Shotcrete MAGAZINE

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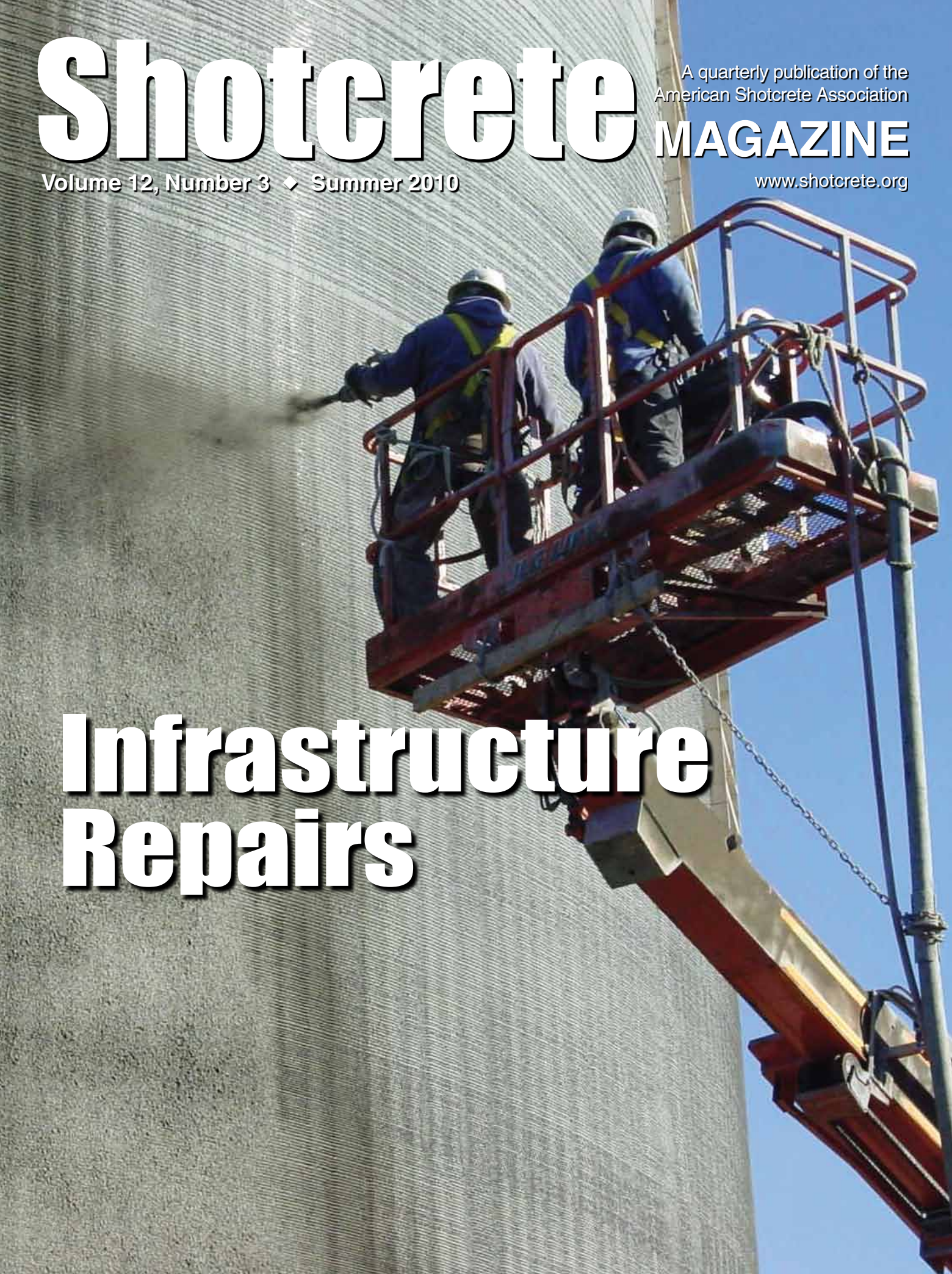

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Circle #22 on reader response form—page 64

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AMERICAN SHOTCRETE ASSOCIATION

Shotcrete MAGAZINE

Volume 12, Number 3
Summer 2010

Features

Departments

On the cover: Shotcreting of wrapped prestressing wires. Photo courtesy of Natgun Corporation.

Shotcrete—A Proven Process for the New Millennium

Preparing for Recovery

By Patrick Bridger

The construction season is now in full swing and I trust that our members and readers are busy. I speak with many of you on a regular basis, and although the economy still is not what it was 3 years ago, we do see signs of moderate recovery. Infrastructure projects—both new construction and repair—appear to be doing well, and tunneling in North America is very strong.

One of the barometers that I have always used to judge economic conditions is the activity in the refractory construction markets. Almost all products that we use go through a heat-treat process of some sort: cement production and minerals processing, steel, chemicals and petroleum products, aluminum, wood, and so on. The good news is that the refractory market appears to be slowly coming back. This is a good indication that the American economy is on the rebound.

ASA's spring committee meetings were held in Chicago, IL, on March 20, 2010, and were well attended. Chicago is a wonderful city and a convenient destination for many. I think another reason for the strong participation is that more members are recognizing the importance of the association's work and are beginning to become active in one or more of ASA's committees. We have a very long list of objectives in each committee, all of which are ultimately intended to increase the amount of shotcrete placed as our economy begins to rebound. Following are highlights of some of the many objectives that the ASA committees are working on.

The demand for certification continues to grow, and the ASA Education Committee is working hard on an effort to review and improve ASA's operation of the ACI Nozzleman Certification Program and the supporting education program. The effort includes the process of creating a more detailed and documented procedure and policy for examiners, hosts, and nozzleman candidates. The requirements of the ACI Nozzleman Certification Program are set very high. Each candidate must have a minimum of 500 hours of nozzling experience. Work experience must be submitted on ASA's work experience verification form to serve as a basis for verifying each candidate's experience prior to participation in certification testing. One of the first outcomes of this review effort is a new work experience verification form that is now available on

ASA President's Message

ASA's Web site. The ultimate goal of this effort is to provide the highest quality of service and program content to the shotcrete industry, so please stay tuned for future updates on the efforts to improve the certification and education processes.

The Education Committee is also working on an update of the ASA educator training module based on the new ACI CP-60(09)—Craftsman Workbook for ACI Certification of Shotcrete Nozzleman. The ASA educator training module is the basis for all ASA education sessions and a critical part of ASA's educational efforts.

The Education Committee is currently seeking applications for the 2010-2011 graduate scholarship. Two scholarships of $3000 (U.S.) each will be awarded, one in the U.S., and the other in Canada. Detailed information is available on the ASA Web site.

The ASA Marketing/Membership Committee, chaired by Joe Hutter, recently coordinated ASA's attendance as an exhibitor at the 2010 International Bridge Conference in Pittsburgh, PA, June 7-9. This was the second year ASA has participated as an exhibitor and the first year presenting a workshop on "Shotcrete for Rehabilitation of America's Infrastructure."

Plans are under way for next year's ASA Annual Awards Banquet to be held in Las Vegas at World of Concrete. The deadline for submissions of projects to be considered for an ASA Outstanding Shotcrete Project Award is September 15, 2010. Anyone interested in nominating a project for any of the categories must submit an application (available on the ASA Web site) by the deadline to be considered. The committee is also working on a 2010 release of a new USB product on underground shotcrete and longer-term plans for a USB product on structural shotcrete.

The ASA Publications Committee has themes set for the *Shotcrete* magazine through the end of next year. ASA has not, however, finalized all of the content that is needed for each of these issues. A new theme is coming for the Fall issue—"Sustainability of Shotcrete." Charles Hanskat is the Chair of our newly formed Sustainability Committee. He is seeking case studies for a few more articles for this issue. Please contact Charles if you have content suggestions for the Fall issue. The Winter issue theme is "Soil Stabilization," which Dan Millett, Chair of the ASA Underground Committee, and I are spearheading. The content of this issue has not been finalized and I will be calling on some of you for contributions.

Shotcrete magazine is one of ASA's most important tools. Melissa McClain, ASA Executive Assistant, will be pleased to hear from anyone who is interested in submitting an article for future issues of *Shotcrete* magazine.

The ASA Safety Committee has been preparing an outline for a comprehensive safety manual. There are many safety documents out there, and we hope to be able to compile material suitable for publishing that is all inclusive of hazards related to shotcreting. This is no small task and will take a considerable amount of time to complete. Once an outline has been completed, the content must be written. While a completion date has not been determined, the goal is to publish this manual and make it available for purchase. This will be a "must-have" book for every shotcrete contractor and safety officer.

The ASA Board of Directors also has a long list of objectives. Some of the more exciting items include:

- The international use of ASA education materials by developing a system of international chapters of ASA;
- Comparative research on in-place performance of cast-in-place concrete versus concrete placed by the shotcrete method;
- Development of a new Shotcrete Inspector Education program in support of a future ACI Shotcrete Inspector Certification program; and
- A joint effort with OSHA to create an OSHA Quick Card focused on soil stabilization with shotcrete.

In closing, I ask each of you to look at your calendars and make note of our next formal meeting on October 23, 2010, in Pittsburgh, PA. Please consider joining us for our committee meetings that day. The meetings are open to anyone that wants to attend. I hope to see many new faces and people that will contribute to ASA.

Certification—Proper Use of an Important Tool

By Chris Darnell, ASA Executive Director

Tools make our work more efficient and effective—when used correctly. When used incorrectly, a tool may not only be ineffective, but it can also become counterproductive and even dangerous.

The ACI Nozzleman Certification is no exception. When used in the right manner with the proper complement of other tools and resources, certification plays an important role in the effective and safe use of shotcrete. When used incorrectly, certification could give a specifier and/or owner a false sense of security and result in subpar in-place concrete and could even pose placement safety issues.

To properly use a tool safely and to its fullest benefit, the user's manual or instructions should be reviewed prior to use. In light of this, let's consider the following as the user's manual for ACI Nozzleman Certification.

ACI Nozzleman Certification User's Manual

Tool Purpose

The ACI Nozzleman Certification program is designed to work with a combination of tools and resources to help provide the industry—and specifiers in particular—with a means of ensuring a basic knowledge and competence in the placement of shotcrete on a project.

Warning: *Use of the ACI Nozzleman Certification program alone, without the other required tools and resources (refer to the "Proper Use" section), can lead to unwanted results, including poor performance or failure of in-place concrete, placement safety issues, project delays, and many other problems resulting from the lack of experience and/or skill of the nozzleman and/or contractor.*

Intended Users

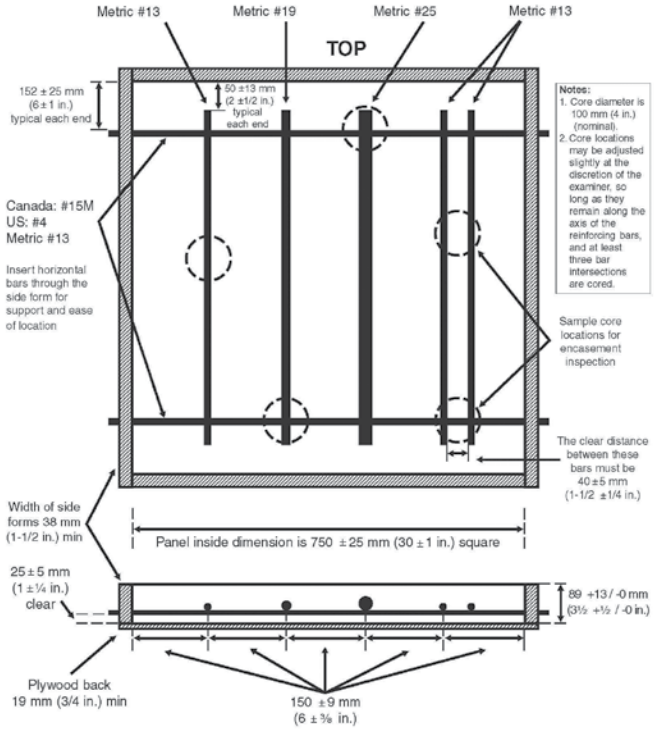
Owners, public officials, and project specifiers, including engineers and architects.

Secondary Users

Construction managers and inspectors.

Proper Use

Cite ACI Nozzleman Certification in the project specification and bid request. Proper use of ACI Nozzleman Certification begins early in the creation of the project specification and bid document. Determine the following: will the project's shotcrete placement require a nozzleman skill level equivalent to or greater than that reflected in the ACI Nozzleman Certification program? (Refer to Fig. 1 for an example of the certification test panel.) Examples might include structural shotcrete placed around reinforcing bar and other objects, or placed in a challenging position such as overhead. If the answer to the question is yes, make sure to include a requirement in the project specification and bid request that all nozzlemen on the project possess a current ACI Shotcrete Nozzleman Certification.



Reinforced test panel layout with core sampling locations -- Includes proposed construction method.

Fig. 1

Check the shotcrete contractor's references and project work history. As important as the nozzleman is in placing shotcrete, he is but one member of a large team and organization. First, make sure the contractor has a strong business history and reputation. Most importantly, make sure he has had successful experience with similar projects. Depending on the difficulty and uniqueness of the project, successful experience in the amount of 5, 10, or more years should be sought.

Check the project work history of the contractor's key personnel. Again, depending on the difficulty and uniqueness of the project, look for a sufficient amount of experience on similar projects from the contractor's key personnel, such as the project supervisor.

Project nozzlemen résumés. Obtain résumés of the nozzlemen that will place shotcrete on the project to help ensure that their experience and skill match or exceed the requirements of the project.

Verify current certification. Once the list of project nozzlemen has been determined, verify that all are currently certified in the required method (wet- and/or dry-mix) and position (vertical and/or overhead). There are a number of ways to verify a nozzleman's certification and those options are listed in the "Tool Components" section.

Verify that on-site nozzlemen are certified. Once the project begins, ensure that the nozzlemen placing shotcrete are on the original list submitted by the contractor and are still currently certified. This is an item that could be added to the inspector's tasks in a preconstruction meeting.

Consider preproject test panels. While a large part of the ACI Nozzleman Certification assesses the nozzleman's ability to properly encapsulate reinforcing bar, if the amount of reinforcing bar congestion increases beyond that in the performance exam test panel (refer to Fig. 1), the test panels that simulate project conditions should be shot by all project nozzlemen. These panels should then be cored to assess the nozzleman's ability to satisfactorily encapsulate the reinforcing bar. *Please note: these preproject test panels and cores that evaluate a nozzleman's ability to encapsulate reinforcing bar are not to be confused with cores taken from test panels shot during the project for strength testing*.

Tool Components

The following components of the ACI Nozzleman Certification program are available to assist users in confirming an individual's current/active certification, as well as the approved method (wet or dry) and position(s) (vertical or overhead). All ACI-certified individuals are listed online and receive the following credentials:

- ACI Certification wallet card: Displays certified individual's full name, certification expiration date, method (wet- or dry-mix), and position (vertical and/or overhead);
- Certificate: Displays certified individual's full name, certification expiration date, method (wet- or dry-mix), and position (vertical and/or overhead); and
- Inclusion in the ACI Certification online directory of certified individuals: www.ACICertification.org/Verify.

The most current source of certification status information is the ACI online directory of certified personnel. It is also much less vulnerable to credential falsification or forgeries.

Other Useful Tools and Resources

- ASA Buyers Guide: **www.Shotcrete.org\BuyersGuide**—The ASA Online Buyers Guide will put you in contact with quality contractors and consultants possessing experience in the project type.
- ACI Nozzleman Certification Program Policies: **www.ACICertification.org**—This site will provide more details on the Nozzleman Certification Program and its requirements.
- ASA Staff: (248) 848-3780 or info@shotcrete.org.
- ACI Certification Department: (248) 848-3790 or john.nehasil@concrete.org.

Conclusion

Hiring a shotcrete contractor solely because he employs a certified nozzleman is short-sighted and irresponsible. Make sure the contractor and his team are well qualified and experienced with your type of project. Due diligence and proper use of the certification tool—as outlined here—could be the difference between the failure and success of a project. The extra work upfront will pay off exponentially as the speed, quality, versatility, and economic advantages of shotcrete are fully realized.

ATTENTION STUDENTS

The American Shotcrete Association (ASA) is committed to its student members and their access to information, not only about shotcrete, but the entire concrete industry. As a result, we are very excited to announce that ASA has partnered with the American Concrete Institute (ACI) to expand the access and exposure for student members of both organizations to all parts of the concrete industry.

ACI has extended its offer of free Student Membership and access to its outstanding publication *Concrete International* to all ASA Student Members.

Beginning with the Winter 2010 issue, all Student Members of ACI now receive access to the electronic version of ASA's award-winning *Shotcrete* magazine.

Both organizations offer free student memberships that allow access to a wealth of information, numerous scholarship opportunities, and an important credential that demonstrates your commitment to education and an understanding of the concrete world.

ASA encourages its current student members to take advantage of the outstanding benefits of ACI's free Student Membership. You can find more information and sign up as an ACI Student Member at:

www.Concrete.org/STUDENTS/stu.htm

ASA also welcomes ACI Student Members to take advantage of ASA's free Student Membership. You can find more information and sign up as an ASA Student Member at:

www.Shotcrete.org/MembershipApplication.asp

AMERICAN SHOTCRETE ASSOCIATION

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ANNOUNCING THE

2010-2011 American Shotcrete Association Graduate Scholarship PROGRAM

The American Shotcrete Association (ASA) is now accepting applications for Graduate Scholarships for the 2010-2011 academic year! The purpose of the ASA Graduate Scholarship Program is to attract, identify, and assist outstanding graduate students pursuing careers in the field of concrete with a significant interest in the shotcrete process.

One scholarship will be awarded to a graduate student attending an accredited college or university within the United States and the second scholarship will be awarded to a graduate student attending an accredited college or university within Canada.

Based on essays, submitted data, and references, the ASA Scholarship Committee will select scholarship recipients who appear to have the strongest combination of interest and potential for professional success in the shotcrete industry.

Two $3000 (USD) awards are available through ASA to eligible applicants for the 2010-2011 academic year. Applications and all required documents must be received by 5:00 p.m. EST on **September 3, 2010**.

Obtain all application information and requirements at:

www.shotcrete.org/ASAscholarships.htm

AMERICAN SHOTCRETE ASSOCIATION

Case Study

Wabush Wharf Rehabilitation

By Marc Ferland and Philip Sawoszczuk

The Port of Sept-Îles, Wabush's Wharf, on the shore of the Gulf of St. Lawrence was originally constructed in the early 1950s to allow cargo ships containing iron ore pellets to get from Labrador City to the Great Lakes region, the heart of the American manufacturing industry. The iron ore mining sector is continuously developing and the Sept-Îles Port must remain operational for a long time to come. Since its construction, the columns and beams of Wabush Wharf have been subjected to years of exposure to salt water, freezing-and-thawing cycling, the impact of waves and ice, and high/low tide cycles. Until recently, the original concrete has withstood the extreme exposure. The continuous exposure to the salt water, however, eventually allowed chloride ions to penetrate the concrete and reach the steel, causing substantial reinforcing bar corrosion and significant damage to the concrete structure.

A consulting firm was retained by the Port of Sept-Îles to evaluate the damage to the wharf and design a strategy to rehabilitate the structure. They specified that all corroded steel be exposed, cleaned, and, if necessary, replaced. Concrete removal would be tedious and difficult because most of the damaged areas were located in the underside of the structure where access is very difficult.

