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"Experimental Study on Utility of GGBS as Fine Aggregate in Concrete"

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Abstract—*As we all familiar with the term Concrete that, it is a mixture of cement, fine aggregates, coarse aggregates & water. Industrial structures, Bridges and Highways etc, leading to utilization of large quantity of Concrete. Concrete may be used as a sub-base / base coarse material in the rigid pavement.*
Therefore the over use of river sand for construction has various undesirable social and ecological consequences. Fine aggregates i.e. natural sand is increasingly becoming scares and costlier day by day. In order to meet the demands, concrete industries are constantly looking for supplementary materials like fine aggregates. Quarry dust, wastes from demolished concrete, industrial wastes like copper slag etc… are tried. Here an attempt is made that GGBS is replaced as Fine aggregate partially and fully in Concrete. GGBS obtained from the manufacture of Iron in Steel industries. In this Experimental Investigation sand is partially replaced by GGBS in various percentages like 25%, 50%,75% and 100% with a constant water/cement ratio of 0.5 and different dosages of admixture for M20 grade concrete as per 10262:2009. It is found by results that, the Compressive Strength is found to be more in case of 50% of sand is replaced with GGBS, it is observed that as percentage of replacement is increases and compressive strength in increases up to 50%. After increasing the percentage of replacement of GGBS the strength decreases. The Split Tensile Strength is decreases with replacement of GGBS with Sand.

Keywords*: Portland Cement, Ground granulated Blast Furnance Slag (GGBS), Natural sand (NS), Admixture.*

1. INTRODUCTION:

1.1 General

Concrete is an artificial material in which the aggregates i.e. both fine and coarse are bonded together by cement, when mixed with water. Concrete can also be considered as a material which consists of a binding material within which there are embedded fragments of aggregates. The demand on concrete is likely to increase in future to match the requirement resulting from growing population, housing, transportation and other amenities. Now-a-days the most suitable and widely used construction material is concrete. This building material, until these days, went through lots of developments. The definition of concrete is the mixture of Cement, Aggregates and Water or sometimes super-plasticizers. In the beginning it is soft, ductile or fluid, and gradually will be solid. Fine aggregates i.e. natural sand is increasingly becoming scares and costlier day by day.. However, growing environmental restrictions to the exploitation of sand from river beds. And Concrete Industries have a considerable impact on the environment. Because it is not an environment friendly material. And Increasing amount of industrial by products & wastes has become a major environmental problem. Therefore to meet the global demand of concrete in the future, it is becoming a more challenging task to find suitable alternatives to natural aggregates for preparing concrete and also the government is look into prevent the soil pollution and also reduce the health hazards. So for all these problems only one of the best key solution is to utilize these wastes in the concrete.

1.2 About GGBS

In this project slag is obtained from JSW steel plant, Bellary (Karnataka), is used to replace for fine aggregate. Steel slag is a byproduct obtained either from conversion of iron to steel in a Basic Oxygen Furnace (BOF), or by the melting of scrap to make steel in the Electric Arc Furnace (EAF). Like other industrial byproducts, slag actually has many uses, and rarely goes to waste. It appears in concrete, aggregate road materials, as ballast, and is sometimes used as a component of phosphate fertilizer. This substance is produced during the smelting process in several ways. Firstly, slag represents undesired impurities in the metals, which float to the top during the smelting process. Secondly, metals start to oxidize as they are smelted, and slag forms a protective crust of oxides on the top of the metal being smelted, protecting the liquid metal underneath. When the metal is smelted to satisfaction, the slag is skimmed from the top and disposed of in a slag heap to age. Aging material is an important part of the process, as it needs to be exposed to the weather and allowed to break down slightly before it can be used.

