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A Review on Admixture in Concrete

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ABSTRACT

Admixtures are liquids or powders added in concrete, based on mix design computations, with an objective to improve the fresh as well as enhance the hardened state properties of concrete. Workability, strength and finish of the concrete influence the quality, cost and durability of the concrete. With the growing challenges of environment pollution and adoption of sustainable construction practices, in addition to cost-quality-time pyramid of construction projects, adoption of smart construction practices is the key. Concrete production using admixtures is one of the solutions to meet the above challenge. Chemical admixtures, along with the mix water, impact the rheology of concrete. Chemical admixtures influence the fresh state as well as hardened state properties of concrete. The beneficial impact of use of chemical admixtures on concrete mix can be visualized through the megastructures that have been constructed in the recent past or under construction. Admixture chemistry plays a significant role to transform normal concrete mix into a high performance concrete mix. This paper attempts to present the time line on the development of chemical admixtures, transformation observed in the admixture chemistry and the applications of the admixtures in some major concrete constructions.

Keywords: Concrete; Admixtures; High Performance Concret

INTRODUCTION

There are essentially four ingredients in concrete, i.e. the coarse aggregate, fine aggregate, cement and water. However, in order to improve certain properties of the concrete both in plastic and hardened state, it is necessary to add the fifth ingredients in the concrete mix, either it can be a mineral or chemical admixture.

If concrete mix is properly designed, most concrete do not need any admixtures. There may be a need to produce concrete with a particular result and using admixture may be the most convenient way. It is very important to note that any type of admixtures should be used only when there is a valid reason to use it.

What is Admixture?
A material other than water, aggregate, and hydraulic cement, used as an ingredient of concrete or mortar and added to the batch immediately before or during its mixing, to modify one or more of the properties of concrete in the plastic or hardened state, is termed as Admixture.

Uses of Admixtures
Use of admixture may be encouraged in following situations:

i) In specialised job like pre-stressed concrete bridges, precast concrete elements requiring high early strength and retention of workability at elevated temperature. Early gain of strength enables earlier release from precast mould, thus speeding up production.

ii) In the circumstances where increased workability of concrete is required without reducing the compressive strength or without changing of water- cement ratio, especially when the concrete pores are restricted, due to congested reinforcement or due to complicated formwork.

iii) In ready mix concrete where retarding action with high workability is required for long distance transportation before placing.

iv) Where reduction in permeability in concrete is required e.g. in hydraulic structures, marine structures, damp proof courses, retaining walls, swimming pools, basements and kitchen garden terraces etc.

v) Where high performance concrete is required, use of one or more admixtures can influence the strength at a later stage and improve resistance to chemical attack.
vi) In the circumstances where concrete is exposed to corrosion attack from external media in severe exposure conditions, a very high level of chloride is anticipated.
vii) Admixtures enhancing bonding properties can be used to bond old concrete with new and also for patching operations.

In view of the increasing importance of the use of admixture in concrete, it is essential to ensure that persons engaged in the production/handling of concrete should have a sound understanding of the material being utilised.

Before selection of the admixture to be used in concrete, the purpose of use of admixture should be clearly known.

Admixtures, which have been elaborated in the following Paras, are used to modify the properties of concrete.

Effects of Admixtures on the properties of fresh concrete

(i) To increase workability without increasing the water cement ratio.
(ii) To retard or accelerate time of initial or final setting.
(iii) To modify the rate of bleeding.
(iv) To retard segregation or increase cohesion.
(v) To improve pump ability.
(vi) To reduce the rate of loss of workability.

Effects of Admixtures on the properties of hardened concrete

i. To accelerate the rate of strength development especially at early stage.
ii. To increase the strength.
iii. To increase the durability.
iv. To decrease the permeability.
v. To control expansion by alkali-aggregate reaction.
vi. To improve bond with reinforcement.
vii. To improve bond with old/new concrete.
viii. To improve impact or abrasion resistance.
ix. To inhibit corrosion of embedded reinforcement.

Types of Admixtures
As per IS: 9103, admixtures are of the following types:

(a) Accelerating admixtures
(b) Retarding admixtures
(c) Super plasticising admixtures
(d) Water reducing admixtures
(e) Air entraining admixtures

Accelerating Admixtures :-
A cement accelerator is an admixture for the use in concrete, mortar, rendering or screeds. The addition of an accelerator speeds the setting time and thus cure time starts earlier. This allow concrete to place in winter with reduced risk of frost damage. And the accelerator can be chloride based (calcium chloride) or non chloride base (triethanolamine, sodium thiocyanate, calcium formate, calcium nitrite or calcium nitrate). Chloride based accelerators are usually adopted in non- reinforced concrete structure. In such case, the amount of accelerators is limited to 2% of the mass of cement.