The original specification called for the replacement concrete to be placed using a form-and-pump method and the repairs were tendered to the invited contractors this way. The hired contractor, who specialized in maritime civil construction, soon realized the overwhelming challenges and complications they needed to overcome if they proceeded with the specified repair method. Much of the difficulty was related to limited access due to the location of the structure. Representatives of the contractor met with engineers from the consulting firm to explore options that might alleviate the access problem.

The shotcrete process was suggested as an alternative, but the unfamiliarity of shotcrete by the owners made them reluctant to accept this option. Nevertheless, the consulting firm and the contractor, who previously partnered with a

Wabush Wharf extending into a cove near Sept-Îles. Loading cranes and supply trucks are also visible on top of the 60-year-old concrete structure

particular shotcrete subcontractor on other projects, succeeded in convincing the port authority to accept their recommendation. Factors that lead to the acceptance of shotcrete included the explanation that shotcrete was just a process for placing concrete and the properties that were originally specified for the form-and-pump mixture (including air entrainment for improved durability, silica fume for reduced permeability, and the use of coarse aggregate to reduce shrinkage) would also apply if shotcrete was chosen as a concrete placement method. The contractor also ensured that every nozzleman working on the shotcrete subcontractor's team would be ACI certified. In addition, an impressive track record of the shotcrete projects by the contractor was submitted, including the bobsled track for the 1980 Lake Placid Olympic Games and the Sudbury Neutrino Observatory.

Another benefit provided by the shotcrete process that contributed to its acceptance was scheduling and time constraints. During the 3-year timeline estimated for the project, the window in which construction could take place was only open from June to September, leaving only 3 to 4 months per year to prepare and complete the work. The contractor, with help from the shotcrete subcontractor team, estimated that they could complete the repairs in the amount of time it would take to set up formwork. All parties agreed that shotcrete was clearly the superior repair method.

The consulting firm and the shotcrete subcontractor worked with material supplier engineers to determine an acceptable shotcrete mixture with all of the properties required for this project. It was agreed that the product used must contain air-entraining admixture to provide resistance to continued effects of freezing-and-thawing cycles, and silica fume to reduce permeability and increase resistance to washouts from wave action in the tidal zones during shotcrete operation. The use of silica fume also added the additional benefit of lowering the permeability of the hardened concrete, which limits chloride ion migration to the steel reinforcing bar, thus protecting it from future corrosion.

Even before the project began, the shotcrete crew realized that they faced some unique challenges, mainly due to the location of the project, but felt confident that there were no challenges that they hadn't overcome before. Safety concerns caused by high winds frequently forced the crews to suspended work. The team also had to operate with the rhythm of the tides, starting at one end of the wharf during high tide and moving down with the receding tide.

During the shotcreting operation, the shotcrete machine and compressors were set up on the deck of the wharf and the hose ran across the deck onto a floating barge platform below. The special barge

Barge platform supporting both a finisher and a nozzleman, working in tandem to complete the repair patch before moving to another area

Nozzleman applying the initial coat of shotcrete to a repair 3 to 6 in. (75 to 150 mm) deep using the dry-mix process during high tide

Concrete finisher creating an edge on the repair patch during high tide. The securily fastened metallic trellis can be seen in the uncompleted section

A finisher is completing the repair with a trowel while a fork-lift and some of the shotcrete equipment remain on top of the wharf, allowing efficient resupplying while creating more space

Finished repair zone beneath the wharf along some support beams

platform was leased from the contractor and spanned the width of the wharf. It was large enough to carry both the shotcrete crew and the finishing crew. The barge platform provided two purposes. It could float on the surface of the water when the tide was high, but it could also be suspended from the wharf when the tide was low. This unique capability allowed for quick progression from repair zone to repair zone. When each section was completed, the crews moved back onto the deck as the platform-barge moved to the next section.

The demolition and the surface preparation procedures were conducted using hydrodemolition, which provided optimal surface preparation without introducing microcracking in the concrete substrate. On some occasions, when the tides and the waves were high, the repair section had to be first cleaned with potable water to remove salt contamination from the wire mesh and algae growth from the existing substrate. In some areas that were below the waterline during high tide, more than 6 in. (150 mm) of deteriorated concrete had to be removed. Most of these sections were repaired in a single pass.

Representatives from The Port of Sept-Îles were extremely satisfied with the performance of the contractor and in particular made reference to their attention to detail. The contractor, consulting engineers, and owner were also pleased with the on-site technical support and the assistance with mixture design selection provided by the materials supplier. The shotcrete subcontractor was awarded contracts to repair the wharf during the summers of 2007, 2008, and 2009, during which time over 590 yd^3 (450 m^3) of shotcrete were applied. The shotcrete subcontractor is currently negotiating contracts for several other sections of the wharf, also to be repaired within the next few years using the dry-mix shotcrete process.

Marc Ferland *is President of Béton Projeté M.A.H., a shotcrete contractor in the province of Québec, Canada. The company has over 25 years of experience in the shotcrete business and specializes in artificial rock, pools, spas, water parks, water gardens, statues, zoo exhibits, parking lots, repair, and much more.*

Philip Sawoszczuk*, Jr.Eng., is a Technical Services Representative for King Packaged Materials Company. His areas of expertise include rehabilitation and preservation of infrastructure, structural engineering, and durability of concrete. He received his degree in civil engineering from McGill University, Montreal, QC, Canada.*

Wabush Wharf Rehabilitation

Consulting Firm
Axor Experts-Conseils
Sept-Îles, QC, Canada

Contractor
Bouchard & Blanchette Marine Ltd.
Sept-Îles, QC, Canada

Shotcrete Subcontractor
Béton Projeté M.A.H.
St-Ferréol-les-Neiges, QC, Canada

Material Supplier
King Packaged Materials Company
Burlington, ON, Canada

Material: King MS-D1
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Circle #9 on reader response form—page 64

The Howard A. Hanson Dam

By Marcus H. von der Hofen

Howard A. Hanson
Courtesy U.S. Army Corps of Engineers

Howard A. Hanson Dam, 1990s
Courtesy U.S. Army Corps of Engineers

Flood in Kent Valley, part of the Green River Valley region, 1930s

The Howard A. Hanson Dam, located in the foothills of the Cascade Mountain Range, is one of many in the state of Washington. Dedicated in 1962, the dam brought necessary flood relief to the Green River Valley and opened the way for increased valley development. Named for Seattle Attorney and State Legislator Howard A. Hanson (deceased 1957), who campaigned long and hard for the project, the dam has changed South King County from flooded farmlands to a sea of warehouses, industrial plants, condominiums, and shopping centers.

Hanson, an early campaigner for flood control in the valley, was a member of the Washington State Legislature in 1907, and became the Chief Civil Deputy Prosecuting Attorney for King County in the 1920s. In the late 1920s, he became Chair of a Rivers and Harbors Subcommittee of the Seattle Chamber of Commerce.

Hanson felt that flood control in the valley would aid not only valley farmers, but also the economic development of both King and Pierce counties. Taking his campaign on the road, it was Hanson who turned the project into a regional, rather than localized, undertaking.

After World War II, Hanson organized efforts leading to contributions by the State and King County totaling $2 million. Unfortunately, the tireless advocate for Eagle Gorge Dam passed away on November 4, 1957, and was never able to see the fruits of his labors. In his honor, the name of the dam was changed in 1958 to the Howard A. Hanson Dam by an Act of Congress (www.HistoryLink.org).

On July 31, 2008, the general contractor was awarded a $5,888,250 contract for providing reaction plane strengthening at the Howard Hanson Dam additional water storage fish passage (Phase II). One of the components of this contract was the use of shotcrete in combination with rock anchors to create a slope stabilization structure to be installed concurrently with the excavation process. The "top down" installation process, combined with multiple ground conditions and a remote location, created a very challenging project.

One of the advantages to making this a successful project was the U.S. Army Corps of Engineers' prequalification of the construction team as part of the contracting process for Phase II. Understanding the critical sequencing and being able to provide solutions to changing conditions is critical to this type of project.

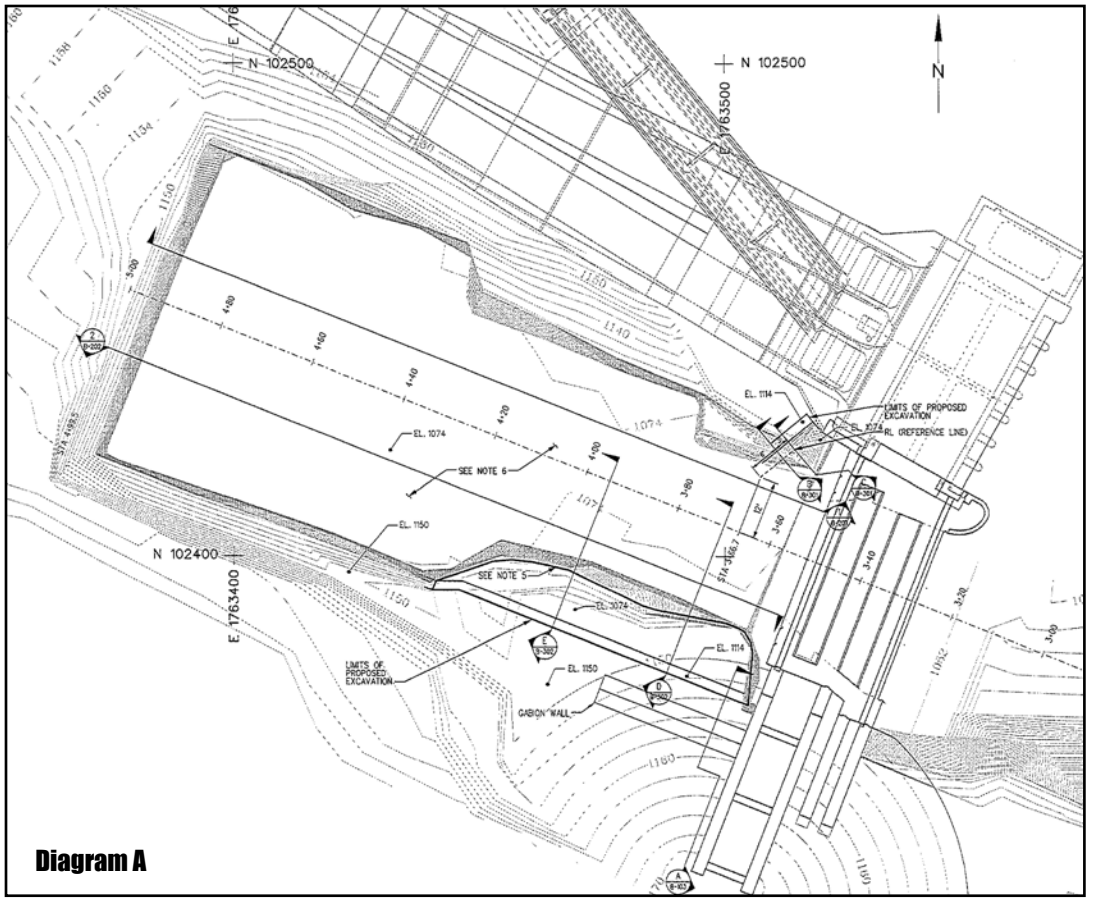

Diagram A

Blasting, excavation, drilling, reinforcing, and shotcreting with critical time frames, multiple ground conditions, and structural configurations is a challenging task for an expert team of contractors; there would be no time for a learning curve.

The scope of the project involved excavating and stabilizing a 67 ft (20.4 m) long, 76 ft (23.2 m) high section of the south slope of the structure, shown in Diagram A. The area would be broken into six levels (lifts) of excavation. Each level of excavation was divided into two sections of support type. Directly adjacent to the reaction plane would require a 6000 psi, 10 in. (41.4 MPa, 254 mm) minimum thickness shotcrete structure with continuous No. 9 Grade 75 bar reinforcing on all sides of the 40 ft (12.2 m) long rock dowels and 4 x 4 in. (101.6 x 101.6 mm) w4.0 x w4.0 welded wire fabric over the entirety. The second section was reinforced with similar rock bolts and a 6 in. (152.4 mm) minimum thickness steel fiber shotcrete (refer to Diagram B).

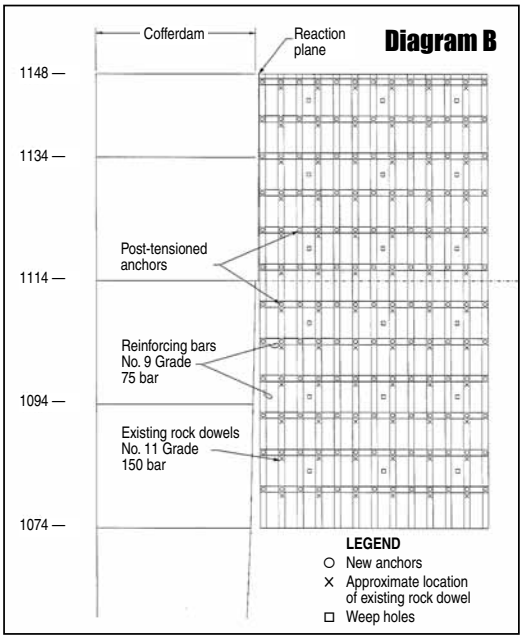

Diagram B

It wasn't that long ago that many engineers might not have thought shotcrete could be used on that size of reinforcing bar. The shotcrete industry has come a long way in its 100-plus years of existence and it is quite common for an experienced shotcrete contractor to shoot around large reinforcment.

All of the rock anchors, weep holes, and shotcrete were to be installed no later than 3 days after excavating a lift. Wet-mix shotcrete was the chosen method of placement. The shotcrete was supplied via a concrete truck. Because of the proximity of the project, additives were used to increase the loading-to-discharge time. The lack of radio contact onsite and long road time made staging of trucks especially critical for the project, yet delivery proved to be more economical than other possible methods.

A great deal of time is put into determining the ground conditions that are going to be encountered.

Soils reports, boring logs, and sample pits give crucial information to help predict what will be encountered but, unfortunately, they are not always accurate. The Puget Sound area is a beautiful region of abundant wildlife and pristine forests that comes with a price: rain—and of course more rain—and let's not forget rain mixed with snow. The conditions are often changing from moment to moment and require judgment from experience often not found in a book.

In this case, the general contractor and the shotcrete contractor's first task turned out to be mitigating poor rock and unforeseen soil veins. Shotcrete can be an exceptional tool for dealing with this problem. Flashing areas of instability with shotcrete provided enough ground support to make the drilling operation safe. This process is well known, but because of the irregular rock face in this case, it would require a creative guide wire setup to ensure the flashing did not encroach into the structural wall. Of course, this still takes time and because of the concerns of the proximity to the dam structure, additional time to complete a lift was not an option.

Immediately following the first hurdle was the rain and groundwater. Preemptive measures were taken during the first lift by creating a shotcrete gutter at the top that would channel runoff away from the wall. This step, while often left out, can be a job saver when a rain squall drops in during the middle of the operation. Water coming out of the face is the most difficult to deal with during placement and sometimes can be impossible to stop. An experienced shotcrete contractor should understand the principles and limitations of the products and procedures used to deal with the situation. A great deal of time and money can be spent with on-the-job learning—something this project did not afford.

The U.S. Army Corps of Engineers had a great deal of misconceptions about what quality shotcrete looked like and the right way to solve the issues, as they had gone through in Phase I of the project with a large contractor who convinced them that a certified nozzleman and some equipment is all you need to shotcrete. Phase I was plagued with problems and cost overruns that were avoided in Phase II.

Spillway at Howard A. Hanson dam, 1990s
Courtesy U.S. Army Corps of Engineers

Phase I and Phase II jobs combined, as the shotcrete contractor finishes the bottom lift under the heat tent during Phase II

Marcus H. von der Hofen *is the Pacific Northwest Area Manager for Johnson Western Gunite Company, San Leandro, CA. He has been in the commercial construction field since 1982 and is an active member of ACI Committees 506, Shotcreting, and C660, Shotcrete Nozzleman Certification. He is a charter member of ASA, joining in 1998, and is Co-Chair of the ASA Education Committee.*

The Howard A. Hanson Dam

Owner
U.S. Army Corps of Engineers

Contractor
C.A. Carey Corporation
Issaquah, WA

Subcontractors
Jensen Drilling Company
Eugene, OR

SubTerra, Inc.
North Bend, WA

Johnson Western Gunite Company
San Leandro, CA

Shotcrete Supplier
CalPortland
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FIELD GUIDE TO CONCRETE REPAIR APPLICATION PROCEDURES

Concrete Repair by Shotcrete Application

Field Guide to Concrete Repair Application Procedures

Concrete Repair by Shotcrete Application

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Introduction

One of the most economical and effective methods of concrete repair is by the shotcrete process. This is particularly true for repairs that would otherwise require forming, such as vertical and overhead repairs. Repair materials, comprised of cementitious products with aggregates, are placed pneumatically onto prepared substrates, finished, and cured with no additional steps required. The use of bonding agents is not required or advised because consolidation and bonding of the material occurs during proper shotcrete application. As with all repair techniques, proper surface preparation is paramount in attaining a permanent repair solution.

When do I use this method?

This technique is most economical on vertical surfaces, such as columns, walls, beam sides, pier caps, and overhead horizontal surfaces such as ceilings, beam bottoms, slab soffits, and deck overhangs.

What is the purpose of this repair?

The shotcrete process is typically used to restore structural integrity, increase concrete cover over reinforcement, or both. It's typically used when forming requirements are difficult or prohibitively expensive or as another repair tool in the designer's and contractor's tool kits.

How do I prepare the surface?

The most important requirement for successful concrete repair is surface preparation. Deteriorated or spalled concrete should be removed back to sound concrete. If reinforcing bars are exposed, they must be undercut to provide mechanical bond for the shotcrete. Corrosion products on reinforcing bars should be removed by abrasive or high-pressure water blasting. The repair boundaries should be left at an outsloping 45 degree angle to facilitate air and rebound escape. The outer edge of the repair area should be sawcut to a depth of about 3/4 in. (20 mm) to prevent the formation of feathered edges (Fig. 1).

Step-by-step procedures for surface preparation are:

- Observe or sound the concrete to determine areas of delamination or deficiency;
- Remove unsound concrete with a hand-held chipping hammer or ultra-high-pressure water blaster so as not to unnecessarily damage substrate concrete and reinforcing bar. Remove any resulting loose or fractured material;
- Replace or supplement damaged reinforcement as necessary. Consult the designer for required sizes and spacing. Separate lap splices by one bar diameter to facilitate placement of repair material. Do not place new reinforcing steel directly behind or in front of existing reinforcing steel (Fig. 2);
- Abrasive blast or water blast the reinforcing steel and the surface of the area to be repaired to remove any contaminants; and
- Spray the surface with water and allow to dry back to a saturated surface-dry (SSD) condition.

How do I select the correct materials?

Shotcrete can be placed by two processes: wet-mix and dry-mix. In most repair operations, the choice is left to the contractors, who often select the process they are most comfortable with and have the right equipment for. Maximum aggregate size will generally be less than 1/2 in. (13 mm), and the grading of the total aggregate constituent should conform to ACI 506R, "Guide to Shotcrete," or ASTM C1436, "Standard Specification for Materials for Shotcrete," requirements. The materials can be ready mixed, prepackaged, or site batched. They can include fibers, silica fume, or other additives for enhancing physical properties and performance. Bonding agents are not recommended as they may act as bond breakers. Potential drying shrinkage problems can usually be minimized with the addition of fibers and proper curing conditions. An attempt should be made to generally match the substrate concrete and the repair material in strength characteristics unless the substrate concrete is very weak.

