Self-compacting Concrete with Alccofine and Glass Fiber

Ranjan Abraham, T.R. Neelakantan, C. Ramesh Babu

Abstract – Self consolidating concrete (S.C.C.) is a type of concrete which need not be provided any kind of external work for compaction and gets consolidated by own weight and thereby providing a lot of economic and technical benefits. It flows under own weight to completely fill forms and pass without segregation, through closely spaced reinforcement. Alccofine is a pozzolanic material and the ultrafine particles of Alccofine provide better workability, strength as well as the economy. Properties of M40 S.C.C. control mix was compared with S.C.C. mixes incorporating 1% of glass fiber and replacing different percentages (0%, to 15% by weight) of cement with Alccofine was studied. Optimum replacement of cement was assessed by studying properties in the fresh state and in the hardened state, and then comparing results with properties of control mix. Fresh state properties of S.C.C. were assessed by L box test, slump-flow test and V funnel test. Compressive strength, flexural strength, and splitting tensile strength tests were done to assess hardened state properties. Properties of S.C.C. in Fresh and hardened state were seen to be enhanced by addition of Alccofine and Glass fiber.

Keywords : ***Self compacting concrete, Alccofine, Glass fiber***

I. INTRODUCTION

Self consolidating concrete (S.C.C) is a revolutionary product in construction industry. S.C.C. was developed by Okamura and Ozama in Japan. This concrete fills formwork by own weight and pass without segregation, through congested reinforcement. S.C.C. can be used to cast any complex shapes. Fresh concrete possesses high fluidity and good cohesion. Concrete which follows E.F.N.A.R.C. (European Federation of National Associations Representing for Concrete) Guidelines are considered to be S.C.C. It avoids need for vibration, reduces labour cost, noise pollution and construction time and improves filling capacity and minimizes voids of concrete in highly congested structural members. In the study, glass fiber was incorporate in S.C.C. and optimum replacement of cement with Alccofine was assessed. M40 mix was selected for the study and different fresh state and hardened state properties of S.C.C. were assessed for mixes with various proportions of Alccofine and the results compared with results of control mix

Revised Manuscript Received on December 5, 2019

***** Correspondence Author

Ranjan Abraham*, Civil Engineering Department, Kalasalingam Academy of Research and Education, Krishnankoil, India. Email: ranjan@klu.ac.in

T.R. Neelakantan, Civil Engineering Department, Kalasalingam Academy of Research and Education, Krishnankoil, India. Email: neelakantan@klu.ac.in

C. Ramesh Babu, Civil Engineering Department, Kalasalingam Academy of Research and Education, Krishnankoil, India. Email: babussr@gmail.com

II. OBJECTIVE

Design M40 S.C.C. control mix; assess optimum replacement of cement with alccofine in control mix and to compare properties of samples prepared with control mix and with mix containing one percentage glass fiber and optimum replacement level of Alccofine.

III. MATERIALS

Cement holds mineral fragments into compact mass. Portland cement having a grade of 53 was used for study. Tests were conducted to find sp. gravity, std. consistency and initial setting time and results tabulated in Table-1.

Table I: Cement Properties

Sl. No.	Physical Property	Result
1	Specific Gravity	3.15
2	Standard Consistency	34 %
3	Initial Setting Time	45 minutes

Aggregates which pass through 4.75 mm and retained on 75 microns sieve are considered as fine aggregates. Fine aggregate used in the study was manufactured sand (M- Sand) conforming to Zone II. Properties of fine aggregates were assessed as per guidelines in IS 2386-1968 and results listed in Table-2.

Table II: Fine aggregate Properties (F.A.)

Sl. No.	Physical Properties	Result
1	Specific Gravity	2.68
2	Water Absorption	1.88 %
3	Bulk Density	1.531 kg/l

Fly ash is a bye-product, and is obtained from gases of power station by electrostatic and mechanical means. Fly ash used had specific gravity value of 2.1 and was collected from Alan hydraulic bricks, Angamali, Kerala. 12mm nominal size broken granite stones were used for study. Aggregates in grading Zone II were used in the study. Tests were carried out as per IS2386-1968 and results tabulated in Table 3.

