PARTIAL REPLACEMENT OF FINE AGGREGATE WITH BLAST FURNACE SLAG

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ABSTRACT
Concrete is the most widely used construction material today. The increasing popularity of concrete construction materials in placing a huge burden on the materials natural sand usage. In a view of environmental problems faced today considering fast reducing of natural resources like sand and crushed granite aggregate. In this present study fine aggregate is replaced with Blast Furnace Slag. The result obtained encourages the use of those materials as a replacement in six levels i.e., 0%, 5%, 10%, 15%, 20% and 25%.

M20 grade of concrete mix is prepared by using cement, sand, crushed stone, GGBF Slag and water. Feasibility of Blast Furnace concrete mix is assessed by conducting compressive strength by casting cubes of 150*150*150 mm dimensions and split tensile strength on cylinders and it is compared with conventional concrete specimens of same dimensions. The test result indicate that BFS can effectively been used as partial replacement for fine aggregate in concrete for 7 days and 28 days.

This project presents the laboratory investigations and comparative study on the feasibility of BFS as partial replacement of fine aggregate in determination of compressive strength of concrete.

I. INTRODUCTION

Concrete is the most widely used man-made construction material all around the world. It is obtained by mixing cement, water and aggregates and sometimes admixtures in required proportion.

By varying the ingredients of concrete, depending upon the purpose and use, the properties of concrete can also be changed. In the construction purpose the most widely used concretes are normal density/normal weight concrete. The density of normal concrete ranges from 2200kg/m^{3}to 2600kg/m^3. The density of light weight concrete ranges from 300kg/m^3 to 1900kg/m^3. The density of heavy weight concrete ranges from 3360kg/m^3 to 3840kg/m^3 .

The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on the environment. Presently a large amount of slag generated from various Iron and Steel Plants. This waste in form of slag, cause a great impact on environment and humans. This paper describes the use of GGBS (Ground Granulated Blast Furnace Slag) and its feasibility in use of it as a partial replacement to sand (or Fine Aggregate).

Blast furnace slag is a by-product of iron manufacturing industry. 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. After the molten iron tapped off, the remaining molten slag, which mainly consists of siliceous and aluminous residues, is then rapidly water- quenched, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size which is known as ground granulated blast furnace slag (GGBFS).

NEED OF THE PROJECT

Our aim is to establish that blast furnace slag used in of natural aggregate in fine aggregate is as good as regular concrete in terms of strength and durability.

- To study the properties of concrete where fine natural aggregate is partially replaced by GGBFS.
- To prepare the testing cubes of size 150mm*150mm*150mm by fine aggregate replacement with GGBFS at a ratio of 0%,5%,10%,15%,20%,and 25%.
- To determine the compressive strength for cubes and Split tensile strength for cylinders at various ages of 7days and 28days.
- To determine the compressive strength and Split tensile strength results of natural aggregate concrete with GGBFS concrete

OBJECTIVES

The objective of present study is to find out the compressive strength and Split tensile strength of concrete using blast furnace slag as partial replacement of natural fine aggregate.

The main objective of the present investigation is to produce density of concrete using available aggregates economically. Keeping the cement content and coarse aggregate content constant, the quantity of fine aggregate is used and the compaction give the density of concrete.

The basic objectives of investigation are:-

- To find or examine the suitability of locally available blast furnace slag for producing density concrete.
- To find the ratio of coarse and fine aggregate of blast furnace slag for maximum strength.
- To find the compressive strength and Split tensile strength of concrete.
- To find the mix proportion using ISI method of concrete design procedure.

LIMITATIONS

- The present investigation is confined only to find out compressive strength and Split tensile strength of concrete.
- The coarse and fine aggregate are brought from the local area.
- The blast furnace slag brought from the GERDAU STEEL PLANT (Tadipatri).
- The study on W/C ratio on the strength of concrete is limited to M20 only on concrete of constraint.

