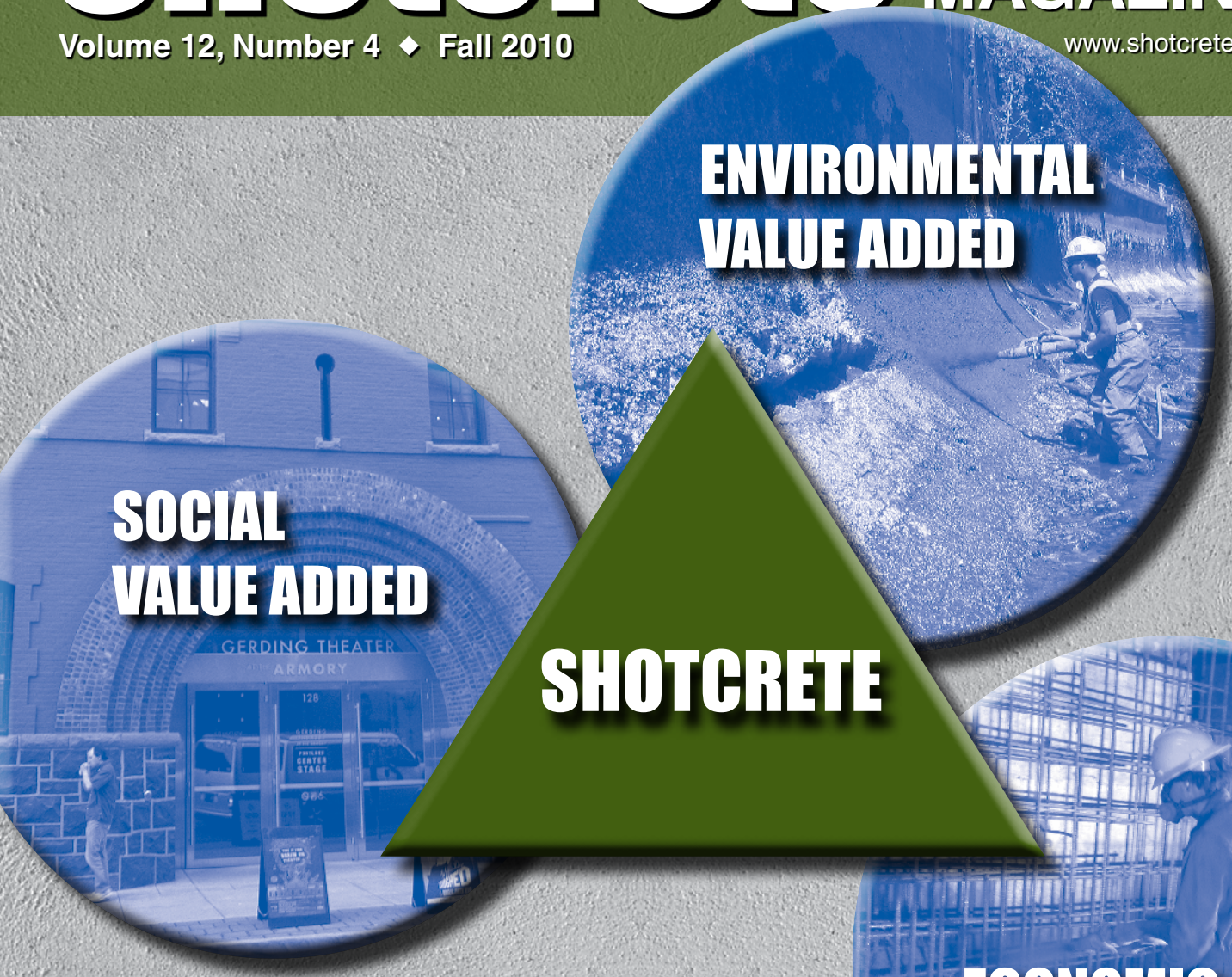
Shotcrete MAGAZINE

A quarterly publication of the American Shotcrete Association

Volume 12, Number 4 ◆ Fall 2010

www.shotcrete.org



Sustainable Shotcrete

AMERICAN SHOTCRETE ASSOCIATION

Some like it WET...

Some like it DRY...

We've Got The Best of Both Worlds.

REED **WET-mix Shotcrete Pumps and**
DRY-mix "*Guncrete*" Gunite Machines.
On the job since 1957 and still
the best in the industry.

Call us Toll-Free at 888-779-7333

REED

REED - An Independent Member of the Shea Family of Companies
13822 Oaks Avenue, Chino, California 91710 • 909-287-2100 • Fax: 909-287-2140 • Toll-free: 888-779-7333 • www.reedpumps.com

Circle #22 on reader response form—page 64

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

American Shotcrete Association
38800 Country Club Dr.
Farmington Hills, MI 48331
Phone: (248) 848-3780 • Fax: (248) 848-3740
E-mail: info@shotcrete.org
Web site: **www.shotcrete.org**

Shotcrete MAGAZINE

Volume 12, Number 4
Fall 2010

Features

Departments

On the cover: Image adopted from sustainability module found on the Breakthrough Management Group India Web site. www.bmgindia.com/knowledge-bank-corporate-social-responsibility.htm

Shotcrete—A Proven Process for the New Millennium

Predampening

A Voice from the Past Emphasizes a Need for Today's Shotcrete Industry

By Patrick Bridger

As I was preparing to write this President's Message, I began to search out information on the Internet looking for anything I could find related to the very early days of the cement gun and the "gunite process." Much to my surprise, I found dozens of patent applications dating from 1923 to 1952. The names on some of these patent applications included Anderson, Downey, Mayer, Gillespie, Mac Rae, and Schaefer, just to name a few. One of these patent applications filed on January 26, 1922, by John V. Schaefer, of Chicago, IL, was of particular interest to me. The description for the patent was "Method of Making and Applying Mortar."

Schaefer first describes mortar as a suitable hydrated mixture of adhesive materials, such as portland cement and sand, but also includes kindred materials such as lime, comminuted cinders, slate, and stone. From here, I'll quote the description out of the patent document:

> "Heretofore mortars have been produced and applied through the use of compressed air and an apparatus commonly known as a 'cement gun.' It has been the practice, heretofore, to separately convey dry cement and dry sand to a nozzle where the same are brought together and from which they are projected by the compressed air into the atmosphere to the point of application. Water is also projected from the nozzle, simultaneously with the cement and sand. It is understood and intended aforesaid prior practice that the cement, sand, and water mix, hydrate and combine after projection, either at the point of application or in the atmosphere between the nozzle and the point of application.
>
> The methods or processes heretofore employed possess several disadvantages. It has been the usual experience that the quantities of free dry cement are uselessly on and about the work and on the clothes and persons of the workmen. The wind may cause such deposits to collect at considerable distances from the desired point of application. This phenomenon is commonly called 'dusting.' Quantities of dry sand are also deposited and borne away by the wind or fall to the ground.
>
> These deposits of free dry sand and cement are objectionable because they produce more or less discomfort and danger to the workmen and other persons who may be around the work. They represent a waste of materials. Also, the removal of the deposits causes delays and entails expense.
>
> I believe that these deposits and 'dusting' result from an insufficient period of time allowed for thorough mixing, combining, and hydrating of the various elements constituting the mortar and the difficulty of such actions taking place after projection from the nozzle.
>
> One of the objectives is to provide an improved method or process for making and applying mortar. Another objective is to provide a process whereby objectionable deposits of uncombined ingredients will be prevented. Another objective is to eliminate 'dusting.' Another objective is to provide a process for more efficiently, satisfactorily, and expeditiously making and applying mortar in the proper condition to produce the desired results.
>
> A further object is the provision of a method for completely forming mortar while in transit in a closed conduit and projecting it there from in a completed state. Other objects and advantages will hereinafter appear.

ASA President's Message

In carrying my invention into effect, I mix the sand and cement by first thoroughly dampening the sand and cement to an extent which will moisten substantially every grain without permitting accumulation of free water. This may be done by steam, vapor, spraying, dampening and then draining the sand, or otherwise. I then thoroughly mix the cement in a dry state, in desired proportion, with the sand, so that each grain of sand is coated and completely enclosed in an envelope of cement and held thereon by adhesion caused by the dampened grains. This forms a nonadhesive mixture as a whole, so that it will not stick to the inner surface of the pipe or hose in transit and at the same time the small amount of water is not sufficient to cause crystallization of the cement."

Schaefer then continues to explain that the dampened material is in a more receptive condition for further hydrating every particle of cement to the action of the water being injected and projected by the nozzle.

Ninety years later, it is not uncommon for me (and you) to see dry-process shotcrete being applied without the material premoistened or predampened. There are five important reasons to predampen any prepackaged shotcrete mixture.

- First, proper predampening greatly reduces dust at the machine and at the point of placement. Dust is a serious health concern for shotcrete crews and predampening will significantly reduce the work-site dust and improve the working environment;
- Second, the cost of operating and maintaining shotcrete equipment is a primary concern for shotcrete contractors. Predampening will greatly reduce the wear and tear on the gunning machine wear parts. Less wear and tear on your equipment will extend equipment life, as well as lower maintenance and operating costs;
- The third advantage is a big one for anyone on a shotcrete crew. Predampening eliminates static electricity and the resulting "torture" crews grow to dread;
- Fourth, overspray and rebound are significantly reduced as a result of proper predampening. Reduction of overspray and rebound leads to material cost savings; and
- Fifth, and most important, proper predampening improves the overall in-place quality of the concrete.

The advantages to predampening are significant and proven. Simply put, all dry-mix shotcrete material should be predampened prior to feeding the gunning machine. This message should be reinforced and required in all documents related to the dry-process method of shotcrete.

So what are you still waiting for?

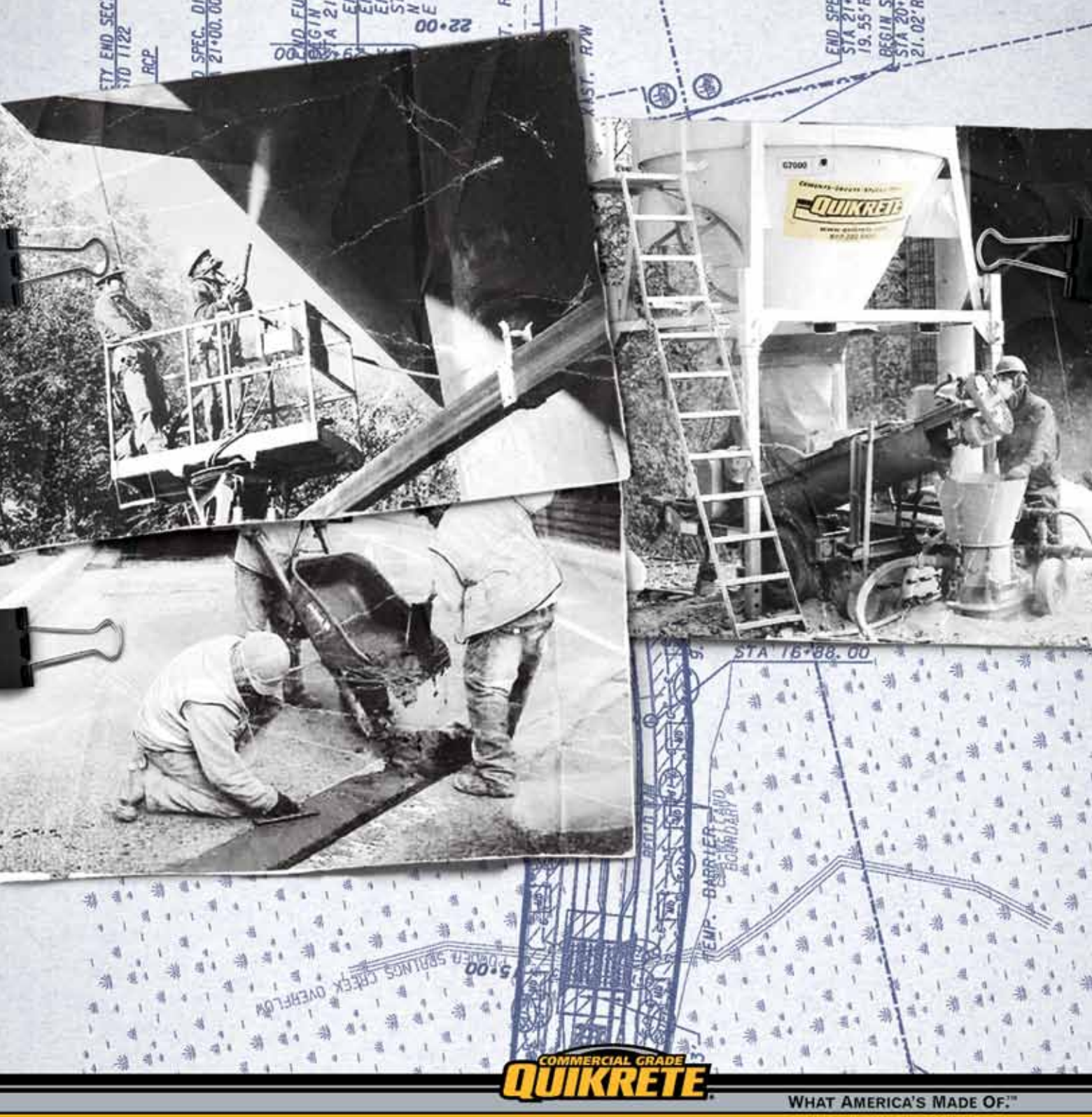
It's time to get your nozzlemen trained and certified!

The American Shotcrete Association, in partnership with the American Concrete Institute, has developed a comprehensive program to upgrade the knowledge and skills of shotcrete nozzlemen and to facilitate ACI examination and certification. Provide your clients with the assurance that your nozzlemen have demonstrated that they have the capabilities to perform the job right—the first time!

To learn more or to schedule an ASA training session and an ACI Shotcrete Nozzleman Certification examination, visit www.shotcrete.org or call (248) 848-3780.

aci
American Concrete Institute®

AMERICAN SHOTCRETE ASSOCIATION



COMMERCIAL GRADE QUIKRETE®

WHAT AMERICA'S MADE OF.™

CEMENT & CONCRETE PRODUCTS™

Adheres to arches, overheads, decks and DOT specifications.

When bridge columns and pier hammerheads on Pennsylvania's Noblestown Road Bridge needed structural repair, QUIKRETE® Shotcrete MS with corrosion inhibitor got the job done. Crews were able to make full-depth, monolithic vertical and overhead repairs with virtually zero rebound. Plus QUIKRETE Shotcrete MS reaches 9,000 psi. With over 90 manufacturing plants, we can speed this and hundreds of other high-performance products to you nationwide. For a free construction product guide, visit quikrete.com or call 1-800-282-5828.

Circle #5 on reader response form—page 64

A Shotcrete Industry Challenge Turns Into a Big Opportunity

By Chris Darnell, ASA Executive Director

What a difference a year makes; it was exactly 1 year ago that the Staff Editorial in *Shotcrete* magazine identified and expanded on the serious challenge the sustainability movement was creating for the shotcrete/concrete industry.

"The current political and social environment is resulting in significant changes that are and will significantly impact the shotcrete industry. The green/environmental or sustainability movement has grown to a point that it is now a leading force in shaping governmental policy. The U.S. government is embracing policies that will impact our industry's ability to conduct business… Much of our membership and industry could be blindsided by the changes that are taking place. These changes will impact items such as operating costs and safety requirements, but perhaps even more importantly will be the ability to win or even submit a project bid."

I am both amazed and pleased to report to you on the number of important accomplishments that our association has made in just 1 year. As a result of strong leadership and work by the ASA Board of Direction and the ASA Sustainability Committee, the "Sustainability Challenge" is quickly turning into a real advantage for the shotcrete industry and its future growth.

At this point, it is important to recap the last year's body of work before speaking to future plans.

CJSI

The first action the ASA Board of Direction took in response to this challenge was to become an active partner with dozens of other concrete-related associations in the Concrete industry's Joint Sustainability Initiative (CJSI). The CJSI is the concrete industry's effort to present a unified industry approach and promotion of concrete and its sustainability benefits.

ASA's continued participation in this effort not only strengthens the overall concrete industry, but also helps further the recognition of shotcrete as a key component of the concrete world.

Note: In an effort to keep ASA members up to date on the latest information regarding sustainability issues and their potential impact on the concrete/shotcrete industry, ASA will include a link in the member version of its e-newsletter to the latest CJSI Industry Trends report.

ASA Sustainability Committee

The ASA Board's next step was an equally critical one: the formation of the ASA Sustainability Committee. Chaired by Charles Hanskat and populated by 15 other leaders of ASA, the Sustainability Committee has become the workhorse on our sustainability efforts and accomplishments.

One of the first efforts of the Sustainability Committee was to identify and quantify the sustainability advantages of shotcrete. The resulting list was a real eye-opener for all involved once they were able to see the total quantity and quality of the sustainability advantages of shotcrete!

Sustainability-Themed Issue of *Shotcrete* magazine

Because the aforementioned sustainability advantages of shotcrete were so significant, coupled with the importance and attention sustainability has taken on in the construction world, plans were immediately made to produce this sustainability-themed issue of *Shotcrete* magazine. This issue will be a great resource for our industry as we educate ourselves as to just what sustainability is, begin to discuss the sustainability advantages of shotcrete, and look at real-world examples of these advantages.

The Sustainable Concrete Guide—Applications from the USGCC

The Sustainability Committee's next task was a partnership with the U.S. Green Concrete Council (USGCC) on the development of materials for two chapters in an important new document for the entire construction industry. The document, with a planned release in late 2010, is titled *The Sustainable Concrete Guide—Applications* and will serve as a reference for the architect/engineer on how best to use concrete products and systems in a sustainable manner. The committee has done an exceptional job in creating content for the two sections on shotcrete and another on repair.

Shotcrete Sustainability Educational Seminar at World of Concrete 2011

ASA has developed and will be conducting a 90-minute seminar titled "Sustainability of Shotcrete Construction" on Thursday, January 20, 2011, as part of World of Concrete's Educational Seminar series. ASA Board Member and

Sustainability Chair Charles Hanskat will partner with Past ASA President Chris Zynda to bring the concrete industry up to speed on shotcrete's numerous sustainability advantages.

GreenSite at World of Concrete

ASA will, for the first time, in addition to its traditional booth, have an informational display inside GreenSite at World of Concrete. GreenSite is a section of the World of Concrete show that enables organizations to promote and educate the concrete industry on the latest green-build technologies. This will be the perfect setting to reintroduce the 100+-year-old shotcrete process in this new sustainability context.

Next Steps

While a lot has been accomplished in just 1 year, ASA has just begun its sustainability efforts. A number of additional initiatives and projects are in progress that will leverage the already completed work and create critical tools for our industry to use in educating the construction world and significantly increase the use of shotcrete. Two of the more significant planned efforts follow.