Table III: Coarse aggregate Properties (C.A.)

Sl. No.	Physical Properties	Result
1	Specific Gravity	2.80
2	Water Absorption	1.20 %
3	Bulk Density	1.412 kg/l

Alccofine used in the study is processed from slag of high glass content with high reactivity prepared by controlled granulation.

Particle size distribution of the product ranged from 0.1 - 17 micron with average size of particle of 4 micron. Alccofine used for this study is collected from Counto micro fine Pvt. Ltd., Mumbai, with a specific gravity of 2.9. Density of alccofine used was 654 kg/m^3, Surface area 12000 cm^2/g, particle shape – irregular, D10 – 1.80µ, D-50 – 4.75µ, D90 – 8.70µ and CaO – 33.40 %, Al_2O_3 – 19.85 %, SiO_2 – 34.55 % MgO – 9.60 %, Fe_2O_3 – 1.95 % and SO3 – 0.65 %. Cem-FILL anti-crack high dispersion glass fibers of, 12 mm length, diameter 14 microns and aspect ratio of 857 was used in study. Super plasticizer used for study was Master Glynium SKY 8233. It is based on modified poly carboxylic ether. The product is used in high performance concrete application. It has low alkali content and free of chlorides and goes well with any cement. Potable water was used for preparing mixes and also for curing.

IV. MIX PROPORTION

There are no standard methods for S.C.C. mix design. In this study, mix was designed by Nan – Su et. al. method [1], which met the requirements in EFNARC guidelines [2]. Design of mix was done for M40 grade S.C.C. by partial cement replacement with Alccofine having a fraction ranging from 0 - 15%. 1% of glass fiber was also added to each mix. Nomenclatures of mixes listed in Table 4.

Table IV: Nomenclature

No.	Mix	Explanation
1	S.C.C.	Control mix
2	S.C.C.-A0:G	0%Alccofine + 1% glass fiber
3	S.C.C.-A5:G	5%Alccofine + 1%glass fiber
4	S.C.C.-A10:G	10%Alccofine + 1%glass fiber
5	S.C.C.-A15:G	15%Alccofine + 1glass fiber

Various S.C.C. mixes were prepared and tested to check whether they satisfied EFNARC Guidelines [2]. Finally control S.C.C. mix, with required fresh properties, was selected. Different mixes were then prepared by adding constant 1 % glass fiber and replacing cement content with Alccofine. Mix proportion for control S.C.C. mix and mix with glass fibre and replacing cement content with Alccofine are listed in Table 5.

Table V: Mix proportions of S.C.C.

Mix	Cement (kg)	Fy. A (kg)	C.A. (kg)	F.A. (kg)	Water (kg)	S.P. (%)	Alccofine (kg)	Glass fiber (kg)
S.C.C.	420	230	791	857	257	0.3	-	-
S.C.C.-A0:G	420	230	791	857	257	0.3	0	6.5
S.C.C.-A5:G	399	230	791	857	257	0.3	21	6.5
S.C.C.-A10:G	378	230	791	857	257	0.3	42	6.5
S.C.C.-A15:G	357	230	791	857	257	0.3	63	6.5

V. RESULT AND DISCUSSION

Fresh and hardened state properties of all mixes were tested and found out. T_{500}, Slump flowing, V-funnel and L-box tests were conducted to determine fresh properties. Horizontal flow of concrete in absence of obstruction was assessed by Slump-flow test. Slump flowing test gave an assessment of filling ability. V funnel test gave filling ability of S.C.C. The L box test provided passing ability of S.C.C. Fresh properties of mixes are listed in Table - 6. All values were within the limits specified by EFNARC guidelines

Table VI: Fresh properties of S.C.C.

