Partially Replacement of Fine Aggregate with GGBS

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Abstract
According to this paper we investigates that the possibility of utilizing granulated blast furnace slag (GGBS) in cement concrete as a sand substitute, for reducing the environmental problems related to the fine aggregate mining and waste disposal of slag. The percentage of GGBS replacement is 0,5,10 and 15 % to natural sand for the standard w/c ratio of 0.4 is considered. The extended work is done with 100% replacements of natural sand with GGBS in the w/c ratios of 0.4 and 0.6.In this we studied the flow characteristics of the various mixes and their compressive strengths at various period. Demands for natural sand in concrete is increasing day by day. We undertake this experimental study to investigate the influence of partial replacement of cement with ground granulated blast furnace slag (GGBS) in concrete containing quarry dust as fine aggregate. GGBS is one of the by-product of steel manufacturing industries. On utilization of the industrial soil waste or secondary materials for the production of cement and concrete is encouraged in field of construction because it contribute to reducing the consumption of natural resources. By replacing the fine aggregate to find out the strength, durability and corrosion resistance properties of concrete. The penetration of chloride ions by means of impressed voltage technique in saline medium and gravimetric weight loss method. ***The*** *replacement of fine aggregate by GGBS in the range of 0% (without GGBS), 5%, 10% and 15%.Concrete mixtures were mixed completely, tested and find out the compressive, flexural and split tensile strength are compared with the conventional concrete.*

Keywords - *GGBS, Workability, Compressive strength, Split tensile strength, Flexural strength, Physical properties, Chemical properties, Mechanical Testing*.

I. INTRODUCTION

Ground granulated blast furnace slag (GGBS) is a by-product from the blast furnaces used to make iron. The temperature is about 1500 degrees centigrade can operated and fed with the mixture of iron ore, coke and limestone in careful manner. In this the iron ore is reduced to iron and the remaining materials from a slag that can be floats on top of the iron. And tapping off the slag in periodically as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching optimizes that the cementations properties and produces granules similar to coarse sand. Then dried the granulated slag and make it to fine powder.

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 affect the properties of concrete particularly in the hardened state. In India, the natural river sand can defined as fine aggregate which is traditionally used in mortars and concrete. However, growing environmental restrictions to the exploitation of sand from riverbeds have resulted in a search for alternative sand, particularly near the larger metropolitan areas. Thus the manufactured fine aggregates appear as an attractive alternative to natural fine aggregates for cement concrete. The artificial sand is irregular and more porous. Grading will vary over wide range resulting in internal porosity and reduction in workability of mortar or concrete.

The Manufactured sand achieved compressive strength which is equal to or higher than concrete. Lubricating the aggregate system without increasing the water requirement of the mixture. The Various types of slags from copper and steel industry are being used in mortar and concrete. Alternative materials for aggregates derived from construction and demolition wastes, recycled aggregates and quarry wastes. These aggregates are successfully utilized in concrete production.

In India we produce 7.8 million tons of blast furnace slag. All the blast furnace slag is granulated by quenching the molten slag by high power water jet, making 100% glassy slag granules.

GGBS which as a by-product of Duracem GGBS company, Auto Nagar, Visakhapatnam. One of the main objective of this project is to determine the concrete strength of M25 Grade by partial replacement of sand by GGBS. It concluded that the maximum compressive strength of concrete increased by replacement of fine aggregate. It was observed that, the flexural strength of concrete at 28 days is higher than design mix (without replacement) for 0, 5, 10 and 15% replacement of fine aggregate by GGBS. Observed that 7 days, 14 days and 28 days compressive strength. The results of compressive, split tensile strength test have indicated that the strength of concrete.

II. MATERIAL PROPERTIES

A. Cement

Ordinary Portland Cement 53 grade (OPC 53) was used throughout the investigation. The cement used has been tested for different properties as per IS: 4031 (1988) and IS: 8112 (1989). The physical properties of cement are given in Table 1.

Table 1: properties of cement

S.No.	Descriptions	Test values	IS:8112-1989 Requirement
1.	Fineness, Blain's Value, m2/kg	255	More than 255
2.	Normal consistency (%)	30.5	No standard value
3.	Setting time (min) Initial setting time Final setting time	 125 285	 <30 > 600
4.	Soundness Le-chatelier method (mm) Autoclave expansion, %	1 Nil	10 0.8
5.	Compressive strength, MPa 3 days 7 days 28 days	 32.5 41.6 50.8	 23 33 43

Table 2: Chemical Properties of Materials

S no	Constituents Percentage contents	Cement clinker
1	Cao	60 to 66
2	Sio2	17 to 24
3	Al2o3	3to 7
4	Fe2o3	0.5 to 0.6
5	Mgo	0.1 to 4.0

B. Fine Aggregates

The fine aggregates used for this work were natural river sand and GBFS. Natural sand Confirms to grading zone II and GBFS confirms to grading zone III as per IS: 383 (1970). The physical properties of sand such as sieve analysis, specific gravity, bulk density, etc., were determined as per IS: 2386 (1963).

