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

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Abstract— In addition to hybrid fibers, an experimental analysis on concrete behaviour by partial replacement of cement using GGBS to boost 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 was obtained from standard tests and compared with partial replacement of GGBS in cement. The chemical inorganic strength inhibitors used were alkali resistive glass fibre (GF) and polypropylene fibre (PF). In this analysis various percentages of glass and polypropylene fibers (0 percent, 0.2 percent, 0.4 percent, 0.6 percent, 0.8 percent and 1.00 percent) together act as a hybrid fibre with different percentages of GGBS (0 percent, 10 percent, 20 percent, 30 percent, 40 percent and 50 percent) are used to understand their effect on the reinforced concrete hybrid fibre. It is noted that the addition of fibers and up to 20 percent replacement of GGBS as the binder will boost the properties of concrete at 1.4 percent (0.6 percent polypropylene and 0.8 percent glass fibers).

Keywords— Hybrid Fibers, Hybrid Fibre reinforced concrete, Glass fibre, Polypropylene fibre, Ground granulated blast furnace slag, compressive strength, Split tensile strength and flexural strength.

1. INTRODUCTION

Concrete is the most commonly used commodity in the world for construction. Cement replacement experiments are being carried out to overcome its harmful effects on the environment and to minimize its use. In the concrete mix, fibers can disperse evently, such that surface cracking is often observed. This supplement converts large single cracks into a system of many smaller cracks, which is desired from the standpoint of protection and durability[4]. Optimum doses of PP and GF were collected from 7 days and 28 days of HFRC compressive strength with a combination of glass fibre (0.2 percent, 0.4 percent, 0.6 percent, 0.8 percent and 1 percent) and polypropylene fibers (0.2 percent, 0.4 percent, 0.6 percent, 0.8 percent and 1 percent) and cement replacement by GGBS (0 percent, 10 percent, 20 percent, 30 percent), and cement replacement by GGBS (0 percent, 10 percent, 20 percent, 30 percent).

- Research Significance: This study offers details on the conduct of HFRC with GGBS replacement for higher concrete strength relative to standard concrete. The optimum fibre material mixture was derived from the compressive strength of the concrete. In this paper, under compression, stress and flexure, hybrid FRC mixes carrying different combinations of polypropylene and glass fibers were examined.

2. LITERATURE REVIEW

Alaa M. Rashad * *et.al* :

In this study , the potential was explored to improve the compressive efficiency of high-volume GGBS (HVS) glue when viewed at elevated temperatures using small-scale metabolite (MK)(MMK). To produce HVS glue, Portland concrete (PC) was somewhat subjected to GGBS at a level of 70 percent, by weight. Afterword, with an addition of 2 percent by weight, GGBS was halfway subjected to MMK at levels ranging from 2 percent to 10 percent. Ready for six exclusive blends. The key blend was formed from 30 per cent PC and 70 per cent GGBS to produce HVS glue (with no MK expansion). This blend was allocated as mMK0. The remaining five blends were developed by halfway supplanting GGBS with MMK at different levels ranging from 2% to 10% with a 2%, by weight point. MMK particles are much better than GGBS particles just as MMK has higher Al_2O_3 content that causes much higher pozzolanic motion. But the compressive consistency has improved. Six cement blends have been selected for analysis. Which integrate control blend without filaments, steel fiber fortified cement (SFRC) with 0.5 percent steel strands and four half breed fiber reinforced cement (HFRC) of steel and polyester strands with a full volume component as 0.5 percent and attempts were made to link the various design properties with the amount of strands used.

Anithu Dev[1] *et.al*:

Their concentration was obtained from standard tests on mechanical properties such as compressive strength, dividing rigidity, break module, flexibility modulus of ordinary solid (NC), steel fiber enhanced cement (SFRC) and a mixture of fiber enforced cement. The full strand volume was set at 0.5 per cent of the absolute cement volume. A decrease in polyester fiber content (HFRC4) quality was found at 0.2 per cent. This may be due to the effect of fiber balling on higher fiber content. For SFRC, 0.5 percent steel filaments with an expansion of 11.19 percent are acquired with a greater compressive strength than NC. There was negligible variation of compressive quality among HFRC. Split rigidity is greatly influenced by the expansion of the filaments. HFRC3 (0.35% steel and 0.15% polyester) provides the most extreme level of split rigidity, which is 3.2% higher than SFRC.

