Admixtures for concrete

Admixtures are chemicals which are added to concrete at the mixing stage to modify some of the properties of the mix. Admixtures should never be regarded as a substitute for good mix design, good workmanship, or use of good materials.

1. Uses of admixtures

The most common reasons for using admixtures in concrete are:

- To increase workability without changing water content.
- To reduce water content without changing workability.
- To effect a combination of the above.
- To adjust setting time.
- To reduce segregation and/or bleeding.
- To improve pumpability.
- To accelerate the rate of strength development at early ages.
- To increase strength.
- To improve potential durability and reduce permeability.
- To reduce the total cost of the materials used in the concrete.
- To compensate for poor aggregate properties.

2. Types of admixtures

Admixtures are normally categorized according to their effect:

- Plasticizers (water-reducing agents)
- Superplasticizers
- Air entrainers
- Accelerators
- Retarders
- Others

Many admixtures provide combinations of properties such as plasticizer/retarders or plasticizer/air entrainers. Each admixture type is discussed in the following sections.

2.1 Plasticizers

When added to a concrete mix, plasticizers (water-reducing agents) are absorbed on the surface of the binder particles, causing them to repel each other and deflocculate. This results in improved workability and provides a more even distribution of the binder particles through the mix.

The main types of plasticizers are lignosulphonic acids and their salts, hydroxylated carboxylic acids and their salts, and modifications of both.

Dosage

The typical dosage of a plasticizer varies from 200 ml to 450 ml per 100 kg of cementitious material.

Uses

- Plasticizers usually increase the slump of concrete with a given water content.
- Plasticizers can reduce the water requirement of a concrete mix for a given workability, as a rule-of-thumb, by about 10%.
- The addition of a plasticizer makes it possible to achieve a given strength with a lower cement content.
- Plasticizers may improve pumpability.

Practical considerations

- A number of plasticizers contain a retarder and can cause problems if overdosed.
- Some plasticizers contain chlorides which may increase the danger of corrosion of reinforcing steel.
- While some plasticizers entrain varying amounts of air, others are reasonably consistent in the amount of air they entrain.
- Where plasticizers are used to increase workability, the shrinkage and creep will invariably be increased.

2.2 Superplasticizers

These admixtures are chemically distinct from normal plasticizers and although their action is basically the same, it is more marked.

When they are used to produce flowing concrete a rapid loss of workability can be expected and therefore they should be added just prior to placing.

Superplasticizers are usually chemical compounds such as sulphonated melamine formaldehyde, sulphonated naphthalene formaldehyde, and modified lignosulphonates.

Dosage

The normal dosage of a superplasticizer is between 750 ml and 2500 ml per 100 kg of cementitious material.

Uses

Superplasticizers are used to best advantage:

- In areas of congested reinforcement.
- Where a self-levelling consistence facilitates placing.
- For high-strength concretes by decreasing the water: cement ratio as a result of reducing the water content by 15–25%.

Practical considerations

- Special mixes must be designed for superplasticizers and their use must be carefully controlled.
- The effect of a superplasticizer may disappear as soon as 30 minutes after mixing.
- They have a relatively high unit cost.
- Where superplasticizers are used to produce very high workability, the shrinkage and creep will be increased.

2.3 Air entrainers

An air-entraining agent introduces air in the form of minute bubbles distributed uniformly throughout the cement paste. The main types include salts of wood resins, animal or vegetable fats and oils and sulphonated hydrocarbons.

Dosage

Typical dosage for air-entraining agents is between 50 ml and 150 ml per 100 kg of cementitious material.

Uses

- Where improved resistance of hardened concrete to damage from freezing and thawing is required.
- For improved workability, especially in harsh or lean mixes.
- To reduce bleeding and segregation, especially when a mix lacks fines.

Practical considerations

- Air entrainment may reduce the strength of concrete and overdosing can cause major loss of strength. As a rule-of-thumb, 1% air may cause a strength loss of 5%. It is therefore important that mixes be specially designed for air entrainment and that the percentage of air entrained during construction be monitored.
- Because the doses are so small, special dispensers and accurate monitoring are required.
- Different types and sources of cement/cement extenders may result in the entrainment of different amounts of air for the same dose and mix proportions.
- A change in cementitious content, in the grading or proportions of the fine fractions of sand will normally alter the volume of air entrained.
- The amount of air entrained may depend on the source and grading of sand in concrete.
- Forced-action mixers entrain larger volumes of air than other types.
- Increasing ambient temperature tend to reduce the volume of air entrained.
- The use of ground granulated blastfurnace slag (GGBS) and fly ash (FA) tends to reduce the amount of air entrained.
- Duration of mixing can also affect air content.

2.4 Accelerators

These admixtures speed up the chemical reaction of the cement and water and so accelerate the rate of setting and/or early gain in strength of concrete.

Among the main types of accelerators are calcium chloride, calcium formate, soda ash, potassium chloride and a number of organic materials. Calcium chloride appears to be the only one that is reasonably predictable in its performance, but it tends to promote corrosion of steel in concrete.

