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An Experimental Study of Effects of Superplasticizer on Fresh and Hardened Properties of Concrete

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Abstract:- This paper presents the results of an experimental research on the workability and compressive strength of ordinary and standard concrete. Superplasticizers are commonly known as High Range Water Reducers (HRWRs) because it permits low water cement ratio as well as the workability also affected. In this paper the properties of concrete mixtures with three different dosages of superplasticizers SNF have been investigated. In this experimental programme superplasticizer Sikament®170(SWP) of basically modified naphthalene/melamine formaldehyde sulphonate dispersion and having brown liquid confirming to IS: 9103-1999 & IS: 2645, ASTM C 494/C494M, Type F has been used. The properties investigated are workability on the fresh state and compressive strength on the hardened state of concrete by using three mixes with three superplasticizer dosages (0.2%, 0.4% and 0.6%) is used. Various concrete mixes (M-20, M-30 and M-40) are design by IS 10262:2009, Concrete Mix Proportioning - Guidelines. Compressive strength at 7 and 28 days was also determined. The graphs between different percentage of superplasticizers with W/C ratio and compressive strength are plotted. Overall 72 specimens (concrete cube) with the dimension of 150 mm x 150 mm x 150 mm were fabricated at laboratory.

Keywords:- Concrete, Compressive Strength, Superplasticizer, Water Cement ratio and Workability etc.

I. INTRODUCTION

It has long been a concrete technologist’s dream to discover method of making concrete at the lowest possible water/cement ratio while maintaining a high workability. In very recent decades, superplasticizers creates milestone in the advancement of chemical admixtures for Portland cement concrete. To a considerable extent this dream has been fulfilled with the advent of superplasticizers. Have indeed added a new dimension to the application of admixtures with regards to production of high strength and flowing concrete. It is now possible to produce concrete with compressive strength of the order of 90 MPa. In addition, these are also suitable for use with other cementations materials like fly ash and blast furnace slag. The capability of superplasticizers to reduce water requirements 15-25% without affecting the workability of concrete. Their addition to concrete or mortar allows the reduction of the water to cement ratio, not affecting the workability of the mixture. The dramatic effect of superplasticizer (SP) on properties of fresh and hardened concrete has studied and the properties of concrete inspected are compressive strength and slump test. Superplasticizers are used to produce normal workability at a lower w/c ratio. HRWRs therefore used to increase the strength and reduce permeability of concrete by reducing the water content in the mixture; or greatly increase the slump to produce “flowing concrete” without adding water. These admixtures are essential for high strength and high performance concrete mixtures that contain higher content of cementitious materials and mixtures containing silica fume. At a given water /cement ratio and water content in the mix, the dispersing action of superplasticizer increases the workability of concrete, typically by raising the slump from 75mm to 200 mm. HRWR admixtures are very efficient at dispersing fine grained particles like cement, fly ash, ground granulated blast-furnace slag and silica fume. HRWRs admixtures may have adequate resistance to freezing and thawing. The normal dosage of a superplasticizer is between 750 ml and 2500 ml per 100 kg of cementitious material. In water reduced SP concrete no undue segregation and bleeding of concrete occurs due to decrease in water cement ratio.

II. OBJECTIVES OF STUDY

The main objectives of this study are to explain (I) Definitions of admixture (II) Classification and uses of admixtures (III) Different dosages (IV) and its effects of properties of fresh and hardened concrete.

