shotcrete MAGAZINE
A quarterly publication of the American Shotcrete Association
VOLUME 22, NUMBER 3 • SUMMER 2020
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Safety



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Volume 22, Number 3 • Summer 2020

FEATURES

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

DEPARTMENTS

On the cover: Main photo, Shotcreting a curved retaining wall.

Overlay images – PPE, courtesy of Mike Ballou; Back end cover for pump, courtesy of Seattle Tarp Company; Shotcrete Helmet, courtesy of Shotcrete Helmet.

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Opportunities for the Advancement of ASA

By Ryan Poole

It would appear that the purported Chinese curse, "May you live in interesting times," seems to be the order of the day, and while "uninteresting times" of normalcy, peace and tranquility are much easier to deal with, that is not where we currently find ourselves. However, there are always opportunities available if we will only pay attention and look for them.

When ACI canceled its Concrete Convention – 2020 Spring, ASA also moved to hold all ASA Spring 2020 Committee Meetings in an online format. This circumstance, presented the opportunity to extend the online technology that ASA's Executive Committee and Board of Directors had already been using for their monthly and summer meetings, to all ASA Committee Meetings. While the Underground Committee has been holding its meetings online every three months for some time, this is something new for the balance of ASA Committees.

As meeting schedules were prepared and meetings were held, it was clear that this new approach appealed to members as well as allowing our committees to keep moving forward on their activities and programs. I was impressed by the numbers of members who attended the online meetings and also the level of participation of members attending the meetings.

A number of advantages were immediately apparent as we worked our way through the various committee meetings. First, ease of attendance – without the requirement to travel to an ACI venue, more members had the opportunity to attend more of ASA's meetings. Second, the level of participation seemed higher – more members seemed to be interested and engaged in the discussions. Third, productivity - both the committee chairs and members fully supported the idea that this new way of holding meetings, in regards to both frequency and length of meetings, could be a more fruitful approach to meeting committee needs moving forward. That is to say, if a particular committee wished to meet every two, three, or four months they can do so, allotting adequate time to address the range of topic(s) or the complexity of particular issues to be discussed, rather than be constrained by time limitations of meeting rooms and schedules to accommodate other committee meetings in a physical setting. Due to scheduling requirements for our previous in-person meetings this level of flexibility has not been available. We look forward to continuing the opportunity for individual committees and ASA as a whole to meet online, as well as in-person at some point in the future to be more productive in advancing our objectives.

I hope that anyone who had not been previously able or interested in participating directly in the work of the Association takes advantage of these new opportunities and consider participating in any or all of the committees that may be of interest to you. Those interested in joining a committee as an active voting member are required to hold an individual, sustaining or corporate membership in good standing. Please contact **info@shotcrete.org** if you wish to find out more about committee involvement.

In these "interesting times" remember that opportunities will continue to present themselves both for the betterment and advancement of ASA and for each of us individually. I was once told by someone whom I consider to be very wise: "opportunity missed is opportunity lost." This is something that is always important and should well be remembered as we move forward in our new "normal."

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Education Committee

By Derek Pay

As part of the education and safety committee, I wanted to take a moment to look at some job-related injury statistics for the year 2019, published by the Bureau of Labor Statistics (BLS). As of December 2019, there were a little over 133 million full time workers in the United States. In 2019, "the total number of injuries per 100 full time workers is 2.8." The good news is, that number has steadily decreased over the past 15 years. As we dive a little deeper into these statistics, we look at the top three most common work-related injuries in 2019, and the shotcrete industry has an extremely high risk of all three, which are:

- Overexertion and bodily reaction (33 incidents per 10,000 full-time workers)
- Trips, slips, and falls (approximately 27 incidents per 10,000 full-time workers)
- Contact with objects or equipment (approximately 24 incidents per 10,000 full time workers)

Every day nozzlemen exert great efforts to properly respond to plugs, mitigate physical injury from maneuvering heavy hoses, and contend with extreme temperatures, often after placing large volumes of concrete. Other dangers include:

- Working on scaffolding over 30 ft (9 m) in the air;
- Shooting out of manlifts that may reach over 80 ft (24 m);
- Working on hill sides with steep slopes being tied off while negotiating around reinforcing bars, stake forms, etc.

All these and more can cause serious injury with a trip, slip, or fall. One of the most powerful and dangerous pieces of equipment that we operate is the concrete pump. Shotcrete designed pumps can convey materials at up to 2000 psi (14 MPa) through the delivery hose. The pump also includes a swing tube that when moving from side to side has an immense force that it can take off a limb in one swing change.

How can we, as a shotcrete industry, reduce the risk of these type of injuries for our workers? Knowledge. The most powerful tool that we have as shotcrete workers to protect ourselves and our fellow shotcrete crew members, whether it be nozzleman, trimmers, pump operators, blow pipe operators, chemical pump operators, or rebound thrower, is knowledge. Knowledge is power. Knowledge is safety. Instructing and training your crews through weekly or even daily toolbox meetings conveys this knowledge to all involved on the job site. More communication and education enables your crews to better protect themselves against these extremely high risks. Risks that can result in devastating injuries.

How can ASA help? Our mission includes providing knowledge resources and education to increase the quality and safe practices of shotcrete application. Our Education and Safety Committees have been working closely together to provide these resources since their inception. To increase the shared mission of the two committees, the ASA Board of Directors voted earlier this year to merge the two committees. We now operate as the ASA Education Committee with Task Groups assigned to the various concerns of the Association with safety being a high priority.

Previously, the Safety Committee developed and approved a Safety Presentation for the Wet-Mix Process, following the creation of ASA's Safety Guidelines for Shotcrete. Currently, the committee is working to take smaller safety segments and create on-demand video presentations to be used for short toolbox meetings or "train the trainer" resources. The goal is to provide resources to our member companies to allow them to create informative toolbox talks applicable to the shotcrete industry.

Recognizing that shotcrete placement is site specific, we are working to provide these resources to promote safety and educate shotcrete professionals. These tools will cover topics such as: proper nozzle position, respirators, hearing protection, proper and safe delivery line clean out, etc. We hope these resources will enable our shotcrete crew members at all ability levels to become more knowledgeable about shotcrete specific dangers and then use this knowledge to reduce risks for them and their fellow crew members in the face of these dangers.

These resources will be an exclusive Sustaining and Corporate member benefit. Look for them soon on our new Sustaining/Corporate Member Community on our website –

to be released later this year. The Education Committee welcomes your input on safety concerns you would like to see covered in our resource tool kit.

By taking a few minutes a day to identify potential hazards and their corresponding preventative measures, risks can be reduced. This is best achieved through timely, relevant, and constructive education, often communicated in a variety of ways. Ultimately this keeps our workers performing safely, at full potential and for the long haul.

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Challenges and Opportunities

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

What a roller coaster of a year we've all experienced. For ASA we have moved to Virtual Inc, our new association management firm March 1. We've made good progress in adopting to new management software, a totally rebuilt website, a new magazine graphics development staff, as well as implementing new customer service and accounting processes. All while keeping our core business up to speed.

Of course, what would 2020 be without mentioning the pandemic. It hit us hard in Michigan in late March. Fortunately, all our ASA staff and families have stayed safe and well and we had already planned to work from home. In many ways we were better prepared for the change than many other businesses.

The shotcrete construction industry proved very flexible and has weathered the pandemic well. Our shotcrete pool contractors say they have never been busier. In many states, infrastructure repairs were accelerated to allow work to continue with less traffic. Low interest rates seem to have kept much of the commercial work progressing. All while implementing new procedures to keep field crews and office staff safe. A great effort by all.

The number of our shotcrete nozzleman certification sessions were significantly reduced and we have continued at a reduced rate through the summer. However, following all state requirements for conducting the sessions amid the COVID-19 requirements, we have thus far have been successful in continuing to professionally conduct full sessions. Sessions have been ramping up a bit in Fall. We have also conducted Shotcrete Inspector education sessions and Introduction to Shotcrete seminars online to DOTs, specifiers, and pool contractors.

With the forced move away from face-to-face meetings we had to sit back and consider, "How do we keep our members engaged and active to move ASA forward?" Though we have used online web meetings extensively for many years for our Executive Committee monthly meetings, we had limited use with our active committees. When the face-to-face meetings were cancelled in both Spring and Fall, we moved to full virtual meetings. And surprise – we had great attendance and active participation in all our committee meetings. The committee chairs created agendas that drove the meetings efficiently and kept the members engaged. We made great progress in the committee meetings identifying action items for the Board or for more detailed consideration by ad-hoc task groups to meet between full committee meetings.

Our Board meetings kept ASA on track. We moved the Winter 2021 ASA Convention and Technical Conference to a similar date in 2022, as there were just too many questions on how the pandemic would progress by next February. The location remains the Sonesta Resort in Hilton Head Island, SC. The Board at our Fall meeting approved the Ojai Valley Inn for our Winter 2023 Convention. They also approved moving our 2021 Awards Banquet to an online celebration. A distinct advantage of holding our Awards Celebration virtually, and for free registration, is the ability to open up attendance to many more attendees who will be able to see immediately how shotcrete creativity, quality, and durability opens up unique opportunities in concrete construction. Please plan on joining us for this special event on Wednesday, March 24, 2021. A great way to get our Association out to many more in the construction industry.

To further the outreach to our members, we also look forward to starting monthly ASA "Town halls." These will be scheduled online meetings that will include a quick presentation on one of ASA's programs or activities, then open the floor to Q&A. These will be free to attend, and hopefully attract not only current members, but new potential members.Yes, 2020 has definitely been a challenge in many ways. However, by staying flexible, using technology and exploring new methods for outreach and engagement we've made great strides to grow ASA, and serve both our members and the shotcrete industry. Watch for our Awards Celebration registration to open and sign up. Also, watch our Calendar on the website to see when our committees are meeting virtually and sign up to attend as well. The pandemic may have changed many things, but it hasn't changed our commitment to serve you and the shotcrete industry with timely, relevant information and certification services. Thank you to all our Association members who continue to support these efforts!

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All Those Small Numbers We Ignore - What Do They Mean?

By Oscar Duckworth

We have all seen those small letters and numbers that mark practically everything we use in construction. To most, these are meaningless markings that are meant for someone else. However, with shotcrete, nothing could be farther from the truth.

Nearly every component we use is designed to meet a certain specification, capacity, or load rating. Chains, cables, tires, hardware, even nuts and bolts carry clear markings that define exactly what range(s) they are rated to perform within.

You may not be aware that the delivery line components such as hoses, pipes, clamps, and elbows we use every day are *not* specifically designed for high pressure shotcrete use. They are designed to safely convey concrete or grout materials during routine concrete pumping operations, and function within a specific pressure range known as the component's working pressure. Common concrete placement system components such as pipes, sweeps, hoses, and couplers are available in every price range. These components can appear similar, and fit a certain size profile, but may not be designed to safely function at the high pressures we need for shotcrete placement.

Fig, 1. Similar appearing tires may have very different load ratings.

As a comparison, the vehicles we use, and their weight carrying capacity can vary considerably. Tires are not designed to be vehicle specific. They are designed to a certain size profile and engineered to function within a specific load range known as the tire's weight rating. A common passenger car tire may fit a heavy truck, but the tire may not be designed to safely carry the fully loaded weight of the truck. This is why load carrying capacities are required by federal law to be clearly identifiable on all tires. Tire manufacturers spend millions designing and testing their products prior to assigning a load rating. To select the correct tire, it is essential that we know the expected total loaded weight of the vehicle, and a tire chosen to function within a range at or above its expected fully loaded weight. Guesswork can lead to selecting a tire that may be under-designed and fail under a fully loaded condition. For this reason, federal regulations require the gross vehicle weight rating (GVWR), or fully loaded weight information to be prominently displayed beside every vehicles identification number in the driver's side door area.

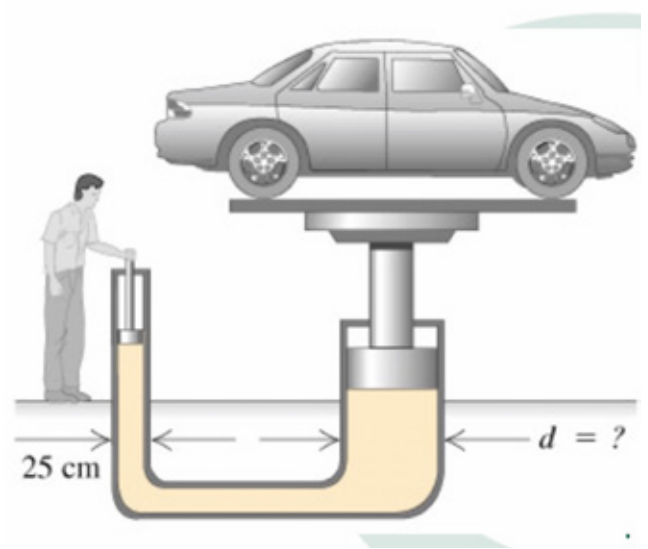
Fig, 2. A high powered Shotcrete pump sheared an un-rated elbow reducer. Luckily, no one was injured.

Like the tire, to properly select delivery line components to be used with shotcrete, it is essential that we know exactly what the expected total "load" or maximum pressure rating of the concrete pump used. Unfortunately, these critically important maximum values are not required to be displayed on the concrete pumping equipment. Additionally, concrete pumps designed primarily for shotcrete placement typically produce far more available pump pressure than a common concrete pump. Worse, few workers can determine a pump's maximum available concrete pressure from information provided by the values displayed on the instrument panel's gauges.

The pressure carrying capacity or "working pressure rating" of each delivery line component is critical because in the event of a blockage, the system will become loaded to the concrete pump's maximum available pressure within moments. Components not designed to function at the pump's maximum concrete pressure become a serious safety hazard.

Fig, 3. Working pressure ratings clearly displayed on common placement components.

So... how can a crew know that placement system components that are designed to convey concrete can be considered safe to be used with the far higher pressures of a shotcrete-specific concrete pump?



Fig, 4. The hydraulic system permits a nearly limitless multiplication of force.

Working Pressure Safety Checklist:

1. Determine the ACTUAL maximum concrete pressure your pump can produce.
2. Become familiar with the location and meaning of the working pressure ratings displayed on reducers, sweeps, hoses, clamps, and other placement system components.
3. Never purchase or use un-rated delivery line components or parts that are designed to a lower working pressure rating than your pump's maximum concrete pressure rating.
4. Educate operators and other workers of working pressure ratings and their relationship to safe operation.
5. Remember that the working pressure rating is for components in as-new condition. It does NOT account for wear.

Delivery line components are designed to safely function within a range not to exceed the posted working pressure. Manufacturers establish safe working pressure limits through over-designing to attain a working pressure of approximately 1/3 to 1/2 of the component's actual burst or failure pressure.

To determine whether a component can be safely used, or is under-designed for shotcrete placement, it is essential to recognize that the maximum available concrete pressure of the pump should not exceed the delivery line component's posted working pressure rating.

SHOTCRETE PUMP EVOLUTION HAS CREATED SAFETY HAZARDS

Early mechanical action concrete pumps multiplied available pushing pressure to the concrete by numerous gears, pulleys, belts, and chains. These machines were not capable of producing concrete pressures above about 300-500 lb/in^2 (2 – 3.5 MPa). Delivery line manufacturers were not required to display working pressure ratings due to the low available pressure of that era.

As placement equipment evolved, hydraulically-driven concrete pumps became available. The hydraulic design allows for a nearly limitless multiplication of force between the available hydraulic pressure and the pushing pressure that can be exerted to the concrete in the delivery line.

The maximum available concrete pressure that can be produced by a modern hydraulic concrete pump MUST be governed by a bypass valve which releases excessive hydraulic pressure at a pre-set limit that is determined by the manufacturer. Without this function, a hydraulic concrete pump is capable of developing concrete pressures far greater than the delivery line hoses, fittings, couplers, and other components can safely withstand. Although elbows, sweeps, and reducers can be efficiency manufactured with thicker materials to facilitate higher working pressures, flexible hoses, particularly their crimped end couplings, cannot. Currently, flexible steel braided or fabric corded delivery line manufacturers offer few, if any placement hoses designed with a working pressure rating above approximately 1250 lb/in^2 (85 Bar). For safety reasons, many, but not all hydraulic concrete pump manufacturers pre-set the factory bypass valve to limit concrete pressures to 1250 lb/in^2 or below. Unfortunately, some pump operators alter the bypass settings to increase pressure above the factory-set levels. As a very general rule, concrete pressure is approximately one-third of the hydraulic pressure displayed on the main hydraulic pressure gauge on the pump's instrument panel. As an example, a hydraulic pressure gauge displaying about 3000 lb/in^2 (200 Bar) would theoretically have a concrete pressure of approximately 1000 lb/in^2 (70 Bar) during placement. Likewise, a gauge reading 3600-3800 lb/in2 (250-260 Bar) would indicate a concrete pressure of roughly 1250 lb/in^2.

THE ANSWERS ARE OUT THERE - READ THE MANUAL!

Concrete and shotcrete pump manufacturers supply detailed operation and safety manuals that clearly define the maximum pumping distance, height, or available concrete pressure that a pump will produce if factory bypass settings are maintained. The only way to correctly determine if a delivery line component can be safely used for shotcrete placement is to know your pump's maximum available concrete pressure rating and validate that the working pressure rating of all delivery line components are equal or greater than that value.