Doo-Yeol Yoo [a]*et.al*:

This study expects to examine the flexural conduct of bars of steel-fibre-strengthened cement (SFRC) under semi-static and impact loads. For this reason , different SFRC pillars with three different compressive qualities (f 0c of approximately 49, 90, and 180 MPa) and four distinctive fiber volume substances (vf 0, 0.5, 1.0, and 2.0 percent) were developed and evaluated. For example of effect load, by expanding the probable vitality and efficiency, an expansion in the heap conveying limit was acquired, and an improvement in post-top behavior was seen by expanding the fiber material. The increase in fiber substance and quality also prompted improvements in the execution of leftover flexural after effect damage. The fiber content slightly affected the compressive consistency and versatile modulus while the strain limit (resisting the pinnacle) increased discernibly with the fiber material. Because of NC and HSC, the decline of the incline in the diving portion of the compressive anxiety strain bend was acquired with an expansion of fiber material, but, for example UHSC, the expansion of steel filaments had no enormous effect on the under pressure durability.

3. 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

Cement: Ordinary Portland 53 grade cement compliant with IS 12269-1987 (I.S.12269,1987) was used. 3.15 was the specific gravity of the cement. Physical characteristics of cement obtained as per IS12269-1987 (I.S. 12269, 1987) while conducting necessary tests. The results in Table.1 are shown.

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

GGBS: The GGBS used in this experimental work is collected from local distributors from JSW cement Limited. The byproduct of melting ore to purify metals is ground granulated blast furnace slag. Slag has a pozzolanic reaction which allows compressive strength to increase. As per IS 4031-1988 (IS 4031, 1988),
Table 1 presents the physical properties of GGBS.

Fine aggregates: As a fine aggregate, locally available river sand conforming to the grading zone II of IS 383-1970 was used. The modulus of fineness is 2.75, with a specific gravity of 2.54. Coarse Aggregates: The coarse aggregate used is the IS383:1970 (IS383-1970) compliant crushed (angular) aggregate. The scale of the aggregates used in the test is 20 mm. The results of the sieve analysis were performed according to the IS 383-1970 (IS383-1970) specification. The modulus of fineness is 6.25 and the real gravity is 2.823.

Water: Clean drinking water is used for the process of casting and curing for the job.

Glass fibre: As shown in Figure 1(a), alkali resistant glass fibers are used in this study. Table 2 demonstrates the properties of glass fibers.

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

Polypropylene fibre: Soft polypropylene fibers were used in this analysis as shown in Figure 1(b). Table 3 demonstrates the properties of polypropylene fibre.

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	

EXPERIMENTAL RESULTS AND DISCUSSIONS

As per IS: 10262(2009), mix design for M25 concrete grade was conducted with a mixing ratio of 1:1.98:3.53 with a water cement ratio of 0.48. Standard format test samples of 150 mm x 150 mm x 150 mm cubes for compressive strength with a mixture of different percentages of glass and polypropylene fibers (0 percent, 0.2 percent, 0.4 percent, 0.6 percent, 0.8 percent and 1.00 percent) were cast and healed for 28 days. In order to achieve the optimal dose of the mixture of fibers in the concrete, the specimens were tested. For 7 days and 28 days, cubes and cylinders with ideal hybrid fibre dosage and varying GGBS percentages (0 percent, 10 percent, 20 percent, 30 percent, 40 percent and 50 percent) were cast and cured. The specimens were tested to achieve the dosage of GGBS to be used for hybrid fibers in concrete under a compression testing machine. Beam samples of 500 mm x 100 mm x 100 mm with ideal hybrid fibre dose and various GGBS percentages (0 percent, 10 percent, 20 percent, 20 percent, 30 percent, 40 percent and 50 percent) were cast and healed for seven days and 28 days. To research the flexural behaviour of hybrid fibre reinforced concrete, the specimens were tested under the Universal Testing Machine according to IS: 516-1979. 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:

To find out the behaviour of normal concrete and HFRC in compression, the compressive strength was determined. By dividing the full load by the area of a cross section of the specimen, compressive strength was obtained. Hybrid fibre reinforced concrete compressive strengths with different percentages of PP and GF are shown in Table 5. Compressive resistance= F/A N/mm2.

