International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES),(UGC APPROVED)
Impact Factor: 5.22 (SJIF-2017),e-ISSN:2455-2585
National Conference on
Sustainable Practices & Advances in Civil Engineering (SPACE 2019)
Volume 5, Special Issue 06, June-2019.

AN EXPERIMENTAL STUDY ON BEHAVIOUR OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT USING GGBS IN ADDITION WITH HYBRID FIBRE

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Abstract— ***An experimental study on behaviour of concrete by partial replacement of cement using GGBS in addition with hybrid fibres to enhance the engineering properties such as compressive strength, splitting tensile strength and flexural strength of normal concrete (NC) and Hybrid Fibre Reinforced Concrete (HFRC) with partial replacement of GGBS in cement have been obtained from standard tests and compared. Alkali resistive Glass fibre (GF) and polypropylene fibre (PF) were utilized as chemically inorganic strength inhibitors. Glass fibres are acquired from molten glass of a specific composition. The replacement of cement with Ground granulated blast furnace slag (GGBS) in hybrid fibre reinforced concrete decreases ecological contamination and improves the mechanical properties of concrete. In this study different percentages (0%, 0.2%, 0.4%, 0.6%, 0.8% and 1.00%) of glass and polypropylene fibres collectively act as a hybrid fibre with different percentages of GGBS (0%, 10%, 20%, 30%, 40% and 50%) are used to know their effect on the hybrid fibre reinforced concrete. Samples cast for testing are cubes, cylinders and prisms. It is observed that at 1.4% (0.6% polypropylene and 0.8% glass fibres) addition of fibres and up to 20% substitution of GGBS as the binder can improve the properties of concrete. Using of hybrid fibres and GGBS improved all the three mechanical properties of concrete like compressive strength, split tensile strength and flexural strength of concrete.***

Keywords— Hybrid Fibres, Hybrid Fibre reinforced concrete, Glass fibre, Polypropylene fibre, Ground granulated blast furnace slag, Compressive strength, Split tensile strength and Flexural strength.

I. INTRODUCTION

Concrete is the most widely used construction material in the world. To overcome its adverse effects on environment and to minimize its usage, cement replacement studies are made. Fibres will spread uniformly in the concrete mix, so that surface cracking is observed mostly. This supplement changes large single cracks into a system of multiple smaller cracks, which is desired from safety and durability point of view [4]. The process of destruction of concrete under high temperature can be delayed by addition of the polypropylene fibres (PP) [4].In present investigation, optimum dosage of PP and GF was obtained from 7 days and 28 days compressive strength of HFRC with a combination of glass fibre (0.2%, 0.4% 0.6%, 0.8% and 1%) and polypropylene fibres (0.2%, 0.4% 0.6%, 0.8% and 1%) and replacement of cement by GGBS (0%, 10%, 20%, 30%, 40% and 50%) are used to study the variation of compressive strength, split tensile strength and flexural strength of concrete in comparison to the conventional concrete.

- Research Significance: This research provides information concerning the behavior of HFRC with GGBS replacement for higher strength of concrete in comparison with normal concrete. Optimum combination of fibres contents were obtained from compressive strength of concrete. Type of cement and supplementary cementing materials such as GGBS play an important role in mechanical behaviour of concrete. In this paper, hybrid FRC mixes carrying various combinations of polypropylene and glass fibres were studied under compression, tension and flexure has been identified.

II. EXPERIMENTAL INVESTIGATION

Materials: In present work various materials are used; OPC 53 Grade, GGBS, fine aggregate: natural river sand, coarse aggregate, water and steel fibres.

Fig.1 (a): Glass Fibre

Fig.1 (b): Polypropylene fibre

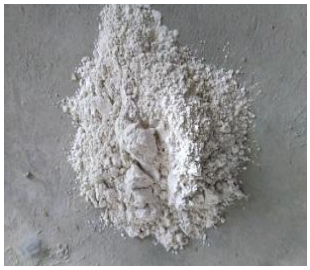

Fig.1 (c): GGBS

A. Cement: Ordinary Portland cement of 53 grade conforming to IS 12269-1987 (I.S. 12269, 1987) has been used. The specific gravity of cement was 3.15. The physical properties of cement obtained on conduction of appropriate tests as per IS12269-1987 (I.S. 12269, 1987). Results shown in Table.1

TABLE 1
PROPERTIES OF CEMENT

Properties	Cement	GGBS
Fineness: Specific Surface	3.75	4.25
Specific gravity	3.15	2.87
Standard consistency of cement (%)	24%	34%
Setting time of cement A. Initial setting time(min) B. Final setting time (min)	135 240	180

B. GGBS: GGBS used in this experimental work is procured from JSW cement Limited, from local distributor. Ground granulated blast furnace slag is the by-product of melting ore to purify metals. Slag has pozzolanic reaction which allows the increase of compressive strength. The physical properties of GGBS are presented in Table 1 as per IS 4031-1988 (IS 4031, 1988).