Those small numbers are important! Paying attention to the working pressure capacity of the components used on your delivery lines is just as important as the size of the pump or nozzle! Don't shortchange your safety by ignoring these details!

*ACI Certified Nozzleman **Oscar Duckworth** is an ASA and American Concrete Institute (ACI) member with over 25,000 hours of nozzle time. He has worked as a nozzleman on over 2500 projects. Duckworth is currently an ACI Examiner for the wet- and dry-mix processes. He serves on the ASA Board of Directors and as Chair of ASA's Education Committee. He continues to work as a shotcrete consultant and certified nozzleman.*

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Safety in Shotcrete Application in Underground Construction

By Raul Bracamontes

Because of its durability, strength, and flexibility in application, shotcrete is often used for the construction and stabilization of tunnels and other underground structures. The fact that tunneling involves general construction risks as well as tunnel specific environmental risks, makes this type of application potentially quite dangerous, and must be treated with caution. Risks cannot be eliminated, but we can implement measures to lower the risk.

The first step is planning. An occupational health and safety strategy for the project should be drawn up and all the precautionary measures must be identified by competent staff. The plan should contain details of emergency procedures as well as the appropriate training for workers related to the construction methods to be used. The goal is to maximize the safety of underground construction workers. Occupational safety and health regulations require employees to receive extensive training in:

- Air monitoring and ventilation
- Illumination
- Communication
- Flood control
- Shotcrete application
- Personal protection tools
- Emergency procedures, including evacuation plans
- Check-in/check-out procedures
- Explosives
- Prevention and protection against fire
- Mechanical tools

UNDERGROUND SHOTCRETE PLACEMENT - IMPORTANT MEASURES TO ACHIEVE SUCCESSFUL SHOTCRETE PLACEMENT

Shotcrete application: After each stage of the excavation sequence has been mucked out, concrete is shotcreted onto the exposed ground surface. The lining is often built up in several layers with mesh reinforcement inserted between the layers. Alternatively, short fibers can be added to the mix to provide some tensile capacity. Once the section of lining is complete, the next stage is excavated, and the process repeats until a continuous tunnel lining is formed. Often, the shotcreted lining does not form part of the permanent work and another permanent lining is installed at a later date, (Alun Tomas, 2020).

For the tunneling cycle to resume safely after shotcrete placement, the shotcrete must first reach a self-supporting state or strength before workers and machinery can return to work under the newly placed material.

Unfortunately, rock falls from recently exposed ground continues to be one of the most serious causes of injury. Underground mine collapse accidents in the United States cause 8 to 10 deaths and more than 800 injuries each year. This represents approximately 30% of fatal accidents and 15% of injuries that occur in underground mines each year.

Weak ground is not self-supporting after excavation and consequently, the support system must be installed concurrently with the active tunnel cycle. In the ground control system, shotcrete is used to provide temporary local surface stability before the primary support is installed. Because the shotcrete must become self-supporting before workers and equipment can work safely underneath, the strength gain characteristics of the shotcrete are critical to the speed of the cycle.

Shotcrete has proved its value to aid rock support on many underground jobs. Shotcrete application is skilled work, and as noted previously, only competent nozzleman should be used. It is of critical importance that personnel are properly trained in the operations they perform.

Fig. 1. Rock fall on jumbo equipment

Seguridad en la aplicación de concreto lanzado en la construcción subterránea

Por Raul Bracamontes

Debido a su durabilidad, resistencia y flexibilidad de aplicación, el concreto lanzado se utiliza a menudo para la construcción y estabilización de túneles y otras estructuras subterráneas. El hecho de que la construcción de túneles implica riesgos generales de construcción, así como riesgos ambientales específicos, hace que este tipo de aplicación sea potencialmente bastante peligrosa y debe tratarse con precaución. Los riesgos no se pueden eliminar, pero podemos implementar medidas para reducir la probabilidad de accidentes.

El primer paso es la planificación. Se debe elaborar una estrategia de seguridad y salud ocupacional para el proyecto y todas las medidas de precaución deben ser identificadas por personal competente. El plan debe contener detalles de los procedimientos de emergencia, así como la capacitación adecuada para los trabajadores relacionada con los métodos de construcción que se utilizarán. El objetivo es maximizar la seguridad de los trabajadores de la construcción subterránea. Las normas de salud y seguridad ocupacional exigen que los empleados reciban una amplia formación en:

- Monitoreo del aire y ventilación
- Iluminación
- Comunicación
- Control de inundaciones
- Aplicación del concreto lanzado
- Equipo de protección personal
- Procedimientos de emergencia, incluidos planes de evacuación
- Procedimientos de ingreso/salida
- Explosivos
- Prevención y protección contra incendios
- Herramientas mecánicas.

COLOCACIÓN DE CONCRETO LANZADO SUBTERRÁNEO: MEDIDAS IMPORTANTES PARA LOGRAR UNA COLOCACIÓN EXITOSA DEL CONCRETO LANZADO

Aplicación de concreto lanzado: Después de que se haya retirado el material de excavación según la secuencia de excavación, se aplica el concreto lanzado sobre la superficie expuesta del terreno. El revestimiento a menudo se construye en varias capas con un refuerzo de malla insertado entre las capas. Alternativamente, se pueden agregar fibras cortas a la mezcla para proporcionar cierta capacidad de tenacidad. Una vez que se completa la sección de revestimiento, se excava la siguiente etapa y el proceso se repite hasta que se concluye con el revestimiento de túnel. A menudo, el revestimiento de concreto lanzado no forma parte de la obra permanente y se instala otro revestimiento permanente en una fecha posterior (Alun Tomas 2020).

Para reanudar de forma segura el ciclo de desarrollo del túnel después de la colocación del concreto lanzado, el concreto lanzado debe alcanzar primero un estado o resistencia auto soportante antes de que los trabajadores y la maquinaria puedan ingresar a una zona recién lanzada.

Desafortunadamente, los caídos de rocas en terrenos recién excavados continúan siendo una de las causas más graves de lesiones. Los accidentes por derrumbes en minas subterráneas en los Estados Unidos causan de 8 a 10 muertes y más de 800 lesiones cada año. Esto representa aproximadamente el 30% de los accidentes fatales y el 15% de las lesiones que ocurren en las minas subterráneas cada año.

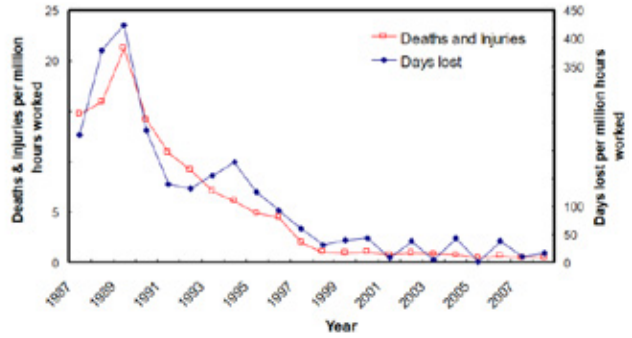
El terreno intemperizado tiende a ser inestable después de la excavación y, en consecuencia, el sistema de soporte debe instalarse al mismo tiempo que el ciclo activo del túnel. En el sistema de control del terreno, el concreto lanzado se utiliza para proporcionar estabilidad superficial temporal antes de que se instale el soporte primario. Debido a que el concreto lanzado debe tener la resistencia adecuada antes de que los trabajadores y el equipo puedan trabajar de manera segura debajo del concreto recién aplicado, el desarrollo de resistencia a tempranas edades del concreto lanzado es crítico para la velocidad del desarrollo del ciclo de excavación.

El concreto lanzado ha demostrado su importancia en el soporte de rocas en muchos trabajos subterráneos. La aplicación de concreto lanzado es un trabajo especializado y, como se señaló anteriormente, solo se debe utilizar un lanzador

Fig. 1. Rock fall on jumbo equipment

The nozzleman needs to have knowledge of the equipment used, especially if new technologies are used, as well as knowledge of the dangers and safety measures related to each stage of construction.

Here is a chart showing how the use of shotcrete in underground construction helped to reduce rock fall accidents in Australian mines between 1987 and 2008.



On the chart you can see death and injuries due to rock falls were substantially reduced when shotcrete was introduced between 1989-1999 in Australian mines.

When shotcrete is used as part of a multi-element ground support system, it is necessary to know when the material has developed a compressive strength of approximately 1.0 MPa (145 psi), the early threshold for safe re-entry of workers and machinery into a shotcreted area. Tunnel staff must have a means of quantifying the shotcrete strength after application to keep their tunnel safe for workers and equipment.

Success in shotcrete application depends on four main things, which are: the quality of shotcrete equipment, the quality of the concrete mixture, the quality of the crew, and good surface preparation. Shotcrete testing is used at the tunnel site to assist workers in determining if the shotcrete used in the ground control support system meets the specified shotcrete performance requirements. These tests measure early compressive strength related to re-entry time (amount of time that elapses before workers can safely re-enter an area of the tunnel), flexural load capacity, toughness, installed quality, and bond strength.

Fig. 2. Shotcrete placement with a remotely operated nozzle

The concrete mixture should be designed to meet the specifications for both workability and strength. It should also be designed to minimize dust emissions.

Ventilation: Good ventilation and lighting of the workplace is essential during shotcrete application. It should be noted that ventilation is the most effective system for controlling airborne dust.

In all underground workings, fresh and clean air circulation needs to be maintained in sufficient quantity and quality according to the number of people and the total power of equipment with internal combustion engines. A minimum of 19.5% and a maximum of 22.5% oxygen in the work environment needs to be maintained. When the mines are up to 1,500 m (4900 ft) above sea level, the minimum amount of air needed per man should be 6 m^3/min (210 ft^3/min) with a minimum of 2.83 m^3/min (100 ft^3/min) recommended for each horsepower of the internal combustion powered equipment (Komarov, 2010).

The following are the maximum permissible limits in the underground environment:

- Inhalable powder: 10 mg/m^3
- Breathable powder: 3 mg/m^3
- Oxygen (O2): minimum 19.5% and max. 22.5%
- Carbon dioxide (CO2): max. 9,000 mg/m^3 or 5,000 ppm. 30,000 mg/m^3 for a span of 15 min
- Carbon monoxide (CO): max. 29 mg/m3 or 25 ppm
- Methane (NH4): max. 5,000 ppm
- Sulfurized hydrogen: max. 14 mg/m^3 or 10 ppm
- Nitrous gases (NO2): max. 7 mg/m^3 or 3 ppm to 5 ppm
- Nitrous gases (NO): 25 ppm
- Sulphurous anhydride: 2 ppm minimum to 5 ppm max
- Aldehydes: max. 5 ppm
- Ozone: max. 0.1 ppm

Adhesion to the rock: Shotcrete support is dependent on adequate bond to the rock. Surfaces contaminated with oil, dust or mud shall be fully cleaned before shotcrete placement.

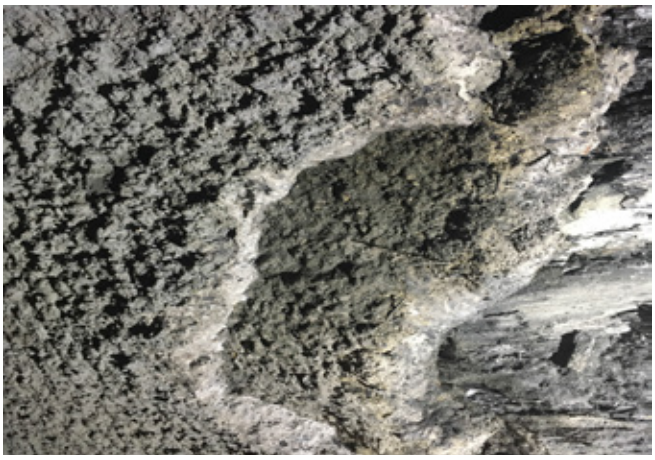
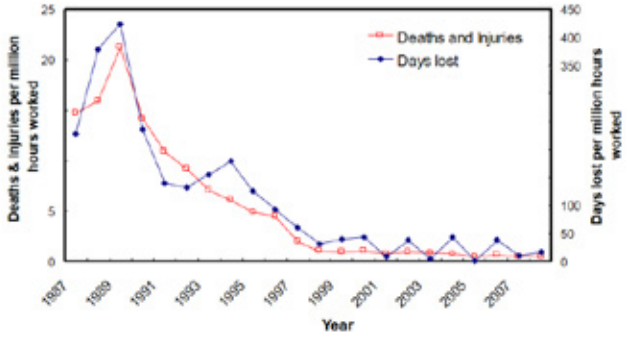


Fig. 3. Lack of surface preparation prevented adhesion between concrete layers and concrete and rock.

competente. Es de vital importancia que el personal esté debidamente capacitado en las operaciones que realiza.

El lanzador debe tener conocimiento del equipo con que trabaja, especialmente si se utilizan nuevas tecnologías, así como conocimiento de los peligros y las medidas de seguridad relacionadas con cada etapa de la construcción.

A continuación, se muestra un ejemplo de cómo el uso del concreto lanzado en la construcción subterránea ayudó a reducir los accidentes de caída de rocas en las minas australianas entre 1987 y 2008.



Las muertes y lesiones debidas a caídas de rocas se redujeron sustancialmente cuando se introdujo el concreto lanzado durante el período 1989-1999 en las minas australianas.

Cuando el concreto lanzado es parte de un sistema de soporte del terreno de múltiples elementos, es necesario saber cuándo el material ha desarrollado una resistencia a la compresión de aproximadamente 1.0 MPa (145 psi), este es la resistencia mínima para el reingreso seguro de trabajadores y maquinaria un área donde se aplicó concreto lanzado. El personal del túnel debe tener un medio para cuantificar el desarrollo de la resistencia del concreto después de su aplicación para garantizar la seguridad de los trabajadores y del equipo.

El éxito en la aplicación del concreto lanzado depende de cuatro cosas principales, que son: la calidad del equipo de lanzado, la calidad de la mezcla, la calidad de la mano de obra y una buena preparación de la superficie. Las pruebas al concreto lanzado se realizan en el sitio para ayudar a los trabajadores a determinar si el concreto lanzado colocado como sistema de soporte cumple con los requisitos específicos. Estas pruebas miden la resistencia a la compresión a tempranas edades relacionada con el tiempo de reingreso (cantidad de tiempo que transcurre antes de que los trabajadores puedan reingresar con seguridad a un área del túnel), la capacidad de carga de flexión, la tenacidad, la calidad instalada y la adherencia.

Fig. 2. Aplicación robótica de concreto lanzado

La mezcla de concreto debe diseñarse para cumplir con las especificaciones tanto de trabajabilidad como de resistencia. También debe diseñarse para minimizar las emisiones de polvo.

Ventilación: Una buena ventilación e iluminación del lugar de trabajo es esencial durante la aplicación del concreto lanzado. Cabe señalar que la ventilación es el sistema más eficaz para controlar el polvo en el aire.

En todas las obras subterráneas, la circulación de aire fresco y limpio debe mantenerse en cantidad y calidad suficiente de acuerdo con el número de personas y la potencia total de los equipos con motores de combustión interna. Es necesario mantener un mínimo de 19,5% y un máximo de 22,5% de oxígeno en el entorno de trabajo. Cuando las minas están hasta 1.500 m (4900 pies) sobre el nivel del mar, la cantidad mínima de aire necesaria por hombre debe ser 6 m^3/min (210 $pies^3$/min) con un mínimo de 2,83 m^3/min (100 $pies^3$/min) recomendado para cada caballo de fuerza del equipo de combustión interna (Komarov, 2010).

Los siguientes son los límites máximos permitidos en el entorno subterráneo:

- Polvo inhalable: 10 mg/m^3
- Polvo transpirable: 3 mg/m^3
- Oxígeno (O2): mínimo 19,5% y máx. 22,5%
- Dióxido de carbono (CO2): máx. 9.000 mg/m^3 o 5.000 ppm. 30.000 mg/m^3 durante un lapso de 15 min
- Monóxido de carbono (CO): máx. 29 mg/m^3 o 25 ppm
- Metano (NH4): máx. 5000 ppm
- Hidrógeno sulfurado: máx. 14 mg/m^3 o 10 ppm
- Gases nitrosos (NO2): máx. 7 mg/m^3 de 3 ppm o 5 ppm
- Gases nitrosos (NO): 25 ppm
- Anhídrido sulfuroso: mínimo de 2 ppm a máximo de 5 ppm
- Aldehídos: máx. 5 ppm
- Ozono: máx. 0,1 ppm

Adherencia a la roca: El soporte del concreto lanzado depende de una adecuada unión a la roca. Las superficies contaminadas con aceite, polvo o lodo deben limpiarse completamente antes de la colocación del concreto lanzado.

