International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Study of Properties of Self Compacting Concrete with Micro Steel Fibers and Alccofine

Bletty Baby[1], Jerry Anto[2]
[1, 2]Department of Civil Engineering, Ilahia College of Engineering & Technology, Mulavoor, Kerala, India-686673

Abstract**—** *Self-compacting concrete (SCC) is a relatively new technology that does not require any vibration for placing and compaction which gives lot of economical and technical benefits. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. SCC has favourable characteristics such as high fluidity, good segregation resistance and the distinctive self-compatibility without any need for vibration during the placing process and so noiseless construction. In this study first the properties of a normal SCC M30 mixwas evaluated. Then mixes with 5%, 10%, and 15% replacement of cement with Alccofine was prepared and optimum percentage was determined by studying the fresh and mechanical properties and comparing it with Normal SCC mix. Optimum percentage was selected as 10%. By making the Optimum percentage of Alccofine constant and varying the Micro steel fiber by 0.5%, 1%, 1.5% another mixes were prepared. This SCC mix will be compared with normal SCC. Fresh properties of the SCC will be tested for slump flow diameter, L-box height ratio, and V-funnel flow time. Hardened properties of SCC will be studied for compressive strength, flexural strength and splitting tensile strength. By studying the compressive strength of different mixes it was observed that all SCC with both Alccofine and Micro steel fibre gave high strength than normal SCC mix. When comparing the Split tensile strength also SCC with Alccofine and Micro steel fibre gave highest result. Flexural strength also gives satisfactory results.*

Keywords**—** *FreshProperties, hardened properties, self compacting concrete, alccofine, micro steel fiber*.

I. Introduction

Concrete is a widely used construction material around the world, and its properties have been undergoing changes through technological advancement. Numerous types of concrete have been developed to enhance the different properties of concrete. When large quantity of heavy reinforcement is to be placed in a reinforced concrete (RC) member, it is difficult to ensure that the formwork gets completely filled with concrete that is, fully compacted without voids or honeycombs. Compaction by manual or by mechanical vibrators is very difficult in this situation. The typical method of compaction, vibration, generates delays and additional cost in the projects. Underwater concreting always required fresh concrete, which could be placed without the need to compaction; in such circumstances vibration had been simply impossible. This problem can now be solved with self-compacting concrete (SCC).European Federation of natural trade associations representing producers and applicators of specialist building products (EFNARC) has drawn up specification and guidelines for Self compacting concrete to provide a framework for design and use of high quality SCC.

SCC is an innovative concrete that does not require any vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction,even in the presence of congested reinforcement. SCC has favourable characteristics such as high fluidity, good segregation resistance and the distinctive self compatibility without any need for vibration during the placing process and so noiseless construction. The unique characteristics of SCC are a rapid rate of concrete placement with very less time. SCC offers a very high level of homogeneity; minimize the concrete void spaces and have uniform concrete strength and also provides the superior level of finishing and durability of structure. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete.

The primary objective of the study is to investigate different properties of SCC including fresh and hardened properties. Objectives of project work also include study the compatibility of using alccofine and micro steel fiber in SCC.

II. Mix Materials

The materials used in the project should confirm certain properties which are given below.

A. Cement

Cement is the well-known building material with adhesive and cohesive properties, which is capable of binding mineral fragment into compact mass. Ordinary Portland cement 53 Grade with properties as give in table has been used in this experimental study.

TABLE I. Properties of cement.

Physical Properties	Result
Specific gravity	3.15
Standard consistency	34 %
Initial Setting Time (min)	120

B. Fly Ash

Fly ash, known also as pulverized- fuel ash, is a by-product obtained by electrostatic and mechanical means from flue gases of power station furnaces fired with pulverized coal. Fly ash can significantly improve the workability of concrete. Fly ash used for this study has a specific gravity of 2.1.

C. Fine Aggregates

Aggregates mainly passing through 4.75 mm IS sieve and retained on 75 microns IS sieve is permitted for fine aggregates. Aggregates conforming to grading Zone II are used in this experimental work [1].

TABLE II. Properties of fine aggregate.

