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The Effect of Superplasticizers on Properties of Concrete

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ABSTRACT-An admixture, according to the ASTM C-125-97 standards, is a material other than water, aggregates or hydraulic cement that is used as an ingredient of concrete or mortar, and is added to the batch immediately before or during mixing to enhance the workability. Superplasticizer (SP) is important to enhance the durability as well. Generally, there are four main categories of Superplasticizers- Sulfonated melamine formaldehyde condensates, Sulfonated naphthalene formal dehyde condensates, Modified lignosulfonates and Sulfonic- acid esters and carbohydrate esters. In this study, three different chemically composed superplasticizers were used for a single grade of M 30 concrete to improve the properties of fresh and hardened concrete in severe weather as workability, compressive strength by adopting superplasticizers at desired dosage, compaction factor, and water absorption. Split Tensile Strength, Cube Compressive Strength Test, Flexural Strength test and Slump Cone test were some of the tests carried on fresh and hardened concrete. The three admixtures had quite distinct and different effects, but they all induced a compaction factor of more than 0.84 and the workability increased for all three admixtures when used at a constant water-cement ratio.

KEYWORDS- Acid esters, compaction factor, modified lignosulfonates, naphthalene formaldehyde, Cubes

I. INTRODUCTION

Concrete is an important versatile construction material, used in wide variety of situations. So it is very important to consider its durability as it has indirect effect on economy, serviceability and maintenance[1]. Concrete is not fully resistant to acids. Most acid solutions degrade Portland cement concrete slowly or quickly, depending upon the type and concentration of acid [2]. As the attack proceeds, all the cement compounds are evenly broken down and leached away together with any carbonate aggregate material[3]. If acids or salt solutions are able to reach the reinforcing steel through cracks or porosity of concrete, corrosion can occur which will cause cracking[4]. Therefore, it is necessary to limit the permeability of the concrete to reduce the penetration of sulphate in solution[5]. The deteriorating effect usually starts at the surface and corners and progressively enters into the concrete[6]. This effect is considerably reduced by adding of admixtures to concrete mix [7]. In the current thesis, Superplasticizers were used in concrete like many other admixtures to perform a particular function, as high range water reducers (HRWR) to distinguish them from other categories of less effective water reducers. Consequently they are frequently described according to their chemical functional properties. In reality, the superplasticizers function similarly to the various admixtures used for concrete but superplasticizers has the ability to reduce water effect to a greater magnitude than the conventional admixtures that were used before. For many years, it was not possible to reduce water/cement ratio of concrete below 0.40 till the advent of super plasticizers [8]. These superplasticizers are rather apparently being changed or modified continuously as research being on admixtures suggests improvements at every stage of its use with modern technology[9]. Thus new additional requirements are being categorized for recognition of the ways of using these superplasticizers, namely to produce water reduced high strength concrete[10].

II. LITERATURE REVIEW

- Franklin (1976)- stated that, superplasticizers are organic polyelectrolytes, which belong to the category of polymeric dispersants. The performance of super plasticizers in cementitious system is known to depend on cement fineness, cement composition mode of introduction to the mixture etc., as well as on the chemical composition of super plasticizers [11].
- Ozkul and Dogan (1999) - demonstrated that the super plasticized concrete could be pumped easily from a height of about 13 m and the filling capacity was greater than 85%. The pumping pressure was the same as for normal pump able concrete and no segregation was observed. For mixtures with water-cement ratios between 0.3 and 0.45, the slump diameters were between 500 mm and 740 mm [12].
- Roncero (1999) - evaluated the influence of two super plasticizers (a conventional melamine based product and a new-generation comb-type polymer) on the shrinkage of concrete exposed to wet and dry conditions. In general, it was observed that the incorporation of super plasticizers increased the drying shrinkage of concretes when compared to conventional concretes, whereas it did not have any significant influence on the swelling and autogenous shrinkage under wet conditions [13].
- Ronneberg and Sandvik, (1990) – stated that, by increasing the dosage of super plasticizers little by little over the range specified by the manufacturers, super plasticizers can be used as high range water reducers[14].

III. EXPERIMENTAL PROGRAM AND DATA

The experiment determined the effects of three available superplasticizers on the fresh and hardened properties of concrete[15-17].

A. Admixtures Used and their Chemical Composition

- Fosroc Auromix 400-Poly-carboxylated Ether Based.
- BASFf Master Polyheed-8126-Sodium Ligno Sulphate.
- Build-Plast Super HR-Sulfonated Naphthalene-formaldehyde condensate.

B. Stage 1-Trial Mix

- Determine the mean target strength (ft) from the specified characteristic compressive strength at 28-day fck and the level of quality control. (ft = fck + 1.65 S)
- Determine the concrete mix proportions for the first trial mix.
- Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size and test them wet after 28-days moist curing and check for the strength [18].
- Prepare trial mixes with suitable adjustments till the final mix proportions are arrived and mean target strength is achieved [19].