Sustainability Advantages of Shotcrete Brochure

As previously mentioned in this column last year, "…many large project owners are requiring contractors to submit documentation regarding the sustainability benefits of their product in order to even bid a project. This trend will only continue as the size of projects requiring such documentation drops to smaller and smaller jobs. It is also a matter of time before state and federal agencies follow suit."

ASA is working on the development of a professional document that will not only identify and quantify shotcrete's sustainability benefits, but will also sell the benefits of the overall process. This document will be a critical tool for contractors and one that ASA will make available to our members for use in marketing and bidding. ASA will also work to supply the document to specifying organizations and personnel.

LEED Work

Another exciting area that ASA will be working on is the recognition and further adoption of shotcrete as a source of points in sustainability rating systems such as the LEED system. The ASA Sustainability Committee, using many of the principles identified in this issue's article "Is Shotcrete Sustainable?" by committee member Lihe (John) Zhang, is beginning to research and formulate strategies for growing the potential source of rating system points for the use of shotcrete on a project.

Continued Promotion of Shotcrete Sustainability Advantages

ASA is working to incorporate these new resources into its overall strategy to promote shotcrete. The sustainability advantages will be a major part of all promotions, including printed material, trade shows, seminars, and presentations.

The Shotcrete Market Is Growing—Will You Help Answer the Call?

The momentum is building as the construction world awakens to the exceptional advantages of the shotcrete process. The sustainability movement has turned out to be a real blessing for our industry and has helped us to identify and now promote these new and additional advantages of our process. The total percentage of concrete placed via shotcrete will undoubtedly continue to grow. The potential for ASA to leverage this growth to its fullest is directly dependent on participation in ASA by our entire industry.

If you have been a reader of this magazine, but have never taken that next step to become a member and/or to participate in an ASA committee, please consider that next step now. We are at a unique and critical point in the development of the shotcrete industry. Will our industry step forward in a unified voice and drive this growth to its full potential?

Please take a moment to review the benefits of ASA membership. You can find general information on page 62 of this issue or visit the ASA Web site: **www.shotcrete.org/ASAmembership.htm**.

BRIDGE REPAIR WITH SHOTCRETE

to do this...

shop online
www.gunite.us

use this...

GUNITE
Supply & Equipment
www.gunitesupply.com
Since 1967

Circle #47 on reader response form—page 64

see video at www.gunite.us

Sustainability of Shotcrete—An Overview

By Charles S. Hanskat

It seems all we hear about in design and construction these days are the buzzwords—sustainability, green construction, LEED, carbon footprint, CO_2, and global warming.

The topics that comprise the concept of sustainability are certainly hot ones that we constantly see in the media. Sustainability is more than a passing fad and has become a major consideration in how we design and build structures from now into the foreseeable future.

But what do we really mean by sustainable construction and why is it important to the concrete and shotcrete industry? This issue of *Shotcrete* magazine is dedicated to the sustainability theme. This article provides an overview on sustainability, its general impact on concrete, and how ASA is actively participating in sustainability initiatives. Other articles in this issue deal with the specific benefits of shotcrete in sustainable construction, and provide case studies of how different projects have created substantial sustainable benefits.

Sustainability 101

"Sustainability" as a concept is huge in scope. The widely used definition for sustainability created by the World Commission on Environment and Development (the Brundtland Commission) in 1987 is:

> "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Who can argue that we shouldn't do this? It really boils down to building today so that all those generations of people who come after us have an opportunity to live quality lives here on Earth. This simple concept is then commonly broken down into three key components to be considered in sustainable development:

- Social;
- Environmental; and
- Economic.

The social component is often considered to be development that is socially desirable, culturally acceptable, and psychologically beneficial. This applies to the individual, the community, the country, and the world. Simply put, we don't want development that creates more negative social impacts such as increased crime and poverty and resource hoarding. We do want to have more construction that instills civic pride, and structures we are proud to have as "good neighbors."

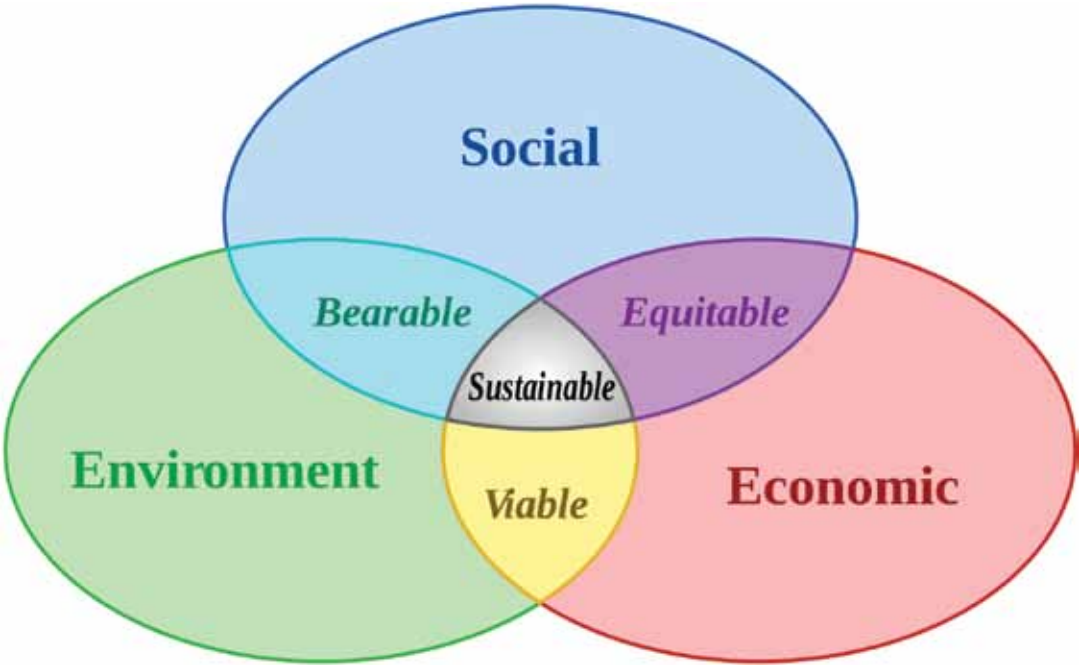
The environmental component is the impact on the environment. This component evaluates how the sustainable development affects the air, ocean, fresh water, land, food, and forests. All development has some impact on the environment—either good or bad. Global warming, acid rain, smog, depletion of the ozone layer, CO_2 levels in the atmosphere, and hazardous waste are environmental issues that have impacted us all over the last 20 years.

The economic component refers to the financial aspect of sustainable development. Is the development economically viable in initial and long-term operational cost? Is it technically feasible at a reasonable cost?

In practice, to achieve sustainable development, we need to evaluate each of these three components and then balance the overlap between them (refer to sustainable development figure).

As an example of the interaction between these three components, consider if a new development is good for the environment but extremely expensive to implement—it may then have a substantial negative impact on the economic and potentially social aspects of the development. A less expensive solution that would favorably impact the environment a little less, could have more positive economic and social impact, and thus move into the center portion and actually be more sustainable.

In evaluating the sustainable benefits of a particular project or product, one must keep a broad perspective on how all three of these components may be affected. For example, many sources have condemned concrete as an unsustainable material simply because of the CO_2 generated in the manufacturing of cement. Yes, it is a fact that cement production creates CO_2; however, this is only one aspect of sustainability (environmental impact) and it completely ignores



Sustainable development
By John Dréo, courtesy of Wikipedia Commons

the overall picture. Concrete is one of the most widely available (social impact) and cost-effective (economic impact) construction materials in the world today. Combined with the extremely long durability and serviceability of well-designed and built concrete structures (economic and environmental impact), the flexibility of concrete shapes (economic and social impact) and the ability to use recycled materials (environmental and economic impact) proves that concrete is an excellent choice for sustainable structures.

What Makes a Sustainable Project?

Just selecting concrete for a structure doesn't automatically make it sustainable. There still needs to be consideration of what can be done to maximize concrete's contribution to the overall sustainability of the project. The recently published U.S. Green Concrete Council (USGCC) book, *The Sustainable Concrete Guide—Strategies and Examples*, lists five key aspects that make for improved sustainability of buildings:

Improving functionality—Increased functionality means a more efficient structure to serve its intended purpose. Concrete—and to an even greater extent, shotcrete—allows great flexibility in structural shapes and efficiency. In some structural areas, such as ground-supported or buried portions of a structure, or in an arch dam, concrete is clearly the only cost-effective product.

Ensuring longevity—The longer the usable life of a structure, the less the need for repair or replacement of the structure that would entail using more resources. Concrete as a material, properly designed and constructed, is unmatched in its ability to provide durable structures.

Enhancing occupant comfort—A more comfortable environment within a building increases the productivity of the users and thus adds to the efficiency of the structure's overall use. The thermal mass of concrete can help moderate inside temperatures. The naturally light color of concrete and the ability to provide a variety of finishes to exposed surfaces can help to enhance natural lighting and reduce the use of other finishing materials.

Reducing the use of resources—Concrete is great for reusing many recycled materials, including supplemental cementitious materials such as fly ash or slag, or reused aggregates from crushed concrete. The ability to increase recycling means less material that ends up taking space in landfills. Also, the long-term durability of concrete means a much longer replacement cycle is needed; thus, resources are not used nearly as often as with other construction materials.

Aesthetics—This aspect addresses the social component of sustainability. Visually pleasing structures can give an increased sense of community pride. Concrete (and more specifically, shotcrete) can produce virtually any shape. It is like clay that architects or engineers can mold to their creative vision.

How to Rate a Project's Sustainability?

There are many different rating systems currently available to evaluate how a potential project may

provide enhanced sustainability. In the U.S., the three most commonly used systems are:

- Leadership in Energy and Environmental Design (LEED) from the United States Green Building Council (USGBC);
- Green Globes® from the Green Building Initiative (GBI); and
- National Green Building Standard from the National Association of Home Builders (NAHB) and the International Code Council (ICC).

The LEED system was started in 1998 and is now up to an online version 3 as of April 2009. It is produced and maintained by the USGBC (**www.usgbc.org**). In the LEED system, points are given to a commercial or residential building project based on performance in specific areas such as sustainable sites, water use, energy use, indoor environmental quality, stewardship of resources, innovation in design, and regional priorities. Individuals trained in the LEED evaluation and rating system can become certified LEED professionals.

The Green Globes® online tool is maintained by the GBI (**www.thegbi.org**). The current version of the GBI Standard document is ANSI/GBI 01-2010. The Green Globes® online system is the assessment protocol applying the GBI standard to evaluate and rate sustainable buildings. The online tool provides a score based on user input, and then offers best practices guidance for possible improvements.

The National Green Building Standard is primarily a residential green building rating system. It is maintained by the NAHB and was developed meeting the ANSI consensus process. There are four threshold levels, starting with Bronze as an entry-level green building, to Emerald as the highest level of sustainable green building incorporating energy savings of 60% or more. Single-family and multi-unit homes, residential remodeling projects, and site developments are all covered in the Standard. NAHB has a Green Scoring Tool available online at **www.nahbgreen.org**.

An interesting comparison study of the LEED and Green Globes® rating systems was prepared by the University of Minnesota in 2006. A PDF of the study was available at the time of writing this article at http://www.myfloridagreenbuilding.info/pdf/GG_LEED_10_06.pdf.

For projects outside the U.S., the BRE Environmental Assessment Method (BREEAM) rating system is commonly used. More information on this system can be found at **www.breeam.org**.

What is ASA Doing about Sustainability?

In 2009, ASA joined with 20 other concrete and cement-related associations to support the Concrete Joint Sustainability Initiative (CJSI). The CSJI was formed in Spring 2009 by the American Concrete Institute (ACI), the Portland Cement Association (PCA), and the National Ready Mixed Concrete Association (NRMCA) to focus industry efforts on sustainability in a coordinated and concentrated manner. The CJSI is not a stand-alone organization and has no staff. All work of the CJSI is supported entirely by the staff of the member organizations.

Currently, the member organizations of the CJSI include:

- American Coal Ash Association **www.acaa-usa.org**
- American Concrete Institute **www.concrete.org**
- American Concrete Pipe Association **www.concrete-pipe.org**
- American Concrete Pressure Pipe Association **www.acppa.org**
- American Shotcrete Association **www.shotcrete.org**
- American Society of Concrete Contractors **www.ascconline.org**
- Architectural Precast Association **www.archprecast.org**
- American Segmental Bridge Institute **www.asbi-assoc.org**
- Cast Stone Institute **www.caststone.org**
- Concrete Reinforcing Steel Institute **www.crsi.org**
- Concrete Sawing and Drilling Association **www.csda.org**
- Concrete Foundations Association **www.cfawalls.org**
- Expanded Shale, Clay and Slate Institute **www.escsi.org**
- Interlocking Concrete Pavement Institute **www.icpi.org**
- International Concrete Repair Institute **www.icri.org**
- National Concrete Masonry Association **www.ncma.org**
- National Precast Concrete Association **www.precast.org**
- National Ready Mix Concrete Association **www.nrmca.org**
- Portland Cement Association **www.cement.org**
- Post-Tensioning Institute **www.post-tensioning.org**
- Precast/Prestressed Concrete Institute **www.pci.org**

- RMC Research and Education Foundation
  www.rmc-foundation.org
- Silica Fume Association
  www.silicafume.org
- Slag Cement Association
  www.slagcement.org
- Tile Roofing Institute
  www.tileroofing.org
- Tilt-Up Concrete Association
  www.tilt-up.org
- Wire Reinforcement Institute
  www.wirereinforcementinstitute.org

Additionally, in late 2009, the ASA Board of Directors recognized the need for a focus group within ASA to address the sustainability issue. As a result, the Board established a new standing committee on sustainability. The mission of the Sustainability Committee is to compile and distribute information on the sustainability of shotcrete construction. The Sustainability Committee has been quite active since its formation in identifying key aspects of shotcrete construction's contribution to improving sustainability in a variety of concrete structures.

The committee has recently contributed material to help development of a new book being produced by the USGCC, *The Sustainable Concrete Guide—Applications*. This book is intended to be a follow-up reference to the book, *The Sustainable Concrete Guide—Strategies and Examples*, mentioned previously. Contributions to the book include a full chapter on shotcrete and also supplemental material for the repair chapter.

Interested in Learning More?

You will find much more information on the sustainability of shotcrete in the articles and case studies that follow in this issue of *Shotcrete* magazine. For more detailed information about the sustainability of concrete, you may also find these Web sites of interest:

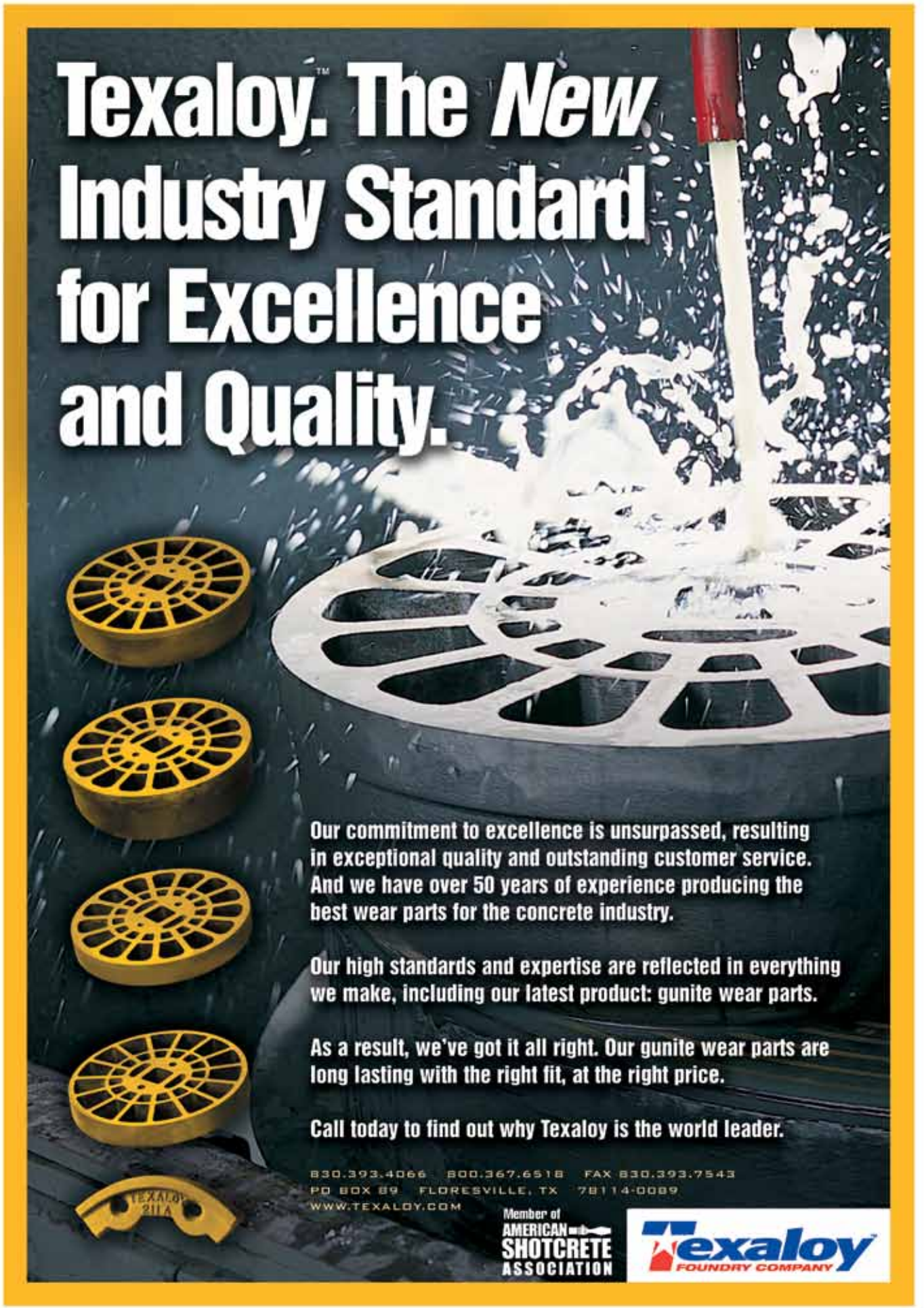
- **www.ConcreteThinker.com**
  by Portland Cement Association
- **www.greenconcrete.info**
  by National Ready Mixed Concrete Association
- **www.green.concrete.org**
  by American Concrete Institute
- **www.greenrooftops.org**
  by National Ready Mixed Concrete Association
- **www.perviouspavement.org**
  by National Ready Mixed Concrete Association
- **www.tilt-up.org/sustainability**
  by Tilt-Up Concrete Association
- **www.concretecentre.com**
  by The Concrete Centre
- **www.sustainableconcrete.org**
  by the Concrete JSI

Also, the two books from the USGCC are valuable references on concrete's role in sustainable construction. *The Sustainable Concrete Guide—Strategies and Examples* is available for purchase now and the new book *The Sustainable Concrete Guide—Applications* should be available by the end of 2010. You will find information on these books at **www.usgreencouncil.org**.

