ADMIXTURES FOR SHOTCRETE

Shotcrete is normal concrete placed by a spraying process. In any kind of support work where shotcrete is used it is considered essential in Europe that a set accelerating admixture is incorporated into the mix.

This is particularly so in underground construction where the shotcrete is required to bond and harden very quickly after placement on a surface. A high early strength is usually specified for tunnelling construction where shotcrete is employed to provide a primary lining and forms part of the supporting structure. This is an important part of the tunnelling method used currently in Europe where rock, bolts and shotcrete act as supporting components. The theory and practice for this method developed in Austria and this is given the name of the New Austrian Tunnelling Method.

Our company supplies approximately 80% of all the accelerating admixture used in Austrian tunnelling contracts. The information which follows is based on the experience of the contractors and the manufacturers.
To obtain the best results an initial setting time of at least 2 minutes and a final setting time of no more than 4 minutes is required.

In addition a twenty four hour compressive strength of 28 - 34 N/mm² (4000 to 4850 psi) is required.

The addition of chemical admixtures to accelerate the setting times of a shotcrete mix should produce the required early strength without lowering the final strength.

The admixtures must be added to the mixture of sand and cement as late as possible to avoid premature reaction with the cement due to the presence of moisture in the aggregates.

**SETTING TIMES**

The setting of shotcrete when using the WALLCRETE accelerating admixture, is investigated by testing for the initial and the final setting time on a standard mortar. This mortar is composed of 140 grammes of sand, maximum particle size 3 mm, with a water content of 3% by weight, 60 grammes of cement, 30 - 35 grammes of water plus Wallcrete dosages in variable percentages of the cement weight.

The sand, cement and Wallcrete ingredients are dry mixed 15 - 20 seconds with a spatula with water added in three different tests, zero (immediately) then after one and five minutes respectively.
These tests are necessary to investigate the setting times when using transporting hoses with various lengths.

The sand, cement and admixture mortar is turned out of the cup and hand formed into a pat 80 mm diameter by 40 mm thick on a pane of glass. Initial and final setting times are measured by the Vicat needle. The tests are performed at a temperature of 20° - 22°C.

Quality control

The usual method adopted is by spraying into special moulds but this tends to be used less and less because the results so obtained are not reliable enough.

The mould comprises a framework 120 x 120 x 360 mm long which is hung vertically on a wall. The mould is filled as the wall is sprayed. When the shotcrete is of sufficient strength the mould is removed from the wall and the test prism cured in conditions duplicating the site. It is necessary to ensure that the prism are of the standard dimensions 120 x 120 x 360 mm and some cutting or filling may be necessary to ensure these are maintained.

Each of these prisms can be tested for flexural strength once and for compressive strength twice. Tests are carried out after 1, 3, 7 and 28 days according to requirements.
Core drilling

We believe that results obtained when using small drilled concrete cores are more reliable.

Special core drilling equipment is used to obtain the sample core cylinders from the tunnel lining. These cylinders are 56 mm long by 50 mm diameter for the compressive strength test.

The correlation with the cube compressive strength is very good as long as the core is cut with care and the ends are perpendicular to the axis of the cylinder.

Cores should not be drilled from the shotcrete lining until the latter has reached a compressive strength of about 70 x 14.22, 7 N/mm$^2$ approx., 995.4 psi as there is a danger of pull out. This required strength is usually reached after 15 - 18 hours.

It is not easy to achieve a really adequately functioning shotcrete with a good strength capacity and optimal set behaviour without some means of dispensing the admixture to the mix.

The addition of accelerators can be carried out in the liquid or powder form. It is therefore necessary to differentiate between two types of dispensers. One which adds the admixture to the mix before it enters the shotcrete machine and one which adds the liquid with the water at the nozzle.
Our experience lies with the powder dispenser which uses the feeding conveyor to the shotcrete machine as a power source and if properly calibrated can achieve an accuracy of half a percent. There is always the danger of a lack of mixing between cement and powder admixture. The dispenser feed geared to the conveyor belts is our answer to this problem. Our results prove that the method works without having complicated dispensers in a rough environment.

Note: Wallcrete has been renamed Accrete for USA and UK markets for obvious reasons.
50 kg capacity hopper

feed adjustment for calibration

support frame

synchronising wheel on rubber conveyor belt

shotcrete machine hopper

conveyor belt with dry mix

DIAGRAMATIC REPRESENTATION OF ADMIXTURE DISPENSING SYSTEM FOR DRY MIX
ACCRETE is a set accelerating and waterproofing admixture designed for use with shotcrete. There is an added advantage in that this admixture will assist in the reduction of rebound from the sprayed surface.

The primary requirement of the engineer's specification for quality of structural concrete may be checked by prior tests. The cement compatibility must be checked before the required quantity of ACCRETE for the mix can be ascertained. This will be carried out as part of the Wallco Chemicals Ltd service. Normally this addition expressed as a percentage of cement weight per cubic metre is between 2 - 7%. Factors affecting this quantity will be the cement type, thickness of applied concrete and the required rate of setting and hardening. Where possible it is recommended that careful batching and mixing are employed for shotcrete mixes so that consistency may be maintained. The addition of ACCRETE to the mix should be made at a point just prior to the mix entering the shotcrete machine hopper.

Using the WALLCO ADMIXTURE DISPENSER which can be calibrated to suit flow of materials on a conveyor feed the percentage addition can be maintained within reasonable limits.

For details of shotcrete machines please see our leaflets on the WALLCO ICOMA 70 - 75 and WALLCO MINI available on request.

SPECIFICATION

COLOUR - grey

BULK DENSITY - 0.7 kg/litre

SOLUBILITY - partially in water

SENSITIVITY TO HUMIDITY - hygroscopic

PHYSIOLOGICAL EFFECT - slightly caustic (on a par with OPC)

PACKAGING - 25 kg bags

STORAGE LIFE - one year in dry conditions
AGGREGATE GRADING FOR SPRAYING MATERIAL

The aggregates have decisive influence on the quality of the spraying material. Best results have been achieved by using the grading curve shown.

THE INFLUENCE OF THE PROPORTIONATE BATCH OF ACCRETE WITH RESPECT TO THE RATE OF SETTING

Raising the admixture content of ACCRETE accelerates the rate of setting of cement. The diagram shows the rate of setting by ACCRETE being metered 0.5 - 7% in cement weight; Vicat Method.

STRENGTH DEVELOPMENT OF SPRAYED CONCRETE CONTAINING ACCRETE COMPARED WITH CONCRETE WITHOUT ADMIXTURE

A = 0
B = 2% ACCRETE
C = 4% ACCRETE