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A Research on Strength of Concrete by Replacing Natural Sand with Granulated Blast Furnace Slag

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Abstract: ***There are numerous negative social and environmental effects of overuse of river sand for construction. To reduce this, various substitutes have been used such as quarry dust, demolished concrete waste, industrial waste such as copper slag, eco sand etc. GBFS (Granulated Blast Furnace Slag) is a slag obtained from the manufacture of iron in steel industries. This research aims to investigate the possibility of replacing Granulated Blast Furnace Slag (GBFS) as sand substitutes in concrete. In this research, natural sand was replaced by GBFS in various percentages (0%, 25%, 50%, 75% and 100%) with a constant water cement ratio of 0.45. Tests such as sieve analysis, specific gravity, fineness modulus and bulk density were done for fine aggregates and GBFS sample. Different mixed proportions for different percentage replacement of fine aggregates was obtained for M30 grade concrete as per IS 10262: 2009. The durability test was done for cubes of control mix and GBFS mix (0%, 25%, 50%, 75% and 100%). It was found the strength of concrete was improved due to the addition of GBFS as fine aggregates. Test results showed that the compressive strength of concrete increased with increase in percentage of GBFS up to 75%. Beyond 75%, there was a marginal decrease in strength of concrete.***

Keywords: GBFS; Acid Attack Test; Compressive strength Test; Sulphate Attack Test.

I. INTRODUCTION

Sand is a major ingredient used in mortar and concrete preparation. River sand is now scarce due to river flooring and other environmental issues as usual due to the increasing population of concrete buildings. The need for sand is increasing due to the increasing popularity of concrete buildings, which increases the cost of sand and leads to sand shortages. It is important to find the new substitute material to replace the river sand because of the non availability of river sand. However, the impact on the environment can be reduced by using industrial waste material, and this is said to be waste hierarchy. Utilization of industrial product in the sector could become an important route for large scale safe disposal of industrial waste. GBFS is obtained by quenching molten iron Slag from a blast furnace in water or steam to produce granular product which is then dried. The quality of iron and blast furnace slag are interdependent. GBFS has good property in terms of durability, appearance and higher ultimate strength so that when used with ordinary Portland cement, high sustainability level can be obtained. GBFS is very effective in reducing the expansion due to aggregate silica reaction in concrete. This research is an attempt to partially replaced GBFS from natural sand with various percentages (0%, 25%, 50%, 75%, and 100%) with constant water cement ratio of 0.45. the concrete blocks were kept in the solution of sodium sulphate and hydrochloric acid for checking the durability test for 28 days curing.

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II. OBJECTIVES

To explore the possibility of using GBFS as the replacement of Natural River sand in mortar with various experimental works. In this research work ,the mortar mix of 1:2 was selected for 0%, 25%, 50%, 75%, 100% replacement of natural sand with GBFS are carried out with compressive strength tests.

III. EXPERIMENTAL WORKS

A. Materials Used

Cement, sand, GBFS and water were the key ingredients used in this research.

a. Cement

Ordinary Portland cement (Chettinad 43 grade) was used throughout the investigation. The cement used has been tested for various properties and found to be confirming to the various specifications of IS 269-1976. The studied properties of cement are given in Table 1 below.

Table- 1: Physical Properties of Cement

Description	Test Values
Specific gravity	3.15
Normal Consistency	33%
Initial Setting Time	41 min

b. Fine Aggregate

The fine aggregate used throughout the investigation were natural sand. The physical properties of natural river sand passing through 4.75mm sieve such as sieve analysis, specific gravity, bulk density etc were determined as per IS 2386-1963

c. Granulated Blast Furnace Slag

The GBFS confirms to grading zone II as per IS 383: 1970 has been used. The physical properties such as fineness, specific gravity etc, are determined in accordance with IS 2386-1963 shown in Table 2.