Charles S. Hanskat *is a Principal at Concrete Engineering Group, LLC, a firm he founded in 2008 located in Northbrook, IL. He received his bachelor's and master's degrees in civil engineering from the University of Florida. Hanskat is a licensed professional engineer in 22 states. He has been involved in the design, construction, and evaluation of environmental concrete and shotcrete structures for nearly 35 years.*

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.

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.



Circle #35 on reader response form—page 64

Sustainability with a Capital "S"

By Marcus H. von der Hofen

Today we are inundated with the goal of green building, LEED points, eco-communities, our ecological footprint, global warming, resource management, and many other accolades of sustainability. What often gets lost in the definition is the societal aspect of sustainability. The word itself, as defined, means to "maintain," "support," and "endure"; we seem to be only focused on it from an environmental focus—which is obviously important—but shouldn't there be more?

Do we put enough importance in the preservation of the buildings, the landmarks—or better yet—the history and heritage that they possess? I'm proud to say that a great number of projects that I have participated in over the last two decades have involved the preservation, renovation, and reuse of buildings that might have ultimately been torn down, taking with them the history and human imprint they carry, along with the resources they used to build them. With innovation, we can sustain these structures for generations to come, to be used and enjoyed with a positive impact on our environment.

The First Regiment Armory Annex—known to locals as the Portland Armory—was built in 1891 to house the Oregon National Guard. This impressive building was built in the Romanesque Revival style that was popular at that time. The semicircular arcades and stone cladding used many of the materials native to the Northwest. My first encounter with the building was during the late 1990s, early 2000s while working in the Pearl District of Portland. This industrial/warehouse area of Portland, OR, was in the process of going through a transition and becoming a residential retail zone. An area known as the Brewery Blocks was being redeveloped using major portions of the old Blitz-Weinhard facility that had been operating since 1862.

Massive brick and unreinforced masonry structures were upgraded with the use of structural shotcrete to seismically retrofit and renovate these structures while keeping the historic look intact. The development was a major success, as many local residences and businesses stormed to the area because of its old-school charm and modern amenities.

The last piece of this urban redevelopment was the Portland Armory. Before developers knew what they were going to with the structure, they had to stabilize the deterioration just to make it safe to explore. Shotcrete was used to address the most important historic structures so that exploration and design could proceed (refer to Fig. 1 and 2). Thus, my adventure began, helping to build what is today known as the "Gerding Theater at the Armory," home of Portland Center Stage.

Fig. 1: Structure stabilization

Fig. 2: Structure stabilization

Fig. 3: Shotcrete soldier pile shoring

Fig. 4: Shotcrete walls and one-sided forming

Fig. 5: Shotcrete after stripping forms

Fig. 6: Building within a building

A general contractor from Oregon largely responsible for the Brewery Blocks projects took on the $36.1 million renovation. To say this was an extremely difficult project would be an understatement. The first task was to excavate and shore two stories down while the historic structure remained. The system was comprised of a combination soldier pile tieback and soil nail wall using a temporary shotcrete facing. The majority of the structure—a building within a building—was constructed using structural shotcrete placed against one-sided forms and the in-place shoring systems. The process reduced forming by 50%, allowed placement against the existing brick structure without risk of damage, and solved access problems that would have been uneconomical with a conventional cast-in-place system. Crews placed over 1500 yd^3 (1147 m^3) of structural shotcrete in some of the most complex situations to help make this project a success.

In the end, the Portland Armory received a Platinum LEED Certification, becoming the first building to receive this recognition in the city of Portland and the first on the National Register of Historic Places. A building that has had three presidents speak in it, housed soldiers, a professional basketball team, and more is now a state-of-the-art theater at over 100 years old—now that's Sustainability.

Photos courtesy of Tony Johnson of Hoffman Construction and Mark Rado

Fig. 7: Outside during renovation

First Regiment Armory Annex Renovation

General Contractor
Hoffman Construction
Oregon

Excavating and Shoring
Versatile Drilling and NW Cascade

Shotcrete Placement
Johnson Western Gunite

Fig. 8: Today

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; Co-Chair of the ASA Education Committee; and serves on the ASA Board of Direction.*

ASA ANNOUNCES AVAILABLITY OF NEW ONLINE BUYERS GUIDE

New online tool offers the industry free access to products and services of the leading companies in the shotcrete industry

The new American Shotcrete Association (ASA) Buyers Guide is now available free to the concrete industry at **www.shotcrete.org/BuyersGuide**.

The ASA Buyers Guide provides a new and important tool to locate those companies that continually prove their commitment to the shotcrete process and its quality by supporting ASA through Corporate Membership.

This new service enables users to search for companies based on products and/or services related to shotcrete across seven main categories:

- Admixtures
- Cement/Pozzolanic Materials
- Consulting
- Contractors
- Equipment
- Fibers
- Shotcrete Materials/Mixtures

Searches can be further refined using over 100 subcategories and geographic criteria.

AMERICAN SHOTCRETE ASSOCIATION

www.shotcrete.org/BuyersGuide • (248) 848-3780

WORLD OF CONCRETE®
WORLD OF MASONRY | TECHNOLOGY FOR CONSTRUCTION
hanley wood

January 18-21, 2011 · Seminars January 17-21
Las Vegas Convention Center · Las Vegas, Nevada

YOUR WORLD. YOUR SHOW.

This is your show—the industry's ONLY annual international event dedicated to the commercial concrete and masonry construction industries. When it comes to discovering the machinery, technology, resources and new ideas you need to sustain and grow your business, nothing compares to World of Concrete.

AMERICAN SHOTCRETE ASSOCIATION

SUPPORT ASA: REGISTER ONLINE USING SOURCE CODE **A17** AND GET FREE EXHIBITS-ONLY ENTRY TO WOC 2011

START YOUR YEAR OFF RIGHT: **www.worldofconcrete.com**

Circle #43 on reader response form—page 64

Is Shotcrete Sustainable?

By Lihe (John) Zhang

The shotcrete process was developed over 100 years ago. From the first cement gun made by Carl Akeley in Chicago in 1909, to the robotic spray arms now used all over the world, shotcrete has developed into a sophisticated technology with continuing advances in materials process, including mixture design optimization, shotcrete batching and production, transportation and application, and quality management systems. Shotcrete technology has gradually built up its reputation as a viable construction methodology through integration of new technologies, including the use of supplementary cementitious materials (SCMs), and new generations of chemical admixtures and fiber reinforcement. Shotcrete provides a unique process for applying concrete materials for ground support for both above-ground and underground new construction, repair, and retrofit. It has been proven to be an economic and technically effective system. This article briefly visits the history of shotcrete technology development from a sustainability point of view and attempts to answer the fundamental questions: Is shotcrete now sustainable, and if so, how can shotcrete be made more sustainable? This article further explores sustainability developments in the shotcrete industry based on decades of project experience, technology advancements, and the optimized use of resources. This article also attempts to quantify the merits of using shotcrete from a LEED point perspective.

Sustainability and Green Building

Sustainability is typically referred to as a development "that meets the needs of the present without compromising the ability of future generations to meet their own needs."[1] The definition of sustainability, green building, or sustainable development for buildings and construction is not universally agreed upon, but it is commonly accepted in industry that sustainability means the reduction, reuse, and recycling of resources and energies, reducing the carbon footprint (that is, CO_2 emissions), and minimization of environmental impact while improving the functionality of buildings. Technologies and construction methods related to sustainability include: 1) green cement and concrete technologies, including operation and production with a reduced carbon footprint, performance-based concrete mixture designs, use of SCMs, thermal transmission of concrete, longevity and life-cycle assessment, and storm-water management; and 2) construction methods that help to reduce social, environmental, and economic impacts while keeping construction activities safe and secure.

There are rating systems developed to evaluate a concrete structure's success in meeting pre-defined goals related to sustainability. These rating systems include LEED (**www.usgbc.org**), Green Globes by the Green Building Initiative (**www.thegbi.org**), and Green Ready Mix Plant Certification Program (**www.nrmca.org**). The most widely used standard related to shotcrete is, however, the LEED point system. Brief instructions regarding the LEED system, especially the related rating points and historical background of green building and concrete, can be found in another article in this magazine.[2]

Review of Shotcrete in Terms of Sustainability

Shotcrete is defined by ACI 506R-05, "Guide to Shotcrete,"[3] as concrete (or sometimes mortar) conveyed through a hose and pneumatically projected at high velocity onto a receiving surface. While the material component of shotcrete is essentially concrete, the process of shotcrete application is unique. It involves pneumatic projection of the concrete materials at high velocity so that compaction is achieved on the receiving surface. It is therefore necessary to review the materials and mixture design, admixtures and additives, application process, and durability for shotcrete with respect to sustainability. Appendix A provides a comprehensive list of advancements in shotcrete technology during the past century. Based on a review of these developments, it is proposed to answer the basic question: Is shotcrete sustainable?

Green Cement and Concrete

One of the most advanced green technologies in the shotcrete industry is the addition of SCMs such as fly ash, slag, silica fume, and metakaolin, to replace cement. Production of 1 ton of cement is accompanied with the emission of about 1 ton of CO_2. Most SCMs are industrial by-products or waste. Replacing cement with SCMs reduces the

cement content of the mixture and therefore reduces CO_2 emissions.[1] Although replacing cement with SCMs does not achieve a carbon neutral state, that is, zero carbon emission, it does reduce the overall carbon footprint. The current LEED rating system grants one credit for 7.5% replacement and two credits for 15% replacement of cement with SCMs.

Besides carbon footprint reductions, the benefits of adding SCMs have been widely acknowledged by the building and construction industries. These advantages include: 1) improved workability for fresh shotcrete: for example, silica fume can be added to improve cohesiveness, adhesion, and thickness of buildup for overhead applications; and fly ash can be added to improve pumpability; 2) improved strength; and 3) improved durability such as reduced permeability, increased chemical resistance, and mitigation of potential alkali-aggregate reaction.

Performance-Based Design with SCMs

Most current shotcrete specifications tend to be performance-based instead of prescription-based. ACI Committee 506[3,4] is working toward predominantly performance-based specifications. A typical performance-based shotcrete specification is as follows:

Fly ash has been widely used in shotcrete mixtures for the merits primarily of workability and durability that it imparts, but this also provides sustainability. Fly ash is a waste by-product from the burning of coal for power generation. Traditionally, a large portion of fly ash has been used for landfill. Landfill and storage of fly ash is always also associated with high costs and, most importantly, a negative impact on the environment. The reuse of fly ash reduces the costs of landfill and storage, and further minimizes environmental impact. For cast-in-place concrete, fly ash is typically added at between 20 to 50% by mass of the total cementitious materials. For shotcrete, fly ash is typically added at between 15 to 20% by mass of the total cementitious materials. Requirements for a typical shotcrete mixture design with fly ash are listed in Table 1.

Silica fume has been found to provide superior performance for both concrete and shotcrete. Silica fume is typically added at 8 to 10% by mass of cement. Silica fume improves the cohesiveness of the fresh shotcrete, that is, it makes the shotcrete stickier. For overhead applications and vertical applications where stickiness is a requirement, adding silica fume is one of the best solutions. Although dry-mix shotcrete benefits the most from silica fume addition, using silica fume in wet-mix shotcrete is also beneficial. Silica fume improves compressive strength, permeability resistance, and durability. Silica fume-modified shotcrete mixtures are widely used in bridge retrofits, marine structure repair, and for underground support in tunnels and mines.

Metakaolin is a new SCM and it produces concrete and shotcrete that is intermediate in performance between fly ash and silica fume in terms of strength improvement. Metakaolin is a mined product and is typically added at between 10 to 20% by mass of cement. Metakaolin improves the cohesiveness of fresh shotcrete and the later-age strength development of shotcrete. It was first used in shotcrete on a mining project in British Columbia, Canada, in 2008.[4]

Other green technologies include limestone binary cement technology, but it has yet to be tested in shotcrete. Recycled aggregate has been tried in shotcrete but it is less promising due to its high variability in quality.[5]

Air Entrainment for Both Wet- and Dry-Mix Shotcrete

Air entrainment of wet-mix shotcrete improves pumpability and, most importantly, is very effective in improving resistance to freezing and thawing. For wet-mix shotcrete, an air content of 6 to 9% at discharge from the concrete truck into the shotcrete pump normally results in an in-place shotcrete with 3 to 5% air content. For dry-mix shotcrete, an air-entraining admixture can be

Table 1: Requirements for a typical shotcrete mixture design with fly ash

Target requirements	
Minimum compressive strength	5076.3 psi (35 MPa) at 28 days
Slump	2.4 to 3.1 in. (60 to 80 mm)
Maximum water-cementitious material ratio (*w*/*cm*)	0.40
Air content	4 to 5% as shot
Maximum size of aggregate	0.4 in. (10 mm)
Calculated mixture design parameters	
Fine aggregate content	75.0%
Plastic density	140 lb/ft^3 (2240 kg/m^3)
Fly ash content (percent by mass of cement)	20.0%

added to produce an air content of about 4% for the hardened shotcrete.[6]

Sustainable Construction and Application

When applied to a receiving surface (for example, rock mass, soil, insulation board, plywood or steel formwork, or masonry for historical buildings), shotcrete is pneumatically projected at high velocity. This process provides good consolidation of the materials and minimizes the use of formwork. Compared to cast-in-place concrete construction, shotcrete typically reduces the amount and time for formwork installation, removal, and associated labor costs. For structural shotcrete, single-sided formwork can be used to provide a receiving surface (Fig. 1 and 2). For soil and rock slope stabilization projects when shooting against existing excavations (soil or rock), the use of formwork can often be eliminated entirely.

The modern dome construction process is another good example of using shotcrete with no formwork. An airform, which can also act as the final waterproofing membrane, is used as the form, with shotcrete applied from the inside (Fig. 3).

Fig. 1: Single-sided plywood formwork set up as a shotcrete receiving surface in California
Photo courtesy of Chris Zynda

Rebound Collection

Rebound is associated with the shotcrete application process. It can vary from 5 to 10% by mass of applied materials for wet-mix shotcrete, and 15 to 40% for dry-mix shotcrete. An appropriate collection of rebound materials and associated cuttings and trimmings from finished shotcrete surfaces can, however, reduce environmental impact. Rebound materials should not be reapplied to a shotcrete structure but can be collected (Fig. 4) and used as backfill materials for foundations or can be used to cast concrete blocks.

Shotcrete is Sustainable

The preceding review indicates that shotcrete, as currently used, is a green material and can be designed and applied in a sustainable way. Therefore, it is concluded that shotcrete is sustainable.

Having said that, it is important to ask the following questions:

- Have the construction and green-building industries recognized and accepted that shotcrete is sustainable?
- How does the sustainability of shotcrete help the development of the shotcrete industry?

Although numerous structures, including new construction and repair of buildings, bridges, dams, tunnels, retaining walls, swimming pools, and marine structures have been built or repaired with shotcrete for more than a century, there are still questions and concerns from owners, architects, and engineers regarding shotcrete and how it compares to cast-in-place concrete.[7] These can be summarized as follows:

- **Is shotcrete the same finished product as cast-in-place concrete?**
  Shotcrete is not yet recognized in all jurisdictions as a suitable construction technology when compared to conventional cast-in-place concrete construction. Questions are asked

Fig. 2: Shotcrete applied to a masonry wall for seismic retrofit for a heritage building in Vancouver, BC, Canada

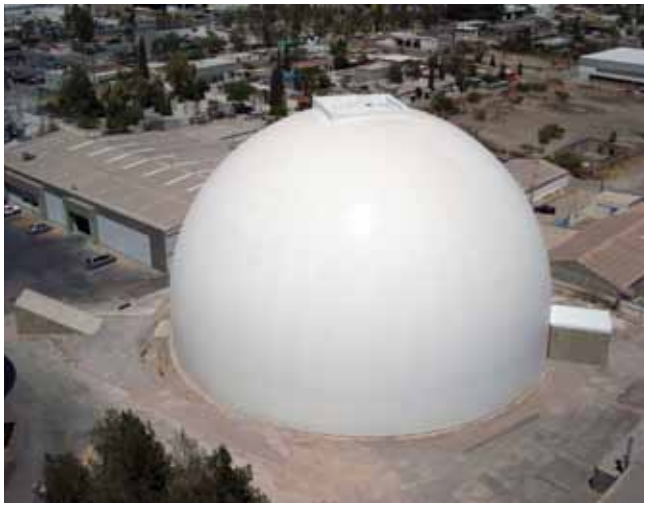



Fig. 3: Shotcrete applied to waterproof membrane to construct a dome
Photo courtesy of Ryan Poole

regarding the durability and permeability of shotcrete. Most of the time, previous project experience and the evaluation of mock-ups can be used to allay such concerns.

- **Is shotcrete durable?**
  Improvement of durability will extend the service life of the structure and therefore contribute to sustainability. Durability for shotcrete can be assessed by evaluating properties such as boiled absorption and volume of permeable voids (ASTM C642-06), resistance to freezing and thawing (ASTM C666/C666M-03(2008)), rapid chloride penetration (ASTM C1202-10), and others. Microstructure of the hardened shotcrete and fluid transportation mechanisms during the service life of the hardened shotcrete are important properties to understand in assessing durability. Some research work[8] found that the variation of cement paste content of the shotcrete, which is influenced by the gradation and percentage of aggregates in the mixture formulation, will affect permeability. There is still a need for more fundamental research, however, into the porosity, pore structures, and fluid transport mechanisms for shotcrete for durability to be more fully understood.

Fig. 4: Rebound materials collected and used as backfill materials

Making Shotcrete More Sustainable

Contribution to LEED Points

LEED certification is now frequently required for new buildings and it is important that shotcrete can be recognized to contribute to LEED points. LEED accepts technologies that can make buildings greener. Shotcrete can contribute to LEED points[9] with the use of SCMs. The following are specific methods:

- MR C4, one to two points, recycled content. Using 10% post-consumer and preconsumer waste, such as a fly ash as cement replacement, can garner one LEED point, and using 20% replacement can garner two LEED points.
- MR C8, one point, durable building. Using concrete to meet CSA durability requirements and life-cycle requirements. Construction of buildings with 100 years of design life will, for example, contribute to LEED points.
- MR C5, one to two points, regional materials. Using aggregate, cement, and SCMs produced and supplied locally will contribute to LEED points.

The reduction or elimination of formwork will reduce materials costs, shorten the construction schedule, and save labor costs. Time savings of up to 4 months in a 1-year construction schedule have been achieved. There is a large cost savings through the use of shotcrete instead of cast-in-place concrete for formwork setup and stripping and through the elimination of concrete vibration costs. The advantage of using shotcrete in terms of formwork cost savings is an important

contribution to sustainability, but it has yet to be acknowledged by the green building industries. Unfortunately, the current LEED rating system has not yet recognized this advantage. It is up to the shotcrete industry to bring this important factor to the attention of the green building industry.

