A Study on Flow and Strength Characteristics of Superplasticized Concrete

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Abstract - *In modern days, due to optimum and rapid construction there is a high demand for the use of chemical admixtures. Among these admixtures, nowadays, superplasticizer has a great market as workability is one of the major issues of a freshly prepared concrete, which can be enhanced by superplasticizer. These superplasticizers, on one hand, they enhance the workability to sufficient extent by lowering the flow and shear resistance and on the other hand, lower the water-cement ratio. Even in the case of self-consolidating concrete, superplasticizer greatly enhances the workability of fresh and hardened concrete. The dramatic effect of superplasticizer on properties of concrete in fresh and hardened state was studied and the properties of concrete inspected are workability and strength. The effect of superplasticized concrete was experimented, together with one control mix. An experimental investigation was conducted to determine the dosage of superplasticizer. In this study, concrete designed for strength of 53 Mpa at 28 days with ordinary portland cement (OPC) was evaluated for its early age properties. The study is based on the effect of two different types of superplasticizer namely: Sulphonated Naphthalene Formaldehyde (SNF) and Poly Carboxylate Ether (PCE) and comparing with that of control mix. The results of the study reveal the complex nature of interactions between cement and superplasticizers in concrete.*

Key Words: Admixtures, superplasticizer, dosage, workability, strength

1. INTRODUCTION

Concrete is used as a construction material, from sidewalks to bridges to skyscrapers, as well as concrete pavement. It is a material composed of coarse and fine aggregates, portland cement and water. The ratio of water to cementitious materials used in the mixture influences many important characteristics of concrete. By the reduction of amount of water, the cement paste will have higher density, which results in higher paste quality.

An increase in paste quality, will yield higher compressive and flexural strength, lower permeability, increase weather resistance, and reduce tendency to shrinkage cracking . An admixture is a material, added to the concrete to modify properties of fresh and hardened concrete. Chemical admixtures include three basic categories like water-reducing agents, air-entraining agents, and setting agents. Moreover, the use of an optimum dosage of the admixture is also essential since low dosages may result in loss of fluidity, and over dosage could lead to segregation, set retardation and uneconomical use of the superplasticizer.

Superplasticizers are water reducing chemical admixtures, which are added to reduce the water content in a mixture or to slow the setting rate of the concrete while retaining the flowing properties of a concrete mixture. They are used to modify the properties of concrete or mortar to make them more suitable to work by hand or for other purposes such as saving mechanical energy. This paper is an effort to study workability, concrete compressive strength, splitting tensile strength and flexural strength in the presence of chemical admixture SNF and PCE.

2. PROPERTIES OF CONCRETE

Cement: OPC is the most common cement used in general concrete construction manufactured by grinding a mixture of limestone and other raw materials. This type of cement is preferred where fast pace of construction is done. OPC is available in 3 grades namely grade 33, grade 43 and grade 53. OPC-53 grade is used for this investigation. The properties of the cement are as shown in Table- 1.

Table 1: Properties of Cement

Properties	Test results
Specific gravity	3.15
Initial Setting Time	30(Min)
Final Setting Time	600 (Max)

Fine aggregates: Manufactured sand has been used as fine aggregate. The specific gravity and water absorption was found to be 2.60 and 1.42 respectively. The particle size distribution was determined by sieve analysis and they belong to zone II. The grain size distribution curve for fine aggregate is given in fig. 1.

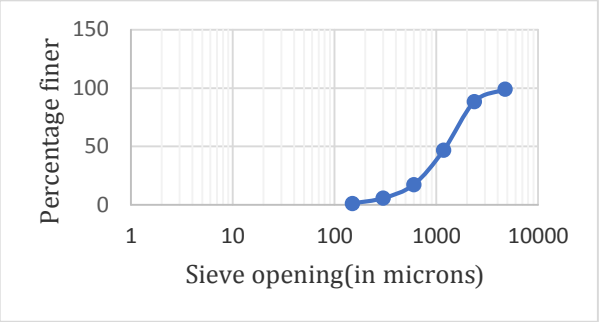

Figure 1. Grain size distribution of Fine aggregate

Coarse aggregates: Locally available crushed granites aggregate of 20mm and 12mm downsize conforming to IS 383 was used. The specific gravity and water absorption for 20mm size was found to be 2.75 and 0.24% respectively, and for the case of 12mm size it was found to be 2.74 and 0.57% respectively. The results of sieve analysis of coarse aggregate are shown in Table 1 and Table 2.