Fig. 1: Steel Slag

The main objectives of the investigation are:

1. To Determine the Physical properties of Ground Granulated Blast Furnance Slag.

2. To study the Compressive strength and Split Tensile Strength performance at 7, 14 and 28 days of curing period by replacing of GGBS at 0%,25%,50%,100%

3. To determine the physical properties of 53 grade cement.

4. To obtain the maximum percentage of replacement of GGBS in Concrete as Fine aggregate.

5. To Study and compare conventional Concrete and modified Concrete for the different strength characteristics.

2. MATERIALS AND METHODOLOGY.

The basic tests are conducted on various materials like OPC 53 grade Cement, Fine aggregate, Coarse aggregate and Steel Slag to check their suitability for making Concrete. The experimental investigation has been carried out on the test 3 specimens of Cubes and Cylinders, each to study the strength properties with replacing fine aggregate by Steel Slag in various percentages namely 0%, 25%, 50%, 75% and 100% of Steel Slag. Specimens are cast as per mix design and the tests are conducted after proper curing, the tests are Compressive Strength of cubes (150mm x 150mm x 150mm), Split Tensile Strength of cylinders (150mm x 300mm). From the studies, optimum results are found out and compared with the conventional concrete.

Following materials has been used in the present experimental investigation:

2.1 Cement:

OPC 53-Grade Was Used In This Investigation. It Conforms To IS: 8112 – 1989 With a Specific Gravity Of 3.15 & Normal Consistency of 32%.

2.2 Aggregates:

Natural Sand having Specific Gravity of 2.40, fineness modulus of 4.51 & water absorption of 1.0%. Natural sand confirms to grading zone II of IS:383– 1970 has been used.

Coarse aggregates passing through 20mm sieve and retained on 12.5mm sieve having Specific Gravity of 2.72 and water absorption of 0.50% is used in the present investigation.

3.3 Water:

Clean potable water free from organic substances is used in this investigation both for mixing and curing of concrete.

3.4 Chemical Admixture (super plasticizer):

It is used to reduce water content to obtain maximum workability.

3.5 Ground Granulated Blast Furnance Slag

Ground granulated blast-furnace slag is the granular material formed when molten iron blast furnace slag is rapidly chilled (quenched) by immersion in water. It is a granular product with very limited crystal formation.

3. EXPERIMENTAL INVESTIGATION:

3.1 Mix Proportioning:

The M20 concrete mix is designed as per IS: 10262 - 2009 & IS: 456 -2000. This phase mix of M20 grade concrete with replacement of 0%, 25%, 50%, 75%, & 100% of natural sand by GGBS with addition to different dosages of admixture is carried out to determine optimum percentage of replacement of NS by GGBS & optimum admixture content at which max. Compressive strength is achieved. Mixing time of concrete by manual means is totally 5 minutes. Compaction is done by using a 16mm rod in 3 layers with 25 strokes for each layer.

The concrete is left for 24 hours in the moulds undisturbed, and then demoulded and placed in curing tanks untill the day of testing. 3 specimens were prepared for each set, and tested after 7 days, 14 days & 28 days of curing from the date of casting.

3.2 Method of Testing:

Compressive Strength of cubes is tested as per **IS:516-1959**, Split Tensile Strength of Concrete on cylinders is done as per **IS : 5816-1999**

Fig. 3.2.1: Compressive Strength Testing Machine

Cubic Specimen:

150 X 150 X150mm

Compressive strength is calculated by

$\sigma = F / A$

Where,

F = Compressive load [KN]

A = C/S Area of the cube [mm²]

Fig. 3.2.2: Split Tensile Strength Test Machine

Cylindrical specimen:

- ✓ Diameter 150mm
- ✓ Length 300mm
- ✓ The tensile strength is calculated using the equation,
  F= 2P/ (πDL)
  Where,
- ✓ F = Tensile strength of concrete (in MPa).
- ✓ P = Load at failure (in N).
- ✓ L = Length of the cylindrical specimen (in mm).
- ✓ D = Diameter of the cylindrical specimen (in mm).

