

EXPERIMENTAL INVESTIGATION ON CONCRETE WITH REPLACEMENT OF FINE AGGREGATE BY GRANULATED BLSAT FURNACE SLAG

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Abstract – In this paper to investigate of utilizing granulated blast furnace slag as a sand replacement in concrete. The natural sand availability is very low nowadays, granulated blast furnace slag is an alternative material for used in concrete, and they collected from waste of industrial materials. For decreasing the environmental hazards related to the fine aggregate mining and waste disposal of slag. The present investigation has been undertaken to study the effect of granulated blast furnace slag replaced different percentages 0%, 20%, 50%, 70%, 90% of sand, for the standard w/c ratio 0.45 is considered. The concrete specimens were tested at different ages of 7 days, 14 days, and 28 days. An experimental program was carried out to explore on lab test including compressive strength, split tensile, flexural strength and behavior of concrete with replacement of fine aggregate by granulated blast furnace slag.

Key Words: Sand, Granulated Blast Furnace slag, compressive strength, split tensile, flexural strength.

1. INTRODUCTION

The major challenge of our society is the protection of environment, sand is most important material used in concrete, they availability is very low nowadays, another alternative material of granulated blast furnace slag is used in concrete replaced by natural sand. This paper is discuss the replacement of fine aggregate by granulated blast furnace slag in different percentages are 0%, 20%, 50%, 70%, 90% replaced in concrete. The granulated blast furnace slag is collected from waste of industrial material; Blast furnace slag is by product of steel industries. The molten slag has a composition of 40% silicon dioxide and 39.3% calcium oxide, which is closely to the chemical composition of river sand. Research shows that Blast furnace slag gives large pozzolanic reaction and improved the bond between the paste and aggregate. The granulated blast furnace slag in concrete by replacing natural sand is a most promising concept because its impact strength is more than natural sand. It reduces the use of natural sand and cost of making concrete.

1.1 Literature Review

B.Nagendra Babu et al,(1) Natural resources of construction materials like sand are going on decrease day

by day due to increase in construction works. So, we have to select an alternative for this problem. We select copper slag as one of alternative. It is a glossy substance which a by-product obtained from smelting and refining of copper. The percentage of cement, water and coarse aggregate kept constant within the mixture, while the % of copper slag as a replacement for sand varied from 0% to 50%. Compressive strength test was conducted. From those comparative studies were noticed that optimum % of dosage of copper slag. B.M.Mithun et al., (2) The present study is conducted to evaluate the performance of weathered steel slag coarse aggregates based geopolymer concrete. geopolymer concrete with steel slag coarse aggregates are prepared by replacing natural granite aggregates at different replacement levels i.e. 0% to 100% and various fresh and mechanical properties are studied, steel slag coarse aggregates recorded slightly lower compressive strength along with lower tensile strength and modulus of elasticity. Er.Arvindeer Singh et al,(3), The compressive strength, flexural strength and split tensile strength of concrete for grade M25 and M30 with stone dust as fine aggregate were found to be comparable with the concrete made with the river bed sand. The increase in compressive strength of concrete with 20% replacement and 50% replacement of fine aggregate with stone dust is found to be 8 to 10%.Effective utilization of quarry dust in concrete can save the waste of quarry works; and also produces a 'greener' concrete.

Zine Kiran Sambhaji et al ., (4), Copper Slag behaves like to River Sand both having same contain Silica (SiO₂). The Compressive Strength of Concrete with partial replacement of Sand with Copper Slag up to 50% can be comparable with control mix. It is observed that, the workability of concrete increased with the increase in copper slag content of fine aggregate replacements at same water-cement ratio, the replacement of CS 90% Medium, 100% High workability of concrete. Samdish Abrol, et al., Feb (5), Optimization of steel slag content to achieve a strength equivalent to that of 28 days strength at high volume replacement level. The optimum value of compressive strength can be achieved by 20% replacement of steel slag. The optimum value of flexural strength can be achieved by 20% replacement of steel slag. Sarbjeet singha et al., (6) Granite cutting waste and marble slurry as a replacement for fine aggregate in concrete manufacturing. The optimum compressive strength was observed at replacement percentage of 25% and 15% respectively with

GCW and MS content. The flexural strength of concrete specimens was also enhanced with the addition of GCW and MS. UPV test reflected that best compaction and minimal flaws and cracks occurred in GCW and MS concrete at replacement percentages of 25% and 10% respectively. Both GCW and MS exhibited lesser permeability than control concrete specimens.

