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STRENGTH STUDIES ON HYBRID FIBRE REINFORCED CONCRETE

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Abstract: This study intends to examine the stress strain behaviour of hybrid fibre reinforced concrete (HFRC) in which cement is partially replaced with flyash. Fly ash based concrete is an environment friendly alternative to conventional concrete made from alkali activated aluminosilicate and aggregate. The variables considered in this study are volume fractions of glass and polypropylene fibres and percentages of cement replacement with flyash. The tests were carried out on cube and cylindrical specimens for different fibre volume fractions of glass and polypropylene (0%, 0.2%, 0.4%, 0.6%, 0.8%, 1%) and flyash (0%, 10%, 20%, 30%, 40%, 50%) percentages. This paper presents the results of tests in compressive strength, split tensile strength and stress strain behaviour of HFRC. The optimum dosage of fibre content is found to be 1.4% (0.6% polypropylene + 0.8% glass fibres).At 20% replacement of cement with flyash the strength of concrete is gradually increased.

Keywords: Hybrid Fibres, Hybrid Fiber reinforced concrete, Glass fibre, Polypropylene fibre, Fly ash, Compressive strength, Split tensile strength and stress strain behavior.

1. INTRODUCTION

It is well-known that concrete is a brittle material with high compressive strength and low tensile strength. Adding randomly distributed fibres into concrete is one of the approaches to increase the tensile strength and the tensile strain of concrete, which forms fiber reinforced concrete (FRC). Many types of fibers have been considered for addition into concrete, such as steel fibers, glass fibers, polypropylene fibres, carbon fibers and natural fibers. The compressive strength of FRC may increase or decrease when compared with plain concrete of the same mix proportion depending on the type and quantity of fibers adopted, while the deformation capacity of FRC in compression is generally better than its plain concrete. While the benefit of single fiber may be limited, hybrid fibers have been investigated to achieve better performance. For example, when both stiff and ductile fibers are included, stiff fibers can provide strength increment while ductile fibers can increase the deformation capacity (or toughness) of FRC. Many studies have been conducted to investigate the behavior of hybrid fiber reinforced concrete (HFRC). However, the study on hybrid glass and polypropylene fiber reinforced concrete is rare. In this study, the stress strain behavior of normal strength hybrid glass and polypropylene fiber reinforced concrete was explored. The major parameters studied including water/binder ratio, fiber content and combination. The test results were carefully analyzed.

2. EXPERIMENTAL PROGRAM

2.1 Mix proportions and material properties:

2.1.1 Cement: Ordinary Portland cement (OPC) of 53 grade conforming to IS 12269-1987 is used. Specific gravity of cement was found to be 3.15.

2.1.2 Fine aggregate: Locally available river sand conforming to zone II as per IS: 383-1970 was used as fine aggregate with a maximum size of 4.75 mm. The Specific gravity is 2.54 and fineness modulus is 2.9.

2.1.3 Coarse aggregate: Coarse aggregate of 20 mm nominal size is used confirming to IS 383-1970. . The Specific gravity is 2.823 and fineness modulus is 6.25.

2.1.4 Flyash: Class F flyash brought from kakatiya Thermal Power Station located at Bhupalpally, Telangana is used. Specific gravity is 2.3.

2.1.5 Polypropylene fiber: In this study, soft polypropylene fibres are used as shown in Figure 1. The properties of polypropylene fibre are given in Table 1.

2.1.6 Glass fiber: In this investigation alkali resistant glass fibres are used as shown in Figure 2. The properties of glass fibres are shown in Table 1.

TABLE-1

PROPERTIES OF FIBRES

Fibre type	Density(gr/cm^3)	Length(mm)	Diameter(mm)	Tensile strength (MPa)	Geometry
PP	0.9	12	0.02	400	Fibrillated
Glass	2.7	12	0.03	4028 to 4650	Fibrillated

Fig 1:Polypropylene fibres

Fig 2:Glass fibres

To investigate the effect of both glass and polypropylene (PP) fibres on the properties of concrete, 25 mixes with varying volume of glass and PP fibres were prepared. The volume fraction of glass and polypropylene fibres varied between 0% and 1% of cement, in steps of 0.2%. After optimisation of fibre content, cement is replaced with Flyash with varying percentages like 0%, 10%, 20%, 30%, 40%, 50%. Fly ash (Class F) was used as the replacement of cement.