4. RESULTS & DISCUSSIONS:

After 7, 14 & 28 days of curing, compression, and split tensile strength tests were conducted on concrete and their results have been discussed below.

TABLE 1: 7 Days Compressive Strength Results.

SL No.	% of GGBS Replacement	7 Days Compressive Strength in N/mm^2
1	0	27.56
2	25	30.23
3	50	35.11
4	75	22.01
5	100	13.33

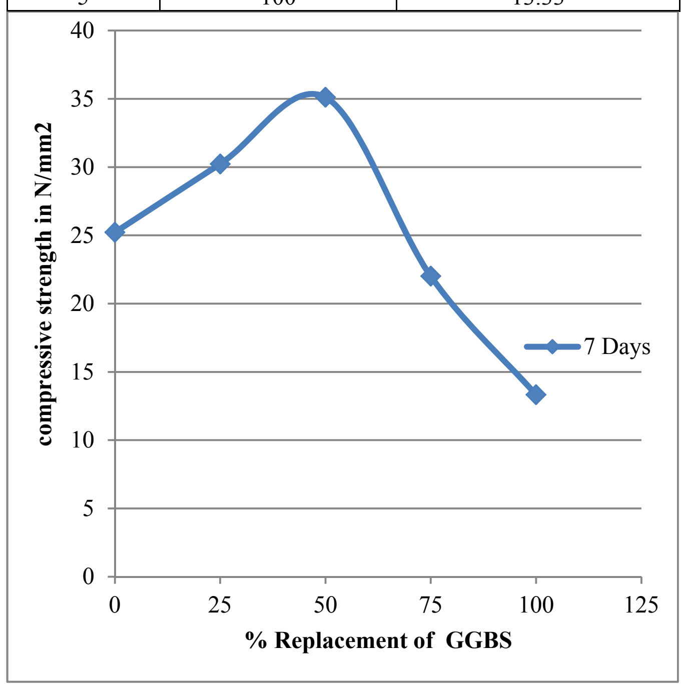

Fig. 4.1: % Replacement of GGBS v/s Compressive Strength in N/mm^2 With Water Cement Ratio 0.5 for 7 Days

TABLE 2: 14 Days Compressive Strength Results.

SL No.	% of GGBS Replacement	14 Days Compressive Strength in N/mm^2
1	0	29.56
2	25	34.25
3	50	38.33
4	75	27.77
5	100	11.11

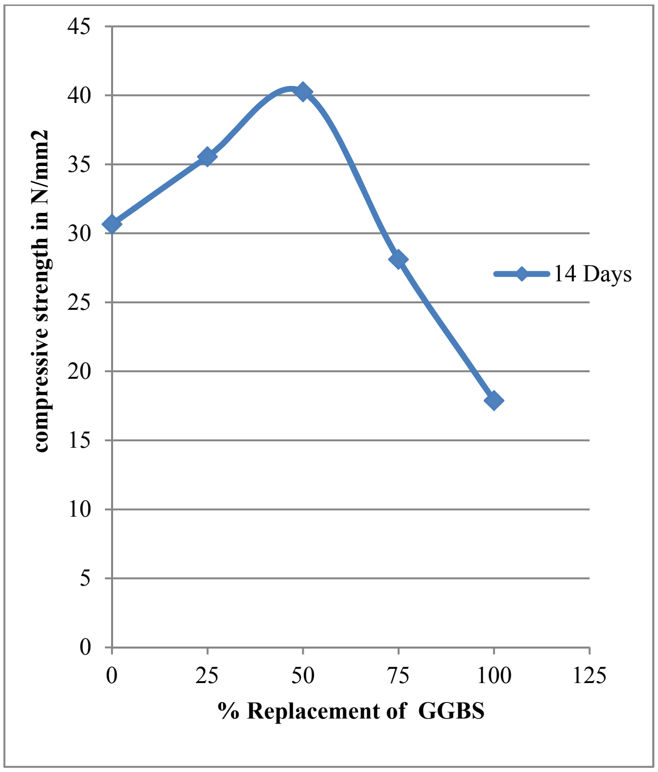

Fig. 4.2: % Replacement of GGBS v/s Compressive Strength With Water Cement Ratio 0.5 for 14 Days.