Dr. K. Chandrasekhar Reddy et al.,(7) Natural sand is replaced by quarry dust with 0%, 10%, 20% and 30%, and in combination Natural sand is replaced by quarry dust with its highest strength & Cement replaced by fly ash with 0%, 10%, 20% and 30%. The immersion test of sulphuric acid (H₂SO₄) is conducted at 5% by volume of water. The result showed that there is an effect of sulphuric acid on concrete

2. METHODOLOGY

As in the literature review I chosen the granulated blast furnace slag as a sand replacement in concrete and different percentages are 0%, 20%, 50%, 70%, 90%, of GBFS in concrete. The concrete required different materials which are described below.

2.1. Cement

The cement used should confirm to IS specifications. There are several types of Cements are available commercially in the market of which Portland cement Specific Gravity is 3.15 the most known and available everywhere. OPC 53 grade confirms to IS 8112:1989 is used for this study.

2.2. Fine aggregate

Naturally available fine aggregate is used for casting specimens. The fine Aggregate was passing through 4.75mm sieve and had a specific gravity of 2.68. The grading zone of fine aggregate was zone II as per Indian Standard Specification (IS 383).

2.3. Coarse aggregate

Coarse aggregate are the crushed stone is used for making concrete. The Maximum size of coarse aggregate used for this investigation is 20mm and the specific gravity is 2.78.

2.4. Water

Water is major factor in construction controlling strength, everything else being equal, is the amount of water used per bag of cement and curing purpose they used.

2.5. Granulated blast furnace slag

Granulated Blast Furnace Slag consists essential silicates and alumino silicates of calcium. GGBS is obtained from JSW cement company.



Fig 1. Granulated blast furnace slag

The molten slag has a composition of 30% to 40% silicon dioxide (SiO₂) and approximately 40% CaO, which is close to the chemical composition of Portland cement.

The properties like specific gravity, particle size distribution, shape and surface texture are influencing the properties of mortars and concrete in the fresh state. But in some properties like, the mineralogical composition, toughness, elastic modulus and degree of alteration of aggregates are found to be affecting the properties of concrete particularly in the hardened state.

The specific gravity and colour of GGBS is 2.7 and light grey was used. The chemical compositions are given below

Table 1 chemical composition of GBFS

S.NO	Chemical composition	%
1	SiO ₂ (silicon Dioxide)	40
2	Al ₂ O ₃ (Aluminium Oxide)	14.5
3	CaO(Calcium Oxide)	39.3
4	MgO(Magnesium Oxide)	3.5
5	Fe ₂ O ₃ (Iron Oxide)	1.8
6	SO ₃ (Sulphate)	0.5
7	LOI (Loss On Ignition)	0.1

2.6 MIX PROPORTION OF CONCRETE

The concrete mix proportion were made to M30 grade with nominal mix as per IS 456-2000 code of design practice and concrete structure execution. To evaluate first nominal concrete and after evaluate concrete with replacement of fine aggregate by granulated blast furnace slag by range from 20%, 50%, 70% and 90%.