C. Test Data of materials

Grade designation - M30, Type of cement - OPC 43 grade, Maximum nominal size of aggregate - 20mm, Fine aggregate - Zone 1, Minimum cement content - 320 kg, Maximum cement content - 450 kg, Maximum w-c ratio - 0.45, Exposure condition – Severe. Cement used - OPC 43 Grade, Specific gravity - (Cement - 3.15, Coarse aggregate - 2.7, Fine aggregate - 2.65), Water absorption - (Coarse aggregate - 1.1% , Fine aggregate - 1%), Surface moisture - (Coarse aggregate - 1.09%, Fine aggregate - 1%), Maximum nominal size of aggregate - 20 mm, Fine aggregate - Zone I [20].The mean 28 day compressive strength of Trail Mix 4 came out to be 39.76 N/mm2 > 38.25 N/mm2 when adopted at water-cement ratio of 0.38.

D. Stage 2-Mix Design

Prepare design mixes of M: 30 grade at (w/c = 0.38) for 0.05 m3 concrete with suitable adjustments till the final mix proportions are arrived and calculate final values of test results on adding different chemically composed superplasticizers. Then calculate different strength properties of concrete. Table 1 shows the mix design results

Table 1: Mix design with and without Admixtures

Mix	W/C-Mix ratio	Water litres	Cement (kg)	Fine Aggregate (kg/m3)	Coarse Aggregate (kg/m3)
A	1 : 1.82 : 2.27	8.55	22.5	41	51
B	1 : 2.67 : 3.32	6.46	17	45.5	56.5
C	1 : 2.47 : 3.07	6.84	18	44.5	55.42
D	1 : 2.47 : 3.07	6.84	18	44.5	55.42

IV. RESULTS

A. Preliminary Results and Observation

- Cement

The results of testing cement for OPC 43 grade (TCI max) Specific gravity- 3.15, Fineness test of cement - Wt. Of sample-500 g, Mass retained on 90μ IS sieve-20 g, % of cement retained on 90μ sieve - 20/500 × 100 = 4% < 10%) Initial and final setting time – Initial setting time of cement - 155 minutes, Final setting time of cement - 235 minutes.

- Aggregate

Sieve analysis was done according to (IS: 383 1970), results for both fine and coarse aggregate and they are all conform with the requirements.

- Admixtures

The admixtures used for this study were high performance superplasticising admixtures which were used carefully after determining their effects on concrete mixes from the relative studies. The quantities of w/c ratio were kept constant while the quantity of water was adjusted. The doses of the admixture were determined according to the manufacturer guidance.

- Workability

The observed workability of mixes containing admixture (to increase workability) was- Higher than that of the ordinary mix satisfying the objective of the research to increase workability. As a result the concrete workability has been increased without further addition of water to the mix keeping same strength. The amount of mixing water can be reduced when using admixture with concrete mixes designed for a given workability to improve specific properties in Table 2.

Table 2: Workability

Mix Type	Plain Concrete	Auromix 400	BASF	Builtplast Super
Slump	55	60	75	70
Compaction factor	0.84	0.87	0.89	0.88

B. Strength Parameters

- Compressive Strength

Compressive strength results for the mixes were obtained from the average of three cubes under the normal laboratory temperature and same curing conditions for 7, and 28 days. The higher rate of increased strength was in BASF Master Polyheed-8126 and is also higher in Auromix-400 and buildplast super HR but slightly less than BASF based superplasticizer because of the difference doses of the admixture. Compressive strength of various mixes shown in Table 3

- Split tensile and flexural strength

Flexural strength tests are indirect tests to determine the tensile strength of concrete; tests were carried out on (150 x 150 x 700mm). Table 4 shows the Split & Flexural strength of various mixes.

Table 3: Compressive Strength

Mix type	Plain Concrete	Auromix 400	BASF	Builtplast Super
Strength	26.52	27.85	31.70	30.22
	39.04	42.00	44.15	42.07

Table 4: Split tensile and flexural Strength

Mix type	**Plain Concrete**	**Auromix 400**	**BASF**	**Builtplast Super**
FS	5.38	5.92	6.26	5.96
STS	2.69	2.91	3.41	3.15

V. CONCLUSIONS

For the three concrete mixes where admixture was added, we can see that the cement was reduced to some extent as the mix ratio was considerably increased, which in turn helped in saving the cost. Compaction factor of concrete with different admixtures was found to be higher than that of the plain concrete. Thus use of admixtures imparts better workability to concretes. Water absorption of concrete with different admixtures was lower than that of plain concrete. Thus the durability of concrete with admixture is expected to be better than that of plain concrete. Flexural strength and Split tensile Strength of concrete with different admixtures was more than that of the plain concrete. However, tensile strength parameter is seldom considered in RCC designs.

VI. FUTURE SCOPE

For Studying the effect of admixtures on the durability of concrete is still a field of research. In future, the work can be done on higher grades of concrete like M-35, M-40. Tests like Permeability and Further studies has to be carried here in the northern most parts of the country to determine how concrete companies accept using concrete admixtures as a material to improve many properties of concrete especially those concerned with the severe weather conditions of J&K. Further researches using admixtures should be conducted on concrete mixes of high and low workability need to be studied.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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