TABLE 3: 28 Days Compressive Strength Results.

SL No.	% of GGBS Replacement	28 Days Compressive Strength in N/mm^2
1	0	30.66
2	25	32.34
3	50	34.66
4	75	20.44
5	100	10.02

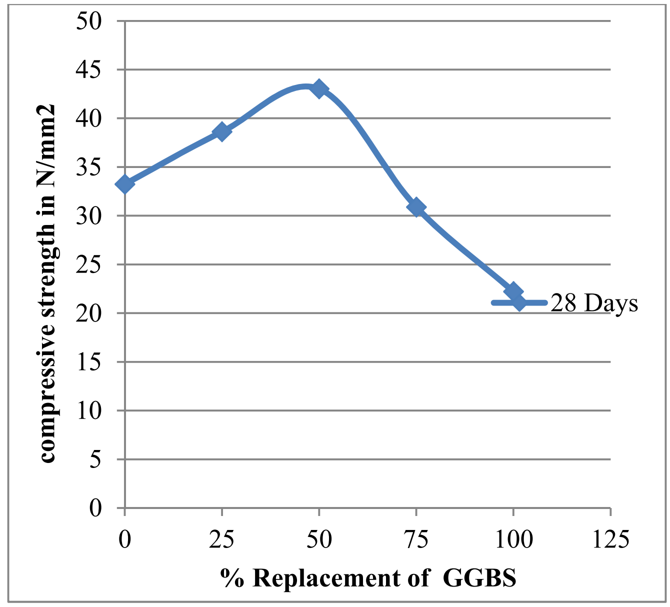

Fig. 4.3: % Replacement of GGBS v/s Compressive Strength in N/mm^2 With Water Cement Ratio 0.5 for 28 Days.

TABLE 4: Comparison of Compressive Strength Test Results.

Sl No.	% of GGBS Replacement	7 Days Compressive Strength in N/mm^2	14 Days Compressive Strength in N/mm^2	7 Days Compressive Strength in N/mm^2
1	0	27.56	29.56	30.66
2	25	30.23	34.25	32.34
3	50	35.11	38.33	34.66
4	75	22.01	27.77	20.44
5	100	13.33	11.11	10.02

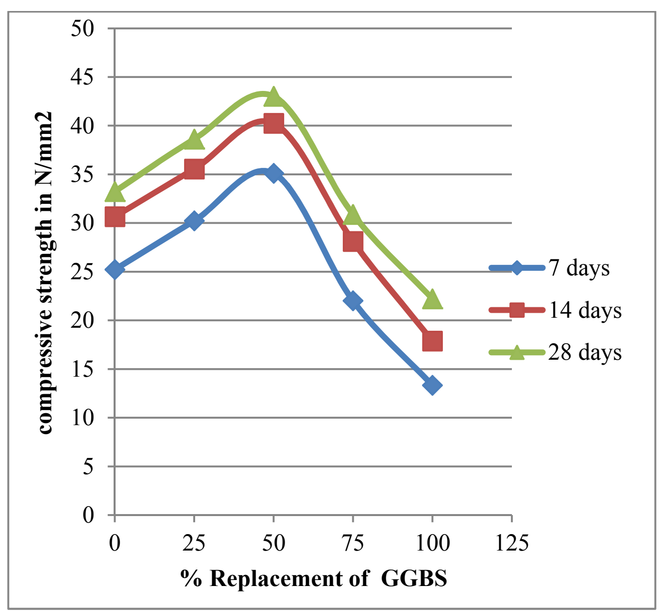

Fig. 4.4: Comparison of 7,14,and 28 days Compressive Strength results.