TABLE 5
COMPRESSIVE STRENGTH OF HYBRID FIBRE REINFORCED CONCRETE

Mix No. (M)	Percentage of Fibers		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

It was observed from the above results that cubes cast with a combination of glass fibre and polypropylene fibre developed a strong compressive strength of 38.28 MPa at 0.6 percent PP and 0.8 percent GF, which is comparatively higher than traditional concrete compressive strengths.

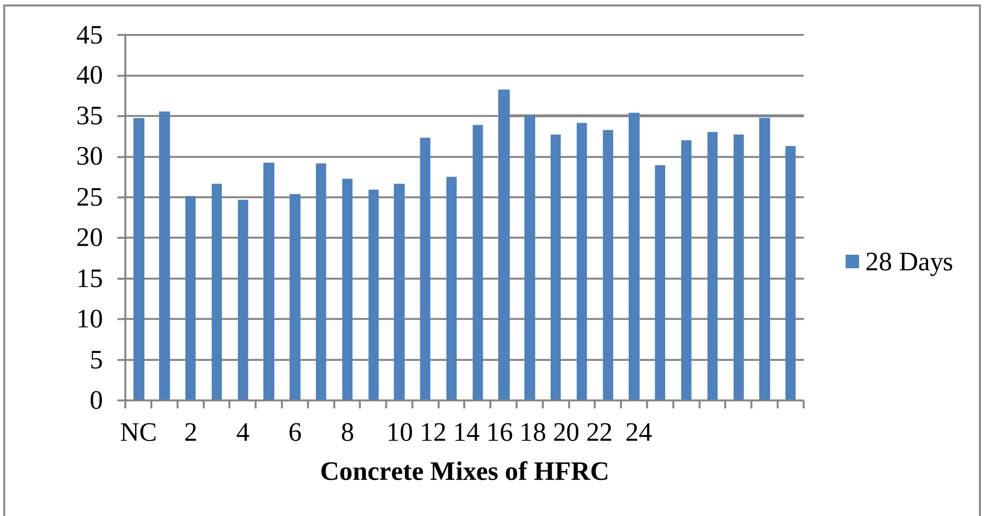


Fig. 2: Compressive Strength of HFRC (PP & GF)

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

Hybrid fibre reinforced concrete compressive and break tensile strengths with different percentages of GGBS are shown in Table 6.

Fig.3: Compressive Strength test.

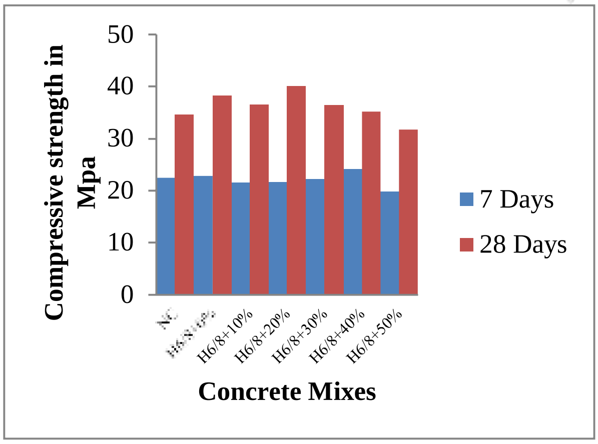
Fig.4: Split tensile Strength test

c. TABLE 6

d. 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 found that cubes and cylinders cast with a mixture of 0.80 percent glass fibre and 0.60 percent polypropylene fibres with 20 percent GGBS cement replacement gave a compressive strength of 0.80 percent glass fibre and 0.60 percent polypropylene fibres with 20 percent cement replacement. 40.07 MPa and 3.64 MPa split tensile strength, higher than traditional concrete and hybrid fibre reinforced concrete cast compressive and split tensile strengths with maximum hybrid fibre dosage.



