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Compressive Strength By Partial Replacing of Sand with GBFS

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Abstract: The natural sand used acquired from the river bed is everlasting supply, but now the sand resources are getting depleted and exhausted. They are driven by the acute need to find a product that can match the properties of natural sand in concrete, the sand manufactured by crushing the natural rocks. The by-product (stone dust) of the crushing and screening process of coarse aggregates is a fine aggregate. Since rock sand contains more fine particles, it requires more water; hence, quality suffers resulting in low compressive strength and durability. The quality problems caused many concrete manufacturers to think for an alternative source of sand in-place of Rock sand, Thus by using GBFS as fine aggregate in replace of natural/rock sand, we may able to conserve natural resources and its use in concrete, and compressive strength results revealed that it could be as an alternative to sand.

Keywords: Physical properties, chemical composition, mechanical properties, and compressive strength.

I. INTRODUCTION

Concrete and sand are naturally available materials and widely used in construction. Aggregate occupies a large volume of about three quarters and next to sand. These two are the key materials responsible for the depletion of natural resources. Alternatives have to used and discovered to preserve the natural resources so that in future global demands are fulfilled. To reduce the burden on the environment, it has been suggested that the necessary processes need to initiated in preserving the environment in its natural state to the highest degree possible.it can be widely used for manufacture of Portland Slag Cement (PSC) , used in other parts like Highway Paving, Industrial Floors, Structural Foundation, Bridge Columns, and Decks, used in Footing and Walls, Slip Form Curbs, Flatwork, Driveways, and Sidewalks. Therefore, the use of alternative sources for natural aggregates is becoming increasingly important. Slag is a co-product of the iron and steel making process[1].

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1) Materials:

Here cement used is conforming to OPC 53 grade, and locally available sand used as fine aggregate conforming to IS specifications [8], and GBFS used as a fine aggregate.

2) Properties of materials:

Cement: Specific gravity = 3.15
Coarse Aggregates: as per code [6-7]
Bulk Specific Gravity = 2.49
Absorption characteristic 3.03%
SSD Specific Gravity of 2.57.
Fine Aggregates: Bulk Specific Gravity = 2.60
Absorption characteristic =1.18%
SSD Specific Gravity was 2.63.

B. *Cement:*

The ULTRATECH Cement Group supplies the cement. The cement properties and it's chemical composition provided by Ultratech Cement Group shown in the below table.

Table 1. Composition & Properties of OPC 53 grade

Chemical Composition	Percentage
SiO_2	17 - 25 %
Fe_2O_3	0.4 - 0.6 %
Al_2O_3	4-8%
CaO	60 - 63 %
MgO	0.1-4.0 %
SO_3	1.3-3.0 %
K_2O+ Na_2O	0.4-1.3 %
Insoluble Residue	0.6-1.75 %
Colour Index	0.01-0.1 %
Calculated Compounds	Percent
C_3S	47 -52%
C_2S	21- 26 %
C_3A	7 - 10 %
C_4AF	14 -16 %
Free lime	1 - 2 %
Properties of cement	
Fineness: Blaine	225 m2/kg
Autoclave Expansion	0.8 %

Granulated Blast Furnace Slag:

JSW Cements provided the GBFS used in this research, and its properties [5] and chemical composition is as follows

i. Fineness' 300 m2/kg
ii. MgO: Max. 5.5%
iii. MnO: Max. 17.0%
iv. Sulphide Sulphur: Max. 2.0%
v. Glass content: Min. 85%
vi. Insoluble Residue: Max. 5%

Fig: 1,2 & 3 Fine aggregate - Natural Sand, Coarse aggregate – 20mm size and GBFS.

Coarse Aggregates: The Coarse aggregates used for the research have a nominal size of 20 mm.

1) Granulated Blast Furnace Slag (GBFS): GBFS is a by-product obtained from the iron and steel industries. It is lightweight as compared to sand, and it is used nowadays in construction due to its similar properties and strength as compared to other alternatives. It is a fire-resistant one and used in various applications such as manufacturing of glass, geopolymer concrete, and various engineering filling as and when required for heavy massive structures to make it lighter one.