III. EXPERIMENTAL PROCEDURE AND APPROACH

This experimental study was based on normal strength concrete with characteristic strength of 20, 30 and 40 N/mm2 at 7 and 28 days. As a binder material Portland Slag Cement (PSC) was used and granite coarse aggregate of 20 mm sieve size well as sand also used. Sikament®170(SWP) used as superplasticizer because it is a high range water reducing admixture as well as non-hazardous and non toxic under relevant safety and health issue. Sikament®170(SWP) is a highly effective super plasticizer with a set retarding effect for producing free flowing concrete in hot climates. It is also a substantial water reducing agent for promoting high early and ultimate strengths. It complies with IS: 9103-1999 & IS: 2645, ASTM C 494/C494M, Type F and BS: 5075, Part 3.Sikament®170(SWP) is basically Modified Naphthalene/Melamine Formaldehyde Sulphonate dispersion and having Brown Liquid appearance. It can be added separately to the freshly mixed concrete or directly to the mixing water prior to its addition to the aggregates. Sikament®170(SWP) is compatible with all types of Portland Cement, including SRC (Sulphate Resisting Cement).Without any admixture mixes was prepared for M-20, M-30 and M-40 grade of concrete for comparing. For investigating the effects of superplasticizer on concrete properties, additional mixes was prepared for M-20, M-30 and M-40 using admixture dosage of 0.2, 0.4 and 0.6% by weight of cement. To assess the workability of the concrete mixes slump test were conducted. To determine the compressive strength concrete cube used which was cured for 7 and 28 days. As per BS 1881: Part 111: 1983 code, for hardened concrete test water curing temperature was 27 ± 2ºC for all samples. Overall 72 specimens (concrete cube) with the dimension of 150 mm x 150 mm x 150 mm were fabricated at laboratory.

IV. MATERIALS USED AND MIX PROPORTIONS

Portland Slag Cement (PSC) 43 grade confirmed to Indian Standards (IS: 8112-1989) was used in the experimental programme. Locally available 20 mm downgraded crushed stone of specific gravity 2.70 and fineness modulus of 6.79 was used as coarse aggregate. Locally available river sand of specific gravity 2.65 and fineness modulus of 2.99 was used as fine aggregate. Both coarse aggregate and fine aggregate confirmed to Indian Standard Specifications IS: 383-1970. In this experimental programme Sikament®170(SWP) of basically modified naphthalene/melamine formaldehyde sulphonate dispersion and having brown liquid confirming to IS: 9103-1999 & IS: 2645, ASTM C 494/C494M, Type F has been used as superplasticizer with density 1.16-1.19 at 30 ^{o} C approx and pH 7-8 was used in the present investigation as SP. The mix composition was selected as per recommendations of IS 10262:2009. The quantities of different ingredients used in the preparation of mix are given in Table 1.

Table 1: Mix proportions used in the trials

Grade of Concrete	Admixture Used	W/C Ratio	Water (Kg/m³)	Cement (Kg/m³)	Fine Aggregate (Kg/m³)	Coarse Aggregate (Kg/m³)
M 20	Nil	0.50	186	372	738	1127
M 20	Superplasticizer	0.46	139.5	300	811	1240
M 30	Nil	0.45	192	427	695	1107
M 30	Superplasticizer	0.45	144	320	780	1242
M 40	Nil	0.40	197	492	652	1084
M 40	Superplasticizer	0.40	148	370	740	1230

V. RESULTS AND DISCUSSION

A. *Superplasticizer Effect on Slump Test*

The results for slump loss of superplasticized concrete summarize in Table 2. SP ratio in percentage and slump in mm were recorded. It showed a relation between dosages of SP and slump loss. And then, the value of slump loss at different specific dosages of SP is then plotted as in two graph as shown in Figure 1 in Y axis the slump (mm) and in X axis ratio of superplasticizer (%).

The (Fig.1) Graphs show slump in mm against of different dosages of Superplasticizers. In Figure (Line Graph) it is clear that with the increase of Superplasticizer the slump (mm) also increases. One specimen of each grade is control specimen here that's why it does not fabricate with any SP. But other three specimens are SP Sikament®170(SWP) using admixture dosages of 0.2, 0.4 and 0.6 percent consecutively by weight of cement. At maximum dosage the slump value in mm also maximum and it shows higher value at 0.6% of each grade of specimens. However, the action of Superplasticizer will help to fluidity the mix for a longer time and it finally results reducing the slump loss during the transportation of concrete to the site. It is visible that, over dosage of these sorts of admixtures will result high slump losses. So, it will not give true slump that as what we expect and desire.

