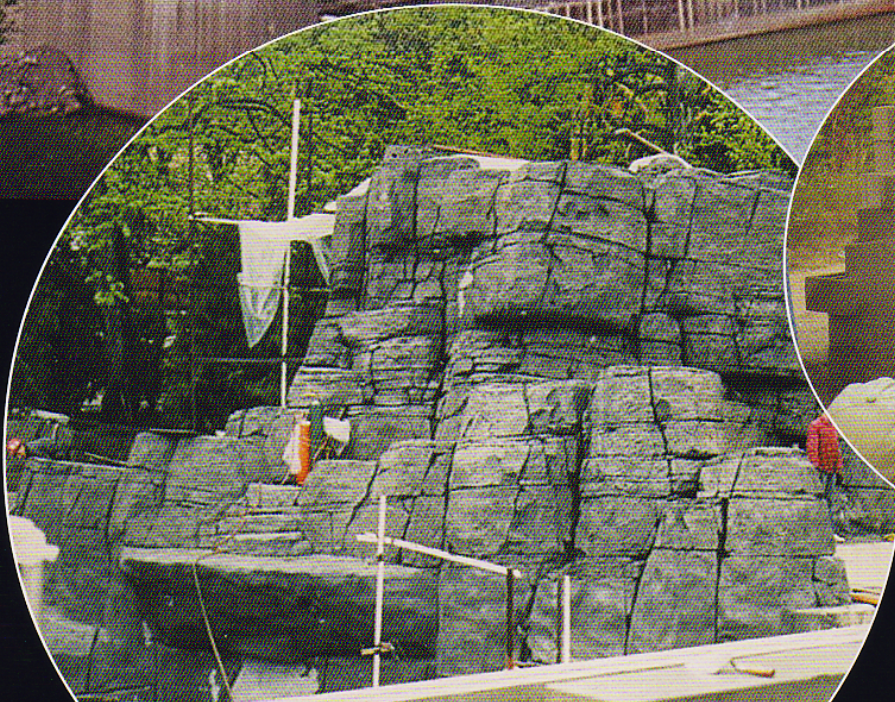
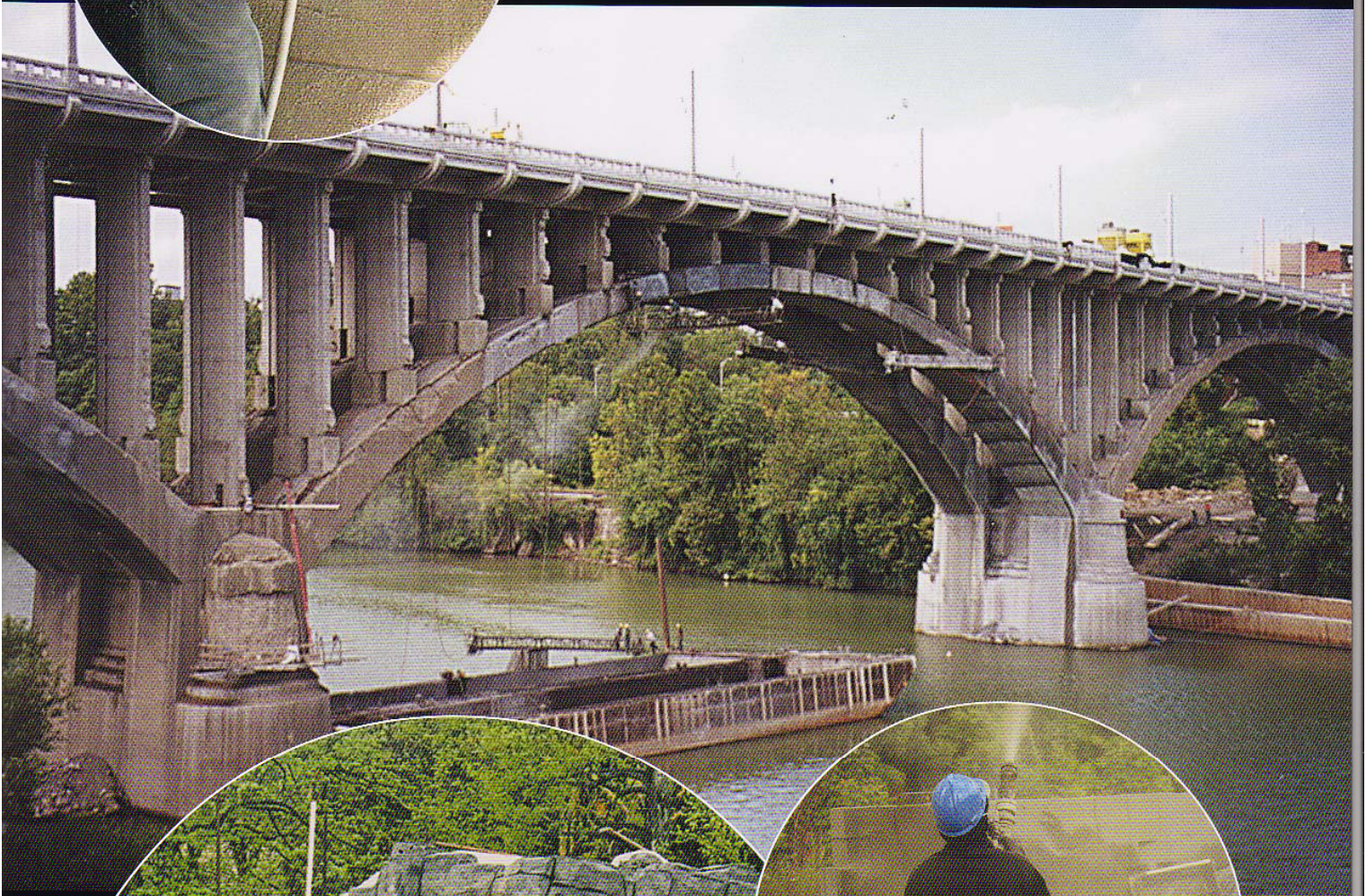
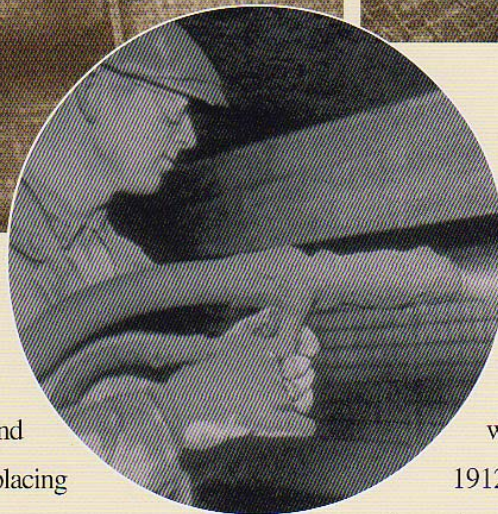
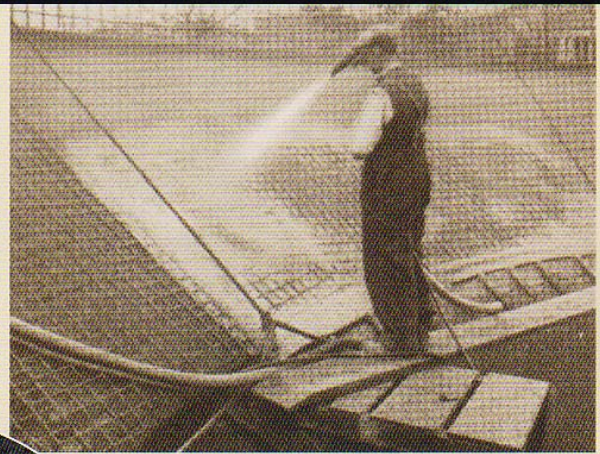
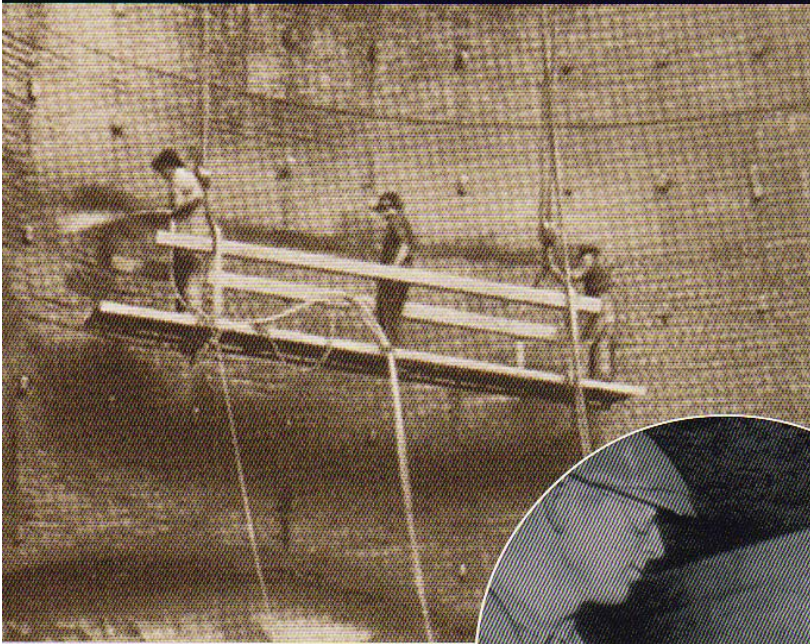