Properties	Result
Specific gravity	2.74
Water absorption %	1.2

D. CoarseAggregates

Aggregate which passes through 75 mm IS sieve and retained on 4.75 mm IS sieve is used as coarse aggregate. Coarse aggregates containing flat, elongated or flaky pieces should be rejected. Coarse aggregate used for the study of SCC is12.5mm granite broken stones. Aggregates conforming to grading Zone II are used in this experimental work [1].

TABLE III. Properties of coarse aggregate.

Properties	Result
Specific gravity	2.74
Water absorption %	1.2

E. Alccofine

Alccofine used in this study is a product based on slag of high glass content with high reactivity obtained through the process of controlled granulation. It provides reduced water demand for a given workability, even up to 70% replacement level as per requirement of concrete performance. Alccofine can also be utilized as a high range water reducer to improve compressive strength. Alccofine used in this work has a specific gravity of 2.9.

F. Micro steel Fiber

Micro-steel fiber used is resistant to corrosion induced by moisture and chemical environments. Amorphous micro-steel fiber is fabricated using an amorphous metal for its enhanced strength, toughness and corrosion resistance to chemical environments and moisture, as compared with general steel fiber.

G. Super Plasticizer (SP)

Master Glenium SKY 8233 was used as super plasticizer for the study. It is an admixture based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. It is free of chloride and low alkali. It is compatible with all types of cements.

H. Water

Water used for mixing and curing shall be clean and free from oils, acids, alkalis, salts etc. Water used for the study was free of acids, organic matter, suspended solids, alkalis and impurities when present may have adverse effect on the strength of concrete. Potable water with Ph value 7 conforming to IS: 456-2000 is used for casting as well as curing.

III. MIX PROPORTION

There is no standard method for determining mixture proportions currently exists for SCC. However, many academic institutions, ready-mixed, precast and contracting companies have developed their own mix proportioning methods. In this study, SCC control mix (M30) was chosen to satisfy all performance criteria for the concrete in both the fresh and hardened states as per EFNARC guidelines [2]. The mix design was carried out as per Nan – su et al method [3]. The Nomenclature for mixes used in the study is given in table IV.

TABLE. IV. Nomenclature.

Mix	Concrete Mix Proportion
SCC	Normal SCC mix
SCC-A5	SCC with 5% replacement of cement with Alccofine
SCC-A10	SCC with 10% replacement of cement with Alccofine
SCC-A15	SCC with 15% replacement of cement with Alccofine
SCC-A10M0.5	SCC with 10% replacement of cement with Alccofine and addition of 0.5% Micro Steel fiber
SCC-A10M1	SCC with 10% replacement of cement with Alccofine and addition of 1% Micro Steel fiber
SCC-A10M1.5	SCC with 10% replacement of cement with Alccofine and addition of 1.5% Micro Steel fiber

The mix which satisfied all the specifications of EFNARC was selected as the mix for the study. Different mixes were prepared by changing the alccofine percentages and also micro steel fiber in the standard mix. The mix designs of SCC and SCC with different mixes are in Table. V and Table. VI

TABLE V. Mix Proportion of normal SCC mix.

Mix	Cement (kg)	FYA (kg)	FA (kg)	CA (kg)	Water (kg)	W/B	SP (%)
SCC	360	210	758	758	230	0.4	0.5

TABLE VI. Mix proportion of SCC Mixes with replacements.

Mix	SCC-A5	SCC-A10	SCC-A15	SCC-A10M0.5	SCC-A10M1	SCC-A10M1.5
Cement (kg)	342	324	306	324	324	324
Alcco (kg)	18	36	54	36	36	36
Micro steel (kg)	-	-	-	2.85	5.7	8.5
FYA (kg)	210	210	210	210	210	210
FA (kg)	759	760	761	760	760	760
CA (kg)	759	760	761	760	760	760
Water (kg)	230	230	230	230	230	230
SP (%)	0.3	0.3	0.3	0.3	0.3	0.3

III. RESULT AND DISCUSSION

Fresh and hardened properties of concrete were studied for SCC. Slump-flow, T-500, V-funnel and L-box tests were carried out in the laboratory to determine the fresh properties of SCC. Fresh properties of concrete are tabulated as in Table. VII. The values obtained are within the range specified in EFNARC guidelines.

The slump-flow is the mean diameter of slump flow test expressed to the nearest 10 mm. The T500 time is the time in seconds the concrete has flowed to a diameter of 500 mm. The time taken for the concrete to flow out of the funnel is measured and recorded in second is the V-funnel flow time. For J-box test, height of the horizontal section of the box measured as H_2 mm. The depth of concrete immediately behind the gate measured as H_1 mm.

