CHEMICAL ADMIXTURES USED IN CONCRETE

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An admixture is a material other than cement, supplementary cementatious material, water, aggregate and fibre reinforcement that is used as an ingredient of concrete, and is added to the batch immediately before or during the concrete mixing. It is added with the purpose of modifying the properties of concrete in accordance with the specific requirements either in the fresh or hardened state. Some of the concrete properties that are most commonly modified with the use of admixtures are the setting time, workability, air entrainment, segregation, amongst many others. Admixtures are normally added to concrete in specific quantities, and the over dosage with admixtures can have negative impacts on the properties of concrete.

Admixtures may be natural or can be chemicals which are manufactured. They provide solutions to difficult construction problems, or they provide fresh or hardened concrete with certain properties which would not be achieved without them. Admixtures can assist with problems related to the durability and strength of concrete, they assist with challenges presented by hot and cold temperatures, and they help with early strength attainment.

USES OF ADMIXTURES

Admixtures are added to concrete with the purpose of improving certain characteristics of the fresh or hardened state of concrete, and therefore improve the performance of the concrete. The following are benefits obtained from the use of admixtures:

- To accelerate the initial setting time of concrete
- To retard the initial setting time of concrete
- To improve workability of concrete
- To improve pumpability of concrete
- To reduce segregation of concrete
- To reduce concrete bleeding
- To increase durability of concrete
- To reduce heat of hydration
- To make light weight concrete
- To reduce permeability of concrete
- To increase the strength of concrete
- To accelerate/retard rate of early strength development
- To control the alkali-aggregate expansion
- To increase the resistance to sulphate attack
- To increase the bond between old and new concrete
- To increase the bond between concrete and steel reinforcement
- To produce coloured concrete or mortar
- To control the corrosion of concrete

TYPES OF ADMIXTURES

Admixtures are categorized into two main groups – chemical admixtures and mineral admixtures. Chemical admixtures are manufactured chemicals which are added to the concrete during mixing to modify the properties of the fresh or hardened concrete. They are normally added to the concrete in very small quantities, in the range of 0.005% - 2% by mass of cement. Mineral admixtures occur naturally or as a by-product of an industrial activity, and are normally added to the concrete in large amounts. Examples of mineral admixtures include fly ash and ground granulated blastfurnace slag. This article will focus on chemical admixtures only. Some common types of chemical admixtures are discussed below:

Accelerators
These admixtures increase the rate of hydration of hydraulic cement. When added to concrete, they shorten the setting time and accelerate the hardening or strength development of the concrete. They enable earlier release of concrete from precast moulds thus speeding up construction. They also reduce segregation and increase density and compressive strength. Concrete cures faster and therefore uniform curing in winter and summer can be achieved. They allow for early use of concrete floors by accelerating the setting of concrete. They reduce water requirements, bleeding, shrinkage and time required for initial set.

Retarders
This type of chemical admixtures decreases the initial rate of reaction between cement and water and thereby retards the setting of concrete. Retarders act by forming a coating around certain components of the cement and they slow down the formation of reaction products in the concrete. Setting and hardening are therefore delayed, and early compressive strength is reduced. These admixtures are particularly useful in conditions where the rate of stiffening of concrete is too fast for the time required for concrete transportation and placement before it sets. Retarders can delay setting for up to more than 6 hours. Retarding admixtures improve the workability, cohesion and extend the setting time of concrete, and provide protection against delays and stoppages in construction work. They keep concrete workable for extended periods of time and in large constructions, they help to prevent cold joints. They also reduce bleeding and segregation of concrete where poor sand grading is unavoidable. Retarders also improve pumpability of concrete by extending the setting time and improving the workability.