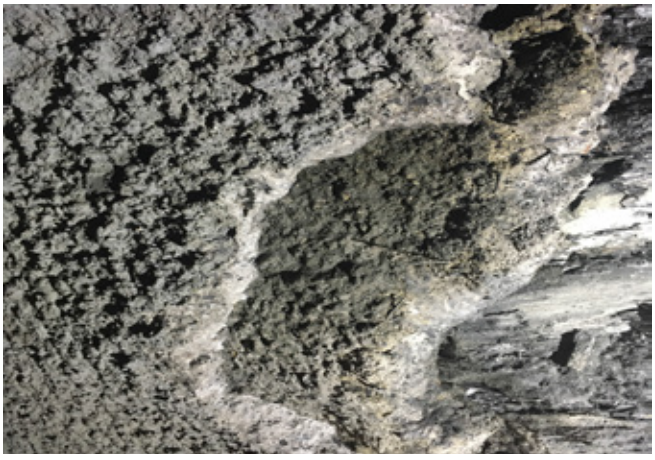


Fig. 3. La mala preparación de la superficie impidió la adhesión entre las capas de concreto lanzado y el concreto con la roca

Fig. 4. Good bonding between shotcrete layers

Proper application of shotcrete in layers does not create a cold joint, as long as you achieve good bond between the layers. Shotcrete will not bond to excessively wet rock surfaces and in these cases, remedial measures are necessary.

Terrain	Strength
I	1 Mpa (145 lb/in^2)
II	0.8 Mpa (116 lb/in^2)
III	0.5 Mpa (72 lb/in^2)
IV	0.42 Mpa (61 lb/in^2)
V	0.31 Mpa (45 lb/in^2)

Fig. 5. Minimum adherence of shotcrete according to type of terrain

Note that the adhesion of shotcrete to the rock could be reduced if using shotcrete rapid-set accelerators. However, an overdose of accelerator will reduce the final strength. The quality of the shotcrete placement shall be verified by routine inspection and testing. During shotcrete placement no other operations should be carried out in the vicinity.

Air compressor for shotcrete application: For robotic shotcrete application, we need to have 10 – 12 m^3/min (375 to 425 ft^3/min) air flow at the nozzle with 6-8 bars (100 lb/in^2). The use of compressed air involves hazards. Proper maintenance of air compressors is vital to their continued safe operation. When using compressed air underground there can be a discharge of oil which means that the air in the tunnel could become contaminated and consequently the concrete as well. Thus, it is necessary to have the supply of air free of oil for shotcrete application.

Compressed air should be taken seriously with careful attention to all precautionary measures. It should not be used to blow down dust from clothes as one single blast of air can burst an eardrum or permanently destroy an eye.

Generally, wet-mix shotcrete produces less dust and rebound than the normal dry-mix process. Accelerators should be used in correct proportions as per "manufacturer's instructions." Non-caustic accelerators are preferred.

PPE: Protective clothing, respirators, hard hat, steel toe boots, ear plugs, and safety glasses should always be used. Dust masks or respirators may be required by crew members when dust emissions cannot be adequately controlled in their work areas.

CONCLUSIONS:

The use of shotcrete in preventing rock fall has been used very successfully and has many benefits. However, even when using shotcrete, underground construction has risks that must be taken seriously. It is very important to have training in shotcrete applications, awareness of the underground risks and appropriate safety procedures, in addition to nozzleman certification. All of these are required for the success and safe application of shotcrete during underground construction. Think safety first!

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2. "Guidelines for good occupational and safety practice in tunnel construction," ITA working group health and safety in works, ITA report no. 001/November 2008.
3. Roof and rib fall incident trends: a 10-year profile, D.M. Pappas and C. Mark Civil engineer and mining engineer, respectively, National Institute for Occupational Safety and Health, Pittsburgh, PA.
4. Early strength performance of modern weak rock mass shotcrete mixes, C.C. Clark, M.A. Stepan, J.B. Seymour and L.A. Martin.

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Fig. 4. Buna adherencia entre capas de concreto lanzado

La aplicación adecuada de concreto lanzado en capas no genera una junta fría, siempre que logre una buena unión entre las capas. El concreto lanzado no se adherirá a superficies rocosas excesivamente húmedas y, en estos casos, es necesario tomar medidas correctivas.

Terreno	Resistencia
I	1 Mpa (145 lb/in^2)
II	0.8 Mpa (116 lb/in^2)
III	0.5 Mpa (72 lb/in^2)
IV	0.42 Mpa (61 lb/in^2)
V	0.31 Mpa (45 lb/in^2)

Fig. 5. Adherencia mínima del concreto lanzado según tipo de terreno

Recuerde que la adhesión del concreto lanzado a la roca podría reducirse si se utilizan acelerantes de fraguado rápido. Además, una sobredosis de acelerante reducirá la resistencia final. La calidad de la colocación del concreto lanzado debe verificarse mediante inspecciones y pruebas de rutina. Durante la colocación del concreto lanzado, no se deben realizar otras operaciones en las proximidades.

Compresor de aire para aplicación de concreto lanzado: Para la aplicación robótica de necesitamos tener un flujo de aire de 10-12 m^3 / min (375 a 425 ft^3 / min) en la boquilla con 6-8 bares (100 lb / in^2). El uso de aire comprimido conlleva peligros. El mantenimiento adecuado de los compresores de aire es vital para su funcionamiento seguro continuo. Cuando se utiliza aire comprimido bajo tierra, puede haber una descarga de aceite, lo que significa que el aire en el túnel podría contaminarse y, en consecuencia, también el concreto. Por lo tanto, es necesario tener el suministro de aire libre de aceite para la aplicación del concreto lanzado

El aire comprimido debe tomarse en serio, prestando especial atención a todas las medidas de precaución. No debe usarse para quitar el polvo de la ropa, ya que una sola ráfaga de aire puede reventar un tímpano o destruir un ojo de forma permanente.

Generalmente, el concreto lanzado vía húmeda genera menos polvo y rebote que el proceso de vía seca. Los acelerantes deben usarse en proporciones correctas según las “instrucciones del fabricante.” Se prefieren los acelerantes no cáusticos o libre de álcalis.

PPE: Siempre se debe usar ropa protectora, respiradores, casco, botas con punta de acero, tapones para los oídos y lentes de seguridad. Otros miembros de la cuadrilla pueden requerir máscaras anti polvo o respiradores cuando las emisiones de polvo no pueden controlarse adecuadamente en sus áreas de trabajo.

CONCLUSIONS:

El uso de concreto lanzado para prevenir la caída de rocas se ha utilizado con mucho éxito y tiene muchos beneficios. Sin embargo, incluso cuando se usa concreto lanzado, la construcción subterránea tiene riesgos que deben tomarse en serio. Es muy importante tener formación en aplicaciones de concreto lanzado, conocimiento de los riesgos subterráneos y procedimientos de seguridad adecuados, además de la certificación de lanzador. Todos estos son necesarios para el éxito y la aplicación segura del concreto lanzado durante la construcción subterránea. ¡Piense en la seguridad primero!

References

1. NIOSH [2014]. Shotcrete design and installation compliance testing: early strength, load capacity, toughness, adhesion strength, and applied quality, Martin LA, Clark CC, Seymour JB, and Stepan MA, Spokane WA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2015-107, RI 9697.
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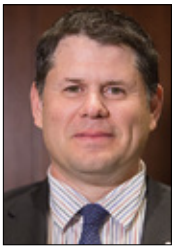

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Site-Specific Mine Site Safety in North America

Comply, or it may be one and done

By Mike Ballou

Show me a person who tells you that safety on a mine site is just plain common sense, and I'll show you someone who doesn't understand mine safety completely.

Mine safety is not simply common sense. It is that, and a whole lot more. Most mines have their own set of mine-specific regulations and rules. Nearly all mines, in Canada, the USA, and Mexico, are required by law, to follow government-mandated requirements such as U.S. Department of Labor- Mining Health & Safety Administration (MSHA) and/or the Occupational Safety & Health Administration (OSHA). Canada and Mexico have their government agencies governing mining as well. Even with strict government regulations, most mines have safety regulations specific to each individual mine. Anyone who desires to visit a mine site needs to accept one thing- whatever the rules and regulations are for a particular mine- these regulations are serious business and are meant to be enforced.

PLAN AHEAD

If you are planning a visit to a mine site try, if possible, to bring your own safety equipment, even if you are there as a visitor or observer. Try to take as many items on this list as is practical.

The typical personal safety list includes:

1. Boots with hard toes (Some mines require metatarsal boots. Find out if they are required)
2. Safety glasses with wrap-around or side shields
3. Hardhat with reflective tape (If you are planning to go underground where head lamps are used, a hardhat with a bracket to attach a head lamp may be required)
4. Hearing protection- either attached to your hardhat or single use foam plugs
5. Reflective vest
6. Coveralls with reflective strips (Some mines do not require reflective strips, but they are a good safety option.)
7. Miner's body belt (If going underground only)
8. Dust mask(s)
9. Respirator (Most mines supply special use respirators)
10. Gloves

It is usually not a good idea to expect the mine to gather up safety gear that will fit you. They may not have it available in your size. Bring yours, and if it is not possible to bring your own, check ahead with the mine, or your escort, and advise them that you will be needing safety gear. Also, it is also advisable, if you plan to shower after going underground, to take your own towel and toiletries, a change of underwear and a lock for a locker that is usually furnished. Although not always required, showering after an underground mine visit is a good safe practice so you can wash away the dust from the mine. Most mines are set up to accommodate guests who wish to shower.

STAY CLOSE TO YOUR ESCORT AND RESPECT THEM BY FOLLOWING SAFETY REGULATIONS

There are times that visitors are allowed on mine sites, either surface or underground mines, with the sole purpose of observing. That said, all visitors entering a mine site are required to comply with mine safety regulations. This is especially true when visiting an underground mine. Stay as close to your escort as possible and practical. Refrain from venturing off to take photos (photo taking may not be allowed), or checking out equipment or products related to shotcrete or mining, unless permission is granted. Try to stay with the group at all times. If you wish to take photos, examine equipment or materials on site, permission needs to be granted first. Don't make assumptions.

If a mine site visitor does not comply with mine site safety regulations or violates them, that person may be escorted off the property and may not be allowed to re-enter the property or go underground. They may also be denied access to other properties that the mine company owns. Please don't think this doesn't happen. I've seen it happen three different times. All three of the individuals made the mistake of not staying with the group at all times and one took unauthorized photos.

SITE-SPECIFIC SAFETY COURSE

Many mines require anyone who wishes to visit a mine site to attend a site-specific course. This may be a short video at the mine, followed with an exam. Requirements depend on the mine. If an individual needs to stay at a mine site for an extended stay or work there, the person normally must take a full government and mine-approved safety course. These more extensive courses may take from one to five days or longer, depending on the requirements of the mine and the purpose of the visit, and if the person is there to work on the mine site.

Accidents in any form on a mine site impact the entire mine. When any accident happens on a mine site it must be reported, whether it is a "lost time injury" - meaning the injured person can go back to work the same day as the accident, or a "lost time

accident" - which means the injured person takes one or more days off work due to the injury.

Active mines must be profitable to operate. Mining is a risky business, so anything that slows production, such as dealing with an accident, is a serious concern. Anything that increases the cost of mining is a serious issue. Mines pay premiums to insurance companies based on their accident record. When there is an accident, even a minor one, insurance premiums may increase and that means decreased profitability.

Our professions as contractors, miners, suppliers in the shotcrete industry often requires us to visit and work on many different mine sites. We need to ensure that we understand and give proper training to our personnel so that mining accidents are avoided. The rules are simple and make sense. Helping to keep an accident-free mine site is in everyone's best interest.

***Mike Ballou** has been in the mining and tunneling business for nearly 30 years and has enjoyed being a part of ASA and ACI for most of those years. He has served on several committees and subcommittees in both ASA and ACI. He is a civil engineer graduate; owner and President of Bullhide Fibers, Inc. based in Hurricane, Utah; and a co-owner of Crossroads Construction Co. Inc., which is an industrial construction company with a focus on mining projects, based in Magna, Utah.*

Safety gear required for mine site visits.

Repairs and Strengthening of Brick Arch Masonry Storm Water Drains for MCGM

ICRI 2019 Project Award Finalist – Project of the Year, Water Structure Category
Mumbai, Maharashtra, India

By Kasturi Projects PVT, LTD

Fig. 1: Completed repair of the storm water drains in the City of Mumbai, India, that are over a century old and were constructed of brick arch masonry during the British Era

The storm water drains in the city of Mumbai, India, are over 100 years old and constructed with brick arch masonry during the British Era (Fig. 1). The storm water drains (SWD) were prone to frequent cave-ins. To prevent cave-ins, enhance their safety, and maintain the SWD system, the Municipal Corporation of Greater Mumbai (MCGM), under the Central Government of India "BRIMSTOWAD" Scheme, initiated a detailed survey and mapping of the SWD for the City of Mumbai.

Many of the defects identified in the brick structures were related to breaks in the masonry lining, allowing the surrounding soil to be washed into the drain and creating voids in the soil. Voids behind brick arches and buried pipelines are detrimental to their structural performance as they benefit from an even distribution of load to remain stable.

CAUSES OF DETERIORATION

Some of the causes for the deterioration identified include:

- Brick arch failure due to surcharge loading. The overloading was due to additional structures constructed over these buried storm water drains;
- Imposed loadings from new roads constructed over buried structures, increasing the surcharge load;
- Surcharging when a drain is not watertight, allowing water leakage into the ground significantly increasing the potential for soil erosion in the ground surrounding the drain;
- Deterioration and spalling of lining and brickwork (Fig. 2), some due to scouring. There was also bond failure due to ingress of water, undermining the integrity of the lining through corrosive effluents;
- Erosion of mortar joints (Fig. 3) impaired the structural strength of the drain, which if not rectified, would result in misplaced bricks;
- Excessive loading was generally the cause of longitudinal cracking. Circumferential cracking was infrequent;
- At one location, roots of an appreciable size penetrated the brick arch construction (Fig. 4). In this case, local collapse of the brickwork was a real possibility in the short term; and
- Hydrogen sulfide attack on concrete and mortar was observed over significant lengths of storm culvert, which receives sewage and storm water. The sulfuric acid attacks mortar, including the mortar matrix of concrete. In places, this corrosive attack penetrated to a considerable depth in the soffits. Deterioration at the waterline was much less frequent but was still quite severe.

STRUCTURAL REHABILITATION

The structural rehabilitation addressed all aspects of upgrading the structural performance of existing SWD and drainage systems. Three approaches normally considered were:

Repair: Repair systems and methods are used to rectify damage to the structural lining or the reconstruction of short lengths of drain, but not those affecting the substantial lengths of the drain line. Repair techniques include the more conventional approaches generally practiced by the municipal body but with greater attention to detail and quality of repairs.

Renovation: The concept of renovation embraces potential cost savings by retaining the most existing structural system possible. Using renovation techniques in this project proved the most expedient and cost-effective way of maintaining "the existing hole in the ground" by stabilizing and sealing the sewer lining where it was deficient, and adding strength to whatever structural sections were still viable.

In Britain, renovation methods typically offer 50% - 80% savings over replacement costs as the linings of the drain can proceed without excavation, temporary support, back filling, and commissioning as accompanied by significant reduction in the disruption of flows, and indirect costs incurred by the community.

Replacement: Replacement is frequently the solution for substantial hydraulic under-capacity, complete structural inadequacy or where other measures, such as supplemental reinforcing, are impractical or uneconomic. In India—where some techniques are unavailable or involve expensive imported technology, and where labor costs are cheaper—replacement is, in almost all cases, less expensive than the current cost of renovation options.

SUMMARY OF REHABILITATION SYSTEMS

Many methods are currently available for the repair, renovation, and replacement of drains. As the rehabilitation of drains in this project was restricted to man-entry sizes generally larger than 48 in. (1200 mm), methods suitable primarily for smaller drains are not mentioned. Methods used on this project include:

- Structural stabilization by grouting and repointing the brick lined arch drains;
- Preformed linings using pipe insertions, preformed segmental linings, precast dry-mix shotcrete, slip lining, cured in-place soft lining, spiral lining, cement mortar lining, and sprayed epoxy lining; and
- In situ reinforced sprayed concrete linings with protective coatings that produce of a monolithic, smooth bore concrete lining reinforced with a specialized protective coating providing protection against extreme acid attack.

REPAIR SYSTEM SELECTION

After detailed analysis and various deliberations, the in situ reinforced sprayed concrete lining with protective coating, along with extensive two layer grouting of cementitious non-shrink grout and polyurethane resin grouts for water control was adopted by MCGM. This methodology was chosen considering the advantages of renovation over replacement.

Fig. 2: Delamination and spalling of brick lining

Fig. 3: Erosion of mortar joints

Fig. 4: Root penetration through masonry lining

SITE PREPARATION

The repair process began with diversion of traffic to access manholes that are primarily on the road. The 24 in. (600 mm) diameter manholes needed widening to facilitate entry for crew and equipment. Temporary coffer dams to stop the flow of water (even during summer) were installed every 650 ft (200 m) along the drain. These dams were necessary since the drains carried both storm water and sewage. To divert flow of water to the downstream side, submersible dewatering pumps placed on the upstream side of the coffer dams were augmented with separate 12 in. (300 mm) diameter temporary pipes running to the surface. The pumping operation continued 24/7 until the section of drain was completely repaired. We were working near a residential area so diesel-operated "silent" generators, air compressors, and receivers were used to keep the working noise levels within the permitted range during the continuous operations. Hydrogen sulfide and other gas levels in the SWD were monitored daily before human entry. An effective ventilation system, lighting system, and emergency evacuation lifelines along with oxygen cylinders were installed in the drain to give the workers a safe working environment.

