ANALYSIS OF GRANULATED BLAST FURNACE SLAG AS A SUBSTITUTE FOR FINE AGGREGATES IN LIGHT WEIGHT CONCRETE

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Abstract:

The over use of river sand for building has a variety of detrimental social and environmental repercussions. Different replacements, including quarry dust, trash from demolished concrete, industrial waste like copper slag, eco sand, etc., have been employed to minimize this. Granulated blast furnace slag, or GBFS, is a byproduct of the production of iron in the steel industry. The purpose of this study is to look at the feasibility of using Granulated Blast Furnace Slag (GBFS) in place of sand in concrete. In this study, GBFS was used in lieu of natural sand in varying percentages (0, 25, 50, 75, and 100%) with a constant water-to-cement ratio of 0.45. For fine aggregates and GBFS sample, tests such sieve analysis, specific gravity, fineness modulus, and bulk density were carried out. With M30 grade concrete, various mixed proportions for varying percentages of replacement of fine particles were determined in accordance with IS 10262: 2009. The cubes of the control mix and the GBFS mix underwent a durability test (0 percent , 25 percent , 50 percent , 75 percent and 100 percent). It was discovered that using GBFS as fine aggregates increased the concrete's strength. According to test findings, concrete's compressive strength rose as GBFS percentage climbed up to 75%. Concrete's strength began to slightly decline at 75 percent.

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

1. INTRODUCTION

Sand is a crucial component in the manufacture of mortar and concrete. River sand is currently in short supply because of river flooring and other environmental problems brought on by the rising number of concrete structures. Because concrete structures are becoming more and more popular, there is a growing demand for sand, which drives up its price and creates a sand scarcity. Considering that river sand is not readily available, it is crucial to discover a new replacement material. Utilizing industrial waste, or what is referred to as waste hierarchy, may lessen the environmental effect. The sector's use of industrial products might develop into a crucial pathway for the large-scale, safe disposal of industrial waste. To create granular product that is later dried, molten iron slag from a blast furnace is quenched with water or steam. Blast furnace slag and iron quality are interrelated. When combined with regular Portland cement, GBFS has excellent durability, aesthetic qualities, and greater ultimate strengths, resulting in a high sustainability level. The expansion brought on by the aggregate silica reaction in concrete is significantly reduced by GBFS. In this study, GBFS is attempted to be partly substituted from natural sand at different percentages (0, 25, 50, 75, and 100%) with a constant water-to-cement ratio of 0.45. For a 28-day curing period, the concrete blocks were stored in a solution of sodium sulphate and hydrochloric acid to assess their durability.

2. OBJECTIVES

To carry out a number of experimental studies to examine the potential for replacing Natural River sand in mortar with GBFS. Compressive strength tests for the replacement of natural sand with GBFS at 0%, 25%, 50%, 75%, and 100% were conducted using the mortar mix of 1:2 in this research study.

3. EXPERIMENTAL WORKS

3.1 Materials Used

Water, GBFS, cement, and sand were the main components employed in this study.

3.1.1 Cement

Throughout the experiment, ordinary Portland cement (Chettinad 43 grade) was used. The cement in use has undergone testing for several qualities and has been confirmed to meet all the requirements of IS 269-1976. Table 1 below lists the cement's investigated qualities.

Table- 1: Physical Properties of Cement

Description	Test Values
Specific gravity	3.15
Normal Consistency	33%

Initial Setting Time	41 min

3.1.2 Fine Aggregate

River sand was the fine aggregate employed throughout the experiment. According to IS 2386-1963, the physical characteristics of naturally occurring river sand that passed through a 4.75mm sieve, including sieve analysis, specific gravity, bulk density, etc.

3.1.3 Granulated Blast Furnace Slag

The GBFS attests to the usage of grading zone II in accordance with IS 383: 1970. As stated in Table 2, the physical characteristics, such as fineness and specific gravity, are calculated in line with IS 2386-1963.

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

3.1.4 Coarse Aggregates

Machine-crushed, well-graded 20mm coarse aggregate is utilized in this evaluation. According to IS 383-1970, the granite aggregates conform to grading zone I. According to IS 2386-1963, aggregates' physical characteristics, including fineness modulus, specific gravity, and bulk density, were examined.

Table – 3: properties of Coarse Aggregate

Description	Tested Values
Fineness Modulus	7.5
Specific Gravity	2.676

3.1.5 Water

The water used for mixing and curing should be clean and free from injurious quantities of alkalis, acid, oils, salt, sugar, organic materials, vegetable growth and other substances that may be deleterious to bricks, stone, concrete or steel. Concrete mixing and curing are done using potable well water.

3.2 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

All specimens have been tested in accordance with the Indian Standards Specifications IS 516-1959, typically three specimens for each combination.