Shotcrete

A proven process for the new millennium



History of Shotcrete



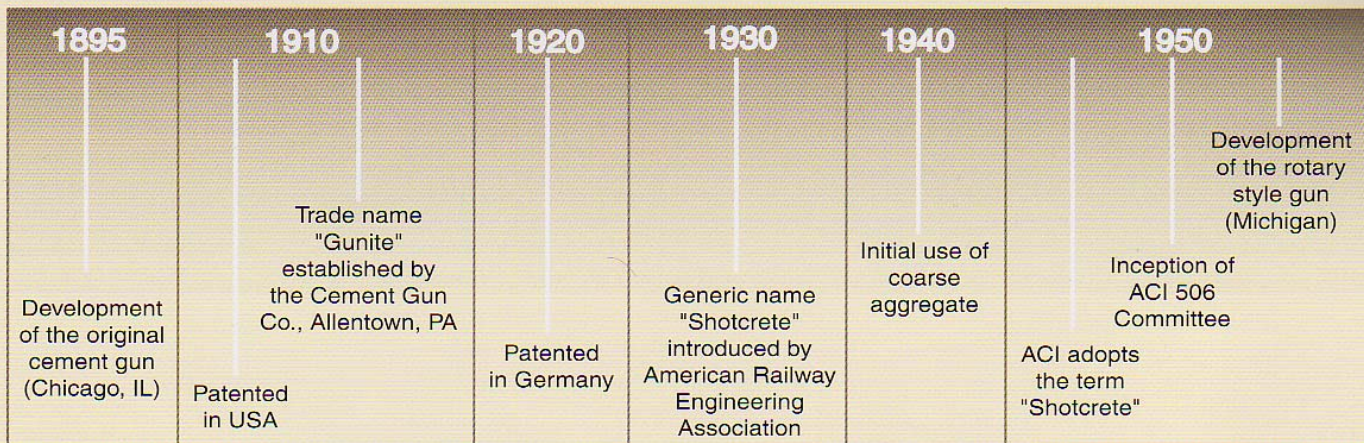
The first steps in the development of shotcrete were taken nearly a century ago. Since then, countless structures have been built, restored, and reinforced using this unique concrete placing method.

The invention of “spraying concrete and mortar onto a surface at high velocity” in 1907 is credited to well-known naturalist Dr. Carl E. Akely. The machine (and process) was introduced at the Cement Show, in Madison Square Garden, N.Y., in 1910. Patents on the equipment and method were granted in 1911, and the process immediately became popular in the industry.

Soon after the issue of patents and registration of the term “Gunite,” the creation of the Cement Gun Company (now called Allentown Equipment), allowed widespread use of the technology. Related companies were formed in various parts of the world and “Gunite” grew rapidly from 1912 through the 1930s. It was during this time when coarse aggregate mixtures were applied

with the Cement Gun that the American Railway Engineers introduced the term “shotcrete” to describe the process.

