# AN EXPERIMENTAL STUDY ON HIGH PERFORMANCE CONCRETE PARTIALLY REPLACING CEMENT AND FINE AGGREGATE WITH GGBS & ROBO SAND

M.D.Narendra[1], G.Gangha[2]
[1]Post Graduate Student, [2]Assistant Professor,
Department of Civil Engineering, SRM University, Kattankulathur, India

## *ABSTRACT*

*Concrete plays a vital role in the development of infrastructure globally and its applications are very significant in this advancing world. Traditionally, the basic ingredients of concrete include Cement, Fine aggregate and Coarse aggregate. In general, Ordinary Portland cement is used in the construction of civil structures. This OPC can be replaced by Ground Granulated Blast furnace Slag (GGBS) which is readily available and costs lower than OPC. Similarly, another important ingredient of concrete is Fine aggregate i.e., river sand which is a highly scarce resource. To meet the growing applications for the river sand, Robosand that possess the similar characteristics as that of river sand can be utilized in the construction activity. High performance concrete is the one which possesses high strength, high workability, high elastic modulus, low permeability and high durability. The present investigation deals with the development of high performance concrete when the cement and river sand are replaced by GGBS and Robosand in various proportions. This study mainly focuses on the discussion of strength and workability characteristics of high performance concrete, when the cement is replaced by GGBS partially in various proportions, together with the replacement of river sand by Robosand in various proportions. Cubes, Cylinders and beams are casted for each proportion and tests are to be conducted for obtaining the compressive strength, split tensile strength and flexural strength of concrete.*

***KEYWORDS:*** *Compressive strength, Durability, Flexural strength, Permeability, Robosand, Split tensile strength and Slump.*

## I. INTRODUCTION

High performance concrete conforms to a set of standards above those of the common applications such as high strength, high workability, high elastic modulus, low permeability and high durability. Concrete is generally a mixture of cement, fine and coarse aggregates. In order to minimize the cost of construction and to utilize the waste product from the iron industry beneficially, cement is replaced with Ground Granulated Blast Furnace Slag partially in various proportions. GGBS is a byproduct of the steel industry and is obtained when molten slag is quenched rapidly with the utilization water jets. GGBS is a non - hazardous and non - metallic waste of the iron industry is eco-friendly and helps in improving the strength, workability and durability characteristics of the concrete.

River sand which is one of the basic ingredients the manufacture of concrete has become highly scarce and expensive. Hence, the crusher dust which is also known as Robosand can be used as an alternative material for the river sand. Robosand possess similar properties as that of river sand and hence accepted as a building material. Robosand basically contains angular particles that pass through 4.75 mm sieve and possess rough surface texture. The present study discusses the compressive strength, split tensile strength and flexural strength of high performance concrete by replacing the River sand with Robosand in percentages of 0, 25, 50, 75 and 100 together with the replacement of cement by GGBS in percentages of 40, 50 and 60 respectively.

### 1.1 Objective

The main objective of the present paper is to study manufacture High Performance Concrete incorporating GGBS and Robosand resulting in required strength characteristics.

## II. MATERIALS

### 2.1. Cement

Ordinary Portland cement of 53 grade of concrete with a specific gravity of 3.12 has been used.

### 2.2. Fine aggregate

Locally available sand confirming zone II and maintaining a specific gravity of 2.58 is used.

**Table.1** Percentage Passing of River Sand and Robosand

| Size of IS sieve | Test Results | | IS:383 -1970 Zone II Requirement | Remarks |
|---|---|---|---|---|
| | % Finer Than | | | |
| | River sand | Robosand | | |
| 4.75mm | 97.34 | 96.5 | 90-100 | River sand and Robosand conforms to zone II |
| 2.36mm | 92.14 | 80 | 75-100 | |
| 1.18mm | 74.51 | 65.5 | 55-90 | |
| 600 µ | 42.94 | 51 | 35-59 | |
| 300 µ | 4.73 | 26.5 | 08-30 | |

### 2.3. Coarse aggregate

Coarse aggregate confirming to IS: 383 -1970 of 20mm and 12 mm with a specific gravity of 2.74 is used.

### 2.4. Super Plasticizer

Ceraplast 300 which is available in liquid form and brown in color and which is having a specific gravity of1.2 is used in order to improve the workability of the concrete.

### 2.5. Ground Granulated Blast Furnace Slag

Ground Granulated Blast Furnace Slag (GGBS) is a by-product from the blast-furnaces used to make iron. These operate at a temperature of about 1,500 degrees centigrade and are fed with a carefully controlled mixture of iron-ore, coke and limestone. The iron ore is reduced to iron and the remaining materials form a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching optimizes the cementitious properties and produces granules similar to coarse sand. This 'granulated' slag is then dried and ground to a fine powder.