Mix	Properties			
	d_f (mm)	T_{500} (s)	t_v (s)	Passing Ability
S.C.C.	660	3.2	9.5	0.85
S.C.C.-A0:G	652	3.5	9.7	0.81
S.C.C.-A5:G	665	3.2	9.5	0.86
S.C.C.-A10:G	680	3.0	9.3	0.89
S.C.C.-A15:G	692	2.8	9.0	0.93

Compressive strength of S.C.C. is measured testing standard cubes of size 15×15×15 cm. For each mix proportion, three cubes were casted, tested after curing of 7 and 28 days and average value of results was considered. The compressive strength of S.C.C. mixes is given in Table-7. Graphical representation of compressive strength is shown in Figure 1.

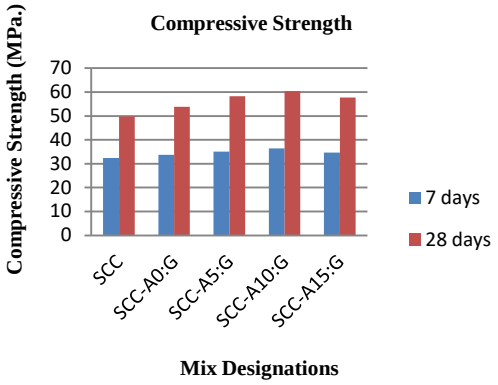

Fig 1: Compressive strength of samples

Table VII: Compressive strength of samples

Mix	Compressive strength (MPa)			
	7-days		28-days	
S.C.C.	34.28	32.44	50.12	49.77
	30.26		48.94	
	32.78		50.25	
S.C.C.-A0:G	30.55	33.77	50.96	53.77
	34.12		54.56	
	36.64		55.79	
S.C.C.-A5:G	36.45	35.11	59.20	58.22
	36.98		59.06	
	31.90		56.40	
S.C.C.-A10:G	35.95	36.44	58.61	60.44
	37.29		61.66	
	38.08		61.05	
S.C.C.-A15:G	33.25	34.66	56.63	57.77
	36.05		57.80	
	34.68		58.88	

From the test results, compressive strength obtained for S.C.C.-A0:G is greater than nominal mix at 28 days. 10% replacement of cement with Alccofine yielded higher strength over control mix and other mixes.

Result showed that, for all ages, Alccofine replacement ranging from 5%, 10% and 15% yielded compressive strength higher than that of control mix. When replacement percentage of Alccofine was increased beyond 10%, strength was observed to be decreased.

Flexural strength of concrete was measured using beam of size 10 cm × 10 cm × 50 cm. Three beams were casted for each mix proportion and average of three test results was taken. The flexural strength is measured after curing 7 days and 28 days. Flexural strength of S.C.C. mixes is given in Table 8 and their corresponding graphical representation is shown in Figure 2.

Table VIII: Flexural strengths of samples

Mix	Flexural strength (MPa)			
	7-days		28-days	
S.C.C.	4.50	4.75	7.05	7.25
	4.80		7.40	
	4.95		7.30	
S.C.C.-A0:G	5.28	5.50	8.26	8.50
	5.65		8.96	
	5.57		8.28	
S.C.C.-A5:G	6.05	6.25	9.24	9.50
	6.30		9.45	
	6.40		9.81	
S.C.C.-A10:G	7.05	6.75	10.56	10.25
	6.45		10.11	
	6.75		10.08	
S.C.C.-A15:G	6.35	6.50	9.50	10.00
	6.90		10.66	
	6.25		9.84	

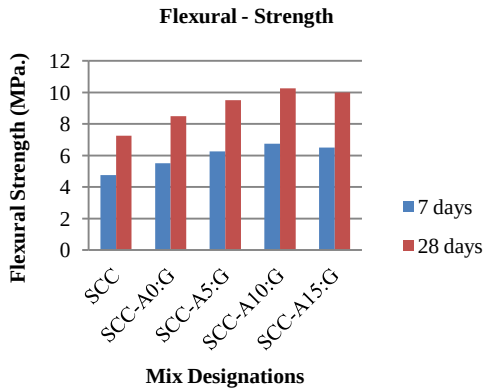

Fig 2: Flexural - strength of samples

From test results, flexural strength obtained for S.C.C.-A0:G at 28 days is greater than nominal mix. Flexural strength for 10% replacement of Alccofine is higher than all other mixes. Result shows that for all ages, the Alccofine replacement ranging from 5%, 10% and 15% yields higher flexural strength than normal concrete mix. Beyond 10% replacement, strength decreases.

