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Experimental Studies on Properties Of Self-Compacting Concrete

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Abstract— the present study aims to investigate the fresh and mechanical properties of Self Compacting Concrete (SCC), with fly ash as a partial replacement of cement. For this purpose fly ash from, "Panipat Thermal Power Station, Panipat" was used. In this study, twenty four mixes were investigated. A Sulphonated Naphthalene-Formaldehyde (SNF) based super plasticiser was used to increase the workability of normal slump concrete. The super plasticiser dosage was kept constant for all the SCC mixes. To make the SCC mix economical, cement was replaced by fly ash in SCC varying percentage ranging from 20% to 40%. The proportions of coarse as well as fine aggregate were kept constant for all mixes. Slump Flow Test, V-Funnel (T_{10sec} and T_{5min}) test, J-Ring test, L-Box test and U-Box test were carried to obtain the fresh properties of SCC mixes i.e. filling ability, passing ability and segregation resistance. The mechanical properties of hardened concrete were also investigated in terms of compressive strength. The test result shows that the compressive strength of SCC mixes is decreased initially by increasing the fly ash content and increased later on. First ten mixes has not satisfied the specific requirements of fresh properties as per the EFNARC standard of SCC mix. Thus, trials were carried out for SCC mix design till the specific requirements for SCC mixes as per EFNARC standard were achieved.

Keywords— Cement, Fly Ash, Super plasticizer, Fine Aggregate, Coarse Aggregate, Water

I. INTRODUCTION

Self-Compacting Concrete (SCC) is a highly flow able and non-segregating concrete and that does not require vibration when cast, yet it is capable of flowing through narrow openings or extremely congested reinforcement. SCC is also known as Self-Consolidating Concrete, Self-Levelling Concrete, and High-Fluidity Concrete. Development of Self- Compacting Concrete is a desirable achievement in the construction industry in order to overcome problems associated with cast-in-place concrete. With regard to its composition, Self-Compacting Concrete consist of the same components as conventionally vibrated concrete, i.e. cement, aggregates and water, with the addition of chemical and mineral admixtures in different proportions. Usually, the chemical admixtures used are Super plasticizer and viscosity-modifying agents, which change the rheological properties of concrete. Mineral admixtures are used as an extra fine material, and in some cases, they replace cement. The objectives of the research were:

To study the fresh properties of SCC mixes.

To investigate the effect of replacement of cement with fly ash in varying percentages (20%-40%), on compressive strength at moist curing of 7,28,56 & 90 days.

To examine the effect of water-powder ratio on properties of SCC mixes.

To study the hard properties of SCC mixes.

II. LITERATURE REVIEW

Jagadish Vengala et al. [11] (In 2004) studied about the mix proportioning procedures for the self Compacting Concrete. The study reviews the principles and method of mixture proportioning of SCC as developed by investigator. This study describe the japans method, European practice and Specification11,Nan-su,et al.15 method and Jagdish Venegala et al. method in detailed for mix proportioning of SCC. This study conclude as, SCC mixes, which are arrived at by any one of the above methods, are likely to have high paste content. For concrete with a maximum size of 16 to 20 mm the paste content (cement + filler + water) is likely to range from 38 to 45 percent by volume. The (absolute) volume of coarse aggregate and fine aggregate are likely to be equal or that of fine aggregate may be more. Viscosity modifying agent are needed in all SCC mixes so that no bleeding or segregation occurs when there are variation in the moisture content of the aggregates a phenomenon that is usually encountered at construction sites. Though the V-funnel, L-box, U-box and slump flow tests are yet to be incorporated into national standard they have become now universally accepted by researchers and practitioners alike.

Chao-Lung Hwang et al. (In 2005) had studied about durability design and performance of self-consolidating lightweight concrete. In terms of the durability, the reduction in cement paste is crucial to both volume stability and long-term reduction of concrete. The comparison of the performance of lightweight concrete under different w/cm ratio and different cement paste content was made. The slump and slump flow spread of fresh self-consolidating light weight concrete (SCLWC) are designed to within 230-270 and556-650 mm, respectively.

The test results indicate that the 91-day compressive strength of SCLWC is up to 56Mpa when cement content is 386 kg/m and water content is 150kg/m. if enough cement paste is used, then the less the paste amount and the denser the packing of aggregate, the higher the strength efficiency of cement and the electric resistance, and lower the chloride ion penetrability capacity of SCLWC. Through physical packing of aggregate, the reduction in water content and cement content will result in lower permeability and higher electrical resistance of LWC.

III.MATERIAL USED

A. Cement

In the present study, Ordinary Portland Cement 43 grade with brand name ' **Ultra-Tech. cement'** confirming to **IS: 8112-1989** was used.