**Table.2** Chemical Composition of GGBS

| Name of the Oxide | Composition (%) |
|---|---|
| CaO | 40 |
| $SiO_2$ | 35 |
| $Al_2O_3$ | 12 |
| MgO | 8.2 |
| $Fe_2O_3$ | 0.2 |
| Others | 5 |

(*Source:* Toshali cements pvt ltd)

## III. METHODOLOGY

### 3.1. Mix Design

The concrete mix is designed for M35 grade and the considered degree of workability is medium. The mix design is carried out according to the IS 10262:2009 for the conventional concrete. The obtained mix proportion is 1:1.93:3.65 with water - cement ratio of 0.4.

### 3.2. Replacement of Cement and Fine Aggregate

In the mix proportion, Fine Aggregate is replaced by Robo Sand in percentages of 0, 25, 50, 75 & 100. For each percentage replacement of fine aggregate by Robo sand, cement is replaced by GGBS partially in percentages of 30, 40, 50 & 60 respectively. Super Plasticizer dosage is between 0.5 and 0.8% by weight of cement. This dosage is varied for each proportion until the required workability is achieved. Table .3 shows the percentage replacement of River Sand with Robosand together with the replacement of cement with GGBS.

**Table.3** Replacement of Cement and Fine Aggregate

| Percentage replacement of | River Sand with Robo Sand | 0 | | | 25 | | | 50 | | | 75 | | | 100 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cement with GGBS | 40 | 50 | 60 | 40 | 50 | 60 | 40 | 50 | 60 | 40 | 50 | 60 | 40 | 50 | 60 |

### 3.3. Test Procedure

The concrete cubes of size 150 mm, cylinders of size 300 mm height and 150 mm diameter and beams of size 500 x 100 x 100 mm are casted and used as test specimens to obtain the compressive strength of concrete, split tensile strength of concrete and flexural strength of concrete. The specimens casted in the above manner are compacted on a vibrating table. Tests are conducted at the end of 28 days from the date of casting.

## IV. RESULTS AND DISCUSSIONS

**Table.4** Test Results

| Percentage Replacement of | | Compressive strength@ 28 days (N/mm²) | Split Tensile Strength @ 28 days (N/mm²) | Flexural strength @ 28 days (N/mm²) |
|---|---|---|---|---|
| Fine aggregate by sand | Cement by GGBS | | | |
| | 30 | 43.42 | 3.21 | 4.10 |
| | 40 | 44.25 | 3.32 | 4.53 |
| | 50 | 48.38 | 3.65 | 5.12 |
| 0 | 60 | 42.56 | 3.81 | 5.83 |
| | 30 | 41.84 | 3.22 | 4.45 |
| | 40 | 44.00 | 3.57 | 4.92 |
| | 50 | 52.76 | 3.72 | 5.43 |
| 25 | 60 | 44.35 | 4.12 | 6.21 |
| | 30 | 42.00 | 3.47 | 4.82 |
| | 40 | 43.34 | 3.65 | 5.37 |
| | 50 | 46.28 | 3.98 | 5.35 |
| 50 | 60 | 41.72 | 4.21 | 6.31 |
| | 30 | 43.15 | 3.45 | 5.43 |
| | 40 | 45.44 | 3.67 | 5.91 |
| | 50 | 47.85 | 3.92 | 6.23 |
| 75 | 60 | 40.22 | 4.32 | 6.52 |
| | 30 | 42.00 | 3.78 | 5.91 |
| | 40 | 43.29 | 4.12 | 6.35 |
| | 50 | 47.77 | 4.22 | 6.67 |
| 100 | 60 | 41.15 | 4.56 | 6.85 |

