STRENGTH AND RHEOLOGICAL PROPERTIES OF FIBER REINFORCED SELF COMPACTING CONCRETE WITH ALCCOFINE

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Abstract—**Self Compacting Concrete is a newly developed concept in which the ingredients of the concrete mix are proportioned in such a way that it can flow under its own weight to completely fill the formwork and passes through the packed reinforcement without segregation and self consolidate without any mechanical vibration. Efforts for improving the performance of concrete over the past few years suggest that cement replacement materials such as Mineral admixtures can improve the strength and durability characteristics of concrete. Alccofine is pozzolanic material and the ultrafine particles of alccofine provide better workability, strength as well as economical one. An experimental investigation was carried out to study the effect of Alccofine on fiber reinforced self compacting concrete. SCC mixes incorporating different percentages (0%, 10%, 20%, 30% and 40%) of alccofine by weight of cement along with 1% of steel fiber. Super plasticizer Conplast SP430 was used to maintain workability with constant Water-cement ratio. Several tests such as Slump flow, V-funnel, L-box, U-box, J-ring tests are carried out to check the rheological properties of concrete. Strength properties was determined such as compressive, split tensile and flexural strength test. This is done to determine the efficiency and optimum percentage of replacement at which maximum strength is achieved.**

Keywords—SCC, Alccofine, steel fiber, Rheological properties, Strength characteristics.

I. INTRODUCTION

Self-compacting concrete (SCC), is defined as the concrete which can be placed and dense into every corner of formwork, purely by means of its self-weight, by eliminating the need of either external energy input from vibrators or any type of compacting effort.

Self Compacting Concrete has been developed in Japan to improve the durability and uniformity of concrete in 1988 by Okamura and Ozawa. The mix composition is chosen to satisfy all performance criteria for the concrete in both the fresh and hardened states. Self compacting concrete is a concrete which flows by its own weight. So it does not requires compaction at site or concrete plants. To achieve this, mineral admixtures and super plasticizers, viscosity modifying admixture are used in mix as chemical admixtures for design of concrete. The main difference between conventional concrete to self compacting concrete is the pore value in concrete mass i.e. highly eliminated pores. In this regards, mass of fine aggregate is typically equal or more compare to coarse aggregate. And selection of coarse aggregate size also gives impact on requirement of self compacting.

There are many advantages of using SCC especially when the material cost is minimized which include, Reducing the construction time and labour cost, Eliminating the need for vibration, Reducing noise pollution, Improving the filling capacity of highly congested structural member.

II. MATERIALS

Experimental program has been designed to provide sufficient information for ascertaining the quality of Alccofine based reinforced self compacting concrete. To evaluate the behavior of Alccofine based reinforced self compacting concrete, both mechanical strength and durability aspects have been studied in this investigation.

A. Cement

Ordinary Portland cement-53 grade have used in examination. The cement was tested according to IS 4031:1988. It confirmed to IS 12269:1987. Its Properties is given in Table 2.1.

B. Fine Aggregate

The fine aggregate used in the experimental investigation was natural river sand confirming to Zone II of IS 383-1987. Sand used in the work which has particle size less than 4.75 mm.

C. Coarse Aggregate

Crushed granite aggregate particles passing through 12.5mm and retained on 10mm I.S sieve used as the natural aggregate which met the grading requirement of IS 383-1970.

D. Alccofine

ALCCOFINE 1203 is a particularly processed product based on slag of high glass content with high reactivity obtained through the process of controlled granulation. ALCCOFINE 1203 have used conforming to ASTM C989-99.

E. Steel Fiber

Steel fibers can improve the compressive strength, tensile strength and flexural strength of concrete. It is also enhance the durability properties of concrete. The crimped steel fibres are used in this study. The length of the fibre is 10mm and the aspect ratio is 25. The shape of the fibre helps in better bonding with the concrete.