TABLE-1: Test Results of Cement Sample

SR. NO.	Characters	Experimental value	Limit as per IS:8112-1989
1	Consistency of Cement	26.5	-
2	Specific Gravity	3.24	3.15 g/cc
3	Initial Setting Time	83 min	>30 min.
4	Final Setting Time	313 min	<600 min.
5	Fineness of Cement	5%	10%
6	Soundness of Cement	10mm	<10mm
7	Compressive Strength		
I.	3 days	23.54 MPa	≥23 MPa
II.	7 days	33.57 MPa	≥33 MPa
III.	28 days	43.60 MPa	≥43 Mpa

B. Fly Ash

The quality of fly ash is obtained from the Electro-Static Precipitators in the plant.

TABLE-2
Properties of Fly Ash

Sr no.	Physical Properties	Test Results
1	Colour	Grey(Blackish)
2	Specific Gravity	2.13
3	Lime Reactivity-average Compressive Strength after 28 days of mixture 'A'.	4.90 MPa

C. Super plasticizer

Super plasticizer of the make **"SIKA VISCOCRETE-10(H1)"** is used as chemical admixture for the concrete.

TABLE-3
Specifications of the Super plasticizer

Basis	Aqueous Solution of Modified Polycarboxylate
Appearance	Brown Liquid
Density	Approx. 1.10
PH	Approx. 5.0

D. Coarse Aggregate

Crushed granite with a maximum nominal size of 16mm as the coarse aggregate is used. Fineness Modulus= 686.1/100=6.86.

E. Fine Aggregate

Locally available Natural River (Yamuna) sand is used as the fine aggregate. Fineness Modulus of fine aggregate= 232.2/100=2.322.

F. ACI Method Of SCC Mix Design

In this method, concrete is first designed by the ACI method of mix design(which usually gives a larger amount of fines when compared with the IS method of mix design).Initially a mix was made with a w/c ratio of 0.5 to get a desired slump flow of around 160 mm to 180 mm. To proceed towards SSC, Coarse aggregates are then replaced with a fine powder (fly ash), by weight starting from a value of 15%, 10%, 15%, etc, until a slump flow of (500 mm– 700 mm) is achieved by Slump Flow Test. Each trial should satisfy flow test, passing ability test and filling ability test.

G. Mixing

The mixing of concrete was done to have a homogenous mixture of all ingredients in concrete. The hand mixing was done for the ingredients. Batching of concrete was done by weight and the process followed was given below:

First, the coarse aggregate was weighted and putted in mixing pan.

Fine aggregate was added to the coarse aggregate, so that it fills the voids.

Fly ash and cement were added to the aggregates. This mixture was thoroughly dry mixed such that the colour of the mixture was uniform and no concentration of any material was visible.

Then required quantity of super plasticizer was added to required quantity of water. To make a solution was added and mixed thoroughly until uniform colour was obtained.

The addition of fly ash to the mix required more time of mixing. After the mix was flowing, the fresh properties were found. The mixing was continued till the completion of all the tests.

H. *Test Methods*

Self- Compacting Concrete is mainly characterized for three fresh properties i.e. filling ability, passing ability and segregation resistance.

1) Filling Ability: The ability of SCC to flow into and fill completely all spaces with the formwork under its own weight. To determine filling ability, the following tests are conducted.

Slump Flow

T_{50cm} Slump Flow

V-Funnel

Orimet.

2) Passing Ability: The ability of SCC is to flow through tight opening such spaces between steel reinforcing bars without segregation and blocking. To determine passing ability the following test are conducted.

L- Box

U- Box

Fill Box

J-Ring

In present study Slump Flow Test,T_{50cm} Slump Flow, V-Funnel, L-Box, U-Box and V-Funnel at $T_{5min.}$ Tests were conducted for each mix.

IV. RESULTS & DISCUSSIONS

A. Slump Flow Test Results

The consistency and workability of Self-Compacting concrete were evaluated using the slump flow test. The results from table shows that the Self-Compacting Concrete was complying with the requirements found in the literature. Thus, Self-Compacting Concrete was assumed to have a good consistency and workability after gradually adjusting the chemical admixtures in the mix.

TABLE-4
Slump Flow Test Results

Mix No.		SCC1	SCC2	SCC3	SCC4	SCC5
Slump Flow Test	T_{50cm} in sec	3	3.5	2	4.5	5
	Dia. mm	696.7	696.7	713.33	660	670
Powder Content	Litres	213	213	213	213	213
Water	Litres	257	256	254.32	253.10	251.85
	w/p ratio	1.21	1.20	1.194	1.186	1.182

B. V-Funnel Results

T_{10SEC} TEST: In this method, time is measured as mentioned in the test methods. The limit for this test is 6-12 sec. All the results are within the limits. By increasing the water/powder ratio, T_{10sec} time increases i.e. the flow ability time increases. But this time increases are up to certain limit only. Results are good at 1.182 w/p ratio.

