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EFFECTS OF GGBFS AS POZZOLANIC MATERIAL WITH GLASS FIBER ON MECHANICAL PROPERTIES OF CONCRETE

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ABSTRACT
From last many decades, usage of concrete has increased on large scale all over the world. Concrete ingredients used are becoming more costly day by day and also demand for the same is increasing widely all over. One of the main ingredients is cement, while production of cement CO_2 is emitted out which is responsible for global warming. Replacement of cement by a pozzalanic material named Ground Granulated Blast Furnace Slag, which is waste product of steel manufacturing industries. Glass fiber of 12mm size was also added to increase both compressive and tensile strength of concrete. In present paper focuses on using GGBFS as replacement material to cement in different percentage 0%, 20%, 30% and 40% by weight of cement and Glass Fiber is also added to concrete in different proportion 0%, 0.03% and 0.06% by total volume. Twelve mixes of concrete with GGBFS and Glass Fiber were studied with w/c ratio 0.39 and Superplasticizer named CONPAST SP-430. Combinable effect of GGBFS and Glass Fiber is best for 30% GGBFS and 0.06% Glass Fiber as we know that concrete starts bleeding above 30% replacement by GGBFS and Glass Fiber controls the bleeding of concrete.

Keywords: Ground Granulated Blast Furnace Slag (GGBFS) and Glass Fiber (GF)

1. Introduction

Concrete is one of the most widely used materials for Civil engineering structures due to its inherent properties. Concrete is mixture of cement, fine aggregate, coarse aggregate and water. Cement is the second largest material used in world after water. During production of cement there is CO_2 emitted out from industry. Producing one ton of Ordinary Portland Cement releases about one ton of CO_2 green house gas into atmosphere and as a result of this production 1.6 billion tons of CO_2 is released every year. This released CO_2 is estimated to be 7% of the CO_2 production worldwide (Ozkan Senul and Mehmet Ali Tasdemir 2009) and CO_2 have many dangerous side effect like global warming. Long studies over years have given that there is no second alternative for replacing cement totally. There is also another problem regarding consumption of lime on large scale all over the world which is extinguishing. One of the waste materials is Ground Granulated Blast Furnace Slag. It is the material confirming up to the mark similar chemical properties as cement do. GGBFS based concrete gives us two in one advantages like as it replaces the cement which has many more drawbacks and also utilizes waste from steel industry. Whatever the facilities provided related to construction in the city should have good durability. So to improve the strength of concrete Glass Fiber is also introduced in concrete.Ground Granulated Blast furnace Slag (GGBFS) is a non-metallic product, consisting of silicates and alumino silicates of calcium and other bases, developed in a molten condition simultaneously with iron in a blast furnace. From structural point of view, GGBS replacement enhances lower heat of hydration, higher durability and higher resistance to sulphate and chloride attack when compared with normal ordinary concrete. On the other hand, it also contributes to environmental protection because it minimizes the use of cement during the production of concrete.

2. Experimental Investigation

2.1.Materials used

Cement

Ordinary Portland cement, 53 Grade conforming to IS:8112-1989[4].The specific gravity of cement was 3.15. Fine aggregate Locally available river sand conforming to Grading zone II of IS: 383 1970[5].Its specific gravity was 2.6. Coarse aggregate Locally available crushed basalt aggregate both 20mm and 10mm size was used in 60:40 proportion of total aggregate used as per IS: 383 – 1970

Ground Granulated Blast Slag (GGBS)

Ground granulated blast furnace slag obtained from Sona Alloys, C-1, MIDC, Lonand, Satara. 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, is highly cementitious in nature and, ground to cement fineness, and hydrates like Portland cement. Properties of GGBFS are as shown below:

Calcium Oxide(CaO)	40-52
Silicon Dioxide(SiO_2)	10-19
Iron Oxide(FeO)	10-40
Manganese Oxide(MnO)	5-8
Magnesium Oxide(MgO)	5-10
Aluminium Oxide(Al2O3)	1-3
Phosphorous Pent Oxide(P2O5)	0.5-1
Sulphur(S)	< 0.1
Metallic Fe	0.5-10

Super Plasticizer

A commercially available sulphonated naphthalene formaldehyde based super plasticizer (CONPLAST SP 430) was used as chemical admixture to enhance the workability of the concrete.

Glass fiber (GF)

The glass fibers used in concrete suppressed the localization of micro cracks in to macro cracks hence tensile strength increase. It improves durability of concrete by increasing the strength of concrete. The Glass Fibers are of Cem-FIL Anti - Crack HD are used for experimentation work.

