

# Rules of Thumb



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In this issue columnist **Keivan Rafie** compares and contrasts dry shotcrete with its wet counterpart, and reviews its operation and equipment

**D**RY SHOTCRETE, THEN KNOWN as “gunite”, was invented in 1907 by American taxidermist Carl Akeley to repair the crumbling facade of the Columbian Museum in Chicago. He used the method of blowing dry material out of a hose with compressed air, injecting water at the nozzle as it was released.

In the Dry Shotcrete process, dry materials are combined in a “pot” and transported pneumatically to a nozzle where water, any liquid admixtures, and an accelerator are introduced into the stream-feed. This mixture is immediately sprayed onto the target surface by compressed air.

The interior of the nozzle is fitted with a water ring, which uniformly injects water into the mixture as it is being discharged from the nozzle and propelled against the receiving surface.

The cementitious material and aggregates are thoroughly mixed and either bagged in a dry condition or mixed and delivered directly to the gun.

## ADVANTAGES OF DRY SHOTCRETE VERSUS WET SHOTCRETE

- Instantaneous control over mixing water and consistency of mix at the nozzle to meet variable field conditions.
- Better suited for placing mixes containing lightweight aggregates, refractory materials, and shotcrete requiring early and higher strength properties.
- Capable of being transported longer distances. Start and stop placement characteristics are better with minimal waste and greater placement flexibility.
- Lower equipment and maintenance costs.
- Bond strengths of new shotcrete to existing materials are generally higher with dry-mix shotcrete.

## DISADVANTAGES OF DRY SHOTCRETE VERSUS WET SHOTCRETE

- Limited to accelerator as the only practical admixture.
- Air-entraining admixtures have little

effect on dry-mix shotcrete since there is no mixing of admixture water and aggregate until impact on the shooting surface. Some contractors prefer to add an air-entraining admixture to a mix to improve workability.

- Applied at a much slower rate than wet-mix shotcrete. Dry-mix shotcrete is often applied at a rate of 1 or 2 cubic yards per hour compared to up to 7 or 8 cubic yards per hour for wet-mix shotcrete.
- Wet-mix shotcrete rebounds somewhat less than dry-mix shotcrete. Rebound is the material that “bounces” off the shooting surface. Rebound for conventional dry-mix shotcrete, in the best of conditions, can be expected to be at around 20 per cent of the total material passed through the nozzle.

## EQUIPMENT

Dry process equipment typically includes compressed air, water (preferably potable), shotcrete pot, accelerator dosing device, and robotized placer (for larger jobs).

Water supply booster pumps for dry-mix should be capable of supplying at least a 10-gallon/minute flow at 60 psi at the nozzle for standard nozzles. The water pressure must be constant and 15 to 30 psi above operating air pressure.

It is advantageous to pre-moisturize this material to three to six per cent, by dry mass, prior to entering the shotcrete gun. A pre-moisturizer is a piece of equipment staged just before the shotcrete gun that uniformly distributes and mixes water to a continuous feed of dry materials.

A dry-mix nozzle typically consists of a tip, water ring, control valve, and nozzle body arranged in a wide variety of configurations.

## OPERATION

It is common practice in dry-mix shotcrete projects to pre-bag all the materials together in a dry condition at the site. In the dry-mix process, dry (powder) admixtures are usually introduced into the mixture during batching. If a continuous feed gun is

being used, they may also be added directly into the gun hopper by a special dispenser.

The batched water-cement ratio for coarse aggregate dry-mix shotcrete typically varies between 0.30 to 0.40.

Typically, a performance specification of 12-hour, 7-day and/or 28-day compressive strengths will be specified, along with a grading for the aggregate.

Test panels are particularly important as laboratory mixtures cannot duplicate as-shot dry-mix shotcrete.

The quality of dry-mix shotcrete is particularly dependent on the skill of the nozzleman, because his or her ability to control the amount of water being added to the mixture is essential.

Putzmeister (one of the leading companies in Shotcrete technology) lists these three as top mistakes made during the shotcreting process:

- Adding water in excess
- Dosing the accelerator uncontrollably
- Forgetting to clean the surface.

Shotcrete can be produced by either the dry-mix or wet-mix process. However, differences in the equipment cost, maintenance requirements, operational features, placement characteristics, and product quality may make one or the other more attractive for a particular application. ☺

## Suggested reading

To find more in-depth information, the author recommends: European specification for Sprayed Concrete (Guidelines), Shotcrete - Elements of a System (E.S. Bernard), and Engineering Properties of Shotcrete (W.R. Lorman).

## Agree or disagree?

Let us know what your experience has taught you. Or let us know what topic should be included in future *Rules of Thumb* columns.  
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