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Compatibility Study of an Admixture with Different Cement Brands of Varying Chemical Composition for SCC

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***Abstract*- Developing countries like India see a lot of infrastructural developments like metros, high rise buildings, roads, airports etc. The use of special concrete also attained faster pace with these developments. Self-compacting concrete is one such development which helps in concreting dense reinforcements. The constituent materials of making concrete conform to Indian standard specifications, but different types of cement may vary from batch to batch and brand to brand in their chemical composition. Therefore the compatibility of a chosen admixture with different brands of cement of same type for the preparation of self-compacting concrete may be a question. In this study, the suitability of a selected admixture with two brands of cement of Portland pozzolana type is determined by finding out the optimum dosage by marsh cone test. The slump retention time of the cement slurry at 0, 30 and 60 minutes is also studied.**

Keywords:* *Marsh Cone Test; Optimum Dosage; Retention Time; Flow Time

I. INTRODUCTION

Modification of concrete is a fact from the time of invention of concrete. It can be either replacement of any material or addition of new ones. Additives can be in mineral form or chemical form. Mineral additives such as flyash, GGBS etc. and chemical additives such as water reducers, air entrainers, set controllers etc. are used to improve the properties of concretes under a variety of conditions. Various types and brands of chemical admixtures are available in the market for each property. Hence the behaviour with a particular material/ admixture also changes. So a study about the compatibility between cement and admixture is necessary before its application in field. To study about the compatibility first one should know the compatibility problems. With the availability of different brands of cement, the behaviour of a particular admixture with each brand of cement differs. Therefore selection of cement and admixture is of prime concern before its application.

A. Compatibility of Admixtures and Cementitious Materials

Concrete faces compatibility problems like cement-admixture incompatibility and incompatibility between admixtures when admixture is added. There can be also incompatibility between supplementary cementing materials and admixtures or cements.

Some of the incompatibility problems reported between cement and admixtures are:

- Slump loss
- Low strength gain rate
- Early stiffening of concrete
- Segregation of concrete
- Increased water demand

From the literature reviews, it is clear that for checking the incompatibility issues there are no specific test methods available. Actual site conditions cannot be simulated as such in laboratory conditions. In most cases, any incompatibility between cement and admixture is misunderstood in the sites as the site engineer is not aware of the real causes of incompatibility. Normally cementing materials or admixture is changed when such problem arises.

B. Origins of incompatibility

Some of the causes of incompatibility problems like early stiffening, retardation etc. are listed below.

Incompatibility of cement and admixtures can be either due to cement or admixtures or both. Chemical composition of cement can predict some extent of incompatibility.
If SO_4/C_3A ratio is too low uncontrolled C_3A hydration occurs which result in early stiffening (flash set). On the contrary when SO_4/C_3A ratio is too high calcium sulphates are converted to gypsum (false set).

Temperature is another factor affecting compatibility. Hot weather conditions lead to increased admixture adsorption thereby leads to fluidity whereas low temperature results in low fluidity.

Higher alkali cements react faster and leads to higher rate of stiffening and higher slump loss.

Timing of admixture addition is also a factor of compatibility. When admixture addition is delayed after the addition of 70% mixing water majority of the cementitious materials will be hydrated and adsorption of admixture is taking place by unhydrated cementitious materials. So more admixtures are available in the paste which results in increased workability and retarded set.

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Presence of lignin based admixtures affect the SO_4/C_3A ratio. It reduces the solubility of sulphates.

Trials can be performed to evaluate the compatibility by applying different brands of admixtures and cements. Incompatibility can be reduced by adding retarding agent or pozzolanic material.

II. MATERIALS

Cement: PPC-brand1 (February 2016)
PPC-brand2 (March 2016)
Water: Potable
Admixture: Auromix 300 plus

A. Material selection and its properties

To select the brands of cement for the study, a survey is conducted to find the types of cements and different brands of cements in various sites in Kochi city. From the survey conducted in 23 sites in and around Kochi city it was found that brand 1-PPC cement is used in 35% sites and brand 2-PPC cement is used in 40% sites and only 25% is used in the remaining. Out of the remaining sites 15% sites uses PSC cement.

For the present study, the chemical admixture Auromix 300 plus is used and it was found that in almost all the sites for SCC works the same admixture is used. Hence this study aims to provide a database for the construction sites in Kochi city in deciding the optimum dosage for different brands/types of cement for the selected admixture type.

1) Test result for physical properties of cement

Two different brands of PPC cements were selected and physical properties were tested in the laboratory.

