

Evaluation of Strength Behavior of Self-Compacting Concrete using Alccofine and GGBS as Partial Replacement of Cement

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Abstract

Background/Objectives: 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. **Methods/Statistical Analysis:** 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 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. **Findings Applications/Improvements:** 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/mm², splitting tensile strength from 3.8 to 7.9 N/mm² and flexural strength from 4.9 to 8.3 N/mm² 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. 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 method for 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 reinforcing bars¹. Such concrete should have a relatively low yield

value to ensure high flow ability, a moderate viscosity to resist 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 replaced with a advanced semi-automatic placing technology and also result in improved health and safety conditions in and around the construction site².

SCC as a high performance concrete, after the addition of Alccofine it produces a high strength concrete which leads to many advantages³ and we can achieve a high performance and strength concrete.

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2. 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's confirmed to IS 12269:2004. Table 1 shows the Physical characteristics of cement (OPC 53 grade).

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

No.	Properties	Test Method	Test Results	Limitations As per IS 12269-2004
1	Normal Consistency in (%)	Vicat Apparatus(IS: 4031Part- 4)	33%	30 -35 %
2	Specific Gravity	Sp. Gr bottle (IS: 4031Part- 4)	3.12	≤ 3.15
3	Initial Setting Time	Vicat Apparatus(IS: 4031 Part - 5)	40 Min	>3
4	Final Setting time		220 Min	<600
5	Fineness of cement	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 considered as coarse aggregate. Regarding the characteristics of dissimilar types of aggregate, rounded aggregates enhance the flow because of less internal friction and crushed aggregates tend to enhance the strength because of angular particles interlocking. Locally available aggregate passing through 12 mm and retaining on 4.75 mm is used for all of the mixes of concrete. Table 2 shows the Physical characteristics coarse aggregate.

2.1.3 Fine Aggregates

Aggregate of size less than 4.75 mm is considered as fine aggregate. Both rounded and crushed sands/calcareous

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 important role 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, zone II the aggregates used were confirmed. Table 3 shows Physical properties of Fine Aggregate

Table 2. Physical characteristics coarse aggregate

No	Physical properties	Results	Code of reference
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 abrasion	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	Specific gravity	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 product formed through the process of controlled granulation its 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 use for moderately long period due to the overall economic system in their creation as good as their enhanced performance characteristics in aggressive environments. GGBS is received by using quenching molted iron slag from a 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	Bulk density(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 per IS 9103)
Physical state	Light brown liquid	Light brown liquid
Chemical name of active Ingredient	Polycarboxylate Polymers	Polycarboxylate Polymers
Relative density at 25 C	1.083	1.08±0.02
Ph	6.92	Min.6
Chloride ion content (%)	0.0079	Max 0.2
Dry material content	34.58	34 (±5%)

3. Results

Results of the study made on self-compacting self-curing concrete by replacing the cement by 30% using GGBS and alccofine 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%. The properties of workability tests are as shown in Table 6 and results confirms to minimum and maximum recommended values even after replacement of cement with GGBS 30% and alccofine (5 to 20%) variation. As an increase of alccofine the slump flow also increases linearly. Thus the combination of GGBS and alccofine replacement cement is suitable for SCC as it satisfies most of the workability 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 size and permitted to cure in water and self for 7, 14, and 28 days which is subjected to compression in a compression

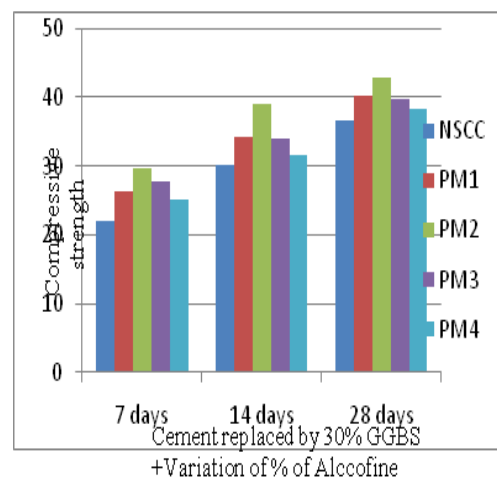


Figure 1. Variation of compressive strength for different mix proportions.