F. Super Plasticizer

Generally super plasticizers are used to improve the workability and reduce water content. According to this the super plasticizer Conplast SP 430 is a high range water reducing agent. There are difficulties and limitations to obtain high workability in the field for a given set of conditions. Specific gravity and Chloride content of super plasticizer are 1.220 to 1.225 at 300ºC and Nil as per IS: 456 respectively.

The test data determined from the materials are as follows,

Table 2.1: Properties of Materials used

S.No	Name of the material	Properties of material	Result
1.	OPC 53 grade	Specific gravity	3.16
		Fineness modulus	3.6%
		Consistency	32%
		Initial setting time	30 min
		Final setting time	10 hrs.
2.	Fine aggregate	Specific gravity	2.6
		Water absorption	0.85%
		Fineness modulus	4.83
		Bulk density	1782.46 kg/m^3
3	Coarse aggregate	Specific gravity	2.63
		Water absorption	0.56%
		Fineness modulus	84
		Bulk density	1652.15kg/m^3
		Impact test	15%
4	Alccofine	Specific gravity	3.1
		Bulk density	650 kg/m^3
		Particle size	<5µ

III. MIX PROPORTION

The very first step to assure the flow requirement of SCC is to determine the optimum dosage of alccofine and super plasticizer. Various mixes were prepared and tested to satisfy the EFNARC guidelines. Finally a mix is chosen which gave fulfilling fresh properties. The addition of different percentage of admixtures would be done in this mix. The optimum dosage of alccofine is 30% and 1.5% of super plasticizer and 1% of steel fiber added to each mix.

The mix proportion was done based on the EFNARC guidelines. The mix design was carried out for M40 normal grade of self compacting concrete with alccofine as partial replacement of cement with a fraction of 0%, 10%, 20%, 30% & 40%.

Mix Ratio

WATER	CEMENT	FINE AGGREGATE	COARSE AGGREGATE
173 l/m^3	496 kg/m^3	858 kg/m^3	841 kg/m^1
0.35	1	1.72	1.68

Combinations of mixes

Concrete label	Explanations
SCC	nominal mix
SCC01	Nominal mix + 1% fiber
SCC02	Nominal mix + 1% fiber + 10% alccofine
SCC03	Nominal mix + 1% fiber + 20% alccofine
SCC04	Nominal mix + 1% fiber + 30% alccofine
SCC05	Nominal mix + 1% fiber + 40% alccofine

IV. EXPERIMENTAL WORKS

A. Fresh properties

To study the fresh concrete properties of self-compacting concrete based on the parameters defining the fresh concrete. Many different test methods have been developed in attempt to characterize the property of Self-Compacting concrete.

Particulars	Test methods
Filling Ability	Slump flow(diameter) Slump flow(time)
Passing Ability	L-box, J-Ring, U-box
Segregation Resistance	V-funnel

According to EFNARC, a slump flow diameter varies from 650 to 800mm is acceptable for SCC. In slump flow ability and segregation resistance can be also resolute. Apart from slump flow L-Box test, U-Box test and V-Funnel test are also performed to evaluate flow ability, passing ability stability of SCC. The L-Box ratio is in range of 0.8-1.0. The V-Funnel time ranges from 8 to 12 seconds.

B. Mechanical properties

All the mixes were tested for various hardened properties like compressive strength, flexural strength & Split Tensile Strength test as per Indian Standards. The six different combination mixes were prepared including conventional for testing. In this investigations, Specimens prepared such as cube size is 150X150X150 mm, cylinder size is 300X150 mm and prism (500X100X100 mm) for each combinations. The testing was done on specimens after 28 days curing. All tests was repeated for three specimens and average value was taken as the mechanical strength.

1. *Compressive Strength*

In this investigation, the cube specimen of size 150mm x 150mm x 150mm were cast, cured and tested in accordance with BIS: 516 – 1959 (method of test for test of concrete). The testing was done on compressive testing machine of 2000kN capacity.

2. *Split Tensile Strength*

The objective of this is to find the splitting tensile strength of the concrete cylinders. This cones under indirect tension test methods. A concrete cylinder of size 150mm diameter and 300mm height was subjected to the action of the compressive forces along two opposite edges. The test was conducted using compressive testing of 200kN capacity.