C. Fine aggregates: Locally available river sand conforming to grading zone II of IS 383-1970 has been used as fine aggregate. The fineness modulus is 2.75, Specific gravity is 2.54.

D. Coarse Aggregates: The Coarse aggregate used is crushed (angular) aggregate conforming to IS383:1970 (IS383-1970). Size of aggregates are used in experiment is 20mm. The results of sieve analysis conducted as per the specification of IS 383 -1970 (IS383-1970). Fineness modulus is 6.25, specific gravity is 2.823.

E. Water: Clean potable water is used for casting and curing operation for the work.

F. Glass fibre: In this investigation alkali resistant glass fibres are used as shown in Figure 1(a). The properties of glass fibres are shown in Table 2.

TABLE 2
PROPERTIES OF GLASS FIBER

Properties	Values
Tensile strength (MPa)	4028 to 4650
Elongation of break (%)	5.81
Diameter (μ)	10
Melting temperature bond	1558
Length of the fibre (mm)	12-13mm

G. ***Polypropylene fibre:*** In this study, soft polypropylene fibres are used as shown in Figure 1(b). The properties of polypropylene fibre are given in Table 3.

TABLE 3

PROPERTIES OF POLYPROPYLENE FIBER

Properties	**Values**
Tensile strength (kg/cm2)	6000
Elongation of break (%)	45-55
Diameter (μ)	33-35
Length of the fibre (mm)	12-13

- ***Mix Proportion***

Mix design was carried out using (I.S. 10262:2009). Mix proportions shown in Table 4

TABLE 4

MIX PROPORTIONS

Unit of batch	**Water (Liters)**	**Cement (Kg)**	**F.A. (Kg)**	**C.A. (Kg)**	**Size of Agg. (mm)**
Cubic meter content	168	350	695	1238	20
Ratio	0.48	1	1.98	3.53	

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

Mix design for M25 grade of concrete was done as per IS: 10262(2009) with mix proportions 1:1.98:3.53 with a water cement ratio of 0.48. Test specimens of standard size 150 mm x 150 mm x 150mm cubes for compressive strength with combination of Glass and polypropylene fibres of varying percentages (0%, 0.2%, 0.4%, 0.6%, 0.8% and 1.00%) were cast and cured for 28 days. The specimens were tested to obtain the optimum dosage of combination of fibres in the concrete. Cubes and cylinders with optimum dosage of hybrid fibres and varying percentages of GGBS (0%, 10%, 20%, 30%, 40% and 50%) were cast and cured for 7 days and 28 days. The specimens were tested under compression testing machine to obtain the dosage of GGBS to be used with hybrid fibres in concrete. Beam specimens of size 500 mm x 100mm x 100 mm with optimum dosage of the hybrid fibres and different percentages of GGBS (0%, 10%, 20%, 30%, 40% and 50%) were cast and cured for 7 days and 28 days. The specimens were tested under Universal Testing Machine according to IS: 516-1979 to study the flexural behaviour of hybrid fibre reinforced concrete. The workability of HFRC and GGBS-HFRC concrete was determined with the help of slump cone test. Decrease in workability was observed when there is an increase in percentage of GGBS in GGBS HFRC concrete.

a. Compressive Strength of the Hybrid Fibre Reinforced Concrete:

The compressive strength was determined to find out the behavior of normal concrete and HFRC in compression. Compressive strength was obtained by dividing the maximum load by the area of a cross section of the specimen. Compressive strengths of Hybrid fibre reinforced concrete with varying percentages of PP and GF are shown in Table 5. Compressive strength = F/A N/mm^2.

TABLE 5

COMPRESSIVE STRENGTH OF HYBRID FIBRE REINFORCED CONCRETE

Mix No. (M)	*Percentage of Fibres*		*Average Compressive Strength for 28 Days (Mpa)*
	Polypropylene Fibre (P.F)	*Glass Fibre (G.F)*	
0	0	0	34.67
1	0.2	0.2	35.56
2		0.4	25.13
3		0.6	26.67
4		0.8	24.65
5		1.0	29.27
6	0.4	0.2	25.36
7		0.4	29.16
8		0.6	27.26
9		0.8	25.96
10		1.0	26.67
11	0.6	0.2	32.36
12		0.4	27.5
13		0.6	33.9
14		0.8	38.28
15		1.0	35.08
16	0.8	0.2	32.71
17		0.4	34.13
18		0.6	33.3
19		0.8	35.44
20		1.0	28.92
21	1.0	0.2	32
22		0.4	33.07
23		0.6	32.71
24		0.8	34.79
25		1.0	31.29

From the above results it was observed that cubes cast with a combination of glass fibre and polypropylene fibres gave a good compressive strength of 38.28 MPa at 0.6% PP and 0.8% GF and which is relatively higher than the compressive strengths of conventional concrete.