Non chloride based accelerators to be adopted for reinforced concrete and prestressed concrete. Accelerators are to be used with caution as an overdose may lead to drying shrinkage, reinforcement corrosion and strength loss at later ages (Lackey, 1992)

High Range Water Reducing Admixtures
Chemical admixture such as high – range water reducers or superplasticizers, viscosity modifying agents, shrinkage reducing and air entraining admixtures, have been used in SCC, Among the chemical admixtures, superplasticizers are essential ingredients for controlling the flowablity or rheology of SCC. Polycarboxylate – based (PC) superplasticizer

are the most common water reducing agents in SCC. Many different commercial grades of PC with different functionalities and polymer structures have been tailor-designed for SCC. The chemical structure of PC influences the worklability retention and rheological performance of SCC (Felekoglu and sarikahya 2008)

Miscellaneous Admixtures

Apart from the above main types of admixtures. There are several other type of admixtures that impact fresh and \ or hardened state properties of concrete. Table 3 presents the other admixtures used in concrete manufacture.

Corrosion inhibitors	
Hydration control	Comprises two part chemical system; Stabilizer or retarder that stops the hydration of cementitious Material and activator that re – establishes normal hydration and Setting. Commonly adopted for ready mix concrete operations.
Corrosion inhibitors	Adopted for parking structure, marine structures and bridges exposed to chloride salts. These admixtures are calcium nitrite, sodium nitrite, dimethyl ethanolamine, amines, phosphate based.
Shrinkage reducing	Adopted for concrete in bridge decks floor slabs to minimize formation of cracks preventing adverse environmental influence.
Colouring admixtures	Natural and synthetic materials to colour concrete for aesthetic and safety applications. To prevent Adverse effects of pigments on concrete properties, the dosage is limited to 6% .

Pumping aids	These admixtures help to improv e pumpability of concrete (height upto 586m achieved in Burj Khalifa project)
Damproofing	Soap, stearate and petroleum based admixture added to concrete mixes with low cement content and high water cement ratio to improve their water impermeability
Bonding admixtures	These rubber, polyvinyl chlorite, polyvinyl acetate, acrylic, styrene butadiene based admixtures aid in improved bonding between old and concrete surfaces.

RETARDING ADMIXTURES

Retarders

Retarders are added to concrete mix to delay the rate of concrete setting. Fresh concrete at a temperature of 30° undergoes increased rate of hardening thereby making concrete placement and finishing difficult. Temperature can be reduced by cooling down the concrete ingredients (cold water or cooling aggregates) Alternatively reducers can be used though it does not reduce the temperature. Retarders extend the concrete setting time which further reduces loss of slump and extends concrete workability. Retarders are commonly adopted for hot weather concreting and mass concreting works (pier foundation or oil well cementation)

Why it is used.

Retarding Admixtures can be used for

1. To Improve workability, cohesion
2. To extend setting time, To provide protection against delays and stoppages and facilitate keeping workable concrete for extended period.
3. Good workability of the concrete throughout the placing period and prevention of cold joints is ensured by adding retarders in the concrete.
4. To minimise risk of long distance delivery in hot weather by extended setting time, improve pumpability of concrete by extended setting period and improved workability of concrete.
5. To reduce bleeding and segregation where poor sand grading is unavoidable.
6. To reduce adverse environmental effects of various natures on concrete and embedded
7. Steel by considerable reduction in permeability

Effects of use of Retarder

Retarding admixture forms a film around the cement grain that prevents or delays the reaction with water. After some times, this film breaks and normal hydration takes place. By the use of retarder in concrete as an admixture, due to increase in slump, the workability can be increased maintaining same water cement ratio and strength of concrete. With

reduction of water cement ratio, the strength of concrete can be increased without loss of workability.

Dosages ranging from 0.05 to 1% by weight of cement for different products are recommended by different manufactures. However, it should be fixed as per design requirement and after site trials.

Super Plasticising Admixtures:-

An admixture for mortar or concrete, which imparts very high workability or allows a large decrease in water content for a given workability.

