CEMENT ADMIXTURES ASSOCIATION

the Sign of Quality

Admixture Current Practice Part 2.
Back to Basics

Admixture Current Practice Sheet – Part 1 provided general background information on current admixture use. Part 2 looks in more detail at admixtures, what they are, how they work and how they are used.

Admixtures
Admixtures are chemicals added to concrete, mortar or grout to modify the properties of the mix in the plastic and/or the hardened state. They are normally supplied as a solution to facilitate accurate addition through a dispenser.

The quantity added is usually based on the cement content and for most admixtures is in the range 0.2 to 2.0% by weight. In terms of active chemical this equates to less than 0.15% on a typical concrete mix. Even at this low content they have a powerful effect, modifying the water requirement, setting time or other properties.

Almost all types of admixtures are covered by a European or National standard that requires them to meet basic performance requirements, provide information on properties that can be used to check uniformity of supply and to have a factory production control system that gives assured quality. The two main admixture standards are BS EN 934 and BS 8443. Those conforming to BS EN 934 can be CE marked.

Admixture use has increased significantly in the last 30 years and they can now be found in most concrete mix designs. The benefits are economic and environmental as well as technical and for most concrete mixes, if an admixture is not being used the question should be why not?

Admixture technology
Admixtures work on the cement/concrete in a number of ways and these can be grouped as follows:

Dispersing admixtures: These make up about 75% of all admixture sales. The admixture adsorbs onto the surface of the cement causing the individual particles to deflocculate and disperse (see fig 1).

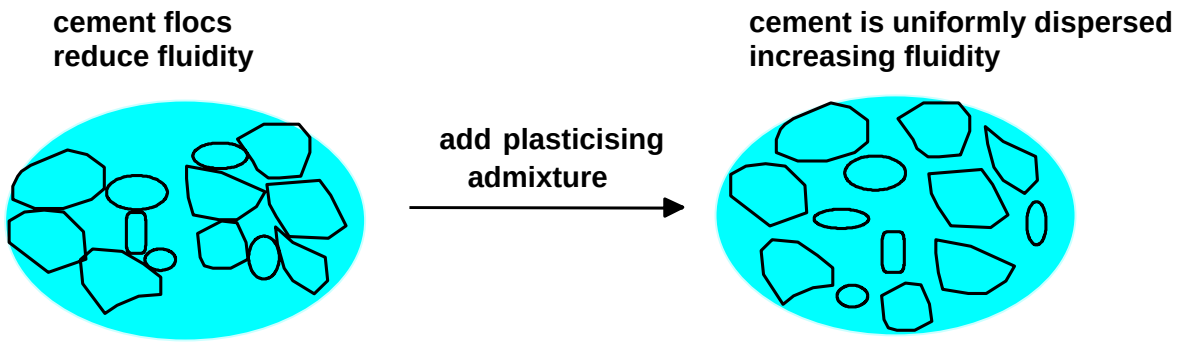

Figure 1: effect of plasticizer or superplasticiser addition on cement dispersion.

This dispersion increases the effectiveness of the water, causing the mix to become much more fluid for any given water content. The effect is called plasticising or superplasticising, depending on the degree of fluidity obtained. If the increased fluidity is not required, the water content of the mix can be decreased, giving a lower water/cement ratio and hence increased strength and durability. This is called 'water reduction' or 'high range water reduction', the demarcation being at around 12 to 14% water reduction for

equal consistence. The third option is to reduce both water and cement content to maintain strength but improve the cost and environmental profile of the mix. A forth option is to use an admixture dosage that will allow two or more of these effects to be obtained at the same time, eg lower water/cement ratio and some increase in fluidity.

Set modifying: These admixtures affect the hydration of the cement, causing it to set faster (accelerating) or more slowly (retarding). Most work by adsorption onto or absorption into the hydrating cement surface, either having a blocking effect or a peptising effect on specific cement phases but some admixtures also affect the solution chemistry of the soluble phases.

Air entraining: These introduce small, stable air bubbles into the cement paste. This can provide enhanced cohesion to the mix and improve freeze-thaw resistance. It also lubricates semi dry or low cement content mixes. Air is sometimes called a plasticiser in mortar mixes because it can reduce water and improve the cohesion and texture of the mix.

Viscosity modifying admixtures: These work on the water in the mix, thickening it or by locking the cement into an enhanced aqueous structure. This increases cohesion and reduces segregation. Viscosity modifying admixtures, often called VMA, find use in pumping, underwater concrete, anti-bleed and segregation reduction for self compacting concrete.

Special purpose admixtures: These are admixtures introduced into the mix to perform a specific purpose, usually in the hardened mix and may not directly affect the mix constituents while in the plastic state. These admixtures include shrinkage reducing, corrosion inhibiting, and water resisting types.

Admixtures will usually have one of the above properties as its ‘primary’ function but may also have one or more of the other properties as ‘secondary’ effects. These secondary effects may be a natural consequence of the chemicals used or may be intentionally built in so that it becomes a ‘multifunction’ admixture, eg plasticising and retarding admixture. These secondary effects can give specific advantages to an admixture and are often what defines the best product for a given concrete mix.

Admixture selection is best carried out in consultation with the admixture supplier who will be able to give advice based on the application for the concrete but also on the other concrete mix constituents.

Plasticising/Water Reducing admixtures

These dispersing admixtures are usually based on refined lignosulphonate, a by-product of the paper pulping industry. They are effective at dosages around 0.3 to 0.5% on cement weight but their water reducing effect is limited to about 12%. At higher dosage, secondary effects such as air entrainment and retardation may limit their use. Blending with superplasticisers may extend their dosage and performance to give a mid-range product.