B. Effect of Superplasticizer on Compressive Strength

Compressive strength of concrete with different dosages of superplasticizers shown in Table 3.This test performed on 7 and 28 days. The values and fluctuation of compressive strength at different specific dosages of superplasticizer are then shown in a graph in Figure 2 & 3.

After conducting the experiment, a graph of compressive strength versus dosages of superplasticizer is shown at Figure 2 & 3. From the graph, it is clear that the strength gains continuously for addition of chemical admixture and the compressive strength is increasing with the increment of superplasticizer dosages. Continuous addition of superplasticizer agent may not be able to increase the compressive strength of concrete continuously rather high dosages reduces the strength significantly.

From the observation of the efficiency of compressive strength it is seen that, compressive strength of concrete specimen is increased with different dosages of superplasticizers for particular grade of concrete.

Table 2: Test Results showing Slump Loss for Superplasticized Concrete

Grade of Concrete	W/C Ratio	Admixture dosages in % by weight of cement	Slump (mm)
M 20	0.50	0.0	25
M 20	0.46	0.2	40
		0.4	55
		0.6	65
M 30	0.45	0.0	40
M 30	0.45	0.2	55
		0.4	65
		0.6	72
M 40	0.40	0.0	60
M 40	0.40	0.2	65
		0.4	70
		0.6	80

Table 3: Test Results showing Compressive Strength for Superplasticized Concrete

Grade of Concrete	W/C Ratio	Admixture dosages in % by weight of cement	Compressive Strength (N/mm²) (Average of 3 Cube)	
			7 Days	28 Days
M 20	0.50	0.0	18.16	27.53
M 20	0.46	0.2	21.16	28.00
		0.4	21.83	29.50
		0.6	22.33	30.33
M 30	0.45	0.0	22.50	37.83
M 30	0.45	0.2	23.70	38.40
		0.4	24.66	38.70
		0.6	25.83	39.46
M 40	0.40	0.0	30.16	41.13
M 40	0.40	0.2	31.56	42.10
		0.4	32.16	43.03
		0.6	32.50	43.86

