



Experimental Study On Optimization Of Ggbs And Robo Sand In Self Compacting Concrete Pavements

¹Guru Brahmaiah, ²A. Siva Nagaraj

¹Post Graduate Student, SVR Engineering College, Nandyal (DT), A.P

²Assistant Professor, SVR Engineering College, Nandyal (DT), A.P

ABSTRACT:

The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in section with congested reinforcement. Use of SCC can also help in minimize hearing related damage on the work site that is induced by vibration of concrete. In this work experimental studies are carried out to understand the fresh and hardened properties of Self Compacting Concrete (SCC) in which cement is replaced by Ground Granulated Blast Furnace Slag (GGBS) and Fine aggregate by Robo sand in various proportions for M50 grade concrete. The proportions in which cement replaced are 10% of GGBS, 20% of GGBS, 30% of GGBS and 40% of GGBS. The Proportion of fine aggregate replaced at 0%, 25%, 50%, 75% and 100%. The compressive strength behavior, Flexural behavior and Split tensile strength behavior of SCC were studied along with workability. The parameters are tested at different ages in accordance with Bureau of Indian Standards (BIS) for the various proportions in which cement is replaced and also the obtained parameters are compared with normal SCC (100% cement). Super plasticizer GLENIUM 8233 is used to maintain workability with constant Water-Binder ratio. The optimum strength was obtained at 30% replacement with GGBS and 100% replacement of robo sand. But abstract the optimum strength mix failed in the aspect of workability. So the optimum mix is considered to be 30% replacement with GGBS and 100% replacement of robo sand both in strength and workability aspect.

Keywords: Self Compacting Concrete (SCC), Robo sand, GGBS, Super plasticizer GLENIUM 8233, Compressive strength, Flexural strength, Split tensile strength and Workability tests

I.INTRODUCTION

Self-compacting concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. Another advantage of SCC is that the time required to place large sections is considerably reduced.

When the construction industry in Japan experienced a decline in the availability of skilled labour in the 1980s, a need was felt for a concrete that could overcome the problems of defective workmanship. This led to the development of self-compacting concrete, primarily through the work by Okamura. A committee was formed to study the properties of self-compacting concrete, including a fundamental investigation on workability of concrete, which was carried out by Ozawa et al. at the University of Tokyo. The first usable version of self-compacting concrete was completed in 1988 and was named "High Performance Concrete", and later proposed as "Self-Compacting High-Performance Concrete".

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. The main components of blast furnace slag are CaO (30-50%), SiO₂ (28-38%), Al₂O₃ (8-24%), and MgO (1-18%). In general, increasing the CaO content of the slag results in raised slag basicity and an increase in compressive strength. The MgO and Al₂O₃ content show the same trend up to respectively 10-12% and 14%, beyond which no further improvement can be obtained. Several compositional ratios or so-called hydraulic indices have been used to correlate slag composition with hydraulic activity, the latter being mostly expressed as the binder compressive strength.

GGBS is used to make durable concrete structures in combination with ordinary portland cement and/or other pozzolanic materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years. Use of GGBS significantly reduces the risk of damages caused by alkali-silica reaction (ASR), provides higher resistance to chloride ingress reducing the risk of reinforcement corrosion and provides higher resistance to attacks by sulfate and other chemicals. Concrete containing GGBS cement has a higher ultimate strength than concrete made with Portland cement. It has a higher proportion of the strength-enhancing calcium silicate hydrates (CSH) than concrete made with Portland cement only, and a reduced content of free lime, which does not contribute to concrete strength. Concrete made with GGBS continues to gain strength over time, and has been shown to double its 28-day strength over periods of 10 to 12 years.

Environmental factors and shortage of good quality river sand has led to the invention of Manufactured Sand Also known as M Sand or Robo Sand. Natural or River sand are weathered and wornout particles of rocks and are of various grades or sizes depending upon the amount of wearing. Nowadays good sand is not readily available; it is transported from a long distance. Those resources are also exhausting very rapidly. The artificial sand

produced by proper machines can be a better substitute to river sand. The sand must be of proper gradation (it should have particles from 150 microns to 4.75 mm in proper proportion).

When fine particles are in proper proportion, the sand will have fewer voids. The cement quantity required will be less. Such sand will be more economical. Demand for manufactured fine aggregates for making concrete is increasing day by day as river sand cannot meet the rising demand of construction sector. Natural river sand takes millions of years to form and is not replenishable.

II. MATERIALS USED

In general, concrete is a mixture of cement, fine aggregate, coarse aggregate and water. In order to utilize waste produced from different sources in concrete, robo sand was used in place of fine aggregate and GGBS from steel industry was used to replace cement partially. The details of the respective material used for the specimen preparation are discussed in the sections below.