Ready mixed shotcrete should be batched and delivered in accordance with ASTM C94/C94M, "Standard Specification for Ready-Mixed Concrete," or ASTM C1116/C1116M, "Standard Specification for Fiber-Reinforced Concrete." Materials for shotcrete mixtures should meet the requirements of ASTM C1436. Prepackaged product should meet the requirements of ASTM C1480/C1480M, "Standard Specification for Packaged, Pre-Blended, Dry, Combined Materials for Use in Wet or Dry Shotcrete Application."

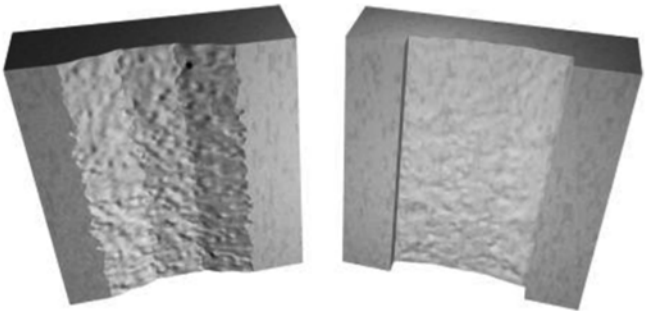

Fig. 1—Repair areas with feathered edges (left) should be avoided by making sawcuts along the edges.

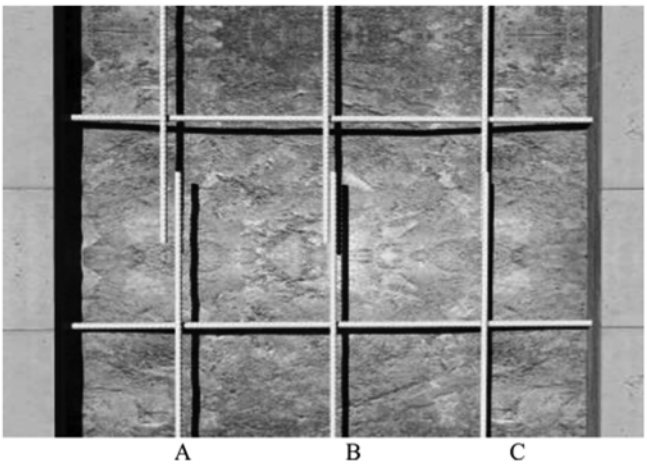

Fig. 2—Separate lap splices of reinforcing bars by one bar diameter to facilitate placing of repair material between the bars: A—Correct; B—Incorrect; and C—Incorrect.

What equipment do I need?

An extensive discussion of the equipment requirements for shotcrete application is contained in ACI 506R.

Equipment necessary for wet-mix shotcrete includes:

- A concrete pump;
- An air compressor;
- Concrete hoses;
- Air hoses; and
- Shotcrete nozzles with air rings.

Equipment necessary for dry-mix shotcrete includes:

- A cement gun;
- A mixer/elevator;
- An air compressor;
- Shotcrete hoses;
- A water pressure booster pump;
- Water hoses; and
- Shotcrete nozzles with water rings.

Equipment common to both processes includes:

- Finishing tools and screeds;
- Air lances for blowing away rebound/overspray;
- Abrasive blast equipment or water blaster; and
- Chipping hammers.

What are the safety considerations?

Shotcrete operations have multiple hazards, and job-site safety practices should include, but are not limited to, the following, where applicable:

- Material safety data sheets (MSDS);
- Protective clothing or skin barriers;
- Protective eye wear, hearing protection, and dust masks; and
- Forced-air respirators during abrasive blasting.

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Preconstruction meetings

Prior to proceeding with the repair, a preconstruction meeting is recommended. The meeting should include representatives for the owner, engineer, contractor, and any other parties involved to explain the means, methods, and materials necessary to achieve the repair objectives.

Repair procedure

Prepare material—Receive transit, site-batched, or prepackaged mixture.

Material placement—Thoroughly wet the prepared surface and bring it to an SSD condition. Begin material placement, filling the corners first and continuously moving the nozzle to encapsulate reinforcing steel and avoid buildup of shotcrete at any one spot. A bond coat of neat cement will automatically be placed due to the initial aggregate rebound. Use a blow pipe to remove any overspray and rebound that accumulates in corners or on reinforcing steel. Repair thicknesses are not limited by the thickness that can be placed in a single layer. Additional layers can be placed as necessary. Preparation of the immediately preceding layer is crucial to obtaining a successful bond. Single layer thicknesses can be increased by the use of additives. Continue bringing the material out to just past the desired plane and allow it to stiffen. When the shotcrete can be worked without disturbing the bond, use a sharp-edged trowel or cutting instrument to trim the plastic material back to the desired plane. Do not overwork the material because this could create delaminations and spalls.

Finish and cure—Excessive finishing is discouraged, although rodding to straight lines is not a problem. Proper curing procedures will enhance the physical properties of the shotcrete and reduce shrinkage cracking. These procedures include moist curing and use of curing compounds as outlined in ACI 308R, "Guide to Curing Concrete."

How do I check the repair?

One of the many benefits of the shotcrete repair process is that it can be observed during placement because there are no forms hiding what is going on in the cavity. Inspectors and applicators can both observe the corners being filled and reinforcing steel being encapsulated. The possibility of honeycombing is largely eliminated if care is taken to prevent voids and unconsolidated overspray and rebound is removed as it accumulates. Once the shotcrete has set, the bond can be verified by sounding for voids with a hammer. If additional bond information is desired, the test methods described in ASTM C1583/C1583M, "Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)," can be followed. A good repair should typically fail in the substrate and, in most cases, have a tensile strength exceeding 150 psi (1 MPa).

References and additional reading

AASHTO Task Force 37 Reports, 1998, 1999, "Guide Specifications for Shotcrete Repair of Bridges," (TF37-1), 108 pp.; and "Inspector's Guide for Shotcrete Repair of Bridges," (IGSRB-1), 80 pp., American Association of State Highway and Transportation Officials, Washington, DC.

ACI Committee 308, 2001, "Guide to Curing Concrete (ACI 308R-01) (Reapproved 2008)," American Concrete Institute, Farmington Hills, MI, 31 pp.

ACI Committee 506, 2005, "Guide to Shotcrete (ACI 506R-05)," American Concrete Institute, Farmington Hills, MI, 40 pp.

ACI Committee 506, 2008, "Guide to Fiber-Reinforced Shotcrete (ACI 506.1R-08)," American Concrete Institute, Farmington Hills, MI, 14 pp.

ACI Committee 546, 2004, "Concrete Repair Guide (ACI 546-04)," American Concrete Institute, Farmington Hills, MI, 53 pp.

American Shotcrete Association, *Shotcrete* Magazine, 43 published articles on Shotcrete Repair, 1998-2008, www.shotcrete.org.

ASTM C94/C94M-09, 2009, "Standard Specification for Ready-Mixed Concrete," ASTM International, West Conshohocken, PA, 11 pp.

ASTM C1116/C1116M-09, 2009, "Standard Specification for Fiber-Reinforced Concrete," ASTM International, West Conshohocken, PA, 7 pp.

ASTM C1436-08, 2008, "Standard Specification for Materials for Shotcrete," ASTM International, West Conshohocken, PA, 2 pp.

ASTM C1583/C1583M-04^{e1}, 2004, "Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)," ASTM International, West Conshohocken, PA, 5 pp.

ICRI Guideline No. 310.1R-2008, 2008, "Guideline for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion," International Concrete Repair Institute, Des Plaines, IL, 12 pp.

ICRI Guideline No. 310.2-1997, 1997, "Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Membranes," International Concrete Repair Institute, Des Plaines, IL, 41 pp.

ICRI Guideline No. 310.3-2004, 2004, "Guideline for the Preparation of Concrete Surfaces for Repair Using Hydrodemolition Methods," International Concrete Repair Institute, Des Plaines, IL, 16 pp.

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American Shotcrete Association (ASA): www.shotcrete.org
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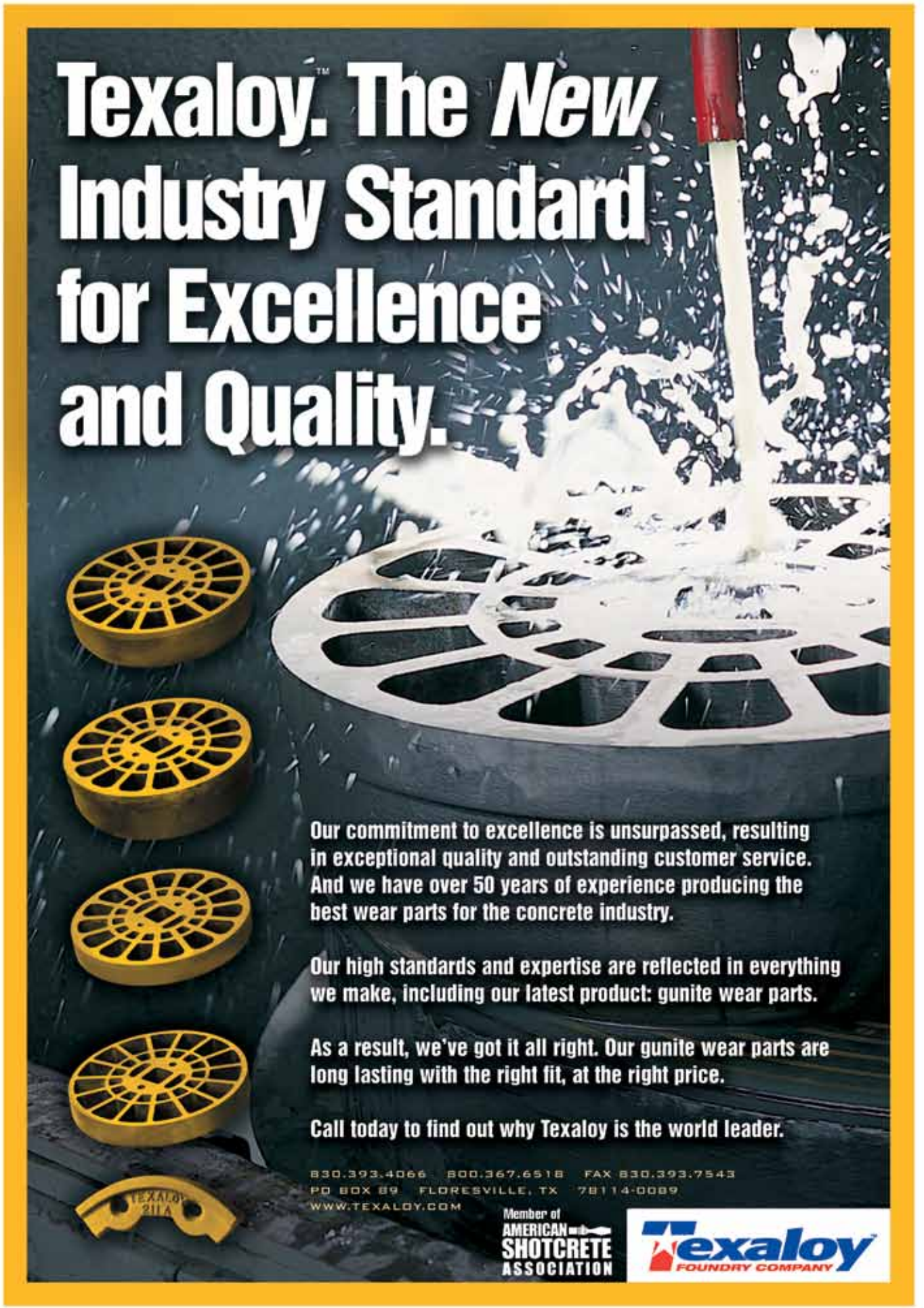

Circle #35 on reader response form—page 64

Shotcrete in Liquid-Containing Concrete Structures

By Charles S. Hanskat

Since its development nearly a century ago, shotcrete has been used for building concrete liquid-containing structures (LCS). An article by George D. Yoggy, "The History of Shotcrete, Part I,"[1] mentions that soon after the development of the cement gun in 1910, gunite was used in a variety of water/wastewater infrastructure applications including reservoirs, dams, sewer tunnels, and water tanks. Figure 1 shows typical tank construction with gunite in 1919 with a nozzleman shooting a sloped wall of a conical floor for a tank.

Today, shotcrete remains a vital part of construction of concrete LCS. The largest use of shotcrete in LCS today is in the construction of circular-wrapped prestressed concrete tanks. In 1942, J.M. Crom Sr. first wrapped high-strength wire in a continuous spiral on the exterior of cylindrical concrete tanks. The "wrapping" method tensioned the prestressing wire before it was placed on the wall, thus avoiding prestressing friction losses (refer to Fig. 2). After placement, the wrapped prestressed reinforcement is encased in shotcrete to provide fully bonded reinforcement, mechanical protection, and corrosion protection (refer to Fig. 3). More than 9000 wrapped prestressed tanks of various sizes and shapes have been constructed to date.

Though not common, some circular concrete tanks have been prestressed by the use of externally-positioned prestressing strands that are tensioned in-place on the wall. The prestressing tendons are then either left exposed on the wall or preferably encased with shotcrete for bonding and protection. This same approach is occasionally used for the repair of concrete tanks.

Fig. 1: Nozzleman applying gunite for a water storage facility in Pittsburgh, PA, 1919

Governing Codes and Standards

In the U.S., both the American Concrete Institute (ACI) and American Water Works Association (AWWA) have technical committees that develop and maintain codes and standards that cover design and construction with shotcrete specifically in LCS. These include:

- ACI 350, "Code Requirements for Environmental Engineering Concrete Structures and Commentary";

Fig. 2: Wrapping prestressing wire on circular prestressed tank
Photo courtesy of Preload Company

Fig. 3: Shotcreting of wrapped prestressing wires
Photo courtesy of Natgun Corporation

- ACI 372R, "Design and Construction of Circular Wire- and Strand-Wrapped Prestressed Concrete Structures";
- ACI 373R, "Design and Construction of Circular Prestressed Concrete Structures with Circumferential Tendons";
- AWWA D110, "Wire & Strand Wound, Circular, Prestressed Concrete Water Tanks"; and
- AWWA D115, "Tendon-Prestressed Concrete Water Tanks."

In general, these ACI and AWWA documents address the requirements for shotcrete materials, placing, cover, and allowable design stresses. The ACI 350 code and the two AWWA standards are mandatory language documents. ACI 372R and ACI 373R are nonmandatory reports that provide guidance for the designer and builder of LCS. Most of these ACI and AWWA documents also reference specific ACI 506 reports or specifications that are applicable to LCS. Both dry- and wet-mix shotcrete are covered.

AWWA documents cover only potable water tanks. ACI documents are more broad-based, covering all types of LCS. The ACI 350 code defines "environmental engineering concrete structures" as concrete structures intended for conveying, storing, or treating water, wastewater, or other liquids and nonhazardous materials such as solid waste, and for secondary containment of hazardous liquids or solid waste.

ACI Committee 350 is also nearing completion of a new construction specification for LCS. This new ACI 350 specification specifically addresses the requirements for the contractor building LCS and parallels ACI 301 for concrete building construction. This new ACI 350 specification specifically addresses the use of shotcrete in all types of LCS. Though intended for new construction, many of the provisions are applicable to the repair of concrete LCS.

Shotcrete in Circular-Wrapped Prestressed Tanks

There are five major builders of circular-wrapped prestressed tanks in the U.S. These companies are The Crom Corporation, DYK Incorporated, Natgun Corporation, Precon Corporation, and Preload Incorporated. Combined, they build several hundred wrapped prestressed concrete tanks each year. These tanks are predominately used in water treatment, water storage, wastewater collection, wastewater treatment, stormwater management, thermal energy storage, and industrial processes. Similar designs have also been used in construction of large liquefied natural gas (LNG) tanks, and in years past, some were used for the storage of low-level radioactive materials.

Some wrapped tank builders use shotcrete for the construction of the complete structural wall (Crom and Precon). Others build a composite wall with a combination of cast-in-place (DYK) or precast concrete (Natgun and Preload) in the structural core of the wall and then use shotcrete for encasing the wrapped prestressing. On large tanks, the cylindrical walls are often tapered, so they are thicker at the base than at the top of the wall. This is easily accomplished with shotcrete or precast, and provides maximum efficiency and economy of the concrete wall materials.

As large users of shotcrete equipment and materials, it is of interest to see how several of these companies produce shotcrete for their tanks. For this article, several of the tank builders were contacted to provide information on their shotcrete usage for tanks.

Crom Shotcrete Operations

The Crom Corporation places approximately 52,000 yd^3 (40,000 m^3) of shotcrete each year. The majority of Crom tanks use a tapered shotcrete wall for the structural core wall. The tanks are prestressed with a wrapped eight- or six-gauge prestressing wire. Crom requires all its nozzlemen to hold ACI Shotcrete Nozzlemen Certification. The majority of its shotcrete is placed using traditional shotcreting equipment as follows:

- Stationary concrete pumps capable of output of up to 50 yd^3 (38 m^3) per hour and maximum pressures of 1100 psi (7.6 MPa). These pumps are typically single-axle units and are sometimes pulled behind concrete trucks; however, increasingly, a central hub is used in the tank to deliver material while the pump remains stationary.
- Air compressors capable of over 600 ft^3/min (17 m^3/min) air output.

Material is delivered to the nozzle beginning with a 5 in. (130 mm) steel line off the back of the pump rock valve cylinder. Hoses are reduced quickly from steel to 3 in. (80 mm) reinforced rubber hose. The reduction of the hose diameter continues until the material reaches the 2 in. (50 mm) placement hose that the nozzleman typically controls. A rubber nozzle with a steel air ring body is located at the end of the hose to deliver uniform air pressure to the material to propel it onto the surface (refer to Fig. 4).

Shotcrete mixtures typically consist of 1:3 mixtures without coarse aggregate. Water cementitious material ratios (*w*/*cm*) are a maximum of 0.42 with slumps of 3 in. ± 1 in. (80 mm ± 25 mm). Mixtures are designed for a minimum 4000 psi (28 MPa) 28-day design strength; however, typical shotcrete mixtures contain 800 lb (360 kg) or greater of cementitious materials, so it is not uncommon to obtain compressive strengths that are much higher than the 4000 psi (28 MPa) design strength. It is also common to replace up

Fig. 4: Shooting core wall at the base of the tank
Photo courtesy of Crom Corporation

Fig. 5: Remotely controlled shotcrete nozzling of tank wall
Photo courtesy of Crom Corporation

to 20% of cement materials with fly ash. Typical air content is around 6% when tested at the point of discharge from the concrete truck.

In addition to traditional equipment, there is a small amount of shotcrete placed using more exotic equipment, including robotic equipment. This equipment is custom fabricated for tank construction and typically requires the use of more powerful concrete pumps and air compressors to achieve the high placement rate that is capable with this equipment (refer to Fig. 5).

Also, for more remote locations, a small amount of shotcrete is batched using on-site batching equipment. These small on-site batch plants with modified silos are capable of storing enough cement to shoot around 75 yd^3 (57 m^3) before it is necessary to recharge the silo. For more information on this type of tank, you can refer to an article in the ASA archives by Lars Balck.[2]

DYK Shotcrete Operations

The majority of DYK tanks use a cast-in-place concrete core wall built with traditional forming methods. DYK wraps a 3/8 in. (10 mm) diameter galvanized strand to prestress their tanks. Shotcrete is used for encasing and protecting the wrapped strands. DYK specifies a shotcrete using a one-part cement, three-part sand mixture for the full shotcrete thickness over the prestressing steel. Approximately 10,000 yd^3 (7650 m^3) of shotcrete are used annually.