Table 6. Workability of fresh SCC

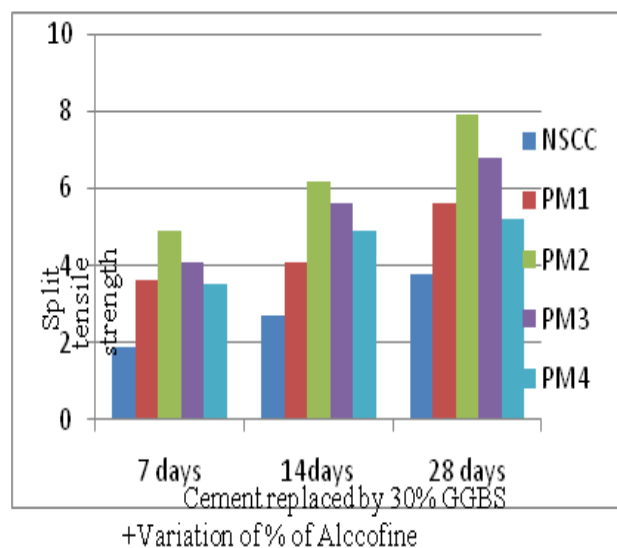
Sl No	Description	SCC	PM1	PM2	PM3	PM3	EFNARC Values	
							Min	Max
1	Slump flow (mm)	655	670	690	710	720	650	800
2	T50 cm Slump flow (sec)	4	3	2	2	2	2	5
3	V-funnel (sec)	9	8	8	7	7	6	12
4	V-funnel T5 Min (sec)	13	11	10	8	7	0	3
5	L-box (H2/H1)	0.8	0.8	0.9	0.95	0.92	0.8	1

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 cement⁴ with GGBS and Alccofine. Variation of com-

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 mix proportions.

pressive strength of normal SCC (NSCC) and other mix proportions (PM1, PM2, PM3 and PM4) as shown in Figure 1.

3.2.2 Split Tensile Strength

The test for determining split tensile strength for concrete employs a cylinder specimen of 150 mm X 300 mm size and specimens permitted to cure water for 7, 14 and 28 days which is subjected to compression in a compression testing machine. The variation of split tensile strength of normal SCC (NSCC) and other mix proportions (PM1, PM2, PM3 and PM4) is shown in 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 different mix 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

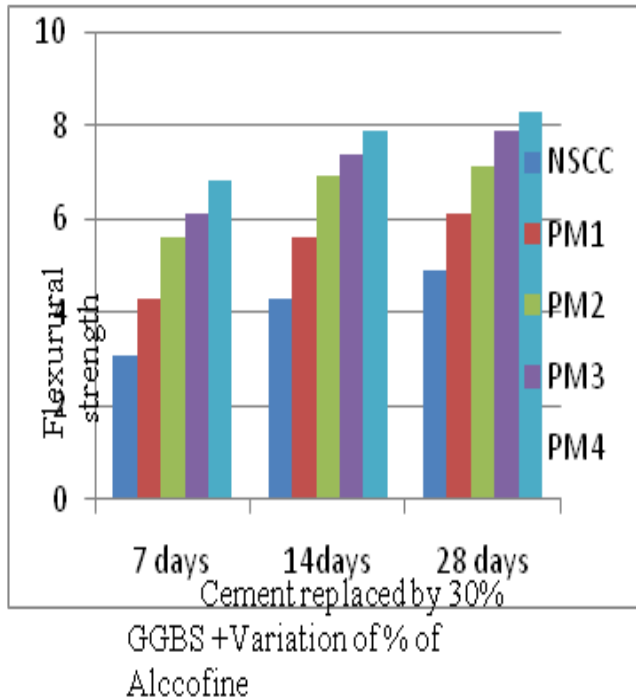


Figure 3. Variation of flexural strength for different mix proportions.

3.2.3 Flexural Strength

The test for determining Flexural strength for concrete employs a beam specimen of 150 mmX150 mmX450 mm size and specimens permitted to cure water for 7, 14 and 28 days which is subjected to compression in a compression testing machine. The variation of flexural strength of normal SCC (NSCC) and other mix proportions (PM1, PM2, PM3 and PM4) is shown in Table 9 and Figure 3.

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.

5. Acknowledgement

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6. References

1. Su N, Hsu K-C, Chai H-W. A simple mix design method for self-compacting concrete. *Cement and Concrete Research*. 2001 Dec; 31(12):1799–807.
2. Okamura H, and Ouchi M. Self compacting concrete. *Journal of Advanced Concrete Technology*. 2003; 1:5–15.
3. Pawar MS, Saoji AC. Effect of alccofine on self compacting concrete. *The International Journal of Engineering and Science*. 2013; 2(6):5–9.
4. Vanitha S, Natarajan V, Prabha M. Utilization of waste plastics as a partial replacement of coarse aggregate in concrete blocks. *Indian Journal of Science and Technology*. 2015 Jun; 8(12). DOI: 10.17485/ijst/2015/v8i12/54462.
5. John A, John E. Study on the partial replacement of fine aggregate using induction furnace slag. *American Journal of Engineering Research*. 2013; 4:1–5.
6. Rao MS, Bhandare U. Application of blast furnace slag sand in cement concrete—a case study. *IJCER*. 2014; 5(4):453–8.
7. Rahane A, Vaibhav B, Abhijeet S, Pradip S. Alccofine steel fibreself compacting concrete. *International Journal of Engineering Sciences Management*, 2016; 48–58.