TABLE I. PHYSICAL PROPERTIES OF CEMENT

Cement	Brand 1	Brand 2
Standard consistency (%)	36	36
Initial setting time (minutes)	60	90
Final setting time (minutes)	180	270
Specific gravity	2.78	2.88
Soundness (mm)	2	0.5
Fineness (%)	9	1
Compressive strength of mortar (MPa) (28 days)	55	56.5

TABLE II. CHEMICAL PROPERTIES OF CEMENT

Cement	Brand 1	Brand 2
Total Loss of Ignition (%)	1.55	1.7
Silicon dioxide (%)	20.98	21
Ferrous and Aluminium oxide (%)	3.68	4.5
Calcium oxide (%)	54.86	61.5
Magnesium oxide (%)	0.39	0.1
Sulphur trioxide (%)	1.07	1.3
Insoluble Material (%)	25.34	22

Chemical properties of cement were given by supplier.

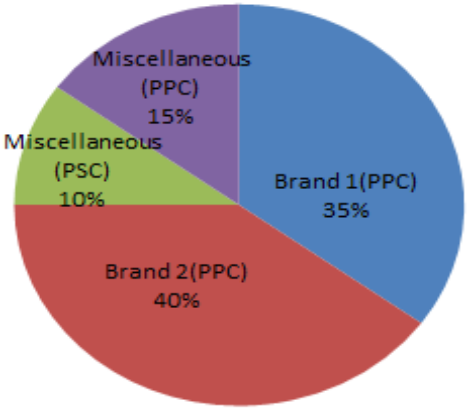

Fig.1. Different brands of cements at sites in Kochi city

B. Superplasticizer (Auromix 300 plus)

Auromix 300 plus is a high performance retarding superplasticizer based on a polycarboxylic ether polymer with long lateral chains intended for applications where retardation and long workability retention(4 hours and more) are required and it can be used for mass raft foundations, pumped concrete, concrete requiring long workability retention, high performance concrete in terms of strength and durability.

TABLE III. PROPERTIES OF SUPERPLASTICIZER

Properties	Results obtained
Appearance	Light yellow coloured liquid
pH	Minimum 6.0
Volumetric mass at 20^0 C	1.08±0.02 kg/litre
Chloride content	Nil to IS:456
Alkali content	Typically less than 1.5g Na_2O equivalent / litre of admixture.

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1) Advantages

- Suitable for higher volume cement replacement of GGBS or flyash
- Increased retardation controls the heat of hydration and yields high ultimate strength
- Higher Young's modulus
- Better resistance to carbonation
- Low permeability
- Better resistance to aggressive atmospheric conditions
- Reduced shrinkage and creep
- Increased durability
- Improved surface finishes with sharper arises
- Compatible with 100 per cent crushed sand

III.MARSH CONE METHOD FOR DETERMINING OPTIMUM DOSAGE OF ADMIXTURE

Marsh cone test is reliable and simple method to study the rheological properties of cements and mortars. Flow time of cement through marsh cone is indicator of viscosity, which depends upon cement-admixture compatibility. It is widely used to study cement- admixture compatibility and to determine optimum admixture dosage of a specific cement-admixture combination. The main principle behind the test is to find the time required for a certain quantity of material (cement slurry) to flow out the cone through a particular size of aperture. The parameters, flow time and fluidity are inversely proportional. As flow time increases fluidity decreases.

A. Apparatus

It consists of a conical brass vessel held on a metallic stand with an orifice of 5mm at its bottom.

A stopwatch is needed to measure the time taken by a certain quantity of cement slurry to pass through the vessel.

A high frequency mixer is also needed to prepare the cement paste with desired w/c ratio.

Fig. 2. Marsh cone apparatus

B. Procedure

700ml of cement paste is prepared in high frequency mixer using 1kg of cement at w/c ratio of 0.4. It is prepared by adding 70% of mixing water with cement initially and mixed for one minute. Afterwards remaining water and superplasticizer at dosage of 0.5% of cement is added and mixed for two minutes at same speed. The slurry is permitted to flow through marsh cone immediately after mixing and time is measured using a stopwatch. Tests were conducted by increasing the admixture dosage at intervals of 0.2% till constant flow time is obtained. Again the slurry is allowed to flow through marsh cone after 30 minutes and 60 minutes of retention. For each case flow time is measured.

C. Marsh cone test results

Graphs were plotted with % admixture dosage on X axis and flow time on Y axis for the two brands of PPC cement at 0 minute, 30 minutes and 60 minutes retention. The dosage after which there is no change in flow time for 0 minute retention is noted as optimum dosage of admixture.