To help control shrinkage, DYK uses polypropylene fibers in the shotcrete mixture. Polypropylene fibers help control cracking from shrinkage and thermal tensile stresses, and add to the toughness of the shotcrete. The fibers are manufactured in accordance with ASTM C1116. DYK uses 0.1% (1.5 lb/yd^3 [0.9 kg/m^3]) polypropylene fibers in each cubic yard of shotcrete material.

Wet-mix shotcrete is applied from a nozzle mounted on a mechanized tower that travels around the circular wall or dome ring at a controlled speed. DYK's equipment uses electro-servo travel speed controls to monitor the vertical nozzle travel. The remotely operated nozzle slowly moves around the tank circumference and up the wall in a uniform spiral path (refer to Fig. 6). To obtain a uniform cure and to help prevent shrinkage cracking, the full cover is built up in numerous layers approximately 3/8 in. (10 mm) thick.

DYK has also developed a machine application to encapsulate the shotcrete in plastic during the curing process (refer to Fig. 7). This innovation greatly improves the moisture retention of the shotcrete during its initial curing. An article on DYK's construction of a 35,000,000 gal. (130,000 m^3) tank can be found in the ASA archives.[3]

Natgun Shotcrete Operations

The majority of Natgun tanks use a precast concrete panel core wall. The tanks are prestressed with a wrapped eight- or six-gauge prestressing wire. Shotcrete is used for providing the final thickness of the core wall over the exterior of the precast panels, and for encasing and protecting the wrapped prestressing wires. Natgun currently uses wet-mix shotcrete on all new tank projects and restoration projects. In 2009, Natgun used a total shotcrete volume of 18,104 yd^3 (13,840 m^3). Prior to the late 1970s, the company used dry-mix shotcrete. All of Natgun's nozzlemen are trained and required to pass the ACI Shotcrete Nozzleman Certification Program.

Natgun has 19 diesel-powered hydraulic piston trailer concrete pumps. In general, these pumps have:

- 5 in. (130 mm) outlets;
- 5 to 6 in. (130 to 150 mm) material cylinders;

Fig. 6: Remotely operated nozzle on automated wrapping/ shotcreting machine
Photo courtesy of DYK Incorporated

Fig. 8: Pump with multiple reducers
Photo courtesy of Natgun Corporation

Fig. 7: Plastic wrapping of shotcrete cover coat for curing
Photo courtesy of DYK Incorporated

Fig. 9: Shotcreting dome ring
Photo courtesy of Natgun Corporation

- 1300 to 1450 psi (9 to 10 MPa) maximum material pressure;
- Harsh or standard mixtures approximately 11 ft^3 (0.31 m^3) hoppers with remixers; and
- Maximum theoretical aggregate size is 1.5 in. (40 mm).

Natgun uses a 5 x 4 in. (130 x 100 mm) reducing elbow off the pump outlet, a straight 4 x 3 x 42 in. (100 x 80 x 1000 mm) reducer to a straight 3 x 2 x 42 in. (80 x 50 x 1000 mm) reducer and then to a 2 in. x 50 ft (50 mm x 15 m) high pressure hose, all with heavy-duty couplings (refer to Fig. 8). Typically, Natgun uses four to five lengths of hose for the average job. Smaller radius tanks will allow less hose and larger radius tanks may require multiple pump locations to shoot the exterior core wall, wire cover, and cover coat shotcrete. Natgun uses two styles of shotcrete nozzles. One employs a swivel air ring in the nozzle body assembly to prevent twisting and kinking of the air and material hose couplings. The other uses a fixed air ring in the nozzle body assembly. The rubber nozzle tips are 1 in. (25 mm) in diameter and fastened to the nozzle body with a conventional hose clamp (refer to Fig. 9).

Natgun's standard shotcrete mixes consist of:

- 1:3 shotcrete mixture—851 lb (386 kg) of cement and 2553 lb (1158 kg) of fine aggregate with air entrainment and water-reducing admixtures to obtain a maximum *w*/*cm* of 0.35 to 0.37 for a 3 to 4 in. (80 to 100 mm) slump at 6 to 8% air as delivered on site. This 1:3 cement-to-fine aggregate mixture is used primarily for the exterior core wall and prestress wire cover.
- 1:4 shotcrete mixture—665 lb (302 kg) of cement, 150 lb (68 kg) of Class F fly ash, and 2650 lb (1202 kg) of fine aggregate with air entrainment and water-reducing admixtures to obtain a maximum *w*/*cm* of 0.35 to 0.37 for a 3 to 4 in. (80 to 100 mm) slump at 6 to 8% air on site. This 1:4 cement-to-fine aggregate mixture is used primarily for cover coat and any other tank component or feature not in direct contact with pre-stressing wires such as pilasters and ladder

Fig. 10: Shotcreting final cover coat of a wrapped tank
Photo courtesy of Preload Incorporated

and antenna pads. To minimize plastic shrinkage, this mixture also incorporates 1.5 lb/yd^3 (0.9 kg/m^3) of 0.25 in. (6 mm) polypropylene fibers.

The gradation of the fine aggregate of these mixtures is critical to maintaining pumpability. Natgun works closely with the concrete supplier and local aggregate producers to obtain the desired gradation. It finds that when there is 18 to 28% of combined particles passing the No. 50 to 100 sieve, the pumpability of the shotcrete and grout mixtures is much better. When the local fine aggregates are too coarse or only manufactured or crushed sand is available, Natgun will occasionally increase the amount of fly ash in the mixture to a maximum of 25% of the total cementitious material to aid in pumpability.

Summary

Current codes and standards (ACI 350, ACI 372R, ACI 373R, AWWA D110, and AWWA D115) that cover concrete LCS have recognized the importance of shotcrete and directly address shotcrete in these documents. A new ACI 350 specification that includes shotcrete should be available later this year.

Currently, by far the most extensive use of shotcrete in LCS is in the construction of wrapped prestressed concrete tanks. The builders of wrapped prestressed concrete tanks in combined volume shoot well over 100,000 yd^3 (2831.7 m^3) of predominately wet-mix shotcrete annually (refer to Fig. 10). All of the tank builders are committed to using highly trained nozzlemen with ACI Shotcrete Nozzlemen certifications.

Shotcrete has a long, successful history in the construction of concrete LCS and is now approaching the century mark since its initial use for water and wastewater infrastructure. When properly used, quality shotcrete in both materials and placement has proven to equal or surpass the durability and serviceability of cast-in-place concrete LCS.

References

1. Yoggy, G.D., "The History of Shotcrete, Part I," *Shotcrete*, V. 2, No. 4, Fall 2000, pp. 28-29.

2. Balck, L., "Shotcrete and Prestressed Composite Tanks," *Shotcrete*, V. 1, No. 4, Nov. 1999, pp. 20-21.

3. McGray, S., "Schwing Boom and Trailer Pumps Complete World's Largest Circular Prestressed Water Tank," *Shotcrete*, V. 7, No. 1, Winter 2005, pp. 4-6.

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Hanskat is an ASA Board member and Chair of the ASA Sustainability Committee. He is also a member of ACI Committees 301, Specifications for Concrete; 350, Environmental Engineering Concrete Structures; 371, Elevated Tanks with Concrete Pedestals; 372, Circular Concrete Structures Prestressed by Wrapping with Wire or Strand; 373, Circular Concrete Structures Prestressed with Circumferential Tendons; 376, Concrete Structures for Refrigerated Liquefied Gas Containment; 506, Shotcreting; and Joint ACI-ASCE Committee 334, Concrete Shell Design and Construction. He is a former member of the ACI Technical Activities Committee and the ACI Board of Directors.

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 level was highlighted when he served as State President of FES and then as National Director of NSPE. He served as a District Director for Tau Beta Pi for 25 years from 1977 to 2002. He is a Fellow of ACI, ASCE, and FES, and a member of ASA, NSPE, ASTM, AWWA and ASHRAE.

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Circle #42 on reader response form—page 64

Shotcrete Repairs to Infrastructure

By Ted W. Sofis

When considering rehabilitating vertical and overhead concrete structures, there is no more efficient way of performing the work than by using shotcrete. By its very nature, shotcrete provides the engineers and contractors several advantages. On an infrastructure repair, the shotcrete method eliminates the need for forming, so the lumber and labor costs involved in this aspect of the work are eliminated from the start. Along with the forms, the form support systems, whalers, Richmond ties, and anchors also become unnecessary. The shotcrete is easily conveyed from the gunning equipment to repair areas through hoses, eliminating the need for cranes, hoists, and hand labor of physically transporting the material. Overhead repair work on culverts, under bridge decks, or on the undersides of arches becomes much easier to perform. Forming and placing concrete for overhead spall repair is a tricky and difficult proposition even under the best of circumstances. Unless it is a full deck repair, where the forms are set from below and concrete is poured from above the deck, there are a great many obstacles to overcome. It is extremely difficult to place concrete without leaving gaps between the concrete substrate in poured overhead repairs. The nature of using a flowable material will cause it to spread out across the bottom of the form, leaving gaps along the top as gravity works against you. This is not the case with shotcrete installation. With shotcrete, you have no forms and the repair material is sprayed directly against the existing concrete surface from the open underside of the repair area. Everything you do is visible and the shotcrete is gunned from the top down, so it becomes much easier to make good repairs. On thin vertical wall repairs, forming becomes more expensive per square foot (square meter) and efficiently placing concrete becomes more difficult as it hangs up and creates honeycomb-like areas. Again, this is not a problem when gunning shotcrete directly into an open area. Shotcrete also allows the contractor to efficiently place material on rounded columns, piers, arches, cones, and other shapes that are not easily formed. When shotcrete is used, the repair material is easily and cost-effectively transported and enables the contractor to efficiently install material overhead and on irregular shapes. It allows the worker to perform the concrete repair faster and more efficiently and, in many cases, provides a better result than using cast-in-place concrete.

Nozzleman gunning dry-process shotcrete—filling the edges of the repair area first—and working toward the middle to avoid trapping rebound in the corners

Preparation Tips

After delineating the repair areas, it is essential to remove all of the deteriorated concrete back to sound concrete. It is also good to get at least 1 in. (25 mm) behind the initial mat of reinforcing bar whenever possible, as it better ties in the repair to the existing structure. Often when the reinforcing bars rust and develop heavy scale, they expand, creating cracks and fissures in the concrete. The concrete outside of the reinforcing bar is often easy to remove; however, it is a good practice to remove even sound concrete if necessary to get 1 in. (25 mm) behind the reinforcing bar to ensure a good repair.

The next consideration is the positioning of the mesh from the finished surface. The mesh or

reinforcing bar should be placed at least 2 in. (50 mm) from the exposed surface to ensure adequate cover. In overhead applications, try to position the mesh within 2 to 4 in. (50 to 100 mm) from the surface. When there is too much unsupported weight of wet material beyond the reinforcement, it tends to pull itself off. Make sure that the reinforcing steel and mesh are securely tied and anchored in place. There should be no flex or give, particularly in overhead applications. The reinforcing steel needs to support a lot of weight—approximately 146 lb/ft^3 (66.23 kg/m^3). Unlike a vertical surface where there is a great deal of lateral support, the reinforcing steel on overhead work must support the mass of the material. When tying mesh overhead, a good way to check your work is to reach up with both hands and pull on the mesh. If the mesh can support your weight without sagging, then it's usually safe to assume that it will support the weight of the applied material. If there is appreciable movement or flex in the mesh, then more anchors and ties need to be made to reinforcing bars to tighten up those areas.

The shotcrete method provides a superior bond to the substrate without the need for bonding agents when proper surface preparation techniques are used. Prior to placing the shotcrete in the repair areas, the area should be cleaned with air and water to remove any dust, sandblasting residue, or other particulates that may have collected in the corners that could inhibit the bond. Wetting the surface prior to gunning will help to reduce the amount of water that the existing concrete substrate will draw from the freshly applied shotcrete. This is important in both the dry and the wet processes because shotcrete contains a lower percentage of water than found in conventionally placed concrete, and losing moisture could ultimately affect the bond and the strength of the shotcrete. It is also a good practice to gun in the edges of a repair area first and work toward the middle so rebound does not collect in the corners. As the shotcrete initially hits the concrete surface, some of the aggregate rebounds off the substrate, leaving a thin layer of cement paste that cushions and bonds the subsequent shotcrete to the existing concrete. It is for this reason that bonding compounds should never be used for shotcrete installations. Bonding compounds, in more cases than not, are detrimental, often creating a bond breaker. Shotcrete is placed at a high velocity and therefore already provides excellent adhesion to the substrate.

Overhead dry-process shotcrete being placed on the underside of a pier hammerhead in Pittsburgh, PA

Shotcrete easily conforms to the circumference of this round bridge pier and works well with irregular shapes and configurations

Shotcrete Placement

With the dry-mix process, the shotcrete mixture is transported by air through the hoses in a nearly dry state and the water is injected through a water ring at the nozzle. This allows the nozzleman to make sensitive adjustments during placement to ensure enough moisture to properly hydrate the material, yet remain stiff enough to

stay in place without sagging or having to use accelerators. The relatively low water content of dry-mix shotcrete provides superior strengths in what is essentially a zero-slump pneumatically placed concrete. In the wet-mix process, the material is mixed with water and then pumped so it is a flowable, low-slump shotcrete mixture where the air and accelerators are injected at the nozzle. With the wet process it is easier to wrap around dense reinforcing bar mats, and one can place greater volumes in less time. There are advantages to each process. With both methods it is important to maintain proper shooting angles, as close to a 90-degree angle to the shooting surface as possible.

Conclusion

Shotcrete provides an economical and efficient method for the rehabilitation of concrete structures. The placement of shotcrete saves time and money. Shotcrete offers the ability to eliminate forming (a costly component of the repair process) and to place material more efficiently in hard-to-reach areas, it easily conforms to unusual shapes, and provides an effective method of placing material overhead. In these difficult economic times, we need to look for new and better ways to do things. The next time you look at a difficult concrete repair job, consider an alternative—a shotcrete repair.

Ted W. Sofis *and his brother, William J. Sofis Jr., are principal owners of Sofis Company, Inc. After graduating from Muskingum College, New Concord, OH, with a BA in 1975, he began working full time as a shotcrete nozzleman and operator servicing the steel industry. He began managing Sofis Company, Inc., in 1984 and has over 34 years of experience in the shotcrete industry. He is an ASA-approved Shotcrete Nozzleman Educator, the Treasurer for ASA, and a member of the ASA Publications and Education Committees. Over the years, Sofis Company, Inc., has been involved in bridge, dam, and slope projects using shotcrete as well as refractory installations in power plants and steel mills. Sofis Company, Inc., is a member of the Pittsburgh Section of the American Society of Highway Engineers (ASHE) and ASA.*

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Wet-Process Shotcrete Placement Formula for Nozzlemen: M+A+R+V+S=PHD

By Mike Norton

The formula M+A+R+V+S=PHD is defined as material, air, reinforcing, velocity, slump= pattern of spray, height of lift in one pass, distance of nozzle from receiving surface.

Material—Different mixture proportions will act differently while encapsulating reinforcing bars. Aggregates (sand and rock types, gradation), water content, cement content, and admixtures will all affect the way the material goes around the reinforcing steel. The way the material is acting around the reinforcing bar will determine the spray pattern and nozzle position needed for good encapsulation. The consistency of material will determine the height of lift taken in one pass without sagging or sloughing. Adjust the distance of the nozzle closer to the receiving surface if shadowing or voids are forming behind the reinforcing bar.

Air—The amount of compressed air entering through the nozzle must be of sufficient volume to enable proper spraying of the material. Again, adjust the nozzle distance from the work to avoid shadowing. The air will actually help keep the material from building up on the reinforcing bar to allow good encapsulation and avoid shadowing. In addition to nozzle air, a separate blow pipe should be used ahead of the nozzleman to remove buildup on the reinforcing bar as well as the receiving surface. The amount of nozzle air will affect the spray pattern, which tends to be wetter at the outer edges; therefore, the pattern of nozzle manipulation should maintain a consistent receiving surface without wet spots, which can cause sagging, sloughing, and even fall outs. The lift height is dependent on how well this is done.

Reinforcing steel/reinforcing bar—The size, configuration, and congestion of the reinforcing bar will be one of the factors determining the distance of the nozzle from the receiving surface. If shadowing is evident, move the nozzle in closer until shadowing is eliminated. Move the nozzle in a pattern to get good material behind the reinforcing bar, to either side of the vertical bars, and above and below horizontal bars. A circular motion works well. Avoid buildup on top of horizontal bars, which can cause a void under the bar. When shooting a multiple reinforcing bar curtain wall, move the nozzle in closer for the back curtain and out farther for the outer curtain. Avoid splitting the front bars with a spray pattern when shooting the back bars, as this will break up the material and may create voids. The nozzle should be directed at a 45-degree angle into the floor/wall corner. This is known as bench shooting and will allow rebound to fall away from work. The more vertical the receiving surface, the more it will tend to sag. As a rule, the more congested the reinforcing, the closer the nozzle will need to be. The configuration of the reinforcing bar will be one of the determining factors on the height of the lift and must be secured to avoid movement. In highly congested reinforcing, shoot around and between bars to force material behind them. Again, avoid splitting the shotcrete stream with the reinforcing steel, which breaks up material and may cause rock pockets or voids.

Velocity—The volume of the material being discharged from the nozzle, along with other variables, will determine the distance of the nozzle from the receiving surface. Higher material velocity will help with the encapsulation of the reinforcing bar. As the velocity decreases, the nozzle will need to be closer to get the same effect. As velocity or volume increases, the nozzleman must be able to maintain control of the nozzle to continue proper placement.

Slump—This will affect the way the material goes around the reinforcing bar. Again, adjust the distance of the nozzle accordingly. Higher slump and wetter material will go around the reinforcing bar with less buildup on the face of the bar. Lower slump and dryer material without sufficient velocity will tend to build up on the reinforcing bar, inhibiting good encapsulation. Dryer material will require the nozzle to be worked more, and likely closer, to avoid shadowing and voids. It is ideal if the nozzleman can see the ribs on the reinforcing bar while shooting. This means there is no build up on the bars and there is both

sufficient plasticity and impact velocity. It is usually a fine line before the material is wet enough for good encapsulation but not too wet to create sagging or even fall-outs. Often, the desired slump is unachievable due to a specified maximum water-cementitious material ratio (*w/cm*). Adjustments to the chemical admixtures can be made by the concrete company to achieve the proper plasticity.

Pattern of spray—The movement of the nozzle creating a spray pattern will need to change depending on all of the variables. Maintaining a consistent material throughout the receiving surface, good reinforcing bar encapsulation, and flat wall surface are keys to a quality application.

Height—The height of a pass or lift in a wall depends on all of the variables again. Do not shoot higher than eye level or shoot up on a wall, as this will cause material to roll over itself and reduce consolidation. Too high of a lift will tend to sag and want to push the reinforcing bar out toward the face of wall.

Distance—In combination, all of the variables will determine the nozzling distance from the receiving surface for good encapsulation of reinforcing without voids or shadowing. Sometimes it is only a matter of inches or feet (millimeters or meters), depending on the situation. The nozzleman is the key to good in-place shotcrete. The nozzleman is able to visualize how the material is going in place and can make adjustments to maintain a quality product.

Mike Norton *has been an employee of Johnson Western Gunite for 20 years. He has over 30 years of wet- and dry-shotcrete nozzleman experience and has shot over 300,000 yd (274,320 m) of structural placement.*

Circle #44 on reader response form—page 64

NEW

Is Your Wet-Mix Placement System Safe?