The low dose and relatively low cost make these admixtures particularly suitable for a wide range of general applications. Used to reduce both water and cement content, they can optimise the mix design for both cost and environmental impact. Most will also slightly increase cohesion, reducing bleed and making placing and finishing easier.

Plasticisers are also an excellent way of providing a higher slump concrete without the need to reduce quality/durability by adding water. High slump concrete used to be associated with too much water, leading to low strength and durability problems. As a result, concrete is still too often specified at 50 to 75 mm slump. Unfortunately using this specification can often have the reverse effect as difficulty in placing on site results in the addition of uncontrolled water. By using a plasticisers, higher slump can be safely specified, eliminating the need to add water on site and increasing the probability that the concrete will be fully compacted. A relatively modest plasticiser dose will provide a cost effective mix with optimised water and cement content as well as a slump of 100 to 125 mm which will be much easier to place and compact.

Superplasticisers/High Range Water Reducers

These dispersing admixtures are based on synthetic polymers and have a much more powerful effect than the plasticising admixtures. Dosage is typically in the range 0.7 to 1.5% depending on type and dilution.

Water reduction ranges from 16 to well over 30%. Although superplasticisers do have secondary effects they are generally not significant until well above the normal dosage range.

Superplasticisers first became widely available in the 1970's and were based on sulphonated melamine or naphthalene formaldehyde polymers. To modify the properties, blends could be made with lignosulphonate or other chemicals. In the mid 1990's polycarboxylate ether (PCE) based superplasticisers were developed. These are more expensive but work at a lower dose and have the added advantage that it is easier to modify the polymer to produce targeted properties such as workability retention, cohesion or early strength. It is the introduction of PCE superplasticisers that has lead to the increasing use of self compacting concrete in Europe. (See Fig 2)

Superplasticisers are frequently used to bring about a combination of both water reduction and increased workability. They are not usually cost effective as cement reducers but as water reducers they can give very high early strength (well over 200% at 16 hours) allowing earlier demoulding of the concrete element. This finds particular application in precast products but also where early access and use is required such as in pavement repairs. Later age strength will also be increased and the low water/cement ratio will give low permeability resulting in improved durability against water ingress, chloride diffusion and carbonation. By also increasing the slump, placing especially through dense reinforcement is improved and better compaction achieved. Surface finish is usually better with less blow holes and other defects.

Superplasticisers use can now be found on almost all large civil engineering contracts and most precast plants now use them to produce self-compacting concrete which has eliminated the need for noisy vibrators, improved surface finish and allowed earlier demoulding with reduced need for heating.

Accelerating admixtures

The need for accelerating admixtures has reduced with the introduction of increasingly powerful high range water reducers that can give very high early strength. The main application for accelerators is where concrete is being placed at low temperatures and even then they will usually be used in combination with a high range water reducer. Some accelerators are better at accelerating the stiffening and others at accelerating the strength gain. Few will be really effective in achieving both.

Chloride based admixtures remain the best all round accelerators but should not be used in any concrete containing embedded steel due to the enhanced risk of corrosion.

Sprayed concrete accelerators are a special group of these admixtures that can give very fast set (typically a few seconds) and some early strength gain. These used to be highly alkaline, presenting health and safety problems during use but modern alkali free types are now available and should be used.

Retarding admixtures

These admixtures extend the time taken for the concrete to stiffen and are very important in preventing cold joints between layers or areas of concrete which are placed some time apart. This can be a particular problem in large pours and or in hot weather.

Retarders by themselves are not very effective in providing workability retention and need to be used in combination with other admixtures that give cohesion and increased initial workability.

It is possible to retard concrete or mortar for very extended periods and then bring about setting, usually by the addition of an appropriate accelerator but for this application advice should always be sought from an admixture supplier.

Air entraining admixtures
Air is usually considered for its ability to impart freeze-thaw resistance to saturated concrete and should always be specified for external slabs and paving as well as any other external concrete that may be saturated when subject to frost action. However, air can give many other benefits to concrete.

Small amounts of air will improve cohesion, reducing bleed and bulking the paste in lean mixes to give easier finishing. It also lubricates the aggregate and can reduce the water and significantly enhance compaction in dry lean concrete or in semi-dry concrete used for some precast concrete products such as bricks, blocks and pavers.

Air entrainment can reduce strength but, apart from freeze-thaw resistance, the amount of air are too small to have a significant effect and in some cases the water reducing effect can more than offset any strength reduction.

Other admixtures
Admixture producers have used their expertise to meet specific needs within the concrete industry and a range of other products have been developed to help concrete meet special requirements within the construction industry. These include:

- Admixtures that help concrete to resist water ingress, these may be hydrophobic and effective against rain and occasional submersion. There are also pore blocking products that will help to resist water under a significant head.
- Underwater admixtures help to prevent concrete from losing cement and fine aggregate while being placed under water or when it is subject to moving water before it can set.
- Shrinkage reducing admixtures help to prevent drying shrinkage cracking. They can be used to increase bay sizes in concrete floors and so reducing problems associated with joints. Another example of use is in radiation areas where dense, crack free concrete is required.
- Corrosion inhibiting admixtures can be used to increase the corrosion threshold of embedded steel where chloride ingress may be a problem.
- Mortar admixtures can retard the set and retain mix consistence so that the mortar can be used over an extended period, typically 36 hours. However, when applied to an absorbent brick or block, water and admixture are sucked out promoting earlier setting.

Technical Information and support
Admixture producers have always been at the cutting edge of innovation in the concrete industry and are pleased to discuss specific problems and help to meet the requirements of new and innovative designs or difficult placing situations. Most producers provide services that include trials and on-site support if necessary. The UK Cement Admixture Association (CAA) can also give general advice and will arrange impartial talks on specific or general aspects of admixture technology and use. For further information, visit the CAA web site: www.admixtures.org.uk.