Table No.3.8 Physical Properties of Glass Fiber

Sr.No.	Property	Value
1	Diameter	14 microns
2	Length of fiber	12mm
3	Appearance	Shiny hair like
4	Aspect Ratio	857:1
5	Shape of Fiber	Straight
6	Tensile Strength	1700 MPa
7	Modulus of Elasticity	72 GPa
8	Specific Gravity	2.68
9	Number of Fiber per Kg	212 million

3. Mix Proportion and Mix details

In this investigation IS 10262-2009 is considered for Mix Design and M_{30} Grade is used. On the basis of trial and error following mix were used:

Water	Cement	CA		FA
		20mm	10mm	
177.055lit	405 Kg/m^3	664 Kg/m^3	443 Kg/m^3	824 Kg/m^3
0.39	1	1.639	1.093	2.034

For 1 m^3 = 2494 Kg /m^3

4. Test Specimens and Test procedure

The ingredients of concrete are weighing properly and mixed thoroughly to get consistency to the concrete considering the mix proportion. Superplasticizer is added to water and then mixed to the dry mix. Specimens were compacted on table vibrator and tapping rod to get a homogeneous mixture. Specimens used are cubes, cylinders and beams specially prepared to measure compressive strength, splitting tensile strength and flexural strength respectively. Dimensions of each test specimen are as under:

Cube: 150mm×150mm×150mm
Cylinder: 150mm in diameter and 300mm long
Beam:100mm×100mm×500mm

5. TESTS AND RESULT ANALYSIS

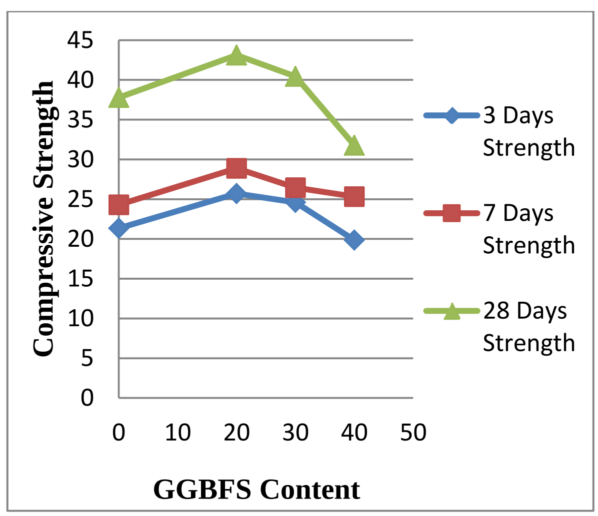
5.1. Compressive Strength Results

The compressive strength of concrete was determined at the age of 3 days, 7 days and 28 days. The specimens were cast and tested as per IS: 516-1959.

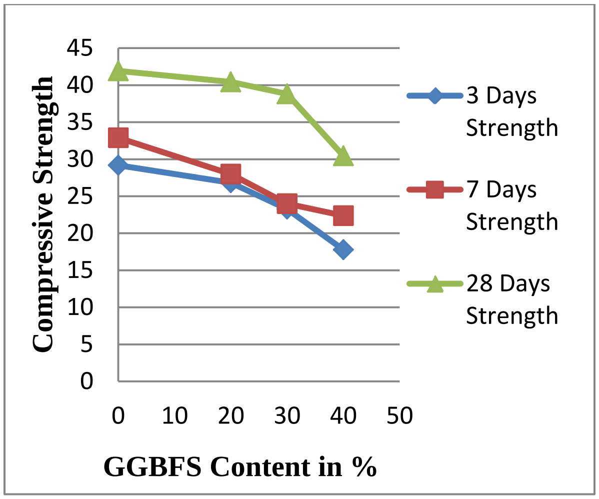
Table No. 1 Compressive Strength of Concrete