Table 2: mix proportion of concrete

GBFS %	Cement (kg/m ³)	Fine aggregate (kg/m ³)	Coarse aggregate (kg/m ³)	Water (liter)	GBFS (kg/m ³)
0	340	748	1241.35	160	0
20	340	598	1241.35	160	150
50	340	374	1241.35	160	374
70	340	224	1241.35	160	524
90	340	125	1241.35	160	673

3. EXPERIMENTAL INVESTIGATION

The concrete test is important in controlling and confirming the quality of concrete. The strength characteristics of cube, cylinder and beam are tested. The compressive strength test, split tensile strength and flexural strength test are conducted below

3.1. Compressive strength test.

The following steps are adopted to conduct the compressive strength test

- The concrete cubes size of specimen 15x15x15 cm is placed in the center of compressive testing machine.
- Load is applied continuously and uniformly without shock
- The load is increased until the specimen fails and record the values of maximum load carried by each specimen during the test.
- Compressive strength are calculated follow steps

$$\text{Compressive strength} = P/A \times 1000$$

Where,

P = load in KN

A= area of cube surface

Table 3: compressive strength of concrete

S.No	% Of replacement of GBFS	Compressive strength of concrete		
		3 Days (N/mm ²)	7 Days (N/mm ²)	28 Days (N/mm ²)
1	0%	13.8	26.2	37.9
2	20%	15.2	29.8	39.2
3	50%	17.4	34.4	43.8
4	70%	18.1	36.9	47.6
5	90%	15.3	32.4	39.3

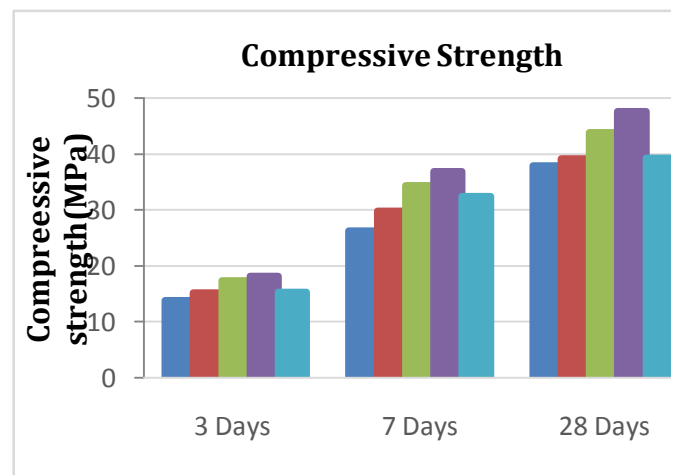


Chart 1: compressive strength vs percentage of slag

3.2. Split tensile strength test

The following steps are adopted to conduct the split tensile strength test

- Draw the dimensional lines on two ends of the specimen. So that they are in the same axial plane.
- Determine the diameter of specimen to nearest 0.2mm by averaging the diameters of the specimen lying in the plane of premarked lines measured near the ends the middle of the specimen.
- Apply the load without shock and increase it continuously at the rate to procedure a split tensile stress of approximately 1.4 to 2.1 N/mm² / min until no greater load can be sustained.
- Note the appearance of concrete and features in the type of failure

The split tensile are calculated follow

$$\text{Split tensile strength} = \frac{2P}{\pi dL} \times 1000$$

where,

P = Load in KN

d = Diameter of cylinder

L = Length of cylinder

Table 4: split tensile strength of concrete

S.No	% Of replacement of GBFS	Split tensile strength of concrete		
		3 Days (N/mm ²)	7 Days (N/mm ²)	28 Days (N/mm ²)
1	0%	2.6	9.1	12.7
2	20%	3.8	9.4	13.2
3	50%	4.2	10.8	14.1
4	70%	4.9	11.9	14.8
5	90%	3.2	9.3	13.4