By Oscar Duckworth

"It's lucky no one was killed," said the nozzleman. "I just didn't see it," was the only explanation offered by the pump operator. Moments earlier, a plug had occurred within a placement hose a few sections downline of the shotcrete pump. As the line pressure climbed quickly toward the maximum, a placement hose ripped open, unleashing a destructive force none of us would ever forget.

Every day we routinely connect a high-pressure shotcrete pump to a wet-mix placement system, but how much do we really know about the potential hazards created by its use? A modern wet-mix shotcrete pump is capable of producing extremely high operating pressures, often 1250 psi (8.6 MPa) or higher. The operating pressure created within a modern wet-mix shotcrete pump can be extremely dangerous if precautions are not taken to assure that placement system components are able to withstand maximum pump pressures.

Today the crew was lucky—no injuries—just an immense cleanup. But next time, who knows? Anytime we use a wet-mix placement system, there is a potential for injury. How do we ensure that our wet-mix placement system is as safe as possible?

Fig 1: Top hose has a working pressure of 800 psi (5.5 MPa), which is underrated for shotcrete placement. The 1250 psi (8.6 MPa) pressure of the lower hose may be acceptable

Wet-Mix Placement System Components

Wet-mix shotcrete placement system components consist of all reducers, couplings, pipes, elbows, and hoses that convey the shotcrete mixture from the pump outlet to the nozzle. All air supply lines and couplers, from the compressor outlet to the nozzle and blow pipe, are also part of the placement system.

Each component must display a working pressure rating that is equal to or greater than the maximum available outlet pressure of the pump to which it is connected (refer to Fig. 1). A working pressure rating is typically 1/3 to 1/2 of a component's burst or failure pressure. Many currently available placement system components will create a hazardous condition if used in conjunction with a modern shotcrete pump. Don Mace, Safety Director, Schwing of America, states, "the Schwing shotcrete pumps can produce in excess of 1250 psi (8.6 MPa) outlet pressure." Mace cites the American Concrete Pumping Association (ACPA) safety guidelines as the only safe use of the Schwing wet-mix equipment. This excerpt is reprinted with permission from the *ACPA Safety Manual* (refer to Fig. 2).

> "Heavy-duty or raised-end couplings are designed to handle pressure up to 2250 psi (15.5 MPa) @ 2:1. They have a tapered face that draws the sections together during assembly.
>
> Grooved-end couplings of a lip height of 0.15 in. (3.8 mm) or less are designed for pressures below 750 psi (5.2 MPa) @ 2:1. The recessed groove is hard to clean when changing sections on the job. This end will fail before the pipe will fail because the groove is cut into the pipe thickness, making it the weakest spot.
>
> Grooved ends are not recommended for wet-mix shotcrete placement."

How About Nozzle Couplings?

Many wet-mix nozzlemen have resisted the use of raised-end clamps at the nozzle, citing their

inherent bulkiness and significant additional weight, which hinders maneuverability and increases fatigue. In the past, the lightweight grooved end clamp was commonly used in this location; however, many nozzle manufacturers no longer produce grooved-end nozzle fittings citing ACPA Safety Guidelines that prohibit their use. Some nozzlemen still prefer the use of a threaded (no clamp) nozzle connector due to its exceptional maneuverability and light weight (refer to Fig. 3). The pipe threads, however, can foul with concrete, making removal and safe installation difficult.

Are Other Couplers Available?

A new flared-end clamping format has recently been introduced by Construction Forms Inc. (Conforms), which uses the lightweight, compact characteristics of a grooved-end coupler with the same working pressure rating of the much larger raised-end coupler (refer to Fig. 4 and 5).

John Schantz, Product Development Engineer, Con Forms, states, "the flared coupling system seems ideal for hand-nozzle shotcrete applications where the placement system must be lifted or carried during placement. Less weight means less effort for the nozzleman and crew with no compromise to safety."

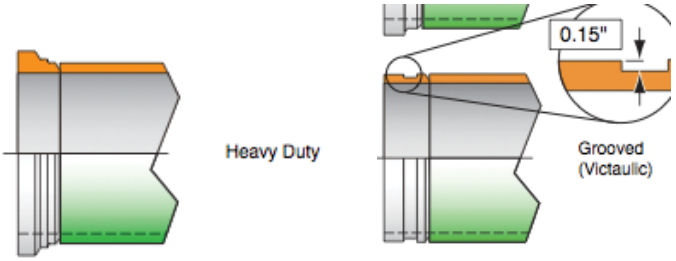
Reduce Pressure When Possible

Wet-mix placement systems, which convey the shotcrete mixture long distances or to higher elevations, can work under enormous pressures. Steps may be taken to reduce pressure and increase safety, such as the use of steel pipe (slick line) instead of rubber hose when possible. Concrete requires less line pressure conveyed through the steel line than through rubber hoses and is more resistant to puncture and abrasion (refer to Fig. 6). If possible, situate the pumping equipment as close to the work area as possible to minimize placement system length. Reduced placement system length means lower operating pressure.

When routing your placement system, avoid or provide protection from chafing and possible puncture from hard or sharp objects.

Never use placement system hoses that display visible abrasion damage. A damaged hose is a potential burst hazard and should be discarded. When possible, route the system away from public areas due to the potential hazards.

The use of the provided pin on a raised-end coupler will prevent an unintentional opening during use and should always be in place.



GENERAL RULES

SAFETY MANUAL

5.9 **WARNING** Do not use a piece of pipeline, end hose, coupling, or any other material delivery component that is not in good condition. **Replace, do not repair damaged pipes and hoses.** Concrete pipeline system is subject to wear, and the rate of wear is affected by pumping pressure, concrete composition, pipeline material, and other factors. Read and understand the minimum wall thickness chart in the *Appendix* of this manual. **Bursting pipes and concrete escaping under pressure is a serious safety hazard!** (See Figure 7)

Figure 7
Delivery system components must be able to withstand maximum pump pressure

5.10 When laying out a pipeline, it is preferable to use an elbow instead of a hose to make direction changes. Elbows have less resistance to flow than hoses, and will therefore reduce the overall pressure required to push the concrete.

5.11 Always use the largest diameter pipeline that is practical, and use steel pipe instead of rubber hose. This will keep the pressure required to push the concrete to a minimum.

5.12 Support the delivery pipeline. Either an "S" transition pipe should be used to bring the pipe to ground level, or **each** section of the pipeline should be supported at the pump outlet level.

5.13 **WARNING** The sections of pipe nearest the pump are subjected to the highest pressure and the greatest wear. Because of this increase of pressure near the pump, you should install only thick walled pipe, in "like new" condition there. Read and understand the minimum wall thickness chart in the *Appendix* of this manual.

5.14 **WARNING** **The maximum concrete pressure of the pump must be the only factor used to determine what thickness of pipe and what type of ends are needed.** In the case of a rock jam or any other type of blockage, **the maximum pressure of the pump will be exerted.**

5.15 Grooved (Victaulic) ends are **not recommended** for concrete pumping. Read and understand the comparison between heavy duty raised, metric, and grooved ends in the *Appendix* of this manual.

5.16 **WARNING** If the pipeline remains on the job (as is the case when pumping a high rise building), **the operator is responsible for checking the pipeline for dents, cracks, wear, and continuity each day before the pour begins.**

Fig 2: Excerpt of American Concrete Pumping Association Safety Manual.

Fig 3: Two inch (50 mm) pipe thread acts as nozzle coupler

Fig 4: Heavy-duty coupler (bottom) weighs nearly 40% more than the flared end fitting (top). Both have a 2 in. (50 mm) interior diameter

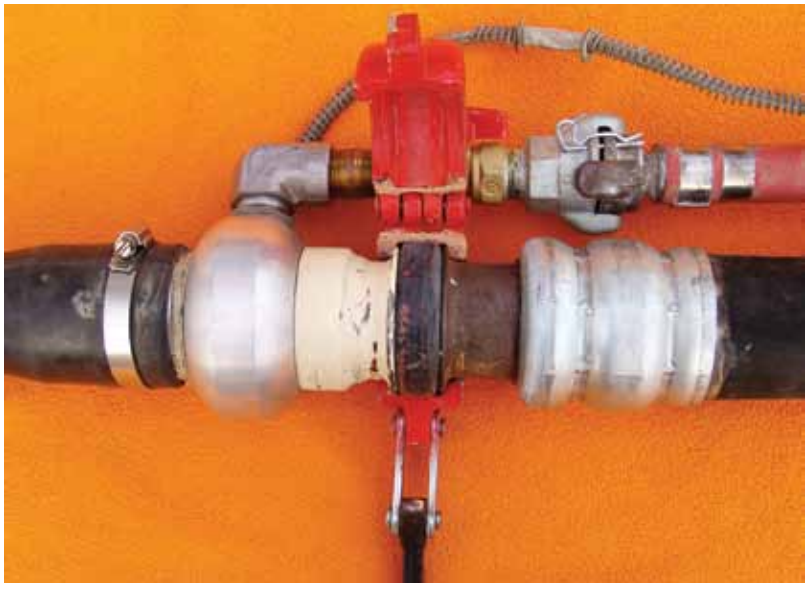


Fig 5: Flared-end coupling and gasket-in-nozzle application

Fig 6: Interference with a foreign object caused this preventable failure

A safe placement system must also include the use of approved components within the air supply lines. If Chicago-style fittings are to be used, safety clips are essential (refer to Fig. 7). Some job-site safety requirements, however, prohibit the use of Chicago-style fittings.

Current safety requirements mandate the use of positive interlocking couplers such as the Thor fittings (refer to Fig. 8) with whip checks installed at all air supply line couplings.

Whenever any material is highly pressurized and conveyed through a pipe or hose, there is the potential for an accident. The proper selection and rigorous inspection of all placement system components for wear, chafing, or cracking are essential elements to the use of a safe wet-mix placement system and should be part of a wet-mix shotcrete crews' daily routine.

Wet-Mix Placement System Safety Checklist

- Know the maximum outlet pressure of your wet-mix shotcrete pump. If the maximum outlet pressure is not known, ask.
- All placement system components must display a working pressure rating at or above the maximum outlet pressure of the pump.
- Safely route the placement system away from sharp objects that may damage or rupture a system during use. Discard components that show visible damage or wear.
- Use only approved coupling devices. Avoid Victaulic-type grooved-end couplings.
- Always use whip checks on air supply line couplings. Use positive interlocking couplers such as Thor fittings.
- If Chicago-type fittings are used, always use safety clips.
- Pressures are greatest near the pump. Only use new or like-new condition parts for the first several sections.
- Keep the placement system as short as is practical—less system requires lower line pressure.

Remember: the failure of any wet-mix shotcrete component while under pressure can cause serious injury or property damage.

Be vigilant about inspecting placement systems. Components are subject to extreme pressures that can quickly cause wear, cracking, or other potentially dangerous damage. Placement systems cannot be inspected too often. Visual inspection by the nozzleman and crew is a key element in the use and maintenance of a safe wet-mix placement system.

Fig 7: A Chicago-style fitting with whip check and safety clip in place

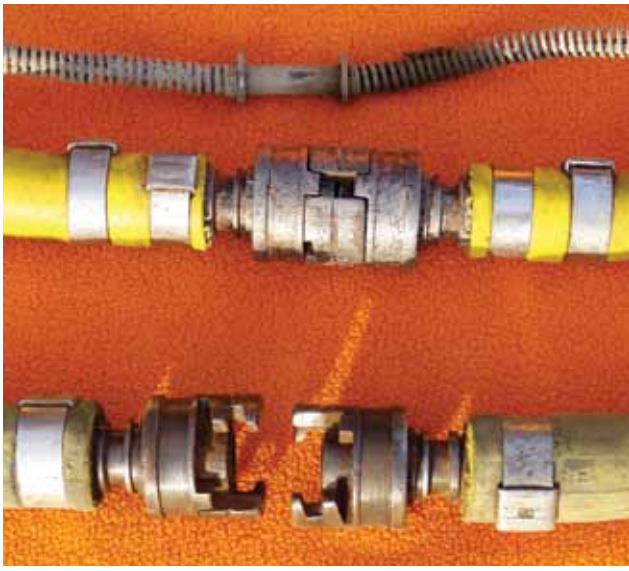


Fig 8: Thor positive-interlocking coupler. Note locking teeth on the open coupler

*ACI Certified Nozzleman **Oscar Duckworth** is an ASA and ACI member with over 15,000 hours of nozzle time. He has worked as a nozzleman on over 2000 projects. Duckworth is currently an ACI Examiner for the wet-mix process and is an approved ASA wet-mix and dry-mix Educator. He continues to work as a shotcrete consultant and a certified nozzleman.*

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Circle #43 on reader response form—page 64

Waterproofing—Is it Necessary in Pool Construction?

By Jerry B. Werner

Of course, we are talking about reducing water penetration through concrete—or waterproofing, as it is known in the pool industry. There seems to be a wide range of opinions on this subject. I have sat through presentations where it was stated that waterproofing was indicated, but understanding the reasons why it was needed and what type of system may be available were not mentioned. I have also read articles in pool trade magazines that would lead one to believe that moisture intrusion into concrete was not a bad thing. There is also the camp that would say that all you need is the proper compressive strength and everything else will take care of itself. Concrete, one would think, will last forever. Unfortunately, this is not the case. The world outside the pool industry has a completely different set of ideas. I am not a pool builder or a pool designer. I am a Civil Engineer and a Florida State Certified Building Contractor and came into the pool industry from nearly 20 years in the concrete repair industry. Before moving to Atlanta, GA, I served on the Board of Directors of the Southeast Florida Chapter of the International Concrete Repair Institute (ICRI). My company was an investigative and forensic engineering group that reviewed failures and recommended methods of repair. Parking garages were leaking mineral deposits on very expensive automobiles, balconies were literally falling off condominiums, building structures were leaking moisture through concrete and stucco, and bridges were failing. While working with the Federal Highway Administration and local Florida Department of Transportation (FDOT) officials, vast sums of money were being spent to address these issues. Epoxy-coated reinforcing bar and other methods such as cathodic protection were being analyzed. Why? Because concrete in itself is not watertight or waterproof. Protection of the reinforcing bar is very important. As steel rusts, it expands and can cause as much as 10,000 psi (69 MPa) force on the concrete, causing it to crack. Once cracks appear, the process only worsens and the downward spiral begins. More cracks mean more water intrusion, which results in faster deterioration. In coastal Florida, we were also dealing with salt intrusion, which acts as a catalyst that accelerates the process. Unsightly efflorescence is mainly an aesthetic issue but its presence may indicate other issues that could lead to structural damage and debonding of tile if left unattended.

Bridge abutment deterioration

To say that reducing the ingress of water in concrete is not required is to ignore the history that we see every day. Over 30 years ago, concrete bridge structures across the U.S. were reported as being structurally deficient. To date, not much has been done to resolve this problem.

Having said all that, is there any correlation between general construction practices and pool construction? Are the rules and processes any different? Well, let's start from the beginning: what is required to ensure that water infiltration issues are being addressed?

First of all, we start with quality construction and proper preparation of the subgrade. If your pool and deck are sinking due to improper soil compaction, cracking will eventually occur, and so will leaks. Secondly, proper steel placement

and cover must be maintained for the protection of steel reinforcement. Thirdly, use the proper concrete for the conditions that you are confronted with. Whether you are using wet- or dry-mix shotcrete or cast-in-place concrete, there are minimum requirements to meet. ASA has adopted the 4000 psi (27.6 MPa) standard that is found in ACI 318-08. That, however, is a minimum for normal construction for concrete that is in contact with water. There are two other conditions that would require 4500 psi (31 MPa) minimums for freeze-thaw zones and 5000 psi (34.5 MPa) minimums for concrete subject to chloride ion exposure.

All highway departments start with these minimum concrete standards but continue to experience continued deterioration. Many attempt to use protective coatings, but by their own reporting have had only moderate success because they continue to use inexpensive surface materials that fail to provide long-term effectiveness.

Fourthly, the next process, of course, is the plaster coat. Five years ago most pool builders I spoke to about the benefits of waterproofing would tell me that the plaster coat was all the waterproofing that was needed. This was interesting to me, as my past experience was with exterior stucco. My guide was the Portland Cement Plaster (Stucco) Manual—which referred to stucco as weather-resistant—and ASTM Standard C926, "Application of Portland Cement-Based Plaster," which states that "plaster shall not, however, be considered to be waterproof." Investigating further, I contacted the National Plasters Council and received the National Plasters Council Technical Manual, which states, "In fact, cementitious surface coatings are not intended to completely stop moisture penetration. The coating should be expected to greatly reduce the rate in which moisture penetrates through the coating and into the substrate."

That leaves us with the fact that pool construction should be as good as or better than general construction methods—being subject to continuous water and chemical action—and understanding that concrete and plaster are not waterproof.

What are the proper methods, then, to address all the issues that will provide proper protection of the concrete and reinforcing bar, and prevent efflorescence problems? We have to understand that water comes from the pool, from rain, and from the ground. In a vanishing edge condition, water flows over the top of the weir and sometimes results in efflorescence from the grout on the surface of a tile application. Therefore, we have to match sealing methods with the conditions that we want to prevent. It is not just something that you apply to the inside of the pool. Sealers must also be considered for patios, stone features, and waterfalls. Water that penetrates through a patio can find its way to the back of the shell wall and tile through the groundwater supply. If stone and copings are left untreated, moisture intrusion and thermal changes can result in spalling. This can also be exasperated in salt-generated pool systems. All of these conditions can be mitigated, however, by proper sealing methods.

Applying sealer to pool on 14th floor condo

Vanishing edge sealer application

Efflorescence spa

Efflorescence vanishing edge

Efflorescence vanishing edge (another view)

Efflorescence is an indicator and is the first sign that you are experiencing water intrusion problems. It occurs when moisture that has migrated into the shell wall or mortar and grout dissolves soluble salts in a cementitious mixture and then deposits the residue upon evaporation onto the exposed surface. It will occur very quickly and become a continuous problem for you and your client. To remedy these potential troubles of deteriorating concrete, rusting reinforcing bar, and efflorescence—not to mention leaching chemicals from your pool into the groundwater supply—you need to consider some type of protection beyond quality construction. Quality construction should include a review of the waterproofing needs of your project.

Waterproofing systems basically come in three different types: admixtures; surface-applied systems, such as membranes, cementitious applications, and surface sealers; and deeply penetrating sprayed-on applications that change state from a liquid and reduce permeability from the inside out. In many cases, these products can be used in combination. Compatibility, however, must be evaluated for maximum benefit. Perform your due diligence and select your waterproofing solutions well. For a client to spend a lot of money on their dream pool only to inherit a nightmare is just plain trouble for the pool contractor. The expense and extra effort to make sure you have addressed all of the water infiltration issues will be well worth not having to make a callback.

Patio protection

Pool & Recreational Shotcrete Corner

***Jerry B. Werner**, Director, Aquron Aquatics Division, Aquron Corporation International, is a Civil Engineer and a Florida State Certified Building Contractor (inactive) CBC033127. Werner is also President of Concrete Preservation Systems and works exclusively for the Aquron Corporation.*

As past President of Omega Engineering Consultants, an investigative and forensic consulting firm located in South Florida, Werner performed investigations related to damages and failures from hurricanes and other natural disasters for insurance companies, home owners, and condominium associations. The majority of work, however, focused on moisture intrusion through building systems, much of which was through concrete such as parking decks, concrete or block and stucco wall systems, and seawall protection. Because of moisture and salt intrusion, condominium balconies along the coast lines of Florida were being destroyed to the point of falling off the structures.

