipment and get the machine and all the accessories needed to start the job immediately. Customer equipment repairs or rebuilds, parts, and accessories are available from stock. Training for contractor crews is available for many specialties. To learn more, visit their website at **www.garycarlsonequip.com**.

GARY CARLSON EQUIPMENT CO.
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Gary Carlson
(763) 792-9123

All ASA members and subscribers have access to the electronic version of *Shotcrete* magazine. A link to this e-magazine is sent as an item in the "What's in the Mix" e-newsletter. To ensure that you receive access to every issue of the electronic version of the magazine, send your e-mail information to info@shotcrete.org.

BLASTCRETE INTRODUCES THE MX-20MT

Blastcrete Equipment Company's MX-20MT mixer/pump can be used for shotcrete and refractory work applications. The machine provides twice the output of Blastcrete's MX-10 mixer/pump, but with nearly the same compact footprint. It's mounted to a single-chassis trailer for convenience and easy transportation, setup, and cleaning. The MX-20MT features a 1.1 ton (1 tonne) mixer with a high-speed hydraulic agitator that keeps materials blended and in suspension as it flows to the 4 in. (102 mm) swing-tube piston pump. The pump operates with up to 2200 psi (15 MPa) pumping pressure for consistent installation of as much as 22 tons/h (20 tonnes/h) of material. The unit can vertically pump refractory material more than 300 ft (90 m). Users can load the hopper with as much as 2500 lb (1100 kg) of material. Visit the Blastcrete Equipment Company website: **www.blastcrete.com**.

NORMET LAUNCHES A NEW GENERATION OF EQUIPMENT

See the display at the World Tunneling Conference Exhibition in Bergen, Norway

This new offering improves the mechanization and automation of the most demanding underground work phases and sets the new standard for sprayed concrete, charging and lifting, and installation works in hard rock tunneling.

The new Spraymec Norrunner 140 DC with its long reach spray boom is designed to meet the highest production capacity requirements of Scandinavian sprayed concrete works with an average spraying capacity up to 900 ft^3/h (26 m^3/h). It is also capable of accurately spraying water and frost-protection linings in a thin layer segment (<3 in. [< 75 mm]). Routine service is made easy as all operational access points are reachable from ground level.

The optional "smart" boom is a new tool to help the spray operator attain better results with less rebound as its coordinated motion control is linked to concrete pump output.

The new Himec and Charmec offerings have rigid frame carriers that provide enhanced driving stability over the articulated carrier used in earlier models. The carriers also have four-wheel and crab drive, giving better maneuverability in tunnels. The engine in the new carrier is placed on the side of the equipment and therefore all engine and exhaust after-treatment system's service points are easily accessed from the tunnel floor level. The improved Himec and Charmec models have an optional driving-from-the-basket feature. The operator in the basket can safely and easily move each unit from the work platform.

All Himec lifting equipment models can be quickly modified to Charmec explosive charging equipment by adding an ANFO or emulsion explosive charging unit. The new Himec models are available with several single- or twin-boom configurations.

The new generation equipment displayed at the World Tunneling Congress are the Spraymec NorRunner 140 DC and the Himec RM T 125, which has been modified to a Charmec charging vehicle by installing an emulsion charging unit.

For further information please contact: Sven Fåland, Sales and LTC Manager, Normet Scandinavia AB, E-mail: sven.faland@normet.com; or Janne Lehto, Vice President, Region EMEA, E-mail: janne.lehto@normet.com.

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Download the 2018 Media Kit: www.shotcrete.org/media/pdf/ASAMediaKit.pdf

SHOTCRETE FAQs

As a service to our readers, each issue of *Shotcrete* will include selected questions and provide answers by the American Shotcrete Association (ASA). Questions can be submitted to info@shotcrete.org. Selected FAQs can also be found on the ASA website, http://shotcrete.org/pages/products-services/technical-questions.htm.

Question: *What is the cure time for shotcrete?*

Answer: Shotcrete is a placement method for concrete construction. Shotcrete-placed concrete should be properly cured to provide desired strength and reduce potential shrinkage. ACI 308.1-11, "Specification for Curing Concrete," and ACI 308R-16, "Guide to External Curing of Concrete" are excellent reference documents. ASA recommends curing a minimum of 7 days, and prefers curing with water, maintaining a continuously wet surface condition for the 7-day period. If using a curing membrane instead of water curing, ASA recommends applying the curing membrane at twice the curing membrane manufacturer's recommended application rate, and applying in two layers with the second perpendicular to the first. If applying a coating over the final concrete surface, you should check with the coating supplier to verify the duration and properties required before application of the coating.