2.2 Mix design and sample preparation:

M25 grade of concrete is adopted and mix design is obtained using IS: 10262-2009 with mix proportion 1:1.98:3.53:0.48. As the work is carried out in 2 stages, the quantities of cement added are not same. The proportions of different materials added in the concrete mix are listed in table-4.

TABLE-2

QUANTITIES OF MATERIALS

Mix(flyash replacement) (M25)	Cement (kg/m^3)	Flyash (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Water content (lt/m^3)
0%	350	0	694.94	1236.52	168
10%	315	35	694.94	1236.52	168
20%	280	70	694.94	1236.52	168
30%	245	105	694.94	1236.52	168
40%	210	140	694.94	1236.52	168
50%	175	175	694.94	1236.52	168

In first stage of work (i.e., optimisation of fibre content), three cubes for each mix were casted with different combinations of volume fractions of glass and polypropylene fibres as shown in table-1.Test specimens include cubes(150 mm x 150 mm x 150mm) and cylinders(diameter 150mm and height 300 mm).Totally 75 cubes were casted, cured for 7 days &28 days and tested for compressive strength. After analysing the test results, the fibre content was optimised and second stage of work is carried out in which cubes and cylinders were casted for each mix with partial replacement of cement with flyash and tested for 7-day strength and 28-day strengths (both compressive and split tensile strength).

2.3. Test set-up and loading procedure:

The cube specimens were tested for compressive strength and cylinders for split tensile strength under compression testing machine. The stress-strain behaviour of HFRC cylinders is tested in a specially made apparatus known as extensometer fitted with two dial gauges .The entire set up is fitted in compression testing machine and loading is done and dial gauge readings on left and right are noted down and these values are used for calculation of strains.

3. RESULTS AND ANALYSIS:

3.1 28 day Compressive strength of HFRC:

The values of compressive strength of Hybrid fibre reinforced concrete with different proportions of glass and polypropylene fibres are listed below,