II. LITERATURE REVIEW

Oner(2007), presented a laboratory investigation on optimum level of GGBS on the compressive strength of concrete. Concrete was obtained by adding GGBS in 0%,15%,30%,50%,70%, 90% and 110% of cement content and the specimens were moist cured. The test results proved that the compressive strength of concrete mixtures containing GGBS increases as the amount of GGBS increase. After an optimum point of 55% replacement, the addition of GGBS does not improve the compressive strength. The early strength of GGBS concretes was lower than the control concretes. As the curing period is increased the strength increase was higher for the GGBS concrete. The optimum level of GGBS content for maximizing strength is about 55%-59%.

Pazhani.K,(2010) presented that the slump for 100% replacement of fine aggregate with copper slag increases by 60-85 mm. The replacement of 30% cements by GGBS leads to decrease in water absorption up to 4.58%, chloride ion permeability by 29.9% and pH value by 0.39%. The replacement of 100% of fine aggregate by copper slag decreases water absorption by 33.59%, chloride ion permeability up to 77.32% and pH value by 3.04.

VenuMalagavelli,(2010) studied the characteristics of M30 grade concrete with partial replacement of cement by GGBS and sand with ROBO sand (crusher dust). Compressive strength and split tensile strengths of the cubes and cylinders were increased with increase in % of ROBO sand. The percentage increase in compressive strength were 19.64% and 8.03% after 7 and 28 days and increase in split tensile strength was 1.83% after age of 28 days by replacing 30% sand with ROBO sand. Percentage increase in compressive strength of concrete was 11.06% and 17.6% after 7 and 28 days by replacing 50% cement with GGBS and 25% sand with ROBO sand.

III. MATERIALS AND PROPERTIES

Cement: Cement may be described as a material with adhesive and cohesive properties that make it capable of bonding, mineral (aggregate) in compact whole. In this process, it imparts strength and durability to the hardened mass called concrete. The cement used in the making of concrete are called hydraulic cement so named, because they have the property of reacting chemically with the water in an exothermic process is called hydration that results in water resistant products. The products of hydration form a viscous cement paste, which coats the aggregate surfaces and fills some of the void spaces between the aggregate pieces. The cement paste losses consistency of the cement paste is either excessively wet there is a danger of quality of the hardened concrete or may also result in a honey comb appearance. The freshly set cement grains strength with time. On account of progressive filling of the void spaces in the paste with the reaction products, also resulting in the decrease in porosity and permeability.

All along India, we have been using natural sand. The volume of concrete manufactured in India has not been much, when compared to some advanced countries. The manufacture development such as express highway projects, power projects and industrial developments have started now. Availability of natural sand is getting depleted and also it is called manufactured sand.

COARSE AGGREGATE

Material are large to be retained on 4.7mm sieve size are called coarse aggregate. A maximum size of 10mm is usually selected as coarse aggregate up to 20mm.Aggregate are the important constituents in concrete. They give body to the concrete, reduce the shrinkage and effect economy. Earlier, aggregate were considered as chemically active and also that certain aggregate exhibit chemical bond at the interface and paste.

The fact that the aggregate the concrete it is very essential that one should know more about the aggregates which constitute major volume in concrete is in complete. Cement is the only factory made standard component in concrete. Other ingredients namely water and aggregates are natural materials and can vary to any extent in many of their properties.

BLASTFURNACE SLAG

Ground-granulated blast-furnace slag is obtained by quenching molten iron slag from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.

The chemical composition of a slag varies considerably depending on the composition of the raw materials in the iron production process. Silicate and aluminates impurities from the ore and coke are combined in the blast furnace with a flux which lowers the viscosity of the slag. In the case of pig iron production the flux consists mostly of a mixture of limestone and forsterite or in some cases dolomite. In the blast furnace the slag floats on top of the iron and is decanted for separation. Slow cooling of slag melts results in an unreactive crystalline material consisting of an assemblage of Ca-Al-Mg silicates.