After World War II, the use of “Gunite” continued to grow rapidly as new technology was developed. In the 1950s, the creation of the Gunite Contractors Association, the introduction of the rotary gun for dry-process shotcrete,



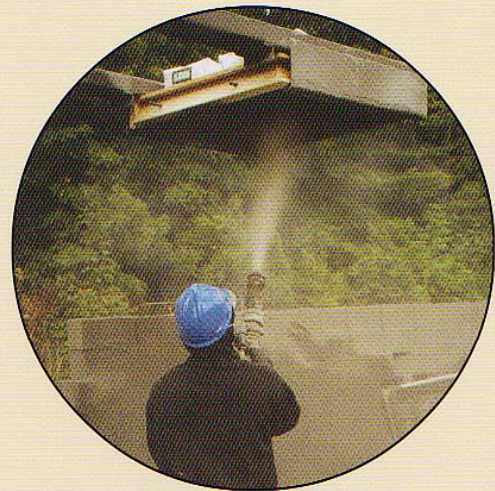
and the first use of the wet process provided new and expanded opportunities. A significant step during this period was the formation of ACI Committee 506, and the publication of valuable documents, such as SP-14, Shotcreting, to assist the industry in understanding the requirements for quality shotcrete construction.

During the 1970s, technical advancements in materials and equipment brought marked improvements to uses for shotcrete construction. Silica fume was introduced to impart new properties to concrete that improved its use for ground support. The Engineering Foundation organized the first conference for “The Use of Shotcrete for Underground Support.” Perhaps the most significant step in this period was the development of efficient concrete pumps that could be used for wet shotcrete application.

In the 1980s, admixtures were developed to provide almost total control of consistency, hydration, and in-place performance of wet shotcrete. Packaging of dry shotcrete materials and admixture developments, such as air entraining for dry shotcrete, also enhanced the performance of the dry process. The introduction of steel fibers provided the possibilities of integral reinforcement to meet specific requirements for structural repairs and underground support applications.

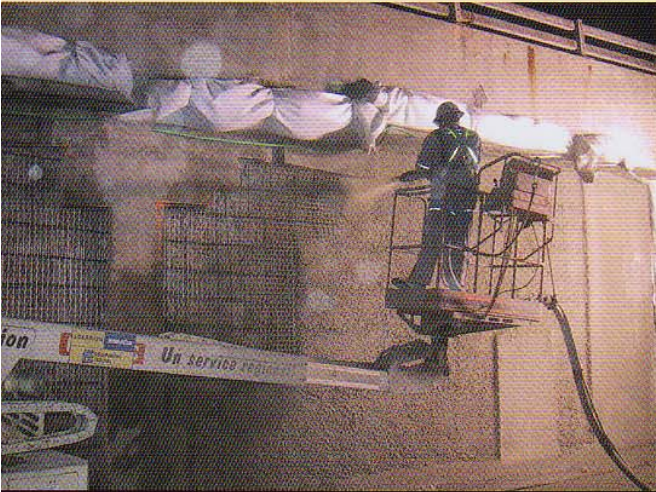
During these years, the progress in the method of shotcreting has been the result of practitioners who both investigated and evaluated the performance of materials for shotcrete. Recently, because of the relationship between the industry and the research community, developments in shotcrete have increased dramatically, and many qualities of the process have been improved.

In 1998, the American Shotcrete Association was formed to promote the use of shotcrete by education, encouragement, and support of all persons and organizations that can benefit from this method of concrete placement. The focus of this organization and this publication is to provide current and accurate information to all in the industry who wish to improve the quality and expand the use of shotcrete.



1955	1970	1975	1980	1985	1998	2000	
Introduction of the Wet Mix method	First Practical use of Steel Fiber reinforced shotcrete by US Army Corps of Engineers	First use of Silica Fume in shotcrete in Norway	First use of Silica Fume in North America (Vancouver, BC)	Introduction of Prepackaged Materials	First use of Air Entrainment in Dry Mix Process	Formation of the American Shotcrete Association	ACI Nozzleman Certification established

Features & Benefits



The properties of both wet and dry process shotcrete can be further enhanced through the addition of many different additives or admixtures such as:

- **Silica Fume** — Provides reduced permeability, increased compressive and flexural strength, increased resistance to alkali and chemical attack, improved resistance to water washout, reduced rebound levels, and allows for thicker single pass applications;
- **Air-Entraining Admixtures** — Improve pumpability and adhesion in wet-process shotcrete and freeze-thaw durability in both wet and dry processes;
- **Fibers** — Control cracking, increase toughness values, improve impact resistance and energy absorption; and
- **Accelerators** — Improve placement characteristics in adverse conditions, allow for thicker single pass applications, increase production capabilities, and reduce the occurrence of fallouts on structures subjected to vibration.

Shotcrete has often been described not as a material but as a process. Both wet and dry processes produce a material that exhibits superior hardened properties to high quality conventional concrete, such as high strength, low permeability and high durability. These properties allow shotcrete to be used in most cases as a structural material.

Shotcrete has high strength, durability, low permeability, excellent bond and limitless shape possibilities.

Although the hardened properties of shotcrete are similar to conventional cast-in-place concrete, the nature of the shotcrete placement process provides additional benefits, such as excellent bond with most substrates and instant or rapid capabilities, particularly on complex forms or shapes.



Methods of Application

Dry Mix



Pre-blended dry or damp materials are placed into the delivery equipment. Compressed air conveys material through a hose at high velocity to the nozzle, where water is added. Material is consolidated on the receiving surface by the high-impact velocity.



Wet Mix

All ingredients, including water, are thoroughly mixed and introduced into the delivery equipment. Wet material is pumped to the nozzle where compressed air is added to provide high velocity for placement and consolidation of the material onto the receiving surface.