Table 2. The chemical Composition of GBFS

Chemical Constituents (As Oxides)	GBFS (in %)
SiO2	38-40.0 %
Al2O3	12-13.5%
CaO	35-39.2%
MgO	3- 3.6%
Fe2O3	1-1.8%
SO3	0.1-0.4%

Mechanical Properties:

Table 3 Mechanical Properties of GBFS

Property	Value
Los Angeles Abrasion	35-45%
Impact	12%
Crushing	8%

Table:4 Preparation of blocks with 0% replacement of sand

Material	Quantity
Cement	11 kg
Sand	22 kg
Aggregates	44 kg
Water	4.95 liters

Preparation of blocks with 100% replacement of sand with GBFS

Table:5. Preparation of blocks with 100% replacement of GBFS

Material	Quantity
Cement	11 kg
GBFS	22 kg
Aggregates	44 kg
Water	4.95 liters

Preparation of blocks with 50% replacement of sand with GBFS

Table:6. Preparation of blocks with 50% replacement of sand with GBFS

Material	Quantity
Cement	11 kg
Sand	11 kg
GBFS	11 kg
Aggregates	44 kg
Water	4.95 liters

Preparation of blocks with 25% replacement of sand with GBFS

Table:7. Preparation of blocks with 25% replacement of GBFS

Material	Quantity
Cement	11 kg
Sand	16.5 kg
GBFS	5.5 kg
Aggregates	44 kg
Water	4.95 liters

II. IMPLEMENTATION AND TESTING

The experimental program has planned and carried out in four stages. They are mixing materials, casting, curing, and testing of specimens[9]. The process experimentally done in four stages from mixing the Ingredients after weighing them required proportions and then followed by placing concrete into the moulds of 150 mm size and compacting it with tamping rods giving 25 blows at each level. Then the cubes are removed from the blocks after 24 hrs right after placing them. Then the curing of blocks is done in the desired ages of 3days, 7days & 28 days, and the compressive strength of the blocks determined with the help of a compressive strength testing machine [2-4].

Fig:4 Procurement of materials

Fig:5 mixing of materials

Fig:6 & 7 curing and testing of specimens

Fig:8 Casting of moulds

III. RESULTS AND DISCUSSIONS

The results have made analyzed, and the graphs showing the strength variations plotted. The effect of partial replacement of sand with GBFS is listed below. In the present project, work investigation is carried out on the concrete specimens by replacing with various proportions of fine aggregates, and their strength properties of specimens are determined. The results given in the tables and variations plotted graphically.

Table 8: Maximum load for samples using 0% GBFS

No of days	3 Days	7 Days	28 Days
1st sample	510 kN	540 kN	550 kN
2 nd sample	500 kN	530 kN	540 kN
3 rd sample	510 kN	520 kN	540 kN

Table:9. Compressive strength using 0% GBFS – Results

No of Days	Load(P)	Compressive strength (MPa)
3 D	506 kN	22.48
7 D	530 kN	23.55
28 D	543 kN	24.13

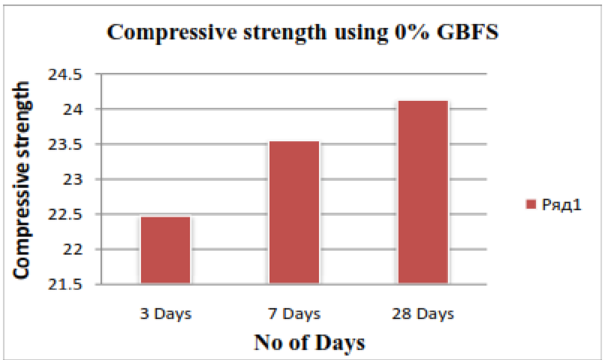

Fig:9 Compressive strength using 0% GBFS

Compressive strength using 100% GBFS

Table 10. Maximum load for samples using 100% GBFS – Results

No of Days	3 D	7 D	28 D
1st sample	560 kN	580 kN	640 kN
2nd sample	550 kN	590 kN	630 kN
3rd sample	570 kN	600 kN	630 kN

Table 11 Compressive strength using 100% GBFS – Results

No of Days	Load(P)	Compressive strength (MPa)
3 D	560 kN	24.88
7 D	590 kN	26.22
28 D	633 kN	28.10

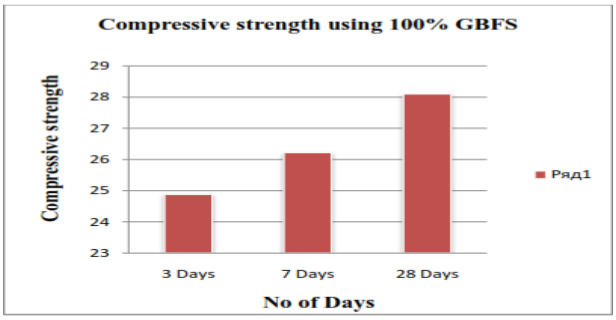

Fig:10 Compressive strength using 100% GBFS

Compressive strength using 50% GBFS

Table 12 Maximum load for samples using 50% GBFS – Results

No of days	3 Days	7 Days	28 Days
1 st sample	590 kN	610 kN	640 kN
2 nd sample	610 kN	620 kN	650 kN
3 rd sample	590 kN	620 kN	650 kN