IV EXPERIMENTAL INVESTIGATION

Mix proportion

Water	Cement	Fine aggregate	Coarse aggregate
191.6 lts	383	569	1197
0.5	1	1.54	3.12

COMPRESSIVE AND SPLIT TENSILE STRENGTH OF CONCRETE

Find out the compressive strength of concrete, cubes of size 150mm width of size and 150mm of width and 150mm depth and 150mm length were casted. For each mix proportion 6 no. of cubes were casted. To assess 7 days compressive strength for 3 cubes were tested and the remaining 3 cubes were tested on 28 days for 0% 6 cubes, 5% 6 cubes, 10% 6 cubes, 15% 6 cubes,20% 6 cubes,25% 6 cubes, total 36 cubes were prepared. Similarly for the split tensile strength, cylinders of size 150mm diameter and 300mm height were casted. In this case replacement of Blast Furnace Slag for fine aggregate.

CASTING OF CUBES

The standard size of cubes 150 mm*150 mm*150 mm size are cast iron; strong enough to prevent distortion are used. They are made in such a way so that they can be easily removed. The inside of the mould is given a thin coating of oil to prevent adhesion easily.

After placed the vibration table in order to get perfect compaction for 30 sec mixing the concrete as per the procedure, the concrete placed in cubes in 3 layers by compacting each layer with tamping rod of 16mm diameter, 60 cm long with bullet pointed edges with 25 times. After manual achieving complete mixing the concrete is placed in cubes in three layers. After filling the cubes, cubes are placed in vibration motion and vibrate it for 2 minute excess concrete is removed by steel scale.

After 24 hours of casting, the cubes are removed and dry weight of all 36 cubes is found out.

CURING AND TESTING

All the 36 cubes are kept in curing tank for 7 and 28 days. In 1 curing tank volume of water is taken as 500 lit. After 7 and 28 days are over, all the cubes are taken from the curing tank and surface is cleaned with a waste cloth. All these 36 cubes are weighted in a weighing machine and wet weight of each cube is found out. For each percentage 3 cubes are tested on 7 days and remaining 3 cubes are tested on 28 days and average value of compressive strength is found out.

CUBES ON VIBRATING MACHINE

CURING OF CUBES

V. TEST RESULTS

Table: Compressive strength at 7 days curing of cubes of partial replacement of blast furnace slag

S.NO	% replacement of GGBFS	NO. of days	Average weight of 3 cubes(gms)		Average compressive load of 3 cubes(KN)	Average compressive strength of 3 cubes(Mpa)
			Dry weight	Wet weight		
1	0	7	8317	8351	390	17.33
2	5	7	8347	8362	457	20.31
3	10	7	8364	8393	607	26.98
4	15	7	8352	8375	647	28.76
5	20	7	8389	8403	680	30.32
6	25	7	8356	8385	690	30.67

Table: Compressive strength at 28 days curing of cubes of partial replacement of Blast furnace slag

S.NO	% replacement of GGBFS	No of days	Average weight of 3 cubes(gms)		Average compressive load of 3 cubes-(KN)	Average compressive strength of 3 cubes –Mpa
			Dry weight	Wet weight		
1	0	28	8396	8417	685	30.44
2	5	28	8374	8424	720	32.00
3	10	28	8298	8341	776	34.49
4	15	28	8375	8391	870	38.67
5	20	28	8274	8294	954	42.40
6	25	28	8324	8357	967	42.98

Table: average compressive strength at 7 and 28 days

S.NO	Nomenclature ofspecimen	7 days average compressive strength in Mpa	28 days average compressive strength in Mpa	% difference on the 7 days compressive strength	% difference on the 28 days compressive strength
1	NGFA-0	17.33	30.44	-	-
2	GGBFS-5	20.31	32.00	+17.20	+5.71
3	GGBFS-10	26.98	34.49	+55.68	+13.30
4	GGBFS-15	28.76	38.67	+65.95	+27.04
5	GGBFS-20	30.32	42.40	+74.96	+39.29
6	GGBFS-25	30.67	42.98	+76.98	+41.20