Passing ability, $PA = H_2/H_1$ (1)

Fig. 1. Slump flow.

TABLE VII. Fresh properties of SCC.

Mix	Properties			
	d_f (mm)	T_{500} (sec)	t_v (sec)	Passing Ability
SCC	590	3	10	0.94
SCC-A5	630	3	9	1.66
SCC-A10	660	2.5	8.5	2.33
SCC-A15	680	2	8.3	2.95
SCC-A10M0.5	640	3	8.7	2.1
SCC-A10M1	650	3.5	9	2.0
SCC-A10M1.5	655	3.5	9.3	1.7

The mechanical properties such as compressive strength, flexural strength and split tensile strength [4] were carried out in the laboratory. The compressive strength is measured using cube of size 150mm × 150mm × 150mm at 3, 7 and 28 days of curing. The Split tensile strength is conducted on cylinder of size 300 mm × 150 mm at 7 and 28 days of curing. The flexural strength of concrete is conducted on beam of size 100 mm × 100 mm × 500 mm at 7and 28 days of curing.

Table VIII, Table IX and Table X shows compressive, flexural and splitting tensile strengths of various mixes

TABLE VIII. Compressive strength of SCC.

Property / Mix	Compressive Strength(N/mm^2)		
	3day	7day	28day
SCC	14.1	23.9	39.2
SCC-A5	18.2	29.4	43.1
SCC-A10	21.5	36.8	46.4
SCC-A15	16.7	26.5	41.9
SCC-A10M0.5	22.1	23.9	39.2
SCC-A10M1	24.4	42.7	51.2
SCC-A10M1.5	23.2	41.3	46.9

TABLE IX. Split tensile strength of SCC.

Property / Mix	Split Tensile Strength(N/mm^2)	
	7day	28day
SCC	1.7	2.54
SCC-A5	1.94	2.63
SCC-A10	2.23	3.14
SCC-A15	1.82	2.59
SCC-A10M0.5	2.5	3.2
SCC-A10M1	2.67	3.5
SCC-A10M1.5	2.59	3.3

TABLE X. Flexural strength of SCC.

Property / Mix	Flexural Strength(N/mm^2)	
	7day	28day
SCC	5.25	7.25
SCC-A5	5.51	8.36
SCC-A10	6.3	8.92
SCC-A15	4.23	7.1
SCC-A10M0.5	6.38	9
SCC-A10M1	6.9	9.7
SCC-A10M1.5	6.5	9.4

Graphical Representation of comparison of Compressive strength, Flexural strength and splitting tensile strength of Normal SCC mix and SCC mix made by replacing 5%, 10% and 15% of cement with Alccofine (SCC-A5, SCC-A10, SCC-A15) is shown in Fig. 2, Fig. 3 and Fig. 4.

From the Fig. 2, Fig. 3 & Fig. 4 and Table VIII, Table IX and Table X all the SCC-A5, SCC-A10, SCC-A15mixes shows higher values in terms of compressive, flexural and splitting tensile strength values compared with normal SCC mix. Among the three mixes strength properties SCC-A5 and SCC-A10 increased, but SCC-A15 shows a decrease compared to other two mixes. So SCC-A10 was selected as the optimum.

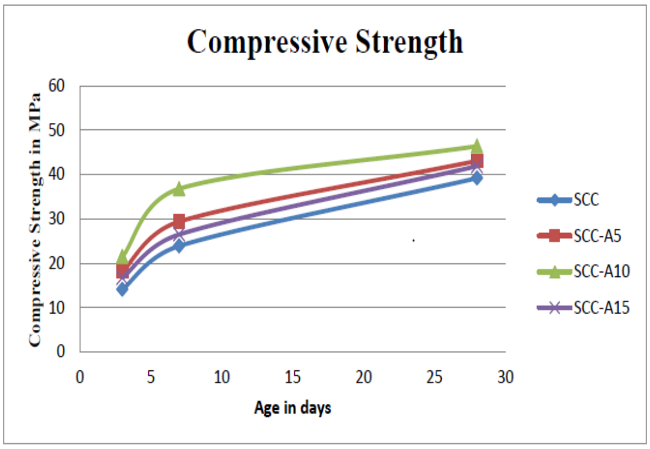

Fig. 2. Graphical representation of compressive strength of SCC and SCC with Alccofine.