3.3 Water Absorption Test

river sand with GBFS have been tested for percentage of water absorption. The differences in the weight of cubes are measured and noted.

3.4 Compressive Strength Test

According to IS 516:1959., the compressive strength of cubes was calculated for various mix proportions. At the seven-day, twenty-eight-day, and ninety-day curing stages, the compressive strength development of concrete with various GBFS replacement percentages is assessed.

3.5 Sulphate Attack Test

The cast cubes are room-temperature-cured in the lab for a total of 28 days. In order to check the sulphate attack on the concrete, the cubes are submerged in a 5 percent solution of sodium sulphate with water for a total of 28 days at lab temperature. At 30 and 60 days, the weight change of the cubes was calculated as a percentage.

3.6 Acid Attack Test

The curing procedure is used to treat the cubes that were cast using different mix formulations. After 28 days of curing, the cubes are placed in a 5 percent solution of water and hydrochloric acid, which is kept at room temperature in the lab. Calculating the weight shift in cubes as a percentage allowed for the detection of acid attack on concrete.

4. RESULTS AND DISCUSSIONS

4.1 Water Absorption Test

The water absorption for various blends of natural sand replacement with GBFS is discovered and listed in Table 5 below.

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

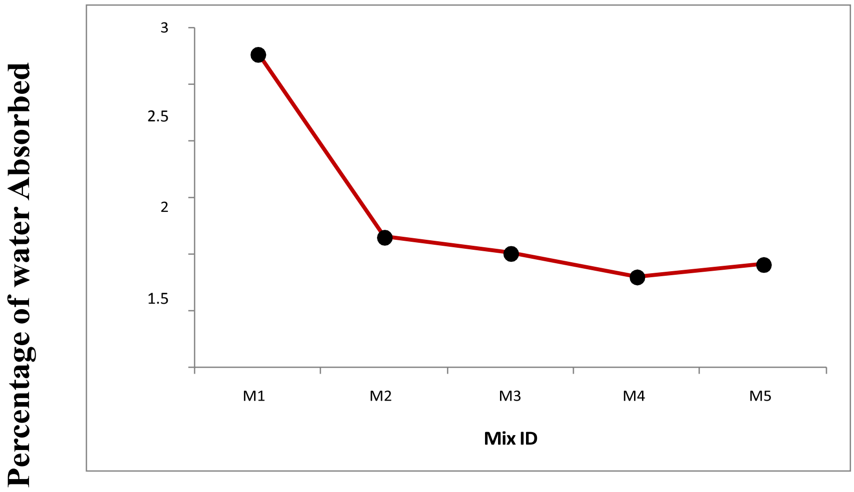

Fig-1: Percentage of water absorption

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.

4.2 Compressive Strength

The compressive strength development of cubes with various percentages of GBFS substitution is shown in Table 6 below for curing times of 7, 28, and 90 days.

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 that has been replaced with GBFS by 75% exhibits greater strength than standard mix. The greatest compressive strength, which corresponds to 7, 28, and 90 days, has been reached at 20.74 MPa, 28.4 MPa, and 34.66 MPa, respectively. It demonstrates that a considerable degree of compressive strength loss occurs when GBFS is replaced entirely.

