Admixture Technical Sheet – ATS 3

Set Retarding

Set Retarding / Water Reducing / Plasticising

1 Function

Set retarding admixtures are water soluble chemicals that delay the setting of the cement. They do not plasticise significantly and have little or no effect on the water demand or other properties of the concrete.

Set retarding water-reducing admixtures not only delay the setting of the cement but also increase initial workability by plasticising the concrete or reduce its water demand. The majority of commercially available retarding admixtures are of this type.

Retarding water-reducing and retarding high range water reducers are used to:

- Delay the setting time of concrete
- Prevent the formation of cold joints
- Increase initial workability
- Improve workability retention to the concrete
- Increase ultimate strength
- Produce economies in mix designs

It should be noted that while a retarder is needed for retention of slump, addition of a retarding admixture does not in itself produce slump retention and other changes to the mix will probably be needed.

2 Standards

These classes of admixture are covered by the requirements of BS EN 934 Part 2: Concrete admixtures – Definitions requirements, conformity, marking and labelling. The specific requirements for each of the three categories are stipulated in Tables 8, 10 and 11.1 and 11.2 respectively.
All CAA manufacturers CE mark their products to show they conform to this standard.

3 Materials

The main types of chemical used for retarding admixtures comprise:

Hydroxy carboxylic acid salts
Saccharides and polysaccharides
Citric acid salts
Tartaric acid salts
Boric acid salts
Salts of phosphoric, poly-phosphoric and phosphonic acids.

These may be also be used in conjunction with Lignosulphonates, sulphonated naphthalene/melamine-formaldehyde condensates or polycarboxylates to produce retarding water reducing and retarding high range water reducing admixtures.

4 Mechanism

The retarder molecule chemically adsorbs onto the cement particle in a mechanism similar to that described for water reducers. The main difference is the strength of the chemical bond that is formed. This bond links the retarder molecule onto the cement surface, blocking and slowing down the rate of initial hydration of the cement.
Retarder molecules may also chelate calcium ions in solution, slowing the crystallisation of portlandite and nucleation of CSH.

These two mechanisms slow the development of hydration products, delaying the stiffening and setting of the cement but once initial hydration starts, the retarder molecules are swamped and normal hydration proceeds.

5 Use

5.1 Admixture Selection

The choice between the different types of retarding water reducing admixtures is often determined by properties such as mix cohesion. Selection may therefore be based on the particular mix characteristics of the concrete.

Sucrose and other polysaccharides are very efficient retarders but a dosage versus setting time graph may often be exponential, making accurate prediction more difficult. These types are often blended with lignosulphonate to produce cost effective, retarding/water reducing admixtures.

Hydroxy carboxylic acid salts will often reduce cohesion in the mix potentially enhancing bleed and segregation. Polysaccharides, especially if blended with a lignosulphonate, tend to stabilise some air and may enhance cohesion.

For phosphate based products, the retardation / time graph is often linear, and this is a major advantage for this type of retarder. They are also less likely to give excessive retardation if overdosed.

5.2 Dosage

Retarding admixtures based on sucrose and other similar polysaccharides are very powerful, and their retarding effects are rarely linear so that small increases on the intended dosage can lead to large increases in retardation. They are very cost effective with typical dosages in the range 0.1% to 0.6% by weight of cement to yield a delay of set of 3 hours to 50 hours. Retarding high range water reducers are generally dosed in the range 0.5 to 1.5% dose.

Retarding admixtures based on phosphates and particularly phosphonates are designed to have a more linear effect of dosage upon setting time. The dosage rate used may be quite high with typical dosages of 0.1% to 3.0% by weight of cement to yield a delay of set of 1 hour to 35 hours.

Retarders are quite sensitive to temperature. At low temperatures retardation will be further extended. At very high temperatures, the converse is true and it may be difficult to achieve the required workability retention and extension of stiffening time.

Due to the potential sensitivities of retarding admixtures it is strongly suggested that trials are undertaken to establish dose to retardation profiles over the range of temperatures that may be expected in normal use. As an approximation for every 1^{o} C under 20^{o} C the retardation will be extended by 1 hour.

5.3 Cement type

Retarding admixtures and water reducing retarding admixtures can be used with all types of Portland cement, including all those covered by EN197-1. However, it is very important to note that their effectiveness in terms of retardation of set is very dependent upon the type of cement.

If additions such as ground granulated blastfurnace slag (GGBS) or fly ash (PFA), are used or a CEM 2 or CEM 3 cement, the level of retarder will need to be reduced relative to a CEM I cement in order to achieve a given level of retardation.

The chemistry of the cement is also important in determining the effect of retarders. Cements low in tricalcium aluminate (C_3A) typically require significantly less retarder for a given degree of retardation.