SURFACE PREPARATION AND DEMOLITION

In most areas, the internal brick masonry lining was eroded. Where deterioration was evident, the old lining was manually removed with 11 lb (5 kg) breaking hammers (Fig. 5). Lightweight hammers were used to avoid disturbing the bricks and mortar lining. After removal of the lining, the debris generated was taken out of the drains manually. High-pressure (7250 psi [500 bars]) waterjet washing was used to clean the brick surface and remove loose, damaged mortar pointing (Fig. 6). Loose bricks, where removed, were replaced with new bricks.

REPAIR PROCESS

The repair process included the following:

- Longitudinal cracking at the crown was opened and sealed with a non-shrink polymer and fiber-reinforced mortar. Thereafter, a 4 in. (100 mm) wide by 4 in. deep x about 8 in. (200 mm) length opening was made in the crown of the brick arch masonry and four to six #5 (#16M) diameter T or FE 500 D grade (500 MPa [72,500 lb/in^2]) steel reinforcement pins were installed with mortar anchors and the opening filled with polymer modified fiber reinforced mortar to have an effective "crack stitching" of the masonry crown. This was repeated for the full length of the cracks at a 20 in. (500 mm) spacing;
- Repointing the mortar joints where eroded;
- Injecting a two component sealing rigid polyurethane resin to stop water ingress into the drains (Fig. 7);
- Installing reinforcement FE 500D per the structural drawings and anchoring to the brick arch masonry at sufficient interval with anchors and spacers (Fig. 8);
- Wet mix shotcrete, M-30 Grade (30 MPa [4300 lb/in^2), was applied to the entire brick masonry internal surface at a thickness ranging from 5 in. (125 mm) to 9 in. (230 mm) per structural requirements (Fig. 9). The application was completed in one or two passes per site conditions;

Fig. 5: Demolition of deteriorated brick lining with lightweight breaker

Fig. 6: High-pressure waterjet washing

Fig. 7: Installed ports for injecting 2-component rigid polyurethane resin

Fig. 8: Fixing steel reinforcement

- Drilling 1 in. (25 mm) diameter x 22 in. (550 mm) long holes into the brick masonry (Fig. 10), installing injection packers, and grouting using a non-shrink cementitious, anti-washout grout, to the point of rejection (Fig. 11). The goal was to fill the voids behind the buried drain structure and into the mortar joints to strengthen the pointing; and
- Spray applying a 0.25 in. (6 mm) thick two-component mineral-based mortar system to form a lining that is resistant to aggressive environments (Fig. 12). The ceramic-based mineral coating can withstand extreme pH (3-12), chloride and sulfate loading, biogenic sulfuric acid attack, and abrasion. In addition, the coating is breathable, preventing damage due to hydrolysis and osmosis.

SUMMARY

This rehabilitation model (upon successful testing) was adopted by the MCGM, and as of 2018, over 3.1 miles (5 km) of SWDs have been successfully repaired.

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Fig. 9: Placing wet-mix shotcrete

Fig. 10: Drilling holes into the brick masonry

Fig. 11: Fixing injection packers and grouting using a non-shrink cementitious, anti-washout grout

Fig. 12: Spraying two-component mineral-based mortar system to form a lining

PROJECT TEAM

Repairs and Strengthening to Brick Arch Masonry Storm Water Drains for MCGM

SUBMITTED BY
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REPAIR CONTRACTOR
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MATERIALS SUPPLIERS/ MANUFACTURERS
MC Buachemie (I) Pvt Ltd
Ponda, Goa, India
Totale Global Pct Ltd
Thane, Maharashtra, India

Rajendra Kasturi Pai *After graduating with a BA in Science, Pai went on to complete a MA in Management and then completed a certificate course in Public Health & Sanitation. Thereafter, he joined the late Mr. R. P. Kasturi in establishing a Private Limited Contracting Company in 1996, to carry out sand blasting and specialized coating works, and then graduated into concrete repairs, dry-mix shotcrete placement, and waterproofing. To further gain professional knowledge he attended several continuing education programs namely, Injection Repairs and Protection of Concrete Structures, a two-week course conducted by BZB; Krefeld Germany, BTS Tunnel Design; a Construction Course from the University of Warwick, UK; and a Grouting Fundamentals and Current Practices & Tunneling at Colorado School of Mines, USA. He also has attended several major manufacturer trainings in grouting from BASF, MC Bauchemie, TPH, and GCP De-Neef, to name a few. He has currently around 30 years' experience in concrete repairs, waterproofing, dry-mix shotcreting, plumbing, and sanitation. Plus, in the past 7 to 8 years he has started using wet-mix shotcrete as an extension to the dry-mix shotcrete experience.*

ANNOUNCING

ACI'S SHOTCRETE INSPECTOR CERTIFICATION & ASA'S SHOTCRETE INSPECTOR EDUCATION

Shotcrete's growing use in construction and its reference in the newly released ACI 318-19, "Building Code Requirements for Structural Concrete," necessitates the employment of on-site inspectors who are knowledgeable about shotcrete materials, application, and quality. The ASA Shotcrete Inspector Education is an excellent review session for the material referenced in ACI's Shotcrete Inspector Certification Program and will count as part of the required work experience for certification. Look for a seminar near you, or request to host one!

WHO:

- ACI Certified Construction Inspectors or Field Testing Technicians;
- Testing lab or third-party inspection firms responsible for monitoring shotcrete placement; and
- Building officials, owners, or suppliers desiring a more thorough understanding of the requirements for quality shotcrete placement.

WHY:

- Gain insight to materials, equipment, and application techniques for quality shotcrete placement;
- Learn the visual clues essential to evaluate the quality of shotcrete placement; and
- Understand the ACI and ASTM specification requirements for materials, methods, testing, and protection for shotcrete placement.

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OSHA's Respirable Crystalline Silica Rule on Shotcrete Operations – Revisited

By Charles Hanskat

This is a revised version of the original article printed in the Summer 2016 of Shotcrete magazine before the OSHA rule was put in place. This revision has added site measured values for air monitoring of crew members on shotcrete projects, as well as ASA's response to OSHA's request for information in August 2019. Also, included is a short section on applicable respirators. With this revision our intent is to put the current information you need about the OSHA rule and its impact on shotcrete operations in one place for ready reference.

BACKGROUND

The Occupational Safety and Health Administration (OSHA) rule dealing with worker exposure to crystalline silica has been in force for just over three years. The rule represented years of effort by OSHA to develop a standard that is intended to help protect over two million construction workers from respirable crystalline silica. This is one of the biggest rules OSHA has developed, and it is addressed to two different workplace environments – construction and general industry/maritime operations. Our field shotcrete operations fall into the construction category. This is a very comprehensive standard addressing not only permissible levels of exposure, but also exposure monitoring, medical surveillance, and housekeeping.

Crystalline silica has been a known health hazard for decades. Significant levels of exposure can lead to silicosis, lung cancer, other respiratory diseases, and kidney disease. How is one exposed to respirable crystalline silica? Common job site concrete work including cutting, drilling, jackhammering, chipping, grinding, or sand blasting of concrete present the highest potential for exposure above the safe limits established in the rule.

The rule was published June 23, 2016, and OSHA started enforcement September 20, 2017. The rule deals with all exposures of respirable crystalline silica, except those environments that have proven exposure less than an action level of 25 µg/m^3 over an 8-hour time weighted average (TWA).

So, what about silica fume, a common supplemental cementitious material widely used in shotcrete? ACI defines silica fume, in CT-18 ACI *Concrete Terminology*, as "very fine non-crystalline silica produced in electric arc furnaces as a byproduct of the production of elemental silicon or alloys containing silicon." The key here is that silica fume is a NON-CRYSTALLINE material. However, most producers of silica fume do note that trace amounts of crystalline silica, less than 0.5% of the overall silica fume material, are present in their materials.

The OSHA rule significantly reduced the permissible exposure limits (PEL) in construction environments from the previous 250 µg/m^3 over an 8-hour TWA to 50 µg/m^3. Thus, even trace amounts of crystalline silica in silica fume may impact our shotcrete crew's exposures. All our shotcrete mixes use sand as an aggregate, so handling of quantities of sand in site batching operations, or from rebound may also produce small amounts of crystalline silica that add to the worker exposure. Also, many of our shotcrete projects involve repair of existing concrete, so surface preparation techniques may produce crystalline silica.

In the August 15, 2019 Federal Register OSHA publicly asked for further guidance on the effectiveness of engineering and work practice control methods not currently included for the tasks and equipment listed on Table 1 of the Respirable Crystalline Silica standard for construction. The agency also requested information on tasks and equipment involving exposure to respirable crystalline silica that are not currently listed on Table 1, along with information on the effectiveness of engineering and work practice control methods in limiting worker exposure to respirable crystalline silica when performing those tasks. Both dry-mix and wet-mix shotcrete were included in the OSHA request for information.

TWO ALTERNATIVE APPROACHES FOR COMPLIANCE PROVIDED IN THE RULE

The new rule offers two ways to be in compliance. The first method, and the one OSHA expects most contractors to use, provides a table (Table 1) that predefines specific equipment and associated exposure conditions, along with control and respiratory protection measures required. The second method applies to any tasks that are not listed in Table 1 and can be selected as an alternative by the Contractor for tasks in Table 1. Unfortunately, shotcrete is not covered in Table 1, so active monitoring is the only option available to shotcrete placement. However, for those shotcrete contractors doing repair or surface preparation that involves sawing, drilling, grinding, or hammering of hardened concrete many of those operations are covered in Table 1.

Work Tasks Covered by Table 1 - If your work environment is covered in Table 1, and you meet the specified engineering and work practice control methods, along with the required respiratory protection, you do not need to monitor for crystalline silica or comply with the PEL. It is also noted that if combined tasks from Table 1 sum more than 4 hours, the over 4-hour respiratory protection must be used.

Excerpt from Table 1: Specified Exposure Control Methods When Working with Materials Containing Crystalline Silica			
Equipment/Task	Engineering and Work Practice Control Methods	Required Respiratory Protection and Minimum Assigned Protection Factor (APF)	
		≤ 4 hours per shift	> 4 hours per shift
Jackhammers and handheld powered chipping tools	Use tool with water delivery system that supplies a continuous stream or spray of water at the point of impact.		
	– When used outdoors.	None	APF 10
	– When used indoors or in an enclosed area.	APF 10	APF 10
	OR		
	Use tool equipped with commercially available shroud and dust collection system.		
	Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions.		
	Dust collector must provide the air flow recommended by the tool manufacturer, or greater, and have a filter with 99% or greater efficiency and a filter-cleaning mechanism.		
	– When used outdoors.	None	APF 10
	– When used indoors or in an enclosed area.	APF 10	APF 10
Handheld power saws (any blade diameter)	Use saw equipped with integrated water delivery system (Fig. 1) that continuously feeds water to the blade.		
	Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions.		
	– When used outdoors.	None	None
	– When used indoors or in an enclosed area.	APF 10	APF 10
Handheld grinders for mortar removal (i.e., tuckpointing)	Use grinder equipped with commercially available shroud and dust collection system.	APF 10	APF 25
	Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions.		
	Dust collector must provide 25 cubic feet per minute (cfm) or greater of airflow per inch of wheel diameter and have a filter with 99% or greater efficiency and a cyclonic pre-separator or filter-cleaning mechanism.		

Figure 1: Using water with a cutoff saw when cutting materials that contain crystalline silica substantially reduces the amount of dust created during these operations.

Active Monitoring - This method requires monitoring for crystalline silica at times and with activities that represent the highest exposure conditions if the amount of silica may be at or above the action level of 25 µg/m^3.

- Measure and record the amount of silica that workers are exposed to over an 8-hour TWA for all the tasks the employee may be reasonably exposed to (Fig. 2). Exposure assessments must be repeated every six months or less if the exposure is above the action level, but below PEL. If exposures are above the PEL assessments must be every three months or less.
- Protect workers from exposure to crystalline silica above the PEL of 50 µg/m^3 over an 8-hour TWA. If control of the PEL below the 50 µg/m^3 is not feasible, supplemental respiratory equipment may be needed.
- Use dust controls to protect from silica exposures above the PEL of 50 µg/m^3.
- Provide proper respirators to workers when dust control measures are not adequate to limit exposures to the PEL.

Figure 2: Worker with cutoff saw and personal air monitoring equipment.

The monitoring option further requires employees to be notified in writing of the assessment results of the monitored levels of crystalline silica within five days. Also, if the PEL of 50 µg/m^3 is exceeded, the employees must receive written notification of the corrective actions taken. Additionally, the employee (or their designated representative) MUST be allowed to observe the monitoring. The observer must also be provided clothing and equipment to protect them from exposure at no cost to the observer.

ADDITIONAL REQUIREMENTS FOR BOTH ALTERNATIVES

The construction employer must:

- Produce, and implement a written exposure control plan. The plan must identify tasks that produce exposure, and engineering and work practice methods used to protect workers. This may include restricting access to particular work areas where high exposures may occur. Also, the plan must include housekeeping methods for dust control.
- Designate a "competent person" to implement the written exposure control plan in the workplace, with frequent and regular inspections to verify compliance. The competent person must be capable of identifying existing and foreseeable respirable crystalline silica hazards and have authorization to take prompt corrective measures to eliminate or minimize them.
- Implement housekeeping methods to control and limit dust that may contain silica. This includes prohibiting any dry sweeping or brushing, and no cleaning of clothes or surfaces with compressed air. Wet sweeping or HEPA-filtered vacuuming are allowable options.
- Must offer medical exams including chest X-rays and lung function tests every three years for workers who are required to wear a respirator for 30 or more days a year. The medical exams must be conducted by a physician or other licensed health care professional (PLHCP) who's legally permitted scope of practice allow them to independently provide these medical evaluations. Employers must make available an initial baseline medical exam within 30 days after the initial assignment to the work covered by the rule. The PLHCP provides a written medical report to the employee within 30 days that includes: the results of the exam indicating any medical condition that would increase their risk after material exposure to silica; any recommended limitations on employee's use of respirators; and recommended limits on the exposure to silica; and if there are concerns about the results of the chest X-ray where additional evaluation by a specialist is appropriate. The PLHCP must give the employer a report with much more limited information including only: the date of the exam; a statement they have met the requirements of the OSHA rule, and any recommended limitations on the employee's use of respirators.
- Communicate to all workers potentially exposed to silica the health hazards associated with exposure to respirable crystalline silica and identify all MSDS that include crystalline silica. The employer must communicate at least the potential hazards that result in cancer, lung effects, immune system effects and kidney effects.

- Provide information and training sessions that identify: work operations that could produce silica exposure; specific measures the employer implemented to protect employees from exposure to silica; the identity of the competent person; and the purpose and description of the medical surveillance program. The contractor must further ensure that each employee can demonstrate knowledge and understanding of the training.
- Maintain accurate records for 30 years of:
  - » All exposure measurements – including name, social security number (SSN), and job classification of all employees represented by the monitoring, and indicating those employees who were actually monitored.
  - » The objective data – including the crystalline-containing material, the source of the data, and the testing protocol with results of the testing.
  - » Each employee covered by medical surveillance including name, SSN, all PLHCP reports and information provided by employer to the PLHCP.

OSHA REQUEST FOR INFORMATION – AUGUST 2019

In the August 15, 2019 Federal Register, OSHA publicly asked for further guidance on the effectiveness of engineering and work practice control methods not currently included for the tasks and equipment listed on Table 1 of the Respirable Crystalline Silica standard for construction. OSHA also requested information on tasks and equipment involving exposure to respirable crystalline silica that are not currently listed on Table 1, along with information on the effectiveness of engineering and work practice control methods in limiting worker exposure to respirable crystalline silica when performing those tasks. This gave us an opportunity to provide OSHA input on potential shotcrete-specific revisions to the rule.

ASA put out a request for input to our corporate members and received some testing results documenting their crew exposure limits on specific projects. The results on three different wet-mix jobs were quite variable:

Nozzleman	12, 32, and 34 µg/m^3
Pump Operator	11.5 µg/m^3
Finisher	9, 12, and 24 µg/m^3
Blowpipe	17 µg/m^3

With those results our response to OSHA included:

"Thank you for the opportunity to comment on Item 23 - Application of Dry-Mix or Wet-Mix Shotcrete.

Shotcrete placement uses two different processes, wet-mix and dry-mix. Wet-mix uses premixed concrete and then accelerates from the nozzle at the end of the delivery line with air. Dry-mix uses relatively dry concrete materials conveyed by air through the delivery line and adds water at the nozzle to create the wet concrete mix and accelerate into place.

Wet-mix has less dust than dry-mix as water is added much earlier in the process. However, there are shotcrete accessories that pre-dampen the dry-mix materials or add water earlier in the flow of materials through the delivery line to reduce dust and improve mixing.

Shotcrete placement is always conducted on a concrete construction job site. Shotcrete placement is sometimes conducted indoors or in confined spaces, but more commonly is exposed to the outdoor environment. As a result, wind can affect the material stream and movement of dust from the placement location. However, to prevent stray material and dust from reaching adjacent areas often shotcrete placement is contained by plastic sheeting or tarps.