Cement

Cement is a binder substance that sets and hardens and can bind other materials together. Cement used in construction can be characterized as being either hydraulic or non-hydraulic in nature, depending upon the ability of the cement to be used in the presence of water. The most important uses of cement is as a component in the production of mortar in masonry and in concrete as combination of cement and as an aggregate to form a strong building material. Ordinary Portland cement is the most common type of cement generally used around the world. Locally available 43 grade cement of ACC brand is used for experimental purpose. The physical properties of cement are given in Table 1.

Table 1: Properties of cement

Properties	Experimental Results	Standards
Specific Gravity	3.13	3.10 - 3.15
Initial setting time (min)	42 min	30 (min)
Final setting time (min)	450 min	600 (max)
Fineness (%)	0.5	0.1 (min)

Aggregates

Construction aggregate, or simply aggregate, is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag and recycled concrete. Aggregates are the most mined materials in the world. The aggregate serves as reinforcement to add strength to the overall composite material. These aggregates are mainly classified into two types namely fine aggregate of size less than 4.75mm and coarse aggregate of size more than 4.75mm. Locally available river sand is used as fine aggregate. Gravels constitute major part of coarse aggregates. The physical properties of aggregates are given in Table 2.

Table 2: Properties of aggregate

Property	Fine Aggregates	Coarse Aggregates
Specific Gravity	2.61	2.76
Water Absorption	0.50%	0.5%
Moisture Content	Nil	Nil
Maximum size (mm)	4.25	20
Fineness modulus	2.51	7.56
Grading Zone	Zone II	---



Fig. 1: Coarse aggregate



Fig. 2: Fine aggregate Table Error!

No text of specified style in document.: Sieve analysis of fine aggregate

IS Sieve (µm)	Weight retained (g)	Percentage weight retained (kg)	Percentage cumulative weight retained	Percentage finer
4750	3.9	0.39	0.39	99.61
2360	8.1	0.81	1.20	98.80
1180	86.5	8.65	9.85	90.15
600	493.3	49.33	59.18	40.82
300	274.0	27.40	86.58	13.42
150	79.0	7.90	94.48	5.52
Pan	5	0.5	100	0

Fineness modulus of fine aggregate = $278/100 = 2.78$; Based on the IS 383:1970, the fine aggregate is confined to zone II.

Table 4: Sieve analysis of Coarse aggregate

S. No	Sieve size	Mass retained on sieve	% mass retained	Cumulative percentage mass retained	Cumulative % fine
1.	100mm	0.000	0.0	0	100.00
2.	80mm	0.000	0.0	0.0	100.00
3.	40mm	0.000	0.0	0.0	100.00
4.	20mm	8.523	56.82	56.82	43.18
5.	10mm	6.427	42.84	99.66	0.34
6.	4.75mm	0.050	0.34	100.00	0.00
7	2.36mm	0.000	0.00	100.00	0.00
8	1.18µm	0.000	0.00	100.00	0.00
9	600µm	0.000	0.00	100.00	0.00
10	300µm	0.000	0.00	100.00	0.00
11	150µm	0.000	0.00	100.00	0.00
12.	Pan	0	0	100	0

Ground Granulated Blast Furnace Slag

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. GGBS is purchased from local vendors in Vijayawada. The properties of GGBS are listed in Table 5.

Table 5: GGBS Properties

PHYSICAL TEST REPORT ON GGBS (GROUND GRANULATED BLAST FURNACE SLAG) REFERENCE IS :1727- 1967 (Reaffirmed 2013) Source : JSW , Vijayawada	
Test Conducted	Results
Specific Gravity	2.88
Fineness-Specific surface in m ² /kg by Blaine's permeability method	369
Comparative compressive strength ,%	
7 day	64.0
28 day	76.0
Residue on 45 micron sieve ,%	2.0
Compressive strength (MPa)	
7 day	27.0
28 day	36.0

(Source :JSW Cement Limited)

Robo Sand

The cubical particle shape helps make concrete more cohesive. A perfect gradation ensures fewer voids and increases the compressive strength. Well balanced physical and chemical properties in robo sand make for more durable buildings. Robo sand is produced under controlled conditions with raw material from a single source resulting in a very consistent quality with no seasonal fluctuations. The complete absence of deleterious materials eliminates wastage and works out economical for use in concrete. An optimum level of fine content helps overcome deficiencies such as segregation, bleeding, voids and honey combing. Easy availability of robo sand in huge quantities around the years leads to execution of construction projects on time.

