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# A Review on Effectiveness and Compatibility of Superplasticizers In The Presence Of Mineral Admixture in Cementitious System

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***Abstract***
*The process of hydration and chemical interactions are changed by the inclusion of different chemical and mineral admixtures to Portland cement concrete, which results in unexpected concrete behaviour. Due to efficient and quick construction, chemical admixtures are highly demanded in modern society. Currently, among these admixtures, superplasticizer has a large demand because it may improve the workability of freshly produced concrete, which is one of its main problems. Rheological behaviour or study of flow of matter of cement paste changes with composition of cement, amount of mineral and chemical admixtures, family of superplasticizer, etc. This paper provides an overview of the need for research on cement admixture compatibility.*
***Keywords:*** *Mineral admixture, Superplasticizer, Compatibility.*

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## I. INTRODUCTION

Ordinary Portland cement (OPC) is by a long shot the most imperative kind of cement. Although they are minimal costlier than low-grade cement, they offer a 10-20% reduction in cement utilization. A stand out amongst the most imperative advantages is the quicker rate of advancement of strength. The make of OPC is diminishing everywhere throughout the world from the perspective of blended cement because of lower energy consumption, ecological contamination, and economic and different advantages. Modern concrete almost always processes addictive either in mineral or in chemical form.

Admixtures are ingredients that are added to the concrete batch immediately before or during mixing. They confer certain beneficial effects to concrete, including frost resistance, sulfate resistance, controlled setting and hardening, improved workability, increased strength, etc. Special concretes are made with coloring pigments, polymer latexes, expansion producing admixtures, flocculating agents, antifreezing chemicals, corrosion inhibiting formulations, etc. Admixtures influence the physical, chemical, surface-chemical, and mechanical properties of concrete and its durability. Accelerating admixtures reduce the time of setting and increase the rate at which the strength is developed. They are used in cold weather concreting. Examples of accelerators include calcium chloride, formates, carbonates, nitrites, amines, etc. Water reducing admixtures reduce the amount of water (about 8–10%) required for concrete mixing at a given workability. These admixtures improve the strength and durability of concrete. Refined lignosulfonates, gluconates, hydroxycarboxylic acids, sugar acids, etc., act as water reducers. Retarders lengthen the setting times of concrete. They are particularly useful for hot weather concrete operations. Phosphonates, sugars, unrefined lignosulfonates, carbohydrate derivatives, and borates are some examples of retarders.

Superplasticizing admixtures can reduce water requirement by about 30%. The most popular formulations are based on sulfonated naphthalene formaldehyde and sulfonated melamine formaldehyde. Particularly chemical admixtures such as water reduces and set controllers are invariably used into enhancing the properties of fresh and hardened concrete. A chemical admixture is any material that is added in small quantities to the concrete mixture that enhances the properties of concrete in a fresh or hard state. The defines that admixture as a material other than water, aggregate, hydraulic cement, and fiber reinforcement used as an ingredient of concrete or motor and added to the batch immediately before or during its mixing [1].

The proper use of admixtures offers beneficial effects to concrete, including improved quality, acceleration or retardation of setting time, enhanced frost and sulphate resistance, control of strength development, improved workability, and enhanced finish ability. It is estimated that 80% of concrete produced in North America these days contains one or more type of admixtures. As an essential component of concrete, different types of chemical admixtures have been widely applied to improve properties. Chemical admixtures enable the manufacture and construction of high performance ready-mix and also precast concretes.[2].

Admixtures vary widely in chemical composition and many perform more than one function. Two basic types of admixtures are available: chemical and mineral. All admixtures to be used in major concrete construction should meet specifications: tests should be made to evaluate how the admixture will affect the properties of the concrete to be made with the specified job materials, under the anticipated ambient conditions, and by the anticipated construction procedures.