Thus, you can see we have many variables as a result of material, equipment, placement techniques and job site conditions. It is hard to envision a single Table 1 entry that covers shotcrete, or even two that covers our two processes.

Our Association is the largest international group dedicated to high quality, efficient and safe shotcrete placement. A large majority of our members are shotcrete contractors or field crew members conducting work throughout North America. We are investigating how to work together with our members to support collecting of representative data industry-wide in formats and quantities needed for OSHA consideration.

Several of our members have independently conducted onsite monitoring of their shotcrete crews during shotcrete placement. Those crew members not in close proximity to the nozzle, such as the concrete pump operator in wet-mix, have experienced 8-hour TWA concentrations well below the 25 µg/m^3 Action Level for respirable crystalline silica. Crew members close to the nozzle stream (nozzlemen, blow pipe operators, hose draggers) have experienced levels from below the 25 µg/m^3 AL level to as high as 34 µg/m^3 (still below the 50 µg/m^3 PEL). Variations coincide with the location (indoor or outdoor), equipment, nozzleman, process and environmental conditions such as wind. Shotcrete contractors generally provide respirators to their crew most directly exposed to the dust from shotcreting operation.

We'd like guidance on how we could document specific tasks for potential inclusion in Table 1 or in the "Alternative Exposure Control Methods" portion of the standard. It appears this would require collecting "objective data" with air monitoring data from industry-wide surveys demonstrating employee exposure to silica associated with a specific process, task, or activity. OSHA states that the data must reflect workplace conditions closely resembling, or with a higher exposure potential than, the processes, types of material, control methods, work practices, and environmental conditions in the employer's current operations.

The terminology "workplace conditions closely resembling" is rather hard to quantify. How closely do the conditions need to be the same? How many different aspects of the site conditions would need to be documented for each site monitoring data collection? How many individual samples and locations would need to be collected to be acceptable to OSHA for documenting exposure for a specific task and exposure?

Ultimately with an investment in time and effort we hope to make it easier for our member contractor companies and crew members to meet the OSHA requirements for their shotcrete work. To help us accomplish this task we would appreciate your input on how we can best approach developing, documenting and conducting an industry-wide survey that would meet OSHA's requirements."

We have not as of this date had a response from OSHA. However, given the impact of COVID-19 and the government and construction industry in March 2020 it may well have delayed any response.

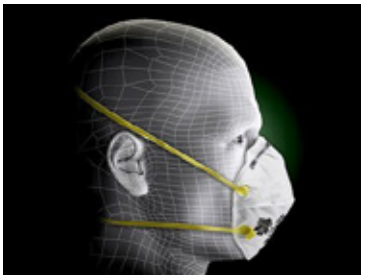

Figure 3: 3M N-95 Particulate Dust Mask

DUST MASKS AND RESPIRATORS

For workers under the 25 µg/m^3 actionable limit no respirator is required. However, a N-95 dust mask (Fig. 3) can provide the crew member better protection against dust encountered during an 8-hour workday. The double rubber band paper mask meets OSHA and NIOSH minimum requirements. The N series is for environments free of oil aerosols. The R series is resistant to oil mist for up to an 8-hour shift, and the P series is oil proof with time use restrictions specified by the manufacturer.

The problem with the double rubber band dust masks is when the worker breathes, the exhaust breath has nowhere to escape but upward around the nose causing the worker's safety glasses to fog up. Another issue with the paper mask is that a worker can go through many paper masks in one day. Moist breath, sweat or other types of contamination in the air can necessitate one or more new masks during the workday.

When evaluating the costs of disposable dust masks compared to the cost of a fitted half-face mask respirators, many companies find the fitted half mask respirator is more cost effective. The half mask respirators are made to be reusable, so it can be cleaned and disinfected on a regular basis. The only ongoing cost is the cartridges and prefilters.

For workers between the 25 µg/m^3 actionable and 50 µg/m^3 PEL the Assigned Protection Factor (APF) 10 level of respiratory protection can be met by a fitted half-face air-purifying respirator fitted with P100 particulate filters (Fig. 4). Fitted respirators require both a qualitative and quantitative fit test and generally need the worker to be clean shaven for best efficiency.

For those workers or companies looking for more protection, higher APFs can be met by:

- Full facepiece air purifying respirator (APF 50) (Fig. 5)
- Powered Air-Purifying Respirator, half-mask (APF 50) or full facepiece (APF 1000)
- Supplied-Air Respirator or Airline Respirator (APF 10 to 1000)
- Self-Contained Breathing Apparatus (APF 10 10,000)

Refer to OSHA CFR 1910.134 – Respiratory Protection for more input on respirators and their protection levels.

Figure 4: 3M Half-face Air Purifying Respirator with P100 Filters

Figure 5: 3M Full-face Respirator

SUMMARY

OSHA's rule for control of exposure to crystalline silica is very comprehensive and intended to protect workers on our job sites. This is one of the most comprehensive rules OSHA has promulgated and introduced extensive medical monitoring and recordkeeping requirements that will require a significant increase in the contractor's required duties that will certainly require more staffing to implement. In this article, we have introduced most of the key points, however you should visit the OSHA website (www.osha.gov/silica-crystalline) where extensive documentation on the rule, along with FAQ, and the text of the rule are readily available.

The rule has been in full effect since 2017. You should certainly review all the provisions of the rule and determine what your company needs to do to meet the requirements. At this time, site monitoring seems to be the only method that meet the OSHA requirements. Regarding our request to OSHA for more guidance on producing a "standard engineering control method" for our variety of shotcrete placement activities progresses, we will keep you informed.

The key here is that silica fume is a NON-CRYSTALLINE material. However, most producers of silica fume do note that trace amounts of crystalline silica, less than 0.5% of the overall silica fume material, are present in their materials.

Charles Hanskat *is the ASA Executive Director. He received his BS and ME in civil engineering from the University of Florida, Gainesville, FL. Hanskat is a licensed professional engineer. He has been involved in the design, construction, and evaluation of environmental concrete and shotcrete structures for over 40 years. Hanskat is also a member of many ACI, ICRI, ASTM and AREMA technical committees that deal with shotcrete and environmental structures.*

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Getting Back to Work

By Ted W. Sofis

THE SHUT DOWN

The COVID-19 Pandemic affected our lives in ways none of us have ever experienced in our lifetimes. I've been in construction for 45 years and I have never seen our economy shut down, businesses closed, or people required to stay at home. In 2001, the attacks of September 11th temporarily shut down air travel and the stock market, but the American economy remained intact and air travel resumed within a couple of weeks. However, COVID-19, has affected our lives in ways that we could never have imagined. Schools and universities were closed; professional, collegiate and high school sports seasons were suspended and canceled; and restaurants and businesses were closed. We were told to stay home and work remotely, if possible, and businesses across the country followed those directives.

In recent months, on bids that I've submitted, I dealt with estimators working from their homes. In Pennsylvania, we were issued stay at home orders and our offices were closed. Only essential and emergency work could be performed. Construction was not among the industries given an exemption. Initially, the wording from our governor was all but essential businesses were to be closed. Within a week that was amended to only "life sustaining" businesses could remain open. In other states, like Florida and North Carolina, construction work continued. And in Florida, I was informed, more DOT work was scheduled to take advantage of the decreased number of drivers on the roadways.

REOPENING THE ECONOMY

Counties in Pennsylvania were coded red, yellow, and green for the various stages to reopening. In Pittsburgh where I live, we moved into the Green Phase on June 5th, meaning that we could open and perform work as long as we observed the state's COVID-19 protocols. These mandated procedures included the

Emergency Tunnel Repairs

SHOTCRETE HELMET PAPR PROTECTS AGAINST COVID-19

By Nick Quail

Shotcrete Helmet is the most advanced respirator for Shotcrete application today. It is also a very highly rated respirator for the protection against COVID-19, a virus transmitted by droplets. The challenge is to convince customers to wear a Shotcrete Helmet Powered Air Purifying Respirator (PAPR) instead of disposable masks, like N95 or filtering facepieces. Why? Because the Shotcrete Helmet PAPR respirator will offer a more secure form of respiratory protection.

Here are eight "talking points" of why a Shotcrete Helmet PAPR will afford you better protection against COVID-19 than N95 respirators or cloth masks:

1. The Shotcrete Helmet is a unique, compact "all-in-one" respirator system. You do not need visors, goggles, or other PPEs. It is a total and complete protective device without hoses, cables, or other accessories located on a belt. Batteries, blowers, and filters are all part of the Shotcrete Helmet itself.
2. Shotcrete Helmet's fan and filter air intake system is located at the back of the helmet. As a result, the air intake area is farther away from the potential droplets area. A dual set of powerful fans takes air in through the twin filters and pressurizes the air into the helmet.
3. Exhale air valves are located away from the mouth and nose of wearer and built into the lower area of the fabric collar. You can further protect the collar exhale valves from contamination by wearing coveralls with a collar.
4. The Shotcrete Helmet uses HE filters that are 99.97% - efficient against DOP (0.3 micrometers). This means it has a higher filter capacity than most common protective devices. Only PAPRs, such as the Shotcrete Helmet, can use HE filters. Most disposable masks used in healthcare are only 95% efficient. As the Shotcrete Helmet uses positive pressure, impurities are kept out by the pressure of filtered air and not pulled in by inhaling.
5. The Shotcrete Helmet differs from common respirators as it has a fixed visor that makes for zero risk of aerosol penetration.
6. No accessories, no hoses, no cables, no straps to avoid any contamination. The Shotcrete Helmet is easily washed and cleaned.
7. The user does not need to do a "fit test" as needed for common respirators. Anyone with beard, mustaches or eyeglasses can wear the Shotcrete Helmet.

Railroad Tunnel Shotcrete Repair

wearing of face masks, providing hand washing stations, cleaning and disinfecting surfaces, and equipment every day or every shift. As I drove home from the office on June 5th, I noticed that traffic was returning to normal for the first time in three months. Georgia and Texas began reopening long before we did. The timetables, for reopening have varied from state to state and in Pennsylvania, from county to county.

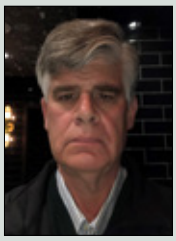
RETURNING TO NORMAL

So, questions remain. Where do we go from here? Will we be able to make up for the months we lost? How will the COVID-19 restrictions and procedures affect our productivity? In the northern US states and in Canada we lost a significant part of our construction season. As we ramp up our activities we can begin to address these questions and issues. I can't claim to have the answers to these concerns, but I do know this. Shotcrete work is difficult and it requires people with determination to perform the work. I've always felt that being a good shotcrete nozzleman requires certain personal qualities. There is a degree of toughness that all good nozzlemen seem to possess. It takes people with confidence and self-reliance and a certain amount of cockiness, to do the work we do, and to do it well. I have confidence that the work will get done. I believe when we get back into the swing of things we will make up for much of the lost ground. I say this because I know the people in the industry and the nature of who we are.

***Ted Sofis** and his brother, William J. Sofis Jr., are the Principal Owners of Sofis Company, Inc. After he received his BA in 1975 from Muskingum College, New Concord, OH, Ted 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 40 years of experience in the shotcrete industry. He is a member of various ASA committees and an ACI Shotcrete Nozzleman Examiner for shotcrete certification. Over the years, Sofis Company, Inc. has been involved in bridge, dam, and slope projects using shotcrete and 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.*

8. The Shotcrete Helmet reduces consumption of disposable masks, that means less cost of maintenance and less environmental impact.

Shotcrete Helmet



***Nick Quail** is a member of ASA and the President of shotcretehelmet.com, The St George Company. He started as the Technical Manager of The St George Company after receiving his BA from the University of Waterloo, Waterloo Ontario, then went on to become the President after buying the company in 2006. Nick has over thirty years of experience in the respiratory protection business and supply's helmet respirators to all fields of industrial, medical and agricultural applications.*

COVID Q&A

How has COVID affected your volume of work?

Our volume of work was not impacted. However, everything is online now and not in person or via travelling.

What COVID related changes are working well in your field work processes?

My "field work" was primarily in-person meetings. All of these are now replaced by web-meetings.

Axel G. Nitschke, Ph.D., P.E., VP,*
Tunnel Practice Leader (NATM), WSP

How has COVID affected your volume of work?

We, mutually with the owner, had to cancel a large job due to COVID, since the measures and safety procedures we would have had to implement were too costly compared to our pre-COVID pricing.

What COVID related changes are working well in your field work processes?

All of our supervisors and crew are taking COVID seriously and are implementing the safety protocols necessary to protect themselves and those working around them. They understand that if anyone in the crew gets sick, they all have to be quarantined for 14 days.

What do you find most challenging in providing COVID protection to your crew?

The most challenging time was in mid to late March when it was very difficult to purchase respirators and face masks due to the lack of inventory. Thankfully, the unavailability of those items was short-lived.

Randle Emmrich, President,
COASTAL GUNITE CONSTRUCTION COMPANY

Water vs. Air Clean Out Procedures

Is air or water better for clearing shotcrete material lines?

By Frank Townsend, Ross King, and Lars Balck

Improper clearing of wet-mix shotcrete material hose is a frequent cause of accidents. Cleaning out a hose looks easy and it would seem that a hose full of compressed air is harmless. How hard can this be? "Just hold down the end of the hose while we pump out the material" is the popular notion. But this is dangerous! Check out the YouTube video, "BOOM! He didn't see that coming" and you can witness how dangerous this approach to clean out can be. Fortunately, the individual in this video wasn't seriously hurt, but he definitely could have been.

Some burly nozzlemen think they can manhandle the end of a concrete hose when using compressed air to clear concrete out of the line. What they soon learn is the hose will whip out of their hands, launch them into the air, while spraying concrete over everyone nearby. Plus, there's the potential for injury when the 2 lb (1 kg) coupling at the end of the hose whips around and hits a crew member in the head.

Many videos can be found on the internet that demonstrate the hazards of clearing a concrete line using compressed air. There can be no argument - using compressed air to clear a concrete line is much more dangerous than using water. The reason is simple. Air is compressible, water is not. Compressing air is like compressing a spring. When the spring or air is released there is a sudden release of energy which, for the shotcrete hose, is an explosive discharge out the end of the hose. As you saw in the above mentioned YouTube video, a burly man was thrown 15-20 ft (4.5-6.0 m) through the air splatting into the muddy ground. How did this happen? The air compressed behind the concrete in the line and when it reached the end of the line there is a sudden, massive release of energy. Compressed air is stored energy. When blowing out a delivery line with air you must use extreme caution. The exit end of the hose MUST BE CONTROLLED. Water on the other hand, doesn't have the same explosive potential as air since it doesn't compress and store energy. Water will also do a better job of cleaning cement paste from the interior of the line.

Most experienced contractors use both air and water to clear their lines. First, begin cleanup right after shooting is complete. Don't wait. Waiting allows the concrete to stiffen, making the cleanup more difficult. Next, restrain the hose discharge end with a positive restraint. This may be a tractor bucket, tiedown or specially fabricated steel box to restrain the end and capture the waste concrete. Compressed air can then push out the bulk of the fluid concrete followed by filling the hose with water and inserting a sponge (often called a pig, or go-devil) pushing the water out to clean the interior wall of the delivery line. Finally, compressed air is again blown through the line.

WET-MIX HOSE CLEARING:

With wet-mix shotcrete, all the concrete ingredients including water, are mixed together prior to pumping. The fluid concrete mixture is pushed through the material hose by a concrete pump at a pressure of between 1000-1250 psi (6.9-8.6 MPa). That is ten times the pressure in a dry-mix shotcrete hose, making wet-mix clean out much more dangerous. As long as the concrete remains fluid, the lines are usually easy to clean. However, at the end of a long, hot day concrete can quickly build up in the line, making clean up more hazardous.

Below are recommended procedures to clear a wet-mix shotcrete line:

Using air:

1. After shooting is complete stop pumping and reverse the pump (to relieve pressure)
2. Empty the pump hopper
3. Disconnect the reducer/elbow (candy cane) from the hopper and restrain, using tractor bucket or other similar restraint
4. Remove the nozzle and attach an airline injection adapter
5. Restrain the exit end of the hose
6. Have one person carefully, slowly, inject air while a second person in direct contact with the person controlling the air valve monitors the hose exit. Slowly increase air volume until concrete begins flowing out of the elbow. As soon as movement occurs decrease the air flow (usually only ¼ to ½ the initial air flow is needed).
7. After the line has been cleared, fill 10 ft (3 m) of the line with water and insert a pig
8. Attach air adapter and push the pig through the line using air for extra cleaning
9. Blow air through the line a final time

Using water (safer):

1. After shooting is complete, stop pumping and reverse the pump
2. Empty the hopper
3. Fill hopper with water
4. Remove the nozzle and place exit end of hose into a bucket of water
5. Reverse pump to draw the water and concrete and into the hopper
6. Before completely emptying bucket, stuff sponge into the end of the line and suck the sponge into the hopper (sponge will stop at reducing elbow) cleaning the line
7. Empty and clean hopper

DRY-MIX HOSE CLEARING:

Dry-mix shotcrete uses air flow to transport a dry mixture of aggregate and cementitious material. The dry concrete material only fills a portion of the hose and is carried to the nozzle by air flow at a pressure of 100-120 psi (0.7-0.8 MPa). When shooting is stopped for more than 45 minutes, the material hose should be cleaned out. The dry-mix material hose should only have a small accumulation of dry concrete materials which is easily cleared by running pressurized air (air (100-120 psi) from the shotcrete gun through the hose). Although there generally isn't sufficient moisture in the line to create a blockage, anything can happen on a shotcrete job so the nozzleman and crew should be prepared for a burst of material from the end of the hose. Restrain the exit end of the hose.