Process Benefits

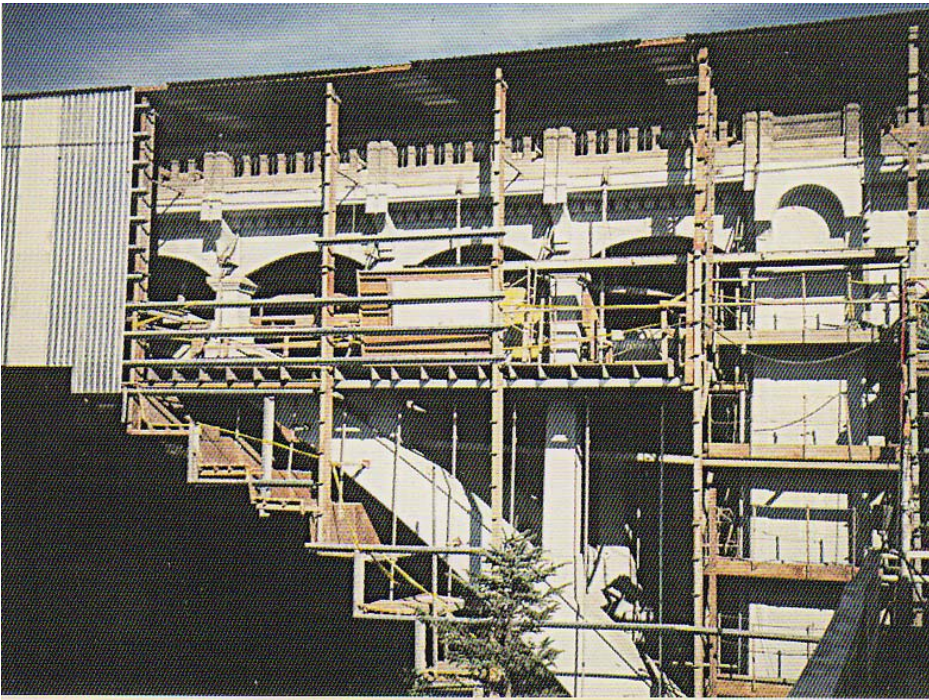
- Little or no formwork is required;
- Cost effective method for placing concrete;
- Ideal for irregular surface applications; and
- Allows for easier material handling in areas with difficult access.

Wet or Dry?

Although both wet and dry shotcrete have specific benefits, advancements in both material and equipment technology make both processes almost interchangeable. In most applications, the preferred method is determined by:

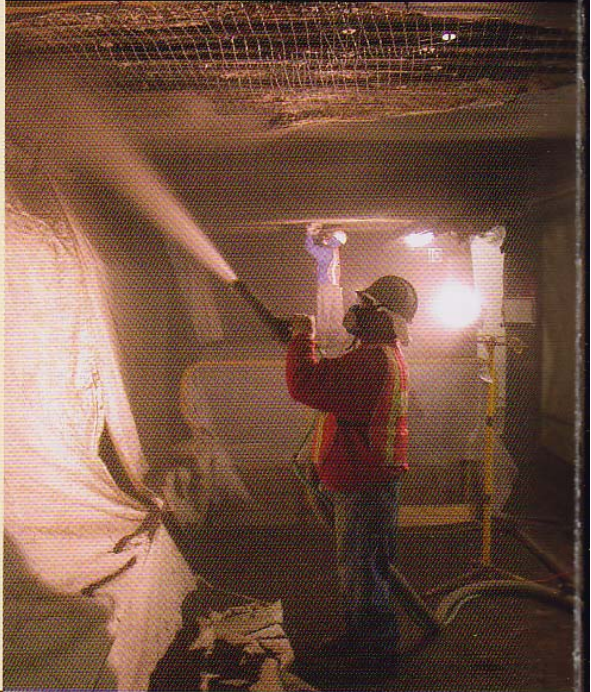
- Economics;
- Availability of material and equipment;
- Site access; and
- The expertise and preference of the contractor.

Today, rebound levels, dust levels, and properties such as bond strength, compressive strength, and durability can be similar whether the wet or dry method is used.



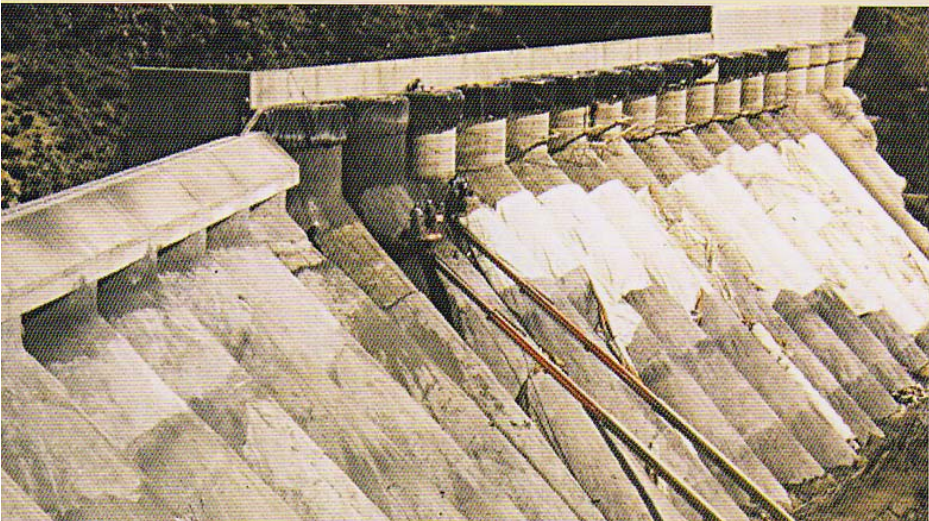
Repair

Parking Garages



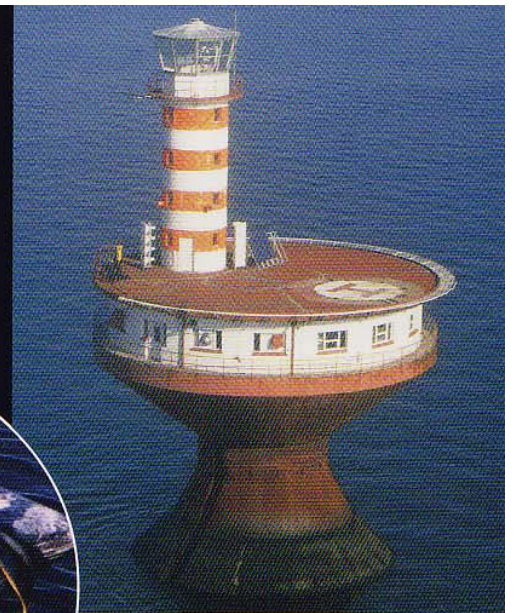
Bridges

Repair and restoration of concrete is one of the fastest growing segments of the construction industry. This growth is not restricted to infrastructure, but extends to the private and industrial sectors. From tanks and pools, to chemical and automotive, to retaining walls and highway structures, the opportunities are endless. Shotcreting is often the best alternative when repair and restoration are being contemplated, and can be the ideal application method for both reinforced and non-reinforced construction.



