Effect of Re-Dosing Superplasticizer to Regain Slump on Concrete

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Abstract— This research is preliminary study about addition of second and third dosage of superplasticizer to regain the slump, after it losses certain percentage of slump in concrete. To accomplish this 53 grade Ordinary Portland cement were used in preparing concrete mix with a cement content of 420 kg/m^3 and three different types of superplasticizers were used. Water cement ratio was kept constant. To achieve equal workability a slump of 120±20mm was targeted for all mixes. Concrete control specimens without admixture were also cast for comparison. Re-dosing of superplasticizer was done when there was a drop in slump value below 50mm and time of re-dosing were noted. Based on findings from the study, re-dosing of superplasticizer is possible to regain the slump in field and it was also found that there is not any adverse effect on compressive strength of concrete due to addition of second and third dose of superplasticizer in concrete. This study will help to solve slump loss problem of ready mix concrete during delivery time.

Keywords— Concrete , Compressive strength, Re-dosing, Slump, Superplasticizer

I. INTRODUCTION

In the construction industry pumpability and high workability of concrete play an important role especially where concrete is produced away from actual job site, for example as 'ready mixed concrete (RMC)' is produced at a batching plant. To achieve high workability in the fresh state and to have considerable slump-retention apart from cement, aggregates and water, a fourth ingredient namely an admixture is introduced in the concrete. As per ACI 116R [11], admixture can be defined as "a material other than water, aggregates, cementitious materials, and fiber reinforcement, used as an ingredient of a cementitious mixture to modify its freshly mixed, setting, or hardened properties and that is added to the batch before or during its mixing". Chemical admixtures have become one of the essential components of concrete in concrete technology in recent years. Various chemical admixtures different in composition have been offered to the users today in response to the needs of the construction market. The most commonly used for this purpose are those of plasticizers and superplasticizers which have the ability of increasing the workability of concrete considerably.

Currently available superplasticizing admixtures are micromolecular organic agents which often can be divided into four groups according to their chemical contents as sulphonate melamine formaldehyde, sulphonate naphthalene formaldehyde, modified lignosulphonates, and copolymers contain sulphonic and carboxyl groups [3]. These admixtures do not entrain a significant amount of air as they do not markedly lower the surface tension of the pore water of concrete with respect to conventional plasticizers and they can therefore be used rather in higher proportions [4]. Since 1980, around which time the superplasticizer concept took roots in India, many apprehensions have surfaced in the minds of construction agencies, e.g slump loss, segregation of concrete, entrainment of air, etc. The latest apprehension is about its slump retention properties. Rapid slump loss was observed in many construction sites which occurred after 45 minutes after the addition of superplasticizers.

II. EXPERIMENTAL WORK

2.1 Objective and Scope

The variation of contribution of superplasticizer and also its effect due to re-dosing to the compressive strength of concrete was investigated in the study. To accomplish this, three types of superplasicizers were used in preparing the concrete mixes. Admixture is added to water by weight of the cement content and concrete specimens cast were tested at the end of different curing periods to determine the compressive strengths. Control concrete specimens were also cast for comparisons.

2.2 Material Characterization

Cement used is 53 grade Ordinary Portland cement. Physical properties of cement used are given in table 1. M-sand of fineness modulus 2.96 and crushed stone passing through a 20mm sieve has been used in the present study. Physical properties of fine aggregate and coarse aggregate is given in table 2 and 3 respectively. Three commercial superplasticizers were used in the study, two of which belong to the same family. SP-1 and SP-2 are polycarboxylate-based superplasticizer and SP-3 is naphthalene-based superplasticizer. Properties of superplasticizers are given in table 4.

Table I : Physical Properties of Cement

Brand of cement	53 grade OPC
Standard consistency	34%
Initial setting time (in mins)	140
Final setting time (in mins)	320
Specific gravity	3.141

Table II : Physical Properties of fine aggregates

Specific Gravity	2.54
Water absorption	11%

Table III : Physical Properties of coarse aggregates

Specific Gravity	2.778
Water absorption	0.25%

Table IV: Properties of superplasticizer

Superplasticizer	Type	Aspect	Relative density	pH
SP1	PCE	Light brown liquid	1.01±0.01 at 25ºC	≥6.0
SP2	PCE	Light brown liquid	1.09±0.02 at 25ºC	≥6.0
SP3	SNF	Dark brown liquid	1.242 at 30ºC	≥6.0

2.3 Experimental Work

Cement content of 420 kg/m^3 was adopted for the mix design (1:1.65:2.73) bearing all the superplasticizers at the dose level as recommended by the manufactures to obtain a slump of 120±20 mm. Pan type concrete mixer was used. Initially binder, coarse aggregate and fine aggregate were weighted and put in the mixture and dry mixed for one minute. Then weighted amount of water was added and mixed for one minute. Finally weighted amount of superplasticizer was added and mixed for two minutes. Total mixing time was around four minutes.

