ANALYSIS OF SELF-COMPACTING CONCRETE'S STRENGTH BEHAVIOR WITH ALCCOFINE AND GGBS AS A PARTIALLY CEMENT SUBSTITUTE

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Abstract: The study investigates that alccofine and GGBS combination can be used in the SCC as the strength enhancer. SCC being a high performance concrete after the addition of alccofine, produces a high performance and high strength concrete. Mix design for SCC can be carried out by Nan-Su method which is considered as a simple mix design and the dosage of super plasticizer will be determined by trial and erroras substantial result of characteristics of fresh and hardened concrete and effect of alccofine (5%, 10%, 15% and 20%by volume) by keeping the GGBS percentage constant (30%) on rheological properties and strength properties were investigated. The improvement in behaviour of SCC is because of enhancement in union strength and pore refinement by GGBS. The outcome implies that the workability of SCC with 5% and 10% alccofine by volume of concrete leads to decline of other rheological properties given by codal provisions (EFNARC). In contrast, the improvement in properties of concrete like compressive strength from 36.6 to 42.9 N/mm^2 , splitting tensile strength from 3.8 to 7.9 N/mm^2 and flexural strength from 4.9 to 8.3 N/mm^2 at 28 days was observed with increase in alccofine dosage. Finally, the conclusion has been drawn that alccofine and GGBS combination can be used in the SCC as the strength enhancer.

Keywords: Alccofine, Ground Granulated Blast Furnace, High Performance Concrete, Placement of Cement, Strength Behavior

1. 0 INTRODUCTION

Self-compacting concrete has evolved as an innovative technology, capable of achieving the status of being an outstanding advancement in the field of concrete technology, making concrete structures without vibration have been done in the past. Modern application of self-compacting concrete is focused on high performance, better and more reliable and uniform quality. The methodfor achieving self-compatibility involves not only high deformability of paste or mortar, but also resistance to segregation between coarse aggregate and mortar when the concrete flows through the confined zone of reinforce inbars [1]. Such concrete should have a relatively low yield value to ensure high flow ability, a moderate viscosity toresist segregation and bleeding, and must maintain its homogeneity during transportation, placing and curing to ensure adequate structural performance and long term durability. The successful development of SCC must ensure a good balance between deformability and stability. The manual compaction of fresh concrete is replacedwith advanced semi-automatic placing technology and also result in improved health and safety conditions in and around the construction site [2].

Self-compacting concrete (SCC) represents a significant advancement in concrete technology, addressing the challenges associated with traditional concrete placement methods. Developed in the late 1980s in Japan, SCC is characterized by its ability to flow and fill molds under its own weight, achieving uniformity and density without the need for mechanical vibration (Okamura & Ouchi, 2003). This property not only enhances workability but also improves the overall quality of concrete structures.

The formulation of SCC involves a careful balance of materials, including high-quality cement, well-graded aggregates, and supplementary cementitious materials, which work in tandem with chemical admixtures to achieve the desired performance (Fagerlund, 2008). The use of superplasticizers is particularly crucial, as they significantly reduce water content while maintaining the concrete's workability.

One of the key advantages of SCC is its ability to flow into complex geometries and around congested reinforcement, which is particularly beneficial in high-performance applications such as bridges, high-rise buildings, and precast elements (Gravina et al., 2013). Additionally, SCC minimizes the risk of segregation and bleeding, leading to improved durability and reduced maintenance needs over the lifespan of the structure.

The adoption of SCC has been steadily increasing worldwide, driven by its numerous benefits, including reduced labor costs, faster construction times, and enhanced structural integrity. As the construction industry continues to evolve, the role of self-compacting concrete is likely to expand, contributing to more efficient and sustainable building practices.

SCC as a high performance concrete, after the addition of Alccofine it produces a high strength concrete which leads to many advantages and we can achieve a high performance and strength concrete [3].