Dosage

<u>Calcium chloride</u>: 2% by mass of all cementitious material. Calcium chloride powder or flakes should be added to and dissolved in water which must then be kept agitated. This solution should be dispensed with the mixing water. Calcium chloride solution is also available – refer to the supplier's directions regarding dosage.

<u>Non-chloride accelerators</u>: 500-ml to 2 000-ml per 100-kg of cementitious material.

<u>Shotcrete accelerators</u> react almost instantaneously, causing stiffening, rapid set and rapid hardening of the shotcrete. Refer to the supplier's directions regarding dosage.

Uses

- Where rapid setting and high early strengths are required (eg in shaft sinking).
- Where rapid turnover of moulds or formwork is required.
- Where concreting takes place under very cold conditions.

Practical considerations

- Certain accelerators may increase drying shrinkage, cracking and creep.
- They may cause lower flexural strengths.
- Many chloride-based accelerators promote corrosion of reinforcing steel.
- Calcium chloride should not be used in:
  - reinforced concrete
  - water-retaining structures
  - prestressed concrete
  - steam-cured concrete
- Overdosing with these materials can cause marked retardation.
- Accelerators work more effectively at lower ambient temperatures.

2.5 Retarders

These admixtures slow the chemical reaction of the cement and water leading to longer setting times and slower initial strength gain.

The most common retarders are hydroxylated carboxylic acids, borax, lignins, sugar and some phosphates.

Dosage

Typical dosages for retarders are between 150 ml and 500 ml per 100 kg cementitious material.

Uses

- When placing concrete in hot weather, particularly when the concrete is pumped.
- To prevent cold joints due to duration of placing.
- In concrete which has to be transported for a long time.

Practical considerations

- If a mix is overdosed beyond the limit recommended by the supplier, retardation can last for days.
- Retarders often increase plastic shrinkage and plastic settlement cracking.
- Delayed addition of retarders can result in extended retardation.

2.6 Other admixtures

Other admixtures with different chemical compositions and effects are available (eg pumping aids, pigments, expansion aids and grouting admixtures). These are beyond the scope of this leaflet, and information should be obtained from the admixture suppliers.

3. Design of mixes

A laboratory test programme should be carried out to optimize dosages of admixtures with the cements/blended cements and aggregates which will be used on the site. This programme should be based on good concrete mix design and correct laboratory methods. It is also essential to verify the proposed mixes under site conditions.

The control mix (ie one without admixture), should be prepared before any other to prevent trace contamination with the admixture under test.

Changes in materials or ambient conditions (eg temperature) may also change the effectiveness of admixtures; trials are essential if such changes are envisaged.

If more than one effect is desired, then more than one admixture may be required. The compatibility of admixtures, particularly if from different suppliers, needs to be tested using materials from the site.

4. Storage and handling

Most admixtures are aqueous solutions of active chemicals that are biodegradable. These two factors define the general rules for storage.

Admixtures should be protected from frost, as most have freezing points at or below 0°C. When an admixture freezes, the chemicals crystallize out of the solution and do not readily go back into solution on thawing.

It is also necessary to protect admixtures from heat because their degradation is accelerated at elevated temperatures. They should be stored out of direct sunlight and away from other heat sources. Many admixture companies provide light-coloured or reflective packaging for admixtures to reduce heat absorbtion.

Admixtures generally contain preservatives to reduce biodegradation and extend shelf life. Despite this, the activity and effectiveness of an admixture will gradually decrease with time. Therefore they should be used on a first-in-first-out basis.

Admixtures are normally stored on site in 200 ℓ drums or in bulk storage tanks. Bulk liquid storage tanks are often supplied, serviced and maintained by the admixture supplier. Drums should be handled with care.

5. Dosage and dispensing

The correct dosage of admixture is crucial for satisfactory mix performance and the proper use of well maintained and calibrated dispensing equipment is essential.

Admixture suppliers normally provide, install and service dispensers which are either manual or automatic.

Admixtures should be added to a concrete during mixing with the last portion of the mix water in order to ensure even dispersion of the admixture throughout the concrete, unless delayed addition is necessary for a specific purpose. The admixture should not be added directly to the dry cement or aggregates.

For the majority of admixtures it is not necessary to change the concrete mixing procedure. Any special requirements will be given in the admixture manufacturer's product literature.

6. Safety

While most admixtures are not hazardous to health, certain admixtures are caustic in nature and some may be flammable. The following safety procedures apply to all admixtures.

Avoid eye, mouth and skin contact as all chemicals should be regarded as toxic and corrosive. Contamination should be washed off immediately with plenty of fresh water. Contaminated clothing should be removed and washed.

Seek medical advice in cases of serious eye contamination, ingestion or excessive inhalation of fumes.

Admixture spillage will cause floor areas to become slippery and unsafe. Spillage should immediately be hosed down with water to prevent accidents.

Treat all chemicals as flammable.

Cement & Concrete Institute

PO Box 168, Halfway House, 1685

Tel (011) 315-0300 • Fax (011) 315-0584

e-mail info@cnci.org.za • website http://www.cnci.org.za

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