International Journal For Recent Developments in Science & Technology
2581-4575
Crossref
A Peer Reviewed Research Journal

# A STUDY ON DEVELOPMENT OF GGBS AND ROBO SAND IN SELF SOLID CONCRETE

Ranadheer Sagi1, Sk Khaleel 2
1 Assistant professor, Dept. of Civil engineering, RGUKT Basar, Telangana-504107,India
2 Assistant professor, Dept. of Civil engineering, RGUKT Basar, Telangana-504107,India

## ABSTRACT

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 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%0f 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 SSC 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 SSC (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 the optimum strength mix failed in the aspect of workability. So the optimum mix in 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

## 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%), $SiO_2$ (28-38%), $Al_2O_3$ (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 $Al_2O_3$ 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 worn out particles of rocks and are of various grades or sizes depending upon the amount of wearing. Now-a-days 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 repleneshible.

## 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 tobe 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 type's 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 |
|---|---|---|

2581-4575
International Journal For Recent Developments in Science & Technology
Crossref
A Peer Reviewed Research Journal

| | | |
|---|---|---|
| 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 | --- |

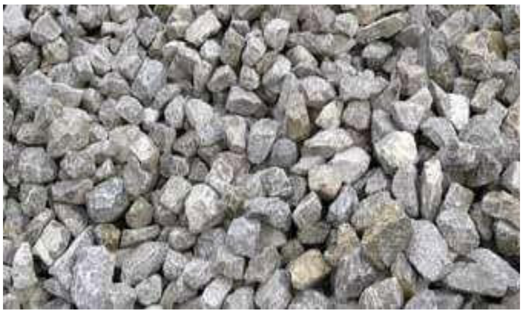

**Fig. 1: Coarse aggregate**

**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**

2581-4575
International Journal For Recent Developments in Science & Technology
Crossref
A Peer Reviewed Research Journal

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 (GROUNG GRANULATED BLAST FURNACE SLAG) REFERENCE IS :1727- 1967 (Reaffirmed 2008) 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 ,%<br>7 day<br>28 day | <br>64.0<br>76.0 |
| Residue on 45 micron sieve ,% | 2.0 |
| Compressive strength (MPa)<br>7 day<br>28 day | <br>27.0<br>36.0 |

(Sourse :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 weight retained (kg)** | **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 |

International Journal For Recent Developments in Science & Technology
2581-4575
Crossref
A Peer Reviewed Research Journal

| | |
|---|---|
| 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 self compacting property. The desired range for SCC in L-Box test is 0.8 to 1.0. In thios 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 box test**

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 |

2581-4575

International Journal For Recent Developments in Science & Technology

Crossref

A Peer Reviewed Research Journal

| | |
|---|---|
| Mix9 | 34mm |

**Tests on Hardened concrete**

Compressive strength of concrete is one of the main parameter 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.

| | **Compressive Strength(Mpa)** | | **Split Tensile Strength(Mpa)** | | **Flexural Strength(Mpa)** | |
|---|---|---|---|---|---|---|
| Mix design | 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 |

## CONCLUSION

Based on the results obtained from the experiments conducted the following conclusions are drawn.

- Robo sand is a suitable replacement for fine aggregate in concrete.
- For 7 days strength of compressive, flexural and split tensile, maximum is found for Mix 9.
- 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 conventional mix.
- 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% more than the conventional concrete.
- The optimum strength is obtained for 30% GGBS and 100% robo sand Compaction. But this combination failed in self compaction point of view.
- For split tensile and flexural strength, the maximum 28 days strengths occurs at 30% GGBS+ 100% robo sand combination.
- With Respect to both strength and workability, optimum mix is concluded as 30% GGBS and 50% robo sand Replacement

## FUTURE SCOPE

- 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.

## REFERENCES

[1] Bui VK, Montgomery D, Hinczak,I, Turner K. Rapid testing method for segregation resistance of self-compacting concrete. Cement and Concrete Research 2002; 32(9): 1489–1496.

[2] Sahmaran M, Yurtseven A, Ozgur Yaman I. Workability of hybrid fiber reinforced self-compacting concrete. Building and Environment 2005; 40(12): 1672-1677.

[3] Sahmaran M, Ozgur Yaman I. Hybrid fiber reinforced self-compacting concrete with a high-volume coarse fly ash. Construction and Building Materials 2007; 21(1): 150-156.

[4] Domone PL. A review of the hardened mechanical properties of self-compacting concrete. Cement and Concrete Composites 2007; 29(1): 1-12.

[5] Şahmaran M, Yaman IO, Tokyay M. Transport and mechanical properties of self consolidating concrete with high volume fly ash. Cement and Concrete Composites 2009; 31(2): 99-106.

[6] Liu M. Self-compacting concrete with different levels of pulverized fuel ash.

[7] Batham G, Bhadauria SS, Saleem A. A Review: Recent Innovations in Self Compacting Concrete. International Journal of Scientific & Engineering Research 2013; 4(11).

[8] Koli G, Gundakalle VD. Properties of Self Compacting Concrete using GGBS and Manufactured Sand. International Journal of Research and Scientific 2016; III(IX).

[9] Kavitha S, Umadevi R. Evaluating the Strength gain and Structural properties of Self Compacting Concrete. International Journal of Informative & Futuristic Research (IJIFR) 2016; 3(6): 1840-1853.