Table -2: Properties of Natural sand and GBFS

Properties	Natural Sand	GBFS
Specific Gravity	2.71	2.505
Grading Zone	II	II
Fineness Modulus	2.196	2.646
Uniformity Co-efficient	2.79	2.7

d. Coarse Aggregates

The coarse aggregate used her is machine crushed into well grade 20mm and down sized. The granite aggregates confirming to the grading zone I as per IS 383-1970. The physical properties of aggregates were tested such as fineness modulus, specific gravity, bulk density, as per IS 2386-1963 is shown in Table.3.

Table.3. Properties of Course Aggregate

Description	Tested Values
Fineness Modulus	7.5
Specific Gravity	2.676

e. Water

Drinking well water is used for mixing and curing the concrete.

B. Casting and Testing of Cubes

Required numbers of cubes were casted. Mixing was performed at room temperature. Portable water was used for the preparation of cement concrete cubes. Three sets of cubes were casted to determine the compressive strength of cubes at 7 days, 28 days and 90 days. Table 4 shows the mix combinations for different trials.

Table – 4: Mix combinations with replacement of GBFS

Mix ID	Combination
M1	Cement + 0% GBFS + 100% FA + CA
M2	Cement + 25% GBFS + 75% FA + CA
M3	Cement + 50% GBFS + 50% FA + CA
M4	Cement + 75% GBFS + 25% FA + CA
M5	Cement + 100% GBFS + 0% FA + CA

In compliance with the Indian Standards Specifications IS 516-1959, all specimens has been tested on average for three specimens for each mix.

C. Water Absorption Test

The cubes casted for different percentage or replacement of river sand with GBFS have been tested for percentage of water absorption. The differences in the weight of cubes are calculated.

D. Compressive Strength Test

The compressive strength of cubes for different mix proportions was determined as per IS 516:1959. The compressive strength development of concrete containing different replacement percentage of GBFS is determined at 7 days, 28 days, and 90 days curing.

E. Sulphate Attack Test

The casted cubes are cured for the period of 28 days at the lab in room temperature. After curing for 28 days, the cubes are immersed in the 5% solution of sodium sulphate with water for the period of 28 days at the lab temperature in order to check the sulphate attack in concrete. The percentage of change in weight of cubes at 30 days and 60 days were calculated.

F. Acid Attack Test

The cubes casted with different mix combinations are subjected to curing. After curing for a period of 28 days, the cubes are immersed in the 5% solution of hydrochloric acid with water in the lab at room temperature. The percentage change of weight in cubes was determined in order to check the acid attack in concrete.

IV. RESULTS AND DISCUSSIONS

A. Water Absorption Test

The water absorption for different mixes of the replacement of natural sand with GBFS is found and tabulated below in Table.5.

Table.5 Percentage of Water Absorption

Mix ID	Percentage of river sand replaced by GBFS	Percentage of Weight loss
M1	0	2.77
M2	25	1.15
M3	50	1.007
M4	75	0.8
M5	100	0.91

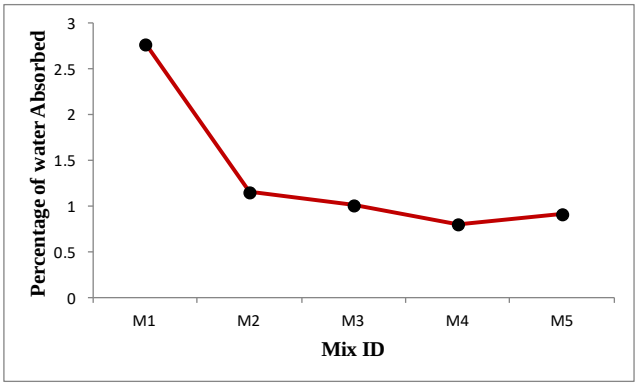

Fig-1: Percentage of water absorption

The percentage of water absorption reduced at the mix 75% mix replacement of GBFS and it shows the percentage of water absorption is more in other mixes.

B. Compressive Strength

The compressive strength development of cubes containing different percentage of GBFS replacement is shown below in Table 6 for 7, 28, 90 days curing.

