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Partial Replacement of Fine Aggregate with GGBS

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Abstract: Leaving the waste material directly into the environment can lead to various problems. So it becomes necessary to reuse waste material in an emphasized manner. Waste used to produce new products or used as admixtures so that natural resources used in an effective manner and environment protected from waste deposits and depletion of natural resources. Iron & Steel plants generate waste in form of Slag from Blast Furnace while reducing Iron Ore to Iron. This waste in form of Blast Furnace Slag usually collected in dumping grounds of the industries and they cause harmful effects to the environment. Annual production of Steel in India is about 89.58 Million MT/annum according to 2015 figures, and world production 1622.8 Million MT/annum. In addition, generation of Waste Slag according to figures of 2013-14 in India is larger than 13.5 Tg/annum (10^6 MT/annum).

Keywords: GGBS, Compressive Strength, Tensile Strength.

INTRODUCTION

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 (SiO_2) 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 (GGBS).

MATERIALS AND METHODS

Cement

OPC (Ordinary Portland Cement) 43 Grade of ACC confronting to IS 269:1976 and IS 4031:1968 adopted in this work. Test conducted on Cement are as follow,

Table 1: Cement

Sr. no.	Test	Result	IS Requirement
1.	Fineness Of Cement	1%	As per IS 269:1976 Max. 10%
2.	Consistency Of Cement	34%	-
3.	Initial Setting Time	35 min.	As per IS 4031:1968 Min. 30 min.
4.	Final Setting Time	575 min.	As per IS 4031:1968 Max. 600 min.

Coarse Aggregate

The aggregate used in this project mainly of basalt rock, which comes under normal weight category. The aggregates used are locally available. About 50% of the aggregate used are of 10-12 mm size and remaining 50% are of 20mm size. The coarse aggregate tested for their suitability for the experiment. The test conducted on aggregate are as in Table No. 2.

Table No. 2: Coarse Aggregate

Sr. No.	Test	Result
1.	Size Of Aggregate	10-12mm
2.	Crushing Value	20.55%
3.	Impact Value	11.74%
4.	Abrasion Value	17.4%
5.	Flakiness Index	16.2%
6.	Elongation Index	14.6%

Sand

Natural sand, easily available and low in price used in the work. It has cubical or rounded shape with smooth surface texture. Being cubical, rounded and smooth texture it gives good workability. Sand used here taken from Girna River. Particles of this sand have a smooth texture and are blackish. Tests conducted on Sand shown in Table No. 3.

Table No. 3: Sand

Sr. no.	Test	Result	IS Requirement
1.	Fineness Modulus	3.07%	As per IS 383:1970 Max. 3.2
2.	Moisture Content	7.2%	-

GGBS:

GGBS was collected from the Dumping Yard, Kalika Steel Alloys Private Limited, Jalna, Maharashtra and processing to get initial raw material took place at the college itself by the help of Jaw-Crusher to crush initially obtained boulders to get fine. Then crushed material finally sieved to obtain material confronting for replacement with Sand/Fine Aggregate before mixing in concrete. Tests conducted on GGBS is shown in Table No. 4.

Table No. 4: GGBS

Sr. no.	Test	Result	IS Requirement
1.	Fineness Modulus	3.17%	As per IS 383:1970 Max. 3.2
2.	Moisture Content	None In Sample Used	-

Note: College itself provided all the materials and equipment, except GGBS. Sand obtained from Girna River, which was gray blackish in color.

Concrete Mix Design

In the present study, M20 grade with the nominal mix as per IS 456-2000 was used. The concrete mix proportion (Cement: Sand: Coarse Aggregate) is 1: 1.5: 3 by weight and a water cement ratio of 0.45.

Casting and Testing Detail

Total number 12 cubes and 8 cylinders were casted. GGBS partially replaced in concrete in step of 20% (0%, 20%, 40% and 60%). For each percent of marble powder replacing Cement, three cubes & two cylinders were casted for 28 days.

The final strength of cube & cylinder tested after 28 days curing. Compression Testing Machine (CTM) used for testing the Compressive Strength of cube and Split Tensile Strength of cylinder. The crushing loads noted and average compressive strength and tensile strength for three specimens and two specimens respectively is determined for each, given in Table No. 5 and Table No. 6 respectively.