Normal water reducers are well-established admixtures called plasticizers in concrete technology. A normal water reducer is capable of reducing water requirement by 10 to 15%. Higher water reductions by incorporating larger amounts of these admixtures result in undesirable effects on concrete like bleeding, segregation and hardening. So, a new class of water reducers, chemically different from the normal water reducer and capable of reducing water content by about 30% has been developed. The admixtures belonging to this class are known as super plasticizers. Super plasticizers are, in fact, the extended version of plasticizers.

At a given water/cement ratio and water content in the mix, the dispersing action of super plasticizers increases the workability of concrete, typically by raising the slump from 75 mm to 200 mm, the mix remaining cohesive. The resulting concrete can be placed with little or no compaction and is not subject to excessive bleeding or segregation. Such concrete is termed as flowing concrete and is useful for placing in very heavily reinforced sections, in inaccessible areas, in floor or road slabs, and also where very rapid placing is desired.

The principle mode of action of super plasticizers is their ability to disperse cement particles very efficiently. As they do not entrain air, they can be used at high dosage rates without affecting strength.

There are four main categories of super plasticizers based on their chemical composition:

1. Sulfonated melamine formaldehyde condensates
2. Sulfonated naphthalene formaldehyde condensates
3. Modified lignosulfonates
4. Others such as sulfonic acid esters and carbohydrate esters.

Why it is Used

(i) Cement content can be reduced to greater extent keeping the same watercement ratio. This will lead to **economy.**
(ii) Water cement ratio can be reduced significantly keeping same cement content and workability. This will lead to **increase in strength.**
(iii) Higher workability can achieved at very low water cement ratio, like casting concrete with heavy reinforcement.
(iv) To reduce permeability.
(v) Where early strength development is required in pre-stressed concrete or casting of floor, where early access for finishing equipment is required.

Effects of use of Super plasticizers
By use of different dosage of super plasticizers, the slump is increased resulting into better
workability of concrete and the better strength can be achieved by reduced water cement ratio.

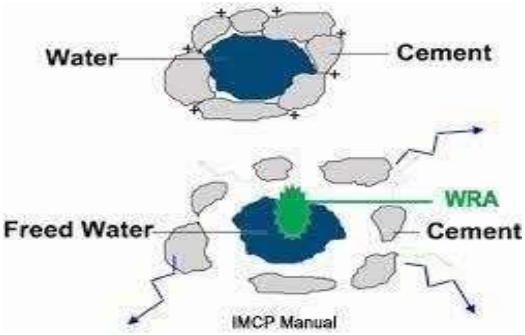
Saving of cement up to 20% can be achieved by different dosage of super plasticizers in the concrete at constant water cement ratio (0.55) and workability (80-90) slump.

The normal dosages of super plasticizers are 1 to 3 litres per cu. m. of concrete of the liquid super plasticizers containing about 40% of active material. When super plasticizers are used for large water reduction and for high strength, their dosage is much higher; 5 to 20 litres per cubic metre of concrete.

Generally, the dosage recommended by the manufacturer should be taken as guidelines and the correct dosage is decided based on site trials. The typical test results show the increase in workability and increase in strength due to use of super plasticizers.

Water Reducing Admixtures:-
Water reducing admixture sometimes referred to as plasticizers, are designed to free trapped water that is present in

concrete mixtures and are used in variety of applications to ensure or improve workability. And WRA are added in concrete mix for different purposes either to lower water cement ratio and increase the strength of concrete mix or obtain higher slump without adding water or reduce cement content.



Air Entraining Admixtures:-

Air – Entraining Admixture and what they do: Air- Entraining admixtures facilitate the development of a system of microscopic air bubbles within concrete during mixing. They increase the freeze-thaw durability of concrete, increase resistance to scaling caused by deicing chemicals, and improve workability.

1. Salt of wood resins (vinsol resin)
2. Synthetic detergents
3. Salt of petroleum acids
4. Salts of sulfonated lignin
5. Salts of proteinaceous material
6. Fatty and resinous acids and their salts
7. Alkyl benzene sulfonates
8. Salts of sulfonated hydrocarbons

The vinsol resin or sulfonated lignin salts based admixtures introduce and stabilize microscopic air bubbles. Such air entrained concrete has improved resistance to surface scaling caused by chemical deicers (Klieger, 1966)

Admixtures Manufactured/ Available in India

Detailed information about the Admixtures manufactured/ available in India is given in "Guide lines on use of Admixtures in Concrete" issued by R.D.S.O., Lucknow in December-1999 (Report No. BS- 25).

Users may contact to the manufacturer for getting catalogues for all available products in the market along with technical and price details etc.