Table 13 Compressive strength using 50% GBFS – Results

No of Days	Load(P)	Compressive strength (Pa)
3 D	596 KN	26.40 MPa
7 D	613 KN	27.20 MPa
28 D	646 KN	28.71 MPa

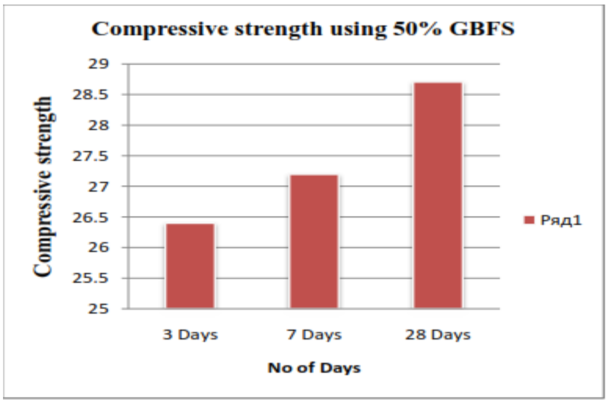

Fig:11 Compressive strength using 50% GBFS

Compressive strength using 25% GBFS

Table 14. Maximum load for samples using 25% GBFS – Results

No. of days	3 Days	7 Days	28 Days
1 st sample	530 kN	550 kN	610 kN
2 nd sample	520 kN	560 kN	620 kN
3 rd sample	530 kN	550 kN	620 kN

Table 15. Compressive strength using 25% GBFS – Results

No of Days	Load(P)	Compressive strength (MPa)
3 D	526 kN	23.37
7 D	553 kN	24.57
28 D	616 kN	27.37

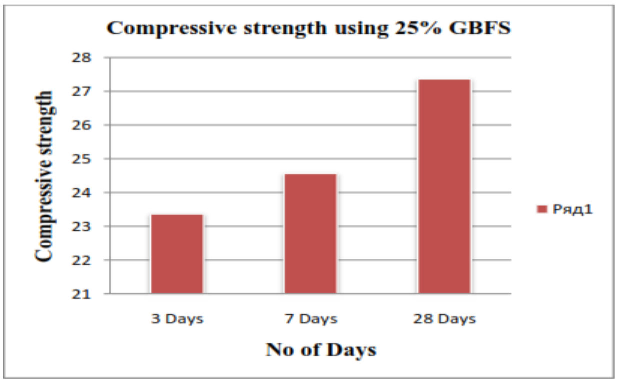

Fig:12 Compressive strength using 25% GBFS

Table 16 Comparing the Compressive Strength Values and Graphs of Different Cases

No of Cases	3 D	7 D	28 D
Case 1	22.48 MPa	23.55 MPa	24.13 MPa
Case 2	24.88 MPa	26.22 MPa	28.10 MPa
Case 3	26.40 MPa	27.20 MPa	28.71 MPa
Case 4	23.37 MPa	24.57 MPa	27.37 MPa

Comparing the Compressive Strength Values and Graphs of Different Cases:

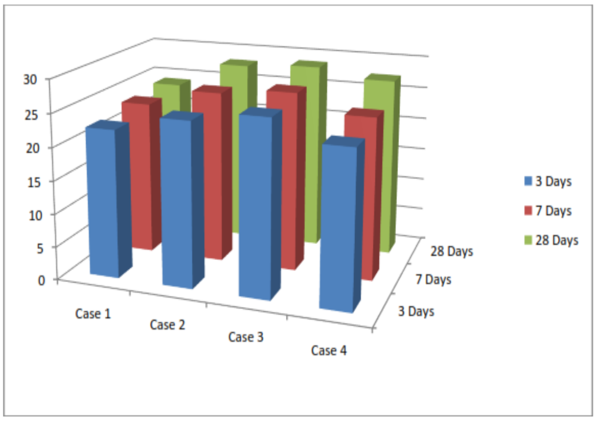

Fig:13. Comparison of Test Results

Case 1: Compressive strength using 0% GBFS
Case 2: Compressive strength using 100% GBFS
Case 3: Compressive strength using 50% GBFS
Case 4: Compressive strength using 25% GBFS

IV. CONCLUSION

From the investigation, conclusions are as follows.
Generally, the addition of GBFS to the concrete mix shows high strength development
The experiment has been carried out with 0, 25, 50, and 100% replacement of sand by GBFS (granulated blast furnace slag). The high strength concrete showed good strength development between the ages of 3, 7, and 28 Days at 50% replacement.
The concrete containing 50 % granulated blast furnace slag carries more strength for about 4 -5 % than the concrete with 100% natural sand.
Thus, Granulated Blast Furnace Slag sand can consume as an alternative to river sand available today.

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