Table 6: Sieve analysis of robo sand

IS Sieve (μm)	Weight retained (g)	Percentage retained (kg)	weight	Percentage cumulative weight retained	Percentage finer
4750	5	0.5		0.5	0.5
2360	95	9.5		9.5	10
1180	250	25		25	35
600	116	11.6		11.6	46.6
300	270	27		27	73.6
150	135	13.5		13.5	87.1
Pan	5	0.5		--	0

This is fine aggregate is confining to Zone II according to IS-383

Experimental Investigations for robo sand

As the study includes finding various properties for robo sand for the use in concrete, procedure for all the experiments based on the Indian standard codes are explained below.

Table 7: Slump flow test result

S. No	Slump flow test
Mix1	723 mm
Mix2	725mm
Mix3	736mm
Mix4	742mm
Mix5	753mm
Mix6	742mm
Mix7	719mm
Mix8	694mm
Mix9	626mm

L-Box Test

L-Box test is carried out on each mix immediately after mixing to tests its selfcompacting property. The desired range for SCC in L-Box test is 0.8 to 1.0. In thesis test, all the mixes gave desirable results.

Table 8: L-Box test result

S. No	L box test
Mix1	0.88
Mix2	0.90
Mix3	0.94
Mix4	0.95
Mix5	0.98
Mix6	0.97
Mix7	0.94
Mix8	0.90
Mix9	0.84

V funnel test

V-Funnel test is carried out on each mix immediately after mixing to tests its self compacting property. The desired range for SCC in V-Funnel test is 8 sec to 13 sec. All the mixes prepared gave desirable results except mix 1.

Table 9: V-funnel test result

S. No	V funnel test
Mix1	15 sec
Mix2	13sec
Mix3	11sec
Mix4	10sec
Mix5	9.8sec
Mix6	9.41 sec
Mix7	9.11 sec
Mix8	8.67 sec
Mix9	8.12 sec

U boxtest

U-Box test is carried out on each mix immediately after mixing to tests its self compacting property. The desired range for SCC in U-Box test is less than 30mm. All the mixes prepared gave desirable results except mix 8 and 9, where robo sand is used in high quantities which results in high friction between particles of cement and fine aggregate.

Table 10: U-box test result

S. No	U box test
Mix1	32 mm
Mix2	28mm
Mix3	27mm
Mix4	26mm
Mix5	24mm
Mix6	26mm
Mix7	29mm
Mix8	31mm
Mix9	34mm

Tests on Hardened concrete

Compressive strength of concrete is one of the main parameters to assess the concrete performance as it is strong in compression. Compression action occurs in columns, footings etc. Along with compression, split tensile strength and flexural strength of concrete were measured.

Mix design	Compressive Strength(Mpa)		Split Tensile Strength(Mpa)		Flexural Strength(Mpa)	
	7days	28 days	7days	28days	7days	28days
M1	39.26	57.43	3.29	5.06	4.57	6.70
M2	41.50	58.97	3.48	5.62	4.74	6.85
M3	41.68	60.53	3.89	5.94	4.82	6.78
M4	44.06	64.96	3.87	6.01	5.12	6.74
M5	40.56	61.47	3.69	5.60	5.06	6.87
M6	44.97	65.52	4.11	6.45	5.76	7.42
M7	46.07	67.60	4.26	6.53	5.56	7.38
M8	47.71	72.29	4.47	7.05	5.78	8.60
M9	49.58	73.46	4.53	7.07	5.70	8.32

III. CONCLUSION

- Based on the results obtained from the experiments investigation the following conclusions are drawn.
- For 7 days strength of compressive, flexural and split tensile, maximum is found for Mix9 when compared to other mixes.
- For the variation of GGBS from 0% to 40% with 10% interval, the maximum 28 days compressive strength obtained at 30% replacement. The strength at 30% GGBS is 9.38% more than conventionalmix.
- With 30% GGBS optimization and variation of robo sand from 0% to 100% with 25% interval, the maximum 28 days compressive strength obtained at 100% replacement. The strength at this point found to be 26.39% when compared conventionalconcrete.
- The optimum strength is obtained for 30% GGBS and 100% robo sand in Compaction.
- For split tensile and flexural strength, the maximum 28 days strengths occur at 30% GGBS+ 100% robo sand combination in concrete.
- With Respect to both strength and workability, optimum mix is concluded as 30% GGBS and 50% Replacement of Robo sand As Fine Aggregate in concrete.
- Robo sand is a suitable replacement for fine aggregate in concrete

IV.FUTURESCOPE

- In the present study, concrete was tested for its fresh and hardened properties. So further it may be tested for its durability properties.
- Micro structure of self-compacting concrete made with robo sand and GGBS may be analyzed using x-ray diffraction.
- Self-compacting concrete can be tested for higher grade of strengths with alternating various admixtures.

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