Cylinders

Table: Tensile strength at 7 days curing of cylinders of partial replacement of blast furnace slag

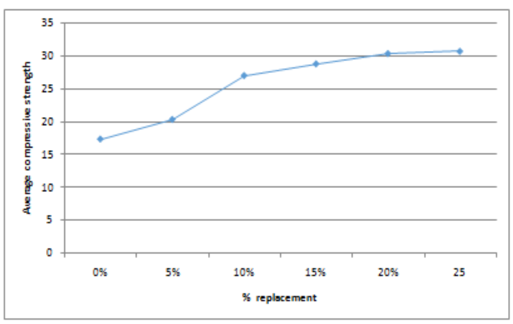
S.NO	% replacement of GGBFS	NO. of days	Average weight of 3 cylinders(gms)		Average tensile load of 3 cylinders(KN)	Average tensilestrength of 3 cylinders(Mpa)
			Dry weight	Wet weight		
1	0	7	12678	12697	160	2.26
2	5	7	12850	12885	182	2.57
3	10	7	12610	12656	200	2.83
4	15	7	12800	12840	218	3.08
5	20	7	12740	12800	236	3.34
6	25	7	12874	12925	240	3.40

Table: Tensile strength at 28 days curing of cylinders partial replacement of GGBFS

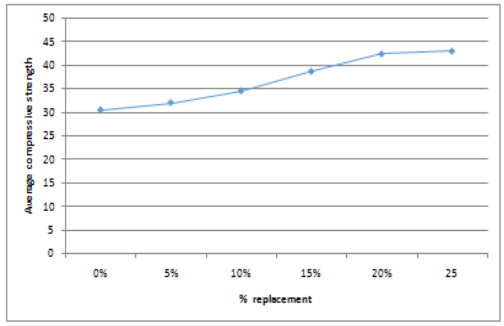
S.NO	% replacement of GGBFS	No of days	Average weight of 3 cylinders(gms)		Average tensile load of 3 cylinders -(KN)	Averagetensile strength of 3 cylinders (Mpa)
			Dry weight	Wet weight		
1	0	28	12850	12917	380	5.38
2	5	28	12897	12905	432	6.11
3	10	28	12836	12893	486	6.88
4	15	28	12907	12958	530	7.50
5	20	28	13004	13050	558	7.89
6	25	28	12835	12900	565	7.99

Table: Average Split Tensile strength at 7 and 28 days

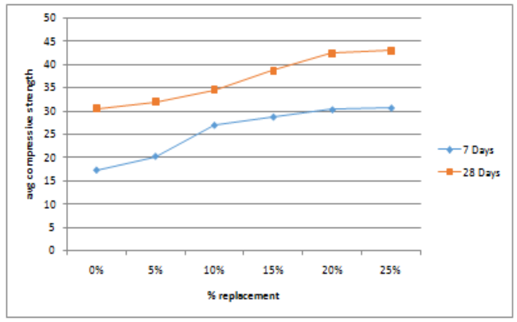
S.NO	Nomenclature of specimen	7 days average tensile strength in Mpa	28 days average tensile strength in Mpa	% difference on the 7 days tensile strength	% difference on the 28 days tensile strength
1	NGFA-0	2.26	5.38	-	-
2	GGBFS-5	2.57	6.11	+13.72	+13.57
3	GGBFS-10	2.83	6.88	+25.22	+27.88
4	GGBFS-15	3.08	7.50	+36.28	+39.41
5	GGBFS-20	3.34	7.89	+47.79	+46.65
6	GGBFS-25	3.40	7.99	+50.44	+48.51



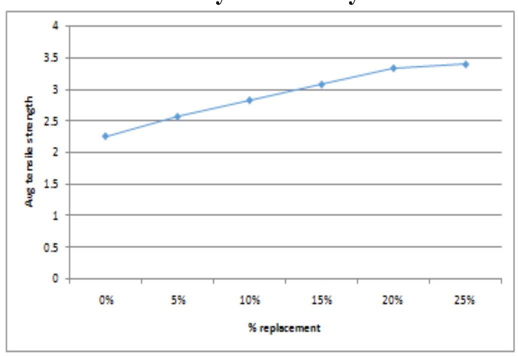
Graph 1: Compressive strength of concrete cubes at 7 days