TABLE 5: 7 Days Split Tensile Strength Test Results.

Sl No.	% of GGBS Replacement	7 Days Split Tensile Strength in N/mm^2
1	0	4.66
2	25	2.12
3	50	2.26
4	75	1.95
5	100	1.74

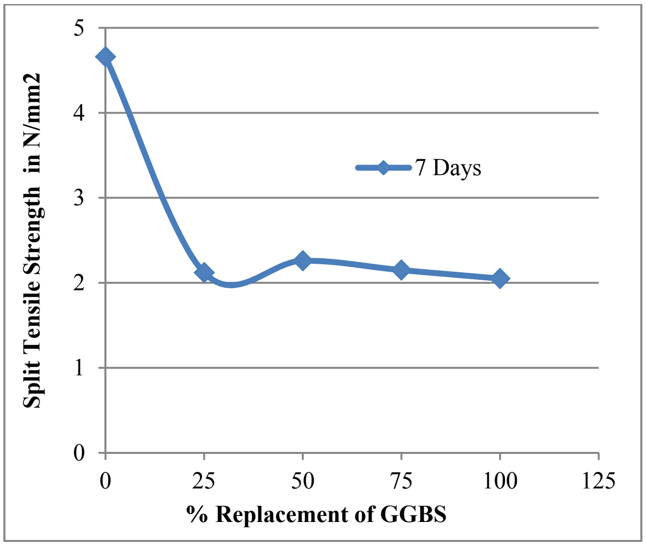

Fig. 4.5: % Replacement of GGBS v/s Split Tensile Strength With Water Cement Ratio 0.5 for 7 Days.

TABLE6: 14 Days Split Tensile Strength Test Results.

Sl No.	% of GGBS Replacement	14 Days Split Tensile Strength in N/mm^2
1	0	5.68
2	25	2.5
3	50	2.82
4	75	2.36
5	100	2.05

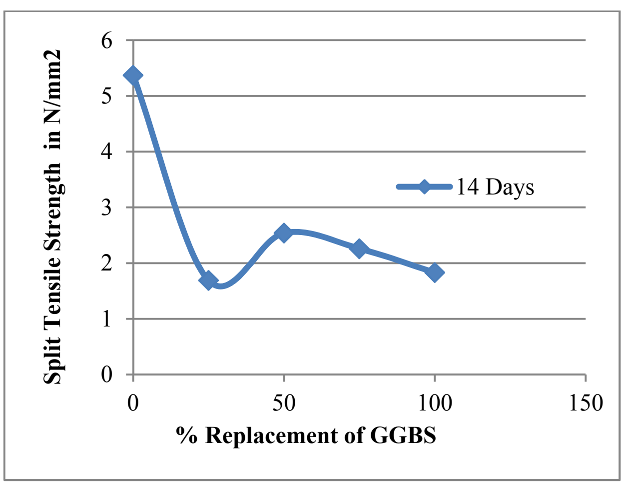

Fig. 4.6: % Replacement of GGBS v/s Split Tensile Strength With Water Cement Ratio 0.5 for 14 Days.

TABLE 7: 28 Days Split Tensile Strength Test Results.

Sl No.	% of GGBS Replacement	28 Days Split Tensile Strength in N/mm^2
1	0	6.20
2	25	2.75
3	50	3.12
4	75	2.75
5	100	2.45