Table No. 5: Compressive Strength

% of GGBS	Avg. Strength at 28 days	Increase in Strength
0	30.15 N/mm^2	-
20	33.41 N/mm^2	10.81%
40	36.22 N/mm^2	20.13%
60	34.96 N/mm^2	15.95%

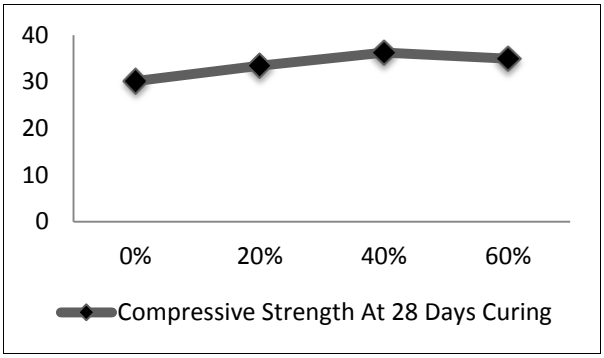
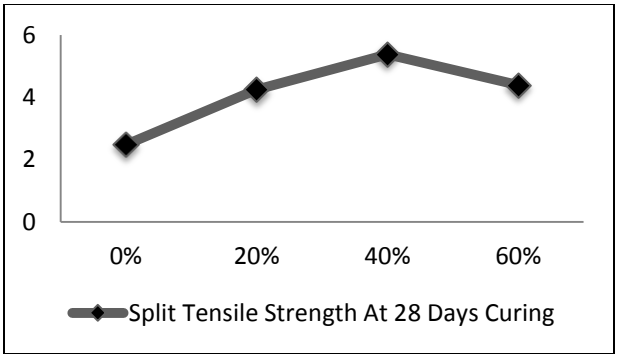


Table No. 6: Split Tensile Strength

% of GGBS	Avg. Strength at 28 days	Increase in Strength
0	2.48 N/mm^2	-
20	4.25 N/mm^2	71.37%
40	5.38 N/mm^2	116.93%
60	4.39 N/mm^2	77.02%



RESULT AND DISCUSSION

A. Compressive Strength

The compressive strength of concrete tested on the cube at different percentage of partial replacement of sand by GGBS in concrete. The strength of concrete tested on the cube at 28 days curing. 28 days test gives the data of final strength of concrete at 28 days curing. Compression Testing Machine (CTM) used for testing the compressive strength of concrete. At the time of testing the cube taken out of the water, dried and then tested keeping the smooth faces in upper and lower part.

Discussion

1. With the partial replacement of GGBS with sand, the strength of concrete gradually increases up to a certain limit then it gradually decreases.
2. With the partial replacement of GGBS with sand up to 20%, the initial strength gain in concrete is high.
3. At 40%, there is 20.13% increase in initial compressive strength for 28 days.
4. The initial strength gradually decreases from 40%.

B. Split Tensile Strength

Split Tensile strength of concrete tested on cylinders at different percentage of partial replacement of GGBS with sand in concrete. The strength of concrete tested on the cylinder at 28 days curing. 28 days test gives the data of final strength of concrete at 28 days curing. Compression Testing Machine (CTM) used for testing the Split Tensile Strength test on concrete along with two wooden boards. At the time of testing, the cylinder is taken out of water further dried and then tested.

Discussion

1. With the partial replacement of GGBS with sand, the strength of concrete gradually increases up to a certain limit, then it gradually decreases.
2. With the partial replacement of GGBS with sand up to 20%, the initial strength gain in concrete is high.
3. At 40%, there's 116.93% increase in initial Split Tensile strength for 28 days.
4. The initial strength gradually decreases from 40%.

CONCLUSIONS

1. The Compressive strength of Cubes is increased with the partial replacement of GGBS up to 40% replace by weight of sand and further any partial replacement of GGBS with sand lead to a decrease in compressive strength.
2. The Split Tensile strength of Cylinders are increased with partial replacement of GGBS up to 40% replace by weight of sand and further any partial replacement of GGBS decreases the Split Tensile strength.
3. Thus, we found out the optimum percentage for partial replacement of GGBS with sand is almost 40% for cubes and cylinders.
4. We have put forth a simple step to minimize the costs for construction with the usage of GGBS, which is freely or cheaply available, more importantly.
5. We have also stepped into a realm of saving the environmental pollution due to the dumping of wastes in form of slag and irregular mining for river sand; being our main objective as Civil Engineers.

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