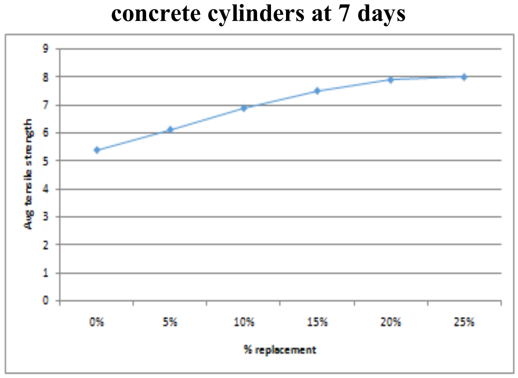
Graph 2: Compressive strength of concrete cubes at 28 days



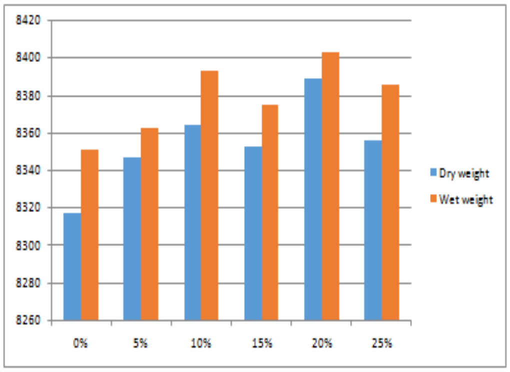
Graph 3: compressive strength of concrete cubes at 7 days and 28 days



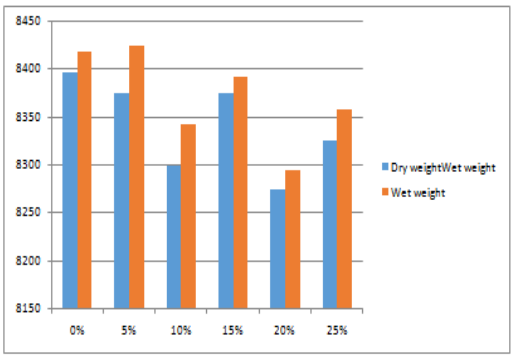
Graph 4: Average Split Tensile strength of concrete cylinders at 7 days



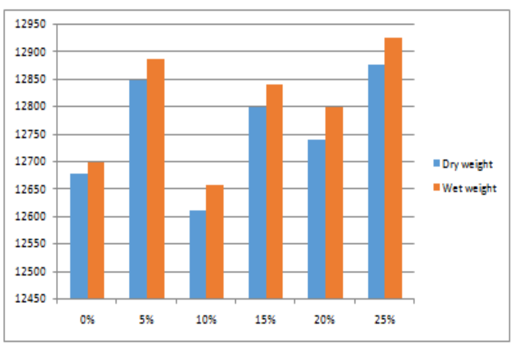
Graph 5: Average Split Tensile strength of concrete cylinders at 28 days



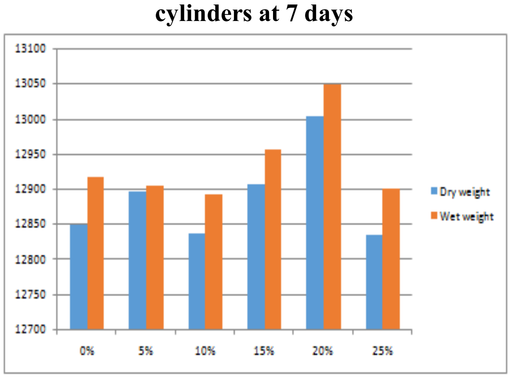
Graph 6: Dry and wet weight of concrete cubes at 7 days