Dams & Reservoirs

& Restoration



Marine

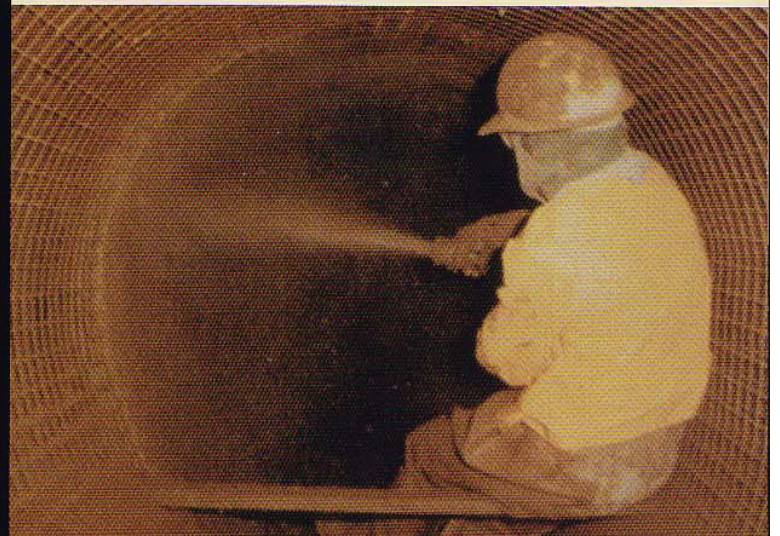


Seismic Retrofit



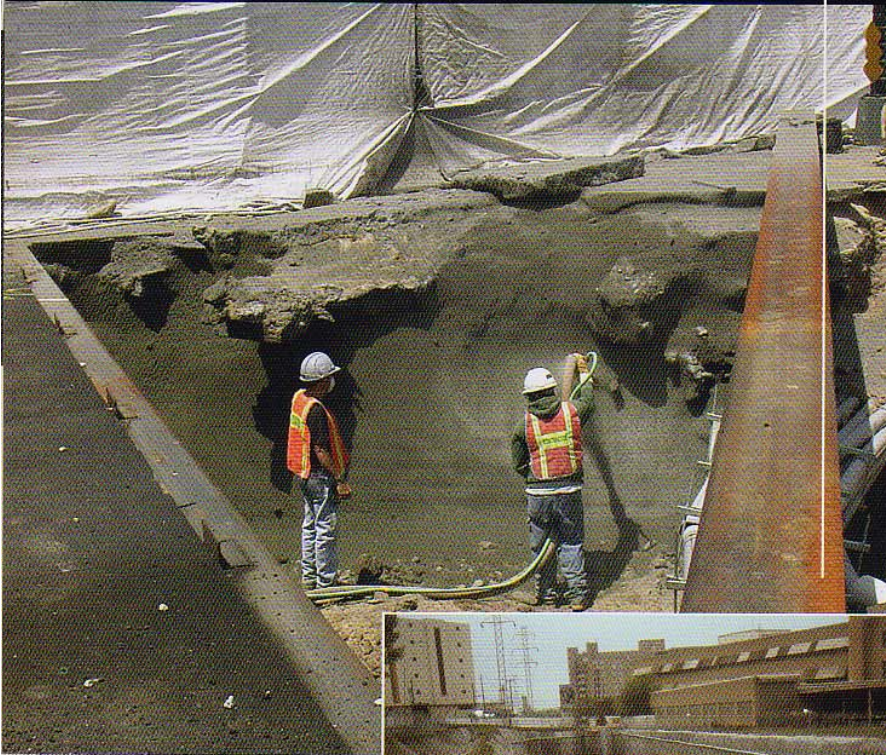
The process is not simple by any means, and the shotcrete professional must be able to integrate new materials with in-place construction to form a composite that will stand up to exposure and use. As important as the materials is the coordination of effort from the contractor, materials supplier, engineer, and architect. When all of these pieces are in place, the project can be completed on budget and within expected performance guidelines.

Sewers



Ground Support

Stabilization



Earth and rock excavations are effectively stabilized with shotcrete and a variety of reinforcement and anchoring systems. Using shotcrete to stabilize soil for excavation has advantages over traditional timber and steel shoring techniques.

Shotcrete:

- Is flexible and easy to install;
- Uses space more efficiently by allowing vertical excavation of alternate panels, creating stable vertical walls very close to other buildings;
- Saves money — can concrete right over the shotcrete (one side forms only); and
- Can be more economical than other systems because of the ability to build maximum dimensions of the property and use the excavation as the form system.

Soil Nailing

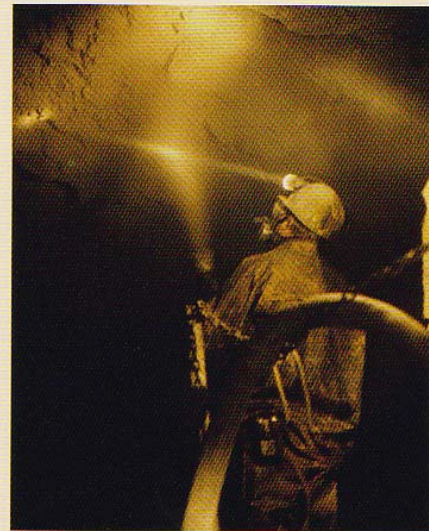
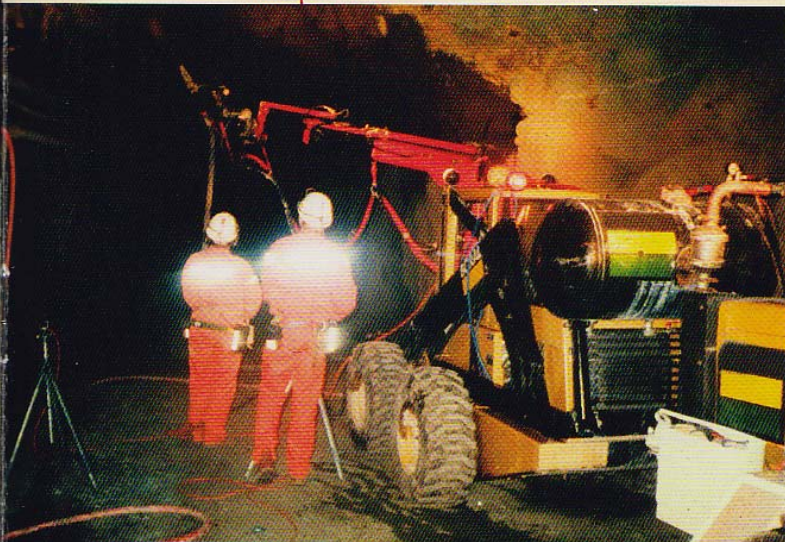