TABLE-3

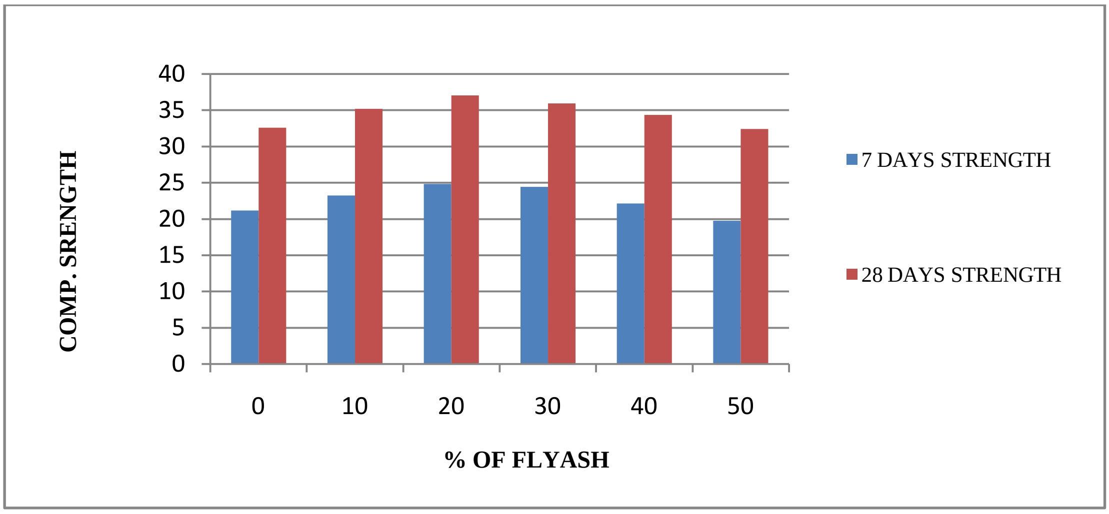
28 DAY COMPRESSIVE STRENGTH OF HFRC

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

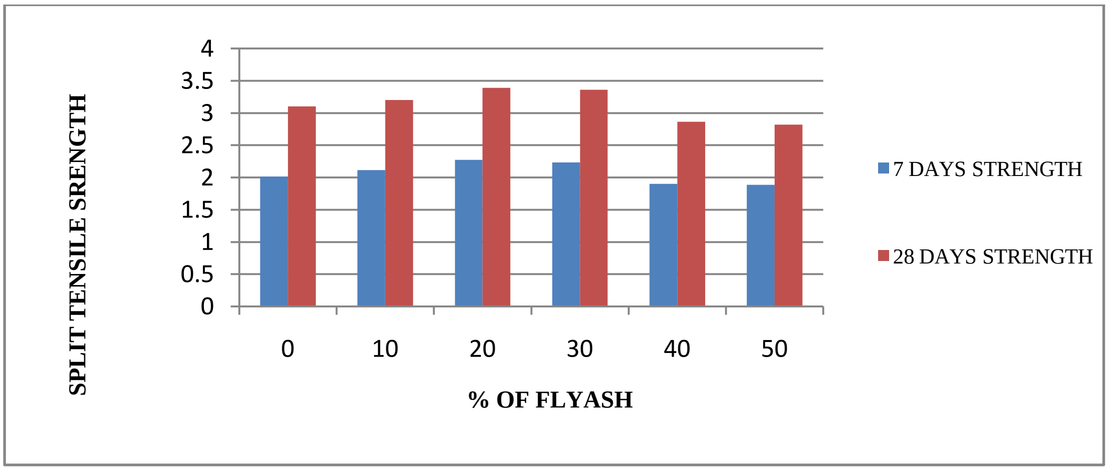
3.2 Compressive strength and split tensile strength of HFRC with partial replacement of cement with flyash

Percentage of flyash(%)	Compressive strength (MPa)		Split tensile strength (MPa)	
	7 days	28 days	7 days	28 days
0	21.19	34.6	2.017	3.104
10	23.23	37.21	2.112	3.2
20	24.823	39.05	2.271	3.39
30	24.45	37.96	2.234	3.36
40	22.155	36.35	1.903	2.862
50	19.776	34.42	1.888	2.819