Werner comes into the pool industry, therefore, from a different perspective. Serving on the Board of Directors of the Southeast Florida Chapter of ICRI prior to moving to the Atlanta area in 2003, he had to deal with numerous cases of concrete failures that were caused by moisture intrusion. In 2008, he helped create the Aquatics Division of the Aquron Corporation, bringing concepts learned over the past 20 years in waterproofing and protecting concrete, and applying them to the pool industry.

A recent member of ASA, Werner now serves on the Pool & Recreational Shotcrete Committee. He has authored several articles for Condo Management *magazine and others, and provides technical direction and training for applicator certification for the Aquron Corporation, Aquatics Division. Waterproofing and control of efflorescence are a main focus for the Aquatics Division of the Aquron Corporation.*

Drakeley Industries, LLC

DRAKELEY INDUSTRIES, LLC

DRAKELEY INDUSTRIES SHOTCRETE REVIEW
THE DRAKELEY POOL COMPANY, LLC

Drakeley Industries, LLC, formed in 2008, is an organization that uses the shotcrete process in two different companies. Drakeley Industries Shotcrete Review is a consulting company that specializes in applied concrete through the shotcrete process. Their job expertise ranges from application techniques to nozzleman certification to judicial expert witness appearances. Having three certified nozzlemen on staff, Drakeley Industries Shotcrete Review instructs and demonstrates from real-world experience. These experiences enhance a working relationship with the on-site nozzleman and shotcrete crew. With the Shotcrete Review team, Drakeley Industries, LLC, always recognizes the difference between lab specifications and field implementations. The company's work history helps companies bridge that gap in better understanding the shotcrete process and implementing these specifications with hands-on training.

The second company under the Drakeley Industries, LLC, umbrella is The Drakeley Pool Company, LLC. This business is a family owned and operated design and construction firm specializing in the installation of concrete swimming pool vessels and related mechanical components. Founded in 2000, The Drakeley Pool Company, LLC, has since developed into a nationally recognized company that focuses on intricate water features and pools.

The Drakeley team has experience from a diverse background of projects—both residential and commercial. With a skilled set of employees and craftsman certified by the American Concrete Institute (ACI), many of the company's projects have been recognized in national publications.

The two key members of the Drakeley organizations are William T. Drakeley Jr. and Jeff Boucher. Drakeley is an active member of ACI Committee 506, Shotcreting. He is the only ACI Certified Shotcrete Examiner from the pool industry nationwide. Drakeley is also an ACI Certified Nozzleman, ACI-approved Examiner, approved ASA Educator, ASA technical advisor, ASA board member, and Vice Chair of the ASA Pool & Recreational Shotcrete Committee. His articles have been published in national and international trade magazines, including ASA's *Shotcrete* magazine and *Water Shapes* magazine, and he has a new shotcrete feature article in the 2010 issues of *Luxury Pools*. In addition, Drakeley is a Platinum Member of the Genesis 3 Group and a licensed member of the Society of Water Shape Designers. He is also the concrete/shotcrete

instructor at the Genesis 3 Pool Construction Schools. As an instructor/trainer, Drakeley has given lectures on shotcrete applications for various trade shows, including World of Concrete. The U.S. judicial system recognizes Drakeley as an Expert Witness in regard to shotcrete applications for the swimming pool industry.

Boucher is Vice President and Managing Partner of The Drakeley Pool Company, LLC, and Drakeley Industries Shotcrete Review. He is a 16-year veteran of the pool industry with expertise in all forms of pool design, construction, and service. Boucher is widely recognized as a leading industry expert in green technology and alternative sanitizers and has contributed to industry articles written on these topics. Having a design and photography background, Boucher's work with Drakeley Pool Co. has been featured in national magazine media. These projects consistently show creative design with and understanding of the proper use of color and texture. Boucher's memberships include the Genesis 3 Design Group, Society of Watershape Designers (in training), Nikon School of Photography, and ASA.

Drakeley Industries, LLCs' good work has not gone unnoticed. The Drakeley Pool Company, LLC, has been featured in such publications as *Better Homes and Gardens*, *Luxury Pools*, and *Passport Magazine*. The staff has been interviewed for reference and expert opinions by *Watershapes*, *Pool and Spa*, and *Aqua* magazines.

All of the staff at Drakeley Industries, LLC, are proud of their accomplishments and look forward to continuing with future projects as they represent the shotcrete industry.

A *Shotcrete* feature:

SAFETY SHOOTER

Rigging for Shotcrete

By Ted W. Sofis

I am not going to talk about hardhats, safety glasses, or hearing protection. We use those items every day in shotcrete construction and they have been covered in past Safety Shooter articles. What I want to address is rigging. Whenever possible, it is quicker and easier to use man-lifts or snoopers (under-bridge inspection cranes) for access, but there are times where it becomes necessary to rig the structure. When you're on the nozzle and up high on a suspended scaffold, you are in a very vulnerable position. A plug in the hose or a surge in air pressure can suddenly throw you off-balance. Therefore, it's important to have a good, substantial, stable place to stand. When you're moving, it is always a good idea to have a helper with you, pulling the hose as you move, because when you are shooting, you are concentrating on gunning. Tugging on a hose, which can often hook on things or slip loose, can cause you to lose your balance. Always remember to securely tie off your hose. The hose can slip off the stage and pull you with it.

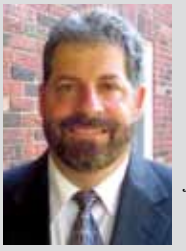
Everyone must be tied off at all times, with the appropriate safety harness and a shock-absorbing or retractable lanyard. Relying on a handrail set up behind you can give a false sense of security. Each worker must have an independent safety line; by independent, I mean a cable separate from the stage or platform on which you're working. That way, if anything should happen to the stage you are standing on, you are not tied to it—you're hooked to another safety cable. When hanging your cables, an allowance needs to be made to position yourself far enough away from the wall, pier, or abutment to be able to shoot it properly. Shotcrete is placed using high velocity, so you need to be at least 4 to 5 ft (1.2 to 1.5 m) away from the gunning surface to achieve a good spray pattern. No nozzleman wants to be right on top of what he's trying to shoot or to lean back against the stage's handrail to get far enough away to properly place the shotcrete. So when hanging your cables, keep this in mind. If you have no structure above you on which to hang your cables, you can use outriggers, which will provide enough distance from the shooting surface to apply the shotcrete efficiently. Be aware of the design capability of your rigging setup. The cables and

Rigging setup for access to bridge pier

Cable rigging under bridge super-structure

climbers should have an adequate safety factor built in for the mass the rigging is to support. Clean any rebound off as you go and do not let it build up on your stages. Rebound and over-spray can add a lot of unnecessary mass to the stages, so it's something that you want to stay on top of. Keep your cables and climbers clean. Make absolutely sure all your men are safety trained for fall protection and follow all OSHA guidelines and safety rules. This is one job where your tool box safety meetings really matter.

Outriggers in place across the top of a dam with stages positioned to be rigged



***Ted W. Sofis** and his brother, William J. Sofis Jr., are principal owners of Sofis Company, Inc. After graduating from Muskingum College, New Concord, OH, with a BA in 1975, he began working full time as a shotcrete nozzleman and operator servicing the steel industry. He began managing Sofis Company, Inc., in 1984 and has over 34 years of experience in the shotcrete industry. He is an ASA-approved Shotcrete Nozzleman Educator, the Treasurer for ASA, and a member of the ASA Publications and Education Committees. Over the years, Sofis Company, Inc., has been involved in bridge, dam, and slope projects using shotcrete as well as refractory installations in power plants and steel mills. Sofis Company, Inc., is a member of the Pittsburgh Section of the American Society of Highway Engineers (ASHE) and ASA.*

Shotcrete FAQs

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

Question: *We have demolished two radioactively contaminated buildings down to their concrete slabs. One of the slabs has a concrete pit that is 26 ft (8 m) deep. The slabs have not been removed because the soil beneath the slabs is contaminated and we're using the slabs as a cover to protect the spread of contamination in the soil until the soil remediation begins. We'd like to use shotcrete to temporarily (up to 5 years) fix the contamination on the slabs and the 5 ft (1.5 m) area surrounding them. The questions we have are: 1) Will shotcrete adhere to the concrete slabs and pit walls for up to 5 years without special preparations? (Portions of the radioactively contaminated concrete are painted and it is dirty from demolition activities); and 2) What is the minimum thickness of shotcrete needed to last for 5 years in this type of application? We do not want to use any wire or fabric mesh as it would require personnel to work in a radiologically controlled environment to install the material.*

Answer: Shotcrete, like concrete, likely will not adhere to surfaces that are painted and dirty from the demolition activities. There should be no issue to the time durability. Shotcrete is pneumatically placed concrete and has great long-term durability characteristics if placed properly.

Shotcrete has been installed in many adverse environments at a thickness of 2 in. (50 mm) with fibrous reinforcement and provided a long service life. Many irrigation districts line their canals with shotcrete and it has provided decades of great service in freeze-thaw exposures.

Question: *What is the recommended cure time for shotcrete pools and spas so that shrinkage cracks in finished tile work can be avoided?*

Answer: Concrete, when applied using the shotcrete process, or cast-in-place, needs to cure for 7 days. Water is the best curing method (7 continuous days). Curing compound can be applied, but the membrane film that is formed will have to be removed by sand or water blasting (5000 psi [34.5 MPa] is recommended) before the plaster or tile can be set (it will create a bond breaker if not removed). There are curing compounds with a dissipating resin, which means after about 30 days in the sun, the material will break down. In either case, it is a good practice to pressure wash the concrete surface to remove the grit and dust out of the pours so that the plaster and tile will have a good bond. This is normal, everyday concrete curing practice that helps to prevent shrinkage cracks. The concrete being applied should have a water-cement ratio (*w*/*c*) of 0.35 to 0.45. Having the *w*/*c* at 0.40 at a 2 to 3 in. (50 to 75 mm) slump will keep the water demand low to help minimize the shrinkage. Wet-fogging freshly placed concrete before the curing process begins will also help prevent shrinkage cracks.

Question: *We are designing underground support for a hydropower tunnel. I want to know whether wire mesh-reinforced shotcrete or steel fiber-reinforced shotcrete will be better and more economical. What are the advantages and disadvantages of both of these types of reinforcement if used for supporting a tunnel for hydropower? Also, for slope protection work, which type of shotcrete is better in terms of reliability, durability, and cost?*

Answer: There are really two questions here: 1) Underground fiber-reinforced versus mesh reinforced; and 2) slope protection fiber reinforced versus mesh reinforced.

1. Underground fiber reinforced versus mesh reinforced: it is not clear what the alternatives are that you are considering, but sprayed concrete has a good, solid track record for ground support. If it is a simple comparison of steel mesh versus steel fiber reinforcement, then the issue is one of a design approach.

   Wire mesh and bolts have a longer history and are simple to design as a rigid structure. To install mesh and bolts, however, requires working under unsupported ground. Mechanized spraying of concrete is done with the operator under supported ground and therefore is intrinsically safer.

   The design of fiber-reinforced sprayed concrete as ground support is approached differently. The sprayed concrete is allowed to deform to a certain extent before coming to rest with the ground forces finding a new equilibrium. The extent of this deformation depends on the energy absorption of the sprayed concrete structure, which is provided for by the fibers.

   Steel fiber-reinforced sprayed concrete is by far faster to place and therefore has economic benefits. As the fibers are discontinuous, there is merit in considering this structure less susceptible to corrosion and consequential durability issues. We recommend consulting ACI 506.1R and ACI 506.5R.

2. Slope protection fiber reinforced versus mesh reinforced: for slope protection, both fiber-reinforced and wire-mesh-reinforced shotcrete work well and are durable, reliable, and cost effective if done properly. Care must be taken with wire mesh reinforcing to ensure that it is maintained in the middle of the section and not on the ground where it is not effective. Wire mesh can also be difficult to install on an irregular surface and require more shotcrete material to cover the area and the mesh. The wire mesh can be an asset to the installer

in providing a grid to support a scaffold system. In many applications, the choice of wire mesh or fibers should be left to the installer with the engineer specifying the minimum requirement for each.

Question: *We are repairing a culvert in Dallas, TX. The concrete wall of the structure is prematurely disintegrating. We are considering a process to temporarily support the ceiling, remove the wall, place a form on one side, and use shotcrete to replace the wall. Does this sound like a reasonable use for shotcrete? What kind of specifications should be used?*

Answer: Yes, this sounds like a good use of the shotcrete process. Your sequence sounds like a good plan. A sample Structural Shotcrete Specification is available from the *Shotcrete* magazine archive on the ASA Web site (**www.shotcrete.org**).

Question: *We're looking at adding approximately 4 in. (100 mm) of shotcrete to an existing 8 in. (200 mm) wall to meet new load requirements. What's the minimum cover between the reinforcement and existing wall for proper encapsulation of the reinforcement?*

Answer: A minimum clearance for the reinforcment off the existing surface should be 0.75 in. (19 mm) or one bar diameter, whichever is greater, to allow a good flow of material around the reinforcing steel.

Question: *I am working on a water feature formed out of cast-in-place reinforced concrete with a hot-fluid-applied waterproofing system over the concrete. To protect the waterproofing, we plan to install shotcrete over it. What minimum thickness of shotcrete is required? Would welded wire fabric or fiber mesh be required as well?*

Answer: In general, we would recommend a minimum of 2 in. (50 mm) of shotcrete.

Either fibers or wire mesh or both should be used in this application. Please note that there are different types of synthetic fibers (microsynthetic and macrosynthetic). Refer to ACI 506.1R for information on fiber-reinforced shotcrete.

If the surfaces are steep or vertical, wire mesh should be used, but provisions need to be included to stabilize the wire mesh. This would likely require attachment points through the waterproofing system.

Does the SHOTCRETE WORLD need to know about YOUR COMPANY and its PRODUCTS or SERVICES?

If the answer is ☑ "YES" then read on.

Advertising in *Shotcrete* magazine is the most cost-effective way to reach the shotcrete industry.

Each issue of *Shotcrete* magazine reaches a growing number of **over 15,000 readers** that includes current and potential designers, specifiers, and purchasers of shotcrete across 95 countries.

The many benefits of advertising in *Shotcrete* have significantly increased with the addition of the electronic version of the magazine.

All advertisers in *Shotcrete* will now have their advertisement appear in *BOTH* the printed copy and the new electronic copy of the magazine at no additional charge.

The electronic copy of *Shotcrete* is sent to all subscribers, and advertisements include a hot link to the advertiser's Web site.

You can also hire our design department to create professional advertising design for your company. From concept to production and printing, we can produce the promotional materials for your ad campaign.

Your advertisement in *Shotcrete* will reach the companies and people that you need to grow your business. The cost for advertising is very affordable, and will certainly provide you with the most "bang" for your advertising dollars.

Shotcrete MAGAZINE
A quarterly publication of the American Shotcrete Association

To obtain a media kit, arrange for advertising, or for answers to questions, contact: info@shotcrete.org or visit our Web site at www.shotcrete.org

Shotcrete Calendar

SEPTEMBER 16-19, 2010
American Society of Concrete Contractors Annual Conference
Little America, Salt Lake City, UT
Web site: **www.ascconline.org**

OCTOBER 5-6, 2010
Strategic Development Council Session #28
Detroit, MI
Web site: **www.concretesdc.org**

OCTOBER 20-22, 2010
ICRI 2010 Fall Convention
Theme: "Transportation Structures"
Omni William Penn Hotel, Pittsburgh, PA
Web site: **www.icri.org**

OCTOBER 23, 2010
ASA Fall Committee Meetings
The Westin Convention Center, Pittsburgh, PA

OCTOBER 24-28, 2010
ACI Fall 2010 Convention
Theme: "Green Concrete in the Steel City"
The Westin Convention Center, Pittsburgh, PA
Web site: **www.concrete.org**

OCTOBER 25, 2010
ASA Fall Underground Committee Meeting
The Westin Convention Center, Pittsburgh, PA

OCTOBER 28 - NOVEMBER 2, 2010
2010 AASHTO Annual Meeting
Beau Rivage Resort & Casino, Biloxi, MS
Web site: **www.transportation.org**

OCTOBER 31 - NOVEMBER 5, 2010
International Pool | Spa | Patio Expo
Conferences: October 31- November 5
Exhibits: November 3-5
VISIT ASA AT BOOTH #327
Mandalay Bay Convention Center, Las Vegas, NV
Web site: **www.poolspapatio.com**

DECEMBER 5-8, 2010
ASTM International Committee C09, Concrete and Concrete Aggregates
Sheraton New Orleans, New Orleans, LA
Web site: **www.astm.org**

JANUARY 17, 2011
ASA World of Concrete Annual Meetings
Las Vegas Convention Center
Las Vegas, NV

JANUARY 17-21, 2011
World of Concrete 2011
Seminars: January 17-21; Exhibits: January 18-21
VISIT ASA AT BOOTH #S10749
Las Vegas Convention Center, Las Vegas, NV
Web site: **www.worldofconcrete.com**

JANUARY 18, 2011
The 2011 ASA Annual Membership Meeting & Sixth Annual Outstanding Shotcrete Project Awards Banquet
Las Vegas, NV

MARCH 15-18, 2011
ICRI 2011 Spring Convention
The Westin Galleria, Houston
Houston, TX

APRIL 2, 2011
ASA Spring Committee Meetings
Marriott Tampa Waterside & Westin Harbour Island
Tampa, FL

APRIL 3-7, 2011
ACI Spring 2011 Convention
Theme: "Concrete—The Strength of Florida"
Marriott Tampa Waterside & Westin Harbour Island
Tampa, FL
Web site: **www.concrete.org**

APRIL 4, 2011
ASA Spring Underground Committee Meeting
Marriott Tampa Waterside & Westin Harbour Island
Tampa, FL

OCTOBER 15, 2011
ASA Fall Committee Meetings
Millennium Hotel & Duke Energy Convention Center
Cincinnati, OH

OCTOBER 16-20, 2011
ACI Fall 2011 Convention
Theme: "Bridging Theory and Practice"
Millennium Hotel & Duke Energy Convention Center
Cincinnati, OH
Web site: **www.concrete.org**

OCTOBER 17, 2011
ASA Fall Underground Committee Meeting
Millennium Hotel & Duke Energy Convention Center
Cincinnati, OH

EPA Opens Public Comment Period on Two Options for Fly Ash Regulation

Please review details on this item under the Sustainability feature of this issue. This is a very important item requiring your education and action.

Blastcrete Equipment Company Announces IRONCLAD Marketing as Agency of Record

Anniston, AL—Blastcrete Equipment Company, manufacturer of concrete mixers, pumps, and related products, has selected IRONCLAD Marketing, Inc., as its Agency of Record. The West Fargo, ND-based company will manage all of Blastcrete's advertising, marketing, and public relations efforts. **Jim Farrell**, President of Blastcrete, chose IRONCLAD based on its experience in the equipment industry and the appeal of working with a smaller, focused agency.

"As a small business ourselves, it was comforting to form a relationship with a team of people who can really relate to us," said Farrell. "I got a sincere and personal feeling from them. They took the time to get to know us, our products, and our needs, and I feel this will help them effectively communicate our message."

All ASA members and subscribers now have access to the NEW 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 all future issues of the electronic version of the magazine, send your e-mail information to info@shotcrete.org.

Blastcrete started out in 1950 as a manufacturer of single- and double-chamber gunite machines. Over the years, the company has continued to innovate and grow, and now offers a full line of products for a variety of industries such as commercial and residential building, insulated-concrete-forming and structural-concrete-insulated-panel building systems, refractory, and underground/mining. In addition to offering swing tube and ball-seat pumps, Blastcrete offers low-pressure squeeze pumps, ideal for shotcrete, gypsum floors, plaster and stucco, cellular concrete, and concrete flatwork. The company also houses an extensive inventory of accessories including high-quality pumping hoses, pipes, shotcrete nozzles, and hose couplings.