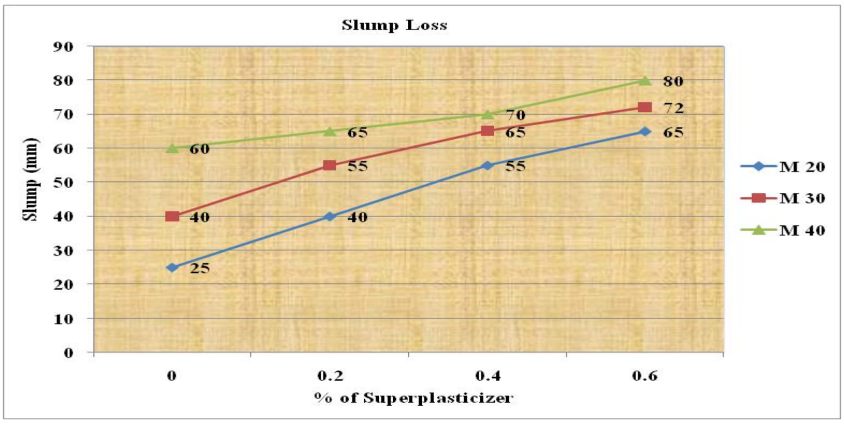

Fig.1: Effect of Superplasticizer Dosages on Slump loss

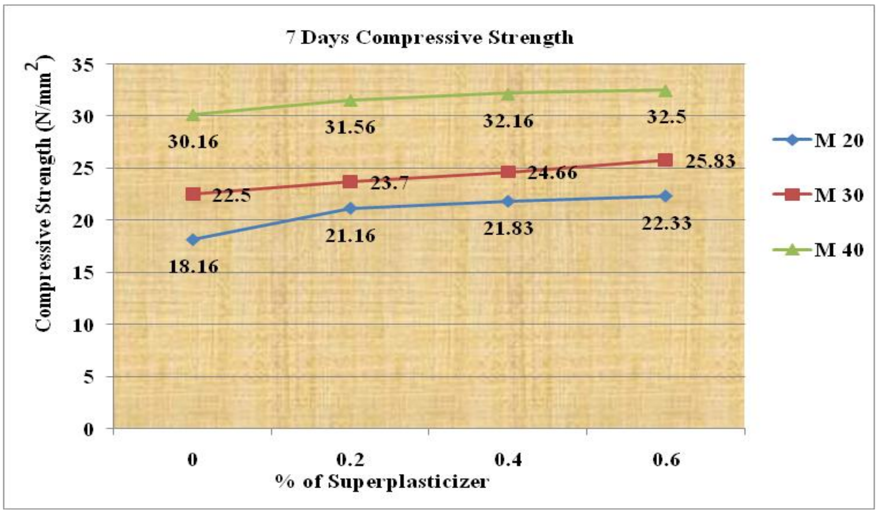

Fig. 2: 7 Days Compressive Strength of Concrete with Different Dosages of Superplasticizer

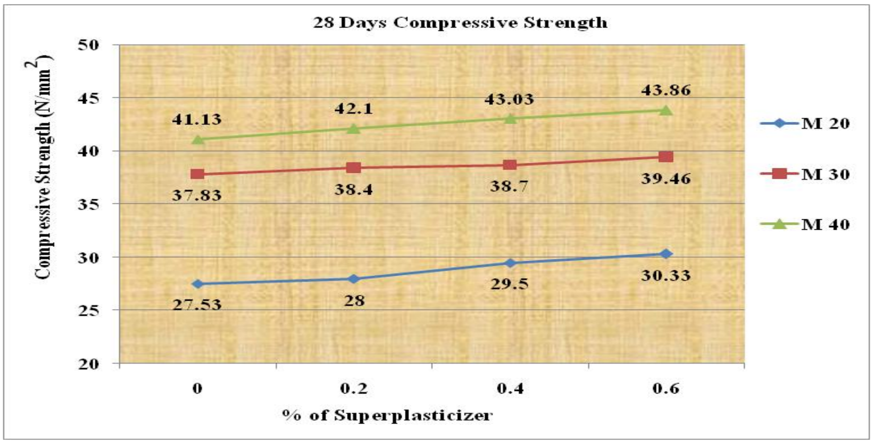

Fig. 3: 28 Days Compressive Strength of Concrete with Different Dosages of Superplasticizer

VI. CONCLUSIONS

This paper covers the various effects of superplasticizer on properties of concrete (workability & compressive strength) with characteristic strength of 20, 30 and 40 N/mm² are studies. From the results presented in this paper, using concrete containing different dosages of a kind of superplasticizer based on modified napthalene/melamine formaldehyde sulphonate the main conclusions are:

1. From the results of the study, it is decided that by addition of superplasticizer the workability of concrete can be enhanced.
2. At a given water/cement ratio and water content in the mix, the dispersing action of superplasticizer increases the workability of concrete, typically by raising the slump from 75mm to 150 mm, the mix remaining cohesive.
3. Compressive strength is improved by SP compared with control; On the other hand, even its ultimate strength is higher than the desired characteristic strength.
4. The compressive strengths of SP concrete are usually higher than the corresponding strengths of the reference mixes.
5. Superplasticizers are able to enhance the placing characteristics of concrete mixtures by increasing the workability level at a given *w/c*. Therefore they allow to make easy placement of concrete mixtures even with low *w/c* as required by strength or durability reasons.
6. There are two possible ways in which superplasticized concrete can be produced high workability concrete, Concrete with low water/ cement ratio, Concrete with reduced cement content.

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