Table-6: Compressive Strength after replacing by GBFS

Mix ID	Compressive Strength (MPa)		
	7 Days	28 Days	90 Days
M1	19.2	26.1	28.6
M2	19.96	26.9	29.82
M3	20.56	28.11	31.42
M4	20.74	28.4	34.66
M5	20.04	21.2	29.23

Natural sand replaced with GBFS by 75% shows better strength than that of conventional mix. The highest compressive strength of 20.74MPa, 28.4MPa, 34.66MPa corresponding to 7, 28, 90 days has been attained respectively. It shows the significant amount of decrease in compressive strength is attained at 100% replacement of GBFS.

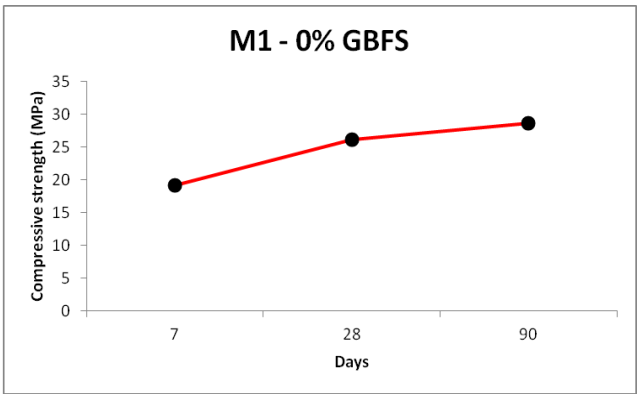

Fig-2: Compressive Strength of 0% GBFS Replacement

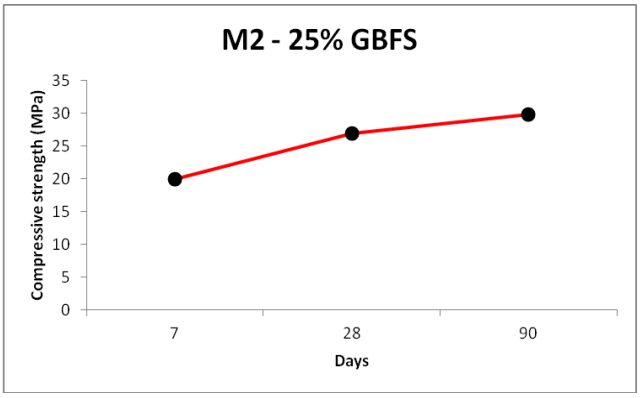

Fig-3: Compressive Strength of 25% GBFS Replacement

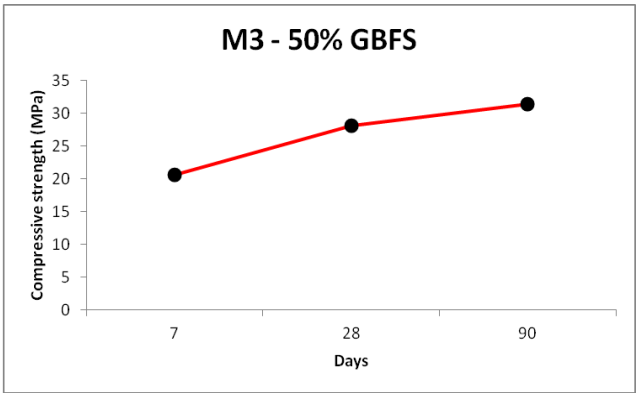

Fig-4: Compressive strength of 50% GBFS Replacement

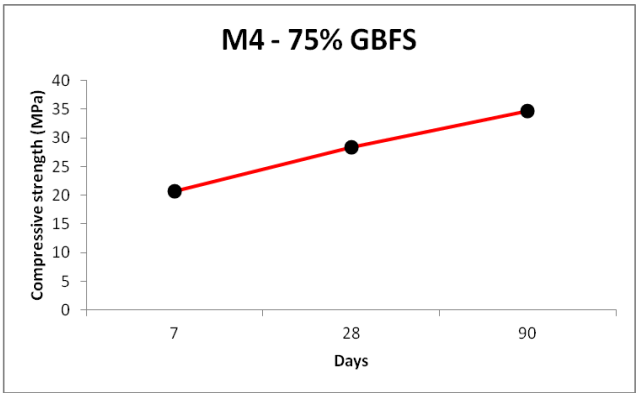

Fig-5: Compressive strength of 75% GBFS Replacement

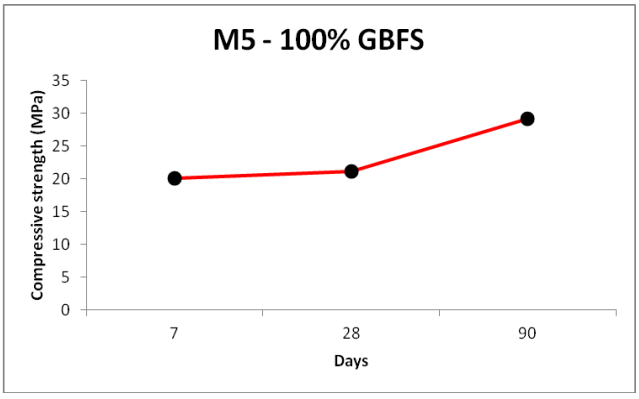

Fig-6: Compressive strength of 100% GBFS Replacement

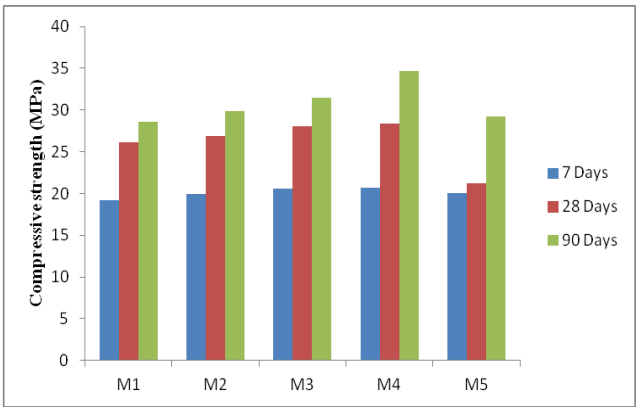

Fig-7: Compressive strength Vs. Mix

C. Sulphate Attack Test

Table- 7.Shown below gives the result for sulphate attack test.

Table- 7: Sulphate Attack Test Values

Mix ID	Percentage of change in Weight	
	30 Days	60 Days
M1	2.208	4.8
M2	1.039	1.005
M3	0.812	0.647
M4	0.520	0.540
M5	0.607	0.373

It is found that the sulphate attacked more in the mixes of replacement of natural sand by 0% of GBFS which adversely effects on the concrete and also have low attack on the mixes of 75% and 100% replacement as compared to the other different mixes.

D. Acid Attack Test

Acid Attack test results are shown below in Table 8.

Table-8: Acid Attack Values

Mix ID	Percentage of Change in Weight	
	30 Days	60 Days
M1	1.86	4.11
M2	1.722	1.22
M3	1.53	1.1
M4	1.12	0.87
M5	0.92	0.84

From the above table it is found that the acid attack more in the mixes of replacement of natural sand by 0% of GBFS which adversely effects on the concrete and also have low attack on the mixes of 75% and 100% replacement as compared to the other different mixes.

V. CONCLUSIONS

- Replacement of 50% to 75% was considered desirable in concrete to increase the compressive strength. However the 100% replacement shows the decrease in the compressive strength. Therefore the replacement of GBFS more than 75% is not recommended.
- Replacement of GBFS from 75% to 100% found favorable in sulphate attack and acid attack tests. But strength of the concrete drastically reduced which is not advisable for implementing in structural members.
- Hence 75% GBFS replacement can be used as fine aggregates without affecting any properties of concrete.

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