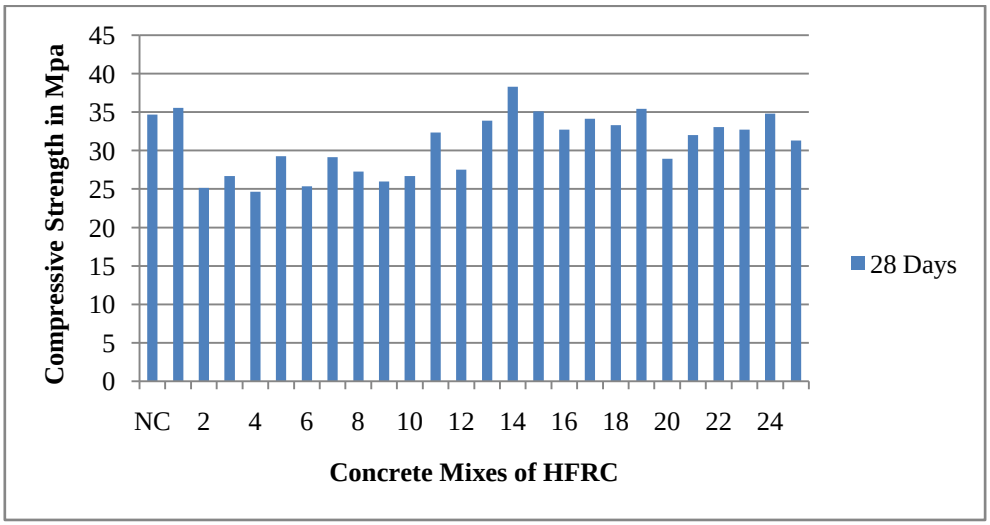

Fig. 2: Compressive Strength of HFRC (PP & GF)

b. Compressive and Split Tensile Strengths of Hybrid Fibre Reinforced Concrete with Partial Replacement of cement by GGBS:

Compressive and Split Tensile strengths of Hybrid fibre reinforced concrete with varying percentages of GGBS are shown in Table 6.

Fig.3: Compressive Strength test.

Fig.4: Split tensile Strength test

TABLE 6

COMPRESSIVE AND SPLIT TENSILE STRENGTH OF HYBRID FIBRE REINFORCED CONCRETE WITH GGBS REPLACEMENT

Mix No. (M)	Percentage of Fibres		Percentage of GGBS (%)	Average Compressive Strength		Split Tensile Strength	
	Polypropylene Fibre (P.F)	Glass Fibre (G.F)		for 7 Days (Mpa)	for 28 Days (Mpa)	For 7 Days (Mpa)	for 28 Days (Mpa)
NC	0	0	0	21.22	36.43	1.92	3.31
0	0.6	0.8	0	22.79	38.28	2.07	3.48
1	0.6	0.8	10	21.48	36.59	1.95	3.32
2	0.6	0.8	20	21.63	40.07	1.96	3.64
3	0.6	0.8	30	22.22	36.44	2.02	3.31
4	0.6	0.8	40	24.15	35.26	2.19	3.20
5	0.6	0.8	50	19.85	31.85	1.80	2.89

From the above results it was observed that cubes and cylinders cast with a combination of 0.80% of glass fibre and 0.60% of polypropylene fibres with 20 % replacement of cement by GGBS gave a compressive strength of 40.07 MPa and Split tensile strength of 3.64 MPa which were higher than the compressive and split tensile strengths of conventional concrete and hybrid fibre reinforced concrete cast with optimum dosage of hybrid fibres.