Here is a proposed LEED point system for considering the formwork savings with shotcrete:

total formwork used with form-and-pour construction
– total formwork used with shotcrete/total formwork used with form-and-pour construction
= LEED credit for formwork saving with shotcrete process

Note 1: The parameter to quantify formwork can be total cost, total quantities such as m^3 or m^2, or weight. It is recommended to use cost.

Note 2: Actual costs will vary for each project. For projects without a detailed breakdown of costs, however, an estimate could be made as outlined in Table 2.

The percentage cost savings to achieve a LEED credit needs to be determined by the shotcrete industry. For example, if a cost savings of 10% is set up to grant one LEED point, then the aforementioned example will contribute to one LEED point.

Formwork savings could contribute to the following potential LEED Credits Categories:

LEED New Construction Materials & Resources (MR)

- MR Credit 1 Building Reuse
- MR Credit 2 Construction Waste Management
- MR Credit 3 Resource Reuse
- MR Credit 4 Recycled Content
- MR Credit 5 Regional Content
- MR Credit 6 Rapidly Renewable Materials
- MR Credit 7 Certified Wood
- MR Credit 8 Durable Building

Repair and Rehabilitate with Shotcrete

The majority of aging concrete structures need to be repaired and rehabilitated across North America. Repair and rehabilitation are among the most effective ways to make structures sustainable. Repair of an existing structure will extend its service life of the structure as opposed to demolishing it and building an entirely new structure. Rehabilitation of existing buildings will reduce energy consumption and contribute to a sustainable environment. Repair will reduce costs of materials and labor, minimize waste materials produced by demolition of the old structure, and reduce environmental impact during demolition and the new construction period. Shotcrete has been found to be particularly cost effective in a variety of repair situations, including[10]:

- where formwork is impractical or can be reduced or eliminated;
- where access to the work area is difficult;
- where thin layers and/or variable thickness is required; and
- where normal casting techniques cannot be employed.

Shotcrete bonds well to the substrate concrete if the substrate is prepared properly, and this will result in extended service life for the structure, in particular for the structures that have deteriorated severely. Figure 5 shows an example of repair of a seawall with shotcrete.

Table 2: Example of formwork savings with structural shotcrete for a commercial building
(numbers are for demonstration purposes only)

Provide total formwork cost with form and pour (including labor, equipment, and materials)

Provide total formwork cost with shotcrete (including labor, equipment, and materials)

Structure component	Company	Form-and-pour cost, U.S.$			Shotcrete cost, U.S.$		
		Formwork materials costs	Labor costs	Equipment, including crane costs	Formwork costs	Labor costs	Equipment, including crane costs
Foundation walls	Shotcrete contractor	10,000	10,000	10,000	0	5000	0
Columns	Shotcrete contractor	10,000	10,000	10,000	10,000	10,000	10,000
Beams	Shotcrete contractor	10,000	10,000	10,000	10,000	10,000	10,000

Note 1: Formwork material costs include costs for wood or steel formwork; labor costs include costs for formwork erection, fasteners, removal, and costs to finish the structure; and equipment costs include crane costs.

Note 2: This is an example only; actual numbers can be calculated for an actual structural shotcrete project.

Total costs for form and pour: $90,000
Total costs for shotcrete: $75,000
Percentage of cost savings with shotcrete: 17%

Most green building rating systems, including LEED, have not yet included repair and rehabilitation as a factor to achieve a point for being sustainable. This allowance should be made, however, because repair and rehabilitation with shotcrete will improve the service life through enhancement of the durability of the existing buildings, and this will lead to the sustainability of structures and buildings.

Seismic Retrofit with Shotcrete to Extend Service Life and Sustainability

More and more buildings and structures are getting close to their design service life as the inventory of buildings needing seismic retrofitting increases. Retrofitting of existing structures and building improves the durability and therefore extends service life. In particular, the seismic retrofit of existing buildings and structures strengthens the structure to meet updated building standards for earthquake requirements. Across North America, many historical buildings are required to be preserved. Figure 6, for example, shows a historical masonry building that was built in 1912 and was seismically retrofitted in 2008 with structural shotcrete.[11] Reinforced shotcrete walls and pilasters were constructed inside of the masonry façade shown in Fig. 6. The historical exterior masonry façade remained for decorative purposes. Retrofitting historical buildings preserves the culture and heritage of the community and therefore contributes to sustainable development.

Retrofit of existing buildings also reduces energy consumption. According to Morgan and Zhang,[12] retrofit of existing buildings in Switzerland could reduce the total national energy consumption by 25% and greenhouse gas emission by 50%. The energy consumption of buildings retrofitted with shotcrete has not typically been calculated. The merits of using shotcrete for retrofitting needs to be studied and assessment measures need to be established.

Other Areas that Shotcrete Might Contribute to LEED Points

Using shotcrete, especially structural shotcrete for buildings, has advantages in thermal transmission. This is related to LEED Energy & Atmosphere C1, 1-10 points, and optimized energy performance. Using concrete to reduce thermal energy consumption, this can be achieved by energy modeling.[13] This includes applying shotcrete to insulated panels to provide a good balance of thermal mass and insulation in the proper locations.

Conclusions

Shotcrete is a sustainable material and can be applied by a sustainable method to construct durable structures. The shotcrete industry has been applying shotcrete in a sustainable way by the integration of advanced green technologies since its inception a century ago. Recognition and acceptance of sustainable shotcrete is needed in the shotcrete industry, the construction industry and, most importantly, the green building industry. This article is intended to open a window for the discussion and reevaluation of shotcrete from the aspect of sustainability.

Fig. 5: Shotcrete repairs to damaged concrete faces rip-rap in the Devonian Park part of the Stanley Park Seawall in Vancouver, BC, Canada
Photo courtesy of D.R. Morgan

Fig. 6: Seismic retrofit of the 100-year-old Wing Sang Building in Vancouver, BC, Canada

Acknowledgments

The author would like to thank D.R. "Rusty" Morgan and Charles C. Hanskat for reviewing this paper. Thanks are also given to ASA members who provided photos for this paper.

References

1. Schokker, A.J., *The Sustainable Concrete Guide—Strategies and Examples*, U.S. Green Concrete Council, 2010, 89 pp.

2. Hanskat, C., "Sustainability of Shotcrete—An Overview," *Shotcrete*, V. 12, No. 4, Fall 2010, pp. 9-12.

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

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

5. Morgan, D.R.; Loevlie, K.; Kwong, N.; and Chan, A., "Centrifugal Sprayed Concrete for Lining Horizontal Pipes and Culverts and Vertical Shafts," 3rd International Conference on Engineering Developments in Shotcrete, New Zealand, Mar. 15-17, 2010, pp. 225-232.

6. Chan, C., "Use of Recycled Aggregate in Shotcrete and Concrete," master's thesis, 1998, University of British Columbia, Vancouver, BC, Canada.

7. Dufour, J.F., "Can Dry-Mix Shotcrete Be Air Entrained?" *Shotcrete*, V. 10, No. 4, Fall 2008, pp. 28-30.

8. Bolduc, S.; Jolin, M.; and Bissonnette, B., "Evaluating the Service Life of Shotcrete," 3rd International Conference on Engineering Developments in Shotcrete, New Zealand, Mar. 15-17, 2010, pp. 57-63.

9. Yoggy, G., "The Elevated Game," *WaterShapes*, V. 11, No. 9, Sept. 2009, pp. 44-49.

10. U.S. Green Building Council, "LEED for New Construction Rating System," V. 2.2, 2009.

11. Morgan, D.R., "Advances in Shotcrete Technology for Infrastructure Rehabilitation," *Shotcrete*, V. 8, No. 1, Winter 2006, pp. 18-27.

12. Morgan, D.R., and Zhang, L., "Seismic Retrofit of Historic Wing Sang Building," *Shotcrete*, V. 11, No. 1, Winter 2009, pp. 8-12.

13. Richner, P., "Sustainability and the Built Environment," *Concrete International*, V. 32, No. 6, June 2010, pp. 39-43.

***Lihe (John) Zhang**, PhD, PEng, LEED AP, is a Materials Engineer for AMEC Earth & Environmental with over 10 years of experience in concrete technology and the evaluation and rehabilitation of infrastructure. He received his PhD in civil engineering from the University of British Columbia, where he conducted research on fiber-reinforced concrete. Zhang is a LEED Accredited Professional and he has been involved with American Concrete Institute (ACI) Committee 130, Sustainability of Concrete. He is a member of ACI Committees 506, Shotcreting, and 544, Fiber Reinforced Concrete; and ASTM Committee C09, Concrete and Aggregate. He is also Co-chair of the ASA Underground Committee.*

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 and Sustainability

By Ted W. Sofis

Sustainability has become one of the big catch phrases of our evolving energy-conscious society. In a world where we are looking at greater demands on our natural resources and energy efficiency, green buildings and economy in general have become integral ingredients in construction planning. Years ago, no one would ever refer to "the carbon footprint" of anything. Time was money and we moved full speed ahead. Today there is a greater awareness of sustainability and its long-term benefits. Architects, engineers, developers, and construction planners are under ever-growing pressure to use more efficient methods in construction. In looking at our industry from this perspective, shotcrete has a lot to offer.

The sustainability of shotcrete becomes apparent when you consider the myriad of ways that the process saves us in labor, materials, material handling, and construction time. The most obvious advantage of using shotcrete is that the material is gunned or sprayed in place, so forming, in many cases, becomes unnecessary. This in itself is a big deal. It not only saves the wood used in forming but also—if you are looking at it from the big picture—saves the lumber and the labor and transportation costs involved in providing the lumber on thousands upon thousands of construction sites. That correlates to a lot of lumber that basically would have been sacrificial. In addition to the lumber materials that become unnecessary, there is a tremendous amount of labor involved in the forming operations. Time and money is expended in the building of forms, whalers, bracing, and forming support structures. This too disappears with the use of shotcrete when material can be sprayed in place without the need for building forms. Even in instances where a one-sided form must be built as a backstop to gun against, the forming structure would only require 50% of the lumber than would be necessary in a conventionally formed-and-poured concrete structure.

Overhead shotcrete repair on a bridge pier near Pittsburgh, PA, provides a cost-effective repair to existing structures that can prolong the life of the structure

Shotcrete enables us to effectively repair the undersides of elevated structures on bridges, parking decks, arches, and other overhead structures. Forming and pouring to place material overhead is terribly expensive and labor intensive. Shotcrete provides an effective, less costly alternative for the rehabilitation of elevated structures. When repairs to an existing structure can be accomplished in a fast and inexpensive manner, the structure can be preserved and its life extended, saving vast amounts of materials that would be necessary in building a new structure. Even on bridge piers, retaining walls, and other vertical surfaces, repairs can be undertaken and completed more efficiently with less labor. This makes repair and rehabilitation a more attractive option. In any argument concerning sustainability, preserving our infrastructure is of vital importance. When the life of a bridge or dam can be extended, the savings in materials, fuel, and transportation are tremendous and the resources that we preserve will be available for other uses.

Shotcrete can easily conform to irregular shapes like arches, domes, cones, and rounded piers, pools, and hillsides. It can easily be placed on surfaces and shapes that would be difficult or prohibitively expensive to form. It enables us to

stabilize slopes on hillsides and rock faces in mining and tunneling operations. In the steel and power industries, shotcrete is routinely used for refractory installations to repair ash hoppers, coal bunkers, burners, ladles, and blast furnaces. Again, in these industrial applications, cost-effective methods of repair prolong the life of the refractory linings. The use of shotcrete saves labor and energy in conveying materials into hard-to-reach areas. It would be difficult to transport material in a boiler or vessel when the only access is an 18 in. (457.2 mm) man door. Transporting repair mortar though a manhole in a storm sewer would not be cost effective without being able to run shotcrete hoses to the work areas.

In shotcrete mixtures, recycled materials can and have been used in prepackaged materials. As technology improves, I have no doubt that more and more recycled aggregates will be used in the future of shotcrete and other methods of construction. Looking for better and more efficient ways of doing things can lead to savings in energy consumption, materials, labor, and time. The use of shotcrete saves us in eliminating or reducing forming costs, transporting material, and prolonging the life of structures. It enables us to make repairs in difficult-to-reach areas and effectively places material with less time and labor.

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.*

In this slope stabilization in Westernport, MD, the shotcrete conforms to the irregular rock surface

Using dry-process shotcrete, the walls of the sump are easily repaired without forming. The newly placed shotcrete is cut down to grade with the edge of a trowel

Using the dry process, the nozzleman guns the lower section of the Two Lick Dam in Indiana, PA, with shotcrete. The material is efficiently placed without having to form the repair areas

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

aci

American Concrete Institute®

Advancing concrete knowledge

Shotcrete Domes: A Model of Sustainability

By Chris Zweifel

Shotcrete domes are one of the most economical and sustainable building types known. Using a minimal amount of building materials, their shape provides the largest floor area and volume for the materials while also providing tremendous strength. The insulation and thermal mass provide significantly reduced energy usage. The ready availability of concrete and reinforcing steel reduces cost and construction time. The combination of all of these factors enables shotcrete domes to be recognized as "green," or environmentally friendly, structures.

Fig. 1: Construction of a typical dome foundation

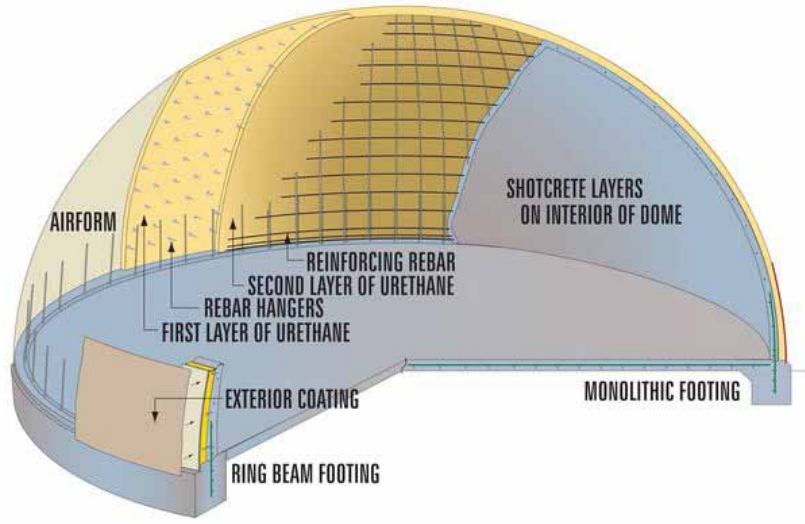


Fig. 2: Typical dome construction

Most domes begin with a simple spread footing or "ring" foundation (Fig. 1). The dome may start at the foundation, or a vertical stemwall might be included to give the dome added height or architectural appeal, or both. A prefabricated fabric form is then attached to either the top of the wall or the foundation, depending on which type of shape is required. The fabric form becomes the roof membrane for the completed structure. Large blowers inflate the fabric membrane that then serves as the formwork for the structure. Once the form is inflated, polyurethane foam is applied on the interior side of the form to the desired thickness. The initial reinforcement is attached with special fasteners embedded in the foam. The shotcrete is applied in gradually thicker layers until reinforcement is encapsulated and the concrete has reached the specified thickness (Fig. 2 and 3). Generally, the entire building enclosure is provided by a single contractor, which translates into significant time savings in the construction schedule. Another schedule saver is realized because the insulation, reinforcing steel, and shotcrete are all applied on the inside of the airform so that the construction can continue though virtually any weather.

The shape of the shell minimizes the wall surface area and maximizes the floor area. A look at two similar buildings will illustrate this advantage. Both projects are concrete warehouse structures. The first is a concrete tilt-up building

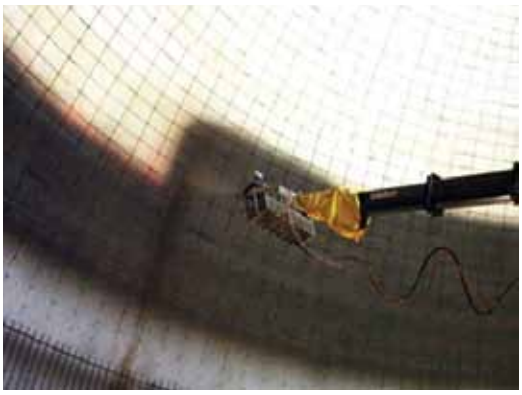


Fig. 3: Shotcrete is applied in layers

Fig. 4: Dome shop with metal building in the background

Fig. 5: Thermographic photo of steel building showing significant heat loss

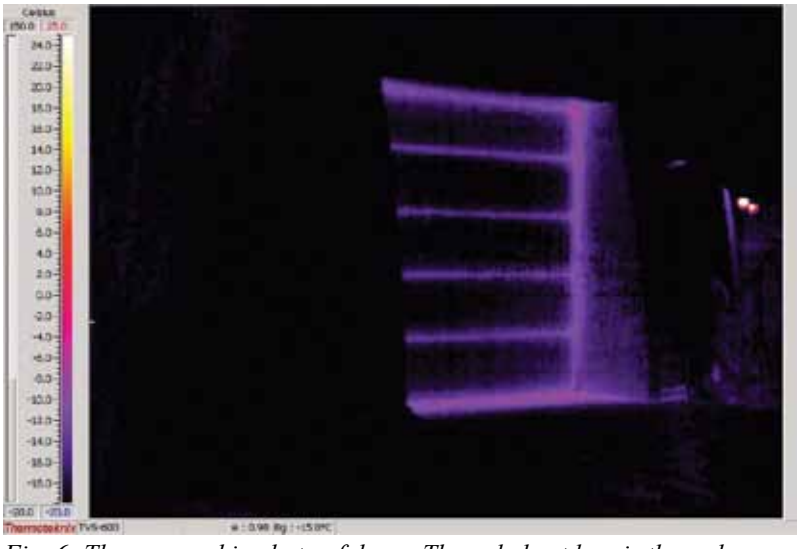


Fig. 6: Thermographic photo of dome. The only heat loss is through the door

that is 142 ft (43.3 m) square. The roof is a steel deck over steel joists. The second project is a shotcrete dome that is 161 ft (49 m) in diameter by 60 ft (18.3 m) tall. For both buildings, the floor area is about 20,000 ft^2 (1858 m^2). The outside surface area of the tilt-up building is 57,650 ft^2 (5356 m^2) and the enclosed volume is 524,200 ft^3 (14,844 m^3). In contrast, the dome has a surface area of only 31,670 ft^2 (2942 m^2) and an internal volume of 723,800 ft^3 (20,495 m^3). Even with a concrete roof, the dome option only uses about 20% more concrete, but uses approximately 40% less steel. The dome does not require any interior columns, which makes it very adaptable for various occupancy modifications over the life of the structure.

Due to their shape and construction materials, domes are inherently very strong. Much of the strength of the domes is because there are no mechanical connectors between the wall and roof. The wall and roof are the same member. Domes are so strong that the difference between a conventionally designed dome and one designed to be a storm shelter is almost negligible. To meet the strict requirement of the Federal Emergency Management Agency (FEMA) Document 361, "Design and Construction Guidance for Community Safe Rooms," the typical dome needs only 5 to 10% more reinforcing steel and no additional shotcrete. Most of this added reinforcement is not due to the increased stresses, but because of prescriptive requirements to provide protection from flying debris. In contrast, many conventional building types are never able to meet the strict requirements of a storm shelter. The ones that can, such as those constructed with reinforced concrete and masonry, often require 100 to 200% more reinforcement.