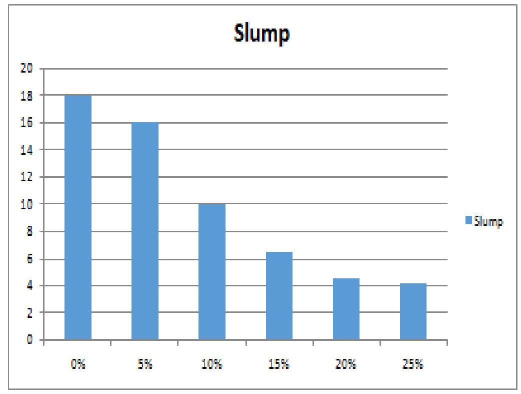
Graph 7: Dry and wet weight of concrete cubes at 28 days



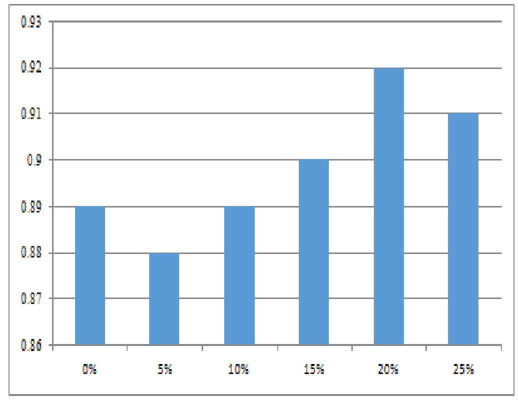
Graph 8: Dry and wet weight of concrete cylinders at 7 days



Graph 9: Dry and wet weight of concrete cylinders at 28 days



Graph 10: Slump values for concrete



Graph 11: Compaction factor

VI. CONCLUSIONS

CUBES (7 Days):

- For 5% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the compressive strength is increased by 17.20% as compared to the normal compressive strength.
- For 10% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the compressive strength is increased by 55.68% as compared to the normal compressive strength.
- For 15% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the compressive strength is increased by 65.95% as compared to the normal compressive strength.
- For 20% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the compressive strength is increased by 74.96% as compared to the normal compressive strength.
- For 25% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the compressive strength is increased by 76.98% as compared to the normal compressive strength.

CUBES (28 Days):

- For 5% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the compressive strength is increased by 5.71% as compared to the normal compressive strength.
- For 10% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the compressive strength is increased by 13.30% as compared to the normal compressive strength.
- For 15% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the compressive strength is increased by 27.04% as compared to the normal compressive strength.
- For 20% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the compressive strength is increased by 39.29% as compared to the normal compressive strength.
- For 25% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the compressive strength is increased by 41.20% as compared to the normal compressive strength.

CYLINDERS (7 Days):

- For 5% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the tensile strength is increased by 13.72% as compared to the normal tensile strength.
- For 10% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the tensile strength is increased by 25.22% as compared to the normal tensile strength.
- For 15% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the tensile strength is increased by 36.28% as compared to the normal tensile strength.
- For 20% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the tensile strength is increased by 47.79% as compared to the normal tensile strength.
- For 25% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the tensile strength is increased by 50.44% as compared to the normal tensile strength.

CYLINDERS (28 Days):

- For 5% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the tensile strength is increased by 13.57% as compared to the normal tensile strength.
- For 10% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the tensile strength is increased by 27.88% as compared to the normal tensile strength.
- For 15% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the tensile strength is increased by 39.41% as compared to the normal tensile strength.
- For 20% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the tensile strength is increased by 46.65% as compared to the normal tensile strength.
- For 25% replacement of Ground Granulated Blast Furnace Slag in Fine Aggregate, the tensile strength is increased by 48.51% as compared to the normal tensile strength.

Finally, results shown that the Ground Granulated Blast Furnace Slag replace in the natural aggregate up to 25% is suitable and gives more compressive strength and tensile strength compared to normal compressive strength and normal tensile strength.

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