Graph 1: Compressive strength of HFRC for different percentages of flyash



Graph 2: Split tensile strength of HFRC for different percentages of flyash



3.3 Stress strain behaviour of HFRC:

STRESS STRAIN CURVES OF HFRC WITH FLYASH

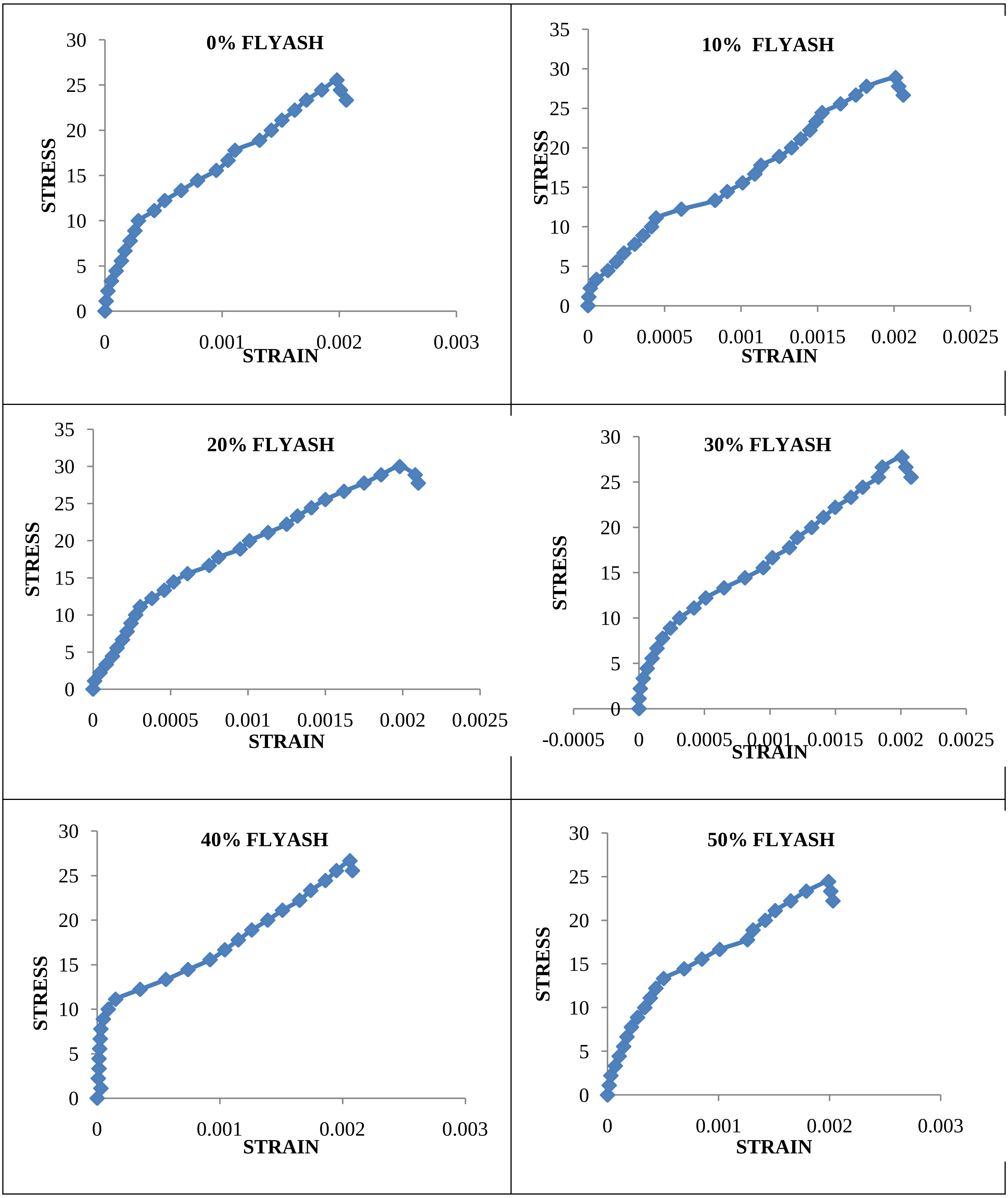
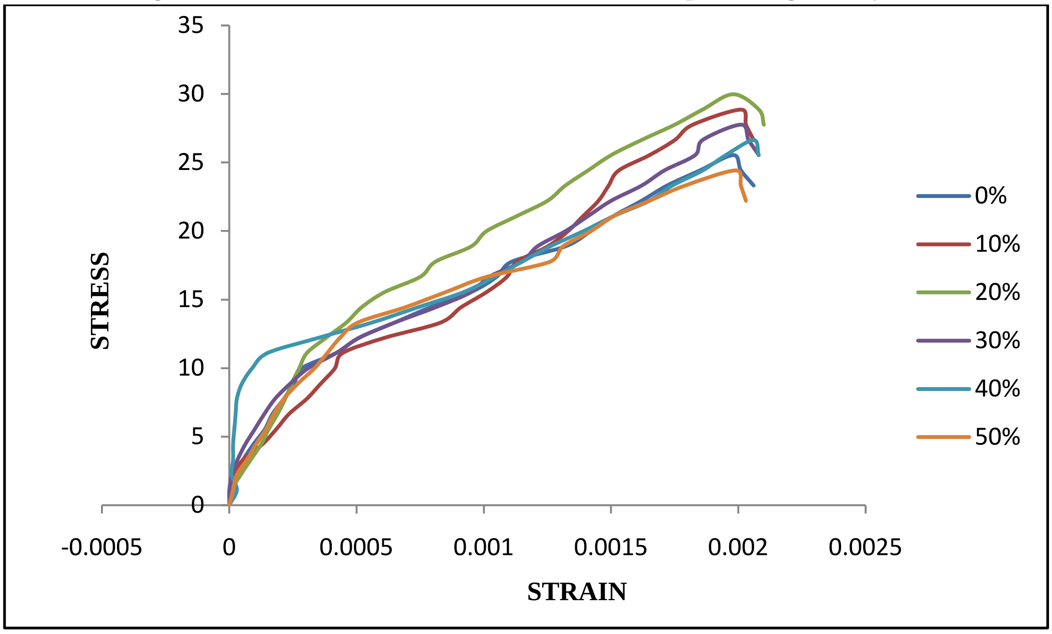


Fig 3:Stress strain curve of HFRC with different percentages of flyash



4. CONCLUSIONS

- The introduction of blended fibers into concrete matrix has positive influences on improving the mechanical behaviour of concrete. The failure pattern of HFRC is ductile, while that of plain concrete is brittle.
- The optimum dosage of the hybrid fibres in HFRC is achieved at 1.4% (0.6% PP +0.8% glass fiber). The compressive strength of specimen with this fiber content is 38.28 MPa, which is 10.45% more than conventional concrete specimens.
- Cement replacement by fly ash leads to increase in compressive strength, split tensile strength and stress-strain behaviour of concrete up to 20 % replacement for M25 grades of concrete.
- It was observed that hybrid fibre reinforced concrete cast with 0.80% of glass fibre and 0.60% of poly propylene fibres with 20% of fly ash showed a maximum stress of 29.97 MPa within the allowable range of strain.
- It can be concluded that by adding 0.6% polypropylene fibre + 0.8% glass fibre and by replacing 20% cement by flyash increased the strength and stress strain behaviour of concrete significantly.

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