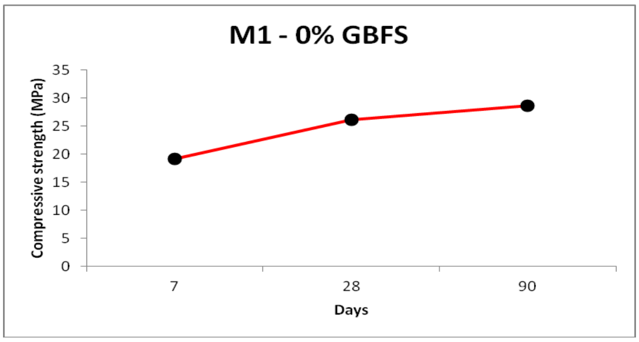

Fig-2: Compressive Strength of 0% GBFS Replacement

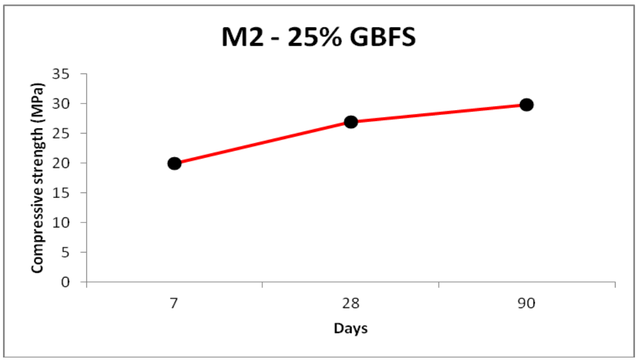

Fig-3: Compressive Strength of 25% GBFS Replacement

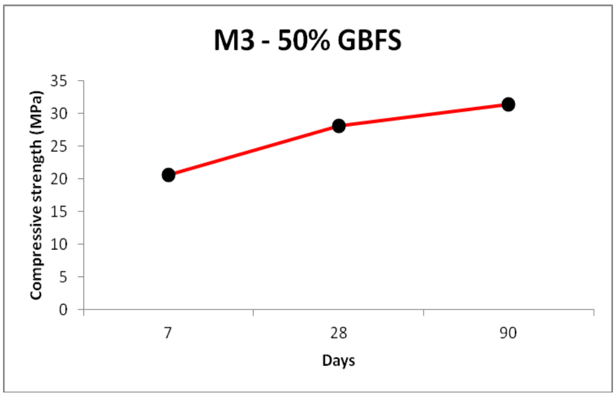

Fig-4: Compressive strength of 50% GBFS Replacement

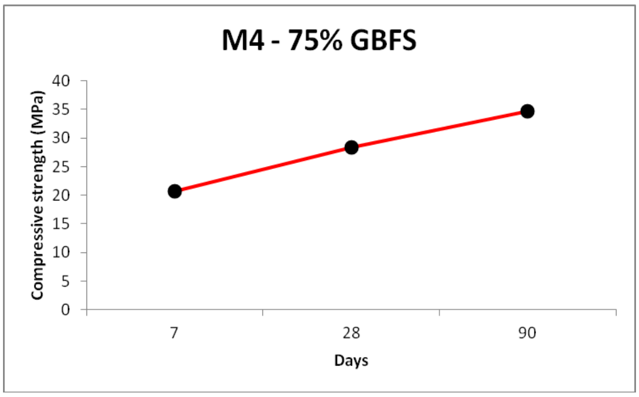

Fig-5: Compressive strength of 75% GBFS Replacement

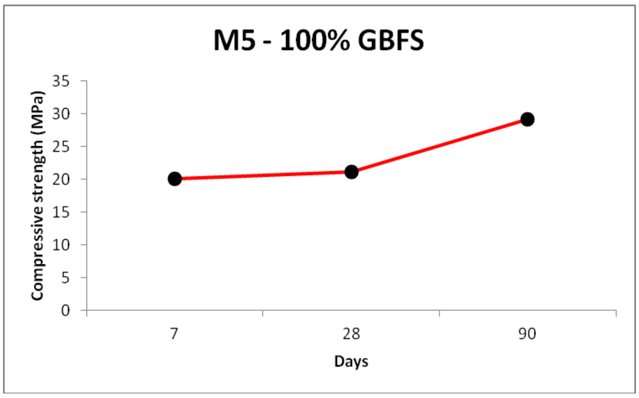

Fig-6: Compressive strength of 100% GBFS Replacement

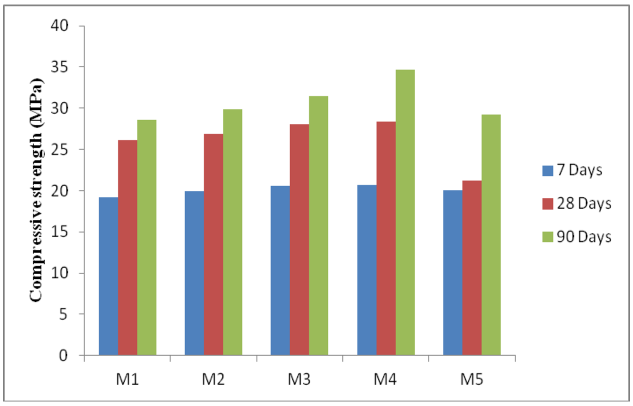

Fig-7: Compressive strength Vs. Mix

4.3 Sulphate Attack Test

Table- 7. Shown below gives the result for sulphate attack test. It was discovered that the sulphate attacked more in the mixes when natural sand was replaced with 0% GBFS, which had a negative impact on the concrete, and that it attacked less in the 75 and 100 percent replacement mixes.

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

4.4 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

According to the above table, mixtures that substitute 0 percent of GBFS for natural sand suffer greater acid attack than other mixes with 75 percent and 100 percent replacement of natural sand. This has a negative impact on the concrete.

5. CONCLUSIONS

- To increase the compressive strength of concrete, replacement of 50% to 75% was thought to be ideal. The compressive strength has decreased, nevertheless, as seen by the 100% replacement. Therefore, it is not advised to replace GBFS by more than 75%.
- In tests for sulphate attack and acid attack, replacement of GBFS from 75% to 100% was favorable. However, the concrete's strength was significantly diminished, making it unwise to use it as structural components.
- As a result, fine aggregates made up of 75% GBFS may be utilized without changing the qualities of concrete.

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