Development of Concrete by Partial Replacement of Fine Aggregate by GBFS

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Abstract— Sustainable construction mainly aims at reduction of negative environmental impact resulted by construction industry which is the largest consumer of natural resources. Over period of time, waste management as become one of the most complex and challenging problem in the world which affects the environment. The rapid growth of industrialization gave birth to numerous kinds of waste by-products which are environmentally hazard and creates problem of storage. The consumption Granular Blast Furnace Slag (GBFS) in Concrete not only helps in reducing greenhouse gases but also helps in making environmentally friendly material. This paper shows the effects of replacing fine aggregate with that of Granular Blast Furnace Slag in concrete properties. The basic objective of this paper was to identify alternative source of good quality fine aggregates which is depleting way very fast due to the fast pace of construction activities. In India the uses of GBFS as waste industrial by-product of iron and steel production provides great opportunity to utilize. It as an alternative to normally available fine aggregate M20. Concrete of M_{20} grade is considered for a WC ratio of 0.40 for the replacement of 0%, 25%, 75% and 100% of GBFS. The investigation revealed improvement in workability, compressive strength and split tensile strength.

Key words: Granulated Blast Furnace Slag, Fine Aggregate, Workability, Compressive Strength, SPLIT Tensile Strength

I. INTRODUCTION

In our world today, concrete has become ubiquitous. It is hard to imagine modern life without it. Approximately five billion tonnes of concrete are used around the world each year. The increase in popularity of concrete as a construction material is replacing a huge burden on the natural sand reserves of all countries .In view of the environmental restrictions of sand extraction from river beds have resulted in search for the alternative sources of fine aggregate, particularly near the larger metropolitan areas. Now a day's, available of river sand is very less. At the same time most of the byproducts is less. So in this project we are partially replacing the granulated blast furnace slag by fine aggregate in various percentages and analysing the behaviour of concrete.

A. General

Granulated blast furnace slag is the by-product generated during manufacturing of pig iron and steel .It is produced by action of various fluxes upon gangue materials within the iron ore during the process of pig iron making the blast furnace and steel manufacturing in steel melting shop. Primarily, the slag consists of calcium, magnesium, manganese and aluminium silicates in various Combinations. The cooling process of slag is mainly responsible for generating different types of slags required for various end-use consumers. Although, the chemical composition of slag may remain unchanged, physical p2roperties vary widely with the changing process of cooling. The GBFS charges with iron ore, fluxing agents (usually limestone and dolomite) and coke as fuel and reducing agent in the production of iron. The iron ore is a mixture of iron oxides, silica and alumina.

From this, the added fluxing agent's alkaline earth carbonates, molten slag, and iron are formed .Oxygen. The preheated air blown into the furnace combines with the carbon of the coke to produce the needed heat and carbon monoxide. At the same time, the iron ore is reduced to iron mainly through the dioxide. The oxides of calcium and magnesium combine with silica and alumina to form slag .The reaction of the carbon monoxide with the iron oxide yields carbon dioxide (Co_2) and metallic iron. The fluxing agents dissociate into calcium and magnesium oxides and carbon dioxide. The oxides of calcium and magnesium combine with silica and alumina to form slag.

The American society of Testing and materials (ASTM) (1999) define blast furnace slag as "the non- metallic product consisting essentially of calcium silicates and other bases that is developed in a molten condition at the same time with iron in a blast furnace." Slag was considered to be essential in the production of iron, but once it served its purpose in refining the metal, it was strictly a nuisance with little or no use. The usefulness of slag was realized with the first ore smelting process.


Fig. 1: GBFS

II. SCOPES AND OBJECTIVES

The scope and objective of the paper to compare the results of River sand and GBFS properties in concrete

- To study the effect of partially replacing fine aggregate with Granulated Blast Furnace Slag.
- To find the various properties of replaced concrete.
- Comparative study of strength and properties of concrete containing natural sand and GBFS.
- To find the optimum strength of the concrete by replacing GBFS.

