SHOTCRETE PRIMER

by Jeff Smith

Concrete shot through a nozzle is just right for a variety of repair and construction techniques

In 1910, a double-chambered cement gun was introduced to the construction industry. The sand-cement product used with this device was called Gunite. In the ensuing years, the pneumatically applied material was called by many names, but today it is widely known as "shotcrete." Initially, its most frequent use was to cast in-ground swimming pools. But the introduction of new mixtures, and new equipment, have made shotcrete an appealing alternative to conventional concrete in a variety of new construction and repair situations. Cost and convenience are the primary benefits. Shotcrete is particularly cost effective where formwork is impractical, or where forms can be reduced or eliminated, access to the work area is difficult, thin layers or variable thicknesses are required, or normal casting techniques cannot be employed. Its excellent ability to bond is often a driving factor in choosing shotcrete over ordinary concrete.

Types of Shotcrete

Shotcrete is basically a combination of sand, cement, and water which is fed through pressurized equipment and literally "shot" or sprayed through a nozzle onto concrete or other substrates such as brick, ledge, or pavement. But just about anything that will hold or create a shape can act as a substrate for shotcrete.

There are two general shotcrete methods — wet and dry. Wet shotcrete is premixed: Sand, cement, and water are fed into a pumping system, through a discharge hose, and shot through an adjustable nozzle onto the substrate. Generally, wet shotcrete is easy to work with and requires relatively simple equipment to apply.

Dry shotcrete methods, on the other hand, do require sophisticated equipment and experienced operators. The sand and cement components of the mix are pumped dry through the discharge hoses and then are wetted out at the nozzle just prior to being shot through a device known as a water ring.

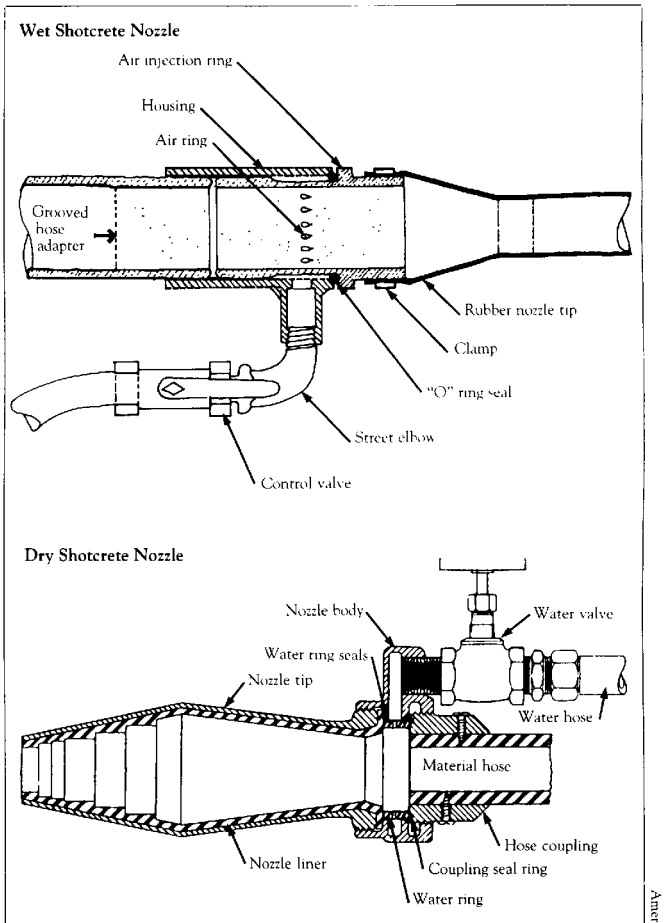
The operator can regulate fluid in the mix, thus fine-tuning the amount of slump (see glossary). In this way, experienced operators can control rebound and create the best water/cement ratio possible for the specific job.

Special Shotcrete

Shotcrete can be modified through a variety of admixtures currently available, which improve the performance of the mix.

Accelerators. Accelerators are the most commonly used shotcrete modifiers. They speed up shotcrete's setting time. Initial setting times can be reduced from three hours down to three minutes, if required. The problem with set accelerators is that they reduce the final strength and durability of the mix. In addition, when being used in wet shotcrete equipment, the accelerators must be added at the nozzle so the shotcrete does not harden in the discharge hoses. Some of the accelerators are caustic, and special care needs to be taken when using them. In my opinion, these calcium-, sodium-, or potassium-based admixtures should be avoided if they are not required.

Silica-fume. Silica-fume, or silicon-dioxide modification is becoming popular. It is an extremely fine (1/60 the size of cement particles) admixture, and acts as a very efficient *pozzolanic* material. Pozzolans can enhance the workability or pumpability of some wet-mix shotcretes, so less cement is required. Reduced permeability and better durability are all advantages of silica-fume modification. More importantly, rebound can be held to less than 5 percent, which makes for a much neater job. A 16-inch layer of shotcrete can be shot overhead in one pass with silica-fume-modified shotcrete. Considering that with hand applied or troweled repair mortars only 2-inch layers can be



Wet shotcrete is premixed and shot through an adjustable nozzle (top) onto the substrate. The equipment is easier to work with, and less sophisticated then that required for dry-mix, where the material is wetted just prior to being shot through a device known as a water ring (bottom).

