

# Fresh And Hardened Properties Of Alccofine Based Self-Curing High Strength Self-Compacting Concrete

P. Sivasankar, S. Karthik, K. Saravana Raja Mohan

**Abstract:** Self-compacting concrete is being vastly used in the present trend due to its self compacting ability. The main aim behind the invention of this product is to enhance good workability, strength in tougher reinforcement conditions. Now that there is scarcity of water, there will be huge demand for water in the coming future. In order to reduce the amount of wastage of water, the work has focused on self curing aspect. LECA is having the ability to act as an internal reservoir within the concrete which reduces the heat of hydration during the initial period. PEG-400 being used for regaining the water content and maintaining the moisture content within the concrete. LECA with PEG-400 makes the self compacting concrete a self curing self compacting concrete. Self-curing capacity in self-compacting concrete makes it different from conventional concrete. Alccofine 1203 at 5%, 7.5%, 10% is added as a cementitious material which enhances workability, strength and reduces heat of hydration. The fresh concrete properties, mechanical properties and performance of this concrete are observed and the effect of LECA and PEG-400 is noted.

**Keywords:** Self-compacting concrete, Self-curing concrete, Alccofine-1203, LECA, PEG-400, High strength.

## I. INTRODUCTION

**A. General** The Self-curing High strength Self-compacting concrete is a project work carried on the basis of replacing the Alccofine 1203 (5%, 7.5% & 10%) by the weight of cement in the concrete and increasing the self-curing properties of concrete when it is added with PEG-400 admixture and LECA. Self-compacting concrete is a special type of concrete which consolidates under its own weight. Self-compacting concrete requires no compaction or vibration for placing of concrete in construction site. It requires less amount of water when it is added with chemical admixture like super plasticizer and viscous city modifying agent. Self-compacting concrete is special type of concrete, it's have highly flowing capacity of congested reinforcement area of construction site without any type of vibration and compaction process. Self-compacting concrete is placed and compaction its own self weigh without any segregation and bleeding. Three types of fresh concrete properties are followed by SCC like passing ability, filling ability and segregation resistance as per EFNARC guidelines.

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Cement is replaced by using the alccofine-1023 by (5, 7.5 and 10%) of total weight of cement content. Alccofine-1203 is the ultra fine material is having silica of 35% and its gives good pore structure of self-compacting concrete. Advanced low viscosity high performance polycarboxylic Superplastizer is used to reduce the water content in up to 30% of self-compacting concrete and increasing the workability. In this concrete after casting is treated to the two different types of curing process, one is water immersion curing and another is a self-curing method. Self-curing is having two type of curing stage, one is internal curing stage and another is external curing stage. LECA is used to the internal curing process and PEG-400 is used to the external curing process.

## B. Research Significance

In the present investigation, a thorough literature review has been performed to use Alccofine one of the supplementary cementitious material along with LECA as a replacement of coarse aggregate as to internal curing for produce high strength concrete which can sustain aggressive environment. Details regarding the strength along with its workability and performance were also studied. Various tests on harden concrete were performed in order to find the effectiveness in each aspect of deterioration.

## II. MATERIALS AND PROPERTIES

OPC 53 grade cement, Potable water, River sand, crushed stone aggregates and LECA were used as raw materials of self-compacting concrete. Alccofine 1203 has been used as a partial replacement of mass of cement content.

### A. Binder Materials

Dalmia OPC grade 53 of ASTM Type-1[1] procured from local cement suppliers was used for this investigation and cement replaced by another binder material likes Alccofine (5%, 7.5%, 10%) of weight of cement . Alccofine1203 is ultra fine supplementary cementitious material obtaining from Ambuja cements limited, Mumbai. It's used to increases a tightness of concrete and gives good pore structure of concrete its conforming IS 12089. The chemical and physical properties listed in Table-1 and Table-2.