Procedure:

1. After shooting is complete continue running air through the material line
2. Stop the gun
3. Remove the nozzle
4. Run more air through the line
5. Kink the hose for a few seconds then release the kink to cause a buildup of pressure followed by a sudden release to clear any buildup. Repeat a few times.

SUMMARY:

We started with the question, whether line cleanout should be done with air or water. Water is preferred because it doesn't have the explosive potential of air, making it safer, because water not compressible. Compressed air, on the other hand, is readily available on all jobs. However, as we discussed, working with compressed air can be hazardous. Each shotcrete company must develop specific safety procedures for cleanout based on their individual equipment and conditions. Proper training of shotcrete crew members on the requirements for safe cleanout should be a top priority.

Keep in mind cleanup typically occurs at the end of the day when shooting is finished, and everyone is tired. The mindset for many, unfortunately, is that when shooting is complete the job is complete. Cleaning up isn't production, so just leave that to others. The reality is, the job is not done until the equipment is put to bed (cleaned up) and the shotcrete is protected (cured). When the equipment is safely cleaned, and the freshly placed shotcrete is being cured then everyone can go home knowing that the day's work was been done right. Don't become the next macho flying man.

The key to cleaning out concrete lines is a containment box or restraining the exit line. Below are examples of containment boxes that restrain the exit.

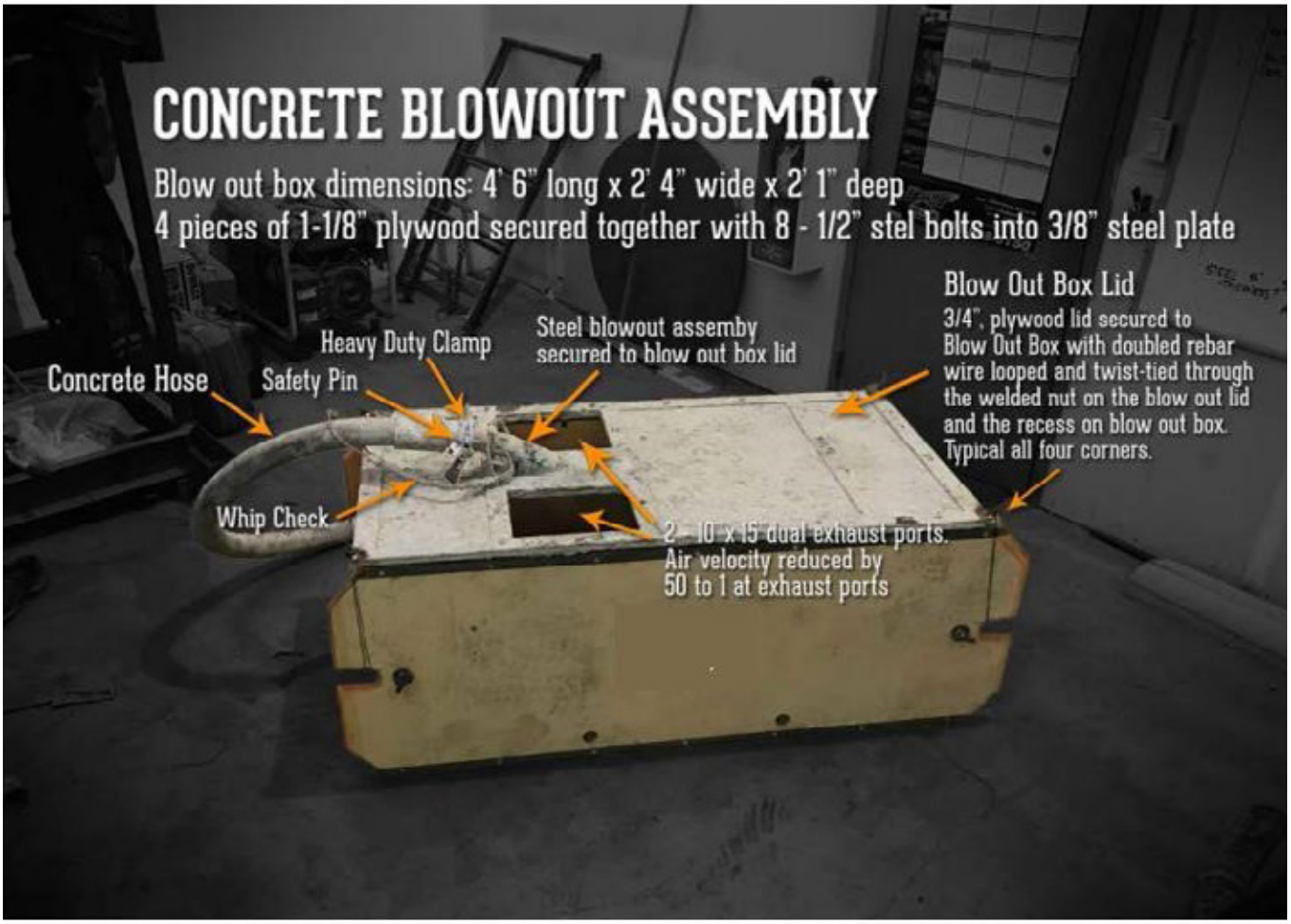


Fig. 1. Containment box

Another example of a containment device to control line cleanout and allow for waste concrete removal.

Fig. 2. Concrete blowout assembly, image courtesy of B. Russell

American Shotcrete Association's "ASA Safety Guidelines" and American Concrete Pumping Association's "ACPA Safety Bulletin" both recommend NOT to use air to clear a concrete line. Members of these two organizations pump a large majority of concrete in the USA and Canada and have learned through their long experience why air cleanout can be so dangerous. So, while air might be easier and more readily available, it must only be used with proper training and safety protocols in place.

Frank E. Townsend III *is the President of Patriot Shotcrete. He received his bachelor's degree in civil engineering from Worcester Polytechnic Institute, Worcester, MA, and his master's degree from the University of Missouri, Columbia, MO. Townsend served the U.S. Army Corps of Engineers and his diverse military background has led to him being deployed around the world. He is an active member of ACI Committee 506, Shotcreting, and the American Shotcrete Association. He has been Awarded the U.S. Army Corps of Engineers' deFluery Medal and Engineer News-Record New York's "Top 20 under 40" design and construction leaders in 2016. He is a member of the Moles and Beavers, which are fraternal organizations of the heavy construction industry.*

Ross King *is Vice President of Business Development for Consolidated Shotcrete in Toronto, ON, Canada. He has more than 40 years of experience as a Principal in the heavy concrete construction business.*

Lars Balck *is a Concrete Consultant and ASA/ACI Nozzleman Examiner. He recently retired from CROM, LLC, as a Senior Vice President. He has been involved in the design and construction of prestressed concrete tanks built with shotcrete for over 40 years. He received his bachelor's degree in civil engineering from the University of Florida and served with the U.S. Army as First Lieutenant in Vietnam as a Combat Engineer. Balck is a Past President of ASA. He is Chair of ACI Subcommittee 506-C, Shotcreting Guide; a past Chair and current member of ACI Committee 506, Shotcreting; and a member of ACI Committees 376, Concrete Structures for Refrigerated Liquefied Gas Containment; 563, Specifications for Repair of Structural Concrete in Buildings; and C660, Shotcrete Nozzleman Certification.*

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ASA's 2021 Outstanding Shotcrete Project Awards Virtual Celebration - March 24, 2021

Mark your calendars! ASA will host the 2021 Awards Celebration virtually, announcing our 2020 Award winners! The ASA Outstanding Shotcrete Project Awards Program recognizes excellence andinnovation in projects where shotcrete placement played a significant role. Awards are granted in the following six categories:

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

Awardees will be given the opportunity to showcase their accomplishments virtually and share impressive details through interviews. Event will be streamed live and offer unique sponsorship opportunities. This year's virtual format allows for even greater exposure to the industry to promote the innovative and outstanding capabilities of shotcrete placement. Plan to be a part of this year's celebration!

Make arrangements to support the awardees by viewing in the comfort of your home or with your fellow colleagues. As our planning for this event progresses, updates will be available at www.shotcrete.org and our monthly What's in the Mix eNewsletters. Sign up today if you are not receiving the newsletter: https://shotcrete.org/news/asa-e-newsletter-subscribe/

SHOTCRETE CONVENTION & TECHNOLOGY CONFERENCE

ASA 2021 Shotcrete Convention & Technology Conference - Rescheduled

The impact of COVID-19 proves to be further reaching than anyone would have imagined eight months ago. After much deliberation and feedback from our members, ASA's Board of Directors decided to postpone the 2021 Shotcrete Convention & Technology Conference until 2022. It became apparent that we would not be able to provide the same unique opportunity in 2021 to explore and showcase shotcrete applications and innovations to the standards previously associated with ASA Conventions. This decision also acknowledges that the opportunity to network and connect with experts in the shotcrete industry contributes significantly to attendee participation. We look forward to providing these opportunities again when it becomes safer and more feasible to do so.

Save the Dates: February 27 – March 1, 2022 | ASA 2022 Shotcrete Convention & Technology Conference

The Sonesta Resort Hilton Head Island, Hilton Head, SC, will remain the venue for ASA's 2022 Shotcrete Convention and Technology Conference. Speakers will be contacted separately with options related to this change in plans. For those interested in submitting abstracts for consideration at the Convention in 2022, the Call for Presentations will remain open until August 1, 2021. Those interested may submit the title of the proposed presentation, speaker information and a short (less than 100 word) abstract to be reviewed by the ASA Technical Committee. Submissions and or questions should be directed to Charles Hanskat (248.983.1701): Charles.Hanskat@Shotcrete.org.

Until we can once again meet safely in a face-to-face event, the work of the Association will continue via Virtual Committee Meetings, Webinars and ASA's Outstanding Shotcrete Project Awards Virtual Celebration! We are working diligently to provide you with a host of Virtual options for learning and connecting with ASA in 2021. Do join us for these amazing opportunities, as they are more accessible than ever right from your computer!

asa
The Art of SHOTCRETE
Photograph Contest

Become "Instagram Famous"

ASA launches a new photo competition! Showcase the Art of Shotcrete by tagging ASA in your Instagram photos. Photos should highlight techniques and designs that show the creativity, functionality, and beauty of shotcrete. Photos will be judged quarterly by ASA's Marketing Committee and winning photos will be featured in Shotcrete magazine and ASA's social media platforms.

There's no limit to the number of images you can submit, so take photos often and submit often. This is an easy way show off your work to the shotcrete community… and be famous!

Submission is easy, add @ArtofShotcrete to your next Instagram post to submit your photo. Submissions close at the end of the 4th quarter, December 31, 2020.

asa QUALIFIED CONTRACTOR

ASA's Contractor Qualification Program – New Webpage!

ASA's Contractor Qualification Program (CQP) establishes a shotcrete contractor's qualifications through a rigorous review of the contractor's past work by the ASA Contractor Qualification Review committee.

Those who have successfully completed the program receive:

- Certificate of Qualification
- The Value of the ASA Qualified Contractor Designation – one-page summary for inclusion on Bid Submissions
- Press-Release template
- Use of the ASA Qualified Contractor Seal for website and promotional materials
- Hard Hat stickers of the same are exclusively available to Qualified Contractors and will be mailed to you in a separate envelope.
- Listing of Qualified Contractors in **Shotcrete** magazine, ASA promotional materials at tradeshows and ASA sponsored events, e.g. ASA Conventions
- NEW - Your listing on the ASA Qualified Contractor webpage

Check out the new ASA Qualified Contactors webpage at www.shotcrete.org/education-certification/asa-qualified-contractors to see who's currently listed as the best of the best in the shotcrete industry!

Tribute to William Glen Allen - 1953 - 2020

By Monica Rourke

What can I say about someone who could light up a room with his smile? Bill and I knew each other for over 20 years. We were not "best friends," but we were colleagues, co-workers and we shared relationships with many of the members of ICRI, ASTM, ACI and the American Shotcrete Association.

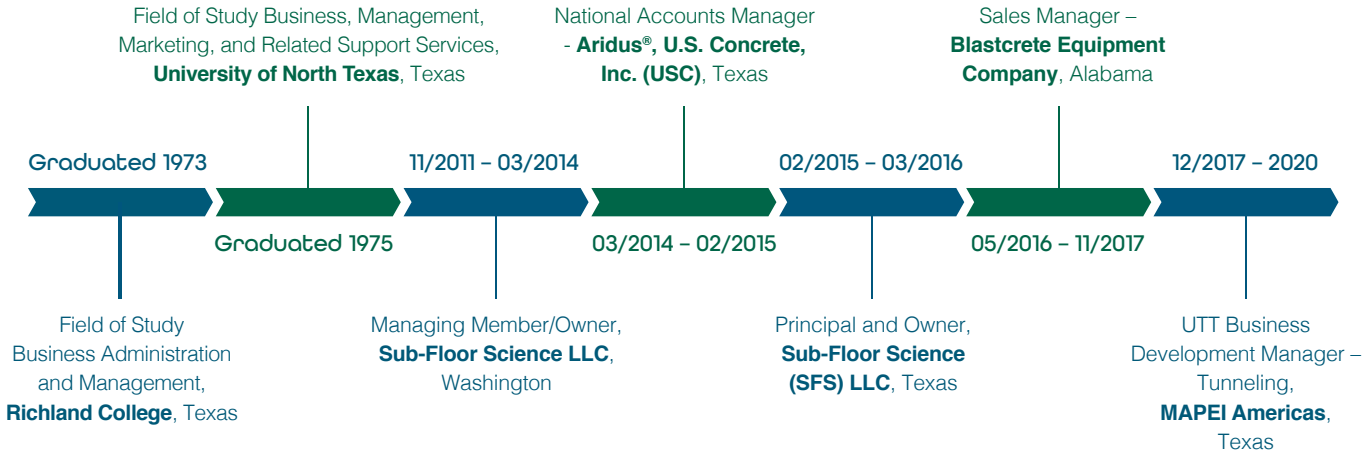
Bill was living proof of what it means to be a truly genuine person. He was a good boss to the people in his charge, an enthusiastic and knowledgeable colleague, a loving father to his two sons, Noah and Gabriel, and a devoted grandfather. He was also a passionate believer and participant in the Jewish religion, loving the Jewish faith and tradition. In November 2019, he managed his "bucket list" wish to travel to Israel, and that journey brought him a sense of courage and peace to face his remaining days with dignity and strength. The character of the life he lived might be summed up in a few words: sincerity, passion and loyalty.

Bill gave energy, commitment and inspiration to his staff and to others with whom he worked. My co-workers at Mapei remember Bill as a happy person, one who not only was cheerful in himself but who gave much cheerfulness to others. He had a beautiful smile, a quirky sense of humor and a gentle demeanor. Bill was bright, logical and systematic in his thinking. He was always willing to share his ideas and information. He was passionately interested in the future of the shotcrete industry and regretted that he would not have the time to spend doing the research and testing he had planned for the future. He was our "go-to" shotcrete expert!

I am sure Bill will be remembered by many for his knowledge and achievements within the shotcrete industry, but he will also be remembered fondly for his friendly smile, his beguiling laugh and his generous heart. He was never one to shy away from a "good joke," a fun time or a mischievous escapade. And there were a few over the years! Perhaps some of you reading this tribute are smiling with your own special memory that you shared with Bill and that's exactly what he would have wanted – no tears – just smiles.

Albert Einstein said, "The value of a man should be seen in what he gives and not in what he is able to receive." In one word, Bill Allen was a man who gave. He gave much to his work, to his faith, to his family and to the future of our industry. And I was proud to call him my friend.

That is why, ladies and gentlemen, I invite you to pause as you are reading this tribute and remember a special time or a moment that you shared with Bill, and if that memory brings a smile to your lips, then Bill would be happy. This is far more than saying "goodbye" to this joyfully talented man, it is a commemoration of his life and his contributions. A candle whose brilliance will light the future and whose unique simplicity and humbleness will inspire many both personally and professionally for years to come. I think of Bill during the last months of his life… Our conversations and his ability to make me feel good about his impending "passing," and that too many times it was him consoling me and making me laugh, instead of the other way around. What can I say? That was Bill. Service above self. A life too short, but a life well spent and well-remembered.



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UMA Geotechnical Construction's Brian DeSpain Promoted to President

Brian DeSpain has been promoted to President of UMA Geotechnical Construction. The company stresses that the active, day-to-day involvement of the top officers will not change. Former president Jim DeSpain, now CEO, will continue to focus on finance and contractual relationships with customers. The transition ensures that UMA will maintain its ongoing commitment to strong client relationships while providing innovative geotechnical solutions for the industrial and commercial construction sectors.