Table3: Physical Properties of Fine Aggregate

S.No	Name of test	Observed value
1.	Specific gravity	2.3
2.	Bulking of sand	11.1%
3.	Sieve analysis	2.6

As per IS 383:1970, the result are within the maximum limit

C. Sieve Analysis

Sieve analysis (or gradation test) is a practice or procedure used to assess the particle size distribution of a granular material. With careful selection of the gradation, it is possible to achieve high bulk density, high physical stability and low permeability. The sieve analysis of fine aggregates determined as per IS: 383 (1970).

D. GGBS

Ground Granulated Blast Furnace Slag which is a by-product of iron manufacturing industry is an accepted mineral admixture for use in concrete. This granulated material when further ground to less than 45micron is called Ground Granulated Blast Furnace Slag (GGBFS).

Table4: Physical Properties of GGBS

S.No	Property	Value
1	Normal consistency	30%
2	Initial setting time in min	55minutes
3	Final setting time in min	9hours
4	Specific gravity	2.98
5	Fineness of cement by sieve	8%

The reduction involved in the setting and hardening of concrete generates significant heat and can produce large temperature rises, particularly in thick section pours. This can result in thermal cracking. Replacing Portland cement with GGBS reduces the temperature rise and helps to avoid early age thermal cracking. The greater the percentage of GGBS, the lower will be the rate at which heat is developed and the smaller the maximum temperature rise.

E. Chemical Composition Of GGBS

Silicate and aluminate impurities from the ore and coke are combined in the blast furnace slag with a flux which lowers the viscosity. In the case of pig iron manufacturing the flux consider mostly of a mixing of limestone and for sterilite or in some cases dolomite.

Table5: Chemical Composition of Ggbs

Components	Percentage
Calcium Oxide	34 to 43%
Silicon Dioxide	27 to 38%
Aluminums Oxide	7 to 12%
Magnesium Oxide	7 to 15%
Iron	0.2 to 1.6%

F. Coarse Aggregate

Material are large to be retained on 4.7mm sieve size (say 5mm for convenience) are called coarse aggregate. A maximum size of 10mm is usually selected as coarse aggregates up tp20mm.

Table 6: Physical Properties of Coarse Aggregate

S.No	Name of Test	Observed Value
1.	Specific gravity	2.88
2.	Sieve analysis	2.30
3.	Crushing test	12.2%
4.	Impact test	11.7%
5.	Flakiness index	36.65%
6.	Elongation index	45.2%

G. Water

Portable tap water available in the laboratory with pH value of 7.0 and conforming to the requirements of IS456-2000 is used for making concrete and curing the specimen as well. Water is an important ingredient of concrete as it actively participates in chemical reaction with cement.

III. METHODOLOGY

3.1 Concrete Mix Design– M25 Grade Concrete

Grade Designation = M-25
Type of cement = O.P.C-53 grade
Brand of cement = bhavya
Fine Aggregate = Zone-II
Sp. Gravity
Cement = 3.15
Fine Aggregate = 2.54
Coarse Aggregate (20mm) = 2.71
Minimum Cement (As per code) =400 kg / m3
Maximum water cement ratio (As per code) = 0.40

Concrete Mix Design Calculation: –

1. Target Mean Strength = 25 + (4 X 1.65) = 31.60 N/mm^2
2. Selection of water cement ratio : 0.40
3. Calculation of water content:

Approximate water content for 20mm max. Size of aggregate = 186 kg /m3 (As per Table No. 5 , IS : 10262).