Superplasticizers are enhanced chemical admixtures with exceedingly viable plasticizing effects on wet concrete. Superplasticizers result in significant upgrades in workability at a given water-cement ratio. For consistent workability, a decrease in water content up to 30 % might be accomplished by utilizing superplasticizers. Superplasticizers are organic poly-electrolytes; they have a place with the class of polymeric dispersants. Among the various superplasticizers, some of the superplasticizers are synthetic and some are derived from natural products. The flow properties are additionally influenced by secondary components like temperature, blending span, mixer type and mixing sequence. So, it is important to study the flow behaviour of cement paste when it is mixed with various percentages of supplementary cementitious material such as fly ash, silica fume, GGBS.

## II. LITERATURE REVIEW

The main aim of this section is to present an overview of research work carried out by various researchers in the field of cement admixture compatibility.

### 2.1 CEMENT

Current global Portland cement production is about 4.6 billion tonnes annually, with 6 billion tonnes predicted by 2050, while India's production capacity has seen a substantial rise from 98 MTs in 1996 to 445MTs in 2020 i.e., a 300% jump [3]. The conventional cementitious mix is a three-phase system consisting of cement, aggregates, and water of which cement and aggregates have their sub-phases. While aggregates may be either fine or coarse, the major sub-phases of cement are – Tri Calcium Silicate($C_3S$), Di-Calcium Silicate($C_2S$), Tri Calcium Aluminate ($C_3A$), and Tetra Calcium Alumino Ferrite($C_4AF$), where, C = CaO; S = $SiO_2$; A = $Al_2O_3$; F = $Fe_2O_3$.[4]. Portland cement is also the most energy-intensive component of a concrete mixture and therefore its partial replacement by any cementitious by-products might result in significant energy savings [5].

### 2.2 ADMIXTURES

The passage of time saw the introduction of a new dimension in the mix termed 'admixture' meaning something added to the mix from outside. Indian Standards of 1953,1957, 1964, 1978, and 2000 never mentioned the use of admixtures till 1978, and the 3rd revision IS:456(1978) covered fly ash only as pozzolana and not as mechanical admixture but only with the approval of the engineer in charge while the term chemical admixture was just introduced. The latest version of IS code, IS:456(2000) says that 'mineral admixtures may be used with the approval of the engineer in charge. This last revision also says that chemical admixture shall conform to IS:9103-1979 and now in the 4th version, the clause of admixtures has been modified because of the availability of the new type of admixtures including Superplasticizers and shall be conforming to IS 9103-1979 [4]. The investigation of the impact of mineral admixtures on the rheology of cement paste and concrete is been studied continuously. Also, it is been noted that Rheological tests on cement paste utilized to effectively choose the sort and dose of mineral admixtures enhanced the workability of the concrete [6]. The use of construction chemicals has affected less use of cement along with a lesser quantity of water for the same workability [7].

#### 2.2.1 Silica Fume

Industrial solid waste used as mineral admixtures is an effective and indispensable material component in modern high-performance concrete [8]. The characteristics of a low water-binder ratio and large numbers of supplementary cementitious materials, such as silica fume (SF), fly ash, slag and metakaolin are employed to occupy the voids between the aggregate particles and cement [9]. Silica fume is used as an artificial pozzolonic admixture which is also called micro silica or condensed silica fume. Silica fume is obtained from coal with quartz reduction in an electric arc furnace and is a waste bi-product of manufacturing silicon or Ferro silicon alloys. Silica fume typically is used at a replacement rate of 5–10% of ordinary Portland cement. Silica fume can be used to increase the strength of concrete and to reduce its permeability [10]. Silica fume is used in concrete to improve its properties. It has been found that silica fume improves compressive strength, bond strength, and abrasion resistance; reduces permeability; and therefore, helps in protecting reinforcing steel from corrosion [11]. Superplasticizers may cause an increase in silica fume concrete permeability however this effect of superplasticizers seems to diminish with higher silica fume content [12]. Compared with the other supplementary cementitious materials in a study of Portland cement was replaced with fly ash up to 40% age silica fume up to

15% and GGBS up to 11 of 70% the result confirms that silica fume performed better than other supplementary cementitious materials. Also, it performed well for all mixes to resist chloride diffusion [13].