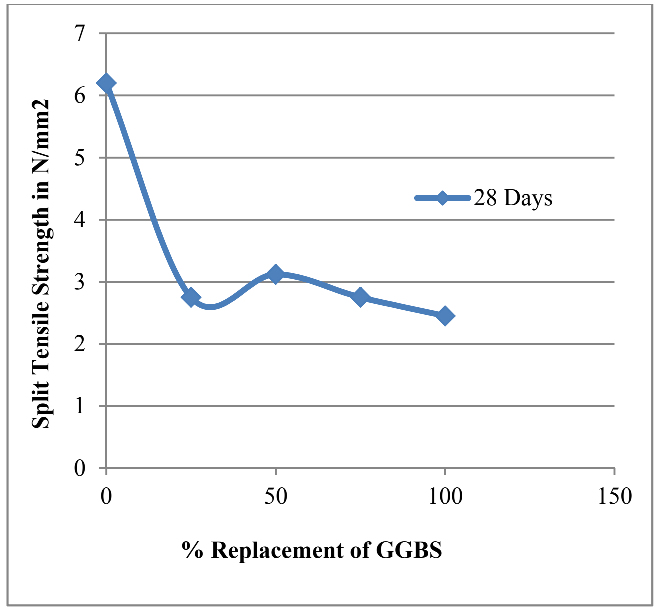

Fig. 4.7: % of GGBS Replacement v/s Split Tensile Strength in N/mm^2 With Water Cement Ratio 0.5 for 28 Days

TABLE 8: Comparison of Split Tensile Strength Test Results.

% of GGBS Replacement	7 Days Split Tensile Strength in N/mm^2	14 Days Split Tensile Strength in N/mm^2	28 Days Split Tensile Strength in N/mm^2
0	4.66	5.68	6.2
25	2.12	2.5	2.75
50	2.26	2.82	3.12
75	1.95	2.36	2.75
100	1.74	2.05	2.45

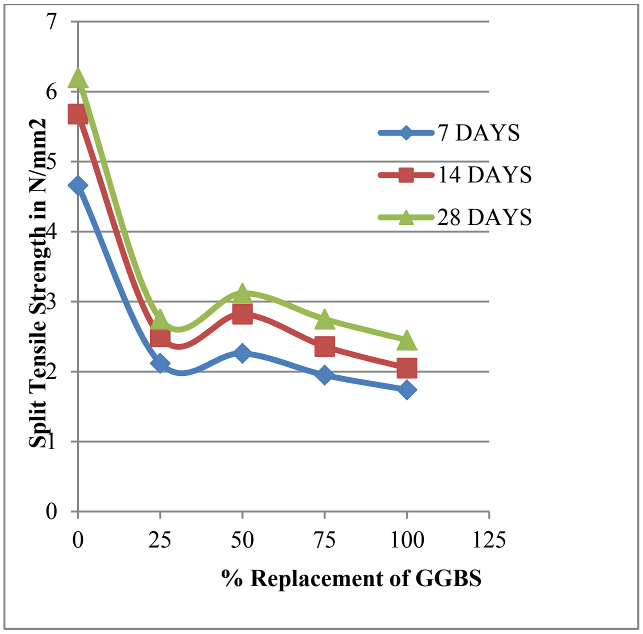

Fig. 4.8: Comparison of 7,14 and 28 days Split Tensile Strength Results.

5. CONCLUSION

Based on the results obtained from this study, the following conclusion is drawn

- The results obtained from compressive strength Tests conducted on concrete containing OPC and various percentage of GGBS is comparable to that of Concrete mix with Sand as fine aggregate.
- Compressive Strength is found to be more in case of 50% replacement of GGBS as Fine Aggregate at 28 Days curing.
- Compressive strength of cubes is found to be 35.11Mpa maximum at 50% GBFS replacement with natural sand, after curing period of 28 days.
- Split Tensile Strength of the cylinders is found to be 2.68MPa are also increased up to 50% replacement of fine aggregate by GGBS. After curing period of 28 days and the Split Tensile Strength is not comparable to conventional Concrete.
- The workability of concrete was found to be increases with the increase in GGBS in concrete up to 50%.
- From the above experimental results,it is proved that the partial replacement of natural sand by GGBS in concrete not only provides the economy in the construction but it also facilitates environmental friendly disposal of the waste slag which generated in huge quantities from the steel industries.
- It is suitable where the Compressive forces are creating, Ex: Footings.

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