III. MATERIALS USED

From various places we are collected the materials and tested in the laboratory. The following materials are

- GBFS
- Fine aggregate
- Coarse aggregate
- Cement

A. Material test and results

Concrete made with hydraulic cement containing fine aggregate, coarse aggregate and GBFS. Materials are tested in the laboratory. Specific gravity test conducted for fine aggregate, coarse aggregate, GBFS and cement. Sieve analysis test and water absorption conducted for fine aggregate, coarse aggregate, GBFS. The comparative results are shown in table 1.

SL.NO	PROPERTY	GBFS	RIVER SAND
1	Specific gravity	2.35	2.25
2	Graded Zone	ZONE I	ZONE I
3	Slit and organic impurities	NIL	4%
4	shape	Cubical particle	Cubical particle

Table 1: Result of GBFS and River Sand

Impact test and abrasion test were conducted for coarse aggregate. Coarse aggregate of nominal size of 20mm is chosen and tests to determine the different physical properties as per IS 383-1970. Test results conform to the IS 383(part III) recommendations. The results of coarse aggregate and properties are shown in table2.

SL.N	PROPERTY	IS LIMIT	20mm
1	Specific gravity	2.7-2.9	2.9
2	Water absorption	2.0-4.0%	1.8%
3	Fineness modulus	6.0-8.5	7.15
4	Impact value test	0-50%	20.49 %
5	Abrasion test	0-50%	16.4%

Table 2: Result of coarse aggregate

IV. MIX DESIGN AS PER IS 10262-2009

Mix design of concrete is the process of selecting the required ingredients of concrete and finding their relative proportion with the aim of producing an economical concrete of certain strength and durability. The characteristic compressive strength of 20N/mm^2 for M_{20} grade of concrete. The cement content was identified as 760kg/m^2. The fine aggregate to 2 kg/m^2. The water cement ratio was taken as 0.40. No super plasticiser was used in the project.

V. MIXING OF CONCRETE

Mixing of concrete may be done by hand and machine. Mixing should be done thoroughly so as to have a uniform distribution of ingredients which can be judged by uniform colour and consistency of concrete.

VI. TESTING OF CONCRETE

The following tests are commonly adopted to measure the workability of concrete.

- Slump cone test.
- Flow table test
- Compaction factor test
- Kelly bell test
- Vee Bee consistency test

We are conducting a fresh concrete test on slump cone test and flow table test.

VII. WORKABILITY TEST AND RESULTS

A. Slump Cone Test

The concrete slump cone test is an empirical test that measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete in that specific batch. This test is performed to check the consistency of freshly made concrete. Consistency is a term very closely related to workability. It is termed which describes the state of fresh concrete.

It refers to the ease with which the concrete flows. It is used to indicate the degree of wetness. Workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable than drier mixes, but concrete of the same consistency may vary in workability. It is also used to determine consistency between individual batches. The slump cone test results are shown in table 3.

S.NO	W/C RATIO	% REPLACEMENT OF GBFS	SLUMP VALUE	TYPES OF SLUMP
1	0.40	0	28.	TRUE SLUMP
2	0.40	25	28	TRUE SLUMP
3	0.40	50	28	TRUE SLUMP
4	0.40	75	30	TRUE SLUMP
5	0.40	100	20	TRUE SLUMP

Table 3: Slump cone test results

B. Flow Table Test

The flow table or flow test is also known as slump-flow test. This method is to determine the consistency of fresh concrete. This test gives an indication of the quality of concrete with respect to consistency, cohesiveness and non- segregation. A mass of concrete is subjected to jolting and the flow or spread of the concrete is measured. The flow is related to workability. The flow table results are shown in table 4.

S.N	W/C RATIO	% REPLACE OF GBFS	FLOW	CONSISTENCY
1	0.40	0	36	STIFF
2	0.40	25	35.5	STIFF
3	0.40	50	32	STIFF
4	0.40	75	25.36	STIFF
5	0.40	100	17.9	STIFF

Table 4: Flow table results

VIII. TEST ON HARDENED CONCRETE

A. Compressive Strength

The compressive strength, as one of the most important properties of hardened concrete, in general is the characteristic material value for classification. 28 days cube compressive strength is tested on cube of size 150mm*150mm*150mm and 7days, 14days, 28 days is tested. The compressive strength test is most common test conducted, partly because it is an easy test to perform, and partly because most of the desirable characteristics properties of concrete qualitavely related to its compressive strength.

