Experimental Studies on Concrete Replacing Fine Aggregate with Blast Furnace Slags

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***Abstract*— In our world today, concrete has become ubiquitous. It is hard to imagine modern life without it. Approximately five billion tonnes of concrete are used around the world each year. The increasing popularity of concrete as a construction material is placing a huge burden on the natural sand reserves of all countries. In view of the environmental problems faced today considering the fast reduction of natural resources like sand and crushed granite aggregate, engineers have become aware to extend the practice of partially replacing fine aggregate with waste materials. In this present study blast furnace slag from two sources were replaced with fine aggregate and the properties of concrete were studied. The optimum percentages of replacement of these materials were found out. The result obtained encourages the use of these materials as a replacement material for fine aggregate.**

***Keywords*— Blast Furnace Slag, Ground Granulated Blast Furnace Slag, Fine aggregate replacement.**

I. INTRODUCTION

The government of India has targeted the year 2010 for providing housing for all the people [1]. Such large scale construction projects require huge amount of money which contributes to about 70 percent cost in developing countries like India. The present need is to replace the scarce and costly conventional building materials by innovative, cost effective and environment friendly alternate building materials. For many years by-products such as fly ash, silica fume and slag were considered as waste materials which have been used in the construction for partially or fully replacing fine and coarse aggregates.

Following a normal growth in population, the type and amount of waste materials have increased rapidly. Many of the non-decaying waste materials will remain in the environment for thousands of years. The non-decaying waste material causes a waste disposal predicament, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy and its aim is to reduce, reuse, or recycle waste, being the preferred option of waste disposal.

Semiha et al [2] studied the properties of Granulated Blast Furnace Slag (GBFS) and Fly Ash addition on the strength properties of lightweight mortars. The results revealed that the use of GBFS with the replacement ratio of 50% in waste PET Lightweight aggregate mortars, reduced the unit weight, increases the compressive strength and reduced drying shrinkage after 90 days.

Arellano et al [3] studied the properties of lightweight concretes of activated metakaolin fly ash binders, with blast furnace slag aggregates. This work investigated geopolymeric lightweight concretes with density 1200, 900 and 600 kg/m^3 by adding aluminium powder in some formulation. The microstructure of the concrete was also studied.

Yun Wang Choi et al [4] studied the characteristics of mortar and concrete containing fine aggregate manufactured from recycled waste polyethylene terephthalate bottles. The results obtained from the research are the sorptivity coefficient was reduced by 25% and the slump value was found to increase with the increase in percentage of polyethylene terephthalate bottle aggregates.

The aim of this research is to study the physical and mechanical properties of concrete, replacing fine aggregate with blast furnace slag and ground granulated blast furnace slag.

II. EXPERIMENTAL PROGRAM

A. Materials Used:

The key materials used in this study were cement, sand, crushed stone, GGBFS and BFS. The cement used was an ordinary portland cement of grade 43 with a specific gravity of 3.14. The fine aggregate confirms to grading zone III as per IS 383-1970 [5] was used in the present research. The specific gravity of the fine aggregate was 2.65. The coarse aggregate used was crushed stone with a maximum size of 20mm. GGBFS was collected from Jindal Steel Works (JSW), Meycheri, Salem. The specific gravity of GGBFS was 2.14. BFS was collected from State Industries Promotion Corporation of Tamilnadu Ltd (SIPCOT), Dindigul which has a specific gravity of 2.39. The molten BFS was crushed manually and was used in concrete. The type of GGBFS and BFS used in the research was shown in Fig. 1. The potable water from the college was used for mixing and curing the concrete.

B. Mix Proportion:

The mix was designed as per IS 10262-1982 [6] to have a characteristic compressive strength of 20 N/mm^2. Based on the mix design the cement content was identified as 383 kg/m^3. The water cement ratio was taken as 0.5. No superplasticiser was used in this study. The details of mix proportion and the quantity of materials used were given in table 1.

TABLE 1
MIX PROPORTION

Sl. No.	Cement	Fine aggregate	Coarse aggregate	Water (lit.)
Mix Proportion	1	1.45	3.24	0.5
By Weight (kg/m^3)	383	556	1241	192

Fig. 1 GGBFS and BFS used in this study

III. SAMPLING AND TESTING METHODS

C. Specimen Preparation:

Concrete was prepared based on the specifications mentioned in IS 516-1959 [7]. The quantities of cement, fine aggregate and coarse aggregate was determined by weight. The concrete was mixed by hand. The concrete was mixed on a non water absorbent platform with a shovel. The workability of the concrete was tested with the slump cone test. For the compressive strength test, concrete specimens were cast in 150mm x 150mm x 150 mm cube steel mould and compacted in a table vibrator to ensure complete compaction. The specimens were covered with sacks for 24 hours to maintain the humidity. After 24 hours the specimen were demoulded and allowed for curing till the date of testing.