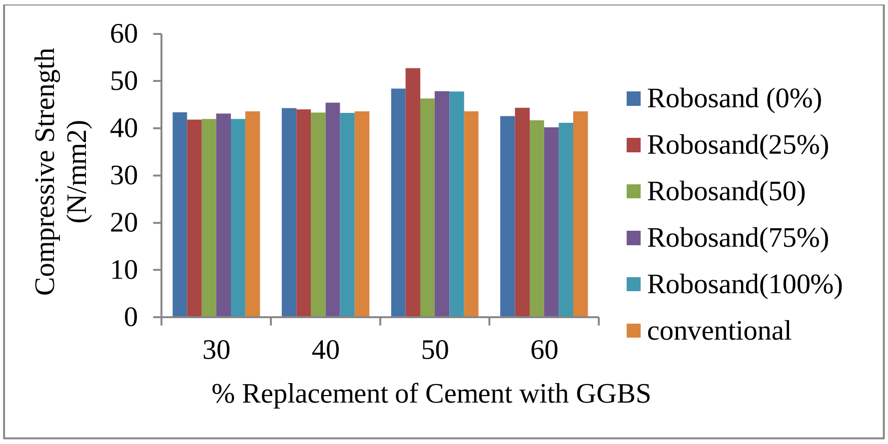


**Figure1.** Compressive strength of concrete @ 28 days

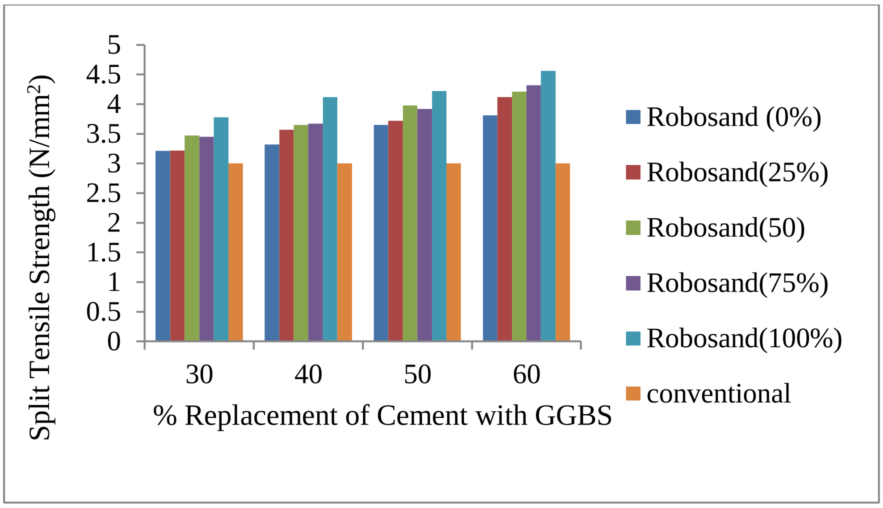


**Figure 2.** Split tensile Strength of concrete @ 28 days

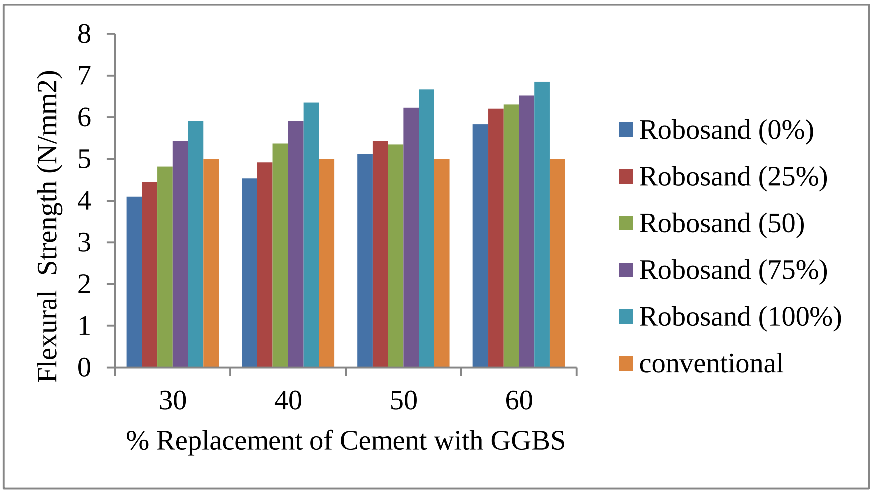


**Figure3.** Flexural Strength of concrete @ 28 days

Tests are performed by replacing the cement with GGBS and River Sand with Robosand in the mentioned percentages and from the tests it is observed that the variation in the percentage of GGBS does not affect the workability of concrete whereas the change in percentage of Robo - sand influences the workability and hence Super Plasticizer dosage is altered for attaining required workability. Table no.4 presents the compressive strength and flexural strength that are obtained for various proportions. Figure no.1 shows the variation of compressive strength at the age of 28 days Figure no.2 represents the variation of Split tensile strength and Figure no.3 represents the variation of flexural strength when the cement is replaced with GGBS and fine aggregate is replaced with Robosand.

## V. CONCLUSIONS

Based on this experimental study, it can be concluded that

1. As percentage of Robosand replacing River Sand is increased, the workability of the mix decreases irrespective of percentage of GGBS replacing the cement.
2. At constant percentage replacement of River Sand with Robosand, the workability of the concrete does not get effected as percentage GGBS replacing the cement is varied.
3. Robosand can replace River Sand 100% without effecting Compressive Strength.
4. The optimum percentage of GGBS replacing cement is 50% for getting maximum compressive strength and the maximum Compressive Strength obtained is 52.76 $N/mm^2$.
5. The Split Tensile Strength increases with the increase in percentage of GGBS as well as with the increase in percentage of Robosand and the maximum Tensile Strength obtained is 4.56 $N/mm^2$ .
6. The Flexural Strength also increases with the increase in percentage of GGBS as well as with the increase in percentage of Robosand and the maximum Flexural Strength obtained is 6.85 $N/mm^2$ .
7. The maximum increase in Compressive Strength is about 17.22% as compared to that of the conventional mix at the age of 28 days.
8. The average increase in Split Tensile Strength is about 26.6 % as compared to that of the conventional mix at the age of 28 days.
9. The average increase in Flexural Strength is about 12% as compared to that of the conventional mix at the age of 28 days.

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## AUTHORS

**Narendra . M. D,** doing M.tech construction engineering management in SRM University, kattankulathur- 603203, kancheepuram district, Tamil Nadu.