Putzmeister America, Inc., 2010 Service School Schedule

Classes help customers maximize the operation and efficiency of their new and existing Putzmeister equipment. Taught by experienced field service technicians, all service school classes are held at Putzmeister America's headquarters in Sturtevant, WI. Regularly scheduled service training classes for customers and distributors that Putzmeister America offers include:

- Practical hands-on training;
- Problem-solving exercises;
- General maintenance and operation tips and tricks; and
- Dynamic graphic presentations.

The 2010 Service School topics include: Truck-Mounted Boom Pump Maintenance and Service School; Truck-Mounted Boom Pump Operations; Truck-Mounted Boom Pump—Spanish; PMA Structural Inspection; Telebelt® Service School; Thom-Katt; and Mortar Machine Operations.

To register, or for more information regarding Putzmeister America's 2010 Service School schedule, visit www.putzmeister.com and click on the "Service Schools" page under "Parts & Service," or call (800) 890-0269.

New Zealand Shotcrete Conference

Attended and submitted by Dudley R. "Rusty" Morgan

The Third International Conference on Engineering Developments in Shotcrete, chaired by **Stefan Bernard**, was held in Queenstown, New Zealand, March 15-17, 2010. It was sponsored by the Australian Shotcrete Society. The Conference was well supported with 33 papers. While the majority of the papers were from authors in Australia and New Zealand, there were also contributions from authors in the UK, Sweden, Norway, Switzerland, Italy, Germany, the U.S., Canada, Japan, Indonesia, and South Korea.

The Conference was well attended, with 128 attendees from 15 different countries. About 80% of attendees were from Australia, 10% from New Zealand, and the remainder from other countries. The papers presented covered 10 different themes: Project Case Histories (mainly tunnels); Shotcrete Systems; Fire Resistance & Shotcrete Appearance; Structural Analysis; Testing of Shotcrete; Testing & Analysis; Air in Shotcrete; Mining Applications; Material Properties; and Certification & Miscellaneous.

The Conference Proceedings have been published by CRC Press. Title: *Shotcrete: Elements of a System*; Editor: Stefan Bernard, 2010; ISBN: 978-0-415-47589-1, as a hard cover book. They are also available as an E-book: ISBN: 978-0-203-84937-8. These proceedings make a valuable contribution to the shotcrete literature and are particularly useful to those involved with the use of shotcrete in the tunneling and mining industries.

Finally, as in all previous Australian Shotcrete Society International conferences, a vibrant social program was provided. Attendees enjoyed a welcoming reception that included a traditional Maori welcome and "Haka." The conference banquet was at a farm that was reached by an awe-inspiring jet-boat ride. Guests got a chance to compete with a sheepdog rounding up sheep (the sheepdog won, hands down). The banquet, with excellent New Zealand cuisine and wines, was followed by some lively dancing "down-under" style. So if you missed this conference, be sure to put the next Australian Shotcrete Society International Conference on your calendar (date and location yet to be determined).

2010 International Pool | Spa | Patio Expo Assigns More Than 87% of Show Floor during Space Draw

With 6 months until show time, the 2010 International Pool | Spa | Patio Expo recently concluded its annual Space Draw process and assigned a staggering 87% of the show floor, far surpassing last year's Space Draw of 65%.

"Exceeding our most optimistic projections, more than 285 exhibitors participated in Space Draw," said **Donna Bellantone**, Director of the Expo. "The impressive list of companies should really energize attendees."

"It is a testament to the strength of the show and the industry that so many companies made an early and decisive commitment to exhibit," said **Bill Weber**, President and CEO of The Association of Pool & Spa Professionals® (APSP), the show's official sponsor. "The exhibitors' enthusiasm and confidence brings a positive energy to the show."

Taking place November 3-5 in the Bayside Halls at the Mandalay Bay Convention Center in Las Vegas, NV, the show will offer pool/spa builders, retailers, service companies, designers, and landscape architects a comprehensive preview of the entire backyard living marketplace.

Rebranded in 2008 as the International Pool | Spa | Patio Expo, the show is made up of the former International Pool & Spa Expo, Backyard Living Expo, and AQUA shows. More than 430 exhibiting companies will fill 1000+ booths and draw 9100+ attendees. Show highlights include 74 educational seminars, the VGB Pavilion, Party on the Patio Pavilion, Product Showcase, Backyard Living Pavilion, Genesis 3 Pavilion, live workshops, and exhibitor product clinics. Sponsors include APSP and *Pool & Spa News*. The show is endorsed by the Genesis 3 Design Group.

ASA will once again be an exhibitor at the 2010 International Pool | Spa | Patio Expo.

April Construction Starts Up 7% from March

Reed Construction Data (RCD) announced that the year-to-date value of construction starts through April 2010, excluding residential contracts, totaled $82.7 billion—11.0% more than in the same span in 2009. Individual month of April starts were 6.6% higher than March starts. This was just short of the usual seasonal gain in April, and therefore has to be interpreted as approximately steady with March.

The value of construction starts each month is summarized from RCD's database of all active construction projects in the U.S., excluding single-family homes.

The new data do not change the expected starts trend in 2010. The total value of starts, adjusting for seasonality, is expected to be steady to slightly down in the next few months and then to begin to rise slowly later in the year. The economic environment for construction is clearly improving. Contractors added 40,000 jobs in the last 2 months. Buildings funded by the stimulus plan are beginning to get started, and the rise in the commercial vacancy rate is now slowing.

April nonresidential building starts were 13% above March—about double the usual seasonal gain—and 31% higher

than a year ago. The starts total, however, was 19% below the 2006 to 2008 average. Starts have recovered substantially from the steep drop early in the recession with no sustained decline expected during the rest of 2010. The April starts gain was due to a large rebound in hospital starts after four weak months, plus smaller pickups in education and commercial buildings.

The full article and stats can be viewed at **www.reedconstructiondata.com.**

Increase Cement Sales Shows U.S. Construction is about to Pick Up

Source: ARI—Aggregate Research.com

A 4-year slump in construction may be nearing an end, with the biggest U.S. building-material makers reporting higher monthly sales that have yet to spread industry-wide.

Cemex, the largest U.S. cement producer, and Vulcan Materials Co., the top gravel supplier, reported monthly volume increases for March and April, their first since 2006. The results exceeded estimates and may lead the Portland Cement Association to increase its growth forecast this year, said **Ed Sullivan**, Chief Economist for the trade association.

"This upturn, even though it's still based on limited data, is to be believed," Sullivan said. "From what I'm hearing, it's a significant uptick in April, and I think we're going to see a very good May as well."

Increases in housing starts and rail shipments of crushed rock, sand, and gravel indicate a rebound in construction, which shed about 1.9 million jobs in the worst economic recession since the 1930s. The latest Commerce Department figures show that year-over-year housing starts rose for a fourth month to an annual rate of 626,000 in March, the highest since November 2008.

The cement association forecasts demand will rise 5.2% this year after dropping 27% last year. Cement demand may rise as much as 7.5 to 8%, as housing rebounds and most stimulus funds for highways and bridges are spent this year, Sullivan said.

About 74% of the $27 billion in stimulus funds authorized for U.S. roads and bridges hasn't yet been spent and most of it will come at the end of this year, Cemex said. In March, Congress authorized $42 billion for the federal highway program for 2010.

Huge Stimulus Funding to Reach Infrastructure Contractors

Source: Oniva

Onvia analysts say 2010 will be the year of maximum stimulus impact as funds that were obligated in 2009 will finally be awarded to contractors who will begin work in 2010. This, coupled with the investments covered by the pending Jobs for Main Street Act, will help fund projects from bridge construction to light rail, and Amtrak fleet modernization to fuel-efficient vehicle purchases. Onvia is the leader in business-to-government solutions and the creator of Recovery.org, a private sector initiative to give businesses transparency into recovery project spending.

"Despite all of the talk about the stimulus working, our research shows most of the funds have not left Washington, although they will in 2010," said **Mike Pickett**, CEO of Onvia. "This year we are tracking 23,500 new projects in the pipeline, and there is $76 billion in stimulus funding that will reach contractors on these projects this year. We also expect competition for these contracts to be fierce as more businesses seek to capitalize on the irresistibly large market created by government spending. It will remain a buyers' market as more companies follow the money and competition keeps a lid on costs. Welcome to the 'Next Economy'—one in which government and businesses operate more closely," said Pickett.

"Government spending is at an all-time high and we do not see that changing in the foreseeable future," said Pickett. "We are witnessing the 'Next Economy,' in which government more actively participates in business interests through regulation, direct ownership, contracting requirements, and other means. For business, the debate isn't about the size of government, but rather how to engage in and influence this vast and growing market."

Industry Personnel

Marc Aguilar

Putzmeister America, Inc., Promotes Aguilar to Vice President of Sales–Latin America and the Caribbean

Putzmeister America, Inc., announced **Marc Aguilar** as Vice President of Sales–Latin America and the Caribbean (LACA). Aguilar, who will report directly to **Dave Adams**, Putzmeister America's President and CEO, will oversee local distributors and the Putzmeister LACA sales team, as well as Putzmeister Brazil Ltda. (PMB).

"Over the past 14 years with Putzmeister, Marc has proven his sales and leadership abilities," notes Adams.

In his most recent position at Putzmeister, Aguilar not only advanced growth and recognition of Putzmeister in LACA, but also gained a firm understanding of the needs of each local marketplace.

"I am confident in his new role that Marc will use this experience and continue with the same level of dedication to lead market growth and develop long-lasting customer relationships," adds Adams. "In recent years, the LACA region has experienced a tremendous growth, and with this trend expected to continue, it's an ideal time for him to step into his new position."

In addition to his new role, Aguilar is currently serving as Chair of the Advisory Board Putzmeister Brasil Ltda.

Previous positions Aguilar has held at Putzmeister include:

- 1995-1996: Export Sales Manager–Putzmeister America
- 1997-1998: Latin America Regional Sales Manager–Putzmeister Werk GmbH
- 1998-2002: Export Sales Manager–Putzmeister America
- 2002-2009: General Sales Manager of LACA–Putzmeister America
- 2009: Regional Director of Sales Latin America–Putzmeister Concrete Pumps GmbH

ASA 2010-2011 Graduate Scholarship Program Now Open

The ASA Graduate Scholarships are available to applicants who have been accepted into a graduate program in the field of concrete at the time of application to an accredited college or university within the U.S. or Canada. To receive consideration for an ASA Graduate Scholarship, the applicant needs only to submit one application. Based on essays, submitted data, and references, the ASA Scholarship Committee will select scholarship recipients who appear to have the strongest combination of interest and potential for professional success in the shotcrete industry.

Two $3000 (USD) awards are available through ASA for the 2010-2011 academic year. One scholarship will be awarded to a graduate student attending an accredited college or university within the U.S. and the second scholarship will be awarded to a graduate student attending an accredited college or university in Canada.

Each ASA Graduate Scholarship award consists of a stipend of $3000 (USD) and is paid in one (1) installment of $3000 (USD) directly to the student's educational institution. The payment will be made in the early winter of 2010.

For more information, visit the ASA Web site at **www.shotcrete.org** and click on "Graduate Scholarships."

ASA Online Buyers Guide—New Functionality

The ASA Online Buyers Guide has become a very important tool for the construction industry, receiving over 1000 searches a month in its first year. ASA is expanding the functionality of the online guide so that users can search for organizations based on the states or provinces in which they do business (in addition to the current specialties information).

The ASA Online Buyers Guide can be accessed at www.shotcrete.org\buyersguide.

If you are interested in becoming an ASA Corporate Member and inclusion in the ASA Online Buyers Guide, please contact ASA staff at (248) 848-3780 or info@shotcrete.org.

Electronic Version of *Shotcrete* magazine on ASA's Web Site

A link to the current version of *Shotcrete* magazine is now a permanent option on the home page of the ASA Web site (www.shotcrete.org). While a link to the e-version of the magazine is sent in the ASA e-newsletter to all subscribers, visitors to the ASA Web site will now be able to view the current issue as well.

Second ACI Shotcrete Nozzleman Certification Program Conducted in Singapore

ASA Certification Session Hosted by Society of Rock Mechanics and Engineering Geology (SRMEG) Singapore with support by the Building and Construction Authority (BCA) Singapore

Shotcrete is used on many projects in Asia today. The quality of the shotcrete applied, however, is sometimes suspect and there are, unfortunately, no standardized quality control methods to evaluate freshly placed shotcrete. Moreover, shotcrete nozzlemen are often changed and replaced even in one single project and rarely do they possess certification.

In this respect, a select group of experienced and acknowledged shotcrete experts has been approved by the American Concrete Institute (ACI) to act as examiners for ACI's Shotcrete Nozzleman Certification Program. The education and certification of a shotcrete nozzleman through the activities surrounding this ACI program provides a nozzleman with not only improved knowledge and skills but also with international recognition as a craftsman.

No certification program can address all potential variables. The ACI Shotcrete Nozzleman Certification Program is focused on specific key elements of the shotcrete process such as knowledge, skills, and abilities. An ACI Shotcrete Nozzleman Certification is issued for a 5-year period from the date of completion of all certification requirements. With the ACI Shotcrete Nozzleman Certification Program, the shotcrete specifier (consulting engineer) will know that the nozzleman has demonstrated the basic knowledge and capabilities to properly place shotcrete. Hence, it is beneficial for their projects to require ACI Certified Shotcrete Nozzleman.

The Society of Rock Mechanics and Engineering Geology Singapore (SRMEG) with the support of the Building and Construction Authority (BCA) Singapore successfully introduced the first ACI Shotcrete Nozzleman Certification Program to Singapore in October 2009. The program was conducted by Marc Jolin, Department of Civil Engineering at Laval University, Canada; ACI-approved Shotcrete Nozzleman Examiner; and ASA member. Jolin is the Chair of ACI Committee C660, Shotcrete Nozzleman Certification, and Secretary of ACI Committee 506, Shotcreting.

The second ACI Shotcrete Nozzleman Certification Program was held May 11-14, 2010, in Singapore. It was again organized by SRMEG with the support of BCA. The ACI Sponsoring Group was ASA and the Examiner was Marc Jolin.

EPA Opens Public Comment Period on Two Options for Fly Ash Regulation

On May 4, 2010, the U.S. Environmental Protection Agency (EPA) announced that it is proposing to regulate coal combustion residuals (CCRs) under the Resource Conservation and Recovery Act (RCRA). CCRs garnered national attention in late 2008, when an impoundment holding disposed waste ash failed in Tennessee. The EPA's proposed regulations would lead to stronger oversight of coal ash impoundments, along with measures to prevent environmental damage and contamination of drinking water.

The proposal calls for a 90-day public comment period before the EPA makes a decision on which of two alternate options will be implemented for addressing the risks of CCR management under the RCRA, the nation's primary law for regulating solid waste. One option is drawn from enforcement powers available under Subtitle C (hazardous waste) of the RCRA, and creates a comprehensive program of federally enforceable requirements for waste management and disposal. The other option includes remedies under Subtitle D (nonhazardous waste) of the RCRA, which gives the EPA the authority to set performance standards for waste management facilities and would be enforced primarily through citizen suits.

Under both approaches proposed by the EPA, the agency would leave in place the Bevill exemption for beneficial uses of CCRs, in which CCRs are recycled as components of products instead of placed in impoundments or landfills.

There is widespread industry concern that if the option involving Subtitle C (hazardous waste) is adopted, the future use of fly ash in concrete would be dealt a critical blow. Despite the Bevill exemption, fly ash may be perceived as a hazardous material. The resulting liability concerns would deter utilities, owners, contractors, producers, and specifiers from assuming such risk.

ASA strongly encourages its members and the overall shotcrete industry to become educated on the two options and to participate in the public comment period.

The American Concrete Institute (ACI) is hosting a Web site (**www.flyash.concrete.org**) that contains the following:

- A brief summary of proposed rule;
- Encouragement to submit comments to the EPA;
- Links to proposed ruling materials including the complete proposal and comparison of the two options;
- Definitions of Subtitles C and D;
- A link to all letters submitted to the EPA, including the ACI letter to the EPA; and
- Counterpoint statements (as they become available).

Cement Industry Recognizes CEMEX U.S. Plants for Environmental Excellence

Source: www.ariaggregateresearch.com

CEMEX has been recognized by the Portland Cement Association (PCA) and Cement Americas for environmental excellence at its cement plants in Xenia, OH, and Lyons, CO, as part of the 2010 Cement Industry Energy & Environmental Awards.

The awards honor individual cement facilities that exemplify the spirit of continuous environmental improvement and support this spirit with action.

"Minimizing the environmental impact of its plants and making their local communities better places are top priorities for cement manufacturers," said Brian McCarthy, PCA President and CEO. "CEMEX went even further by giving back to a community which has supported it for decades."

The CEMEX Xenia facility, also known as the CEMEX Fairborn plant, was recognized for its Land Stewardship activities. The category recognizes a plant's efforts to protect and enhance the surrounding land. The Xenia facility was also recognized for its approach to land stewardship tasks as a cooperative effort with the community, Cedarville University, and the U.S. Fish and Wildlife Service. The plant was also recognized as a runner-up in the Community Outreach category.

The CEMEX cement plant in Lyons, CO, was the runner-up for PCA's Overall Environmental Excellence Award, an honor given to a plant demonstrating merit in several environmental categories, including Outreach, Environmental Performance, Land Stewardship, Innovation, and Energy Efficiency. The Colorado plant was also named runner-up in the Land Stewardship category.

ELOTEX® COPRA900 Provides Protection against Corrosion in Steel-Reinforced Shotcrete Applications

ELOTEX COPRA900 is a corrosion protection additive in powder form for mass modification of shotcrete to protect steel reinforcing bar against corrosion caused by chloride penetration. Due to its powder form, ELOTEX COPRA900 is very easy to handle. Simply mix ELOTEX COPRA900 together with all raw materials during the dry-blend process of shotcrete at the dry-mixing plant. During spray application of shotcrete, the active ingredient of ELOTEX COPRA900 is immediately released and homogeneously distributed throughout the whole shotcrete layer. A protective layer is formed in-place around the reinforcing bar during the setting process without any further treatment or application step. Durability and sustainability of the construction is significantly prolonged. ELOTEX COPRA900 provides the additional benefits of reducing rebound material during spraying and improving the smoothability of the finished surface.

In laboratory corrosion testing, specimens were prepared by spraying shotcrete in molds having steel reinforcing bar fixed in a defined depth from the surface. Test specimens were subjected to cycles of immersion in NaCl solution followed by drying to enrich chloride content in the specimen over time. The testing is still underway; but after 45 cycles, the sample containing ELOTEX COPRA900 exhibits outstanding corrosion protection, whereas the reference sample failed after a few cycles with formation of massive cracks. The rule of thumb for this test method indicates that 45 cycles is equivalent to more than 22 years of field exposure.

The photo shows the sample containing ELOTEX COPRA900 on the top and reference without corrosion protection below.

For more information, contact Michael Schottler at michael.schottler@akzonobel.com.

Normet Introduces the Spraymec 8100 VC

Normet is a specialist manufacturer of mobile equipment for underground tunneling and mining applications with worldwide sales. Normet's range of equipment includes concrete spraying and transport, lifting and installation, explosive charging, underground logistics, and scaling. The equipment can be used in mining and various underground construction projects, such as road, highway and railway tunnels, and other underground spaces (for example, car parks, power plants, and oil and gas storage).