C. V-Funnel T_{5min} Test

This method is used to find the segregation resistance of SCC mix.

TABLE-5
V-Funnel Test Results of SCC Mixes

Mix No.		SCC1	SCC2	SCC3	SCC4	SCC5
V-funnel	T10sec in sec	12	11	10	8	8
V-funnel	T5sec in sec	15	12.5	11	9	9
Powder content	Litres	213	213	213	213	213
Water	Litres	257	256	254.32	253.10	251.85
	w/p ratio	1.21	1.20	1.194	1.186	1.182

D. L-Box Test Results

L-Box test results give the passing ability of SCC.

TABLE-6
L-Box Test Results of SCC Mixes

Mix No.		SCC1	SCC2	SCC3	SCC4	SCC5
L-Box	H_1/H_2	0.3	1	1	1	0.67

E. Compressive Strength Results

The results of Compressive strength mixes at 7 days, 28 days, 56 days and 90 days are given in Table. SCC1 to SCC5 mixes were prepared by varying only water content to find the optimum water content. So the compressive strength is varying the same range. Hence, with the slight variation in water content, the compressive strength is not affected significantly. All the mixes have the 7 days, compressive strength in the range of 16-21 Mpa. 28 days strength of the mixes is in the range of 26-31.5 Mpa. These mixes can be used for the medium strength SCC mixes, as these are useful for most of the constructions. These mix proportions can be easily used for the development of medium strength self-compacting concrete.

TABLE-7
Compressive Strength Results of SCC Mixes at the age of 7, 28, 56 and 90 days

Mix No.		SCC1	SCC2	SCC3	SCC4	SCC5
Date of Casting		22/03/15	23/03/15	26/03/15	27/03/15	28/03/15
Cement	Kg/m^3	485.80	485.80	485.80	485.80	485.80
Fly Ash	Kg/m^3	133.89	133.89	133.89	133.89	133.89
Compressive	7 days	17.10	17.10	16.23	16.14	12.16

Strength	16 days	25.23	26.80	27.54	31.43	29.12
	28 days	35.23	43.54	43.55	57.20	41.66
	90days	50.20	52.22	48.40	66.20	49.30

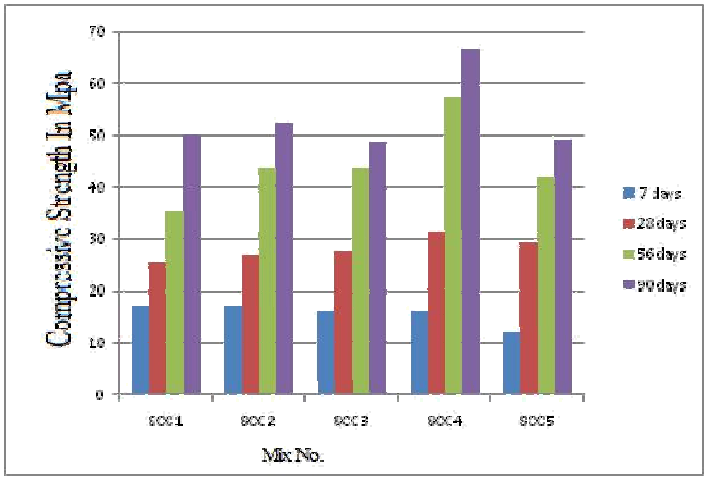

Fig. 1- Compressive Strength Development of the SCC Mixes

V. CONCLUSIONS

The present study is to examine the effect of water/powder ratio on the fresh properties and compressive strength of Self-Compacting Concrete. The cement was replaced with fly ash in varying proportions from 20% to 40%. SCC cubes were tested at the moist curing period of 7, 28, 56 and 90 days for compressive strength. It is observed that compressive strength for most of the mixes increases at higher rate after 28 days.

Compressive strength of the SCC mixes reduces by increasing the percentage of fly ash content.

At 20% to 40% replacement of cement with fly ash, 28 days compressive strength changed from 40.55 Mpa to 32 Mpa.

With the increase in the cement content, compressive strength increases.

At the water/powder ratio of 1.18 to 1.215, Slump Flow Test, V-Funnel Test, L-Box, U-Box Test and J-Ring Test are satisfied, i.e. passing ability, filling ability, and segregation resistance as well within the limits. This range can be used for further studies satisfactorily.

By using the Ordinary Portland cement of 43 grade, normal strength of 25 Mpa to 33 Mpa at 28 days was obtained by keeping the cement content around 350 kg/m^3 to 414 kg/m^3

By increasing the water/powder ratio more than 1.21, the passing ability (U-Box and L-Box) tests were not satisfied.