Horizontal Tensile Stress = $2P/\pi DL$

Where, P = Compressive load on the cylinder.

L = Length of cylinder.

D = Diameter of cylinder.

3. *Flexural Strength*

Flexural tests were conducted on beams of size of 100 mm x 100mm X 500 mm subjected to two point loading at 28 days in UTM. The maximum load applied to the specimen shall be recorded and the flexural strength of concrete expressed as the modulus of rupture (f_b) is calculated.

Modulus of rupture $f_b = 3Pl / 2bd^2$

V. RESULT AND DISCUSSION

1. Fresh properties

The rheological properties of self-compacting concrete are predicted by slump flow (diameter, time), V-funnel, L-box, u-box and J-ring. The values are given below,

Table 5.1: Fresh properties of SCC

Testing Methods	Units	Workability Values						
		Permissible limits	SCC (Control)	SCC01	SCC02	SCC03	SCC04	SCC05
Slump Flow(Diameter)	mm	650 - 800	670	653	657	660	665	670
Slump Flow(Time)	Sec	2-5	3	3.5	3.2	3	2.8	2.8
V-Funnel	Sec	6-12	7	8	8	7.8	7.3	7
L-Box	-	0.8-1.0	0.84	0.93	0.93	0.91	0.9	0.9
U-Box	mm	0-30	22	20	20	22	22	22
J-Ring	mm	0-10	6	7.5	7	7	6.5	6.5

Fig-5.1: Fresh properties of Self Compacting Concrete

2. Compressive and Split Tensile Strength

The Compressive and Split Tensile Strength of self compacting Concrete with various percentage of alccofine replacing for cement and with or without steel fiber. These results are given in table.

Table-5.2: Compressive and Split tensile strength of SCC

Concrete Label	Compressive Strength (MPa)		Split Tensile Strength (MPa)	
	7 days	28 days	7 days	28 days
SCC	27.43	42.2	2.17	3.26
SCC01	28.1	44	2.25	3.39
SCC02	28.6	44.3	2.38	3.57
SCC03	29.64	45.6	2.47	3.72
SCC04	31.26	48.1	2.75	4.11
SCC05	30.03	46.2	2.65	3.98

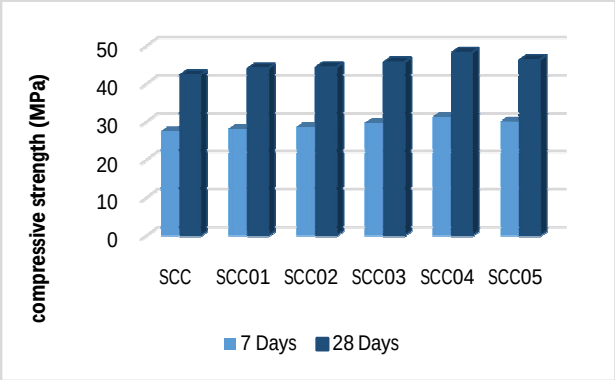

Fig-5.2: Compressive strength of Self Compacting Concrete

From the test results, the compressive strength obtained for the SCC01 is greater than the SCC (nominal) at 28 days. The compressive strength for 30% of alccofine (48.1MPa) is higher than the other replacement mixes also control mix (SCC). The result show that for all ages, the alccofine ranging from 10%, 20%, 30% and 40% yields higher compressive strength when compared to conventional concrete mix. Beyond that there is a decrease in strength for 40% of replacement alccofine.