D. Testing Methods:

After 28-days curing the concrete cubes were taken out of the curing tank and the surface water was wiped off. The dimensions of the specimens to the nearest 0.2mm were taken. The weight of the cube was noted using an electric balance before testing the compressive strength of the cube. The compressive strength test was conducted on a compression testing machine with a capacity of 200 Tonnes. The load was applied on a uniform rate without any shock. The compressive strength was calculated as the maximum load divided by the cross sectional area of the specimen and was expressed in N/mm^2. Three cubes were tested as a representation of a batch.

IV. RESULTS AND DISCUSSION

E. Density:

After 28 days of curing the specimen were taken out of the curing tank and the density of the cube was observed. The results of the density obtained were given in table 2. The relationship between replacement percentage and the density of the specimen were given in Fig. 2. The density of the GGBFS replaced concrete was found to be minimum compared to the density of BFS replaced concrete. The density of BFS replaced concrete was found to be 2459 kg/m^3 for 5% replacement of fine aggregate, and then it starts to increase. The density of GGBFS replaced concrete found to decrease even after replacing 30% of fine aggregate.

F. Compressive Strength:

The results for the compressive strength are presented in table 3 and table 4. The highest 28-day compressive strength of 40.69 N/mm^2 was obtained in this research. The optimum percentage replacement of GGBFS was found to be 20%. When 25% of GGBFS was replaced with fine aggregate the compressive strength of concrete was found to decrease. For BFS 25% replacement was identified as optimum since it gives the maximum compressive strength. The comparison of compressive strength with the density was given in Fig. 3.

TABLE 2
DENSITY OF CONCRETE IN Kg/m^3

Sl. No	Replacement (%)	GGBFS	BFS
1.	0	2518	2518
2.	5	2476	2459
3.	10	2449	2489
4.	15	2410	2518
5.	20	2410	2518
6.	25	2360	2548
7.	30	2331	2548

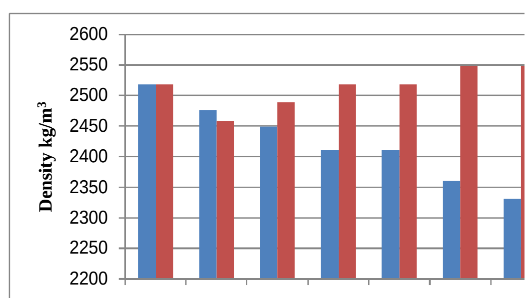

Fig. 2 Density of GGBFS and BFS replaced concrete

TABLE 3
COMPRESSIVE STRENGTH OF CONCRETE WITH GGBFS

Sl. No	Fine Aggregate replacement with GGBFS (%)	Compressive Strength (N/mm^2)		
		7 days	14 days	28 days
1.	0	19.37	21.8	28.92
2.	5	20.26	22.68	29.63
3.	10	20.95	25.58	30.81
4.	15	22.82	30.52	34.59
5.	20	23.56	31.68	35.17
6.	25	20.56	25.44	29.79
7.	30	19.20	24.41	28.78

TABLE 4
COMPRESSIVE STRENGTH OF CONCRETE WITH BFS

Sl. No	Fine Aggregate replacement with BFS (%)	Compressive Strength (N/mm^2)		
		7 days	14 days	28 days
1.	0	19.61	21.8	28.92
2.	5	20.06	24.56	29.36
3.	10	21.36	27.90	31.25
4.	15	22.22	28.77	34.59
5.	20	23.54	30.96	36.47
6.	25	28.92	32.85	40.69
7.	30	22.82	26.89	32.99

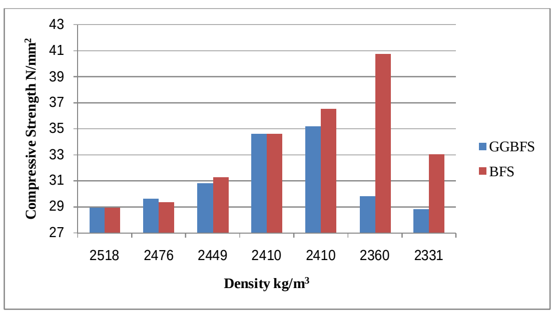

Fig. 3 Relationship between compressive strength and density

V. CONCLUSIONS

The following conclusions were drawn based on the experimental results obtained.

- The results obtained encourage the use of blast furnace slag in concrete as a partial replacement to fine aggregate up to 25%.
- The maximum compressive strength of 40.69 N/mm^2 was obtained by replacing 25% of fine aggregate with BFS.
- Workability was found to be a problem with the fresh concrete, and hence usage of superplasticiser was recommended.
- The usage of BFS will reduce the cost of concrete by 8 to 10%.

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