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An Experimental Investigation on the Effects of Concrete by Replacing Cement with GGBS and Rice Husk Ash with the Addition of Steel Fibers

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Abstract: ***There has been a tremendous increase in the use of mineral admixture by industries during the late 20th century and the rate is expected to increase. Concrete is an artificial material, which is made up of cement, fine aggregates, coarse aggregates and water. The increasing demand for cement and concrete is met by the partial cement replacement by addition of supplementary cementing materials which leads to several improvements in the concrete composites and to the overall economy. Mineral admixtures are used in concrete because they improve the properties of concrete. The lower cement content leads to a reduction for CO_2 generated by the production of Portland cement. An attempt is made to replace the cement with GGBS with 20%,30% 40% and RHA and steel fiber by constant proportion(10% and 1%) for minimum grade concrete i.e., M30 and is tested for fresh and hardened properties at 7,14 and 28 days to identify the optimum percentage of GGBS in concrete. Replacement of cement by GGBS in M30 grade concrete in compressive strength split tensile test and flexural strength improvement up to the replacement of 30% in all ages.***

Keywords: GGBS, RHA, steel fibers, compressive strength, tensile strength and flexural strength

1. Introduction

Concrete has been the major instrument for making steady and reliable infrastructure since the days of Greek and roman civilization. Concrete is the most world widely used construction material. Concrete is a blend of cement, water, and aggregates with or without chemical admixtures. The most important part of concrete is the cement. Use of cement alone as a binder material produces large heat of hydration. Since the production of this raw material produces lot of CO_2 emission. The CO_2 emission from the cement source is very harmful to the environmental changes. Nowadays many experiments have been carried out to reduce the CO_2. The productive way of minimizing CO_2 emission from the cement industry is to use the industrial by products or use of supplementary cementing material such as Ground Granulated Blast Furnace Slag (GGBS), Fly Ash (FA), and Metakaolin (MK). In this present experimental work an attempt is made to replace cement by GGBS and RHA by constant proportion with the addition of steel fibers to overcome these problems.

1.1. Ground Granulated Blast Furnace Slag(GGBS)

Ground Granulated Blast Furnace is a byproduct from the Blast furnace slag is a solid waste discharged in large quantities by the iron and steel industry in India. These works at a temperature of about 1500 degree centigrade and are fed with a carefully regulated mixture of iron. The parent rock is reduced to iron and remaining materials from slag that floats on top of the iron. This slag is regularly tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has been rapidly quenched in large volumes of water. The quenching optimizes the cementitious properties and produces flakes similar to coarse sand. This granulated slag is then dried and ground to a fine powder. The main ingredient of slag is lime (CaO) and silica (SiO2). Portland cement also contains these constituents. The principal constituent of slag is soluble in water and shows an alkalinity like that of cement or concrete.

1.2. Rice Husk Ash (RHA)

Rice husk is an agricultural residue consisting of non-crystalline silicon dioxide with high surface area and high pozzolanic reactivity, thus due to increasing environmental concern and the need to protect energy and resources, utilization of industrial and biogenic waste as supplement material has become an essential part of concrete construction. Pozzolonas improve strength because they are small in size when compared to the cement particles, and can pack in between the cement particles and provide a superior pore structure. RHA has two roles in concrete manufacture, as a substitute for Portland cement, reducing the cost of concrete in the manufacturing of low priced building blocks, and as an admixture in the production of high strength concrete.

1.3. Objective

1. To study the mechanical properties such as compressive strength, split tensile strength and flexural strength of the specimen.
2. To compare the results of different tests with varying proportions of GGBS (20%, 30% and 40%) keeping RHA and steel fiber content constant (10% and 1%).
3. To find the optimum percentage of replacement of cement with GGBS.
4. To find the effects of GGBS and RHA on concrete with addition of steel fibres.

2. Materials and Methods

2.1. Cement

Ordinary Portland cement of 53 grade (Dalmia) conforming to IS 12269-1987 is being used. Table I shows the test results.

Table 1: Properties of Cement

Properties	*Cement*
Specific gravity	3.1
Standard Consistency	31%
Initial setting time	44 min
Final setting time	480min
Finess	4. 33

2.2. Fine aggregate

Natural river sand of size below 4.75mm according to zone II of IS 383-1970 is used as fine aggregate. Table 2 shows the test done on basic properties of fine aggregates.

Table 2: Properties of fine aggregate

Properties	*Fine Aggregate*
Specific Gravity	2.72
Fineness modulus	4.92

2.3. Coarse Aggregate

Natural crushed stone with 20mm size is used as coarse aggregate. Table 3 shows the test results of properties.

Table 3: Properties Coarse aggregates

Properties	*Coarse Aggregate*
Specific Gravity	2.74
Fineness modulus	3.57

2.4. Ground Granulated Blast Furnace Slag

GGBS was collected from AASTRA chemicals, Chennai. Table 4 shows the test results of basic properties of GGBS.

Table 4: Properties of GGBS

Characteristics	*Test result*
Fineness (M / Kg)	390
Specific Gravity	2.85
Particle Size (Cumulative %)	97.10
Insoluble Residue (%)	0.49

2.5. Rice Husk Ash

RHA was collected from Keerthi Rice Mill from Palakad dist, Kerala. The following property of RHA is shown below in the table 5.

Table 5: Properties of RHA

Particulars	*Properties*
Color	Gray
Particle size	<45 micron
Specific Gravity	2.3
Appearance	Very fine

2.6. Steel Fibers

Steel fibers are not a substitution to reinforcement or aggregate. These are added to increase the flexural strength of concrete. Hooked end steel fibers are used.

