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Fresh Properties of Self Compacting Concrete using fly ash and Alccofine

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Abstract: ***Self compacting concrete (SCC) is emerging technology in the construction industry. SCC has the ability to flow and fill the formwork without using any external vibrations. In this study, fresh properties of ternary blended SCC using fly ash (FA) and alccofine (AF) are investigated. In this study, SCC mixes are manufactured in two categories. In the first category, the replacement level of FA was kept at 30% for all concrete mixes with varying dosages of AF (0%, 5%, 10% & 15%). In the second category, the replacement level of mineral admixtures (FA and AF) was kept at 35% with varying dosages of AF (0%, 5%, 10% & 15%). SCC fresh properties were investigated using slump flow, V-funnel & L-box tests. From the first and second category test results, it is observed that the optimum replacement of alccofine can be taken as 10%.***

Index Terms: Self Compacting Concrete, Cement, Fly Ash, Alccofine, Fresh Properties.

I. INTRODUCTION

In the construction industry, concrete used as a construction material throughtout the world. The novel improvement of construction materials has been changing to meet the real world problems. For the sustainable concrete structures, concrete should be more durable and good quality throughout the construction [1]. Nowadays, various emerging trends have been implemented for the enhancement of properties of concrete.

Self compacting concrete is one of the innovative and emerging construction materials which were developed by Okamura in Japan in late1980s to overcome the problems of external vibrations and labour deficiency. It has more advantages compared to conventional concrete like it attains homogeneity without bleeding and segregation and it can easily pass through the congested reinforcing bars under its self-weight without considering any mechanical vibrations [2]. This type of SCC was fulfilled by considering the passing ability, filling ability and high segregation resistance of fresh state SCC. SCC was prepared as same as conventional concrete, used materials are cement, aggregate, and water. With the addition admixtures are used to enhance the properties of SCC, this is the main difference to made of SCC compared to conventional concrete [3]. SCC was prepared with reducing the volume of coarse aggregate so to minimize the risk of flow through the congested bars. Usage of chemical admixtures into the SCC, its cost is increased and also due to high amount of cement most heat of hydration is produced. For the overcome of these problems, mineral admixtures those are byproducts or waste products are used to improve the properties of SCC. Most of the studies shown that mineral admixtures used in concrete were cost effective and reduce the cement content with an improved workability. mineral admixtures used in concrete not only reduce the cost, heat of hydration is controlled due to this thermally induced cracking of concrete is to be reduced [4 & 5]. Previous studies proved that different mineral admixtures including fly ash, GGBS, rice husk ash, silica fume are effect as enhance the properties of both fresh and hardened concrete and reduce water content with good homogeneity.

Bletty Baby and Jerry Anto (2017) investigated on self-compacting concrete containing micro steel fibers and alccofine with partial replacement on cement. They studied on alccofine with 5%, 10% & 15% replacement of cement and they get 10% as the optimum for both fresh and hardened state. Further with 10% alccofine they include micro silica fibers with 0.5%, 1% & 1.5% replacement on cement, they conclude that SCCA-10, M1% gives good results than normal mix SCC [6]. TusharBansal, Shilpa pal & Jaya Maitra (2018) studied on the performance of partial varying the alccofine and Metakoaline percentages (3%, 6%, 9%, 12% &15%) on M60 grade of SCC with constant fly-ash. They conduct the tests on fresh property (slump flow, v funnel, l-box tests) of mix SCC with different retention times of 30, 60, 90 mins, mechanical properties like compressive test were conducted at 7 & 28 days. Their experiment results showed that with increasing percentage from 3% to 15% of Metakaoline, slump flow, blocking ratio decreases and flow time increases with different retention times as compared to normal AF1mix. It is not acceptable for SCC.And with increasing percentage (3% to 15%) of alccofine, slump flow, blocking ratio increases and flow time decreases with different retention times as compared to control mix, acceptable for workability improvement of SCC. The compressive strength was increased to 72.43 MPa to 80.2 MPa up to 12% replacement of alccofine and Metakoaline on SCC further it decreased [7]. M.S. Pawar and Saoji (2013) investigated on alccofine as partial replacement and fly ash keep constant into the cement. They concluded that the physical characteristics of SCC, mechanical properties increased up to 10% alccofine replacement of cement compared alccofine 5% & 15% replacement. Manisha and Karjini investigated on alccofine as 5%, 7.5% & 10% by weight of the cement and fiber volume 1.5% fraction by concrete volume added to find the

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mechanical and fresh properties of concrete. Hybrid fibers enhance the flexural strength as partial replacement of cement in concrete and varying alccofine increases the compressive strength of the fiber reinforced concrete [8]. SinhaDeepa and Sabuwala have reported that pozzolanic materials of alccofine and fly ash act as a highly durable concrete specimen. They showed that alccofine gives the higher slump flow value in concrete but increasing of fly ash gives lesser slump value [9].