2.0 EXPERIMENTAL INVESTIGATIONS

2.1 Materials

2.1.1 Cement

53 Grade-Ordinary Portland cement have used in research.According to IS 4031:1988, the cement was tested and it’sconfirmed to IS 12269:2004. Table 1 shows the Physicalcharacteristics of cement (OPC 53 grade).

Table 1. Physical characteristics of cement (OPC 53grade)

No.	Properties	Test Method	Test Results	LimitationsAs per IS 12269-2004

1	Normal Con-sistencyin (%)	Vicat Apparatus(IS: 4031Part- 4)	33%	30 -35 %
2	Specific Gravity	Sp. Gr bottle (IS: 4031Part-4)	3.12	≤ 3.15
3	Initial Set-ting Time	Vicat Apparatus(IS: 4031 Part - 5)	40 Min	>3
4	Final Setting time		220 Min	<600
5	Fineness of ce-ment	Sieve test on 90μSieve (IS: 4031 Part-1)	5.00%	< 10%

2.1.2 Coarse Aggregates

The aggregate of size greater than 4.75 mm is consideredas coarse aggregate. Regarding the characteristics of dis-similar types of aggregate, rounded aggregates enhance the flow be-cause of less internal friction and crushed aggregates tend to enhance the strength because of angular particles interlocking. Locally available aggregatepassing through 12 mm and retain-ing on 4.75 mm is usedfor all of the mixes of concrete. Table 2 shows the Physical characteristics coarse aggregate.

2.1.3 Fine Aggregates

siliceous sands can be used. The fine aggregate content should be in the range of 1/4th to 1/3rd of the total volume of the mix-ture. Fine aggregate plays a very importantrole in the reduction of segregation. Locally available fine aggregates passing through 4.75 mm sieve was used for all of the mixes of concrete. According to IS: 383-1970, zoneII the aggregates used were confirmed. Table 3 shows Physical properties of Fine Aggre-gate

Table 2. Physical characteristics coarse aggregate

No	Physical prop-erties	Results	Code of refer-ence
1	Specific gravity	2.65	IS 2386 part 3-1986
2	Water absorption	0.15%	IS 2386 part 3-1986
3	Bulk density(kg/m^3)	1366 (loose) 1439 (rodded)	IS 2386 part 3-1986
4	Finess modulus	2.81	IS 2386 part 2-1986
5	Impact value	9.76%	IS 2386 part 3-1986
6	Loss angles abra-sion	35.4%	IS 2386 part 3-1986
7	Flakiness index	14.06%	IS 2386 part 3-1986
8	Elongation index	62.4%	IS 2386 part 3-1986

Table 3. Physical properties of fine aggregate

No	Physical properties	Results	Code of reference
1	Specificgravity	2.5	IS 2386 part 3-1963
2	Finess modulus	2.81	IS383-1970
3	Bulking	10%	IS 2386 part 3-1963
4	Bulk density	1432 (loose) 1600 (rodded)	IS 2386 part 3-1963

2.1.4 Alccofine

Alccofine is high glass content, high reactivity and special prod-uct formed through the process of controlled granulation its The properties of workability tests are as shown in Table 6 and results confirms to minimum and maximum recom-mended values even after replacement of cement with GGBS 30% and alccofine (5 to 20%) variation. As an in-crease of alccofine the slump flow also increases linearly.

raw material primarily consists of low calcium silicates. This meting out with other select ingredients results in controlled particle size distribution. It reduces water requirement for a given workability and resulted in improved compressive strength.

2.1.5 GGBS: Filler (GGBS)

Ground granulated Blast furnace slag cement is in usefor moderately long period due to the overall economic system in their creation as good as their enhanced performance character-istics in aggressive environments. GGBSis received by using quenching molted iron slag froma blast kiln in water or steam to supply a glassy grainy product. Then it is dehydrated and grounded in to a best powder. In the last decade a fine deal of study work has been performed addressing the effectively of GGBS. Table 4 shows Physical properties of GGBS.