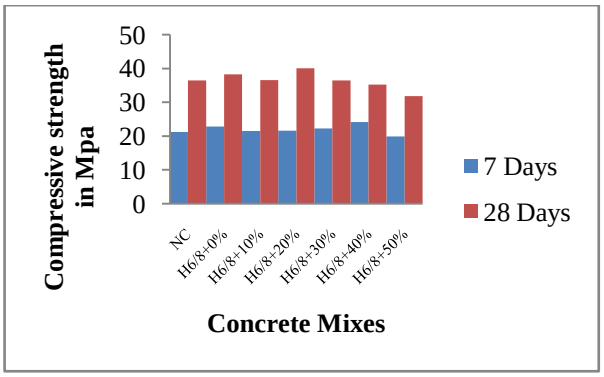

Fig.5: Compressive Strength of HFRC with GGBS

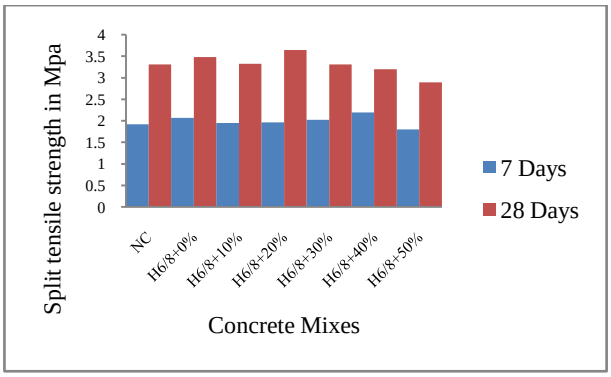

Fig.6: Split Tensile Strength of HFRC with GGBS

c. Flexural strength:

Flexural strength was carried out on 42 prism specimens and average of three prisms for each mix was tested to determine the flexural strength of concrete. The flexural strength of hybrid fiber reinforced concrete with GGBS is shown in table 7. The results indicate that at 20% of GGBS replacement the flexural strength of concrete is maximum. The flexural strength test was conducted on prisms of size 100mm × 100mm × 500 mm at the age of 7 days and 28 days and confirming to IS 516-1959 to find out the behaviour of beams and other flexural members when cast with normal concrete, HFRC and GGBS HFRC concrete. The specimen was mounted on the universal testing machine and two points loading was applied through a hydraulic jack arrangement to cause downward deflection. The loading was continued till the ultimate failure of the specimens was reached. Figure 4 shows the flexural strength. The flexural strength of prisms was calculated as follows:

Flexural strength = $3PL/2bd^2$

Where, P = Maximum load applied to the specimen, b = Measured width of the specimen, d = Measured depth of the specimen and L = Length of the span.

TABLE 7
AVERAGE FLEXURAL STRENGTH OF DIFFERENT CONCRETE MATRIX

	Flexural strength at 7 days (Mpa)	**Flexural strength at 28 days (Mpa)**
Normal Concrete	2.24	3.2
HFRC (0.6%+0.8%)	2.31	3.3
GGBS 10%	2.45	3.5
GGBS 20%	2.66	3.8
GGBS 30%	2.59	3.7
GGBS 40%	2.52	3.6
GGBS 50%	2.38	3.4

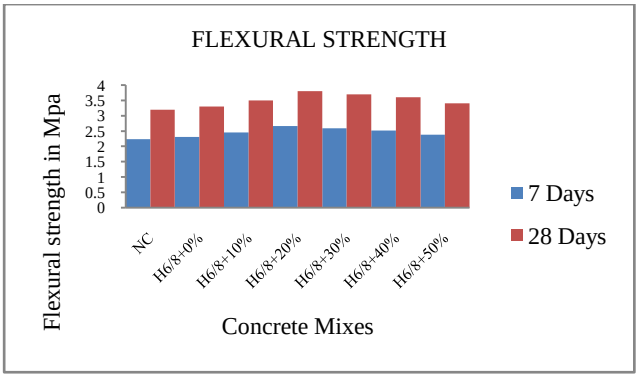

Fig.7: Flexural Strength of HFRC with GGBS

IV. CONCLUSIONS

1) The optimum dosage of the hybrid fibres in hybrid fibre reinforced concrete achieved at 1.4% of fibres i.e., combination of 0.6% of polypropylene fibre and 0.8% of Glass fibre. There is 10% increase in strength on normal concrete with addition of fibers.

2) The compressive and split tensile strength of the hybrid fibre reinforced concrete cast with 1.4% hybrid Fibres (0.6% of polypropylene fibre and 0.8% of Glass fibre) with 20% replacement of cement by GGBS resulted a 10% increase in both Compressive and Split tensile strengths of respectively, i.e. 40.07 Mpa and 3.64 MPa.

3) It was observed that hybrid fibre reinforced concrete cast with 1.4% hybrid Fibres (0.6% of polypropylene fibre and 0.8% of Glass fibre) with 20 % replacement of cement by GGBS gave a maximum flexural strength of 3.8 MPa with a increase of 18.75% flexural strength compared to normal concrete.

4) Hence hybrid fibre reinforced concrete (0.6% of polypropylene fibre and 0.8% of Glass fibre) with usage of GGBS upto 20% as partial replacement of cement not only improves the mechanical properties of concrete but also protects the environment from the hazards of GGBS.

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