Table 6: Properties of Steel fibers

Particulars	*Properties*
Type	Hooked End
Appearance	Clear and Bright
Length	50mm
Diameter	1mm
Aspect Ratio	50

2.7. Water

Ordinary portable water is used in this investigation both for mixing and curing.

2.8. Super Plasticizer (SP)

GLENIUM 51 is used as a superplasticizer. It is a chloride free, super plasticizing admixture. It was used to intensify the workability of concrete

Table 7: Properties of SP

Particulars	*Properties*
Appearance	Light Brown Liquid
pH	>=6
Specific Gravity	50

2.9. Concrete Mix Design

Mix proportion used in this study is 1:1.61:2.65 (M30) with water-cement ratio of 0.4 and super plasticizer of 0.75%.

3. Results and Discussions

3.1 Compressive Strength Results

The cubes of 150x150x150mm sizes are casted with various proportions. The test was carried at the end of 7 days, 14 days and 28 days of curing. The compressive strength of any mix was taken as the average of strength of three cubes.

Table 8: Compressive strength Results

Mix Proportion	*7 Days*	*14 Days*	*28 Days*
Normal concrete	24.67	30.37	37.96
BC1	26.59	32.74	40.92
BC2	28.21	34.72	43.40
BC3	27.20	33.48	41.85

Note: BC1-20%GGBS, BC2- 30%GGBS, BC3- 40%GGBS

The compressive strength of concrete with replacement of cement by GGBS of 20%, 30% and 40% keeping the proportion of RHA (10%) and steel fiber (1%) constant is shown. The test results show that the compressive strength increases as the percentage of slag increases. The strength was found to be increased up to 30% of GGBS and when above30% replacement, there exceeded was a marginal decrease in strength of concrete. For 28 days curing period, the strength of concrete increased about 7.79% and 14. 33% for 20% and 30% and decreased about 20.24% for 40%.

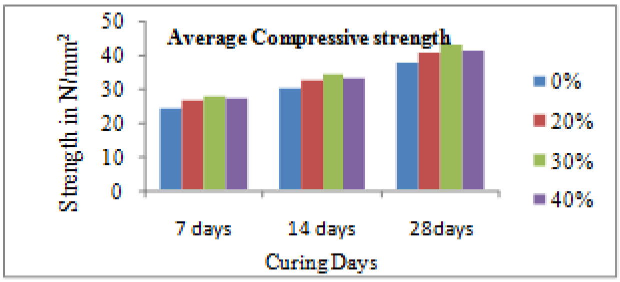

Figure 1: Compressive Strength

3.2 Split Tensile Strength

The split tensile strength is the indirect measurement to determine the strength of concrete. Cylinders of size 150mm diameter and 300mm in length were casted for various percentages of GGBS. The test results shows that there is an increase in the strength only up to 30% slag and beyond 30% the strength showed no change in increase and it was also observed that the strength showed increased only after 28 days of curing period.

Table 9: Split Tensile strength results

Mix Proportion	*7 Days*	*14 Days*	*27 Days*
Normal concrete	1.01	1.74	2.52
BC1	2.18	2.48	3.15
BC2	2.65	2.87	3.64
BC3	2.40	2.56	3.29

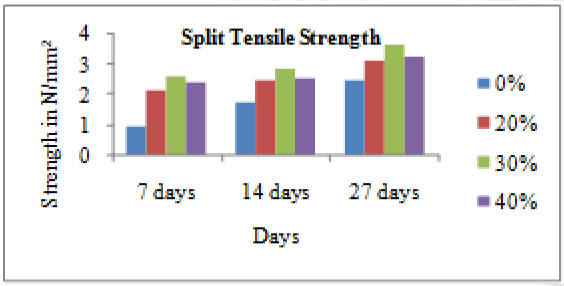

Figure 2: Split Tensile Strength

3.3 Flexural Strength

For each of the different dosages, three prisms with the dimensions of 150 × 150 × 500 mm were prepared. A vibrator was used for compaction of concrete in prisms. All prisms were demoulded after one day and immersed in the curing tank for a period of 28 days to assure sufficient curing. After 28 days, each prism was tested using the loading test setup. The flexural strengths achieved are 5.30N/mm2, 5.79 N/mm2, 6.55 N/mm2 and 5.98 N/mm2 at 0%, 20%, 30% and 40% for GGBS concrete respectively for M30 grade concrete. The report shows that the strength gave good performance for 30% replacement which is more than normal concrete.

Table 10: Flexural strength Results

Mix Proportion	*28 days*
Normal Concrete	5.30
BC1	5.79
BC2	6.55
BC3	5.98

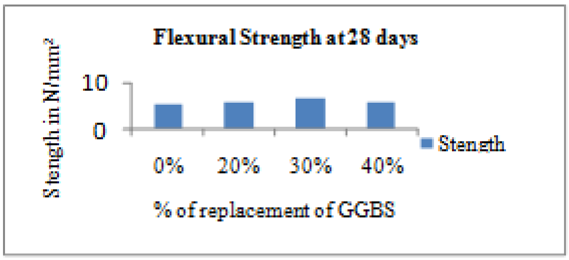

Figure 3: Flexural Strength

4. Conclusions

1. From the mechanical properties, the optimum replacement by GGBS was found to be 30% and beyond 30% all the strength values decreased when compared to normal concrete.
2. It was found that as percentage of GGBS increases, the workability of GGBS increases and the strength gets reduced. In order to increase the strength, cement is replaced by combination of GGBS and RHA.
3. GGBS and steel fibers can be used in concrete as suitable replacement of cement to make concrete strong in both compression and tension and also the use of RHA makes the concrete lighter.
4. Higher strength development is due to filler effects of GGBS, fineness of RHA and properties of steel fiber.
5. Replacing the cement with GGBS keeping RHA and steel fibers is one of the good solutions available to the problem of environmental impacts.

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