### 2.3 SUPERPLASTICIZERS

Superplasticizers (SP) are one of the most important constituents of cement cementitious mix mixes. It makes cementitious mix flowable at a low water-cement ratio without segregation and bleeding as required for high-performance concrete [4]. The increase in cement paste fluidity by the addition of a water reducer relates to the dispersing action exerted by the adsorption of admixture molecules on the solid surface, which modifies the zeta potential of particles or favors their dispersion on account of a phenomenon of steric impediment [14]. Lignosulphate or generally regarded first generation superplasticizers while sulphonated formaldehyde condensate is called second-generation and polycarboxylic and polyacrylics are termed as third-generation superplasticizers. Moreover, the use of optimum dosage of the admixture is also essential since low dosages may result in loss of fluidity, and overdosage could lead to segregation, set retardation and uneconomical use of the superplasticizer [1]. The selection of the type and dosage of superplasticizer can be based on the relative fluidity of cement paste through simple tests, such as with the Marsh cone and minislump, and/or through rheological characterization using a viscometer [15].

The PCE admixtures decrease water content in concrete (up to 40%) much greater than afforded by conventional lignosulfonate-, melamine- or naphthalene-based superplasticizers. This reduction in water content leads to a decline in porosity, thereby raising concrete mechanical strength and durability [16].

### 2.4 INTERACTION OF SUPERPLASTICIZERS

Different superplasticizers act differently with the Portland cement pastes. When the superplasticizers are mixed with cement paste it gets absorbed on the surface of cement particles at early hydration stages [17]. The rheology of cement paste is governed by van der Waals attraction forces between the cement particles and the electrostatic repulsion due to the surface charges on the cement particles. However, as the former force is larger than the latter cement particle seems to eventually flocculate. The action of the superplasticizer is to prevent or delay the flocculation and dispersed the cement particles within the paste [15]. The amount of adsorption of SPs depends on the zeta potential, type, and morphology of cement minerals and hydrates and the molecular weight of SP, which influences the fluidity of cement paste [1].

### 2.5 INFLUENCES ON SUPERPLASTICIZER COMPATIBILITY

Various factors influence the cement superplasticizer compatibility both external and internal. Compatibility between cement and superplasticizers is affected by a combination of reasons, including *cement* composition, admixture type and dosage, *concrete* mix, water-cement ratio, density, and temperature etc., [18,1]. More studies are been focused on temperature changes, high-temperature mixes and so on. The fluidity decreases with an increase in temperature at lower dosages of superplasticizers; however, the fluidity increases with an increase in temperature at higher dosages of superplasticizer [19]. A study of the loss of fluidity over time as a function of the superplasticizer type shows that the trends can vary considerably from one product to another.

#### 2.5.1 Effect on Fresh and Hardened Properties

Superplasticizers (SP) are one of the most important constituents of cement cementitious mix mixes. It makes cementitious mix flowable at a low water-cement ratio without segregation and bleeding as required for high-performance concrete [4]. The fluidity properties mainly depend on the type of superplasticizer and the mixing method, also external factors affect the workability of the mix [19]. The superplasticizer does not have a direct influence in the hardened properties of concrete, but it reduces the water-cement ratio in turn improving the strength of concrete

## III. CONCLUSION

To identify the ideal dose of concrete's constituents, admixture-cement compatibility and admixture-admixture compatibility must be researched. The flow of the cement paste increases with increase in the superplasticizer dosage and remains constant after a particular dosage called saturation dosage or optimum dosage. Different superplasticizers act differently with the Portland cement pastes. Various factors influence the cement superplasticizer compatibility both external and internal. Compared to other supplemental cementitious materials, silica fume has a higher compressive strength.

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