Strength And Workability Characteristics Of High Performance Concrete With Partial Replacement Of Cement And Sand With GGBS & Robosand

M. Sai Lakshmi [1]
Dr. B. S. R. K Prasad [2]
V. Mallikarjuna [3]
S. Krishna Rao [4]

[1]Post-Graduate Student, Department of Civil Engineering, V.R. Siddhartha Engineering College, Vijayawada – 520 007
[2]Associate Professor, Department of Civil Engineering, V.R. Siddhartha Engineering College, Vijayawada – 520 007
[3]Associate Professor, Department of Civil Engineering, V.R. Siddhartha Engineering College, Vijayawada – 520 007
[4]Associate Professor, Department of Civil Engineering, V.R. Siddhartha Engineering College, Vijayawada – 520 007

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 utilized in the creation 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. 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 conducted for obtaining the compressive strength, split tensile strength and flexural strength of concrete. The obtained results are discussed and finally conclusions are made accordingly.

Keywords

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

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 in 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.

Materials

Cement

Ordinary Portland Cement of 53 grade with fineness of 2240 **c**m^2/gm. and specific gravity of 3.18 is used.

Ground Granulated Blast Furnace Slag

GGBS is obtained from Toshali Cements Private Limited, Bayyavaram near Visakhapatnam in Andhra Pradesh. Fineness test is conducted using Blaine's Apparatus. 2.5 gms of GGBS is considered to perform the test and the obtained fineness of the GGBS is 4000 cm^2/gm. The specific gravity obtained for GGBS is 3.38. Table no.1 shows the chemical composition of GGBS.With the usage of GGBS in concrete, the hydrated paste has large number of small capillary pores and small number of larger gel pores than that of the hydrated pasted in concrete with ordinary Portland cement. Small capillary pores lead to lower permeability and offers more durability resulting in High Performance Concrete.

Table.1 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

Fine Aggregate

Locally available River Sand with a fineness modulus of 2.86 and specific gravity of 2.5 and RoboSand having a fineness modulus of 2.67 and specific gravity of 2.69 is used. Table no.2 shows the percentage passing of River Sand and Robosand.

Table.2 Percentage Passing of River Sand and Robosand

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

Coarse Aggregate

Locally available coarse aggregate with sizes 20mm and 12 mm are used.

Super Plasticizer

Ceraplast 300 which is available in liquid form and brown in color and which is having a specific gravity of 1.2 is used in order to improve the workability of the concrete.

Methodology

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.

Replacement of Cement and Fine Aggregate

In the obtained mix proportion, Fine Aggregate is replaced by Robosand in percentages of 0, 25, 50, 75 & 100. For each percentage replacement of fine aggregate by Robosand, cement is replaced by GGBS partially in percentages of 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 no.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**

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.

Results and Discussions

Table.4 Test Results

Percentage Replacement of: Fine Aggregate by Robosand	Percentage Replacement of: Cement by GGBS	Compressive Strength @ 28 days (N/mm^2)	Flexural Strength @ 28 days (N/mm^2)
0	40	43.85	4.50
	50	48.30	5.10
	60	40.44	5.80
25	40	44.00	4.90
	50	51.11	5.40
	60	39.56	6.10
50	40	43.36	5.50
	50	45.23	5.90
	60	38.51	6.30
75	40	44.44	5.90
	50	46.73	6.20
	60	40.59	6.50
100	40	42.29	6.40
	50	45.47	6.60
	60	39.80	6.80

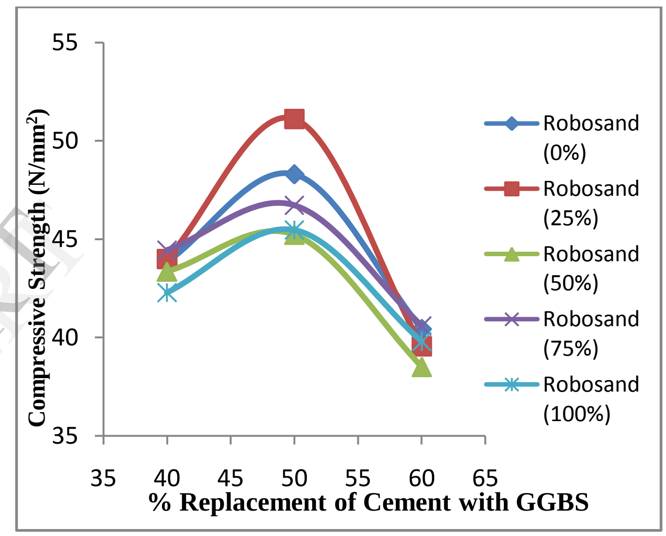

Fig.1 Compressive strength of concrete @ 28 days

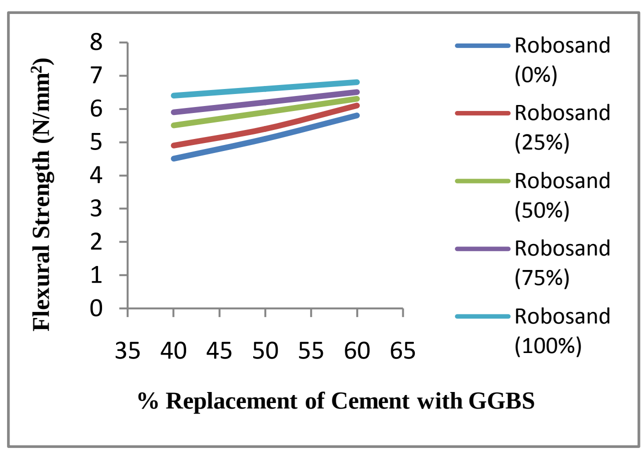

Fig.2 Flexural Strength of concrete @ 28 days

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 and Figure no.2 represents the variation of flexural strength when the cement is replaced with GGBS and fine aggregate is replaced with Robosand.

Conclusions

Based on this experimental study, it can be concluded that

1) As percentage of Robosand replacing River Sand is increased, the slump decreases irrespective of percentage of GGBS replacing cement.
2) At constant percentage of River Sand with Robosand, slump value 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.
5) The flexural strength increases with the increase in percentage of GGBS and Robosand.
6) The maximum compressive strength obtained is 51.11 N/mm^2 and maximum flexural strength obtained is 6.80 N/mm^2.

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