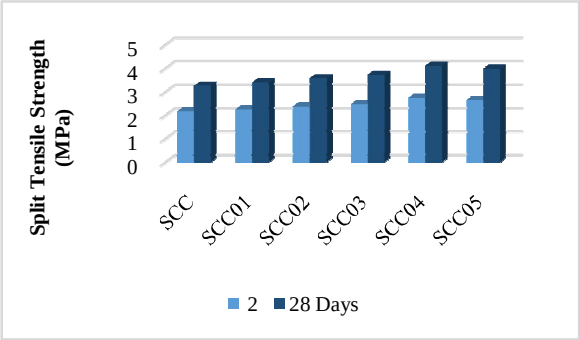

Fig-5.3: Split tensile strength of Self Compacting Concrete

From the test results, the Split Tensile strength obtained for the SCC01 28 days is greater than the SCC (nominal). The Split tensile strength for 30% of alccofine (4.11MPa) is higher than the all the replacement mixes also control mix (SCC). The result show that for all ages, the alccofine ranging from 10%, 20%,30% and 40% yields higher tensile strength when compared to conventional concrete mix. Beyond that there is a decrease in strength for 40% of alccofine replacement.

3. Flexural Strength

The flexural Strength of self compacting Concrete with various percentage of alccofine replacing for cement and with or without steel fiber. These results are given in table.

Table-5.3: Flexural strength of SCC

S.No	Concrete Label	Flexural strength at 28 days (MPa)
1	SCC	7.3
2	SCC01	7.63
3	SCC02	7.67
4	SCC03	7.85
5	SCC04	8.12
6	SCC05	8.02

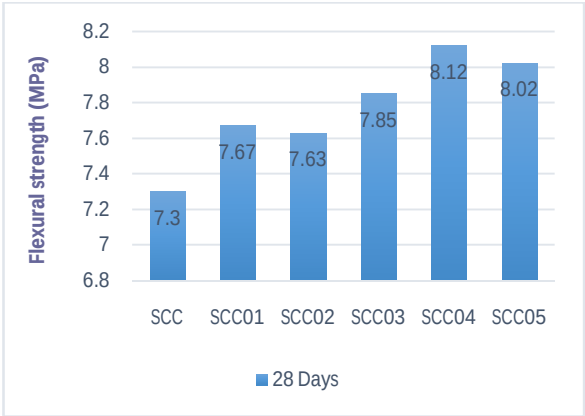

Fig-5.4: Flexural strength of Self Compacting Concrete

From the test results, the Split Flexural strength obtained for the SCC01 28 days is greater than the SCC (nominal). The Split flexural strength for 30% of alccofine (8.12 MPa) is higher than the all the replacement mixes also control mix (SCC). The result show that for all ages, the alccofine ranging from 10%, 20%,30% and 40% yields higher tensile strength when compared to conventional concrete mix. Beyond that there is a decrease in strength for 40% of alccofine replacement.

VI. CONCLUSION

The following conclusions are drawn for feasibility study conducted on reinforced self compacting concrete with alccofine as partial replacement of cement includes,

The conclusion based on the limited observations from the present investigation on study of compressive, split tensile and flexural strength of the concrete made using alccofine as partial replacement of cement with steel fiber (1%) and constant dosage of super plasticizer (1.5%). The replacement level of alccofine ranging from 10%, 20% and 30% yields higher compressive strength than the conventional concrete mix. Beyond that there is a decrease

in the compressive strength of concrete by replacing 40% of alccofine.

- The present investigation has shown that it is possible to achieve self compaction with different percentage of alccofine by the results of slump flow, J - ring, L - box, U – box and V - funnel. The fiber inclusion reduced the fluidity, but presence of alccofine enhance the flow properties.
- Although results obtained from all of the mixes satisfy the lower suggested by EFNARC, all mixes had good flow ability and possessed self-compaction characteristics.
- The addition of steel fiber increases the compressive strength, split tensile strength and flexural strength that is shows the results of SCC01 compared to the nominal concrete mix.
- Compressive strength, split tensile strength and flexural strength variation for the replacement of cement to a level of 30% alccofine indicate as an optimum replacement level. The observed maximum strength in compression, tension and flexural was 48.1MPa, 4.11MPa and 8.12MPa respectively at 28 days.
- The addition of alccofine in SCC improves microstructure of concrete that also helpful to enhance all mechanical properties of concrete.

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