**Table -1** Chemical Properties of Binder Materials

Component	OPC (%)	Alccofine 1203 (%)
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SiO <sub>2</sub>	20.63	35.7
Al <sub>2</sub> O <sub>3</sub>	6.96	21.8
Fe <sub>2</sub> O <sub>3</sub>	3.4	1.4
CaO	61.35	33.6
SO <sub>3</sub>	2.28	0.13
MgO	2.89	6.3

**Table-2** Physical Properties of Binder Materials

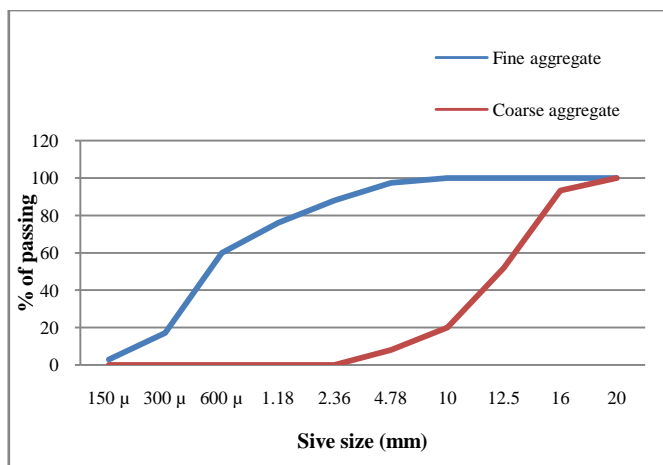
Properties	OPC	Alccofine 1203
Initial Setting time (min)	31	
Consistency (%)	29	
Specific gravity	3.15	2.85
Fineness (cm <sup>2</sup> /gm)	2250	12000
Bulk density (kg/m <sup>3</sup> )	1437	677

## B. Aggregates

River sand has been used as fine aggregate (> 50% of total aggregates) is conforming to zone II grading as per standard of ASTM and crushed stone is used as coarse aggregate (< 50% of total aggregates as per EFNARC 2002) of this investigation. Light weight expand clay aggregate (LECA) is used to 5% replacement of weight of coarse aggregate for internal curing. The properties of aggregates is following the Table-3 and Fig. 1

**Table-3** Physical Properties of Aggregates

Properties	F.A	C.A	LECA
Size (mm)	3.26	12.5	Below 10 mm
Specific Gravity	2.64	2.71	1.17
Fineness Modulus	3.18	6.9	1.63
Water Absorption (%)	0.89	1.87	21



**Fig. 1** Fineness modulus of fine aggregate and coarse aggregate

## C. Chemical Admixtures

Advanced low viscosity high performance polycarboxylic Superplastizer namely (AURAMIX 400) was used for this investigation to increase workability and reduced a water content of concrete. This Superplastizer from Fosroc chemical (Indian) pvt ltd. Polyethylene glycol (PEG 400) is a shrinkage reducing admixture is act to external self-curing agent of self-compacting concrete its obtains from Arihant solvents and chemicals. Viscosity modifying admixture (AURAMIX V100) is used to adjust the fresh self-placing concrete properties without segregation and bleeding [6]. Chemical admixtures properties following by Table-4

**Table-4** Properties of Chemical Admixtures

Properties	S.P	VMA	PEG-400
Appearance	Light yellow	Muddy liquid	Colorless liquid
Specific gravity	1.12	1.02	1.127
Chloride ion content	Nil	Nil	Nil
pH	6.1	≤ 6	4.5 – 7.5

## III. MIX DESIGN & CASTING PROCEDURE

### A. Mix Design

Self-compacting concrete trial mixes maintained the water/powder ratios 0.3 of all WC-SCC and SC-SCC mixes of this investigation. Many trial mixes is contacting to casting the specimens to fresh and harden concrete tests. Finally getting an optimum strength mix and fixed. Cement is replaced that optimum SCC mix by using alccofine 1203 with different percentage (5%, 7.5%, 10%) of weight of cement. From the trial mixes we got optimum chemical admixtures like Superplastizer is 2%, PEG400 is 2% and viscous city modifying admixtures is 0.2% of weight of total binder content of self-compacting concrete. Coarse aggregate is replaced by using of light weight expand clay aggregate (LECA) in 5% of weight of crushed stone aggregate.

**Table-5** Mix Composition of SCC

Materials (kg/m <sup>3</sup> )	WC - SC C- 0%	WC - SC C- 5%	WC - SC C- 7.5 %	WC - SC C- 10 %	SC-SC C- 0%	SC-SC C- 5%	SC-SC C- 7.5 %	SC-SC C- 10 %
Cement	750	712.5	693.75	675	750	712.5	693.75	675
Alccofine 1203	----	37.5	56.25	75	----	37.5	56.25	75
Fine aggregate	550	550	550	550	550	550	550	550