5.4 Yield

Retarding admixtures do not have any significant effect upon the yield of concrete.
Retarding water reducing admixtures, when used to reduce the water content of concrete, will reduce the yield in direct proportion to the water reduction made. This needs to be taken into account when modifying the mix design.

5.5 Overdosing

The level of retardation achieved is related to the dosage used. Any overdose will result in an increase in setting time and this can be significant for some retarder types. Large overdoses of retarders can produce very long setting times.

Provided the overdose is no more than double that which was intended, and the concrete is well cured to prevent it from desiccation, accidentally retarded concrete will normally set and recover strength within two to three days. If the concrete remains fluid for an extended period, re-vibration may be advisable to close any settlement cracks before the concrete stiffens.

Where large, accidental overdoses occur or where large overdoses of a water reducing retarders have been used without a correspondingly large water reduction, the concrete may not recover its strength in a reasonable time. As a general rule, if concrete contains an overdose of a retarding admixture and has not set hard in 5 days, then it may not gain useful mechanical strength.

6 Effects upon properties of concrete

6.1 Strength

As with water reducing admixtures, ultimate strength gain is increased with increasing water reduction.

Retardation of set allows the slower formation of a more ordered, smaller, denser cementitous matrix. This often has the effect of increasing ultimate strength relative to an unretarded mix with the same water cement ratio.

6.2 Workability (Consistence)

Retarding admixtures do not have a significant effect upon initial workability.

Retarding water reducing admixtures can be used to increase initial slump by 60-100mm at a typical dosage of about 0.25% by weight cement. Set retarding high range water reducing/plasticizing admixtures may be used to enable initial workability to be increased to a greater extent, at a typical dosage level of 0.3 to 1.0%. Used to increase initial slump generally helps to reduce the rate of subsequent slump loss.

6.3 Slump loss

Retarding water reducing admixtures are very effective at reducing slump loss when used to increase the initial workability of the mix.
If water reduction is taken at the expense of high initial workability, initial slump loss may be slightly faster.

6.4 Setting time

A prime function of a retarder is to extend the setting (stiffening) time of concrete, usually in order to prevent the formation of cold joints between deliveries of concrete. Even if workability has fallen to almost zero slump, fresh concrete that has not actually set can be vibrated into, and will bond with, a preceding, older pour.

In hot weather, even a small delay in deliveries or a short breakdown of the pump can result in the first concrete pours setting before subsequent pours can be placed and vibrated to form a monolithic joint. In deep pours, if concrete placed early starts to set, the heat generated can cause faster setting of concrete above it and again lead to cold joints. In this situation, retarder dosage can start high and be progressively reduced as the pour proceeds.

6.5 Air entrainment

Retarding admixtures do not normally entrain air, and some types, especially those based on hydroxycarboxylic acid, may actually reduce air content. This may cause these retarded mixes to feel harsher and have more tendency to bleed.
Most types of retarder can be used effectively in combination with an air entraining agent without adversely affecting bubble structure.

6.6 Bleeding

The total volume of bleed water arising from concrete is often related to its setting time because once setting starts, bleeding stops. Thus retarded concretes are always more prone to bleed. Any reduction in air content tends to aggravate this potential problem.
The plasticising component of a retarding water reducing admixture may help to offset this effect and some types are formulated to slightly air entrain in order to reduce bleed.

6.7 Heat of hydration

Retarding admixtures do not reduce the heat output of concrete but do serve to delay the time of peak temperature rise by a similar time interval by which it was retarded. In small sections this may allow more heat dissipation and so peak temperature may be a little lower.
In thick sections there will be no reduction in peak temperature and there is evidence that the peak temperature may even be increased slightly.

6.8 Volume deformation

Creep and drying shrinkage are not significantly affected by the inclusion of retarding admixtures but plastic shrinkage may be slightly increased.

If the concrete is water reduced by the use of a retarding water reducing admixture, then drying shrinkage will be reduced.

6.9 Durability

Provided that the concrete is correctly cured, then retarded concrete should be just as strong and just as durable as equivalent plain concrete. However, because of the extended plastic stage, more attention needs to be paid to protecting the concrete before it sets.

7 Health and Safety of Admixtures

Most admixtures are non hazardous and pose no abnormal health and safety risk but as with all forms of chemical it is essential that the material safety data sheets are read and understood before use. Risk assessments should be conducted to ensure all users are provided with a safe means of use and relevant PPE.

8 Other information

Other CAA information sheets are available including Environmental Product Declarations, use of admixtures in drinking water applications, sustainability, storage and dispensing. These are available at www.admixtures.org.uk under the ‘Publications’ tab.