Admixture Sheet – ATS 6

Water Resisting (Waterproofing) admixtures

1 Function

Water resisting admixtures are more commonly called 'waterproofing' admixtures and may also be called 'permeability reducing' admixtures. Their main function is to reduce either the surface absorption into the concrete and / or the passage of water through the hardened concrete. To achieve this, most products function in one or more of the following ways:

- Reducing the size, number and continuity of the capillary pore structure
- Blocking the capillary pore structure
- Lining the capillaries with a hydrophobic material to prevent water being drawn in by absorption / capillary suction

These 'waterproofing' admixtures reduce absorption and water permeability by acting on the capillary structure of the cement paste. They will not significantly reduce water penetrating through cracks or through poorly compacted concrete which are two of the more common reasons for water leakage in concrete structures.

Water resisting admixtures have been shown to reduce the risk of corrosion of reinforcing steel in concrete subject to aggressive environments but this is subject to appropriate admixture types or combinations of types being used.
Water resisting admixtures have other uses including the reduction of efflorescence, which can be a particular problem in some precast elements.

2. Standards

This class of admixture is covered by the requirements of BS EN 934 Part 2: Concrete admixtures – Definitions requirements, conformity, marking and labelling. The specific requirement is stipulated in Table 9.

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

3 Materials

The size and continuity of capillary pores are best reduced by lowering the free water content of the mix and this can be achieved with a water reducing admixture (WRA) or a high range water reducing admixture (HRWRA) of the types described on sheets ATS1 and ATS2. These WRA's are sometimes sold under the name 'waterproofing' or 'permeability reducing' admixtures. Reducing capillary size alone does not necessarily reduce surface absorption and may even increase it, as capillary suction increases with smaller diameters.

Pore blocking can be achieved by the addition of very fine unreactive or reactive fillers such as limestone or silica fume or by the use of insoluble organic polymers.

The hydrophobic admixtures are usually derivatives of long chain fatty acid of which stearate and oleate are most commonly used.

Some admixtures are combinations of a WRA and a hydrophobic admixture or a WRA and a poreblocker. Others form a two or three part system where a WRA together with a hydrophobe and a pore blocker are used in combination.

4 Mechanism

Water will be absorbed, even into dense concrete, through the capillary pores. These are the voids created by water added at the time of mixing in excess to that required to hydrate the cement. This excess batched water is necessary to provide workability and facilitate proper mixing, transportation, placement and successful compaction of the concrete. Typical good quality structural grade concrete with a cementitious content of say, 350kg – 400kg/m^3 might have between 175 and 200 litres of water added per cubic metre of which only about 98 - 112 litres is needed to hydrate the cement. The remaining 77 - 88 litres (representing 7.7% - 8.8% of the concrete volume), is not used during the hydration phase and is lost through bleeding and natural evaporation, creating a capillary pore network. This in turn, allows water, air and potentially harmful chemicals to enter the hardened concrete.

If the added water can be reduced to a w/c of below about 0.45 (or 157 – 180 litres of added water in the examples given above) the capillary volume can be substantially reduced. The best way of achieving this reduced level of water is to use a water reducing admixture that can also be used to ensure sufficient workability for full compaction and reduce shrinkage.

Pore blocking admixtures are based on very fine reactive or unreactive fillers or insoluble polymer emulsions, which have particle sizes of around 0.1 microns and are small enough to get into the capillaries during the early stages of hydration and physically block them.

Hydrophobic admixtures are designed to be soluble as an admixture and react with calcium components of fresh cement to form an insoluble material which lines the surfaces of the capillaries. Once the capillary dries out, the hydrophobic layer prevents water re entering the capillary by suction but the level of resistance achieved depends upon the effectiveness of the admixture used, the hydrostatic head of water involved and the quality of the concrete.

5 Use

5.1 Dosage

This depends on the water resisting admixture type being used and these values should only be regarded as typical.
WRA types range from about 0.2 to 2.0% by weight of cement. Hydrophobic admixtures are usually used at 1 to 2%. Pore blockers are added at 5 to 10% by weight of cement or more often as a manufacturer's recommended dose per cubic metre of concrete.

5.2 Admixture Selection

A water reducing admixture should always be used to ensure that the w/c of the concrete is below 0.45.

Hydrophobic admixtures can be very effective at reducing surface absorption at low pressure heads and where there is intermittent wetting and drying such as in the tidal or splash zone. Preventing the concrete from undergoing surface wetting and drying cycles can significantly reduce initial and long-term chloride ingress.

Where there is a continuous water head or there are higher water pressures, a pore blocking or a combined pore blocking / hydrophobic admixture type is more effective.

5.3 Cement Type

Permeability reducing admixtures can be used with all types of Portland cement including those covered by EN 197-1 and with other binders blended with CEM 1 cement. It should be noted that retardation might be slightly increased with blended cements and with sulphate resisting cements.

5.4 Overdosing

This depends on the type being used and the manufacturers' data should always be checked. For guidance on water reducing types see the sections on WRA and HRWRA. Significantly increased levels of inorganic fillers may reduce workability. The organic types often entrain air and at high dosage may start to reduce overall cement hydration by blocking reactive surfaces. Both these effects can result in progressively reduced strength as the dosage level is increased above that recommended by the manufacturer.

6 Effects on properties of concrete

6.1 Strength

The water reducing types of permeability reducing admixture will increase the compressive strength of the concrete as a direct result of the lower water/cement ratio.
Hydrophobic types and organic pour blockers may affect the wetting out of cement surfaces during early hydration, leading to a small reduction in strength.
Inorganic pore blockers will generally be neutral or slightly increase strength.
Some organic types can result in the entrainment of an additional 1 to 2% air causing a compressive strength reduction of about 10%. However, this is normally offset by a reduction in water/cement ratio that is usually inherent in the system.

6.2 Workability

Most permeability reducing admixtures are designed to have some water reducing properties. Provided the intended water reduction recommended by the manufacturer is taken, permeability reducing admixtures have little effect on workability.

6.3 Slump loss

This will normally be similar to a control concrete of similar water/cement ratio and initial workability.

6.4 Setting time

The setting time of concrete containing permeability reducing admixtures is typically within 90 minutes of the equivalent plain mix at equal workability and normal temperatures (15 to 25^{0}C). At lower temperatures, setting times may be extended especially where alternative binders are being used to partially replace a CEM I cement. At normal temperatures, high dosages of the hydrophobic types may result in longer setting times.

6.5 Air entrainment

Permeability reducing admixtures based on hydrophobes or emulsions may increase the entrained air. Most are formulated to limit this to 1 to 2% at normal dosage but at high dosage this level may increase.

6.6 Durability

Water Resisting admixtures can be an aid to durability by reducing the ingress of water and hence other water soluble aggressive chemicals such as chloride or sulphate that could otherwise cause more rapid deterioration of the structure. A particularly important feature of hydrophobic types can be the ability to reduce surface absorption. This prevents surface saturation and reduces sub-surface concentration of salts where there is cyclic wetting and drying. This form of absorption has been shown to be a major factor leading to deterioration of some concrete structures.

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

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.