With a background in construction management, geotechnical engineering management, and strategic planning DeSpain, co-owner of UMA, has guided the company through economic downturns while maintaining consistent growth year over year. UMA completes hundreds of projects each year and is expecting record growth in 2020 despite "the new normal." The contractor even expects to add two more drilling rigs in the coming weeks to meet growing demand.

"No one person is responsible for a company's success," DeSpain says. "It takes a collaborative effort of working toward common goals. Even through the toughest of projects, we're fortunate to have a team of dedicated, enthusiastic, and talented people to help build such an amazing company."

An industry leader in the development and refinement of innovative polymer grouting techniques, UMA Geotechnical Construction Inc. creates specialized solutions to assist clients with ground engineering needs that save money and minimize downtime. As one of the first to use lightweight structural polymers to improve subsurface soils at depth greater than 40 feet, UMA is uniquely equipped to deliver safe, predictable, and effective results. The team includes industry experts in structural support, earth retention, and soil stabilization with decades of experience, and is dedicated to ongoing advancement in the field.

AMERICAN CONCRETE INSTITUTE EXPANDS CERTIFICATION OFFERINGS; LAUNCHES ANDROID VERSION OF ACI CERTIFICATION VERIFY APP

The American Concrete Institute (ACI) recently announced the addition of several new certification programs, marking a total of more than 30 certification program offerings now available. To keep pace with the growing demand for ACI-certified personnel on various concrete construction projects, the Institute has launched the ACI Certification Verify app to help supervisors verify the status of ACI-certified individuals on a jobsite.

Available on iOS and now Android platforms, the ACI Certification Verify app was developed as a tool to use on the jobsite for a faster and more seamless verification process. The ACI Certification Verify app allows users to quickly and easily verify the status of ACI-certified individuals through three search options:
1) verify an individual's certification ID number,
2) search by an individual's name, and
3) find the total number of ACI-certified individuals in an area.

ACI currently maintains nearly 130,000 active certifications and offers certification programs through more than 120 sponsoring groups around the world. The Institute has certified more than half a million concrete finishers, technicians, supervisors, inspectors, managers, and more, since the 1980s.

"The expectation for quality concrete construction can be seen in the growing demand for ACI-certified workers on projects spanning the globe, and our certification programs provide competent and proven individuals who have demonstrated the ability to properly test, place, and inspect concrete," said John W. Nehasil, Managing Director, Certification, American Concrete Institute. "The ACI Certification Verify app allows these individuals to prove their certification status and ensure projects can keep moving forward – now on both Apple and Android devices."

The app is available on Google Play and in the Apple App Store and uses the same functionality of the popular concrete.org/verify web-based verification tool. To learn more about ACI Certification or to download the app, visit ACICertification.org.

FOR MORE INFORMATION, CONTACT:
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AMERICAN CONCRETE INSTITUTE TO OFFER REBATES TO U.S. MILITARY VETERANS WHO BECOME CERTIFIED

The American Concrete Institute (ACI) is pleased to this program for U.S. military veterans who obtain an ACI certification. Funded through a generous contribution of $50,000 from CMEC Holdings, Inc. to the ACI Foundation, the program provides rebates of $250 to help ease the financial burden of earning an ACI certification in concrete field testing, concrete construction inspection, flatwork finishing, or one of ACI's other 20+ certification programs.

This rebate program was developed to provide recognition and appreciation to U.S. veterans for their service, and to help meet the growing demand for ACI-certified personnel. U.S. veterans who obtain ACI certifications in multiple programs may apply for the rebate separately for each certification. Rebates may be claimed only once for each first-time certification and are available to U.S. veterans earning their certification on or after June 1, 2018.

"Earning an ACI certification provides an opportunity for growth and demonstration of knowledge – positioning individuals to be at the forefront of the concrete construction job market," stated John W. Nehasil, Managing Director, Certification, American Concrete Institute. "ACI welcomes the opportunity to work with the ACI Foundation and CMEC to ease the financial burden of earning one of our industry-leading certifications."

Full eligibility requirements and application instructions are available at ACICertification.org/veteranrebate.

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SHOTCRETE FAQs

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

Question: *I am working on a fire re-build project near Napa, CA. The existing building has 12 in. (300 mm) thick shotcrete basement walls. There are many areas where the concrete cover spalled off from the rebar. The rebar appears to be in good condition with no visible buckling.*

Is it possible to repair these walls with a 1 1/2 to 2 in. (38 to 50 mm) layer of shotcrete to restore the concrete cover? If so, what sort of surface prep is required? Is a concrete bonding agent required?

Answer: Yes, this is definitely a good application for shotcrete. To restore the cover:

- Chip or hydrodemo back to sound concrete. If a reinforcing bar is more than half exposed, chip at least 1 in. (25 mm) back behind the bar.
- Make sure the surface is roughened and clean.
- Bring the concrete surface to saturated surface dry (SSD) condition. This means the surface feels damp but water is not picked up on a hand.
- Make sure the shotcrete placement is properly executed. Use of an ACI-certified shotcrete nozzleman is recommended.
- No bonding agent should be used. It will interfere with the natural bonding characteristics of shotcrete placement.
- If chipping out a section do not feather edge. Provide a ¾ to 1 in. (19 to 25 mm)) depth of cut at the edge to provide adequate thickness for the integrity of the shotcreted material at the edge.

This article on the excellent bond between shotcrete provides more detail: https://shotcrete.org/wp-content/uploads/2020/05/2014Spr_TechnicalTip.pdf

Question: *Our pool company just completed the shotcrete today and temperatures are expected to reach near freezing tonight. Should the shotcrete still cure properly? Should we be concerned?*

Answer: You say near freezing, so we assume it did not reach freezing. Though the newly place concrete will not gain strength quickly it should not be damaged. As temperatures rise during the day the warmer temperatures should allow more strength gain. Concrete has a chemical reaction to build strength, that generates internal heat. If freezing weather was expected, we would recommend use of a protective blanket on the concrete surface to help hold the heat in and promote quicker strength gain. Generally, in concrete we like to see the concrete surface temperature at 50 °F (10 °C) or higher in cold weather to encourage strength gain.

Question: *I work for a Commercial pool builder. We are doing a Jr. Olympic pool (competition pool) 40 ft by 70 ft (12 m by 21 m) with a 20 ft by 10 ft (6 m by 3 m) swim out area with steps. I would rather have the entire pool shot with shotcrete. The office wants the floor poured first then shoot the walls the next day. Can you talk about any advantages or disadvantages to either?*

Normally we are in a remote location with no power or water. We've had issues with shotcrete cracking on the floors and I understand that can happen because of many factors but poured concrete can as well.

Answer: Casting the floor first is recommended. Note that rebound and trimmings from vertical wall placement are not fully consolidated concrete and must not be used as part of a structural concrete section. Thus, casting first allows:

- No collection of rebound and trimmings from wall construction to get trapped below floor reinforcing steel.
- Provides a stable surface to collect and remove rebound and trimmings.
- Is generally faster placement and allows full consolidation of concrete throughout the floor thickness by immersion vibrators.
- If using wet-mix shotcrete the shotcrete pump can serve as a line pump for pumping concrete into the floor thus requiring no extra equipment.
- Allows proper joint preparation at the floor/wall joint to provide a watertight joint.

Question: *I am looking for information on where, when and why welded wire mesh (WWF) would be recommended in lieu of structural steel reinforcement, or with steel reinforcement, or guidance on how to determine which option or combination is the preferred one.*

Answer: WWF should only be used when the area of reinforcing provides the required reinforcement area. It may serve as supplemental reinforcement to bars, or entirely replace reinforcing bars as long as the required area of reinforcing steel is provided in the concrete section. Where multiple sheets (more than 2 at say a corner) overlap you may need to cutout one or more of the layers to allow good encasement. Don't use steel fibers with WWF as they tend to bunch up where the wires cross.

WWF can be used to provide reinforcing in double curved sections where it would be hard to bend and place reinforcing bars. Also, it may be used where you have a thick concrete cover or unreinforced thickness of a repair area that you wanted to get some reinforcing in place to control depth of any surface or shrinkage cracking.

If the mesh is just being provided to help support shotcrete being shot overhead you may not worry about the area of steel, just adding it in addition to the original design reinforcing. Then a lighter mesh might be used since you aren't really worried about its ability to be reinforcing.

Question: *Our shotcrete contractor started shooting our residential swimming pool on a Friday and stopped 1/3 of way through the process. They plan to restart and complete shooting the pool the following Monday. This site is in Houston and has been averaging 90+ °F (32 °C) average daily temperatures. Aside from soaking the existing pool structure during the hiatus and additional continuous watering through the 10 days after completion to let concrete cure, what steps do I and the contractor need to make to ensure a cold joint will not fail and leak in the future? I will be able to supervise the second shot. What can I do, or make sure the contractor does, to ensure the structural integrity and quality of my investment?*

Answer: Wet curing of newly placed concrete is certainly important. Your 10-day cure sounds great. Properly placed shotcrete against a properly prepared construction joint will provide concrete that acts monolithically and will not be a "cold joint" as is common in cast concrete. There are three key factors for joint preparation:

1. The joint must be roughened. This should be done when the crew finished for the day using a stiff broom or raking with a trowel.
2. On the subsequent shoot the surface should be cleaned (usually using a high pressure, pressure washer).
3. Before shooting bring the surface to a saturated surface dry (SSD) condition. SSD means the pores of the concrete have been filled with water but there is no running water on the surface.

Following these 3 steps are essential for creating a monolithic, watertight joint. Here's a link to an article on why shotcrete doesn't have cold joints: https://shotcrete.org/wp-content/uploads/2020/05/2014Spr_TechnicalTip.pdf

Quality shotcrete placement requires a well-designed concrete mixture, proper equipment, attention to the surface prep, proper placement techniques, and curing. One aspect that can help you ascertain the nozzleman's expertise is to require they have a current American Concrete Institute Shotcrete Nozzleman Certification. You can verify an individual's certification status at: https://www.concrete.org/certification/verifyacertification.aspx?d=Ask

Question: *Do you have any case studies or applications where Ground Granulated Blast Furnace Slag (GGBFS) cement was successfully used in the concrete mix?*

Answer: Shotcrete is a placement method for concrete. Concrete mixtures that have been shotcreted have used all different supplemental cementitious materials (SCM) including slag. Silica fume, and fly ash are also widely used. Generally geographic availability and cost of the slag are a deciding factor on if slag is included in a concrete mixture design. Concrete using alternative binders or cements have been used for specialized applications like refractory, or extremely high early strength gain. Here are links to past articles from our Shotcrete magazine that have considered slag in shotcreted concrete mixtures:

The Use of Slag Cement, Alkali-Free Accelerator, and Macro-Synthetic Fibers - https://shotcrete.org/wp-content/uploads/2020/05/2016Spr_Yurdakul-etal.pdf

Sustainable Shotcrete Using Blast-Furnace Slag - https://shotcrete.org/wp-content/uploads/2020/05/2013Fal_Sustainability.pdf

Question: *We are working on a design-build project located in southern California of which the perimeter walls of the underground parking structure are planned to be shotcrete. Do you recommend any particular ACI publication that would be applicable to the shotcrete operation or does ASA have their own publications, similar to ACI, that are more appropriate to shotcreting?*

Answer: ACI Committee 506 is the technical committee responsible for creating and maintaining the ACI documents related to shotcrete. ACI 506R-16 *Guide to Shotcrete* is an excellent resource for shotcrete information including materials, equipment, crew composition and placing techniques. It is a non-mandatory document that is very descriptive and readable. ACI 506.2-13 (18) *Specification for Shotcrete* is another excellent resource that has mandatory requirements for the contractor's shotcrete placements. Additionally, the ACI 318-19 *Building Code Requirements for Structural Concrete* directly addresses shotcrete for use in buildings.

A past article in Shotcrete magazine describes the additions to cover shotcrete in ACI 319-19: shotcrete.org/wp-content/uploads/2020/06/2019Fal_HanskatHollandSuprenant.pdf

Another past article dealing with *Shotcrete Testing—Who, Why, When, and How* can be found on our website here: shotcrete.org/wp-content/uploads/2020/01/2011Sum_Hanskat.pdf

Question: *I would like to know how could I obtain an expert opinion from ASA stating that a particular person specializes in gunite (dry-mix shotcrete) operations and that the person is amply qualified to perform such work?*

Answer: ASA is the international trade association dedicated to advancement of shotcrete placement. The American Concrete Institute (ACI) has a long history of certification of individual craftsmen in concrete construction. Nearly 20 years ago ASA worked closely with ACI to establish the ACI Shotcrete Nozzleman certification program to evaluate a nozzleman's ability to place quality shotcrete. ASA is the primary group that conducts the ACI Nozzleman Certification sessions around the world. We provide a full day of education before the formal ACI certification and have a team of examiners with proven

shotcrete expertise to rigorously conduct the sessions to ACI's high standards. Many engineers specify that all the nozzlemen on their projects must have ACI Nozzleman Certification. Many concrete-related codes, specifications and standards require ACI-certified shotcrete nozzleman for shotcrete placement of structural concrete.

Thus, ASA doesn't offer an expert opinion on individuals as an association but provide the ASA education and ACI certification upon request. You will find full details of the session services we can provide on our website at shotcrete.org/education then clicking on the "Shotcrete Nozzleman Certification Program" link. An article that covers in greater detail the overall shotcrete nozzleman education and certification process *ACI Nozzleman Certification—Why, Who, When, and How* can be found on our website: shotcrete.org/wp-content/uploads/2020/05/2018Win_Hanskat.pdf

Also, many of our corporate members offer consulting services. You can find them in our free, online Buyer's Guide at Shotcrete.org/BuyersGuide. On the web page you can select the category, subcategory and geographic location to narrow your search.

Question: *Please discuss the differences in curing/shrinking cracking challenges for wet-mix shotcrete versus dry-mix shotcrete (gunite). In my limited experience, wet-mix shotcrete tends to crack easier than dry-mix shotcrete. In general terms, or on average is gunite more porous, but less likely to show cracks?*

Answer: Both wet-mix and dry-mix shotcrete when using proper materials, equipment and placement techniques will produce high strength, low permeability concrete in-place. Dry-mix shotcrete will tend to have a lower w/cm since water is added to the dry concrete materials at the nozzle. Wet-mix needs a higher w/cm and a fairly high cement paste content to facilitate pumpability. This can make wet-mix more susceptible to plastic or drying shrinkage cracking than dry-mix. However, cracking in either dry-mix or wet-mix shotcrete can be controlled by using fogging of freshly finished surfaces and then early curing of exposed shotcrete surfaces.

Wet-mix still has very low w/cm (0.40 to 0.45) to allow vertical and overhead placement without sloughing or falling out and is lower than much of the form-and-poured concrete. The low w/cm and high velocity impact produces excellent compressive strength and low permeability. Properly placed dry-mix will have similar compressive strength and permeability as wet-mix. strength gain.

ASA CONTRACTOR QUALIFICATION PROGRAM

Quality, durable, and economical shotcrete placement requires an experienced shotcrete team, not just an ACI-certified nozzleman.

The ASA Contractor Qualification (CQ) Program provides education and expert review of a shotcrete contractor's past projects. Those contractors who fully meet the requirements will be designated and publicly listed as ASA-Qualified Shotcrete Contractors.

WHO BENEFITS FROM THE PROGRAM?

- Owners wanting a quality, durable concrete structure with shotcrete placement
- Shotcrete contractors wanting public acknowledgment of their commitment to quality
- Specifiers who want expert guidance on the shotcrete contractor's qualifications

What's Involved

1. Attend an ASA full-day Shotcrete Contractor Education Seminar and successfully complete the CQ written exam by the company's Qualifying Individual; and
2. Complete the CQ online application for the process (wet- or dry-mix) and level sought (basic or advanced).

Availability

1. Shotcrete Contractor Education Seminars will be offered at various venues around the country—at trade shows and as sponsored by companies. Find available Seminars: www.shotcrete.org/events
2. Find the CQ online application: https://asacq.secure-platform.com:443/a/solicitations/home/1002

Questions

Program details: www.shotcrete.org/CQ

Contact: info@shotcrete.org

american shotcrete association

asa

SUSTAINING CORPORATE MEMBER PROFILE

Fig. 1: Shotcrete basement walls in high density urban environments – Dallas-Fort Worth.

CCP SHOTCRETE

CCP Shotcrete (CCP) is an Austin, TX based contractor focused on large scale, time sensitive, and technical shotcrete projects in Texas and surrounding states. We assist engineers and owners during the development stage and support preconstruction teams during the bidding phase. We also mobilize to continuously and diligently complete the work as originally specified, or often as a value engineered change order.

MARKETS

CCP serves the heavy commercial, transportation, civil and recreation markets in the southern US. Projects include basement walls for below-grade parking structures, tunnel and culvert linings and aesthetic wall facings.

TODAY

CCP is a team of preconstruction managers, shotcrete placement crews, consultants and estimators. We look for a challenge while providing the inherent benefits of shotcrete to any project. CCP prides itself on their preconstruction phase efforts. The early alignment of expectations and a clear work plan, before site operations begins, always results in successful projects and repeat clients. Pump. Place. Finish. Cure. Everyday.