The polyurethane foam, applied inside the fabric form of the dome, creates a continuous thermal barrier from the footing to the top of the dome. It also creates an envelope that allows minimal air infiltration. This has a great effect on reducing interior air quality issues. The thermal mass of the shotcrete improves the system by storing energy in the form of heat throughout the building. This destratifies the temperature in the building, which reduces the HVAC and ductwork requirements. The electrical requirements to the mechanical system of the building are therefore reduced. This insulation, combined with the dense thermal mass of the shotcrete, translates into significant energy savings. A great visual representation of the energy efficiency of the dome can be shown with a thermographic photograph. Robert Phillips, President of Canadian Dome Industries Ltd., used a thermographic camera to create photographs that show the heat loss. He owns a metal structure

next to a dome (Fig. 4) and used the thermographic camera for measurement on a day when temperatures read –13°F (–25°C). Although the metal building is well insulated, the camera picked up significant heat transfer (Fig. 5). On the dome, however, the only measurable heat loss came from the garage door panels (Fig. 6). The dome itself showed virtually no heat loss.

While the portland cement in the shotcrete used to construct the dome requires a lot of energy to produce, studies show that the most significant environmental impact from buildings comes from their long-term energy use and not the construction products used. An example of the energy savings found in heating and cooling the dome can be seen in the Beggs, OK, school district. The superintendent of the Beggs School District provided solid numbers on the energy savings. During the 2006-2007 school year, the district paid $5500 to heat and cool a 10,000 ft^2 (929 m^2) dome classroom building as opposed to $30,650 for a metal classroom building of the same size. For the school's 30,000 ft^2 (2787 m^2) Event Center dome (Fig. 7), the district paid $6600 for utility costs compared to $42,000 for a similarly sized metal building. Imagine the energy savings that could be achieved if every community had a similarly efficient school.

According to the U.S. Green Building Council (USGBC), sustainable buildings save energy, water, and materials; preserve the local surroundings; assure the health of their occupants; and require little maintenance. USGBC created the Leadership in Energy and Environmental Design (LEED) as a rating system to certify and measure green building design. Shotcrete domes meet the USGBC definition for sustainable design and can also earn significant LEED credits. Some of the ways these credits are earned include the following: using recycled aggregates; savings on formwork, steel, and concrete; transportation savings by using local supplies; reduction of waste and formwork because the airform stays in place; labor and construction speed savings; and thermal mass and operations energy savings. Also, the life cycle of the buildings can be significantly longer. Typical metal buildings have a 50-year life span, but shotcrete domes' life spans can be several times that.

Other benefits include the fact that the controlled atmosphere in the dome allows for the living/working environment to be held to the strictest standards and, because of their shape and construction, domes can be a shelter for natural disasters such as tornados, hurricanes, and earthquakes.

The economic impact is likely the best advantage. New construction is done more efficiently with thinner structural sections using fewer materials. This affects the bottom line by using less time, labor, and materials. A recently constructed charter school in Phoenix, AZ, illustrates that point. The Robert L. Duffy High School has a finished cost of $119 per square foot. By contrast, the average cost of permanent charter school buildings in that area is $130 to $150 per square foot (Fig. 8).

Fig. 7: Beggs Event Center (gymnasium)


Fig. 8: Architectural rendering of Robert L. Duffy High School

Shotcrete dome structures have many economical and structural advantages. Domes use building materials sparingly, produce savings in heating and cooling costs, and their shape allows for an open structure with tremendous flexibility with a variety of uses that include public events centers, schools, auditoriums, storm shelters, and residential, industrial, and storage use. All of these things combine to demonstrate that shotcrete domes make a very green and sustainable building.

***Chris Zweifel**, PE, SE, is a member of ACI Committee 506, Shotcreting, and the Chair of Joint ACI-ACSE Committee 334, Concrete Shell Design and Construction. He received his master's degree from Brigham Young University and owns ZZ Consulting, a small engineering firm that specializes in shotcrete domes.*

AMERICAN SHOTCRETE ASSOCIATION Member Apparel Order Form

ASA Windbreaker

Forest green, microfiber, pullover with white embroidered logo.
Sizes: L, XL, XXL
Price: ~~$40.00 USD~~ $24.00 USD

Baseball Cap

Khaki and army green colored baseball caps. Features a black and green embrodied ASA logo. One size fits most.
Price: $12.00 USD

ASA Golf Shirt

Forest green polynosic golf shirt with white embroidered logo.
Sizes: M, L, XL, XXL
Price: ~~$30.00 USD~~ $18.00 USD

ASA Decal Sticker

6 x 4 in.
$3.00 USD each

ASA Reflective Hard Hat Stickers

2-1/2 x 1-3/4 in.
$50.00 USD per bundle

Member Information

First Name:	Last Name:	
Company:		
Address: (As it should appear on label)		
Phone:	Fax:	E-mail:

Order Information

	Quantity	Size	Cost
Windbreaker (Size: L, XL, XXL)	___ @ $24.00 USD		$
Golf Shirt (Size: M, L, XL, XXL)	___ @ $18.00 USD		$
Baseball Cap	___ @ $12.00 USD		$
Decal Sticker	___ @ $3.00 USD		$
Reflective Hard Hat Stickers	❑ 10 ($10) ❑ 25 ($25) ❑ 50 ($50) ❑ 100 ($100) ❑ 150 ($150) ❑ 200 ($200) ❑ 250 ($250)		
		Subtotal	$
		Free Shipping if within U.S.	$
		Total	$

*IMPORTANT NOTE—If shipment is for outside of the United States, you must contact ASA at 248.848.3780 for shipping options and price.

Payment Information

Payment Type	❑ Visa ❑ MasterCard ❑ Check
Credit Card Number	
Expiration	
Signature	

If you are paying via check, please mail form with payment to:

American Shotcrete Association
38800 Country Club Dr
Farmington Hills, MI 48331

If you are paying via credit card, please FAX form to 248.848.3740.

Thank You For Your Order!

Is Your Company Policy on Equipment Wear Putting You at Risk?

By Oscar Duckworth

Warning! Use of this component will cause explosion, possible bodily injury, or property damage.

Would anyone use a component displaying this warning? Probably not. Any part of a wet-mix placement system that is in contact with the shotcrete mixture, however, is subject to wear and will eventually fail, creating a serious safety hazard.

Wet-mix placement system components are similar to our truck tires: when new, tires can be considered safe to carry their rated capacity. Over time, wear or abuse will reduce overall safety to the point that failure is imminent. Wet-mix placement system components, like truck tires, must be regularly inspected for wear and cannot be used to their failure point without creating a safety hazard.

The use of high-pressure shotcrete equipment can create an enormous risk should a placement system component failure occur. All wet-mix placement system components must be capable of safely carrying the maximum available outlet pressure for the pump.

Can Wear and Failure Be Predicted?

A wet-mix placement system component has reached the end of its service life when there is no longer sufficient material to safely carry the component's original working pressure rating. Internal thinning due to wear is the most common cause of wet-mix placement system failures. Concrete is naturally abrasive, and augers and paddles, which rotate within the concrete mixture, quickly wear from contact. Shotcrete placement requires high-output pressures to convey the low slump mixture through the placement system. Increasing placement system length or vertical lift will further elevate line pressures. As internal pressure is raised, abrasive materials are pressed harder against the interior of placement system components. This creates much higher wear rates than would be common for ordinary concrete pumping operations. Increasing line pressure will always increase wear rates. Shotcrete mixture variations may also increase wear rates. All wet-mix placement system components will wear at different rates due to:

- The amount of exposure to abrasion;
- The material the placement system component is made of;
- The amount of pressure to which the component is subjected; and/or
- Mixture proportion variables.

Because expected service life cannot be predicted, how can a wet-mix shotcrete crew determine when a placement system component has reached the end of its safe service life? A worn placement system component can easily be identified as an oversized interior diameter (ID) by inspection with a measuring device. Validation by measurement assures that a component can be removed from service when it is no longer safe.

Your company policy should clearly define the maximum usable interior diameter for all placement system components and discourage the use of any component that is no longer safe.

Elbows, reducers, and sweeps near the pump possess the greatest burst hazard due to high line pressures, but any placement system failure is a potential risk. If a wet-mix placement system becomes plugged near the nozzle, the entire system will quickly reach the maximum available pump pressure and create a serious safety hazard should a failure occur.

Figure 1 shows two identical 2 in. (50 mm) raised-end reducers: Reducer A is in new condition

Fig. 1: Reducer A (left) is in new condition. Interior diameter is 2 in. (50 mm). Reducer B (right) displays obvious wear. Interior diameter is 2-1/4 in. (56 mm)

Fig. 2: Reducer A (left) displays acceptable wall diameter. Reducer B (right), with a wall thickness of 0.06 in. (1.5 mm), illustrates a burst hazard

Fig. 3: Elbow A (left) displays a 4 in. (101 mm) interior diameter. Elbow B (right) measures 4-5/16 in. (109 mm)

and Reducer B is in daily service. The inside diameter of Reducer A is 2 in. (50 mm). Reducer B has thinned to an internal diameter of nearly 2-1/4 in. (57 mm) or about 10% oversize. Reducer B was then cut open and the material thickness was measured at the component's thinnest area (Fig. 2). Wear had reduced the wall thickness to only 0.06 in. (1.5 mm)—dangerously thin.

Two 4 in. (102 mm) elbows were measured for wear (Fig. 3). Elbow A was in new condition and the interior diameter measured 4 in. (102 mm).

Elbow B was well worn and the interior diameter measured 4-1/4 in. (108 mm). Elbow B was then cut open, revealing a wall thickness of less than 1/8 in. (3 mm).

The worn components—both the elbow and the reducer—are vivid examples of how minor differences in oversized IDs can create major differences in safe wall thickness.

Establishing Safe Wear Limits

National pipe-industry standards define minimum wall thickness requirements for various working pressure ratings. Wet-mix shotcrete placement system components must carry a working pressure rating of greater than 1250 psi (8.6 MPa) to minimize burst hazard. To achieve this rating, a minimum wall thickness of 1/8 in. (3 mm) or more is required for pipe sizes common to wet-mix shotcrete placement (Fig. 4). Most raised-end placement system components are available to safely carry these pressures in "as new" condition.

In an attempt to establish safe wear limits for "in use" components, a total of 24 wet-mix placement system components were tested (Fig. 5). Each had been removed from service after measurement revealed that wear may have increased the interior diameters beyond safe limits. Each component's interior diameter was measured and recorded, then cut open at its thinnest area (Fig. 6) to validate the wall thickness.

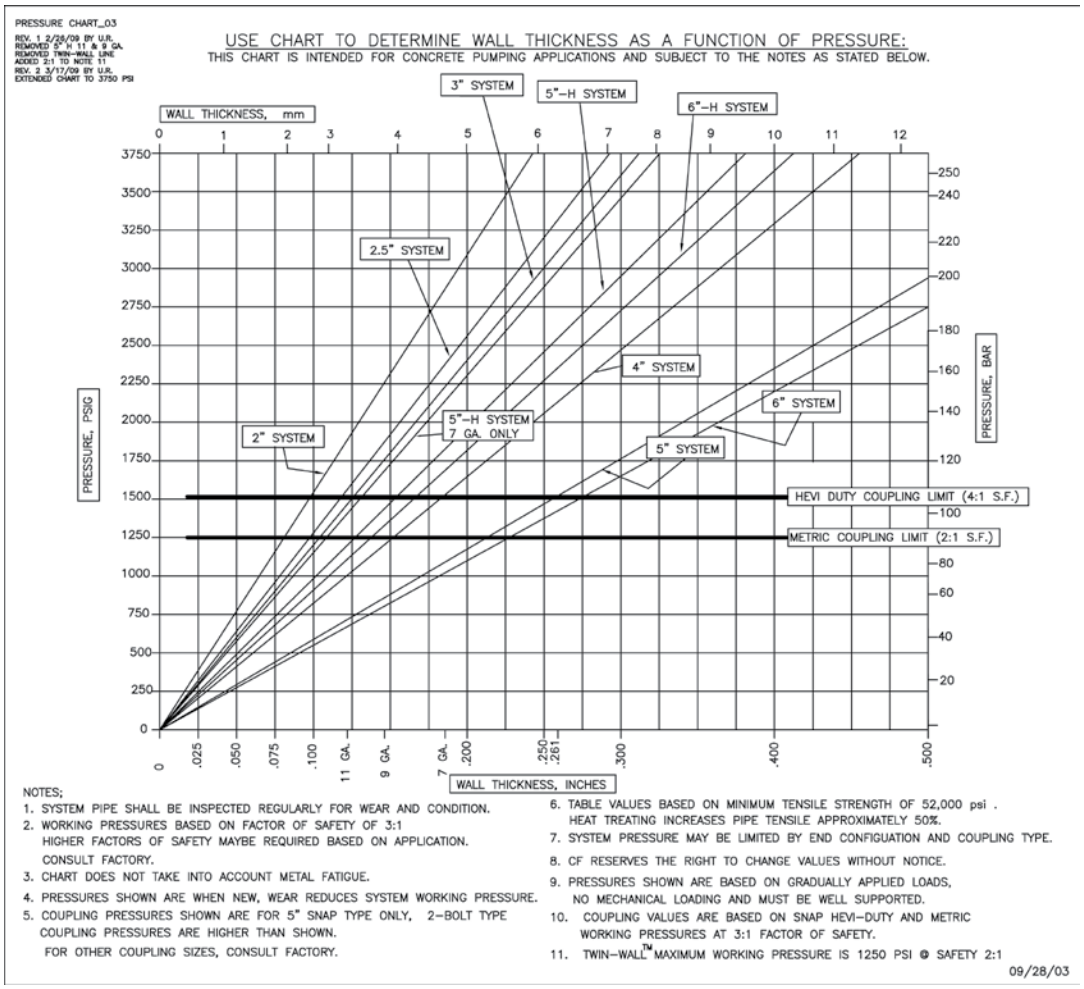


Fig. 4: Wall thickness chart, courtesy of John Schantz, Chief Engineer, Construction Forms, Inc.

Test Results

- The wall thickness fell below 1/8 in. (3 mm) on all 2 in. (50 mm) hose couplers and sweeps with only 1/8 to 5/32 in. (3 to 5 mm) oversized ID.
- The 2 in. (50 mm) reducers (small end) showed a 3/16 in. (5 mm) oversized ID reduced wall thickness below 1/8 in. (3 mm) on average.
- The 3 in. (76 mm) reducers (small end) maintained a 1/8 in. (3 mm) wall thickness only below 3/16 to 1/4 in. (4.8 to 6.3 mm) oversized ID on average.
- The 4 in. (101 mm) reducers (small end) wall thickness fell below 1/8 in. (3 mm) on average at a 1/4 to 5/16 in. (6.3 to 8 mm) oversized ID.

Discussion

- Due to unique component shapes, conventional machinist style calipers were ineffective to measure the actual wall thickness (prior to saw cutting).
- On average, as the interior diameter is increased 5 to 10%, the wall thickness may decrease by 50 to 90%.
- Saw cuts revealed insufficient wall thickness on every component tested.
- No component tested could be considered safe to carry the stated working pressure rating.

Summary

A responsible company would not send a loaded truck out of the yard on bald tires, which presents an obvious, visible safety hazard. Wet-mix placement component safety risks are not obvious. Inspection by measurement is the only method available to assure safe, "in use" components. A company policy that establishes wear limits for all pressurized components should be an important part of everyone's safety program. Rigorous inspection by measurement is mandatory. Discard components before wear creates a safety risk. These are essential steps for safe wet-mix shotcrete placement.

Conclusion

- Never put anyone at risk from wear;
- Never allow a wet-mix placement system component to be used to its failure point;
- Establish wear limits for all placement-system components;
- Inspect and verify placement components with a measuring device before use; and
- Discard any component that may not safely carry its original maximum working pressure rating.

Fig. 5: Placement system components prior to saw cutting

Fig. 6: 2 in. (50 mm) hose couplings create a unique safety risk. Thinnest area of coupler is hidden within collar (pointer), making external wall thickness validation impossible. Saw cutting revealed insufficient wall thickness for any 2 in. (50 mm) coupler, which measured 1/8 to 5/32 in. (3 to 4 mm) oversized ID. Note: Raised-end component shapes created challenges using conventional machinist calipers to determine wall thickness

*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.*

Shotcrete is Concrete

So Why Choose Shotcrete?

Speed

Versatility

Cost Savings

The shotcrete process offers many advantages over other methods of placing concrete—from construction speed and labor and formwork savings, to the ability to construct complex shapes without extensive structural formwork and complex application by hand.

With shrinking project margins and growing quality demands, shotcrete is an attractive and structurally-equivalent option for new construction and rehabilitation. Find out why a growing number of specifiers, designers, and contractors choose shotcrete.

AMERICAN SHOTCRETE ASSOCIATION

Visit www.Shotcrete.org

Education and Certification
Technical Questions and Answers
Demonstrations
Buyers Guide

New ASA Member Benefit: CJSI Industry Trends Report

In 2009, ASA became a full partner in the Concrete industry's Joint Sustainability Initiative (CJSI). In an effort to keep ASA members up to date on the latest information regarding sustainability issues and their potential impact on the concrete/shotcrete industry, ASA will include a link in the member version of its e-newsletter to the latest CJSI Industry Trends report.

If you are an ASA member but do not receive the ASA e-newsletter, it is because we do not have your e-mail address. Please contact ASA staff at (248) 848-3780 to begin receiving the member version of the e-newsletter.

U.S. Green Building Market Predicted to Grow to $173 Billion by 2015

EL Insights reports that the U.S. green building market value will balloon from $71.1 billion to $173 billion by 2015. Commercial green building is expected to grow by 18.1% annually during the same time period, from $35.6 billion to $81.8 billion. In this case, green building is defined as building with resource use and employee productivity in mind.

The projected growth is attributed to a growing recognition of green building's potential cost savings as well as incentives from the government. Green renovation will also comprise a significant portion of future green building, thanks to government projects like the Recovery through Retrofit initiative, which offers $80 billion in energy and environmental retrofits for federal buildings.

GSA Plans to Go "Net-Zero" in New Construction

New Executive Order (EO) 13514 requires that federal agencies comply with a number of green building stipulations, including that 95% of all applicable contracts meet sustainability requirements. While the American Recovery and Reinvestment Act (ARRA) invested over $25 billion in green building projects, the executive order will have a more long-lasting impact on the industry. The General Services Administration (GSA) is investigating a plan to eliminate its impact on the environment altogether. According to **GreenBiz.com/blog**, GSA Administrator Martha Johnson has proposed the government go "net-zero" in all of its new structures.