Table 4. Physical properties of GGBS

Sl.No	Physical Properties	GGBS
1	Specific Gravity	2.65
2	Fineness modulus	2.83
3	Bulk1density(loose, compacted)(kg/m^3)	1346, 1480

2.1.6 Super Plasticizer (SP)

It is a chemical admixture which develops the workability without adding any additional water. In present work, Glenium B233 commercially available super plasticizer brand is used. Table 5 shows Properties of Glenium B233(Super plasticizer).

Table 5. Properties of glenium B233 (super plasticizer)

Parameters	**Results**	**Specifications(as perIS 9103)**
Physical state	Light brown liquid	Light brown liquid
Chemical name of active Ingredient	Polycarboxylate Poly-mers	Polycarboxylate Poly-mers
Relative densityat 25 C	1.083	1.08±0.02
Ph	6.92	Min.6
Chloride ioncontent (%)	0.0079	Max 0.2
Dry materialcontent	34.58	34 (±5%)

3.0 RESULTS

Results of the study made on self-compacting self-curing concrete by replacing the cement by 30% using GGBS and alc-cofine content varied from 5%, 10%, 15% and 20%. Their workability and strength characteristics has been presented under various heading and tabulated in tables and figures.

3.1 Fresh Properties of SCC

The workability tests are carried out for the mixes NSCC, PM1, PM2, PM3 and PM4 with a replacement of cement with GGBS 30% and alccofine 5%, 10%, 15% and 20%.

Thus the combination of GGBS and alccofine replacement cement is suitable for SCC as it satisfies mostof the worka-bility recommendation of EFNARC.

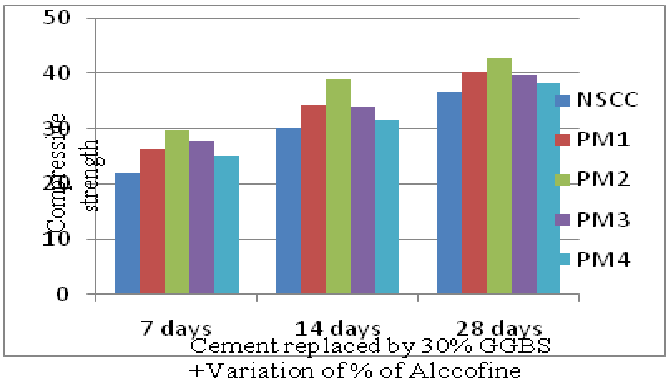
3.2 Hardened Characteristics of SCC

3.2.1 Compressive Strength

The test for determining compressive strength for concrete employs a cube specimen of 150 mmX150 mm sizeand permitted to cure in water and self for 7, 14, and 28 days which is subjected to compression in a compression

Figure 1. Variation of compressive strength for different mixproportions.

Table 6. Workability of fresh SCC



Sl No	Description	SCC	PM1	PM2	PM3	PM3	EFNARC Values	
							Min	Max
1	Slump flow (mm)	655	670	690	710	720	650	800
2	T50 cm Slump flow (sec)	4	3	2	2	2	2	5
3	V-funnel (sec)	9	8	8	7	7	6	12
4	V-funnel T5 Min (sec)	13	11	10	8	7	0	3
5	L-box (H2/H1)	0.8	0.8	0.9	0.95	0.92	0.8	1

Testing machine. The experimental results of compressive strength test are as shown in Table 7.

As noted from the above results PM2 with 10% of Alccofine and 30% GGBS has giving high compressive strength in the early ages (7 and 14 days) and little less strength in later days (28 days). The maximum enhancement in the compressive strength was 40% replacement of cement [4] with GGBS and Alccofine. Variation of compressive strength of normal SCC (NSCC) and other mix proportions (PM1, PM2, PM3 and PM4) as shown in Figure 1.

