

## INTRODUCTION

This circular contains three papers which committee A2E05 "Chemical Additions and Admixtures for Concrete" believes would be of benefit to the industry.

The subjects cover rapid setting admixtures for shotcrete, grouts for filling voids under existing pavements, and nucleation kinetics of calcium chloride. In addition to the authors, the committee would like to acknowledge the contribution of Michael Pistilli to assembling this document.

### RAPID-SETTING ADMIXTURES

by

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### Abstract

Rapid-setting admixtures are commonly used in both dry and wet process shotcrete and in rapid-setting mortars for hand applied patches for stopping leakage, setting bolts and other uses where rapid setting is desired.

In shotcreting operations, rapid setting and rapid strength gain are desirable for early support of rock in tunneling (new Austrian tunnel method) the application of thick layers of shotcrete in overhead and vertical positions and for sealing leakage.

The setting times referred to in this section are measured in minutes. As an example, the proposed ASTM requirements for rapid-setting shotcrete admixtures will require an initial set of less than 2-1/2 minutes and a final set in less than 9 minutes, when measured with Gillmore Needles.

There are available rapid-setting shotcrete admixtures which cause such rapid stiffening that hand mixing in the laboratory is not possible.

These admixtures are available as both liquids and powders. Generally, liquid admixtures are used with wet-process shotcrete and powdered admixtures with dry-process shotcrete.

Rapid-setting admixtures are also formulated with portland cement and sand for use as rapid-setting mortars for sealing leakage.

### Materials

Both organic and inorganic chemicals are used in formulating rapid-setting admixtures. Rarely is only one chemical employed, since one chemical will generally influence time of initial or final setting, but not both. Many of these combinations are covered by active patents.<sup>(1)</sup> Water-reducing admixtures are also quite often employed in these formulated products. Many of these chemicals and combinations are highly caustic and require caution in handling and use.

Chemicals used in powdered rapid-setting admixtures include:

sodium carbonate  
 sodium aluminate  
 sodium hydroxide  
 trivalent iron salts  
 salts of alpha-hydroxy acids  
 aluminum hydroxide

Chemicals used in liquid rapid-setting admixtures include:

sodium silicate  
 sodium aluminate  
 sodium hydroxide  
 aluminum hydroxide  
 salts of alpha-hydroxy acids

#### Addition of Rapid-Setting Admixtures

With wet process shotcrete the liquid admixture is usually pumped by a metering pump through a hose and injected into the air stream, either at the nozzle or directly into the air ring in the nozzle.

With the dry process shotcrete the admixture is usually added to the shotcrete via powder dispensers, as the shotcrete is conveyed to the shotcrete machine. These dispensers can be synchronized to the speed of delivery of the dry shotcrete to the machine.

On small projects where feed conveyors are not used, the dispenser is often mounted directly on the hopper of the shotcrete machine or addition is by hand. With both these methods dosage is only approximate and usually non-uniform.

The powder dispensers used, meter and deliver, either by a small screw conveyor or by a vibrating conveyor.

#### Effect on Concrete or Mortar

These admixtures will impart very rapid time of setting and very high early strengths, but will generally result in reduced ultimate strength.

Specifications for accelerated shotcrete for early support of tunnels range from 600 to 800 psi, core strength at 8 hours. 8 hour strengths as high as 3800 psi have been reported.<sup>(4)</sup> Accelerated dry process can attain very high 28 day strengths, 9100 psi strengths have been reported and 7000 psi at 28 days is common.<sup>(1, 2, 3, 4)</sup>

Drying shrinkage may be increased or decreased, depending on the formulation.<sup>(2)</sup> Rapid-setting admixtures containing aluminum salts should not be used in shotcrete where sulfates may be present. Those containing alkalies should not be used with reactive aggregates where a low-alkali cement has been specified.