Tunneling

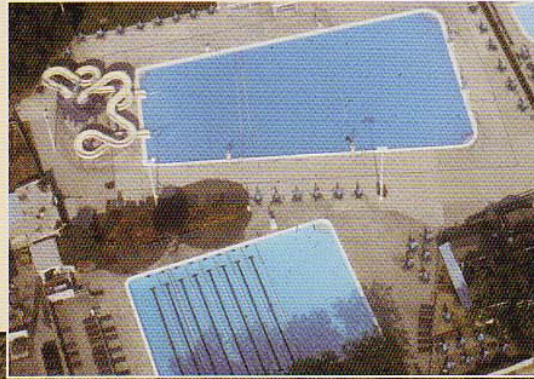
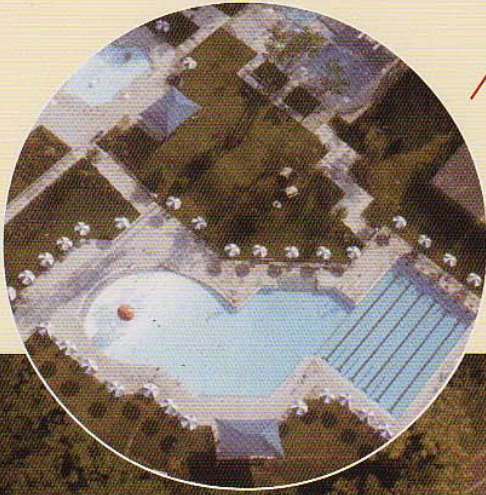
Mining

Shotcrete is ideal for ground support in tunneling and mining. It provides early ground support after blasting or excavating, early strength development, which provides flexibility to allow for ground stabilization and stress relief, and offers the ability to conform to the natural irregular profile of the ground without formwork, which makes it ideal for any tunnel. It is also the preferred material/process for underground stations, side drifts, shops, etc., and provides long-term stability — it can be used as a final or permanent lining for underground structures.



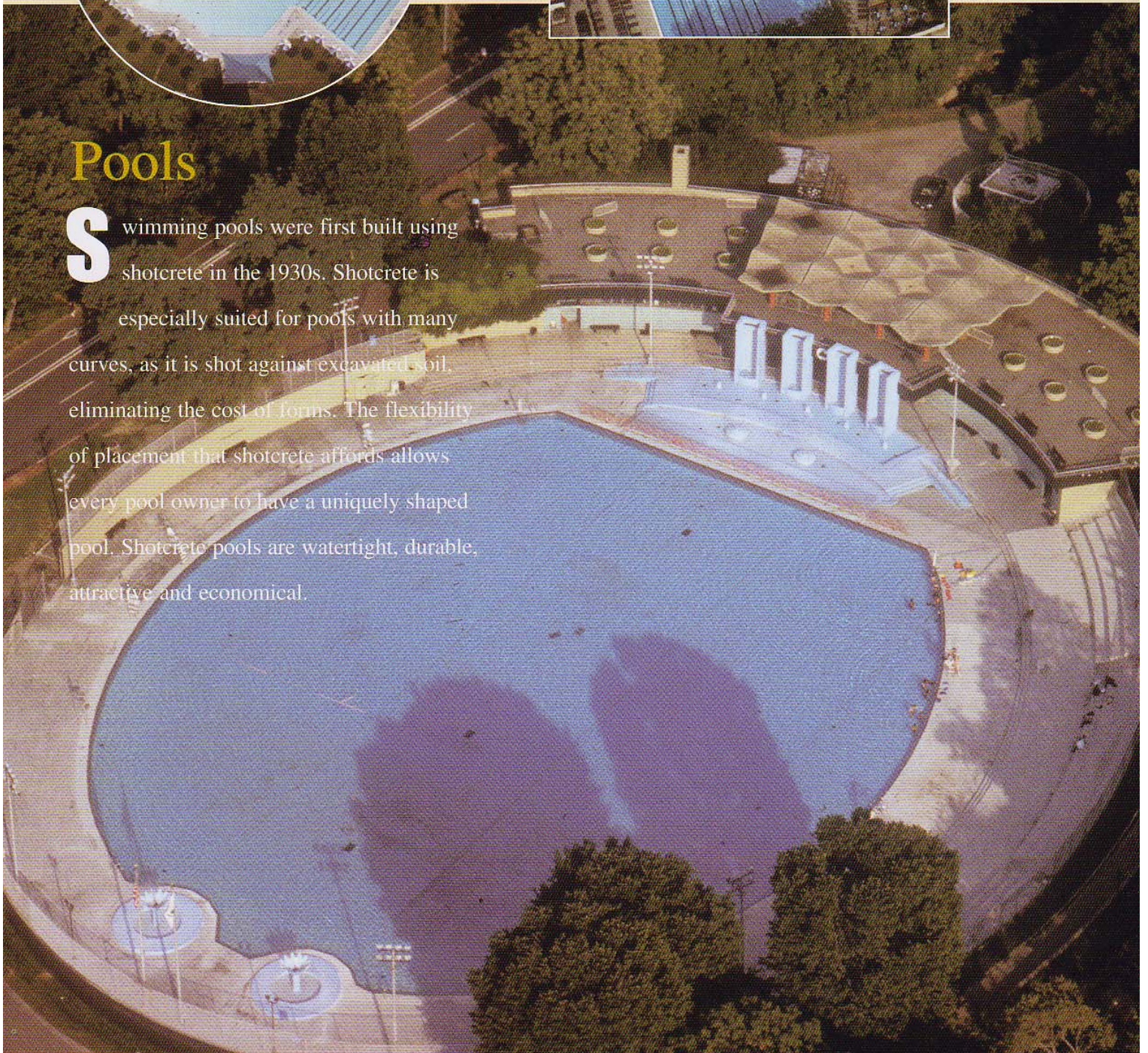
Ground Support

New Construction



Pools

Swimming pools were first built using shotcrete in the 1930s. Shotcrete is especially suited for pools with many curves, as it is shot against excavated soil, eliminating the cost of forms. The flexibility of placement that shotcrete affords allows every pool owner to have a uniquely shaped pool. Shotcrete pools are watertight, durable, attractive and economical.