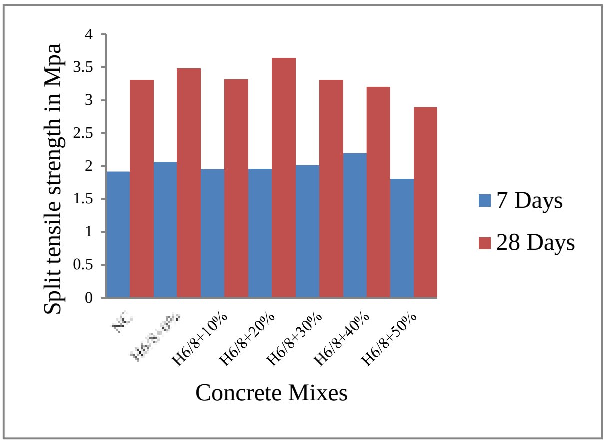


Fig.5: Compressive Strength of HFRC with GGBS Fig.6: Split Tensile Strength of HFRC with GGBS

Flexural strength:

For 42 prism specimens, flexural strength was carried out and an average of three prisms were tested for each mix to assess the flexural strength of the concrete. The bending power of GGBS reinforced hybrid fibre concrete is shown in Table 7. The findings show that the flexural strength of concrete is maximal at 20 percent of GGBS replacement. Concrete At the age of 7 days and 28 days, the flexural strength test was performed on prisms of 100 mm × 100 mm × 500 mm and verified to IS 516-1959 to determine the action of beams and other flexural members when cast with regular concrete, HFRC and GGBS HFRC. The specimen was mounted on the universal test machine and two points of loading were applied to induce downward deflection via a hydraulic jack arrangement. The loading was carried on until the ultimate failure of the samples was achieved. The flexural intensity appears in Figure 4.

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)**
NC	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

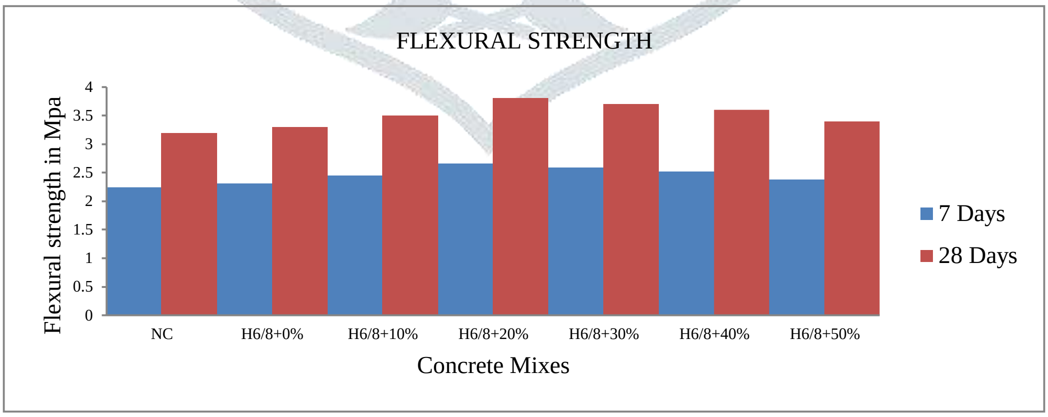


Fig.7: Flexural Strength of HFRC with GGBS

CONCLUSIONS

1) The optimal dosage of hybrid fibers in reinforced concrete hybrid fibers reached 1.4% of fibres, i.e. a mixture of 0.6% of polypropylene fibers and 0.8% of glass fibers. With the addition of fibers, the strength of regular concrete can increase by 10 percent.

2) With a 20 percent replacement of cement by GGBS, the compressive and split tensile strength of the hybrid fibre reinforced concrete cast with 1.4 percent hybrid fibers (0.6 percent polypropylene fibre and 0.8 percent glass fibre) resulted in a 10 percent improvement in both compressive and split tensile strengths of 40.07 Mpa and 40.07 Mpa respectively, i.e. MPa 3.64.

3) It was found that hybrid fibre reinforced concrete cast with 1.4% hybrid fibers (0.6% polypropylene fibre and 0.8% glass fibre) with 20% GGBS cement replacement gave a maximum flexural strength of 3.8 MPa with a flexural strength improvement of 18.75% compared to regular concrete.

4) Thus, hybrid fibre reinforced concrete (0.6 percent polypropylene fibre and 0.8 percent glass fibre) with up to 20 percent GGBS use as partial cement substitute not only enhances concrete's mechanical properties, but also protects the environment from GGBS hazards.

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