Table 1: The result of sieve analysis for 12mm C.A.

Sieve size (mm)	Weight retained (g)	Percentage weight retained	Cumulative percentage weight retained	Percentage passing
16	23	2.3	2.3	97.7
12.5	420	42	44.3	55.7
10	359.5	35.95	80.25	19.75
6.3	182	18.2	98.45	1.55

The grain size distribution curve for 12mm is given in fig. 2.

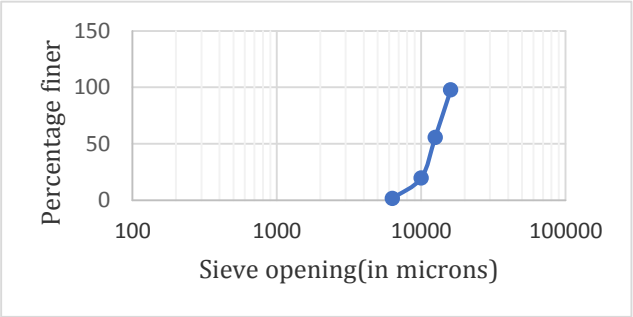

Figure 2. Grain size distribution of 12mm coarse aggregate

Table 2: The result of sieve analysis for 20mm C.A.

Sieve size (mm)	Weight retained (g)	Percentage weight retained	Cumulative percentage weight retained	Percentage passing
25	49.5	4.95	4.95	95.05
20	565.5	56.55	61.5	88.5
16	324	32.4	93.9	6.1
12.5	50	5	98.9	1.1

The grain size distribution curve for 20mm is given in fig. 3.

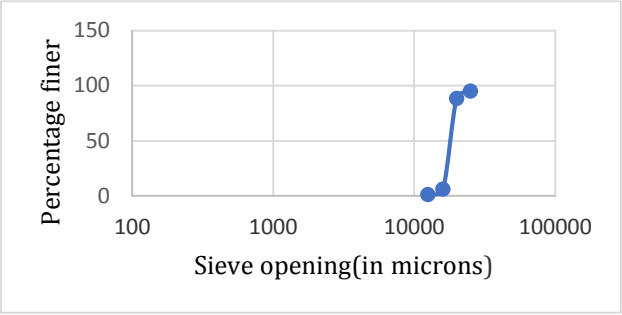

Figure 3. Grain size distribution of 20mm coarse aggregate

Water: Water is a key ingredient of concrete which when mixed with cement, forms a paste that binds the aggregate together. Potable water was used for mixing and curing, and is satisfactory to use. The amount of water in concrete controls many fresh and hardened properties in concrete.

Superplasticizers: Superplasticizers are chemical admixtures, known as high range water reducers which are added to the batch during mixing. These polymers helps to avoid particle segregation as for gravel, coarse and fine sands, hence used as dispersants and enables the production of self-consolidating concrete and high performance concrete. For present investigation, two types of superplasticizers are used namely;

• SNF (Sulphonated Napthalene Formaldehyde) - It is a polymer produced by condensed polymerisation of naphthalene, sulphonic acid and formaldehyde. It is used in the construction industry for manufacturing concrete mix. Also used in dyes, leather and agro industries as a dispersing agent.

• PCE (Polycarboxylate ether superplasticizer) – It shows extremely high water-reduction in concrete with improved workability and increase in strength. They allow a water reduction up to 40% with a relatively low dosage.

Mix Proportions and Samples Preparation

Mix design was done as per IS 10262: 2009, IS 456: 2000 and IS 383:1997. Target mean strength for M35 grade concrete is 43.25 N/mm^2.Water cement ratio was taken as 0.40. Table 3 represents the quantities of mix proportion for one cubic meter of concrete.