Slump was measured immediately after the mixing procedure was finished and recorded as initial slump. Then concrete was kept in pan with plastic cover to prevent loss of water by evaporation. Then sample of concrete was used to measure slump value at varying time intervals. Time at which slump value came below 50mm was noted. This measured slump was recorded as slump before second dosage. Before measuring slump, the sample was mixed for two minutes to make it homogeneous.

Then weighted amount of superplasticizer was added to the concrete as a second dose and mixed for two minutes to make it homogeneous. Amount of superplasticizer to be added for re-dosing is obtained from trial and error method, to regain a slump of 120±20mm.Then slump was measured and recorded as slump after second dose of superplasticizer. Again concrete was kept in pan with plastic cover and slump value was measured at varying time intervals. Time at which slump value came below 50mm was noted. This measured slump was recorded as slump before third dosage.

Concrete cubes of 150mm size were cast to find the compressive strength developed at the age of three, seven and twenty eight days respectively, of mixes obtained before and after re-dosing. The cubes were sealed with a plastic wrap after casting and demoulded after 24h except in cases were retardation was observed. Specimens were cured in water at 28ºC till the time of testing.

III.RESULTS AND DISCUSSION

3.1 Slump Loss

Relation between slump losses with time for different brands of superplasticizers is shown in fig.1. In this study initial slump was fixed as 120±20mm. To make the same initial slump, different superplasticizers needed different intial dose. It was observed that SP3, i.e, naphthalene-based superplasticizer needed higher initial dose when compared to SP1 and SP2.

In stipulated elapsed time, the slump loss was less for those mixes having a higher initial dose of superplasticizer. The rate of slump loss depends on various factors such as initial slump, type and dose of superplasticizer, ambient temperature, type of cement etc. In this case initial slump, ambient temperature, water cement ratio and type of cement were same and only different were type and initial dose of superplasticizer. The mechanism responsible for the slump loss involved chemical and physical process. Loss of consistency in cement paste during the dormant stage is mainly attributable to the physical coagulation of cement particles rather than their chemical effect [5]. The initial hydration can generate a surface charge in both magnitude and direction which may promote the early flocculation of hydrating cement particles, but they can be effectively neutralized and superseded by the ionic charge of superplasticizer molecules. The presence of adsorbed SP molecules on the hydrating cement minimize the interaction between the particles first through the electrostatic repulsive forces and then steric repulsion [9]. This discussion concludes that, naphthalene-based SP require higher dosage. Also higher the initial dosage of superplasticizer more will be disturbance in the hydration and slower will be the slump loss rate.

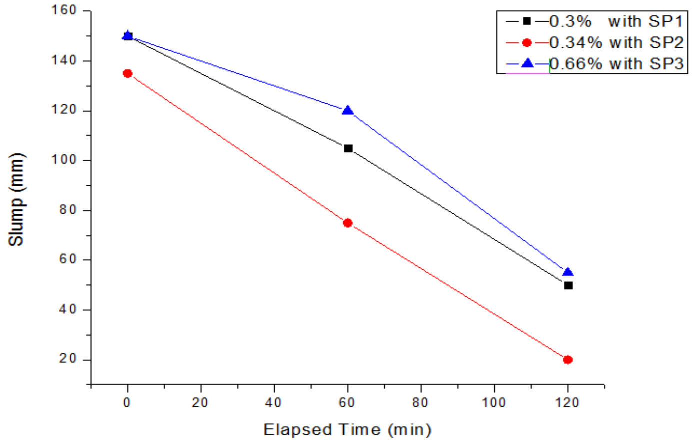

Fig.1. Relation between initial slump, slump loss and elapsed time with same initial slump for different types of superplasticizers with different initial dosage

3.2 Effect of re-dosing of superplasticizer to regain original slump

When superplasticizer was re-dosed the slump was increased. Fig.2, fig.3 and fig.4 shows effect of different types of superplasicizers on slump after first, second and third dosage. When superplasticizer was re-dosed the slump was increased. It may be due to; when the superplasticizer is re-dosed zeta potential of binder particles is increased, at the same time viscosity decreased. Increased zeta potentials help to disperse the cement particles and make the concrete more workable and slump is regained. It was observed that redosing using SP1 resulted in an unstable mix. The loss of stability of mix was manifested in terms of bleeding of concrete. In case of SP2 a stable mix was obtained even after redosing. The amount of second dosage required is less than the initial dosage and slump obtained after second dosage was higher than initial slump. Redosing with SP3 produced a stable mix. As in case of SP2, the amount of second dosage was less than the initial dosage and slump obtained after second dosage was higher than initial slump. In all cases the setting time of cube was more than 24 hours.