Citing the President's Executive Order, Johnson has highlighted the agency's mission to assist other federal agencies to make greater strides in sustainability, excel at greening initiatives, and increase federal building performance. Johnson proposed that the federal government move to a zero environmental footprint, and stressed that GSA is setting its sights on "eliminating the impact of the federal government on our natural environment."

Additionally, under Section 13 of the order, the GSA has been asked to provide recommendations regarding "using Federal Government purchasing preferences or other incentives for products manufactured using processes that minimize greenhouse gas emissions."

It would appear that the GSA is preparing to overhaul the way the federal government purchases services and supplies.

Changing Industry—96% of Americans Surveyed Say Sustainability is Important in Construction

According to a new America THINKS survey from HNTB Corporation, 64% of Americans—up from 58% last November—are willing to pay more today for national infrastructure that is energy-efficient and less wasteful to save money and resources in the future. Additionally, 96% of Americans agree that all new construction should take sustainability into consideration.

"Whether it's on transportation facilities, such as roads and bridges, or in buildings, we're finding that sustainability has become a requirement for many of our clients because their stakeholders are expecting sustainable features," said David Wenzel, AICP, LEED AP, HNTB Sustainability Services Chair. "Particularly with large, complex projects, clients are grappling with understanding this issue and potential responses as they foresee new local, state, and federal mandates on the horizon."

New Edition Available of ASTM International Standards on Sustainability in Building

A new edition of *ASTM International Standards on Sustainability in Building*, a compilation that includes 150 ASTM standards that address sustainability or aspects of sustainability relative to building, including sustainable

design, construction, and operation of buildings, is now available on CD-ROM.

The collection is a valuable resource that helps answer the growing global demand for sustainable building, and includes all of the ASTM International standards referenced by the Federal Green Construction Guide for Specifiers as of January 2010; International Green Construction Code (IGCC) as of the Public Version draft March 2010; and Green Globes green building rating program as of March 2010.

For purchasing information, please visit **www.astm.org**.

Robot Would Eat Rubble, Excrete Bricks

According to *Inhabit* magazine, Designers Youngwoo Park, Hoyoung Lee, and Miyeon Kim are proposing that their "Return Brick" recycling robot could help keep construction materials out of landfills by rolling around construction or demolition sites and gobbling up fragments of rubble and concrete. The "Return Brick" robot could then compress the splinters of construction waste into ready-to-use bricks with Lego®-style interlocking pegs, reducing the need for mortar.

Eighty-nine percent of construction waste is brick and concrete, so there is a large amount of material that could be recycled if only it were properly collected. Return Brick is a small robot that rolls around trolling for rubble, sucking up small pieces of concrete and brick. After it has enough material, the crusher begins to break the waste down into even smaller bits, and then water or a hardening agent is sprayed onto the material. Next, a compressor forms the powdered material into a solid brick and spits it out the side.

The newly formed bricks look like Lego blocks and stack the same way, overlapping and connecting with the pegs and the holes. In theory, the newly formed brick provides similar structural stability with less material.

Green Concrete in the Steel City

Engineers, architects, contractors, educators, manufacturers, and material representatives from all over the world will assemble in Pittsburgh, PA at the ACI Fall 2010 Convention (October 24-28, 2010, at the Westin Convention Center Hotel and David L. Lawrence Convention Center) to collaborate on concrete industry codes, specifications, and standards. Held at the world's first green convention center, "Green Concrete in the Steel City" is intended to expand attendees' knowledge of concrete and sustainability through the 300+ committee meetings, 30+ technical sessions, and forums, tours, and networking events offered.

ACI Concrete Sustainability Forum III, the third in a series of forums addressing the topic of sustainability in the concrete industry, will precede the convention on Saturday, October 23. This, combined with the several sessions approved for continuing education credit by the U.S. Green Building Council (USGBC) and American Institute of Architects (AIA), will provide attendees with valuable insight into sustainability and its effect on the concrete industry.

Mark J. Leahy, General Manager at the David L. Lawrence Convention Center, will lead attendees on a walking tour of the center, explaining its construction and maintenance during the Contractors' Day Tour on Tuesday, October 26. In addition, Contractors' Day will feature the session, "I'm Bidding a LEED Project. Now What?," which will provide an understanding of green construction opportunities and concrete myths.

For more information on the ACI Fall 2010 Convention, call (248) 848-3795 or visit **www.aciconvention.org**.

A *Shotcrete* feature:

SAFETY SHOOTER

Tools

By Cathy Burkert

Tools are such a common part of our lives that it is difficult to remember that they pose many safety hazards. All tools are manufactured with safety in mind. Tragically, a serious accident often occurs before steps are taken to identify and avoid or eliminate tool-related hazards. Workers should be trained in the proper use of all tools. They must learn to recognize the hazards associated with different types of tools and the safety precautions necessary to prevent those hazards.

Five basic safety rules can help prevent hazards associated with the use of hand and power tools:

1. Keep all tools in good condition with regular maintenance programs;
2. Use the right tool for the job;
3. Examine each tool for damage before use;
4. Operate according to the manufacturer's instructions;
5. Provide and use the right protective equipment; and
6. Communication. Have toolbox talks with employees.

Some common citations given by the Occupational Safety and Health Administration (OSHA) for violations relating to hand and power tools include:

- No guards on the grinder. Common injuries occur while grinding welds and the grinder slips, hitting employees.
- The grinder wheel is not rated for the speed of the grinder. Grinding wheels are rated for a certain speed; and using a faster grinding speed may cause the wheel to explode, which is also true of abrasive blades used to cut concrete.
- No protection for rotating parts. All tools must guard rotating shafts and parts to prevent employee's body parts and clothing from getting caught in them. Most tools come with guards and replacement guards can be obtained from the manufacturer.
- Electric cords frayed or without ground. Ground fault interrupt (GFI) outlets should always be used.

For more detailed information on job-site safety, refer to OSHA at **www.osha.gov**.

Pneumatic tools are powered by compressed air and include chippers, drills, hammers, and sanders. There are several potential dangers associated with the use of pneumatic tools. The most serious is the danger of getting struck by one of the tool's attachments or by some kind of fastener the worker is using with the tool. Eye, face, and ear protection

Use of whip checks with pneumatic tools at each connection point

Do not use electrical tools with frayed cords. This can cause electric shock, resulting in injury and/or death

are required when working with pneumatic tools. Working with tools such as jackhammers and pavement breakers pose the hazards of noise and flying debris. Workers must ensure that pneumatic tools are fastened securely to air hoses to prevent them from becoming disconnected. The use of whip checks, along with a short wire or positive locking device that attaches the air hose to the tool, will serve as an added safeguard. A safety excess flow valve must be installed on air hoses over 1/2 in. (12.7 mm) in diameter to shut off the air supply in case the hose breaks. Compressed air shall not be used to blow down or clean off workers. This could result in an air bubble being forced underneath the skin, with severe medical implications following this event.

Hydraulic power tools operate on fluid that is under pressure to make the tool function properly. The fluid must be fire-resistant and retain its operating characteristics at the most extreme temperatures to which it will be exposed. When using hydraulic power tools, never exceed the manufacturer's recommended safe operating pressure for hoses, valves, pipes, filters, and any other fittings.

In addition, employees who use such tools should use the appropriate personal protective equipment (PPE) to guard against some of the following tool-related hazards: falling or flying objects, flying chips and particles, splashing liquids, harmful dusts, toxic fumes, mists, vapors, or gases. Employers and employees have a responsibility to work together to establish safe work procedures. If a hazardous situation is encountered, it should be brought to the immediate attention of the appropriate individual.

Cathy Burkert *received her bachelor's degree in business management and started working at American Concrete Restorations, a Chicago-based shotcrete contractor. She joined the laborers apprenticeship program to learn the intricate details of the trade. After 2 years in the program, she began running her own shotcrete crews and shortly after earned the title of Field Office Coordinator. In March 2009, Burkert became the first female American Concrete Institute (ACI) certified nozzleman for wet-mix process, vertical, and overhead. Burkert has been involved with two ASA infrastructure award-winning projects: in 2008, the Abraham Lincoln Memorial Bridge and in 2009, the Dan Ryan Expressway.*

New ASA Member Benefit—CJSI Industry Trends Report

In 2009, ASA became a full partner in the Concrete industry's Joint Sustainability Initiative (CJSI). In an effort to keep ASA members up to date on the latest information regarding sustainability issues and their potential impact on the concrete/shotcrete industry, ASA will include a link in the member version of its e-newsletter to the latest CJSI Industry Trends report.

If you are an ASA member, but do not receive the ASA e-newsletter, it is because we do not have your e-mail address. Please contact ASA staff at (248) 848-3780 to begin receiving the member version of the e-newsletter, which now includes both the sustainability report and active links to government projects related to shotcrete that are currently open for bid.

ASA Fall 2010 Committee Meetings in Pittsburgh October 23 and 25

The ASA Fall 2010 Committee Meetings in Pittsburgh, PA, will be held at the Westin Convention Center Hotel on October 23 and 25, 2010.

The following committees have scheduled working meetings: the ASA Executive Committee, the Publications Committee, the Pool & Recreational Committee, the Education Committee, the Safety Committee, the Sustainability Committee, the Marketing & Membership Committee, and the ASA Board of Direction.

ASA committee meetings offer participants the opportunity to network with colleagues, provide input on shotcrete materials and publications, and become a part of ASA's overall mission.

These meetings are held in conjunction with the ACI Fall 2010 Convention but do not require preregistration and are open and free to anyone who has an interest in the shotcrete process.

Scheduled times for all meetings can be found at: **www.shotcrete.org/ASAcalendar.htm**.

Visit the ASA Booth at the 2010 International Pool | Spa | Patio Expo

ASA will again have a manned exhibit booth (#327) at the 2010 International Pool | Spa | Patio Expo held at the Mandalay Bay Convention Center in Las Vegas, NV, November 3-5, 2010.

This show continues to be an excellent opportunity for ASA to promote the advantages of shotcrete in the pool industry. The show also provides ASA with an opportunity to reach out to the existing shotcrete/gunite pool contractors with education and quality improvement information.

Free registration is also available to *Shotcrete* magazine readers by using Code 92 when registering for the show.

INTERNATIONAL POOL | SPA | PATIO EXPO
THE BACKYARD EXPERIENCE
hanley wood SPONSORED BY APSP

ASA to Provide Shotcrete Voice at 2011 World of Concrete

ASA will be working hard to promote the advantages of shotcrete to the concrete world at the 2011 World of Concrete (WOC) show in Las Vegas, NV, January 18-21, 2011. Plans include three main focuses.

First, ASA will have a manned 20 x 30 ft booth in the South Hall (#S10749). Responses to this new booth format at the 2010 show were very positive with a record amount of shotcrete information distributed and inquiries answered.

Second, ASA will be conducting a 90-minute seminar titled "Sustainability of Shotcrete Construction" on Thursday, January 20, 2011.

Third—and new this year—ASA will have an informational booth in the GreenSite pavilion in the Central Hall. The GreenSite pavilion focuses on sustainability and will provide an excellent opportunity for ASA to promote the exceptional sustainability advantages of the shotcrete process.

Register Free for World of Concrete 2011 and Help Support ASA Efforts to Grow Your Business

As a Sponsor of World of Concrete, ASA benefits financially from every complementary show registration made using ASA's A17 code. That financial assistance enables ASA to play a prominent role in promoting and growing the use of shotcrete. To take advantage of our free registration to World of Concrete and, at the same time, help ASA grow your potential market, visit **www.shotcrete.org** or **www.worldofconcrete.com** and register using Code A17. You may want to offer this free registration to your customers as well!

Shotcrete Message Delivered at 2010 International Bridge Conference

ASA once again had a manned booth at the 2010 International Bridge Conference (IBC) from which we were able to communicate and promote the use of shotcrete to the infrastructure world. The IBC is an exceptional opportunity for ASA to reach federal, state, and local agency specifying personnel.

In addition to a manned booth, ASA conducted a 90-minute workshop that provided an overview of the shotcrete process and how its versatility has led to its growing use for rehabilitation of bridges and other concrete structures.

REGISTER NOW!

The ASA Annual Membership Meeting and Sixth Annual Outstanding Shotcrete Project Awards Banquet is January 18, 2011.
Refer to pages 46-47 for more information.

AMERICAN SHOTCRETE ASSOCIATION

The ASA Annual Membership Meeting and

- *Architectural*
- *Infrastructure*
- *International Projects*
- *Pool & Recreational*
- *Rehabilitation & Repair*
- *Underground*

Sixth Annual Outstanding Project Awards Banquet

Monte Carlo Resort & Casino
Grand Ballroom, 2nd Floor • Las Vegas, NV
Tuesday, January 18, 2011

6:00 – 7:30 p.m. Registration, networking, cocktails, and hors d'oeuvres
7:30 – 10:00 p.m. Plated dinner,
membership meeting, and awards ceremony







AMERICAN SHOTCRETE ASSOCIATION

The ASA Annual Membership Meeting and Sixth Annual Outstanding Project Awards Banquet

Registration Form

Join us in celebrating another year of membership success and in recognizing our project award recipients. Submit one form per attendee by December 28, 2010.
We look forward to seeing you in Las Vegas!

Banquet Information:

Location: Monte Carlo Resort & Casino
Grand Ballroom, Second Floor
Las Vegas, NV

Date: Tuesday, January 18, 2011
6:00 – 7:30 p.m. Registration, networking, cocktails, and hors d'oeuvres
7:30 – 10:00 p.m. Plated dinner, the membership meeting, and awards ceremony

Attendee Information:

❑ Register me for the ASA Annual Membership Meeting and Sixth Annual Outstanding Project Awards Banquet $80.00

Name _____ Company _____

Address _____

City _____ State _____ Zip _____ Country _____

Phone _____ Fax _____

E-mail _____

On-site registration is required after December 28, 2010, and increases to $95.00 per attendee

Payment Information:

❑ Check (U.S. $) ❑ MasterCard ❑ Visa ❑ Cash

Credit Card # _____ Exp. Date _____

Name on Card _____

Signature _____

Become an ASA Banquet Sponsor:

❑ "Big Shooter"—$5000.00 ❑ Platinum—$2500.00

❑ Gold—$1000.00 ❑ Silver—$500.00

38800 Country Club Drive • Farmington Hills, MI 48331
Phone: (248) 848-3780 • Fax: (248) 848-3740 • E-mail: info@shotcrete.org • Web site: www.shotcrete.org

ASTM C1398-07 Withdrawn, No Current Replacement

ASTM C1398-07, "Standard Test Method for the Laboratory Determination of the Time of Setting of Hydraulic-Cement Mortars Containing Additives for Shotcrete by the Use of Gillmore Needles," has officially been withdrawn by ASTM International.

ASTM International's Withdrawn Rationale stated, "This is a laboratory test method that covers the determination of the time of setting of hydraulic-cement mortars containing additives for shotcrete for comparison with control mixes containing no additives or to compare the performance of shotcrete mixtures which contain additives that produce rapid setting or rapid stiffening of shotcrete.

Formerly, under the jurisdiction of Committee C09 on Concrete and Concrete Aggregates, this practice was withdrawn in June 2010 due to a lack of data for the development of a precision and bias statement. Efforts to generate the required data have not been successful."

The document is still available through ASTM International; future options for the document might include changing its status to a practice, which would not require a precision and bias statement.

Construction Industry Index Shows Hope for 2011 Recovery

Construction industry sentiment may finally be shifting into positive gear. The ENR Construction Industry Confidence Index for the second quarter indicated that the market may be near bottom, with 555 executives forecasting a return to growth in 2011. Two thousand firms in the U.S. were surveyed. The recession everyone hoped would end quickly has now lasted for 2 years, at first causing fear and concern that now has turned to grit and determination to hold on until better times. While no one sees the current market as ready to take off, major firms are beginning to think that the market may pull itself back from the brink in 2011.

Northeast, California Lead Way for Construction Recovery

The Northeast and California are expected to lead the way in recovery for building construction, according to the May Expansion Index from Reed Construction Data. The monthly expansion index is calculated from the Reed database of all construction projects in planning except single-family housing. The index is the ratio of the value of building projects expected to start in the next 12 months to the value of building projects actually started in the previous 12 months. The list of approximately 25,000 projects in the planning phase is edited to include only projects far enough along in planning to be able to start within 12 months. Projects explicitly on hold or stalled at a pre-bid phase are excluded. The relatively high values in the Northeast and California partly reflect the difficulty of obtaining permits. Permits are obtained earlier and often move very slowly to the bid stage.

FHA: About 150,000 U.S. Bridges "Deficient," Need Repairs

A hearing in July at a House Transportation Subcommittee meeting examined funding levels and bridge improvements, as well as the frequency and adequacy of inspections of the nation's highway bridges. The number of deficient bridges has declined by nearly 12% since 1998, but about 150,000 bridges—nearly one in four—still are considered deficient, according to the latest data from the Federal Highway Administration.

While the overall drop can be attributed to improvements in local and rural bridges, according to the Government Accountability Office, the number of deficient bridges in urban areas has increased 11% since 1998.

Terming bridges "structurally deficient" or "functionally obsolete" means they are substandard—not that they are in danger of collapsing or failing.

Industry Personnel

Internationally Renowned Concrete Expert Joins Western Technologies Inc.

Luke Snell

Western Technologies Inc. has announced that **Luke Snell, PE**, has joined the firm as Senior Construction Materials Engineer. Snell is the former Eminent Scholar of the Concrete Industry Management program in the Del E. Webb School of Construction at Arizona State University.

Working out of Western's Phoenix, AZ, office, Snell will be helping clients solve construction and concrete problems through his extensive experience and technical expertise. He has written over 200 articles on concrete, construction materials, and construction education, and has done considerable consulting throughout the U.S., Saudi Arabia, Mongolia, and Algeria.

He is an American Concrete Institute (ACI) Fellow and has received various awards. In 2007, he was named one of the Ten Most Influential People of the Year in the Concrete Industry by *Concrete Construction* and *Concrete Producer* magazines.

Snell is Chair of the ACI International Committee, is a member of several ACI Committees, and is also a past member of the Board of Direction. He has been instrumental in starting ACI chapters in Mongolia, Algeria, and Ethiopia and has worked with India and Saudi Arabia to start concrete certification programs.

American Concrete Institute Announces New Executive Vice President

The American Concrete Institute (ACI) has announced **Ronald G. Burg**, formerly Vice President at CTLGroup, as


Ronald G. Burg

Executive Vice President of ACI. Burg joins the 100-member ACI staff at its Farmington Hills, MI, headquarters.

"As an engineer who has worked my entire career in the concrete industry as a researcher, consultant, and practitioner, I can't think of a more exciting opportunity than to join the staff of the American Concrete Institute," said Burg. "Throughout my professional career, I have always been very impressed with the role ACI plays in the engineering and construction community as the prime source of knowledge, insight, and influence regarding concrete and its applications. As Executive Vice President, I look forward to working with ACI's staff, volunteer members, and the international concrete community as we continue the outstanding history of ACI in providing unparalleled knowledge and insight on all aspects of concrete technology."