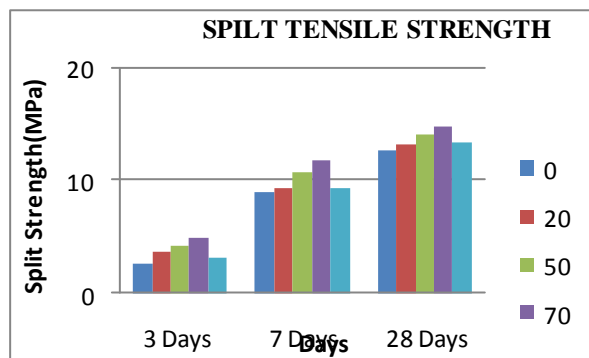


Chart 2: split tensile strength vs percentage of slag

3.3. Flexural strength test

The following steps are adopted to conduct the flexural strength test

- The dimension of each specimen should be noted before testing.
- The specimen is placed in the machine in such member that the load is applied to the upper most surface as cast in the mould.
- The axis of specimen is carefully aligned with the axis of the loading device. No packing is used between the bearing surfaces of the specimen. The load is applied without shock and increasing continuously at a rate of the specimen.
- The load is increased until the specimen fails and the maximum load applied to the specimen during the test is recorded

The flexural strength is calculated follow

$$\text{Flexural Strength} = \frac{PL}{BD^2} \times 1000$$

Where,

P=Load in KN

L= Effective length of beam

b=Width of the beam

d=Depth of beam

Table 5: flexural strength of concrete

S.No	% Of replacement of GBFS	Flexural strength of concrete		
		3 Days (N/mm ²)	7 Days (N/mm ²)	28 Days (N/mm ²)
1	0%	1.4	2.7	5.4
2	20%	2.8	2.9	6.6
3	50%	3.2	3.3	7.1
4	70%	3.8	3.8	7.7
5	90%	2.2	2.8	5.6

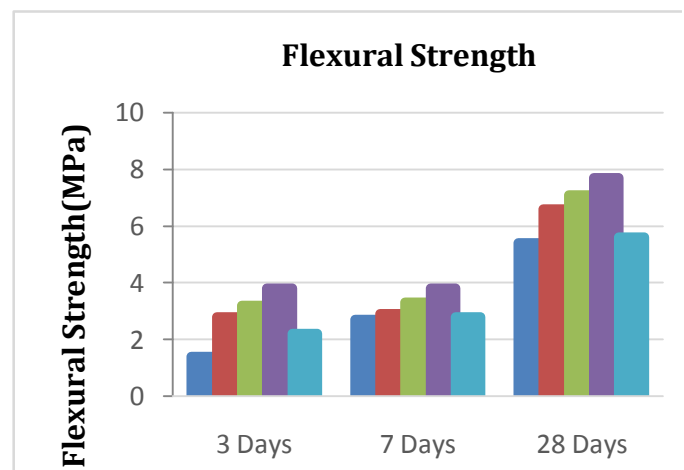


Chart 3: flexural strength vs percentage of slag

4. RESULTS AND DISCUSSION

The above table and charts are used to observe the strength of replce the natural sand as granulated blast furnace slag in concrete. The compressive strength, split tensile strength and flexural strength are GBFS in 50% and 70 % the strength are increased and 90 % of GBFS in concrete are decreased.

The compressive strength of concrete are tested different percentage of GBFS replaced in concrete at the curing days are 3 days , 7 days and 28 days are tested in compression testing machine. From the testing of concrete cubs of increasing the compressive strength at the 50 % and 70% of GBFS in sand, the 90% of GBFS replace as sand the strength are decreased. When it is compared to ordinary concrete than GBFS replaced concrete strength is increased.

The split tensile strength of concrete cylinders and flexural strength of beams are tested in different percentage of GBFS replaced in concrete at the curing days are 3 days, 7 days and 28 days are tested the compression testing machine. The split tensile strength is increased 50% and 70% of replaced in concrete and 90% replace the strength are gradually decreased.

5. CONCLUSION

The experimental investigation show the compressive strength, split tensile strength and flexural strength are achieved up to 70 % of replacement of GBFS in concrete and above 70 % the strength are decreased. The demand for natural sand is increasing day by day, the granulated blast furnace slag is alternative for natural sand and it is freely and cheaply available, reduce the construction cost. The granulated blast furnace slag properties are similar to natural sand and the result shows the ordinary concrete compare to GBFS replaced concrete strength are achieved.

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