4. Calculation of cement content:

Water cement ratio = 0.40
Water content per m3 of concrete = 180 kg
Cement content = 180/0.40 = 450 kg / m3

5. Calculation of Sand & Coarse Aggregate Quantities:

Volume of concrete = 1 m3
Volume of cement = 450 / (3.15 X 1000) = 0.142 m3
Volume of water = 180 / (1 X 1000) = 0.180 m3
Total weight of other materials except coarse aggregate = 0.142+0.180 = 0.322 m3
Volume of coarse and fine aggregate = 1 – 0.322 = 0.678 m3
Volume of F.A. = 0.678 X 0.33 = 0.223 m3 (Assuming 33% by volume of total aggregate)
Volume of C.A. = 0.678 – 0.223 = 0.455 m3
Therefore weight of F.A. = 0.223 X 2.54 X 1000 = 566.642 kg/ m3
Say weight of F.A. = 567 kg/ m3
Therefore weight of C.A. = 0.455 X 2.71 X 1000 = 1233.05 kg/ m3
Say weight of C.A. = 1234 kg/ m3
Cement = 450 kg/m3
Water = 180 kg/m3
Fine aggregate = 567 kg/m3

Coarse aggregate 20 mm = 1234 kg/m3

Water: cement: F.A.: C.A. = 0.40: 1: 1.26: 2.74

IV. RESULT AND DISCUSSION

Fineness of Natural Sand and GGBS Sand

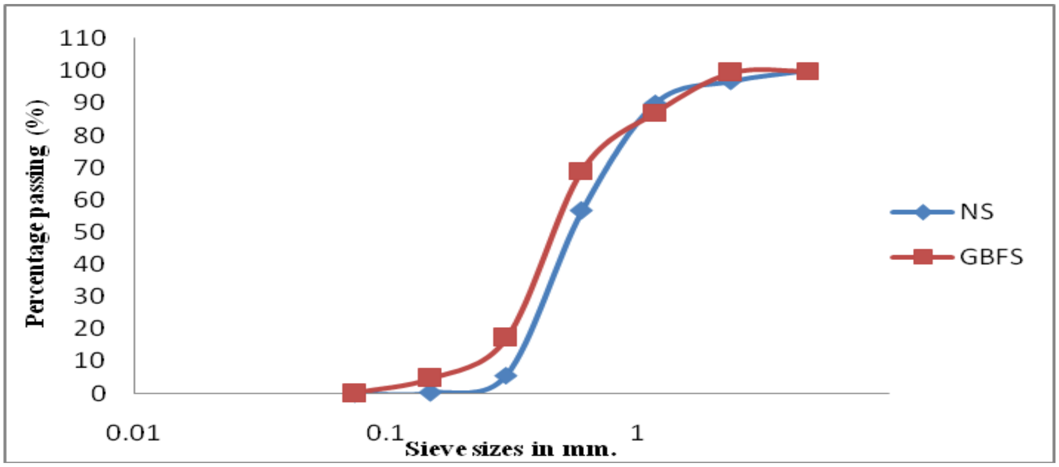

Table7: Particle Size Distribution of Fine Aggregate

S.No	Sieve size in mm	Cumulative %	Passing %
1	**4.75mm**	3.8	96.2
2	**2.36mm**	10	90
3	**1.18mm**	24.4	75.6
4	**600 micron**	42	58
5	**300 micron**	95.1	4.9
6	**150 micron**	103.7	0
	Total	279	

Table8: Test Results Cubes For Compressive Strength

Sl.No	Curing Days	Average Compressive Strength In N/Mm^2			
		Control Concrete	Ggbs Concrete		
			5%	10%	15%
1	7	20.44	23.72	24.86	27.30
2	14	24.77	27.90	29.32	33.97
3	28	31.61	40.67	43.47	45.59