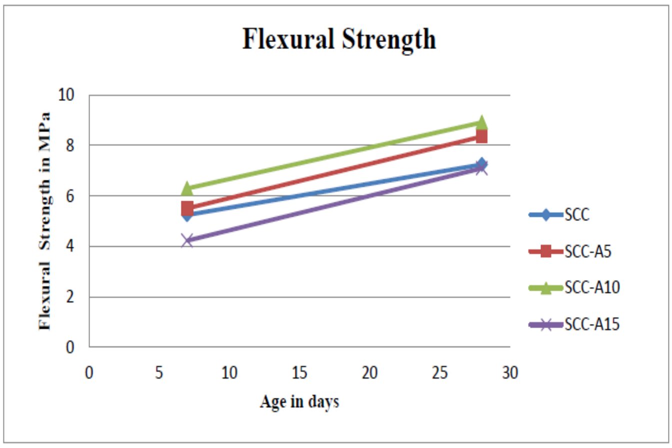

Fig. 3.Graphical representation of flexural strength of SCC and SCC with Alccofine.

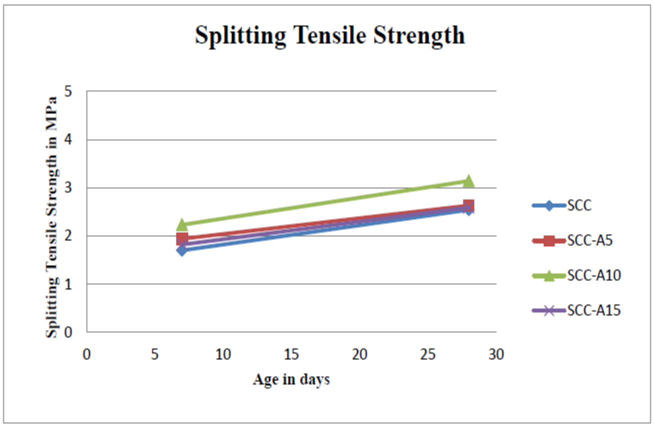

Fig. 4.Graphical representation of split tensile strength of SCC and SCC with Alccofine.

Graphical Representation of comparison of Compressive strength, Flexural strength and splitting tensile strength of Normal SCC mix and SCC mix made by replacing 10% (optimum percentage) of cement with Alccofine and adding 0.5%, 1% and 1.5% of micro steel fiber (SCC-A10:M0.5, SCC-A10:M 1, and SCC-A10:M1.5) is shown in Fig. 5, Fig. 6 and Fig. 7.

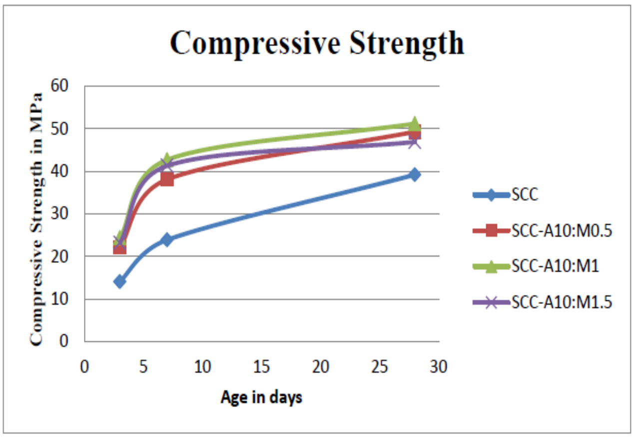

Fig. 5. Graphical representation of compressive strength of SCC and SCC with Optimum Alccofine and Micro steel fiber.