Fig. 2: Initial and primary shotcrete tunnel linings for the Houston Museum of Fine Arts. The 200 ft (61 m) tunnel in will soon be the newest art exhibit space.

The Company's roots began in 2006 when company owners established the design-build concrete skatepark firm, SPA Skateparks. Shotcrete placement's versatility and ability to accelerate a project's schedule was immediately apparent. SPA honed our shotcrete craftsmen skills with steady field experience and recognizing the need for these shotcrete skills in other market segments, CCP Shotcrete was born in 2009 to serve more complicated, larger projects.

Fig. 3: TXDoT project calling for a 4 in. (100 mm) shotcrete lining of over a 172 ft (52 m) long, 14 ft (4.3 m) diameter corrugated metal pipe (CMP).

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CCP Shotcrete
Austin, TX | 512-584-3216
www.CurtisConcretePumping.com

SPA SKATEPARKS

SPA SKATEPARKS

SPA is a turnkey design-build contractor of world class skateparks based in Austin, TX. Our passionate team of active skateboarders and BMXers consists of public planning consultants, construction project managers, and specialized skatepark construction craftsmen who have been perfecting site integrated, poured (and shot) in place concrete skate parks since 2006. SPA owners and brothers, Yann and Jamie Curtis, got their start in skateparks by owning and operating the Skatepark of Austin with their parents from 2002 - 2007. The transition to contracting occurred in 2006 as cities began responding to demand for public-use, concrete skateparks.

DESIGN AND PRECONSTRUCTION

SPA believes a properly developed skatepark consists of not only incredible terrain designed for the users, but also an inviting public space for the entire community to enjoy. These innovative creations often become the ever-so-important "third place" for youth socialization and recreation outside school or home. We offer our years of skatepark planning experience to efficiently and comprehensively guide our clients through the public skate park process.

CONSTRUCTION

SPA regularly serves as either the Prime Contractor or as the specialty skatepark subcontractor, depending on the project delivery method and overall project scope. Our normal course of work consists of subgrade preparation per geotechnical recommendations, custom formwork, concrete, metal fabrication and the subcontracting of supporting amenities. Wet-mix shotcrete is a substantial portion of any project to achieve tight tolerances and required organic shapes. Artistic shotcrete features and decorative concrete work call for constant innovation to ensure long lasting quality and durability.

CONTACT INFORMATION:

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SPA Skateparks
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www.SPAskateparks.com

Fig. 2: City of Plano Texas Carpenter Skate Park

Fig. 3: Over-vertical pocket skate feature. 2018 Outstanding Shotcrete Award in the Pool & Recreational Project category

Fig. 1: Snake run feature at Vandergriff Park

Fig. 4: Steel trowel finish shotcrete skate park bowl

CRUZ CONCRETE AND GUNITING REPAIR INC.
CONSULTANTS ÷ CONTRACTORS ÷ SPECIALTY REPAIRS

Structural Gunite & Shotcrete Repairs + New Construction

CRAFTED WITH PRECISION - DELIVERED ON TIME

SPECIALIZED SHOTCRETE GROUP

Providing concrete repair and restoration on buildings, landforms, transportation systems, marine facilities and beyond.

Founded in 1986, our vision for success is always growing. From the sidewalks of Passaic County to the Tri-State Metropolis, Cruz Concrete has broadened its horizons to seek all projects utilizing shotcrete placement to repair, rehabilitate, or restore concrete structures.

Our services span the private to public sectors including corporate enterprises, state, federal, and military projects offering the highest level of quality shotcrete performance. We offer over 40 years of experience and are Minority Business Enterprise/ Disadvantaged Business Enterprise (MBE/DBE) certified through many agencies in New York and New Jersey.

In addition to repairs, we have also used shotcrete placement for many projects as a value-engineering solution over form-and-pour methods, saving prime contractors time and money. We've also performed rock slope stabilizations, beam encasements, pool construction, and large stand-alone concrete walls. Here at Cruz, we strive to expand our project repertoire, while delivering the highest quality product in the industry.

SECOND GENERATION

Blending backgrounds of landscape architecture, civil engineering, and construction management into a successful business model, Cruz Concrete's next generation strives to uphold the legacy of the past while transforming with the future of the construction industry. Cruz strives to employ the most environmentally-conscious construction practices while also pushing the limits of innovation and design.

QUALIFICATIONS

We provide quality services meeting the benchmarks of our associated groups and agencies. Our President and Founder, Warren C. Cruz, is an ACI-Certified Shotcrete Inspector and Concrete Field Testing Technician - Grade 1. Our nozzlemen are ACI Certified in both the wet- and dry-mix shotcrete process. Ashley Cruz is a registered landscape architect and we are a certified MBE/DBE company. limits of innovation and design.

Nozzleman innovation for fireline encapsulation, 5-feet off the ground, at the Queens Midtown Tunnel. (2019 Outstanding Shotcrete Award)

Lattice girders over waterproofing membrane, to support 9 to 12 inches of overhead shotcrete for the reconstructed ceiling arch of the Park Avenue Tunnel.

Wet-mix shotcrete lining for tank of an on-site wastewater treatment plant,10" thick - It's all about perspective.

Rock slope stabilization in New Jersey at the Lincoln Tunnel.

"True passion comes from the heart, you must always perform with gusto and your final product will be felt."

-Warren Cruz, President

Historic rehabilitation of the battery walls and stairs at Fort Mott State Park, utilizing a mix design to match the existing composition and texture. (2012 Outstanding Shotcrete Award, Honorable Mention)

Newburgh Water Tunnel Bypass Project; a rock stabilization job. The production line for 5000 PSI wet-mix ran up to 60' above the ground, holding back the earth for the new access road for an aqueduct tunnel providing potable water to the residents of New York City.

CRUZ CONCRETE & GUNITING REPAIR INC

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Putzmeister America, Inc. Expands Vehicle Series Line Pump Offering

Earlier this year, Putzmeister America, Inc., (Putzmeister) launched the VSP 60HP and showcased it for the first time at ConExpo in Las Vegas, NV. The machine was well-received since many customers requested an additional pressure model in the line after the flagship model (VSP 70) launched in 2019.

Like the VSP 70, the VSP 60HP Vehicle Mounted Pump doesn't require a CDL to operate, which means more versatility for operators. The pump delivers a high-level performance and output on a rugged flatbed-style chassis. The VSP 60HP is well suited for pumping grout, block fill, and shotcrete applications due to its 6" (150mm) diameter concrete cylinders.

Putzmeister recently launched the next in class, VSP 50. "The VSP50 is a best-in class option for line pumping," said Justin Fagan, Director of Product Management at Putzmeister America. "We listened to our customers' feedback and extended our VSP line with a pump kit that will improve performance with certain material types. The foldable side panels and a clean spacious deck meets a variety of storage and job site requirements. The VSP series is a game changer in the line pumping market."

Coming at World of Concrete 2021 and available for sale starting in January, Putzmeister will be launching the next planned piece of the vehicle-series line – the VSP 80. This model will replace the VSP 70, with a calculated output 79 yd^3/hr (60 m^3/hr).

"The VSP series is a game changer in the line pumping market," said Todd Lutz, COO at Putzmeister America. "The vehicle series is the perfect complement to the city pump because it requires no CDL to drive it, offering an unrestricted product portfolio for a major part of the industry."

For more information about the Vehicle-Series product line, please contact us directly or contact your local sales representative.

Putzmeister Underground Launches Geokret 2.0: Smart Shotcrete Application with Latest Laser Technology

In this era of digital transformation and data analysis Putzmeister Underground presents the complete solution for smart shotcrete application with the latest laser technology, in a digital, intuitive and very flexible way.

The solution is based on the 3D high-resolution scanning of the underground galleries before and after each shotcrete application, comparing results and optimizing the applications

Simple, fast and effective

Putzmeister has designed the intuitive and friendly Geokret app, integrated in the robust tablet, thinking about the operator's daily work. In just a few clicks the customized project is created using the indicated thicknesses, range of colors and angles (which can be determined in advance) and then the 3D laser is active.

In just 60 seconds, the compact and easy-to-use 3D laser scans the gallery, with high precision, and sends the data to the Geokret app. In the same app, the operator will be able to see the comparative data from the scans and ascertain status of the application in near real-time, thus being able to improve the resulting placement.

Without interrupting the normal work cycle, there are no cables or other external elements. All the information is transmitted via Wi-Fi between the laser and the Geokret app. This allows installation of the laser with total flexibility within the gallery to get the best visibility.

Exhaustive analysis in the office software

The solution doesn't end here. Once the shotcrete application is done, the data can be downloaded by USB or sent by Wi-Fi to the powerful office software. It allows you to perform a much more detailed analysis: sections, volumes calculation, thickness and much more.

Putzmeister expands the Vehicle-Series product line.

Key benefits:

- Increased safety and durability. You will know the real application on time.
- Save the costs of wasted material
- Improved shotcreting quality. Know the areas of excess or lack of concrete.You will be able to optimize the application and review where shotcrete is necessary
- Intuitive, easy to use and friendly design Geokret app, to focus on the most important result, your shotcrete application.
- 360° scan in just 60 seconds, with a range of 60 m (200 ft) and very precise (we guarantee an error of only 1 mm [0.04 in.]).
- Wireless data transmission with flexibility in laser positioning
- Powerful software for exhaustive analysis of your collected data. Compare, analyze and optimize.
- Generation of customized and downloadable reports: thicknesses, volumes, sections

Developed with Leica Geosystems

Geokret 2.0 brings together the experience of Putzmeister, with more than 30 years in the underground shotcrete environment, and the latest technology in measurements and topography of Leica Geosystems, the Swiss company recognized for its high quality products and development of innovative solutions for capturing, analyzing and displaying intelligent geospatial data for almost 200 years.

Geokret 2.0 achieves an intelligent, efficient and safe shotcrete application.thickness and much more.

Geokret

Publi-Geokret-2

Putzmeister Underground lanza Geokret 2.0: cómo aplicar shotcrete de manera inteligente con la última tecnología láser

En esta época de transformación digital y era de los datos Putzmeister Underground presenta la solución completa para la aplicación inteligente de shotcrete con la última tecnología láser, de manera digital, intuitiva y muy flexible.

La solución se basa en el escaneo 3D de las galerías subterráneas a sostener antes y después de cada proyección de shotcrete, comparando resultados y optimizando de esta manera las aplicaciones.

Sencillo, rápido y eficaz.

Putzmeister ha diseñado la intuitiva y amigable app Geokret integrada en la robusta tablet de la solución pensando en el trabajo diario del operador. En tan solo unos clicks se crea el proyecto personalizado según los espesores, gama de colores y ángulos que indique (que puede determinar con anterioridad) y se activa el funcionamiento del láser 3D.

En tan solo 60sg el compacto y fácil manejable láser 3D escanea la galería, con alta precisión, y envía los datos a la app Geokret. En la misma app, el operador podrá ver los datos comparados de los escaneos y conocer el estado de su efectivo de la proyección, pudiendo mejorar el resultado insitu.

Sin interrumpir el ciclo normal de trabajo, no hay cables ni más elementos externos. Toda la información se transmite vía Wifi entre el láser y la app Geokret, lo que también le permitirá instalar el láser con total flexibilidad dentro de la galería para obtener la mejor visibilidad

Análisis detallado en el software de oficina.

Pero la solución no termina aquí. Una vez realizada la proyección puede descargar todos los datos de sus proyectos en USB o enviarlos vía Wifi al potente software de oficina que le permite realizar un análisis mucho más detallado: análisis por secciones, cálculo de volúmenes, cálculo de espesores y mucho más.

Beneficios clave:

- Incremento en la seguridad del sostenimiento. Sabrá al momento el estado real de su proyección.
- Ahorro de costes ya que podrá medir exactamente su desperdicio de material
- Mejora de la calidad de la proyección. Conoce las zonas de exceso y carencias de material y optimice la proyección
- Apliación Geokret de fácil uso y diseño amigable, para centrarse en la importante, su proyección de shotcrete
- Escaneo de hasta 360º de la galería en tan solo 60 sg sin ralentizar el ciclo normal de trabajo, con un alcance de 60 m y muy precisos (garantizamos un error de solo 1 mm)
- Transmisión de información sin cables: flexibilidad de posicionamiento del láser
- Potente sofware para análisis exhautivo de los datos recabados en sus proyecciones de hormigón. Compare, analice y optimice.
- Generación de informes personalizados y descargables: espesores, volúmenes, secciones

Desarrollado junto con Leica Geosystems.

Geokret 2.0 une la experiencia de más de 30 años en shotcrete en ambientes subterráneos de Putzmeister con la última tecnología en medición y topografía de Leica Geosystems, la empresa suiza reconocida por sus productos de alta calidad y el desarrollo de soluciones innovadoras para capturar, analizar y presentar datos geoespaciales inteligentes desde hace casi 200 años.

Con Geokret 2.0 logrará una aplicación de shotcrete inteligente, eficiente y segura.

Geokret

Publi-Geokret-2

For over 40 years, **QUIKRETE** has been a leading manufacturer of high-performance shotcretes. Available nationwide in dry process and wet process micro-silica enhanced designs, **QUIKRETE Shotcrete MS** can handle even the most challenging project requirements. **QUIKRETE Shotcrete MS** delivers high strength, very low permeability, low rebound and improved sulphate resistance

quikrete.com

SHOTCRETE CALENDAR

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

NOVEMBER 30 – DECEMBER 10, 2020	**Global Concrete Summit – Virtual** www.globalconcretesummit.com
JANUARY 22, 2021	**ASA's Virtual Town Hall – Kick Off!** www.shotcrete.org/News/Calendar
JANUARY 26 – 28, 2021	**The Pool & Spa Show – Virtual** www.nespapool.org
FEBRUARY 2 – 6, 2021	**Southwest Pool & Spa Show** Gaylord Texan Resort & Convention Center | Grapevine, TX www.swpsshow.com
FEBRUARY 26, 2021	**ASA's Virtual Town Hall – Annual Meeting** www.shotcrete.org/News/Calendar
MARCH 1 – 5, 2021	**MineXchange 2021 SME Annual Conference & Expo - Virtual** www.smeannualconference.com
MARCH, 2021	**ASA's Spring Committee Meetings – Dates TBD** www.shotcrete.org/News/Calendar
MARCH 24, 2021	**ASA's Outstanding Shotcrete Awards Celebration - Virtual** www.shotcrete.org
MARCH 25 – 26, 2021	**Chicago Build 2021 Expo** McCormick Place | Chicago, IL www.chicagobuildexpo.com
MARCH 26, 2021	**ASA's Virtual Town Hall – Meet the Winners!** www.shotcrete.org/News/Calendar
MARCH 28 – APRIL 1, 2021	**ACI Concrete Convention _ Spring 2021** Hilton & Marriott Baltimore www.concrete.org
MAY 3 – 5, 2021	**Deep Foundations Institute – Shotcrete Short Course** Table Mountain Inn & Edgar Mine | Golden, CO www.dfi.org
MAY 11 – 12, 2021	**New York Build 2021 Expo** Javits Center – Hall 3A | New York, NY www.newyorkbuild.com

JUNE 6 – 9, 2021	**ASTM International Committee C09, Concrete and Concrete Aggregates** Sheraton Centre Toronto | Toronto, ON Canada www.astm.org
JUNE 7 – 10, 2021	**World of Concrete 2021** Las Vegas Convention Center | Las Vegas, NV www.worldofconcrete.com
JUNE 8, 2021	**Shotcrete Nozzleman Education @ WOC 2021** Las Vegas Convention Center | Las Vegas, NV www.worldofconcrete.com
JUNE 9, 2021	**Recognizing Quality Shotcrete @ WOC 2021** Las Vegas Convention Center | Las Vegas, NV www.worldofconcrete.com
JUNE 10, 2021	**Shotcrete Contractor Education @ WOC 2021** Las Vegas Convention Center | Las Vegas, NV www.worldofconcrete.com
JUNE 13 – 16, 2021	**2021 SME Rapid Excavation & Tunneling Conference (RETC 2021)** Las Vegas, NV www.retc.org
AUGUST 24 – 26, 2021	**SDC Technology Forum 50** Portland, OR www.acifoundation.org
SEPTEMBER 13 – 15, 2021	**MINExpo INTERNATIONAL® 2021** Las Vegas Convention Center | Las Vegas, NV www.minexpo.com
OCTOBER, 2021	**ASA's Fall Committee Meetings – Dates TBD** www.shotcrete.org/News/Calendar
OCTOBER 17 – 21, 2021	**ACI Concrete Convention – Fall 2021** Hilton Atlanta Downtown www.concrete.org
DECEMBER 5 – 8, 2021	**ASTM International Committee C09, Concrete and Concrete Aggregates** Atlanta Marriott Marquis | Atlanta, GA www.astm.org
FEBRUARY 27 – MARCH 1, 2022	**2022 ASA Shotcrete Convention & Technology Conference** Sonesta Resort | Hilton Head, SC www.shotcrete.org
JUNE 17 – 24, 2022	**North American Tunneling Conference (NAT) 2022** Philadelphia, PA www.natconference.com
MORE INFORMATION	To see a full list, current updates, and active links to each event, visit www.shotcrete.org/calendar.

NEW ASA MEMBERS

american shotcrete association | asa

SUSTAINING CORPORATE MEMBERS

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