Coarse aggregate	400	400	400	400	380	380	380	380
LECA	----	----	----	----	20	20	20	20
Water	141	141	141	141	126	126	126	126
Superplast iciser	15	15	15	15	15	15	15	15
Viscosity modifying agent	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
PEG-400	----	----	----	----	15	15	15	15
Curing conditions	Wat er Curi ng	Wat er Curi ng	Wat er Curi ng	Wat er Curi ng	Self Curi ng	Self Curi ng	Self Curi ng	Self Curi ng
W/C	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

**B. Casting Procedure**

Raw materials of self-compacting concrete is dry mixed by using the batch mixer, after dry mix added half of water in the concrete and mix 2 minutes. Lastly added binder content of SCC to the batch mixture, another half of water and chemical admixtures is mixed well then gradually adding the chemical mixed water to the inside of batch mixture and mix one more 2 minutes. After mixing the concrete check the fresh concrete properties of SCC. After completed fresh concrete properties test casting the 100 x 100 x 100 mm cube specimen [10] for compressive strength test, 100 x 200 mm cylindrical specimen for split tensile strength test and 100 x 100 x 500 mm of rectangular beam specimen for flexure strength [9] were casted. After 24 hours, demould these concrete specimens and put into two type of curing conditions.

**C. Curing process**

**IV. RESULT AND DISCUSSION**

**A. Fresh Concrete Properties**

Self-compacting concrete is having a three type of fresh concrete properties like passing ability, filling ability and segregation resistance. Passing ability of SCC is estimate by the J-ring test; filling ability is find out by using slump flow test and slump T<sub>50</sub> test. And third fresh concrete properties of SCC are segregation resistance from V-funnel T<sub>5sec</sub> test. In slump cone test, fresh concrete is putting in the inside of slump cone (top diameter 100 mm, bottom diameter 200 mm and height 300 mm) [7]. After lifting the

slump cone that concrete is covered 600 – 800 mm diameter of floor. Slump T<sub>50</sub> is same procedure of slump flow test but in this test we record the time period of SCC concrete covered 50cm diameter of floor. In the range of Slump T<sub>50</sub> is below 5 sec. H1 / H2 ratio of J- ring test is 0.8- 1 [7]. V-funnel test is used to find out the segregation resistance properties of self-compacting concrete. In this test we

Curing is an important process of concrete during hydration period to get targeted mean strength. In this investigation two type of curing process done by all concrete mixes. One is a water immersion curing and another is self-curing, both curing process is carried out by 7 and 28 days time period. In immersion curing process we use portable water without any chemical impurities. In self-curing process we maintain the ambient temperature and plastic shrinkage cracks not occurring in self-curing concrete because we use shrinkage reducing admixture likes PEG400. Water curing and self-curing is represented by following Fig.2 and Fig.3.



**Fig. 2 Self-curing of SCC**



**Fig. 3 Water curing of SCC**

measured the concrete flow time of SCC its range is below 15 sec [7]. Table 6 is representing in the fresh concrete properties of SCC.



**Fig.4 J-ring test**



**Fig.5 V-funnel  $T_{5min}$  test**



**Fig.6 Slump flow test**

**Table-6** Fresh Concrete Properties of Water Curing SCC and Self-Curing SCC

MIX NAME	FILLING ABILITY		PASSING ABILITY	SEGREGATION RESISTANCE
	Slump flow test	Slump $T_{50}$ test	J- ring test ( $H_1 - H_2$ )	V- Funnel $T_{5min}$ test
	(mm)	(Sec)	(mm)	(Sec)
WC-SCC-0%	735	2.15	2.4	6.5
WC-SCC-5%	755	2.54	2	6.3
WC-SCC-7.5%	740	2.32	3	6.7
WC-SCC-10%	710	3.07	4.5	7.2
SC-SCC-0%	727	2.24	2	6.3
SC-SCC-5%	761	2.4	2.5	6.6
SC-SCC-7.5%	743	3.2	2.2	7.6
SC-SCC-10%	718	2.81	3	7.1

and 28 days test we caste 3 concrete specimens for hardened concrete test in each concrete mix.