Here we give the tabulated information in brief about the some of Admixtures manufactured / available in India for different Type of Admixtures used in concrete for ready references.

Accelerators

Sr. No.	Product Name	Manufacturer	Standards Compliances
1.	Conplast NC	FOSROC	BS: 5075 (Pt-I), ASTM: C494 Type C
2.	Conplast W	FOSROC	BS: 5075 (Pt-I), ASTM: C494 Type C
3.	Rapid Plast	CICO	ASTM: C494 Type E IS: 9103, IS: 2645
4.	Cemwet ACC	Asian Laboratories	IS: 9103 BS: 5075 (Pt I) ASTM: C494 Type A
5.	ACL -15	Krishna Conchem	IS: 9103

Retarders

Sr. No.	Product Name	Manufacturer	Standards Compliances
1.	Conplast RP-264	FOSROC	IS: 9103
2.	Sikament-227	SIKA	ASTM: C494 Type B, D & G
3.	Sikament- 176 (M1)	SIKA	ASTM: C494 Type G
4.	Rugasol-2 Liquid	SIKA	-
5.	Cemwet SRA Super-1	Asian Laboratories	IS: 9103 ASTM: C494 Type D

Plasticizers

Sr. No.	Product Name	Manufacturer	Standards Compliances
1.	Conplast 509	FOSROC	IS: 9103 BS: 5075 (Pt I) ASTM: C494 Type A &D
2.	Pozzolith LD-10	MBT	ASTM: C494 Type A,B & D BS: 5075 (Pt I)
3.	Cemwet WRA II	Asian Laboratories	IS: 9103 ASTM: C494 Type A & D BS: 5075 (Pt.I)
4.	Pedicrete CF 111-S	PIDILITE	IS: 9103 ASTM: C494 Type G
5.	Plastiment 240	SIKA	IS: 9103 ASTM: C494 Type A

Super Plasticizers

Sr. No.	Product Name	Manufacturer	Standards Compliances
1.	Conplast SP 337	FOSROC	BS: 5075 (Pt-3), ASTM: C494 Type F
2.	Rheobuild 850	MBT	ASTM: C494 Type B,D &G
3.	Cemwet SP 3000	Asian Laboratories	ASTM: C494 Type F &G IS: 9103,
4.	Supercon 300	Krishana Conchem	IS: 9103
5.	Sikament 259 (M3)	SIKA	IS: 9103 ASTM: C494 Type F

CONCLUSION

In conclusion, admixtures are added to concrete to improve its fresh state and /or hardened state performance. Admixture help in executing concreting in difficult conditions Adopting admixtures in concrete manufacture improves its sustainability. Addition of admixture extends the service life of concrete due to improvement in its performance and quality. Use of accelerators help reduce setting time, superplasticizers aid in optimizing concrete mix design, reduce concrete porosity. Air entraining Agents help improve durability of the concrete However, it should be noted that admixtures are not the only factor that determine the performance of concrete it is the concrete mix design , batching, placement and finishing along with ambient conditions that help in achieving long term maintenance free concrete.

REFERENCES

[1]. Aïtcin, P., & Wilson, W. (2015). The Sky's the Limit: Evolution in Construction of High Rise Buildings. Concrete India, 30(2), 15-20
[2]. Dransfield, J. Newman, J. & Choo, B. S. (2003). Advanced Concrete Technology – Constituent Materials. Burlington, Butterworth-Heinemann Elsevier.
[3]. Domone, P. (2006). Self-Compacting Concrete: An Analysis of 11 years of case studies. Cement & Concrete Composites, 28, 197-208.

[4]. Gandage, A., & Ram, V. (2014). Role of Supplementary Cementitious Materials in Self Compacting Concrete – A Review. Indian Concrete Journal, 88(6), 42-59.
[5]. Kett, I. (2010). Engineered Concrete Mix Design & Test Methods. Boca Raton, CRC Press Taylor & Francis Group
[6]. Klieger, P. (1966). Air-Entraining Admixtures. Research Department Bulletin, RX 199, 1-12. Lackey, H. (1992). Factors affecting use of Calcium chloride in Concrete. Cement Concrete & Aggregates, ASTM, 97-100.
[7]. Nmai, C. Tomita, R. Hondo, F. & Buffenbarger, J. (1998). Shrinkage reducing admixtures. Concrete International, 31-37.
[8]. Sika. (2013). Sika Concrete Handbook. Zurich, Sika Services.