CEMENT ADMIXTURES ASSOCIATION

the Sign of Quality

Admixture Technical Sheet – ATS 5

Air-entraining admixtures

1 Function

Air Entraining admixtures are surface active chemicals which cause small stable bubbles of air to be formed uniformly through a concrete mix. The bubbles are mostly below 1 mm diameter with a high proportion being below 0.3 mm.

The benefits of entraining air in the concrete include:

Increased resistance to the action of freezing and thawing
Increased cohesion resulting in less bleed and mix segregation.
Improved compaction in low workability mixes.
Gives stability to extruded concrete
Gives improved cohesion and handling properties to bedding mortars.

Additional information on the use of Air Entraining admixtures is given in Admixture Information Sheet AIS 16

2 Standards

This type of admixture is covered by the requirements of BS EN 934 Part 2: Concrete admixtures – Definitions requirements, conformity, marking and labelling. The specific requirements are stipulated in Table 5.

All CAA manufacturers CE mark their products to show they conform to this standard.

3 Materials

Air entraining admixtures have traditionally been based on:
Abietic acid salts (Vinsol Resin).
Fatty acid salts

These have now been largely replaced with synthetic surfactants based on blends of:
Alkyl Sulphates
Olefin Sulphonates
Diethanolamines
Alcohol ethoxylates
Betaines

4 Mechanism

Air entraining agents lower the surface tension of the water to facilitate bubble formation. Uniform dispersion is achieved by blending surfactants to increase the stability of the interfacial layer between air and water, preventing bubbles from coalescing.

Optimum freeze thaw properties require a large number of very small bubbles, preferably less than 0.3 mm in diameter. These parameters are often referred to as the specific surface (the surface to volume ratio) and the void spacing factor (bubble surfaces 0.4 mm apart = a spacing factor of 0.2 mm) of the air void system.

The air bubbles intersect the capillary system within the concrete. Even in almost saturated concrete they remain dry due to the capillary action. If water in the capillaries freezes the air voids act to relieve the pressure generated by the expansion of the freezing water. The air voids also reduce the osmotic pressures caused by the use of de-icing salts and which would otherwise cause cracking and surface scaling.

5 Use

For additional guidance on use see Admixture Information Sheet AIS 16

5.1 Dosage

Dosage of air entrainers is affected by the other materials used in the concrete but is usually 0.1 to 0.3% by weight of cement. The total amount used should not exceed the manufacturer's recommended dosage unless the influence of the higher dosage has been established. Higher dosages may be needed as ambient temperature increases and this effect becomes very noticeable above about 25^0C.

Aggregates which are very fine may contain a significant level of silt or dust, or which do not have a uniform grading may also require higher dosages of air entrainer. As well as making it difficult to entrain air in these types of aggregate, the air may be unstable and tend to float out.

The cement type and content can also affect the dosage, see 4.3 below.

5.2 Volume of air entrained

This depends on the application and the mix design. For improved cohesion and reduced bleed in concrete, 2 to 3% additional air is usually sufficient. For freeze thaw resistance the level of air is dictated by the paste volume in the mix. For paving concrete, BS 8500 specifies a minimum air content and for 20mm aggregate this is 4.5% and typically results in a target value of 5.5%.

After mixing, air can be lost during transport and pumping. Allowance should be made for this so that the correct level of air is obtained in the in-situ concrete. This may mean testing at the final point of discharge into the structure and compliance levels should be agreed with the contractor before the concrete is delivered.

Obtaining and maintaining the correct volume of air over a series of mixes can be difficult, it requires continuous monitoring and good control of materials and mix sequence.

5.3 Cement

Air entrainers will work with all types of cement but the dosage required may vary. In particular, high cement contents or fine cements (rapid hardening and silica fume) are harder to entrain.

Fly ash usually has residual active carbon which can significantly increase the dosage of air entrainer required and may vary from batch to batch. Some types of air entraining admixture are more tolerant of fly ash than others and so the manufacturer's advice should be sought.

5.4 Overdosing

Overdosing will usually result in a higher volume of air being entrained. This will lead to a reduction in compressive strength and possibly to reduced abrasion resistance on top surfaces.

5.5 Use with other admixtures

Air entraining admixtures should not be premixed or allowed to come into contact with other admixtures prior to addition into the concrete as some types are incompatible. The use of separate dispensers and lines is advisable.

Some superplasticisers can cause a reduction in the quality of the entrained air and manufacturer's advice should be sought if an air entrainer and a superplasticiser are to be used in combination in the concrete. Where other types of admixture are to be used together with air entrainers, BS 8500 and EN 206 require evidence that the performance is not compromised and it is suggested that the manufacturer's advice is sought.

5.6 Curing

For air entrained concrete to properly function and to maximise the benefits in relation to strength and freeze thaw resistance it is essential that proper curing is undertaken. This is especially so when using blended cements which may exhibit different hardening characteristics than concrete made from CEMI cements.

6 Effect on properties of concrete

6.1 Yield

Air entrainment reduces the density of the mix and increases yield. This needs to be taken into account when designing air entrained concrete.

6.2 Strength

For every 1% of additional air entrained, the concrete strength will fall by typically 5 to 6%.To offset this effect water reducing admixtures are usually added in addition to the air entrainer. The admixtures can be added individually to the mix or multifunction admixtures that give water reduction and air entrainment are available. Individual admixtures should never be premixed prior to addition to the concrete.

6.3 Consistence (Workability) In low cement content mixes and those with low fines or harsh aggregates, air entrainment will usually improve consistence and handling properties of the concrete. With these mixes some water reduction may also be possible and can even result in an increase in compressive strength.

In richer, more cohesive mixes, air will increase the cohesion and may make the mix too sticky. In this situation, the percentage of fine aggregate in the mix should be reduced.

As consistence increases, air tends to be less stable in the mix and may float out. As well as reducing the level of entrained air, this can result in a weak frothy surface to the concrete, particular care is needed when vibrating air entrained concrete.

6.4 Setting time

The setting time of concrete is not usually affected by air entrainment

6.5 Other properties

At normal levels of air entrainment, most other properties of the concrete including drying shrinkage and creep are not significantly affected. Permeability under pressure is adversely affected as is abrasion resistance.

6.6 Durability

The main reason for using entrained air is to improve the freeze thaw and scaling resistance and hence the service life of concrete. The improved cohesion and compaction can also enhance the quality and life of concrete structures.

6.7 Surface finish

Poor cohesion in concrete is often the result of using fine aggregates which do not have a good grading profile. However it is not always economically viable to find alternative sources. Poor cohesion can lead to sand runs on vertical surfaces, grout loss where joints are not watertight, weak surfaces due to bleed and segregation and poor compaction where stiff mixes have been used to try and overcome the bleed.

Air entrainment, increases the volume of the paste, filling out the voids in the aggregate grading and supporting the uniform distribution of the aggregate, cement and water. This will always reduce and sometimes eliminate, bleed and segregation within the mix, overcoming the problem areas indicated above.

Air entrainment in an already cohesive mix such as those with high cement content, can cause stickiness which may result in the trapping of larger air voids, especially on shutter surfaces to produce an unacceptable finish. Reducing sand content and or moving to coarser sand may help and air content should be reduced to the minimum allowed. In some situations, a 50 N/mm^2. non air entrained mix may be an acceptable alternative.

6.8 Slip-formed, extruded and Semi-dry Concrete

Air entrainment helps the workability of these types of stiff concrete by aiding compaction under vibration. However, once vibration stops, the concrete stops moving and will then hold its shape without further slumping or deforming.

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

See also AIS 16 for Guidance on the Use of Air Entrainment

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.