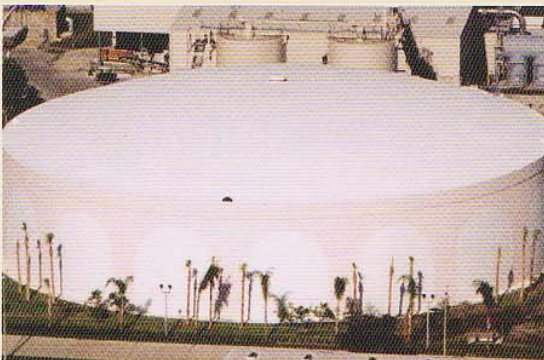


Shotcrete is the preferred material in the construction of many new structures from foundations up to domes and everything in between. After years of investigation and trial, specialty contractors have selected shotcrete because of reduced costs due to minimized forming and the ability to construct straight, curved, and irregularly shaped surfaces while providing a durable concrete structure.



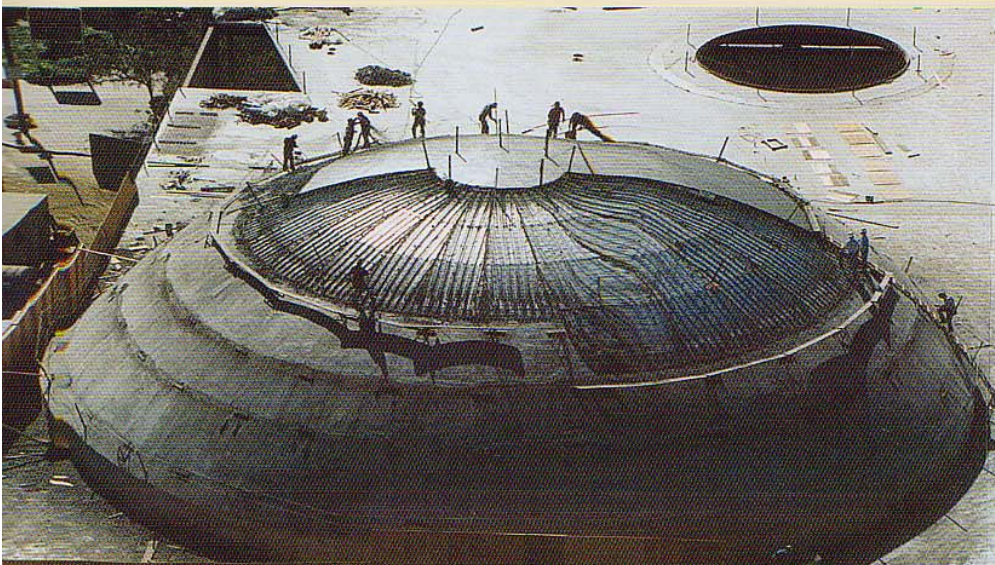
Foundations

Tanks



Nearly 4000 shotcrete tanks have been built since the process was pioneered in the early 1930s. These watertight, durable, and economical tanks, which range in size from 50,000 to 20-million gallons, can be used to store a variety of liquids, including waste water, industrial wastes, and chilled water.

Domes

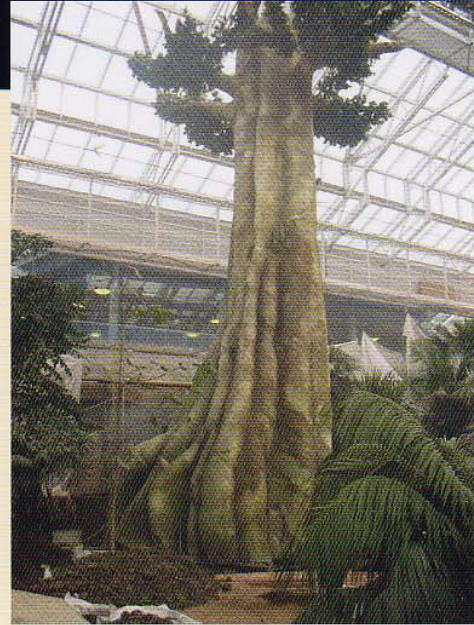


Further, since their initial creation in the 1950s, thousands of shotcrete domes have been built as well, ranging from small shelters to huge vessels spanning over 200 ft.

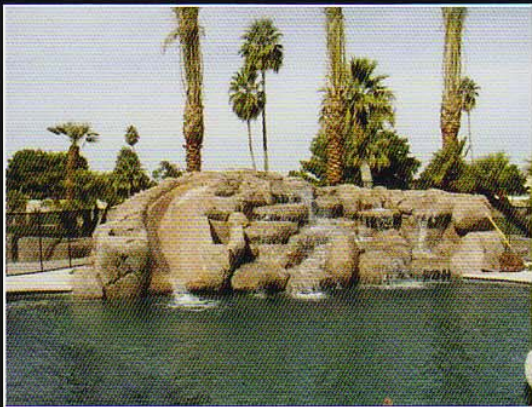
Sturdy, attractive, and cost-effective, these structures are built for a variety of uses, including homes, grain-salt storage, churches, and auditoriums.