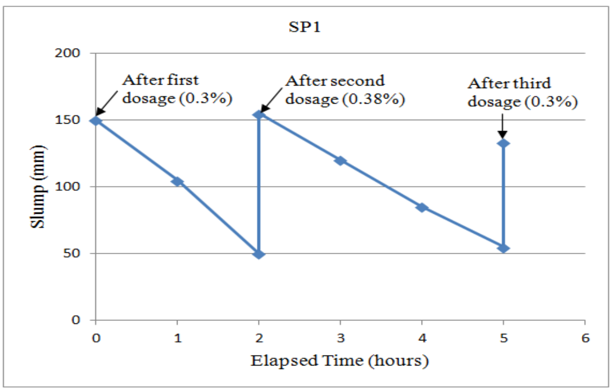

Fig.2. Effect of re-dosing of SP1 to regain original slump

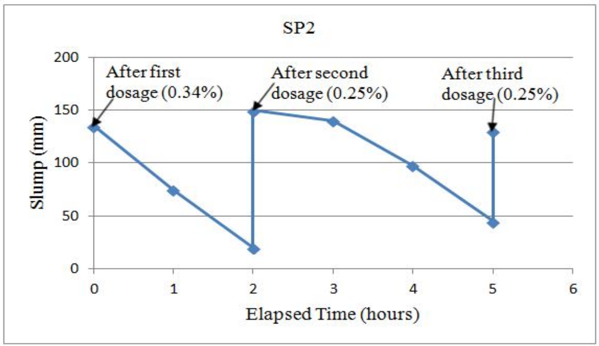

Fig.3. Effect of re-dosing of SP2 to regain original slump

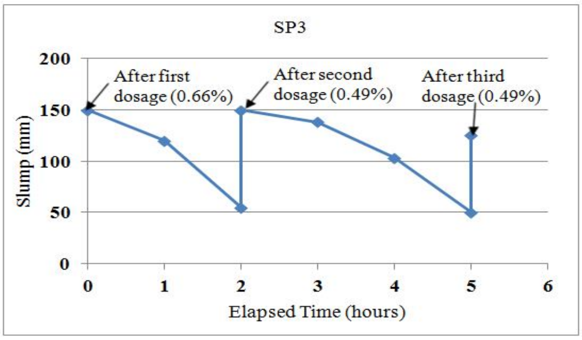

Fig.4. Effect of re-dosing of SP3 to regain original slump

3.3 Effect on Compressive Strength

The compressive strength of concrete after first dosage of superplasticizer is shown in table 5. The compressive strength of superplasticized concrete was found to be higher than that of control mix prepared without addition of superplasticizer. Table 6 and 7 shows the compressive strength of concrete after second and third dosage respectively. It was found that there was no significant difference on compressive strength.

Table V : Average Compressive Strength of cubes after first dosage (in MPa)

Type of SP	3 day	7 day	28 day
SP1	20.29	28.08	40.88
SP2	26.34	30.74	38.88
SP3	25.52	30.10	40.44
Control mix	20.15	27.40	38.60

Table VI: Average Compressive Strength of cubes after second dosage (in MPa)

Type of SP	3 day	7 day	28 day
SP1	20.29	25.92	40.20
PCE 2	26.41	30.86	39.24
SNF 1	25.50	30.40	41.60

Table VII: Average Compressive Strength of cubes after third dosage (in MPa)

Type of SP	3 day	7 day	28 day
SP1	20.29	25.92	40.14
PCE 2	26.34	30.74	39.45
SNF 1	25.52	30.10	41.80

IV. CONCLUSIONS

The findings obtained from the study on re-dosing of superplasticizer to regain the slump are briefly outlined below:

(i) It was observed that naphthalene-based superplasticizer needed higher initial dose when compared polycarboxylate-based superplasticizer.

(ii)In stipulated elapsed time, the slump loss was less for those mixes having a higher initial dose of superplasticizer.

(iii)The properties of hardened concrete such as compressive strength of superplasticized concrete was found to be higher than that of control mix. It can be concluded that superplasticizers improve the strength of concrete by improving the workability of concrete leading to denser and less porous structure.

(iv)Large increase in slump of superplasticized concrete can be maintained for several hours by the addition of a second and third dosage, the amount of second and third dosage being the same as the initial dosage.

(v)There was no significant difference on compressive strength after re-dosing of superplasticizer.

(vi) Use of repeated dosages of superplasticizer is a solution to the issue of slump loss.

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