The special properties of concrete construction essay

Admixtures are used to give special properties to fresh or hardened concrete. Admixtures may enhance the durability, workability and characteristics of a given concrete mixture. Admixtures are used to overcome difficult construction situations, such as hot or cold weather placements, pumping requirements. The use of admixtures to increase the workability or to accelerate the hardening of the concrete will be permitted when approved by the Engineer. Admixture dosages shall result in the mixture meeting the specified plastic and hardened properties.

The major reasons for using admixtures are

1. To reduce the cost of concrete construction.

2. To achieve certain properties in concrete more effectively than by other means.

3. To maintain the quality of concrete during the stages of mixing, transporting, placing, and curing in adverse weather conditions.

4. To overcome certain emergencies during concreting operations.

CHAPTER 2

Set Retarding Admixtures

Set retarding admixtures are water soluble chemicals that have little or no other effect than to delay the setting of the cement. They do not plasticize 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 are also efficient in plasticizing concrete or reducing its water demand. Most commercially available retarders are of this type.

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

Give workability retention to the concrete

Delay the setting time of concrete

Prevent the formation of cold joints

Increase initial workability

Increase ultimate strength

Produce economies in mix designs

Materials Used

The main types of chemical used for retarding admixtures are:

Sucrose and other polysaccharides

Citric acid

Tartaric acid

Salts of boric acid

Salts of phosphoric, poly-phosphoric and phosphonic acids.

The main types of chemical used for retarding water reducing admixtures are:

Hydroxy carboxylic acid salts

Hydroxylated polymers

Lignosulphonic acid salts

These may be also be used in conjunction with sulphonated naphthalene/melamine-formaldehyde condensates or polycarboxylates to produce retarding high range water reducing admixtures. 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 strongly links the retarder molecule onto the cement surface, blocking and slowing down the rate of initial water penetration into the cement. Retarder molecules also chelate calcium ions in solution, slowing the crystallization of portlandite. These two mechanisms slow the growth 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.

Uses

5. 1 Admixture Selection

Where predictable set retardation is required, a retarding admixture is the best choice. Where set needs to be continually amended, a graph of dosage rate versus setting time can be determined for a given mix, at a given temperature. For phosphate based products, the retardation time graph may often be linear, and this is a major advantage for this type of retarder.

Sucrose and other polysaccharides are more efficient, 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. The choice between the different types of retarding water reducing admixtures is often determined by other properties such as mix cohesion. Selection may therefore be based on the particular mix characteristics of the concrete.

5. 2 Dosage

Retarding admixtures based on phosphates and phosphonates are designed to have a linear effect of dosage upon setting time. The dosage rate used may be quite high, as they do not have any effect other than retardation. Depending on the molecule chosen, typical dosages are 0. 1% to 3. 0% by weight of cement to yield a delay of set of 1 hour to 35 hours.

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, but are more difficult to control than the higher dosage phosphate based types. Typical dosages are 0. 1% to 1. 5% by weight of cement to yield a delay of set of 3 hours to 50 hours. Retarding water reducing admixtures are very commonly used at a low dose, typically 0. 2% by weight of cement, to reduce the water content of the concrete by 7 to 10% with only a small delay in setting. They can be used at higher dosages; typically 0. 3 to 0. 6% to reduce water content, but simultaneously to delay the setting time. Greater water reductions may be achieved by using retarding high range water reducers, generally at 0. 5 to 1. 5% dose, depending on the type.

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.

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.

Cements such as CEM1 require the highest level of retarder to achieve a given level of retardation. However, as the proportion of slag or pulverised fuel ash, as used in CEM 2 and CEM3 types increases, then the level of retarder will decrease 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 (C3A) require significantly less retarder for a given degree of retardation than normal cements.

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. Large overdoses of retarders can produce very long setting times and even small overdoses can have this effect if the initial dose is high. 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. Where a dosage range is given, the normal dose should be taken as the bottom of the range. Where very 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 within a reasonable time.

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 has the effect of increasing ultimate strength relative to an unretarded mix with the same water cement ratio.

Acceleration of strength by heat produces the opposite effect, with the rapid formation of a coarse matrix. This explains why steam cured precast concrete rarely produces the same ultimate strength as concrete cured at normal temperatures and produced from the same concrete.

6. 2 Workability

Retarding admixtures do not have a significant effect upon initial workability. However, they generally have a beneficial effect upon workability retention, particularly at elevated temperature.