American Concrete Institute

Shotcrete Makes Fast Work of Exterior in New Building System

High Tech Homes, Inc., in Coral Gables, Florida, has patented a lightweight construction system which uses shotcrete on its exterior walls. Expanded polystyrene, precut to specification, forms integral beams and columns in the sidewalls and endwalls, while cast-in-place concrete is used on the roof. A two-inch layer of shotcrete is pneumatically applied to the exterior walls. Once in place, the exterior is usually finished with stucco, but other materials can be used: The company recommends elastomeric finishes, because they provide more flexibility (than stucco), and more color options. (Two such products out on the market are Visewall Glaze made by Cota Industries, Humble, Texas, and Thorolastic, manufactured in Miami, Fla.)

The system has the approval of BOCA, ICBO, and Dade County. Contractors are using it to build single-family homes and condominiums, as well as commercial buildings. The company claims that a crew of five can complete the shell of a 2,000-square-foot rectangular house in ten days.

The cost of building a home using the system is comparable to a conventional home, but energy savings are substantial. Florida Power & Light has rated the walls at R-42.

High Tech Homes licenses builders to use the system. Gallagher Development Corp., of New Rochelle, N.Y. is the company's first licensee in the Northeast region. Gallagher plans to build two spec homes using the system to see how well they perform. *–NEB*

Polystyrene, wire mesh, reinforcing steel ready for shotcrete.

Shotcrete applied on exterior 2 inches thick.

Completed wall ready for cladding.

applied at a time, labor and time savings can be substantial in thick applications.

Polymer. The addition of latex to shotcrete improves flexural and tensile strengths, and can improve bond as we as reduce absorption and penetration of chlorides (salts). Latex modification results in eight times the resistance to "salt intrusion" by de-icing product: The biggest drawback with polymers is that they are liquids and must be added at the nozzle, requiring sophisticate equipment.

Fiber Reinforcement. In some case: where substantial structural repair is needed, or in new bridge or retaining wall construction, reinforcement is required. Usually this is done by attach ing light-gauge, galvanized wire mesh to the place needing repair. The shot crete is then applied, encapsulating it In Australia, and in some locations in Canada, applicators have experimented with adding small bits of reinforcement to the mix. The problem with this is that there is much less control over where the bits go, and you can have problems with hollows in the shotcrete material, and rebound. It can also cause problems with the equipment.

Using Shotcrete

Shotcrete's biggest advantage is speed. In areas that require large quantities of material, shotcrete is the answer. It's ability to be applied in thick layers and conform to existing substrates is unequalled.

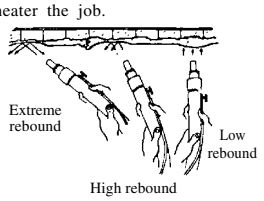
Shotcrete is used extensively as a fast repair mortar or waterproof layer on both vertical and overhead areas. One interesting use of accelerated shotcrete is tidal applications or splash zones where instant set is important. Shot crete was used extensively to repair docks at the Portsmouth Naval Shipyard.

For architectural repair, probably the last thing to come to mind would be shotcrete. The thought of spraying concrete through a nozzle seems to be at best a messy job, with the finished product being irregular and ugly in appearance. But the Washington Mills project (see "Case Study") proves that shotcrete can serve well in architectural repairs. ■

GLOSSARY

Slump: Plasticity, or the workability, of concrete. The more water added, the greater the slump.

Rebound: When shotcrete is sprayed, a certain amount of the mix will bounce off and fall to the ground. The less rebound, the neater the job.



Water/cement ratio: The amount of water compared to the amount of cement is critical. Too much water can greatly reduce the ultimate strength and durability of any cement-based system.

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CASE STUDY:

Project: Washington Mills Rehab, Lawrence, Mass.
Subcontractor: Structural Preservation Systems, Inc., Walpole, Mass. (Joe Cucci, G.M.)

Washington Mills is a 5-story, 180,000-square-foot complex. As Figure A shows, the complex was in total disrepair. The existing concrete facades were completely deteriorated. The depth of patches required would make hand-applied mortars expensive and labor intensive. The brick, however, seemed to be in relatively good shape. Surrounding the Mill complex was little or no space for equipment. In Figure B, workers have been transferred down to the problem areas on rigs attached to the roof. They are shown hammering away the crumbling concrete. Figure C shows the bulk of the required equipment, neatly hidden away in a remote area. of the mill. (At some points, the compressor was as much as 5 stories away, and 300 feet down.) Note the large compressor required to maintain good pressure through the extensive discharge hoses required. Figure D shows nozzlemen applying shotcrete with a cement finisher waiting to tool any uneven areas of patch. Figure E shows the finished product: a neat, well-formed, patched facade that conforms completely to original design. In all, restoring the mill buildings' exteriors took six months, including preparation and hand-troweling. The shotcrete portion of the project took two months and cost 50 percent less than the expense of conventional repair. By using shotcrete as much as possible, the mills' owners were able to realize at least five times the productivity over conventional methods.

Figure C

Figure A

Figure D

Figure B

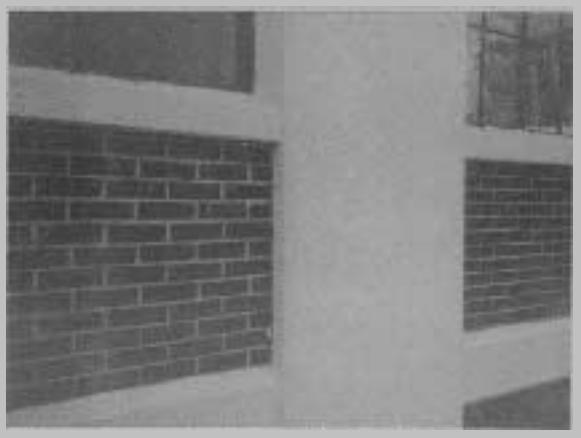

Figure E