**B. Hardened Concrete Properties**

The hardened properties of self-compacting concrete is determine by compressive, spilt tensile and flexure strength tests. Testing specimen like cube (100 x 100 x 100 mm), cylinder specimen (100 x 200 mm) and flexure specimen (100 x 100 x 500 mm) as per IS 516- 1959 [10]. Fig 7 is listed harden concrete tests. Before hardened concrete test we check plastic shrinkage cracks on the surface of both water immersions curing SCC and self-curing SCC. Fig 8, Fig 9 and Fig 10 are represented compressive strength of SCC, spilt tensile strength of SCC and flexure strength of SCC. After 7 and 28 days curing process we take weight of each concrete specimen and tested the hardened concrete specimen by using of compression testing machine for cubes and cylinder at loading rate of 140 kg/cm<sup>2</sup>/sec. Flexural specimen is tested by using static bending testing machine. After testing process cube, cylinder and flexural specimen is noted for crack patterns. From the specimen results, compare the normal water curing to self-curing concrete specimens. In 7



**Fig.7 Tests of hardened concrete**



4.2.1 Compressive Strength.

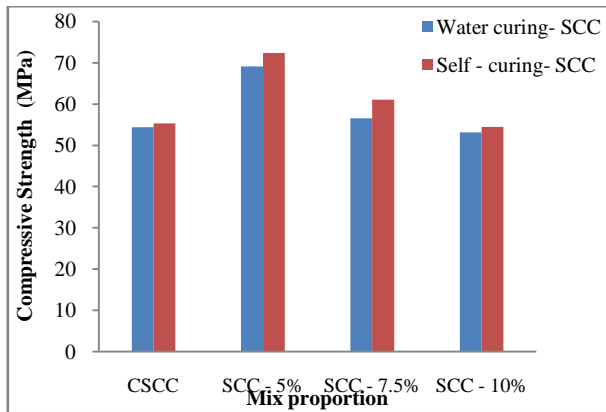


Fig. 8 Compressive Strength of SCC

4.2.2 Split Tensile Strength

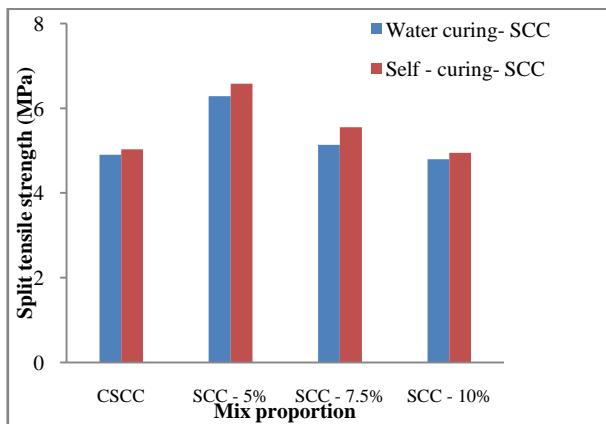


Fig. 9 Split Tensile Strength of SCC

4.2.3 Flexural Strength

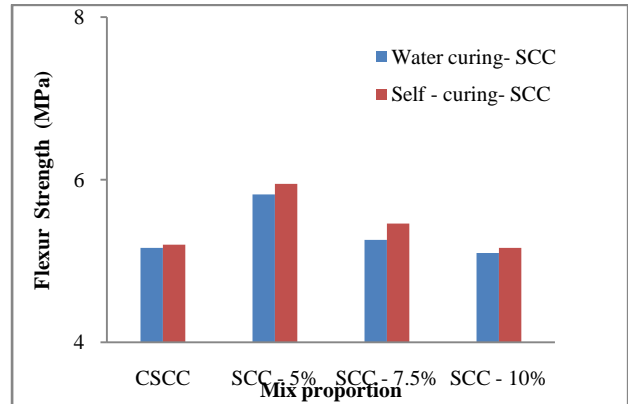


Fig. 10 Flexural Strength of SCC

V. CONCLUSION

From this investigation fix the SCC trial mix and replaced cement by using Alccofine-1203 and coarse aggregate is replaced by using light weight expand clay aggregate (LECA) in weight of crushed stone.

- Fresh concrete properties of without alccofine and 5% of alccofine replacing self-compacting concrete is more sufficient to compared to 7.5% and 10% of alccofine replacing SCC.
- Density of self-curing SCC is 6 -8% lower to compare normal water immersion curing self-compacting concrete.
- 5% of alccofine replacing concrete mix is get more compressive strength in both self-curing and normal water curing self-compacting concrete compared to all other mixes.
- Combination of LECA and PEG-400 gives good curing properties of self-compacting concrete compared to water curing.
- Optimum mix (SCC-5%) is achieved more than 65 MPa. Hence, SCC-5% is high strength concrete as per IS 456- 2013.
- Plastic shrinkage cracks were does not occur in the self-curing SCC compared to normal water curing self-compacting concrete.

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