Retarding water reducing admixtures, have a pronounced effect upon workability. Typically, an increase in slump of 60-100mm results from the addition of a dosage of 0. 25% by weight cement. Set retarding high range water reducing/plasticizing admixtures may be used to enable workability to be increased to a greater extent, at a typical dosage level of 0. 3 to 1. 0%.

6. 3 Slump loss

Retarding admixtures are useful for helping to reduce slump loss, particularly at elevated temperature but it is still important to have a high initial workability.

Retarding water reducing admixtures are very effective at reducing slump loss when used to increase the initial workability of the mix, but less so when used as a water reducer. Indeed, if water reduction is taken at the expense of high initial workability, initial slump loss may be slightly faster and will slow when about half the initial slump is reached.

6. 4 Setting time

The 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 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 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.

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 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 exactly the same time interval by which it was retarded. In small sections this may allow slightly 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.

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 stronger 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. Retarded water reduced concrete will have a lower water content than the equivalent plain concrete, and will be correspondingly more durable.

MECHENISM OF RETARDING ADMIXTURES

Retarding admixture is an admixture that retards the setting of concrete. A retarding admixture causes cement set retardation by one or more offollowing mechanisms:

(1) Adsorption of the retarding compound on the surface of cement particles, forming a protective skin which slows down hydration;

(2) Adsorption of the retarding compound on to nuclei of calcium hydroxide, poisoning their growth, which is essential for continued hydration of cement after the end of induction period;

(3) Formation of complexes with calcium ions in solution, increasing their solubility and discouraging the formation of the nuclei of calciumhydroxide .

(4) Precipitation around cement particles of insoluble derivatives of the retarding compounds formed by reaction with the highly alkaline aqueous solution, forming a protective skin .

Detailed Explanation

According to the first mechanism, a retarding admixture is adsorbed on the surface of cement particles. This layer of retarding admixture around the cement particles acts as a diffusion barrier. Due to this diffusion barrier, it becomes difficult for the water molecules to reach the surface of the unhydrated cement grains and hence the hydration slows down, and the dormant period (period of relatively inactivity) is lengthened. Due to the slow hydration, no considerable amount of the hydration products giving rigidity to the cement paste will be formed and thus the paste remains plastic for a longer time. Later, when the admixture is removed from solution by reaction with C3A from cement or by some other way it is removed and incorporated into the hydrated material, further hydration is eliminated. On first contact of water with cement grains (C3S and C2S) calcium ions and hydroxyl ions are rapidly released from the surface of the cement grains. When concentration of these ions reaches a critical value (at which the solution becomes saturated), the hydration products calcium hydroxide and calcium silicate hydrate start to crystallize from the solution and then hydration proceeds rapidly.

According to the second mechanism, a retarding admixture incorporated into cement paste is adsorbed on the calcium hydroxide nuclei and prevents its growth until some level of super saturation is reached during the induction period of hydration. Thus, retarder lengthens the induction period by causing an increase in the level of calcium hydroxide super saturation before crystallization begins. This is analogous to the poisoning of crystal growth of calcium hydroxide by the retarding admixture as both calcium and hydroxyl ions are present in the solution but unable to precipitate as a result of poisoning of the calcium hydroxide nuclei.

According to the third mechanism, a retarding admixture incorporated into cement paste forms some kind of complexes with calcium ions released by the cement grains during the first few minutes. Formation of the complexes increase the solubility of cement, i. e., increased concentration of Ca2+, OH, Si, Al and Fe in the aqueous phase of the cement pastes will occur when hydrated in the presence of the retarding admixture. Thus the calcium ions and hydroxyl ions will accumulate in solution and will be unable to precipitate to form calcium hydroxide. For example, when ordinary Portland cement is hydrated in sucrose solution, lime is solubilised and a sucrose calcium complex (R – -O â€” Ca+ – -OH) is formed in which Ca+ – -OH group is attached to the five membered ring (R) of the sucrose molecule. Such sucroseâ€” calcium complex will be able to become absorbed on the growing calcium hydroxide nucleus. The adsorption of the complex on the calcium hydroxide nucleus will inhibit its growth as the calcium and hydroxyl ions will not be able to precipitate. In this way, hydration is retarded.

The fourth mechanism is similar to the first but here some kind of insoluble derivatives of retarder are formed by reaction with the highly alkaline solution as pH of the solution rises to over 12 within few minutes after first contact of water with cement. For example, inorganic salt admixtures (borates, phosphates, zinc and lead salts etc.) give insoluble hydroxides in alkaline solution. The cement hydration is suppressed through the precipitation of protective coatings of these insoluble derivatives around the cement grains.