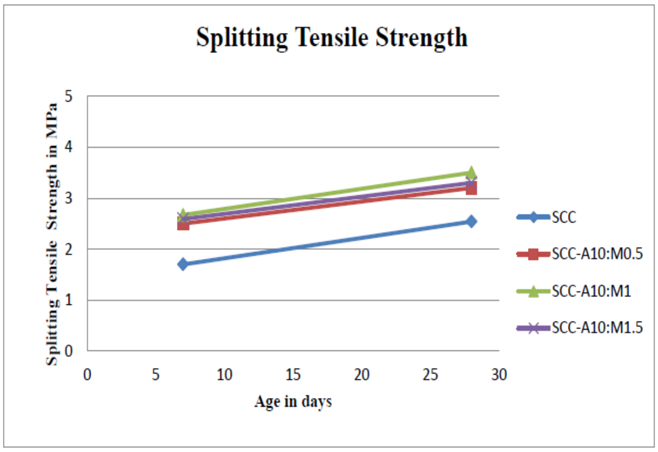

Fig. 6.Graphical representation of split tensile strength of SCC and SCC with Optimum Alccofine and Micro steel fiber.

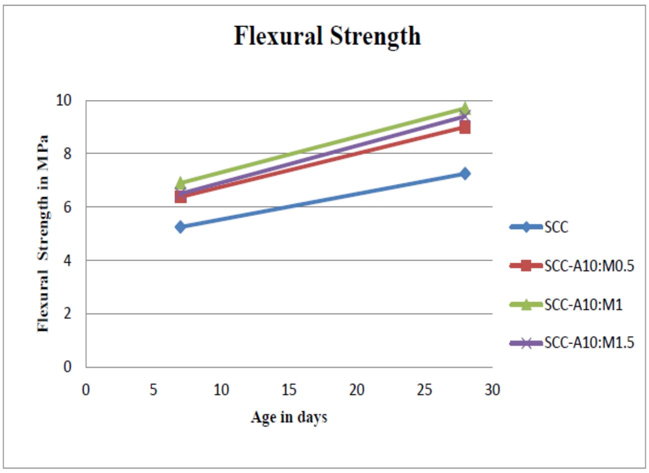

Fig. 7.Graphical representation of flexural strength of SCC and SCC with Optimum Alccofine and micro steel fiber.

From the Fig. 5, Fig. 6 and Fig. 7and Table VIII, Table IX and Table X all the SCC-A10:M0.5, SCC-A10:M1, and SCC-A10:M1.5 mixes show higher Compressive, flexural and splitting tensile strength values of compared with normal SCC mix. But SCC-A10:M1.5 mix gives less strength values compared with other two mixes.

IV. Conclusions

- When mix design for a M30 SCC mix was done as per EFNARC guidelines and Nan – su et al method required strength and workability properties were achieved using fly ash is used as filler.
- For SCC-A5, SCC-A10, SCC-A15 mixes compressive, flexural and splitting tensile strength of all mixes show higher values compared with normal SCC mix. But SCC-A15 shows a decrease compared to other two mixes. SCC-A10 was selected as the optimum.
- For SCC-A10:M0.5, SCC-A10:M1, and SCC-A10:M1.5 mixes compressive, flexural and splitting tensile strength values of all three mixes were more compared with normal SCC mix. But SCC-A10:M1.5 mix gives less strength values compared with other two mixes.

References

[1] IS: 383 -1970, “Specification for coarse and fine aggregates from natural sources for concrete,” Bureau of Indian standard, September 1993, New Delhi.
[2] EFNARC, “The European guidelines for self compacting concrete,” 2005.
[3] Nan Su, Kung-Chung Hsu, and His-Wen Chai., “A simple mix design method for self-compacting concrete,” *Cement and Concrete Research*, 2001, pp. 1799–1807.
[4] IS: 516 – 1959, “Methods of test for strength of concrete,” Bureau of Indian standard, June 2006, New Delhi.
[5] Gonzalo barluenga, Irene palomar, Javier puentes, “Early age monitoring of self-compacting concrete with mineral additions,” *Construction and Building Materials*, 77, pp. 66-73, february 2015.
[6] Mustafa Sahmaran, Alperen Yurtseven, I. Ozgur Yaman, “Study on the workability of hybrid fiber reinforced self-compacting concrete,” *Building and Environment*, 40, pp. 1672–167, 2005.
[7] R. Madandoust, M.M. Ranjbar, and A.A. Moshiri, “The effects of steel and pet fibers on the properties of fresh and hardened self-compacting concrete,” *BHRC*, vol. 15, no. 5, 2014.

[8] M. S. Shetty, *Concrete Technology Theory and Practice*, S. Chand & Company Ltd., New Delhi, 2005.