The average compressive strength on concrete are shown in table 5.

SPECIMEN	% REPLACEMENT OF RIVER SAND	% REPLACEMENT OF RIVER OF GBFS	AVG COMPRESSIVE STRENGTH N/mm^2		
MIX	(%)	(%)	7 DAYS	14 DAYS	28 DAYS
0	100	0	6.66	14	21.33
1	75	25	7	16	22
2	50	50	7.5	17.5	22.5
3	25	75	9	19	25
4	0	100	8	15.5	21

Table 5: Average compressive strength on concrete

B. *Split Tensile Strength*

Split tensile is an indirect method used for determining the tensile strength of concrete. Tests are carried out 150mm*300mm cylinders conforming to IS 5816:1976 to obtain the split tensile strength at the age of 7days, 14days, and 28days. In the split tensile test, the concrete cylinder is placed with its axis horizontal, between plates of the testing machine, and the load is increased until the failure occur by splitting the plane containing the vertical diameter of the specimen. The average split tensile strength on concrete are in shown in table 6.

SPECIMEN	% REPLACEMENT OF RIVER SAND	% REPLACEMENT OF RIVER OF GBFS	AVG SPLIT TENSILE STRENGTH N/mm^2		
MIX	(%)	(%)	7 DAYS	14 DAYS	28 DAYS
0	100	0	6.98	13.4	15.6
1	75	25	7.2	15	17.6
2	50	50	7.8	16	18.3
3	25	75	8	17.6	20.7
4	0	100	6.5	14.3	13

Table 6: Average split tensile strength on concrete

The graphical representation of compressive strength and split tensile strength of concrete are shown in fig 2 and 3 respectively.

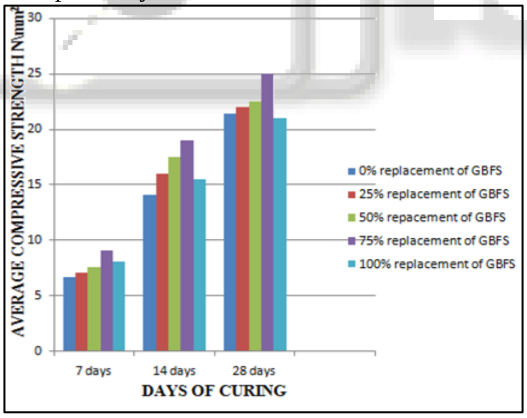

Fig. 2: Average compressive strength on concrete

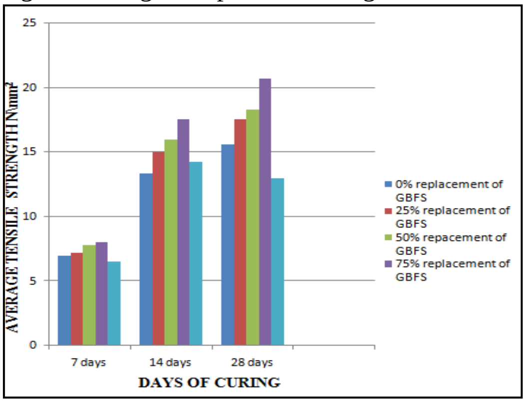

Fig. 3: Average split tensile strength on concrete

IX. CONCLUSION

Based on the experimental investigation, the following conclusions can be drawn:

1) It is observed that concrete replaced by 75% GBFS shows the optimum strength at the age of 7days, 14days and 28days.
2) The compressive strength at optimum result is found out to be 25 N/mm^2 and the split tensile at optimum 20.7 N/mm^2.
3) The degree of workability of concrete is normal by comparing conventional concrete.
4) From the experimental investigation, it is proved that GBFS can be alternative material for fine aggregate by reducing the cost of construction.
5) Use of industrial waste products saves the environment and conserves natural resources.
6) By this the substitution of natural aggregate with GBFS has positive impact on workability, consistency, compressive strength and split tensile strength.
7) As GBFS has high glass content with sharp particles precautions while handling concrete have to be implemented.

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