Table 3: Mix proportion for M35

Material	**Calculated quantity**
Cement	420 kg
Coarse aggregate: 20 mm (55%)	546 kg
Coarse aggregate: 12 mm (45%)	447 kg
Fine aggregate	870 kg
Water	168 kg

4. METHODOLOGY

- Preliminary study of various materials to be used in concrete by various tests such as specific gravity, water absorption, grading of aggregates are done.
- Mix was designed for M35 grade concrete using the properties of aggregates obtained earlier and the quantities for 1 m^3 of concrete was calculated for each nominal mix and ready-mix concrete.
- The dosages for both the superplasticizers were investigated using slump cone test in the laboratory. The test was conducted several times with different

percentage addition of superplasticizer to the concrete mix such that slump falls between 90 to 100mm.

- Several concrete cubes, cylinders, beam were casted with nominal mix and superplasticized concrete mix.
- After curing for 24 hours, specimens were tested for compressive strength, split tensile strength and flexural strength in the testing machines.
- Effect of superplasticizer on strength of concrete was studied and compared with that of a nominal mix.

3. TESTING PROCEDURE

3.1 Slump test

Concrete slump test determines the consistency of concrete mix before setting which is prepared at the laboratory. It is carried out to check the workability of freshly made concrete, and therefore the ease with which concrete flows. The test is carried out using a conical frustum shaped metal mould, known as a slump cone or Abrams cone. This cone is filled with prepared concrete mix in three stages. Each layer is tamped 25 times with a tamping rod. At the end of the third stage, the excess concrete at the top of the mould is removed. The mould is slowly raised vertically upwards, so that the concrete cone does not get disturbed. The concrete then subsides. The slump is thus determined by measuring the distance from the top of the subsided concrete to the level of the top of the slump cone and is recorded in terms of millimeters.

3.2 Strength test

Specimens of concrete with cubes, cylinders and beam have been casted for checking compressive strength, split tensile strength and flexural strength respectively. Standard cast iron moulds of size 150x150x150 mm,300mm long x 10mm diameter and 100x100x150mm are used in preparation of cube, cylinders and beam respectively.

The moulds have been cleaned to remove dust particles and properly applied with mineral oil on all its sides. The superplasticizer is mixed with the constituents of concrete at the time of adding water and thoroughly mixed for a period of at least two minutes. This fully blended mix is then filled into the mould and compaction is done with a tamping rod (25 times) for each three layers. After proper compaction, the excess concrete is removed with trowel and the top surface is smoothened. After casting, the specimens are stored in the laboratory at room temperature. After 24 hours from the time of addition of water to the ingredients, the specimens are removed from the moulds, submerged in the clean and fresh water tank immediately. The samples of both superplasticised concrete and control mix were taken after 28 days of curing. The excess water is wiped out from surface of hardened concrete and tested for compressive strength, split tensile strength and flexural strength.

5. RESULTS AND DISCUSSIONS

5.1 Superplasticizer Effect on Fresh concrete

Superplasticiser ratio in percentage and slump in mm were noted. It showed a relation between dosages of superplasticiser and slump loss. The results for quantity of superplasticizer that should be added to the concrete is shown in Table 4.

Table 4: Dosage of superplasticizer to concrete

Superplasticiser	Dosage (%)	Slump values (mm)
SNF	1.9	90
PCE	0.8	95

5.1 Superplasticizer Effect on Strength on Hardened concrete

Strength of concrete by using two different types of superplasticizers are shown in Table 5. The compressive strength obtained after 7 days and 28 days, also split tensile strength and flexural strength after 28 days of curing were recorded.

Table 5: Strength characteristics of concrete(Mpa)

Type of Mix	Compressive strength		Split tensile strength (28 days)	Flexural strength (28 days)
	7 days	28 days		
SNF	25.75	39.53	4.32	6.73
PCE	32	45.30	4.47	8.72
Control mix	24	36	4.15	6.67

It was observed that the maximum strength was obtained for PCE (Polycarboxylate ether) based superplasticized concrete.

6. CONCLUSIONS

From the study performed on the flow and strength characteristics of super plasticized concrete the following conclusions can be made:

1. An increase in superplasticizer dosage leads to an increase in slump value, due to decrease in plastic viscosity.
2. With the use of superplasticizers the workability and strength of concrete are found to be higher when compared with that of the control specimen which fabricated without any SP.

3. Addition of PCE to concrete results in greater compressive strength, split tensile strength and flexural strength.

4. The compressive strength of concrete increases with period of curing.

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