Trial No.	GGBFS (%)	Glass Fiber (%)	Compressive Strength			% Variation in Compressive Strength over Control Concrete		
			3 Days	7 Days	28 Days	3 Days	7 Days	28 Days
T1	0	0.0	21.333	24.296	37.78	0	0	0
T2		0.03	29.185	32.899	43.11	36.806	35.368	14.108
T3		0.06	25.778	27.704	40.74	20.836	14.027	7.835
T4	20	0.0	25.703	28.889	41.93	20.485	18.904	10.985
T5		0.03	26.815	28	40.444	25.697	15.245	7.051
T6		0.06	22.263	25.481	40	7.641	4.877	5.876
T7	30	0.0	24.593	26.444	40.444	15.281	8.841	7.041
T8		0.03	23.259	24	38.81	9.028	-1.218	2.726
T9		0.06	23.37	26.444	40.15	9.549	8.841	6.273
T10	40	0.0	19.852	25.333	31.778	-6.492	4.268	-15.887
T11		0.03	17.778	22.37	30.444	-16.664	-7.927	-19.418
T12		0.06	17.185	20.444	26.444	-19.444	-15.854	-30.005

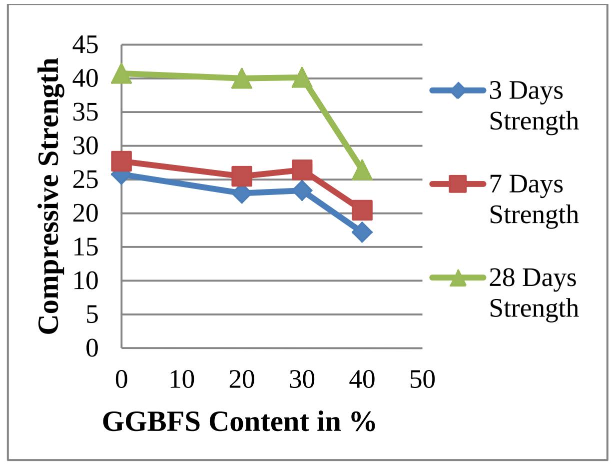
Graph No. 1 GGBFS Vs Compressive Strength when 0.0 % Glass Fiber



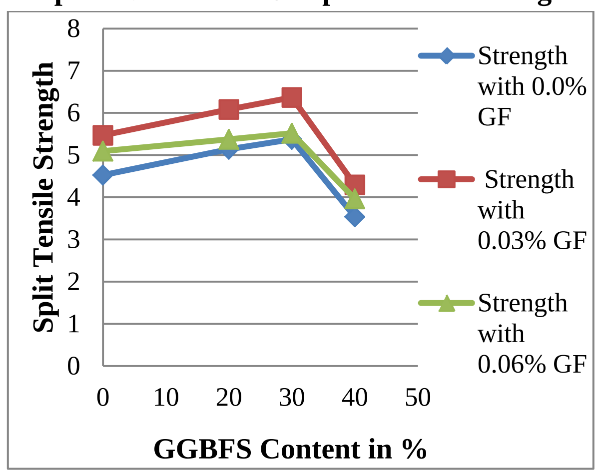
Graph No. 2 GGBFS Vs Compressive Strength when 0.03 % Glass Fiber



Graph No. 3 GGBFS Vs Compressive Strength when 0.06 % Glass Fiber



Graph No.4 GGBFS Vs Split Tensile Strength



Compressive Strength increases with GGBFS addition for 20% up to 41.93N/mm^2 which is more then the control concrete. GGBFS also increase strength up to 30% replacement but there after there is reduction in Strength. GGBFS and Glass Fiber together also give increase in compressive strength then the controlled concrete but they more compressive strength individually. If we check the graph 3 we can get to know that with 30% GGBFS and 0.06% Glass Fiber gives more Strength then 20% GGBFS and 0.06% and all other combinations in the graph.

5.2. Split Tensile Strength Results

The splitting tensile strength of concrete cylinder was determined based on 516-1959. The load shall be applied nominal rate within the range 1.2 N/(mm2/min) to 2.4 N/ (mm2/min). Load is applied until the specimen fails, along the vertical diameter.

Split tensile strength increases between range of 20% to 30% of GGBFS addition and gives more strength for 0.03% addition of Glass Fiber. Here split tensile strength was highest at 30% GGBFS content and 0.03% Glass Fiber content. All the results for split tensile strength are greater than controlled concrete except 40% replacement of GGBFS do not prove better.