At Bauma 2010 in Munich, Normet introduced the Spraymec 8100 VC, the most advanced model for concrete spraying in its Spraymec series.

Spraymec 8100 VC is an electro-hydraulic, self-propelled mobile concrete sprayer that optimizes concrete spraying in tunnel projects with variable tunnel cross sections. It provides efficient spraying from one set-up in tunnels up to 33.8 ft (10.3 m) in height and 52.5 ft (16 m) in width. The maximum vertical spraying reach is 46 ft (14 m). The compact design enables the mobile sprayer to perform spraying in tunnels with cross sections from 161.5 to 1507 ft^2 (15 to 140 m^2).

The Spraymec 8100 VC is designed for high-performance sprayed concrete applications and the use of alkali-free accelerators. It features the latest state-of-the-art control system of the spraying process, the NorSmart. The NorSmart concrete sprayer control system provides efficient, productive, and high-quality concrete spraying with functions like:

- Low-pulsation spraying and pumping;
- Accurate and reliable accelerator dosing (control system integrated into concrete output);
- Accurate spray boom and nozzle movements and positioning;
- Real-time control and fault diagnostics of the spraying process, including a kit for accelerator, concrete, and ambient temperature measurement;
- Logging of all spraying process-related data and USB data transfer; and
- Comprehensive vehicle fault diagnostics

The Normet concrete spraying pump has a theoretical maximum pumping capacity of 1412.6 ft^3/h (40 m^3/h) when the casting option is selected. The standard pumping capacity for spraying operations is 1059.4 ft^3/h (30 m^3/h). The concrete pipe support arm at the forepart of the concrete pipeline makes cleaning of the concrete line easy and fast after each shift. The upper part of the concrete hopper can be turned away for easy service of the concrete cylinders.

Spraymec 8100 VC has an onboard compressor with a capacity of 423.8 ft^3/minute (12 m^3/minute) for efficient and high-quality sprayed concrete applications. Four-wheel drive and four-wheel steering makes the Spraymec 8100 VC easy to maneuver in demanding driving conditions and limited tunnel spaces.

The innovative layout of the Spraymec 8100 features a revolutionary service technician's passage through the whole sprayer. This allows genuinely full and easy access to all service points on the sprayer. With the new layout, 0.5 x 264 gal. (2 x 1000 L) accelerator containers or one 264 gal. (1000 L) accelerator container, a 105.7 gal. (400 L) water tank and a large tool and storage box, together with other options can easily be placed on the sprayer.

For further information, please contact Jukka Pihlava at +41-41-7685200 or visit **www.normetamerica.com**.

Introducing the MixerPump: A Concrete Mixer and Concrete Pump Combined

Cemen Tech and REED have joined forces to create the first-ever MixerPump, a combined volumetric concrete mixer and concrete pump.

For very small jobs, the all-in-one MixerPump drives to the job site, then mixes fresh concrete and pumps the concrete wherever the contractor wants it to go. Contractors only need to make one phone call to schedule both their concrete and concrete placement, saving time and money.

For large concrete projects, the bins of the volumetric mixer can be filled from the top by a loader for continuous batching and pumping more than 30 yd^3/hour (23 m^3/hour).

The pump easily disconnects from the mixer whenever it isn't needed, then quickly reattaches when it is, providing a simple ON/OFF solution. The REED pump can be attached to mobile or stationary Cemen Tech volumetric mixers. A single power source drives both mixer and pump packages.

The MixerPump can pump pea-gravel mixtures, 3/4 in. (19 mm) blend mixtures, 1 in. (25.4 mm) big rock mixtures, and even low-slump shotcrete mixtures. The tapered underside of the volumetric mixer allows for ample storage of pipes and hoses.

For more information about the MixerPump, call Cemen Tech Mobile Mixers at 515-961-7407 or REED Concrete Pumps at 909-287-2100.

Allentown Shotcrete Technology, Inc., Updates AST 25

Allentown Shotcrete Technology, Inc., announced enhancements to the AST 25 robotic nozzle manipulator, which features multiple upgrades and is more user-friendly.

The updated AST 25 model, which appeared at Bauma 2010, now has the ability to operate on either electric or diesel power and offers a wireless remote control for added operator convenience. Used in the underground industry, the track-mounted AST 25 can be used for either wet- or dry-process work with a concrete or shotcrete pump.

"We're excited about the enhancements we've made to the versatile AST 25 robotic nozzle manipulator. The ability to operate on electric or diesel power allows it to be used on any type of job site," says Patrick Bridger, Allentown's President. "With the AST 25's wireless remote capabilities, operators can safely stay out from underneath newly excavated, exposed rock."

Standard features of the AST 25 include:

- 7.5 hp (5.5kW), 460V/60hz or 400V/50hz electric motor for boom and nozzle functions;
- 27 hp (20kW), water-cooled diesel engine for tracks and outriggers;
- Track drive speeds between 1 to 3 mph (1.5 to 5km/h);
- Accommodates larger nozzle sizes of 2.5 or 3 in. (65 or 80 mm);
- 30 gal. (114 L) hydraulic tank capacity;
- Wireless remote control with a charging cable that can be used when wireless is not allowed; and
- 25 ft (7.62 m) vertical spraying range; 35 ft (10.67 m) horizontal spraying range.

For more details, contact Allentown toll-free at (800) 553-3414 or visit the company's Web site at **www.allentownshotcrete.com** to view specifications and download product literature.

Do you have a new product or practice that the shotcrete world should know about? Send us information at info@shotcrete.org.

Gunite Supply Launches Online Gunite Store

Gunite Supply has launched the GUNITE STORE to offer online ordering of shotcrete tools, nozzles, and other accessories. The Web site at www.gunite.us allows gunite and shotcrete contractors to easily search through the catalog of tools and accessories. The site is set up to offer a completely secure environment for placing orders online. The GUNITE STORE is available 24 hours a day for convenience, accepts credit card payments, and calculates shipping to anywhere in the U.S.

The GUNITE STORE offers a complete line of tools, parts, and accessories for the shotcrete contractor. Product categories include wet-mix shotcrete hose, shotcrete clamps, and shotcrete; dry-mix gunite hose, hose couplings, and gunite nozzles; nozzles; plaster nozzles; and finishing tools. Wet-mix shotcrete nozzles are available with grooved or heavy-duty end fittings. The Web store also offers Ridley, Hamm, Spirolet, and Double Bubble brand dry-mix gunite nozzles and parts. Nozzle bodies, tips, and liners are available for all common nozzle sizes. Interchangeable polyurethane or rubber nozzle tips for wet-mix shotcrete nozzles are available for specific spray patterns and applications. Stucco/plaster nozzles are also available in a variety of designs and lengths. The site includes a popular line of finishing tools for both wet- and dry-process shotcrete. Wood and aluminum finishing rods are offered for a range of shaping and finishing duties. A flexible finishing rod is available for smoothing over rounded surfaces after shotcrete placement. The GUNITE STORE features an assortment of fresnos for use on shotcreted floor or ground surfaces. Various trowels and floats are available for light finishing duties.

The Gunite Store has three warehouses and showrooms, located in Monrovia, CA; Houston, TX; and Cincinnati, OH, to ensure a quick response to customer requests and efficient distribution. Visit the store at **www.gunite.us**.

Two New Test Methods from ASTM

ASTM C1550-10,* "Standard Test Method for Flexural Toughness of Fiber Reinforced Concrete (Using Centrally Loaded Round Panel)"—The post-crack behavior of plate-like, fiber-reinforced concrete structural members is well represented by a centrally loaded round panel test specimen that is simply supported on three pivots symmetrically arranged around its circumference. Such a test panel experiences biaxial bending in response to a central point load and exhibits a mode of failure related to the in-place behavior of structures. The post-crack performance of round panels subject to a central point load can be represented by the energy absorbed by the panel up to a specified central deflection. In this test method, the energy absorbed up to a specified central deflection is taken to represent the ability of fiber-reinforced concrete to redistribute stress following cracking.

ASTM C1609/C1609M-10,* "Standard Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam with Third-Point Loading)"—The results of this test method may be used for comparing the performance of various fiber-reinforced concrete mixtures or in research and development work. They may also be used to monitor concrete quality, to verify compliance with construction specifications, to obtain flexural strength data on fiber-reinforced concrete members subject to pure bending, or to evaluate the quality of concrete in service.

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

**These documents are included in ASA's Shotcrete Bibliography*

Report on the Physical Properties and Durability of Fiber-Reinforced Concrete (ACI 544.5R-10)

This document addresses the physical properties and durability of fiber-reinforced concrete (FRC). The effects of fiber reinforcement are evaluated for various physical, short-term, and long-term benefits they impart to the concrete mixture. A variety of test methods, conditions, and properties are reported. The various properties listed, in addition to the wide variety of the choices available in formulating matrix systems, allow performance-based specification of concrete materials using fibers to become a viable option. This document provides a historical basis and an overview of the current knowledge of FRC materials for tailoring new, sustainable, and durable concrete mixtures.

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

AMERICAN SHOTCRETE ASSOCIATION

ASA Membership Benefits

	Corporate	Corporate - *Additional Individual*	Individual	Employees of Public Authorities or Agencies	Nozzleman	Student
Annual Dues	$750	$100	$250	$50	$50	Free
Subscription to quarterly *Shotcrete* magazine (Hard Copy)	X	X	X	X	X	
Electronic Subscription to quarterly *Shotcrete* magazine	X	X	X	X	X	X
Company & specialty information listed in ASA's online Buyers Guide	X					
Company & specialty information listed in *Shotcrete* magazine's annual Buyers Guide	X					
Links to shotcrete related government projects open for bid (*sent twice a month in the member edition of the ASA e-newletter*)	X	X	X	X	X	X
Discount on ACI Nozzleman Certification program	X					
Free advance general admittance registration to World of Concrete	X	X	X	X	X	X
Complimentary ASA shotcrete brochure each year	25		1	1		
Complimentary ASA reflective hardhat sticker each year	10		1	1		
Permission to include ASA logo on corporate letterhead and business cards	X	X	X	X		
Permission to display ASA logo on company web site	X					
Discounted Member pricing on advertising in *Shotcrete* magazine	X	X	X	X		
Free logo and link advertising on ASA website homepage for duration of each issue you advertise in Shotcrete	X					
Opportunity to submit items for Industry News and New Products & Practice sections of *Shotcrete* magazine at no charge	X	X	X	X		
Voting privileges at meetings and director/officer elections	X		X			
Discounted ASA Member prices on all ASA products	X	X	X	X	X	X
Networking and participation opportunities at Annual Membership Meeting and committee meetings	X	X	X	X	X	X
Opportunity to become a shotcrete educator	X	X	X	X	X	
All company employees have opportunity to receive discounted Corporate Additional ASA Memberships ($150 off regular membership price for each employee)	X					
Opportunity to submit entries into the annual Outstanding Shotcrete Project Awards Program	X					
Discount on ASA Underground Shotcrete Education Program	X					
ASA Promotion of nozzleman certification on a national basis in conjunction with ACI					X	
Education & promotion of your shotcrete industry to the overall concrete industry	**X**	**X**	**X**	**X**	**X**	**X**

AMERICAN SHOTCRETE ASSOCIATION

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Phone: (248) 848-3780 Fax: (248) 848-3740
E-mail: info@shotcrete.org Web site: www.shotcrete.org

MEMBERSHIP APPLICATION

Name _____ Title _____

Company _____ Sponsor (if applicable) _____

Address _____

City / State or Province / Zip or Postal Code _____

Country _____ Phone _____ Fax _____

E-mail _____ Web site _____

Please indicate your category of membership:

❑ Corporate	$750	
❑ Individual	$250	
❑ Additional Individual from Member Company	$100	
❑ Employees of Public Authorities and Agencies	$50	
❑ Nozzleman	$50	
❑ Retired	$50	(For individuals 65 years or older)
❑ Student	Free	(Requires copy of Student ID card or other proof of student status)

NOTE: Dues are not deductible as charitable contributions for tax purposes, but may be deductible as a business expense.

Payment Method:

❑ MC ❑ Visa ❑ Check enclosed (U.S. $)

Card# _____ Expiration date _____

Name on card _____ Signature _____

Company Specialties—Corporate Members Only

Company Specialties are searchable in the printed and online Buyers Guide.

Admixtures
- ❑ Accelerating
- ❑ Air Entraining
- ❑ Foaming
- ❑ Retarding
- ❑ Shrinkage Compensating
- ❑ Special Application
- ❑ Stabilizing
- ❑ Water Proofing
- ❑ Water Reducing-Accelerate
- ❑ Water Reducing-High Range
- ❑ Water Reducing-Mid Range
- ❑ Water Reducing-Normal
- ❑ Water Reducing-Retarding
- ❑ Water Repellent

Cement/Pozzolanic Materials
- ❑ Cement-Blended
- ❑ Cement-Portland
- ❑ Cement-White
- ❑ Fly Ash
- ❑ Ground/Granulated Slag
- ❑ Metakaolin
- ❑ Pozzolan
- ❑ Silica Fume-Dry
- ❑ Silica Fume-Slurry

Consulting
- ❑ Design
- ❑ Engineering
- ❑ Forensic/Troubleshooting
- ❑ Project Management
- ❑ Quality Control Inspection/Testing
- ❑ Research/Development
- ❑ Shotcrete/Gunite
- ❑ Skateparks

Contractors
- ❑ Architectural
- ❑ Canal Lining
- ❑ Culvert/Pipe Lining
- ❑ Dams/Bridges
- ❑ Domes
- ❑ Flood Control/Drainage
- ❑ Foundations
- ❑ Grouting
- ❑ Lagoons
- ❑ Mining/Underground
- ❑ Parking Structures
- ❑ Pumping Services
- ❑ Refractory
- ❑ Repair/Rehabilitation
- ❑ Residential

Contractors, contd.
- ❑ Rock Bolts
- ❑ Rock Carving
- ❑ Seismic Retrofit
- ❑ Sewers
- ❑ Skateparks
- ❑ Slope Protection/Stabilization
- ❑ Soil Nailing
- ❑ Storage Tanks
- ❑ Structural
- ❑ Swimming Pools/Spas
- ❑ Tunnels
- ❑ Walls
- ❑ Water Features

Equipment
- ❑ Accessories
- ❑ Adaptors
- ❑ Air Vibrators
- ❑ Bowls
- ❑ Clamps
- ❑ Compressors
- ❑ Couplings
- ❑ Feeder/Dosing
- ❑ Finishing
- ❑ Grouting

Equipment, contd.
- ❑ Guide Wires
- ❑ Gunning Machines
- ❑ Hoses
- ❑ Mixers
- ❑ Nozzles
- ❑ Pipe/Elbows/Reducers
- ❑ Plastering
- ❑ Pre-Dampers
- ❑ Pumps
- ❑ Robotic
- ❑ Safety/Protection
- ❑ Silo Systems
- ❑ Valves
- ❑ Wear Plates

Fibers
- ❑ Carbon
- ❑ Glass
- ❑ Steel
- ❑ Synthetic

Shotcrete Materials/Mixtures
- ❑ Dry Mix
- ❑ Steel-Fiber Reinforced
- ❑ Synthetic-Fiber Reinforced
- ❑ Wet Mix

ASA New Members

CORPORATE MEMBERS

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michael.schottler@akzonobel.com
www.akzonobel.com/elotex

Dome Technology
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www.dometech.com

Normet Americas Inc.
Union Grove, WI
Primary contact: Michael Rispin
mike.rispin@normet.fi

AMERICAN SHOTCRETE ASSOCIATION

INDIVIDUAL MEMBERS

Barry Bartakovits
Barry Bartakovits Custom Pools Inc.
Hellertown, PA

Saheed Mohammed
S Mohammed Construction

Maysam Nemati
Rasht, Guilan, Iran (Islamic Republic of)

Misagh Nemati
Rasht, Guilan, Iran (Islamic Republic of)

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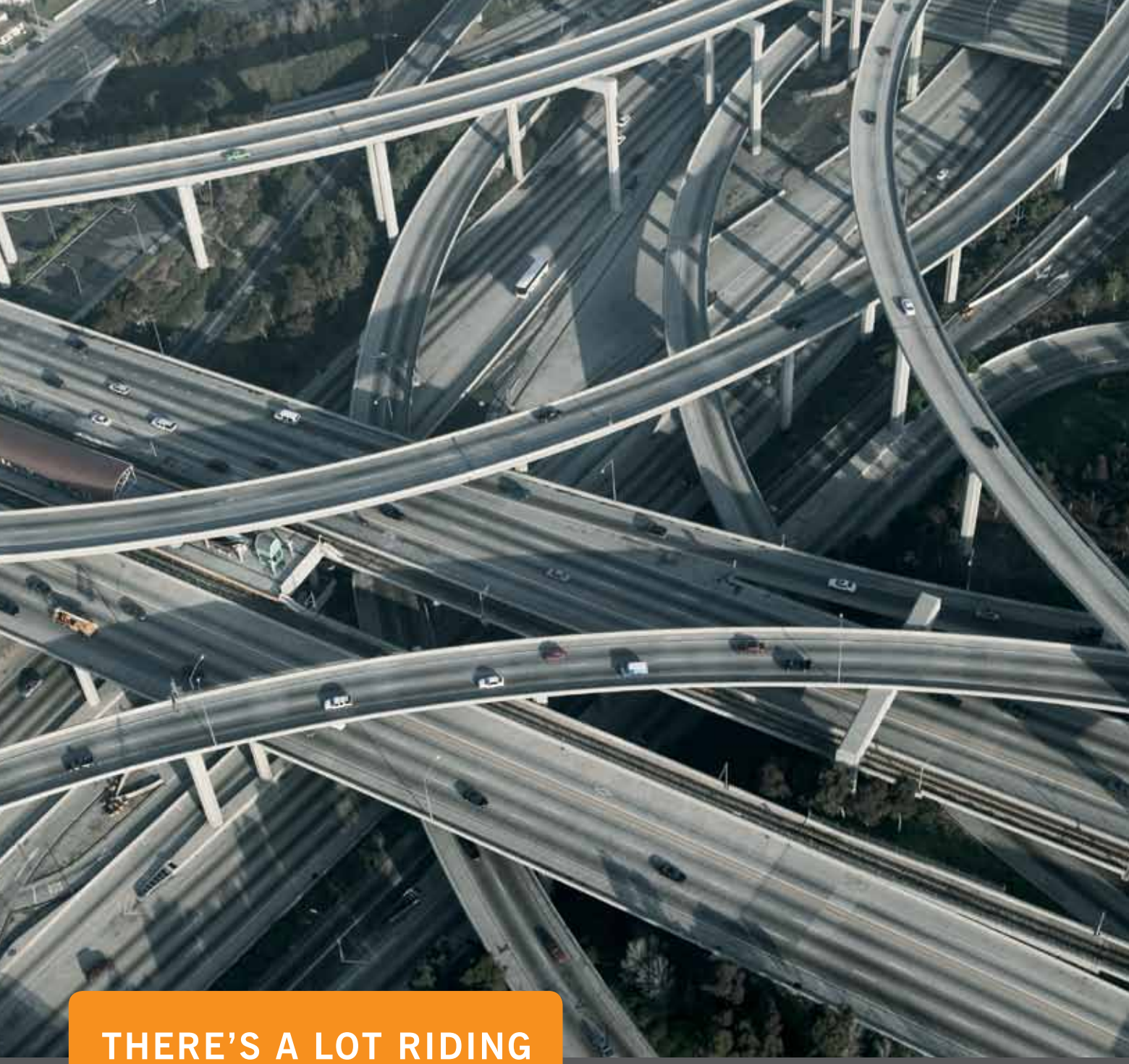

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