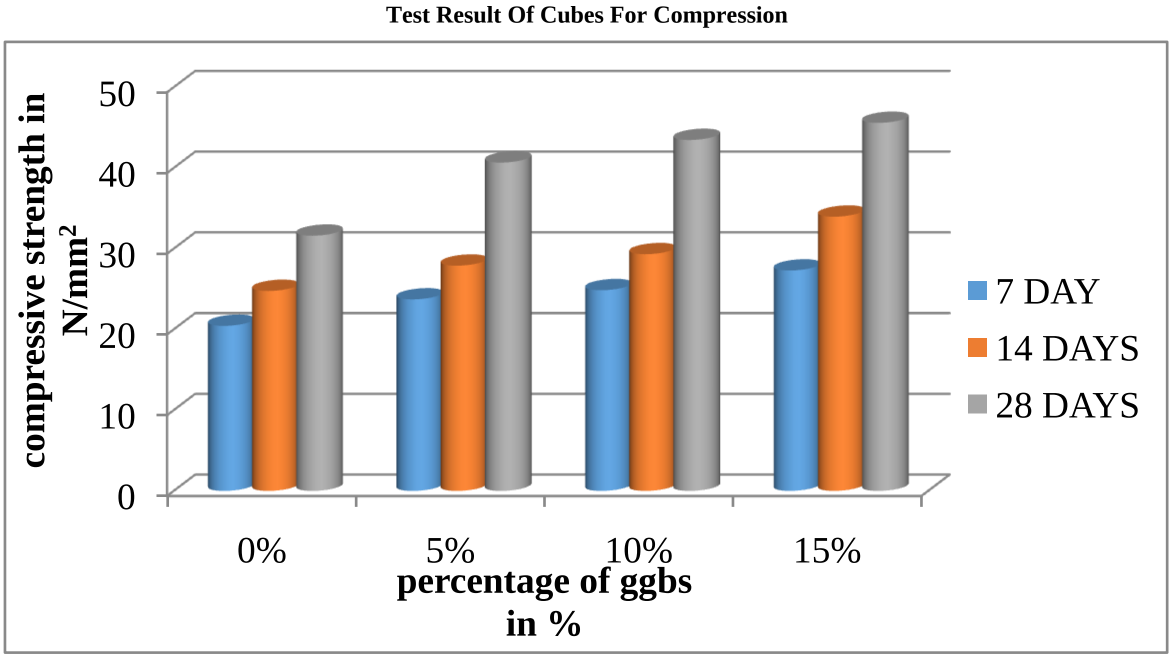

Fig1: Comparison of Compressive Strength of Cubes

- The value variation of compressive strength of cubes for the partial replacement of Fine aggregate with GGBS increased values in the orderof after 28 days 31.61, 40.67, 43.47 and 45.59 for 0%, 5%, 10% and 15% GGBS proportions replacements respectively.

Table9: Test Results Cylinders for Split Tensile Strength

Sl.No	Curing Days	Average Split Tensile Strength In N/Mm^2			
		Control Concrete	Ggbs Concrete		
			5%	10%	15%
1	7	2.5480	2.41	2.54	2.89
2	14	2.7391	2.61	2.78	3.15
3	28	2.9550	3.29	3.32	3.54

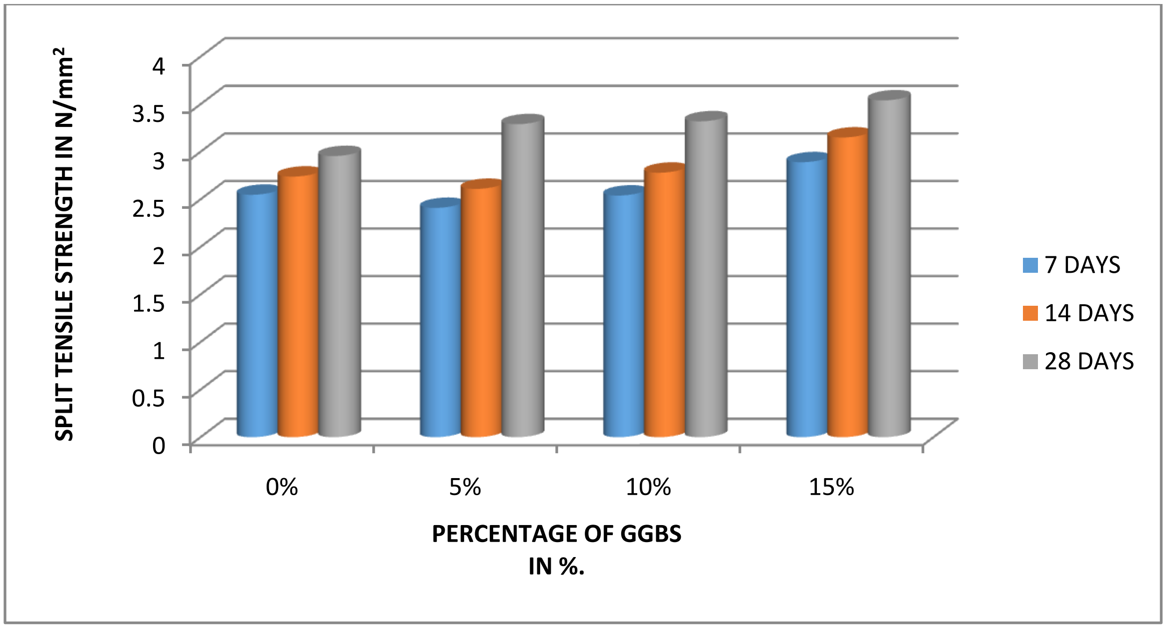

Fig2: Comparison of Split Tensile Strength f Cylinders

- The value variation of split tensile strength of cylinder for the partial replacement of Fine aggregate with GGBS increased values in the order of after 28 days 2.955, 3.29, 3.32 and 3.54 for 0%, 5%, 10% and 15% GGBS proportions replacements respectively.