Question: *I have a project where the foundation sub is planning to shotcrete foundations walls instead of pouring them. They've submitted all the procedural things necessary to prove their competence and know what they're doing. For a portion of our foundation, we're immediately adjacent to an existing building. The sub mentioned today on site that they were not planning to put Styrofoam or anything between our new wall and the existing wall that would resist lateral pressure from the fluid concrete and the question was raised whether this is ok or not (FYI there is still rigid insulation, waterproofing, etc.). The argument is that the concrete is obviously stiff enough to stay in place, thanks to the nozzle-applied admixture, without an interior form that it wouldn't be exerting any lateral pressure on the adjacent wall. I can follow that logic and almost buy it but I'm wondering if we still need something to resist the force applied from actually shooting the concrete in place?*

Answer: Shotcrete is a high-velocity placement of concrete. In most thick walls, as I imagine your foundation walls are, the shotcrete contractor will be bench shooting the walls. This means they will be shooting the full wall thickness in 3 to 4 ft (0.9 to 1.2 m) high lifts where most of the impact forces and weight of the shotcrete is carried by the previously shot material. This results in very low impact forces on the back side of the section. When creating a section with a one-sided form, shotcrete contractors have used thin material, like Masonite, pegboard, or even an expanded mesh material, as we just need to have a surface to define the back of the section.

Question: *Are there industry-standard design guides for the design of formwork for shotcrete? I have reviewed the technical questions and found the article "Dynamic Forces during Shotcreting Operations" by Frederic Gagnon and Marc Jolin, but the impact loads in this article are quite small (approximately 90 lb [40 kg] per nozzle application), and I feel uncomfortable using that as the sole design load. However, since there is little to no hydrostatic load from shotcrete, I am having a difficult time coming up with a reasonable design load in lieu of this.*

Answer: Shotcrete placement produces very localized pressure on the one-sided forms we typically use. The 90 lb (40 kg) is a reasonable figure when shooting directly against the form. If shooting thick walls, we typically use a benching approach for placement that puts most of the force directly on the supporting floor (or earth) and putting little force on the form. Thus, the form is more of a way to define the back surface. You will often see shotcrete forms in lower-height applications using thin forming materials such as Masonite, pegboard, or even a stay-form for the formed surface. Often, the larger load controlling the design on a form may be the wind loads expected during the construction period.

Question: *There is a dam rehabilitation project where stepped reinforced cement concrete (RCC) was used for overflow protection. The surface is spalling rather badly and testing indicated that the RCC was marginal for long-term durability. Is it feasible to place shotcrete over RCC to improve aesthetics and provide additional strength and durability?*

Answer: Shotcrete has been used for over 100 years for slope stabilization on natural soils. Your self-consolidating concrete (SCC) sounds like it could be considered a high-grade soil, so stabilization and protection of the SCC with shotcrete is certainly a good application for shotcrete. The fresh surface of the shotcrete can receive a wide variety of finishes, from an as-shot finish (rough) to a floated or even stamped or carved look. You should consider appropriate amounts of reinforcement (reinforcing bars and/or fibers) to control potential shrinkage cracking, as appropriate for your exposure and serviceability requirements.

Question: *I have three apartment buildings (with three, four, and five units). Their basements were insulated just over 10 years ago with closed cell spray foam with a class one fire rating. Now for some reason, the building inspector*

says I have to cover the foamed walls of all three large basements with 0.5 in. (12 mm) drywall and build stud walls to hang the drywall for fire protection. This would reduce the width of the basement stairs significantly, and they would become so narrow that they would then be out of compliance. These basement walls are uneven fieldstone foundations, with bumps, protrusions, and even some curves.

I was thinking that shotcrete-applied concrete might work much better and be more appropriate than wood and drywall for a sometimes-moist basement. According to the local Building Code, a 2 in. (50 mm) layer of concrete would suffice. How can a shotcrete application be made to adhere to closed cell foam? The wall heights are approximately 7 ft (2 m) plus bond.

Answer: Shotcrete is just a placement method for concrete. So shotcreting will provide the fire resistance of concrete. For securing the concrete, you can place anchors through the foam into the original basement wall. You can consult with an engineer experienced with shotcrete on anchor size and spacing required for supporting the shotcrete layer.

Question: *We are currently working on a job that requires integral color for a sculpted rock facing, but the plant close to the job does not supply color. The DOT we are working for has informed us they will not approve the use of retarder in the mixture so we can order the colored mixture from a plant that is 50 minutes away from the site because they are worried about long-term strength of the material decreasing. Do you know of any literature that we can provide to the DOT regarding effects of retarder on 28-day strength of shotcrete?*

Answer: Shotcrete is concrete. PCA's *Design and Control of Concrete Mixtures, 16th Edition* states:

"In general, some reduction in strength at early ages (one to three days) accompanies the use of retarders. However, increased long-term strength may result from retarding the initial rate of hydration. Excessive addition rates of a retarding admixture may permanently inhibit the hydration of cement."

Thus, if you closely follow the admixture manufacturer's recommendations for dosage, you may get higher long-term strength than non-retarded mixtures. You may also consider use of the newer hydration control admixtures that essentially stop hydration until activated, and can theoretically put the concrete "to sleep" for up to 3 days.

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