Medium strength SCC of 25 to 35 Mpa can be obtained easily with the mix proportions used in this study, with 43 grade cement.

SCC can be developed without using VMA, as was done in the study.

As SCC technology is now being adopted in many countries throughout the world, in the absence of suitable standardized test methods is necessary to examine the existing test methods and identify or, when necessary, developed test methods suitable for acceptance as International Standards. Such test methods have to be capable of a rapid and reliable assessment of key properties of fresh SCC on a construction site. At the same time, the testing equipment should be reliable, easily portable and inexpensive. The test procedure should be carried out by a single operator and the test results have to be interpreted with a minimum of training. Also, the results have to define and specify different SCC mixes. One primary application of these test methods would be in verification of compliance on sites and in concrete production plants, if Self-Compacting Concrete could be manufactured in large quantities.

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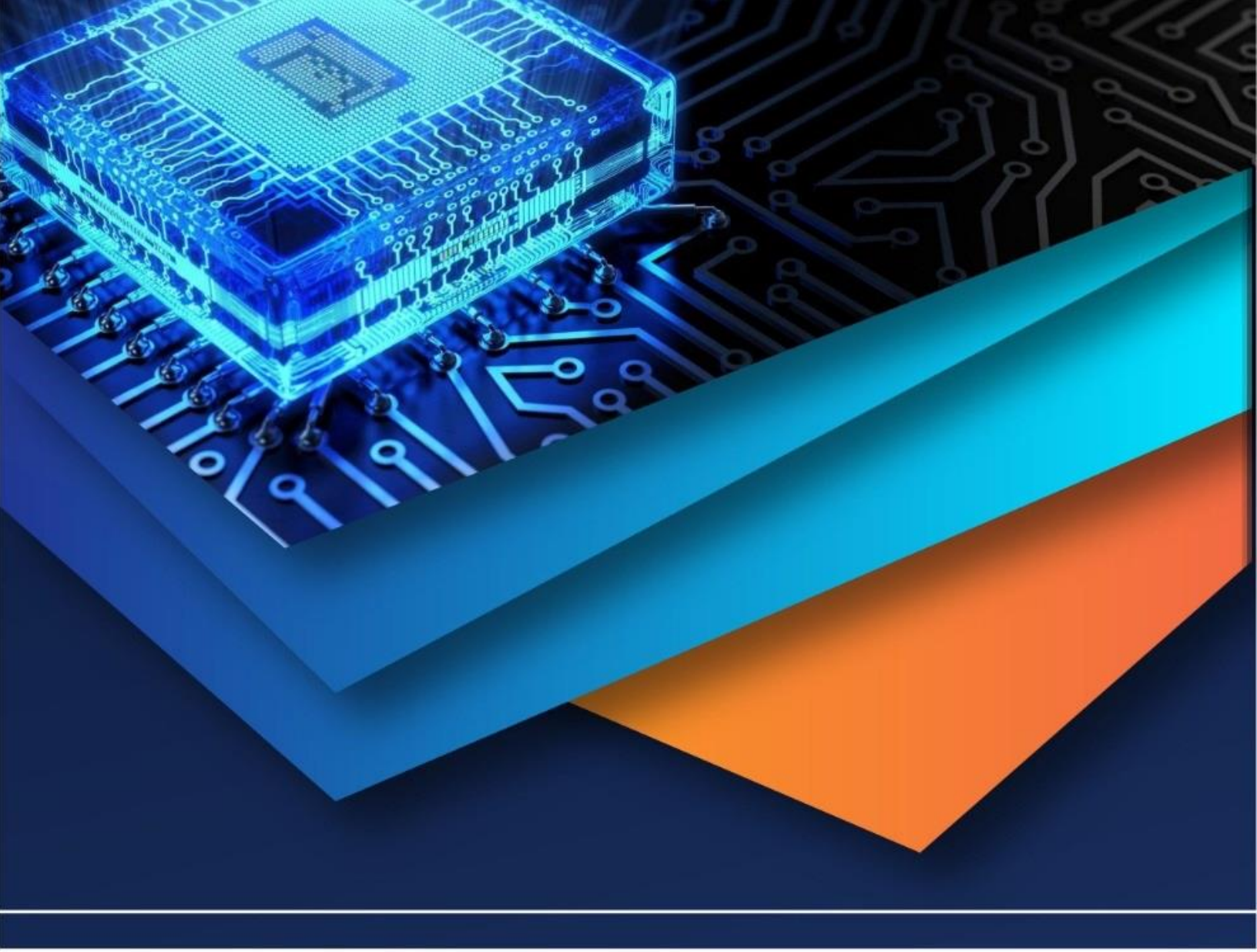

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