Splitting tensile strength test was done on 30 cm × 15 cm. cylinders at 7 days and 28 days respectively, after proper curing. Splitting tensile strength of different mixes of S.C.C. is given in Table 9 and the corresponding graphical representation is shown in Figure 3.

When cement was replaced with 5% of Alccofine, splitting tensile strength increased rapidly. When cement replaced with 10 % of Alccofine, splitting tensile strength increased again. But with the replacement of cement with 15 % Alccofine, there is slight decrease in split tensile strength of S.C.C. Optimum value of replacement of cement with Alccofine is assessed, as 10%.

Table IX: Splitting tensile strength of samples

Mix	Splitting tensile strength (MPa)			
	7-days		28-days	
S.C.C.	3.10	3.25	4.11	4.31
	3.35		4.44	
	3.30		4.38	
S.C.C.-A0:G	3.56	3.39	4.85	4.67
	3.25		4.50	
	3.36		4.66	
S.C.C.-A5:G	3.50	3.47	5.10	4.95
	3.48		4.78	
	3.43		4.97	
S.C.C.-A10:G	3.44	3.61	5.34	5.16
	3.84		5.20	
	3.55		4.94	
S.C.C.-A15:G	3.92	3.54	4.95	5.02
	3.35		5.05	
	3.35		5.06	

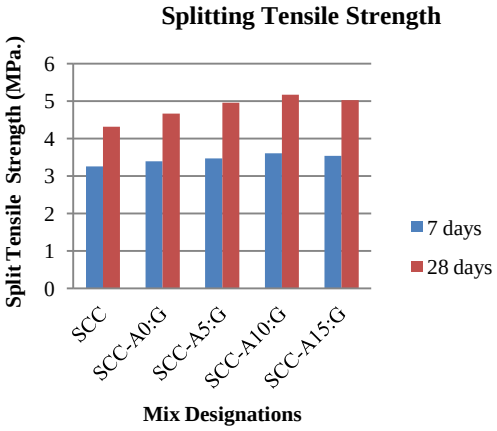

Fig 3: Splitting tensile strength of samples

VI. CONCLUSIONS

Design of M40 S.C.C. mix was done as per E.F.N.A.R.C. guidelines and tested for fresh properties by conducting L box test, slump flow test, V funnel test and results were found satisfactory. Flowability of mixes was observed to be increased with increase of Alccofine content, which was due to increased fineness of Alccofine. Compressive strength, flexural strength, and splitting tensile strength were observed to be increased up to 10% replacement of cement with Alccofine and started decreasing after that. Thus optimum level of replacement of cement with Alccofine was assessed as 10%. Observed maximum strength in compression, flexure and splitting tensile strength after 28 day for mix having 1% glass fibre and 10% cement replaced with Alccofine, were 60.44 MPa, 10.25 MPa, and 5.16 MPa respectively, which are above acceptable values.

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AUTHORS PROFILE

Ranjan Abraham, Research Scholar in Kalasalingam Academy of Research and Education, completed his M. Tech. in Civil Engineering from Mahatma Gandhi University, Kottayam, Kerala. He has more than 14 years of teaching experience. His areas of interest are Structural Engineering and Concrete Technology.

Dr. T.R. Neelakantan is a Senior Professor in Civil Engineering and Director – Accreditation and Ranking at Kalasalingam Academy of Research and Education, Tamilnadu. He obtained his Ph.D. degree in Civil Engineering from Anna University in the year 1998. His working experiences are from Anna University, IIT-Madras, SASTRA Deemed University and the University of Kentucky, Lexington, USA. He published more than 60 articles in reputed journals, and handled many government and private funded projects both in India and USA.
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Ramesh Babu Chokkalingam, completed his Ph.D. from IIT Chennai. He has more than ten years of experience in teaching and research. His areas of research includes pervious concrete, geopolymer concrete, and high volume flyash concrete.