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CEMENT ADMIXTURES ASSOCIATION

ADMIXTURE INFORMATION SHEET AIS 16

CAA Guidance on the use of Air Entraining Admixtures

1 Introduction

Air entraining admixtures (AEA) benefit concrete in providing freeze-thaw durability and enhanced cohesion however their use requires careful control of mix design, transport and placing if these benefits are to be fully realised. Within the admixture industry an often quoted statistic is that AEA account for 5% of sales and 95% of problems. This suggests that air entrainment is not straight forward.

Admixture manufacturers undertake extensive development to ensure that their AEA is tolerant to the wide range of conditions found within concrete supply and use however entrained air will always be inherently unstable and prone to loss. It is therefore essential to a successful outcome that concrete producers and users appreciate that they must also take steps to ensure that the air remains uniformly entrained at the required level up to the point when the concrete hardens and stabilises the air bubbles.

2 The admixture manufacturer

Admixture manufacturers are required to test and CE mark their air entraining admixtures for compliance with the EN 934 part 2 in a specified reference concrete. The key requirement is a bubble spacing factor of not more than 0.20 mm in a hardened test mix with 4 to 6% air content in the fresh concrete but note this bubble spacing factor need not be met over the whole of this air range.

Note: A bubble spacing factor of 0.20 mm is thought to give protection under conditions of rapid freezing and is lower than may be required for many applications. Spacing factor does not currently appear in any UK concrete specifications. UK specifications are normally based on air content in the fresh concrete and this is assumed to still be present in the hardened concrete.

BS 8500-2 clause 4.5 requires evidence of compatibility when an air entrainer is used in combination with other admixtures, based on testing to EN 480-11. If an admixture manufacturer claims that his air entrainer can be used in combination with other admixtures he should be able to provide the evidence for this and give advice on typical changes in AEA dosage that may be required based on that required to give 0.20 mm bubble spacing factor in the EN 480-11 reference concrete.

The admixture supplier cannot be responsible for ensuring that the admixture dosage used by the producer in his specific mix will meet either the required air content in the fresh concrete or that that level of air will still be present in the hardened concrete. The following advice is offered to the contractor and producer to ensure adequate air in the hardened concrete:

3 The Contractor

Adequate freeze-thaw durability will only be achieved if the entrained air bubbles remain uniformly distributed in the concrete after it has hardened. Significant loss of air can occur between delivery and placing. Factors that can contribute to air loss between delivery and hardening include Pumping Vibration, Power finishing

The contractor needs to be aware of this, take steps to minimise loss and if necessary discuss with the concrete producer, the appropriate air content at delivery, possibly based on also checking air at the point of placing.

Bleed, segregation and poor curing can all increase the risk of freeze-thaw damage, even in air entrained concrete.
Power finishing of air entrained concrete can result in a hard surface layer over a weaker high air content layer and can lead to later surface delamination.

4 The Concrete Producer

The specified air content should be met at the point of delivery, not at the batching plant to take account of any losses due to the method of transport.
See BS 8500-1 clauses 4.2.3 – h & Note 2, clause 4.3.3 – f & Note 2,

Also Table A.8 footnote c in relation to the use of ggbs for pavements.

Do not assume that the admixture manufacturers recommended dose will give the correct air content as changes in constituents, mix design and admixture combinations can significantly affect the required dosage.

Ensure that the air meter is calibrated and that full account has been taken of the aggregate correction factor. Failure to do this can result in a significant over estimate of the true air content.

Other factors that influence air content include:

- The type of mixer used. Energy is needed to create the air - water interface, thus to form the air voids.
- Cohesive mixes are harder to entrain but then retain the air better.
- Low cohesion mixes tend to loose air more easily during transport, during vibration and on standing if they are prone to bleed or segregation.
- Slower setting / retarded concretes give time for entrained air to coalesce to larger more unstable bubbles
- Crushed aggregates tend not to entrain as well as rounded materials
- Dust / silt on the aggregates reduces the level of entrain air
- Fly ash can be difficult to entrain due to the part burned carbon content but once entrained the air tends to be well dispersed and stable.
- Adding the AEA after other admixtures usually gives more consistent results
- Increases in concrete temperature tend to reduce the amount of air entrained
- High consistence mixes loose air easily during transport and placing

5 Freeze-thaw background

Freeze-thaw damage is mainly due to water freezing in the capillaries within the cement paste, expanding and cracking the concrete. Entrained air voids intersect these capillaries. Capillary suction ensures that even in saturated concrete, the water stays in the capillaries and does not fill the air void. However, when the water starts to freeze the pressure rises significantly and unfrozen water is forced into the air voids relieving the pressure and preventing damage to the concrete. This process relies on the spacing of the air bubbles being close enough together to allow water to quickly migrate in and out of them under freeze-thaw action.

For effective freeze-thaw resistance, the entrained air needs to be in the form of a large number of small bubbles. This can be measured in the hardened concrete by taking a section, polishing it and analysing the void structure under a microscope.

The optimum bubble size is in the range 0.1 to 0.3 mm but all voids in the range 0.05 to 4.0 mm are considered during air void analysis. An immediate indication of the bubble size can be calculated as the specific surface of the bubbles which should be in the range 20 to 40+ mm^{-1}. The larger the specific surface the smaller the average bubble size.

The more important figure is the bubble spacing factor. This is the average distance from any point in the cement paste to the nearest bubble surface and is the maximum distance water has to travel to reach an air void. This will be controlled by the total number of bubbles so for a given air content, smaller bubbles (large specific surface) will be closer together to give a small bubble spacing factor. If the bubbles are large, more total air is needed to give the same number of bubbles and hence the same spacing factor.

The spacing factor needed mainly depends on the degree of saturation and the speed of freezing. Slow freezing allows more time for unfrozen water to move and relieve the pressure so a large spacing factor is acceptable but if the concrete is saturated and subject to fast freezing a small spacing factor is required. Ironically, the use of deicing salts can produce the fastest freezing rates due to the fact that the melting ice draws its latent heat from deeper in the concrete, causing rapid cooling in this deeper zone.

The CAA website contains further information on admixtures including technical and environmental sheets that are available for free download. **Visit www.admixtures.org.uk**.