Table10: Test Results Beam for Flexural Strength

Sl.No	Curing Days	Average Flexural Strength In N/Mm^2			
		Control Concrete	Ggbs Concrete		
			5%	10%	15%
1	7	3.46	2.78	2.85	3.05
2	28	5.86	6.24	6.53	7.03

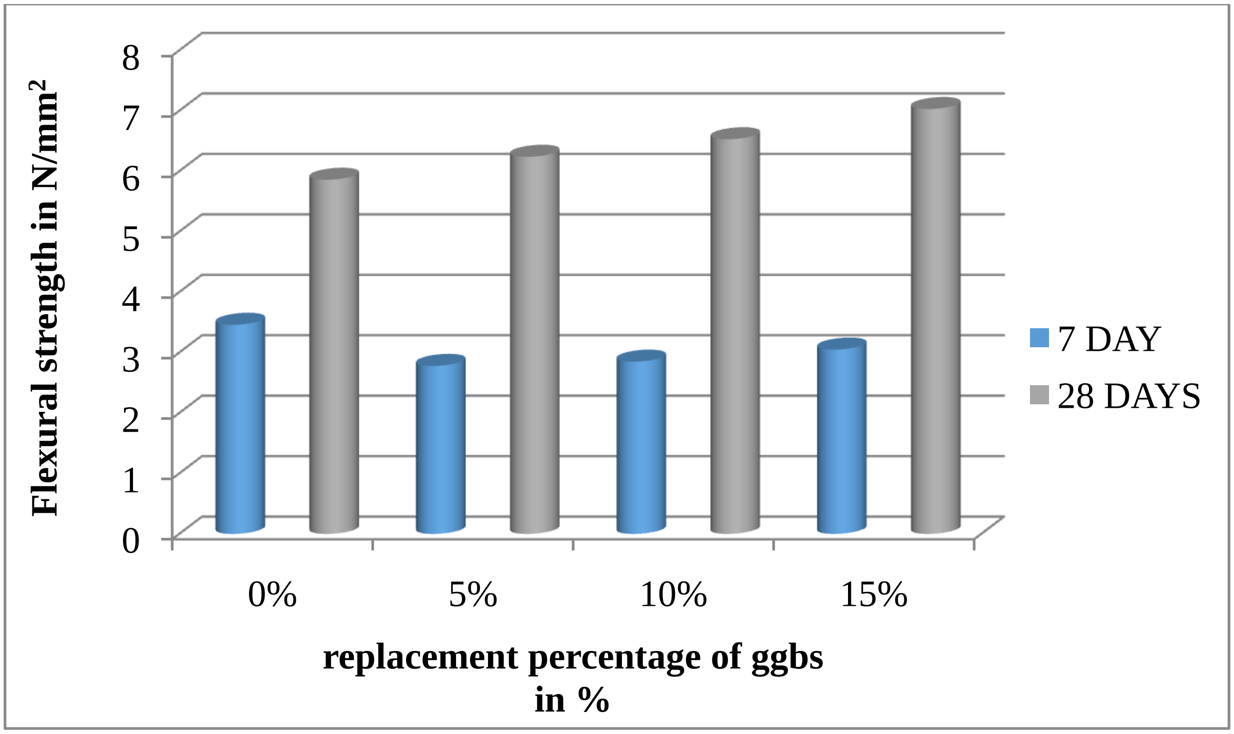

Fig3: Comparison of Flexural Strength of Beam

- The value variation of flexural strength of beam for the partial replacement of Fine aggregate with GGBS increased values in the order of after 28 days 5.86, 6.24, 6.53 and 7.03 for 0%, 5%, 10% and 15% GGBS proportions replacements respectively

V. CONCLUSION

The concrete was prepared for the M_{25} grade concrete with partial replacement of fine aggregate by GGBS with various percentages of 0%, 5%, 10% and 15%. The specimens were casted for 7days, 14 days and 28 days then tested. The results are presented below.

From the above results following conclusion were made

- The maximum flexural strength for partial replacement of fine aggregate with GGBS be achieved by 15% is found to be greater than the conventional concrete.
- It achieved maximum compressive strength when there is partial replacement of fine aggregate with GGBS (15%).
- So the optimum percentage of replacement of GGBS is 15%.

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