Burg began his extensive concrete and construction career with Professional Services Industries, Inc. as a Staff Engineer, Manager of Construction Services, and eventually Quality Assurance Coordinator at the LaSalle Nuclear Power Plant.

During his career at CTLGroup, Burg specialized in litigation, arbitration, and claims support with respect to concrete technology issues, including compliance, construction methodology, strength assessment, durability issues, and in-place performance. Burg played an integral role in the advancement of high-strength concrete, high-performance concrete, and lightweight concrete, including managing multi-disciplinary research and consulting projects, designing and analyzing these specialty concretes, and developing technical seminars and training sessions.

An ACI member since 1984, Burg is a Fellow of ACI and has been active in the Institute. Previously, Burg served on ACI's Board of Direction and numerous committees, including ACI's Technical Activities Committee and ACI's Certification Programs Committee.

Burg is also a member of several other industry associations, including the Construction Institute of the American Society of Civil Engineers, the Precast/Prestressed Concrete Institute, and ASTM International.

A licensed professional engineer in Arizona, Illinois, Michigan, New York, and North Carolina, Burg received his BS in civil engineering from Iowa State University.

Former ACI Executive Vice President **William R. Tolley** retired from ACI at the end of June, after 35 years of service to the Institute.

Allentown Shotcrete Technology, Inc., Announces Mortar Equipment Manager for Latin America and the Caribbean


Alfonso Roa

Allentown Shotcrete Technology, Inc., an industry leader in the design and manufacture of wet- and dry-process shotcrete equipment, has appointed **Alfonso Roa** as its mortar equipment product manager for Latin America and the Caribbean.

Roa brings valuable experience to his new role, having managed the sales and marketing of mortar machines for Putzmeister Ibérica in Spain for the past 5 years. Allentown recently began offering the full line of mortar machines from Allentown, Putzmeister America, and Putzmeister Mortar Machines for the western hemisphere.

"Alfonso brings a wealth of experience in mortar machines to Allentown, "states Bob Harmon, Allentown Sales Manager. "We are pleased to provide our Latin American and Caribbean customers with such a qualified and knowledgeable team player."

NEW

The Evolution of Rock Support in One Old Mine in Mexico

By Raul Bracamontes

An old mine located in Queretaro State, about a 2-hour drive from Mexico City, now uses wet-mix shotcrete as an integral part of its ground control system. This mine has poor ground conditions. The original support method of masonry arches constructed by the Spaniards has evolved to the modern day with the use of robotically applied wet-mix shotcrete containing fibers and alkali-free accelerator.

This is one of the many older mines in Mexico that are still operating today. This mine was founded over 200 years ago, during the Spanish colonization (1780). The rock support has been one of the main issues since then. The Spaniards developed structural arches made with pieces of rock glued with limestone in small tunnels with cross sections 5 ft (1.5 m) high and 4 ft (1.2 m) wide and used pillars made with stone and steel rings to keep the pieces in place. The mine was abandoned during the War of Independence in 1810.

The records show that the mine was bought for an English company in the time of Porfirio Diaz (before the Mexican Revolution). They used steel arches and wood for underground support but they had problems with this system of support. They couldn't prevent the weathering of the rock and the resulting rock falls. Again, the mine was abandoned, this time during the Mexican Revolution of 1910.

Image courtesy of www.map-of-mexico.org

The mine was operated for some time on a very small scale by the locals. Much of the folklore tells stories of corrals for goats, chickens, and donkeys inside the mine. The mine was purchased by a Mexican company, Luismin, in 1992. In this new era, the miners used the same methods of initial support as the English—steel arches and wood. In 1996, the mine started using dry-mix shotcrete and welded wire mesh for rock support. They have learned that with the use of shotcrete with silica fume, they can seal the surface of the rock—preventing weathering—and keep the rock mass in place.

As in most mines, there were the typical problems in using dry-mix shotcrete: very high rebound, dust, and needing to shoot thin layers. In 2001, they changed to the wet-mix method, incorporating steel fibers and shooting with a mechanical boom, making it the first mine in Mexico to switch to wet-mix shotcrete and the only one with robotic application. Today, the rock support is even more important because they are working very close to the old mining developments and creating larger tunnel sections of 10 x 40 ft (3 x 12 m) in some areas. Right now, the mine is developing a rock support program that incorporates a 41 MPa (6000 psi) wet-mix shotcrete using high-range water-reducing admixtures, a low water-cement ratio (*w/c*) (0.40), alkali-free accelerators, and steel fibers over high-strength steel to form lightweight arches.

Raul Bracamontes *works for Adra Tecnologia en Servicios Sa de CV in Mexico. He is an Underground Construction Specialist and an ASA-Approved Shotcrete Educator.*

Shotcrete FAQs

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

Question: *It appears to me that it is typical for laboratory compressive strength results to be far lower than the compressive strength of field samples. Why is this, and are there ways to limit the field strength? A material with a laboratory compressive strength of 5000 psi (34.5 MPa) could have a field strength in excess of 9000 psi (62 MPa), which poses compatibility issues with the substrate material.*

Answer: It is not uncommon for laboratory trial batches of shotcrete to be significantly lower in strength than in field trials. This is due to the pneumatic placement and potential to reduce the water-cement ratio (*w/c*) in the case of the dry-mix process in the actual shotcrete process versus the typical trial batching in the laboratory. To attain similar results, the preliminary testing should be done with the shotcrete process so that you are comparing shotcrete placement to shotcrete placement. The foreman, pump operator, and nozzleman must understand the importance of maintaining similar conditions between the preconstruction trials and the production work. Most crews are motivated to produce the highest strength possible in the field and do not focus on moderating the strength to match the existing material. If the contractor and crew understand the goal and can produce the desired results under preconstruction mock-ups, then they should be able to produce a similar result in the field within reasonable tolerances.

Question: *Our shotcrete subcontractor has advised us to not install a bonding agent between the existing concrete and shotcrete placed over it, stating that the best bonding agent is the shotcrete itself. Is this true? Should we not install a bonding agent?*

Answer: Your shotcrete contractor is right. The bonding agent will cause many more problems than it will cure. Refer him to *ACI RAP Bulletin 12*, published this year (www.concrete.org/general/RAP-12.pdf). Much more important than a bonding agent is the surface preparation, which must have a rough profile to create as much surface as possible to which the shotcrete can bond. The natural process scrubs a bonding coat of neat cement into the old concrete surface, creating the perfect bond.

Question: *I work for a municipal Department of Public Works where my division provides environmental management services for construction projects. Shotcrete has been specified on a trenching project. One of our consultants tested the shotcrete from a reputable supplier of ready mix concrete, which turned out to contain asbestos. Is this possible? What is the likelihood to find asbestos in shotcrete? Will this be on the shotcrete composition that may require this screening sampling any time it is specified?*

Answer: It is highly unlikely that concrete or shotcrete from a commercial source would contain asbestos. Asbestos is not being used or recommended in any mixtures we are aware of in the past few decades. Many concrete and shotcrete mixtures now contain fibers of various compositions such as polypropylene, nylon, and cellulose (wood) fibers. If you are dealing with a very good commercial supplier of ready mix concrete and shotcrete, you should approach them about your concerns.

Question: *Our shotcrete contractor recently placed an exterior wall using a one-sided form. The formwork side of the wall was sandblasted to achieve a required finish. After the sandblasting, lines or shadowing on the surface of the wall were visible where the reinforcing bar inside the wall was present. What is the cause of this shadowing and what specifications would address this issue?*

Answer: Shadowing can result from many causes. The most common reason for shadowing is that the reinforcing bar was placed too close to the formwork and the nozzleman could not properly compact the shotcrete behind the reinforcing bar. Shadowing may indicate a slight or a major variation in the density of the shotcrete due to shotcrete placement around the reinforcing steel. ACI 506R-05, "Guide to Shotcrete," and ACI CCS-4(08), "Shotcrete for the Craftsman," discuss placement of shotcrete around reinforcing steel. We are not aware of any reference to this in any standard specification except that shotcrete should be reasonably uniform.

Question: *A pool subcontractor installed a shotcrete pool last week. After a recent rain, water was pouring into the pool from behind the shotcrete (that is, plumbing penetrations and the vertical walls). Is this a problem or will it be corrected with the plaster work?*

Answer: Water intrusion around plumbing and light fixture penetrations is not uncommon but should be resolved prior to plastering. Water "pouring" into the pool through the walls would indicate the possibility that the walls were not properly installed and should be investigated prior to plastering. A local testing laboratory that specializes in concrete and is knowledgeable in shotcrete should be engaged to determine the quality of the shotcrete in place.

Question: *What is the formula mixture for a shotcrete swimming pool?*

Answer: There is no particular "formula" for shotcrete swimming pools or any other structures. The mixture proportions are dependent on the structural requirements for the specific project, the quality of the materials available, the process being used (wet- or dry-mix shotcrete), and other factors. For guidance in this area, you should read ACI 506R-05, "Guide to Shotcrete." In this publication, there is guidance on proportions for various shotcrete mixtures.

Shotcrete Calendar

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

Executive Committee—CLOSED
7:00 a.m.-9:00 a.m.
Room: W-WASHINGTON

Sustainability Committee
9:00 a.m.-10:00 a.m.
Room: W-WASHINGTON

Pool & Recreational Shotcrete Committee
10:00 a.m.-11:00 a.m.
Room: W-WASHINGTON

Education Committee
11:00 a.m.-12:00 p.m.
Room: W-WASHINGTON

Safety Committee
12:00 p.m.-1:00 p.m.
Room: W-WASHINGTON

Publications Committee
1:00 p.m.-2:00 p.m.
Room: W-WASHINGTON

Marketing & Membership Committee
2:00 p.m.-4:00 p.m.
Room: W-WASHINGTON

Board of Direction
4:00 p.m.-6:00 p.m.
Room: W-WASHINGTON

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 24-26, 2010
ACI Committee 506 Fall Meetings
The Westin Convention Center
Pittsburgh, PA

OCTOBER 24
506-A, Shotcreting-Evaluation
9:00 a.m.-11:00 a.m.
Room: C-311
506-G, Shotcreting-Qualifications for Projects
11:00 a.m.-1:00 p.m.
Room: C-402

OCTOBER 25
506-E, Shotcreting-Specifications
8:30 a.m.-10:30 a.m.
Room: W-EXECUTIVE BOARDROOM
506-C, Shotcreting-Guide
10:30 a.m.-12:30 p.m.
Room: W-EXECUTIVE BOARDROOM
506-F, Shotcreting-Underground
3:00 p.m.-4:00 p.m.
Room: W-CRAWFORD WEST

OCTOBER 26
506, Shotcreting
8:30 a.m.-11:30 a.m.
Room: C-318

OCTOBER 25, 2010
ACI C660, Shotcrete Nozzleman Certification Fall Committee Meeting
The Westin Convention Center
Pittsburgh, PA
1:00 p.m.-3:00 p.m.
Room: C-311

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

Underground Committee
5:00 p.m.-7:00 p.m.
Room: W-FAYETTE

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
Register for FREE with ASA Source Code 92
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**

Shotcrete Calendar

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

JANUARY 17-21, 2011
World of Concrete 2011
Register for FREE with ASA Source Code A17
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
Monte Carlo Resort & Casino
Grand Ballroom, 2nd Floor
Las Vegas, NV

JANUARY 20, 2011
World of Concrete 2011 Seminar: Shotcrete Construction and Sustainability Benefits
1:30 p.m.-3:00 p.m.
Las Vegas Convention Center
Las Vegas, NV
Web site: **www.worldofconcrete.com**

MARCH 15-18, 2011
ICRI 2011 Spring Convention
The Westin Galleria, Houston
Houston, TX
Web site: **www.icri.org**

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

JUNE 5-8, 2011
2011 International Bridge Conference
VISIT ASA AT BOOTH #607
David L. Lawrence Convention Center
Pittburgh, PA
Web site: **www.eswp.com/bridge/**

JUNE 12-15, 2011
ASTM International Committee C09, Concrete and Concrete Aggregates
Marriott Anaheim, Anaheim, CA
Web site: **www.astm.org**

SEPTEMBER 12-15, 2011
Sixth International Symposium on Sprayed Concrete
Tromsø, Norway
Web site: **www.sprayedconcrete.no**

OCTOBER 12-14, 2011
ICRI 2011 Fall Convention
The Westin Cincinnati
Cincinnati, OH
Web site: **www.icri.org**

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

DECEMBER 4-7, 2011
ASTM International Committee C09, Concrete and Concrete Aggregates
Tampa Marriott Waterside
Tampa, FL
Web site: **www.astm.org**

Letter to the Editor

This letter to the editor was written by William (Bill) T. Drakeley Jr., in response to the Pool & Recreational Shotcrete Corner article in the Summer 2010 issue of Shotcrete *(V. 12, No. 3), "Waterproofing—Is it Necessary in Pool Construction?" by Jerry B. Werner.*

As a practitioner and student of the shotcrete process, I am always looking for learning tools to help in our concrete endeavors. *Shotcrete* magazine is one of these tools. I would like to state for the record that all of us here at Drakeley Industries enjoyed the article written by Jerry B. Werner regarding pool waterproofing. As an industry voice from the pool sector, it is refreshing to read information by others that promotes the use of minimum-strength concrete in water vessels. This constant message will help raise the bar in overall pool construction. I would like to further this discussion on pool concrete and its capacity to hold water. First and foremost, let us take a look at some definitions of terminology used in the concrete industry and highlighted by Webster's Dictionary, the American Concrete Institute (ACI), and ASTM International (ASTM):

Webster's Dictionary

impervious—adj—incapable of being penetrated, as by water

impermeable—adj—not permitting passage, especially to fluids; impervious

watertight—adj—so tight as not to let water pass through; completely separate; such that no flaw or weakness in it

waterproof—adj—proof against water; vt — to make impervious to water

damp—n—humidity; adj—moist

ACI Concrete Terminology

damp—either partial saturation or moderate covering of moisture; implies less wetness than that connoted by "wet" and slightly wetter than that connoted by "moist."

dampproofing—treatment of concrete or mortar to retard the passage or absorption of water, or water vapor, either by application of a suitable coating to exposed surfaces, or by use of a suitable admixture or treated cement, or by use of a pre-formed film such as polyethylene sheets placed on grade before placing a slab.

permeability to water, coefficient of—the rate of discharge of water under laminar flow conditions through a unit cross-sectional area of a porous medium under a unit hydraulic gradient and standard temperature conditions, usually 20°C.

porosity—the ratio, usually expressed as a percentage of the volume of voids in a material to the total volume of the material, including the voids.

waterproof—impervious to water in either liquid or vapor state (see also *dampproofing*). (*Note: Because nothing can be completely "impervious" to water under infinite pressure over infinite time, this term should not be used.*)

waterproofing—see *dampproofing* (preferred term).

water-repellent—property of a surface that resists wetting (by matter in either liquid or vapor state) but permits passage of water when hydrostatic pressure occurs (see also *watertight*).

watertight—impermeable to water except when under hydrostatic pressure sufficient to produce structural discontinuity by rupture.

ASTM C1543-02, Appendix X1.1.1

permeability—permeability is the characteristic that describes the ease with which a fluid moves through concrete [Young, J. F., SP-108, pp. 1-18].

These terms and their definitions give us a better understanding of what to consider when constructing a water-retaining vessel (such as a pool). If we take a close look at the term "waterproof" as defined by ACI, it states that basically nothing is waterproof (or technically, dampproof) under infinite pressure over infinite time. With this said, can our concrete that is placed through the shotcrete process be watertight? This is where I disagree with Mr. Werner's conclusions. The answer, I believe, is a resounding "yes"—pool concrete can and should be watertight. We are in the business of making vessels that require this condition. Clearly, as noted by Mr. Werner in ACI 318R-05, Table 4.2.2, "Requirements for Special Exposure," concrete strengths that protect reinforcement and have a low permeability start at 4000 psi (27.6 MPa) and increase based on the

exposure. Water migration, low density, and high rates of porosity are an indication of a bad installation and are not to be mistakenly construed as normal or acceptable. Now, is 4000 psi (27.6 MPa) the number we should be shooting for? (No pun intended.) As a shotcrete examiner who administers the nozzleman testing procedures all across the country, one of the key facts that I overemphasize—especially to pool contractors—is that 4000 psi (27.6 MPa) is a bare minimum for watertight concrete. ACI CP-60, "Craftsmen Workbook," Sections 3.2.1 and 3.2.2, (Dry- and Wet-Process) clearly states that typical ranges for dry-process concrete are 4500 to 9000 psi (31 to 62 MPa) and typical ranges for wet-process concrete are 4000 to 8000 psi (27.6 to 55 MPa). From first-hand experience (6000 psi [41.4 MPa] pool concrete after 7-day wet cure), getting these strengths in a pool vessel will certainly yield favorable and, dare I say, watertight, conditions under any hydrostatic pressures less than structural discontinuity by rupture.

Now, even if you have these high strengths, can some concrete not be watertight? The answer is again a resounding "yes." Nozzleman techniques and applications are crucial in pool construction to ensure that the structural concrete is placed in a manner that not only will yield high strengths but also be monolithic in nature and watertight. ASA's Nozzleman Certification Program is designed for this type of application. Watertight pool vessels and proper nozzle techniques are nothing new. Our pool company currently services a half dozen pool structures built in the 1960s on a weekly basis that have no plaster, paints, or sealants to hold the water. The structures have bare concrete applied through the dry process that happened to be installed correctly. In today's pool arena, a lack of density or degree of permeability results in leakage, indicating porosity and is usually called efflorescence. These material deposits are a direct result of voids in the substrate that lack proper in-place consolidation. Again, proper installations using correct velocities in material compaction will eliminate a lot of these problems.

In general, does the pool industry need waterproofing or dampproofing? This is also a definite yes. As Mr. Werner can attest to, there are way too many pool construction outfits out there that do work that requires his company's waterproofing services. My point is that this is not—nor should be—an acceptable norm in our water-shaping industry. Raising the bar in the pool industry's case means we as builders need to pay attention to existing standards and techniques and not bandage problems that all too often are now viewed as acceptable. The water or dampproofing industry for the pool sector exists primarily because of poor installations and not because the shotcrete process does not produce a watertight product.

A dry shotcrete pool completed in the late 1960s with no proofing, sealants, or plaster (new tile and coping but original pool structure and surface)

William (Bill) T. Drakeley Jr. *is a third-generation watershaper and President of Drakeley Industries and Drakeley Swimming Pool Company in Connecticut. He is a Genesis 3 Platinum Member, an American Concrete Institute Certified Nozzleman, an ASA-Approved Shotcrete Educator, an ACI-Approved Shotcrete Examiner, his company is a corporate member of ASA, and he is an ASA board member. Drakeley is an instructor for the Genesis 3 Construction School, with a focus on the shotcrete process. He has been a contributing writer for* Shotcrete *magazine's "Pool & Recreational Shotcrete Corner" and has had projects featured in* Luxury Pools *magazine,* Better Homes & Gardens, *and* Aqua *magazine. Drakeley Pools was the recipient of ASA's "Outstanding Pool & Spa Project" for 2005 through 2008.*

Job Communication On Site

By Marcus H. von der Hofen

There are a lot of us that have been doing this stuff for what seems like forever. Regardless of our experience, if we do not communicate, we continue to hit the same road blocks. Simple exercises in on-the-job communication can help make your job safer and more productive.