Plasticizers
Plasticizers either increase the workability of freshly mixed concrete without increasing water cement ratio or maintain the workability with a reduced amount of water and are therefore referred to as water reducing admixtures. Their function is to reduce the water content of the mix, usually by 5 to 10%, and sometimes even up to 15%. Thus, the purpose of using a water reducing admixture in a concrete mix is to allow a reduction in the water cement ratio while retaining the desired workability or, alternatively, to improve its workability at a given water cement ratio. The actual reduction in water depends on dose of admixtures, cement content, type of aggregate used, ratio of cement, fine and coarse aggregate etc. Therefore, in order to achieve the optimum properties of the concrete, it is essential to do trial mixes with the actual material to be used on the job. With the use of plasticizers, it is possible to increase the workability of the concrete without changing water-cement ratio and thus without reducing the compressive strength of the concrete. This is particularly useful when concrete pours are restricted either due to congested reinforcement or due to thin sections.

Super-plasticizers
Super-plasticizers perform a similar function to plasticizers, but are able to reduce the water content by up to 30%. These admixtures are a different class of water-reducers which may be used without facing the problems associated with using plasticizers in larger quantities, such as bleeding, segregation and hardening. They are an extended version of plasticizers, and they increase the workability of concrete, with the ability to increase the slump from 75mm to 200mm, while maintaining the cohesiveness of the concrete. Super-plasticizers are particularly useful for self-compacting/flowing concrete for application in elements such as heavily reinforced sections and inaccessible areas. They don't entrain air and therefore reduce permeability.

Air-entraining admixtures
Air entraining admixtures are used to form small (smaller than 1mm), stable, evenly distributed air bubbles in the concrete mix. Entrained air improves cohesion and reduces bleeding; it improves the compaction of low-workability concrete, it improves freeze/thaw resistance of hardened concrete and it improves handling properties of concrete.

Water-resisting admixtures
Water-resisting admixtures are materials that reduce the capillary absorption of water into hardened concrete. Their main function is to reduce the permeation of water into the concrete. They do this by reducing the size, number and the continuity of pores in the concrete; as well as by blocking the pore structure by adding fine-unreactive or reactive fillers. They also prevent permeation by lining the capillaries with a hydrophobic material to prevent water from being drawn in by capillary suction. They are particularly effective against rain, surface water, low pressure heads in structures, water ingress in tidal and splash zones as well as the build-up of absorbed chloride at the surface of the concrete. They are often used in combination with water-reducing plasticizers. Water-resisting admixtures assist with enhancing the durability of concrete structures by reducing the ingress of water and air into the concrete.

Bonding admixtures
Bonding admixtures are polymer emulsions which serve the purpose of improving the adherence of fresh concrete to hard concrete. They are particularly suited for repair work. The combination of the emulsion with concrete results in the formation of a latex-modified concrete, or a polymer Portland cement concrete. Bonding admixtures improve the tensile and flexural strength of concrete, the durability and the bonding properties of concrete.

POSSIBLE NEGATIVE EFFECTS OF ADMIXTURES

It is very important to use admixtures as specified by the manufacturers, as straying from this can have detrimental effects on concrete both in the fresh and hardened states. Some possible negative impacts of admixtures are:

- Overdosing of some admixtures may cause retardation in setting time of concrete.
- Higher dosages of super-plasticizer affect the shrinkage and creep properties of concrete.
- Higher dosages of plasticizer may cause segregation and premature stiffening under certain conditions.
- Higher dosages of super- plasticizer may increase rate of loss of workability.
- One of the most commonly used retarder is gypsum. Addition of excess amount of gypsum may cause undesirable expansion and indefinite delay in setting of concrete.
- Excess use of accelerators cause more heat evolution and there are chances of cracks in the concrete.
- In the case of air-entrained concrete, strength decreases in proportion to the amount of air. It is observed that 1% of entrained air reduces strength by about 5.5%. The optimum air content is ranging from 3 to 6 percent.

CONCLUSION

Many chemical admixtures are used in concrete with the aim of improving the concrete performance and quality in both the fresh and hardened states. Chemical admixtures modify properties such as setting time, workability, air entrainment and segregation. These admixtures most commonly include accelerators, retarders, plasticizers, super-plasticizers, air entrainers, water-resisting admixtures and bonding admixtures. Chemical admixtures may however have adverse effects on concrete, particularly when overdosed. They may cause retardation of the concrete, loss of strength and negative impacts on concrete durability.

References

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