Table 7. Variation of compressive strength for different mix proportions

Sl.No.	Mix	Average Compressive Strength N/mm2		
		7 Days	14 Days	28 Days
1	NSCC	21.9	30.2	36.6
2	PM1	26.2	34.2	40.2
3	PM2	29.6	38.9	42.9
4	PM3	27.7	33.9	39.8
5	PM4	25.2	31.6	38.2

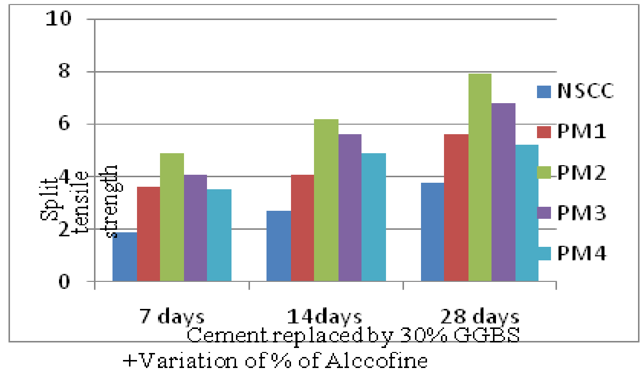


Figure 2. Variation of split tensile strength for different mixproportions.

3.2.2 Split Tensile Strength

The test for determining split tensile strength for concreteemploys a cylinder specimen of 150 mm X 300 mm sizeand specimens permitted to cure water for 7, 14 and 28 days which is subjected to compression in a compressiontesting machine. The variation of split tensile strength ofnormal SCC (NSCC) and other mix proportions (PM1, PM2, PM3 and PM4) is shown in [7] Table 8 and Figure 2.

Table 8. Variation of split tensile strength for different mix proportions

No.	**Mix**	**Split Tensile Strength (N/mm2)**		
		7 Days	**14 Days**	**28 Days**
1	NSCC	1.9	2.7	3.8
2	PM1	3.6	4.1	5.6
3	PM2	4.9	6.2	7.9
4	PM3	4.1	5.6	6.8
5	PM4	3.5	4.9	5.2

Table 9. Variation of flexural strength for differentmix proportions

No	**Mix**	**Flexural strength (N/mm2)**		
		7 Day	**14 Day**	**28Day**
1	NSCC	3.1	4.3	4.9
2	PM1	4.3	5.6	6.1
3	PM2	5.6	6.9	7.1
4	PM3	6.1	7.4	7.9
5	PM4	6.8	7.9	8.3

Siliceous sands can be used. The fine aggregate content should be in the range of 1/4th to 1/3rd of the total volume of the mixture. Fine aggregate plays a very importantrole in the reduction of segregation. Locally available fine aggregates passing through 4.75 mm sieve was used for all of the mixes of concrete. According to IS: 383-1970, zoneII the aggregates used were confirmed. Table 3 shows Physical properties of Fine Aggregate

4. Conclusion

From the study the following conclusion are drawn:

- GGBS and Alccofine combination was witnessed to improve the mechanical and rheological characteristics of

SCC which can results in high performance as well as high strength concrete.

- Mix design for SCC can be carried out by Nan-Su method which is considered as a simple mix design and the dosage of super plasticizer will be determined by trial and error as substantial result of characteristics of concrete.
- Workability characteristics of SCC with GGBS and Alccofine at different percentages satisfies EFNARC recommended values. Hereafter it can be used to producing SCC.
- The strength difference between GGBS and alccofine proportioned SCC specimens and control SCC specimens became high distinct in the beginning age of curing itself.
- Compressive strength and split tensile strength variation for the replacement of cement to a level of 30% GGBS and 10% of Alccofine, indicate that an optimum replacement level. The observed maximum strength in compression and tension was 42.3 N/mm2 and 7.9 N/mm2.
- The addition of GGBS and Alccofine made the SCC very resistive in flexure and maximum improvement in 28 days strength was observed to be 8.3 N/mm2, hence additions SCC increases the flexural strength.

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