Architectural

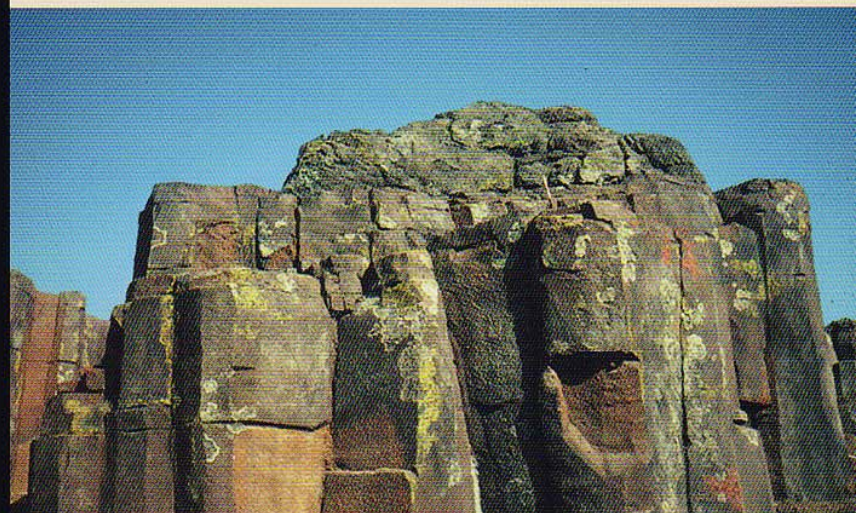
Shotcrete has become the material of choice for an increasing number of architectural applications. From intricately formed building structures to landscapes and zooscapes — shotcrete meets the construction needs of architects, designers, and contractors alike. And shotcrete construction can often be completed faster and more economically than other conventional construction techniques.



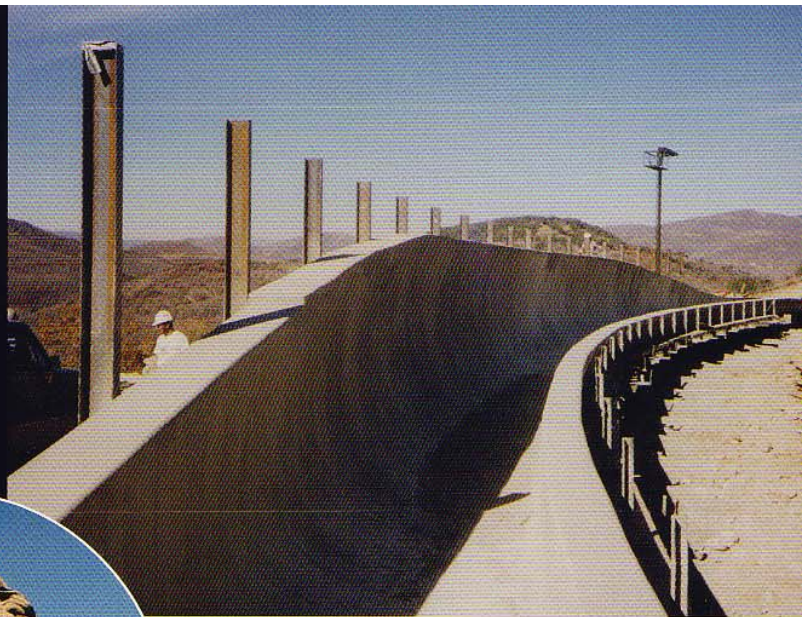
Zoos



Landscape

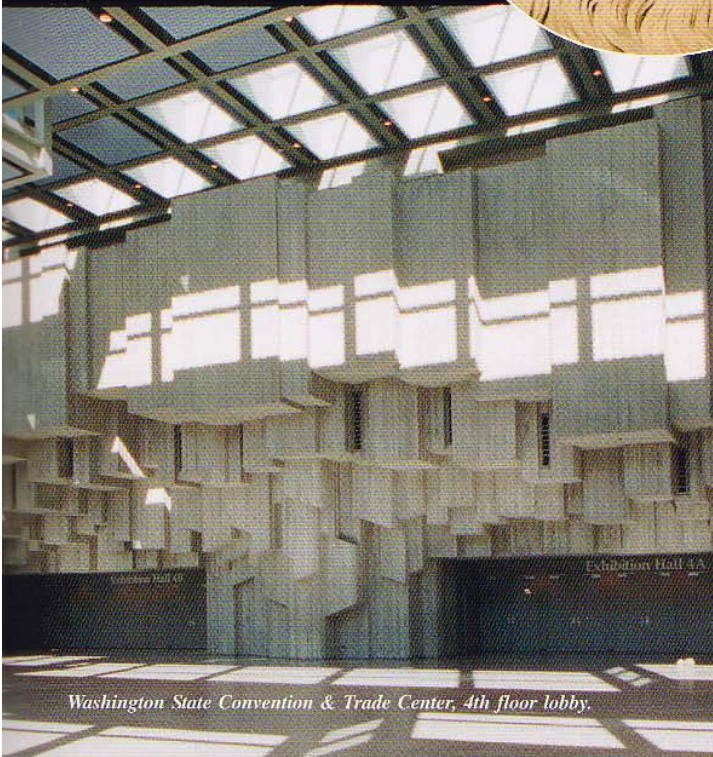


Specialty



The shotcrete process has been used for repair and installation of new linings in industrial melting and firing facilities since 1915.

The relining of blast furnaces, ladles, and casting facilities, as well as petroleum and cement producing plants, are some of the applications that employ both wet- and dry-process shotcreting of specialty, heat-resistant materials. The shotcreting process allows for new installations during down time, and “hot” installation of certain materials as a routine part of the production cycle — another advantage of this unique concrete construction method.



Washington State Convention & Trade Center, 4th floor lobby.

Refractory



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www.shotcrete.org

The American Shotcrete Association, formed in March 1998, is a non-profit organization of contractors, manufacturers, engineers, owners, and others with a common interest in promoting the use of shotcrete. The purpose of the organization, as stated in its bylaws, is as follows:

- Educate the construction community as to the benefits of the use of shotcrete;
- Encourage and promote the use of shotcrete by providing useful and accurate information to the concrete specifying and purchasing communities;
- Support and promote the education and training of those in the shotcrete industry and the proper methods, materials, and techniques to obtain high-quality shotcrete; and
- Strive to maintain the highest standards of ethics and conduct for the members of the association.

The association's many standing committees include:

Certification/Education, Marketing, Membership, Publications, Safety, and Underground.

