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CEMENT ADMIXTURES ASSOCIATION

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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 and 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 through concrete.

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 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 water reducing or high range water reducing admixtures (WRA) of the types described on sheets ATS1 and ATS2. These WRA are often 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 silica fume or by the use of insoluble organic polymers such as bitumen introduced as an emulsion.

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 and a hydrophobe and or pore blocker are used in combination.

3 Mechanism

Water will be absorbed, even into dense concrete, through the capillary pores. These are the voids created by the excess water that was added at the time of mixing to provide workability. A typical concrete has 200 or more litres of water added per cubic metre of which only about 90 litres are needed to hydrate the cement. The remaining 110 litres; or 11% of the concrete volume, creates the capillary pore network which allows water, air and other chemicals to enter the concrete.

If the added water can be reduced to a w/c of below about 0.45 (or 160 litres of added water) the capillary system loses much of its continuity and permeability is significantly 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.

The 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, are small enough to get into the capillaries during the early stages of hydration and physically block them.

The hydrophobic admixtures are designed to be soluble as an admixture but react with the calcium of the fresh cement to form an insoluble material which adsorbs onto the surfaces of the capillaries. Once the capillary dries out, the hydrophobic layer prevents water re entering the capillary by suction but resistance is limited and depends upon the head of water involved, the quality of the concrete and the effectiveness of the admixture.

4 Use

4.1 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 dose per cubic metre of concrete.

4.2 Admixture Selection

A water reducing type should always be used if a separate WRA or HRWRA is not being employed and the aim should be to get the w/c to below 0.45 and preferably below 0.40.

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 chloride ingress and concentration at the surface. A key factor in reducing overall chloride diffusion.

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

4.3 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.

4.4 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 dosage level is increased above those recommended by the manufacturer.

5 Effects on properties of concrete

5.1 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 normally offset by a reduction in water: cement ratio that is usually inherent in the system.

5.2 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.

5.3 Slump loss

This will normally be similar to a control concrete of similar w/c and initial workability.

5.4 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.

5.5 Air entrainment

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

5.6 Durability

Permeability reducing admixtures are 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 is the ability to reduce surface absorption. This prevents surface saturation and reduces 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 structures.