In the present study, the main objective is to replace the cement with varying proportions of fly ash and alccofine to investigate the fresh properties of SCC.

II. MATERIALS

A. Materials

Cement was the one of the important material used as a construction material. Ordinary Portland cement of 53 grade was used in this study for the grade of concrete [10]. The physical and chemical properties of OPC 53 grade are shown in below Table 1.

Table 1 Physical Properties of cement

Characteristics	Test Results	Values asper BIS:12269 - 2013
Grade	53	53
Fineness modulus	6.5%	< 10%
Specific gravity	3.12	3.15
Standard consistency	32%	30% - 35%
Initial setting time	50 min	>30 min
Final setting time	450 min	< 600 min
Soundness	1.2 mm	< 10 mm

B. Fly ash

Fly ash is an industrial by-product obtained from the coal industry by electrostatic furnace, which a fuel ash is obtained from the pulverized coal. The size of the fly ash particle is 10-25µm. It helps to enhance the fluidity, workability of concrete and decrease the permeability of concrete; those are forming good quality of fly ash. The quality of class F fly ash is confirmed by IS 3812-2003. In this study used fly ash has specific gravity is 2.3.

Table 2 Fly ash Physical properties

Characteristics	Test Results
Fineness modulus	1.19%
Specific Gravity	2.3

C. Alccofine

Alccofine is a new product from Ambuja cement, based on the slag of high glass content with low calcium silicate. Alccofine 1203 is an ultrafine cementitious material; reduce water demand up to 70% replacement for a given workability of concrete structures. Alccofine 1203 was used as confirmed by ASTM C989-99. The physical properties of alccofine are shown in Table 3.

Table 3 Physical properties of alccofine

Characteristics	Test Results
Specific Gravity	2.9
Specific surface area (m^2/kg)	1200
Bulk density (kg/m^3)	680
Particle	
D_{10}	1.5 Micron
D_{50}	5 Micron
D_{90}	9 Micron

D. Fine aggregate

River sand confirming to zone II was used as fine aggregate. Specific gravity of fine aggregate was 2.682 [9]. The fine aggregate confirmed to IS 383-1970 was used.

Table 4 Physical properties of fine aggregate

Characteristics	Test Results	Values asper BIS:12269 – 2013
Specific gravity	2.682	2.1-3.2
Fineness modulus	2.71%	2-4%
Water absorption	1.023%	< 5%

E. Coarse aggregate

Crushed stone used as coarse aggregate in this study, the size of the aggregate used as below 12mm, this range of aggregates reduce the inter blocking effect of SCC in congested areas; it can improve the flow ability without blocking of the particles [9]. The specific gravity of 2.781 was used as coarse aggregate in this study.

Table 5 Physical properties of Coarse aggregate

Characteristics	Test Results	Values asper BIS:12269 – 2013
Specific gravity	2.781	2.1-3.2
Fineness modulus	7.22%	6.5-8%
Water absorption	0.83%	< 5%

F. Superplasticizer

Superplasticizer is a high range water reducing admixture used to reduce water content for required workability of SCC. In this study, Conplast SP430 was used as a superplasticizer.

Table 5 Physical properties of Superplasticizer

Characteristics	Test Results
Appearance	Brown liquid
Specific gravity	1.20
Chloride content	Nil
Water absorption	24%

Water

Potable water was used for concrete mixing

III. FABRICATION OF SELF COMPACTING CONCRETE MIXES

In this study, SCC mixes are manufactured in two categories. In the first category, the replacement level of FA was kept at 30% for all concrete mixes with varying dosages of AF (0%, 5%, 10% & 15%). In the second category, the replacement level of mineral admixtures (FA and AF) was kept at 35% with varying dosages of AF (0%, 5%, 10% & 15%). Firstly, the materials including cement, sand, coarse

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aggregate, fly ash and alccofine were added into the pan mixer and mixed properly for 5 minutes. Afterwards premixed liquid including water with superplasticizer was added to the dry mixture of the pan and mixed for 5 minutes. Having prepared fresh mixes, the fresh properties of SCC such as filling ability, passing ability and high segregation resistance were investigated using slum flow, V-funnel and L-box tests. Filling ability is the ability to flow under its self-weight into all spaces within the formwork. Passing ability of SCC is the ability to pass through congested openings such as gap between steel and reinforcing bars under its self-weight. Segregation resistance is the ability to maintain uniform paste throughout the process of transporting and placing, without separation and migration. The fabrication of concrete mixes of two categories is shown in Table 6.

Table 6 Fabrication of SCC mixes

Mixes	Cement	Fly ash	Alccofine
First Category			
FA30AF0	70%	30%	0%
FA30A5	65%	30%	5%
FA30A10	60%	30%	10%
FA30A15	55%	30%	15%
Second Category			
FA30A5	65%	30%	5%
FA25A10	65%	25%	10%
FA20A15	65%	20%	15%

IV. FRESH PROPERTIES

For finding fresh properties of SCC, different tests are conducted on fresh SCC including T_{50} slump test, V-funnel and L-box tests. These tests are helpful to evaluate the workability and consistency of SCC.

