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CEMENT ADMIXTURES ASSOCIATION

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Admixture Sheet – ATS 10

Foamed Concrete / Low density fill

1 Function

Foamed Concrete Admixtures are surfactants that are diluted with water before passing the solution through a foam generator which produces a stable pre foam, similar to shaving cream. This pre foam is then blended into a cementitous mortar in a quantity that produces the required density in the foamed mortar (more usually called foamed concrete).

Low Density Fill Admixtures are also surfactants but are added directly into a sand rich, low cement content concrete to give 15 to 25% air. This low density fill; also called Controlled Low Strength Material (CLSM), has good flow properties and finds use in trench filling applications and other similar low strength void filling jobs.

2 Materials

Two types of admixture are available for these applications:

Synthetic surfactants or blends of surfactants that give good foaming properties are used for both pre foams and CLMS but are usually tailored to one or other.

Protein based admixtures are also available and are often favoured for foam concrete applications because a more stable and creamy prefoam is produced.

3 Mechanism

For foamed concrete, pre foam is first produced in a foam generator. Two generator systems are available for doing this.
One passes the dilute surfactant solution through an in line mixer together with compressed air. This produces a low density foam with an expansion factor in the order of 40 to 1 with respect to the admixture solution.
In the second system the admixture solution is jetted onto a wire gauze in a tube where it mixes with air sucked into the back of the tube by venturi action.
There is little difference between the two systems in terms of the quality of the final foamed concrete but the former generally produces a better looking pre foam.

Since the pre foam has no significant density, blending 50% by volume of the pre foam with a mortar of density 2200 kg/m^3 will produce a foamed concrete of density 1100 kg / m^3. Any density can be obtained in a range from about 600 to 2200 kg/m^3 by adjusting the ratio of the pre foam and mortar.
This blending can be carried out in the back of a readymix truck or can form part of a continuous process in dedicated equipment. There are a number of variations on this general principle.

Low density fill is essentially the same mechanism as air entrained concrete. The admixtures simply use more powerful surfactants at greater concentration and higher dose. The concrete mix design is critical and a higher than normal sand (or other fine filler) fraction is necessary. The sand to cement ratio can be used to give some measure of control over the final density; however, it is difficult to get below about 1700 kg/m^3 with this system.

4 Use

4.1 Dosage

The dosage of admixture per cubic metre of foamed concrete depends on the expansion of the pre foam and on the density of the final concrete. The lower the density, the higher the dose. As a guide, foamed concrete of final density 1100 kg/m^3 will require 0.5 to 0.8 litres of admixture per cubic metre.

Low density fill admixtures vary in dose between manufacturers. A very simple and convenient method of dosing is to supply concentrated admixtures in a capsule that can be thrown into the back of a readymix truck mixer. These typically have an addition of 0.1 litres per 100 kg of cement. More dilute products are supplied in conventional drum form and can be added through an admixture dispenser at plant or site. Dosage varies from 0.1 up to 0.45 litres per 100 kg of cement.

4.2 Cement type

Foamed concrete can be produced with all types of CEM 1 cement. It is less affected by changes in cement type including the use of PFA than is the case with normal air entrained concrete. This is due to the relatively high levels of surfactant being used.

4.3 Base mix

For foam concrete the base mix is typically between 1:1 to 3:1 filler to Portland cement. At higher densities; 1500 kg/m^3, the higher filler loading and a medium concreting sand may be used. As the density is reduced the amount of filler should also be reduced and at densities below about 800 kg/m^3 filler may be completely eliminated. The filler size must also be reduced, first to a fine concreting or mortar sand, and then to limestone, PFA or GGBS at densities below about 1100 kg/m^3.

For Low Density Fill, more conventional concreting materials are used but the coarse aggregate will be reduced to less than 50% of total aggregate and for higher air contents can be eliminated completely. The fine material may be sand or other recycled fine material.

4.4 Yield

These systems are typically foamed / air entrained in the range 20 to 60% air. As this normally takes place in a readymix truck, the volume of base mortar or concrete mixed in the drum must be reduced to allow for the final volume of foamed concrete.
The amount of stable air and hence density is difficult to control precisely so a degree of both under and over yield must be allowed for when estimating deliveries.

4.5 Overdosing

In foamed concrete, variations in admixture dosage above that recommended by the manufacturer have a relatively small effect on the prefoam performance. However, if the density is reduced by addition of too much pre foam to the mortar, it is difficult to then increase the density of the mix.

In Low Density Fill the admixture is usually working at maximum performance in order to achieve 20 to 30% air and overdosing has little effect on properties.

4.5 Specification

As strength is normally a characteristic minimum strength, if a low strength material is required, it is advisable to also indicate a maximum strength. Where low density is required, the maximum density should also be specified. Account should be taken on these properties if the mix is to be pumped or it will be placed in a deep lift as these may affect the stability of the foam.

5 Effects on properties of concrete

5.1 Strength

With the high levels of air involved, these are normally low strength systems, typically in the range 0.5 to 8 N/mm^2 although higher strengths can be produced. Water cement ratio has relatively little effect on strength but other factors like filler content and particle size do, especially in the foamed systems and below about 1000 kg/m^3 it is usual to use no sand but a 1:1 blend of Portland cement with a fine filler.

It should be noted that these systems are not as strong as autoclaved blocks of similar density.

If the concrete is saturated at the time of compressive strength testing, a low result will be obtained due to the internal hydraulic pressures set up as the sample deforms under load.

5.2 Workability

The air has a strong plasticising effect and these systems are normally of high workability with slumps ranging from 150 mm to collapsed. This is an advantage for most applications of these systems and it can be difficult to make low slump if this is required. Slump is normally retained for a reasonably extended period if slow mixing is maintained but it is quite thixotropic and it can be difficult to restart flow once the concrete has been static for several minutes.

5.3 Fresh properties

The high air content eliminates any tendency to bleed and with good insulation properties, as the mix temperature increases during setting the air expands slightly which ensures good filling and contact in confined voids.

In foamed concrete, if the mix is over sanded or uses an over coarse sand, the bubble structure may not be strong enough and segregation or bubble collapse can occur leading to volume loss and/or a weak top surface. Foamed concrete can be pumped but care should be taken to avoid a significant free fall down the last length of pump line as turbulence may destroy the bubble structure. If the depth of the foamed concrete is to exceed about 1.5 meters, checks should be carried out to ensure that the mix is stable against collapse at the intended head.

5.4 Hardened Properties

Although foamed concrete will give enhanced thermal, and fire rating properties, it is not usually the most cost effective solution for these applications unless access is difficult. Its value lies in its good void filling ability with a rigid hardened structure which will not deflect under low loading and also the low density where loading on other parts of the structure are critical. On exposed surfaces there will be some shrinkage but this tends to be in the form of micro cracking. Abrasion resistance is not high, especially at the lower densities so a surface coating is usually needed. The air cells are closed and do not immediately fill with water but at lower densities this will progressively occur if there is any pressure head.