Table No. 2 Splitting Tensile Strength of Concrete

Trial No.	**GGBFS (%)**	**GF (%)**	**Splitting Tensile Strength in N/mm^2**	**% Variation in Splitting Tensile Strength**
T1	0	0.0	4.527	0.00
T2		0.03	5.471	20.842
T3		0.06	5.329	17.717
T4	20	0.0	5.140	13.550
T5		0.03	6.084	34.385
T6		0.06	5.093	12.508
T7	30	0.0	5.376	18.508
T8		0.03	6.367	40.635
T9		0.06	5.329	17.717
T10	40	0.0	3.537	-21.869
T11		0.03	3.844	-15.098
T12		0.06	4.716	4.174

5.3. Flexural Strength Test on Beams

The results of flexural strength are presented in table below:

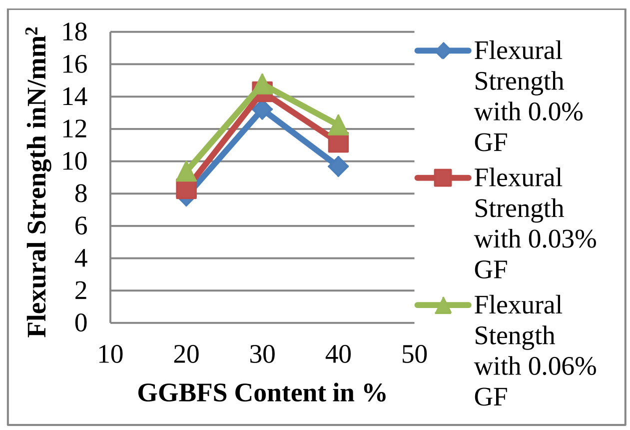
Table No. 4.11 Flexural Strength of Concrete

Trial No.	**GF (%)**	**GGBFS (%)**	**Flexural Strength in (N/mm^2)**	**% Variation in Flexural Strength**
T1	0.0	0	10.91	0
T4		20	7.85	-28.06
T7		30	13.21	21.07
T10		40	9.675	-11.34
T2	0.03	0	12.5	14.54
T5		20	8.3	-23.94
T8		30	14.3	31.04
T11		40	11.175	2.4
T3	0.06	0	13.25	21.42
T6		20	9.375	-14.08
T9		30	14.775	35.39
T12		40	12.24	12.16

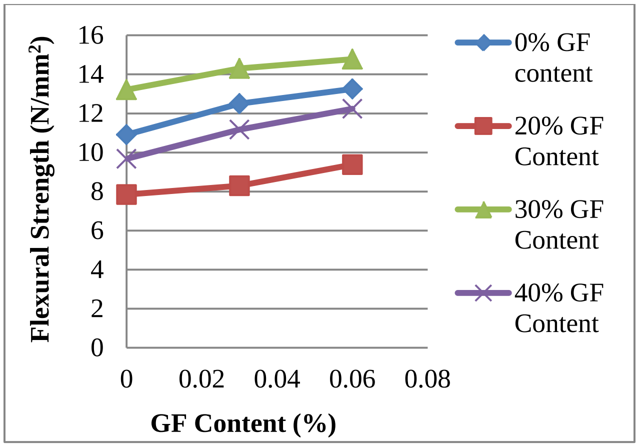
Discussion

Highest flexural strength was achieved at combination 30%GGBFS and 0.06%GF i.e. trial number T9. Flexural strength is reduced at 20% addition of GF. Results in the Graph 4.10 shows that Flexural strength for 0%, 20%, 30% and 40% GGBFS increases with increase in GF content.

Graph No. 4.9 %GGBFS Vs Flexural Strength



Graph No. 4.10 %GF Vs Flexural Strength



6. CONCLUSION

a) It is observed that the GGBFS based Glass Fiber can have higher strengths.

b) Compressive Strength is highest at the T2 trial means with 0.03% of Glass Fiber.

c)Splitting Tensile Strength is highest at the T8 trial means with 30% GGBFS and 0.06% Glass Fiber.

d) Based on the results the compressive and split tensile strengths are increased as the percentage of GGBFS increased.

e) Combinable effect of GGBFS and Glass Fiber is also good for 30% GGBFS and 0.06% Glass Fiber as we know that concrete starts bleeding above 30% replacement by GGBFS and Glass Fiber controls the bleeding of concrete.

f) Higher strength development is due to filler effect of GGBS and properties of glass fibers.

g) As split tensile strength increases, formation of micro-cracks are avoided which is due to Glass Fiber addition.

h) From the experimental results 20-30% of cement can be replaced with GGBFS.

i) The addition of super plasticizer also tends to reduce strength of concrete due to the chemical action between the super plasticizer and GGBS.

j) The flexural strength increases with increase in Glass Fiber content.

k) Results shows that the flexural strength increases for 0%, 30% and 40% GGBFS content, with increase in GF content.

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