A. Slump flow & T_{50} test

This test is used to determine the filling ability characteristic of SCC. Present days slump flow test is one of the most commonly used SCC tests. Firstly, fresh concrete is poured into the frustum cone. When cone lifted upwards it spread evenly and reaches up to 50cm diameter within limiting time. The main difference of the slump flow test to the conventional slump as per ASTM C 143 is the slump flow measures the spread and flow property of concrete.

B. L-Box Test

This test is used to determine the passing ability of SCC. In this test, the concrete is poured into the L-box of vertical part. When the control gates are lifted, the fresh concrete flows through the horizontal part of L-box and then determine the blocking ratio of h_2/h_1. If concrete flows freely into the horizontal part within limiting value it gives good workability of SCC.

C. V-Funnel

This test is used to assess the filling ability and viscosity of SCC. The fresh concrete poured into the V funnel apparatus with maximum aggregate size of 20mm. the funnel is filled with approximately 12 liters of concrete and the time it takes through the apparatus is measured, record as the V funnel flow time. The above fresh of acceptance range are detailing in the Table 7.

Table 7 SCC-Workability requirements as per EFNARC [11]

Test method	Properties	Limiting Value
Slump Flow	Filling ability	650-800 mm
T50	Filling ability	2-5 Sec
L-Box	Passing ability	0.8-1.0
V-Funnel	Viscosity	6-12 Sec

1. RESULTS AND DISCUSSION

A. Fresh properties

SCC fresh properties of two categories are represented in Table 8.

Table 8 Fresh properties of SCC mixes

Mixes	Slump flow (mm)	T_{50} (Sec)	V-funnel (Sec)	L-box (h_2/h_1)
First Category				
FA30AF0	690	2.72	6.24	0.98
FA30AF5	640	3.14	7.86	0.89
FA30AF10	685	2.86	6.83	0.95
FA30AF15	540	6.31	13.71	0.71
Second Category				
FA30AF5	640	3.14	7.86	0.89
FA25AF10	651	2.82	7.02	0.91
FA20AF15	632	4.91	8.67	0.81

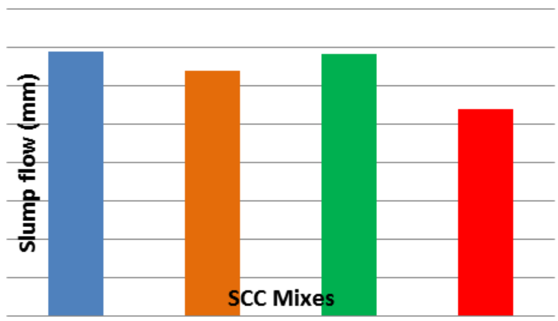

Figure 1 Slump flow of first category SCC mixes

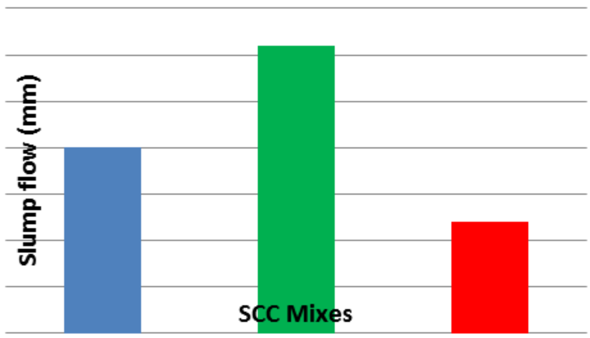

Figure 2 Slump flow of second category SCC mixes

From Table 8, it is observed that the mix FA30AF10 got the fresh properties which were almost similar to the mix

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FA30AF0. It can be said that cement can be replaced by 30% FA and 10% AF to attain successful SCC mixes. The further increase of AF beyond 10% decreased the SCC fresh properties as shown in Fig. 1. From the second category results, it is noticed that FA25AF10 got better values of SCC fresh properties when compared to those of FA30AF5. The further increase of AF to 15% decreased the SCC fresh properties as shown in Fig.2. From the first and second category test results, it is observed that the optimum replacement of alccofine can be taken as 10%.

V. CONCLUSION

1. In the first category, the combination of fly ash and alccofine has improved the workability properties of SCC up to 40% replacement of cement (30%FA and 10%AF)
2. In the second category, the combination of fly ash and alccofine has improved the workability properties of SCC up to 35% replacement of cement (25%FA and 10%AF)
3. SCC mixes with 15% alccofine performed poorly both in fresh and second categories.
4. Optimum dosage alccofine can be taken as 10% for successful SCC mixes

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