1. Basic Procedure

Get together with the parties involved and go over your plan. You know your trade hands-down, but do you understand the other guys'? Define your requirements for the job and let the others (trades) know what you will be doing. Many times, frustrations can be avoided simply by talking before you get started. Equipment setup, hose routing, and rebound removal are a few of the things we do almost without thinking, but it's also the most frustrating when you have to do it twice. A simple walk-through helps avoid conflicts between trades and can make your life easier.

2. Safety

We are out there with many trades and they can't read your mind. They might not know they are in a bad spot and the same goes for you. We go through hours of safety training, pre-job hazard analysis, personal protective equipment use, paperwork, and on and on. I've seen far too many instances where by simply communicating to someone what they were going to do, an accident would not have occurred. Be courteous and professional and say something before you perform a task if it could affect others.

3. Complete Your Task or Else

How many times have you thought that someone else is going to do something and it doesn't happen? How many times have you gone to do something and couldn't get it done? Countless times? We all have the same problems but you can limit the effect they have by communication. Let people know when you can't do something and start the problem-solving early. If you see something that is going to cause an issue in the future, address it now. We all know concrete doesn't wait.

It's not easy out there in the field and it won't ever be. Far too many people underestimate the skill and dedication that it takes to be a professional constructor. Respect your trade and the others and let's knock out some great jobs and do it like it's meant to be.

Communication will help you get the job done!

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; Co-Chair of the ASA Education Committee; and serves on the ASA Board of Direction.*

Have YOU Visited the ASA Web site Lately?

There have been significant changes and new services added!

FEATURES —

- ASA Buyers Guide
- Technical Inquiry Submission
- Shotcrete Video Demos
- *Shotcrete* Magazine Archive
- Outstanding Shotcrete Project Awards
- Products
- Education
- Certification
- And Much More

AMERICAN SHOTCRETE ASSOCIATION

WWW.SHOTCRETE.ORG

Airplaco Improves Pro-Cretor Shotcrete Pump/Mixer

The Airplaco® Pro-Cretor is a multipurpose shotcrete and grout pump/mixer. Airplaco has improved the Pro-Cretor by upgrading the engine horsepower and offering a range of optional features. This all-in-one machine is designed for concrete/shotcrete contractors and is suitable for municipalities, road departments, Public Works departments, and Departments of Transportation (DOT). The Pro-Cretor includes a 10 ft^3 (0.28 m^3) material mixer and high-pressure swing-tube pump for a self-contained solution to several projects encountered by contractors and road departments, including concrete resurfacing, bridge repair, tunnel repair, culvert lining, grouting, slabjacking/mudjacking, and road stabilization.

Standard features include a 46 hp (34 kW) diesel engine, a 10 ft^3 (0.28 m^3) mixer, an 11 ft^3 (0.31 m^3) hopper, dual 3 in. (76.2 mm) hard chrome cylinders, variable volume, a full-flow 3 in. (76.2 mm) s-tube, 1300 psi (9 MPa) output pressure, all-hydraulic cycling, and a water meter. For more product information, including options, visit **www.airplaco.com**.

Blastcrete Equipment Company Introduces Dampcon Rig System

Blastcrete Equipment Company has announced the launch of the Dampcon Rig predampening and gunning system. Consisting of a variable speed mixer, conveyor, and gunite machine, the Dampcon Rig offers contractors a complete system to predampen and install dry-process shotcrete materials, and is ideal for concrete repair and precise refractory gunning installations.

The Dampcon Rig features Blastcrete's 020 "Piccola" Rotary Gunite machine to offer precise material output control and a delivery rate of up to 6 yd^3 (4.6 m^3) per hour. The user-friendly machine is easy to operate and maintain, and features a simplified one-bolt clamping system. Unlike typical systems that include three to four adjustment bolts, the Blastcrete system has been designed to require just one bolt, making it easy to adjust and ensuring an excellent seal every time.

A 9 ft^3 (6.8 m^3) capacity paddle-style mixer is designed to predampen the gunning materials, and minimize dust and wasteful rebound material. Furthermore, the unit includes rubber wipers that clean out and reduce material buildup in the mixer. A material elevator with a cleated-belt conveyor transfers material to the gunite machine's receiving hopper. The mixer is also equipped with a water meter and bar to ensure that the proper amount of water is added to each batch.

The entire unit is designed to be extremely easy to clean and maintain. By mounting the gun on casters, it can be easily pushed to the front of the frame so the belt can be cleaned. In response to customer requests, the mixer features swing-out capabilities for further simplified maintenance and cleaning. Simply unclamp, swing out the mixer, and open the door for access. The entire unit can be cleaned quickly using just compressed air.

For more information, contact Blastcrete Equipment Company at (800) 235-4867 or visit the company's Web site at **www.blastcrete.com**.

Allentown Shotcrete Technology, Inc.'s 2011 Powercreter® 20 Now in Production

"This version of the Powercreter 20 has both a larger hopper and mixer," says Patrick Bridger, President of Allentown. "These features make projects more efficient for our customers by accommodating larger amounts of material."

Ideal for midrange pumping requirements, the 2011 model uses the sturdy Thom-Katt® frame and familiar Thom-Katt control box.

"Because the 2011 version incorporates Thom-Katt parts, we determined it would be most efficient to move Powercreter 20 manufacturing to Putzmeister America," adds Bridger.

Standard features of the Powercreter 20 include a hopper capacity of 9.5 ft^3 (270 L); rated up to 17 yd^3/h (13 m^3/h); maximum concrete pressure up to 2000 psi (13.8 MPa); Deutz TD 2011L04i diesel engine; smooth delivery and the least pulsation of any shotcrete machine available; easily handles harsh mixtures, including low cement, low moisture, and refractory pumping castables; and can be fed by concrete truck, on-site mixer, or optional integrated batch or continuous mixer.

The 2011 version of the Powercreter 20 will be available for order in fall 2010.

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

Allentown Shotcrete Technology, Inc., Updates AST 25

Allentown Shotcrete Technology, Inc., has 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 a 7.5 hp (5.5 kW), 460V/60 hz or 400V/50 hz electric motor for boom and nozzle functions; 27 hp (20 kW), water-cooled diesel engine for tracks and outriggers; track drive speeds between 1 and 3 mph (1.5 and 5 km/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; 25 ft (7.62 m) vertical spraying range; and 35 ft (10.67 m) horizontal spraying range.

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

BASF Announces Breakthrough in Concrete Repair

The Building Systems business of BASF's Construction Chemicals division has announced the launch of ZERO-C Concrete Repair Technology, a line of cementitious repair mortars that exhibit no cracking when tested in accordance with ASTM C1581. ZERO-C is the first concrete repair material formulated and proven to eliminate material cracking.

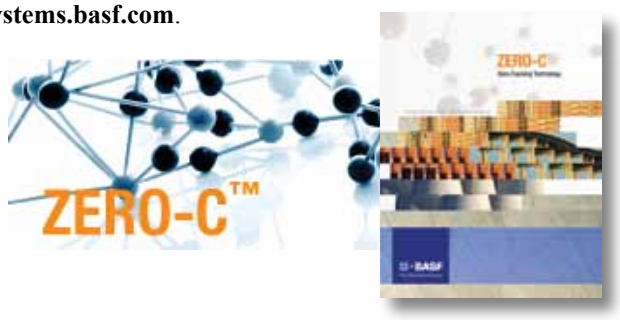
The problem of cracking in concrete repair does not have a simple solution; cracking in concrete is influenced by many factors. Scientists at BASF have unlocked the solution, addressing four critical material properties by using state-of-the-art chemistry to create a new level of performance and the next generation of concrete repair.

Evaluating crack performance requires consideration of all forces that influence cracking. The newest and most reliable scientific test for measuring crack resistance in concrete repair materials is ASTM C1581, commonly known as the "ring test." ZERO-C is the industry's first product to exceed both ASTM International and ICRI requirements for "low cracking potential products," showing no cracking at 60 days when tested according to the ring test.

In addition to crack resistance, ZERO-C's patent pending, mix-and-match material design brings simplicity to the job site. A single base mortar can be modified by using different liquids to change the material consistency as project demands change, reducing the number of materials that have to be stored on the job site.

Additionally, the weatherproof, recyclable mortar bags with handles eliminate solid waste and make bags easier to carry. The durable liquid pouches are tough enough to prevent damage, yet they are made with 50% less plastic than jugs. The pouches fold flat when empty to create less waste and lower disposal costs on site.

For more information, call (952) 496-6073 or **www.buildingsystems.basf.com**.



CONCRETE ENGINEERING GROUP LLC

Concrete Engineering Group, LLC

Concrete Engineering Group, LLC is a consulting engineering firm committed to bringing decades of experience in solving all types of concrete problems to owners, engineers, contractors, material suppliers, and attorneys when and where they need it. Our three principals, Charles Hanskat, George Seegebrecht, and Mike Caldarone are Professional Engineers, each with over 30 years of experience in the concrete industry. Our highly experienced staff members provide direct client contact and support for the client's project.

Typical projects are all generally related to concrete and shotcrete design, materials, construction, evaluation, repair, litigation support, and expert witness testimony. Specific areas of expertise include:

- Concrete and shotcrete materials evaluation for suitability in applications;
- Commercial development, production, and use of high-performance concrete;
- Concrete placing, finishing, and protection issues;
- Testing of concrete materials, cementitious mixture designs, research, and testing of concrete properties;
- Durability and serviceability of concrete in various exposures (marine, industrial, and fire);
- Repair recommendations for various types of concrete distress;
- Design, performance, and durability of liquid-containing structures;
- Code and standard interpretation;
- Cast-in-place, precast, and prestressed concrete;
- Thin-shell concrete structure design and construction; and
- Educational seminars on various aspects of concrete and shotcrete design and construction.

Concrete Engineering Group, LLC's clients are owners, engineers, contractors, design-build firms, insurance companies, material suppliers, and attorneys around the world who need consulting expertise on concrete and shotcrete. The firm has evaluated concrete structures from days and weeks old to well over 100 years old. It has also helped owners, engineers, material suppliers, and contractors recognize and prevent potential problems with concrete that can be so costly in both time and expense if allowed to occur in a completed structure.

More information about Concrete Engineering Group, LLC can be found on the firm's Web site: **www.ConcreteEngrs.com**.

ASA New Members

CORPORATE MEMBERS

Concrete Engineering Group LLC
Northbrook, IL
Primary contact: Charles Hanskat
charles.hanskat@concreteengrs.com
www.concreteengrs.com

Ram Construction Services
Livonia, MI
Primary contact: Richard Maxwell
rmaxwell@ramservices.com
www.ramconstructionservices.com

Sika Corporation
Lyndhurst, NJ
Primary contact: Ketan Sompura
sompura.ketan@sika-corp.com
www.sikaconstruction.com

CORPORATE ADDITIONAL INDIVIDUAL MEMBERS

Eddie Conrad
RAM Construction Services
Livonia, MI

Paul Wild
RAM Construction Services
Livonia, MI

INDIVIDUAL MEMBERS

William Clark
Arcadis US Inc
Belleville, IL

Kelly Illerbrun
PCL Construction Management Inc
Calgary, AB, Canada

Antwon Vaughn
Chucks Concrete Pumping LLC
Richmond, VA

STUDENT MEMBERS

Sergio Arango
Medellín, Antioquia
Colombia

Nima Ghafari
Quezon City, Manila
Philippines

Andrea Hutson
Omaha, NE

Saeed Kia
Tehran, Islamic Republic of Iran

Wei Victor Liu
Edmonton, AB, Canada

Pablo Matute
Jocotenango, Sacatepequez
Guatemala

Vahid Poorjafary
Rasht, Islamic Republic of Iran

Mohammad Ali Sadeghian
Tehran, Islamic Republic of Iran

Herbert Rojas Silva Santisteban
Lima, Peru

Craig Stanton
Norman, OK

Martina Svyantek
Auburn, AL

INTERESTED IN BECOMING A MEMBER OF ASA?

Read about the benefits of being a member of ASA on page 62, find a Membership Application on page 63, and, visit www.shotcrete.org to learn more!

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

38800 Country Club Dr., Farmington Hills, MI 48331
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

READER RESPONSE SERVICE

Please send information on the products or services circled below:

1	2	3	4	5	6	7	8	9
10	11	12	13	14	15	16	17	18
19	20	21	22	23	24	25	26	27
28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45
46	47	48	49	50	51	52	53	54

Please print clearly

Name _____

Company _____

Address _____

City _____

State/Province _____ Zip/Postal Code _____

Country _____

Phone: _____

Fax: _____

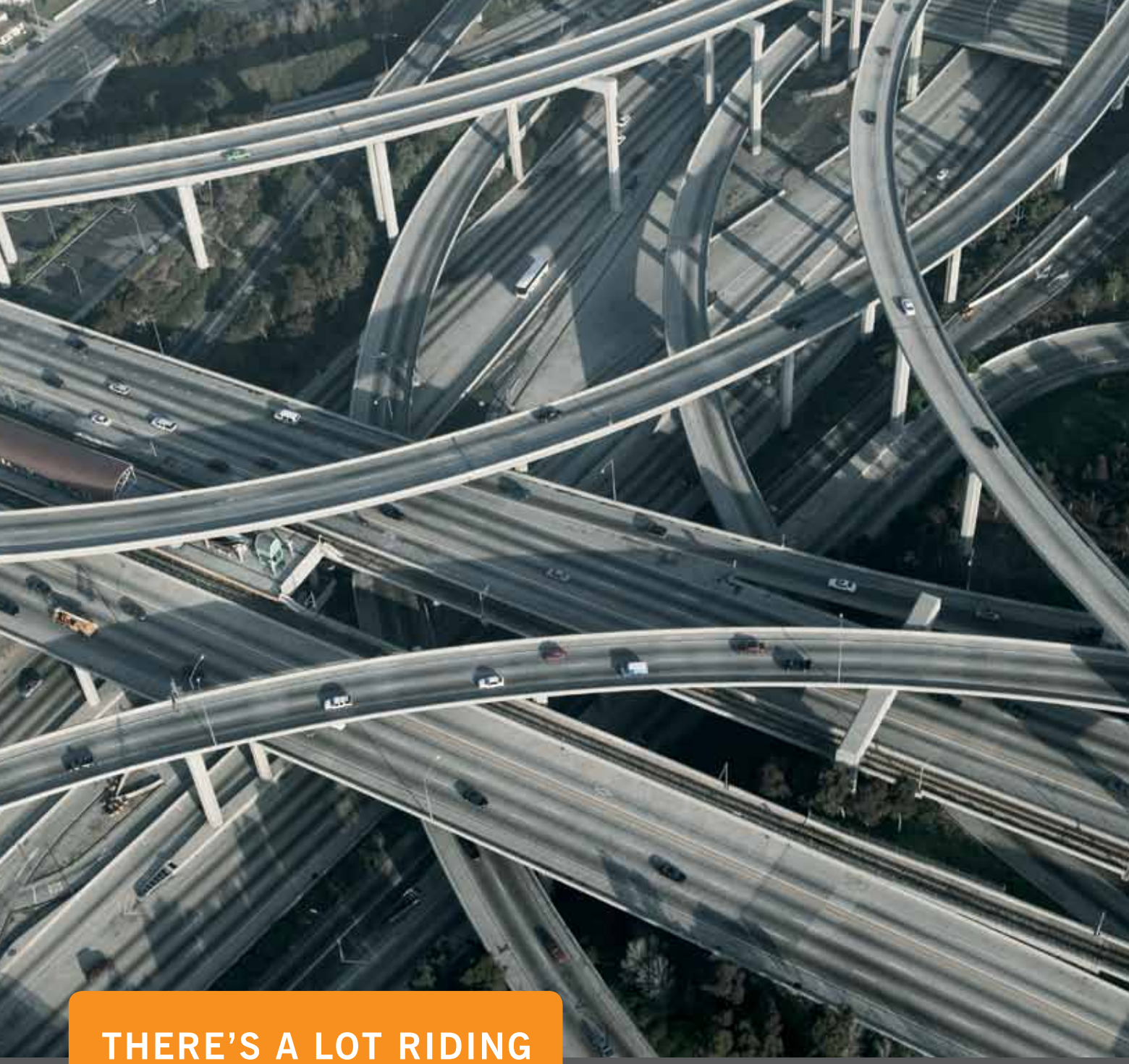
E-mail: _____

Fax or mail to: American Shotcrete Association
38800 Country Club Dr. • Farmington Hills, MI 48331
Phone: (248) 848-3780 • Fax: (248) 848-3740

Fall 2010

ADVERTISERS IN THIS ISSUE

Reader Response Numbers in Parentheses Page



THERE'S A LOT RIDING ON YOUR PROJECT

LET KING SUPPORT YOU

In any project, even the smallest decisions can have big consequences. Every day, our team of industry experts shares vital insights and expertise with customers like you. From Minneapolis to Manhattan and throughout the Americas, King shotcrete products come packaged with unparalleled customer support.

www.kingshotcrete.com

KING PACKAGED MATERIALS COMPANY

1 800 461-0566

www.kpmindustries.com

constructionproducts@kpmindustries.com

KING

Mixing Strength With Satisfaction

Circle #29 on reader response form—page 64

POWERCRETER® 20

Does much more than look good on paper.

MAX VOLUME OUTPUT: 17 yd^3/hr (13m^3/hr)
MAX CONCRETE PRESSURE: 2085 psi (144 bar)
MAX AGGREGATE SIZE: 1" (25mm)
HORIZONTAL PUMPING DISTANCE: 700' (210m)
VERTICAL PUMPING DISTANCE: 400' (120m)

ENGINEERED TO REDUCE PULSATION AND NOZZLEMAN FATIGUE WHEN SHOTCRETING, THE VERSATILE POWERCRETER 20 CAN BE FED BY A READY MIX TRUCK, ON-SITE MIXER, OPTIONAL INTEGRATED BATCH MIXER OR CONTINUOUS MIXER. ITS HIGH PRESSURE SWING TUBE PUMP DESIGN HANDLES HARSH MIXES, INCLUDING LOW-CEMENT, LOW MOISTURE, REFRACTORY PUMPING CASTABLES. IDEAL FOR A BROAD RANGE OF PUMPING APPLICATIONS, THE POWERCRETER 20 TURNS PERFORMANCE INTO PROFIT.

WWW.ALLENTOWNSHOTCRETE.COM/PC20 OR 1-800-553-3414

Allentown
SHOTCRETE TECHNOLOGY
A Putzmeister COMPANY

Circle #11 on reader response form—page 64