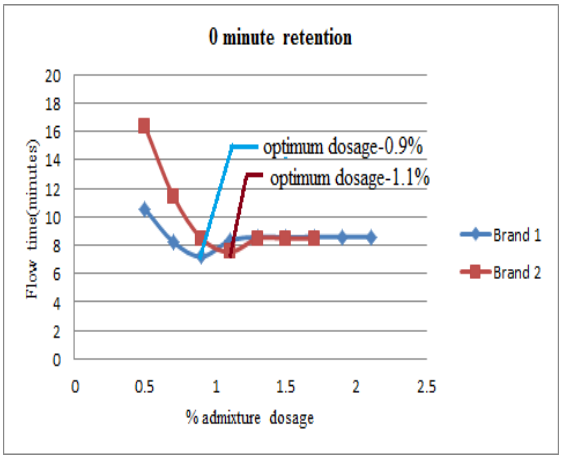

Fig. 3. Marsh cone test results of 0 minute retention

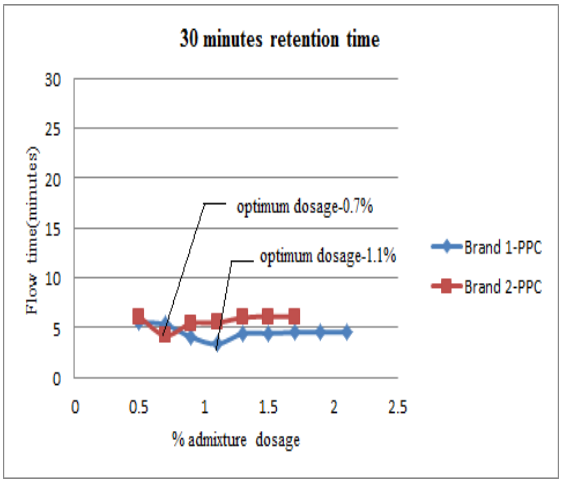

Fig. 4. Marsh cone test results of 30 minute retention

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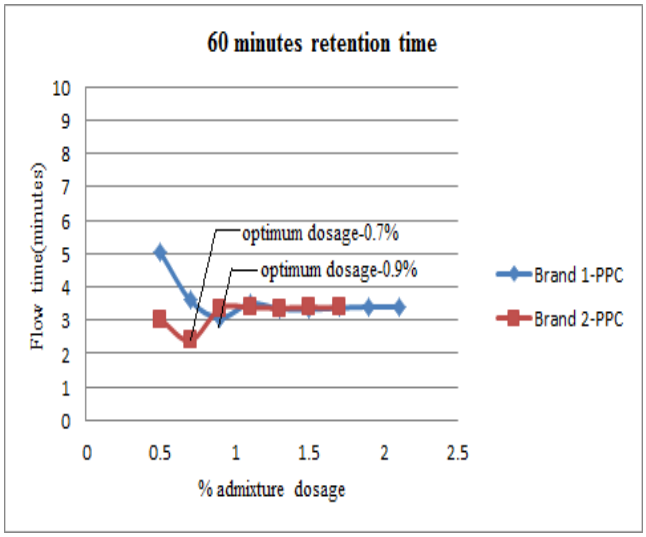

Fig. 5.: Marsh cone test results of 60 minute retention

IV. RESULTS

Saturation dosage varies with the type of the superplasticizer and cement. Flow time decreases with increase in dosage of superplasticizer. The saturation dosage of admixture can be defined as that point beyond which there is no significant decrease in the flow time. Flow time after reaching saturation dosage is either same as saturation dosage or more or less constant after saturation point.

Saturation point can be taken as the maximum admixture content to be used in concrete because there after no significant change will occur in flow time.

Optimum dosage of two brands of cement varies. Brand 1 showed 0.9% and brand 2 showed 1.1% saturation dosages at 0 minute retention.

Flow time and % dosage for brand 1 is lower than brand 2. With the addition of admixture beyond 1.5%, flow time has no variation.

It may be due to the variation in chemical properties. From the results obtained it is observed that even though both the selected cements are PPC their saturation dosage differs.

Fineness of cement also plays a role in the variation of admixture dosage. As fineness increases surface area increases and resulting in more adsorption of admixture. Fineness is directly proportional to saturation dosage. As fineness increases saturation dosage also increases. Consistency, setting time etc.also depends on fineness. As fineness increses, setting time also increases.

Flow time decreases as retention period increases and dosage at which flow time is lowest differ from 0 minute retention to 60 minute retention. Optimum dosage of brand 1 cement is 1.1% and that of brand 2 is 0.7% at 30 minute retention whereas optimum dosage of brand 1 cement is 0.9% and that of brand 2 is 0.7% at 60 minute retention.

V. DISCUSSIONS

Due to compatibility problems before application at fields compatibility check between cement and admixture should be done. So to reduce incompatibility problems check the compatibility whenever cement and admixture are changed.

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