Mechanical Properties of Hybrid Fiber Reinforced Concrete Using Flyash

G Chaithanya [1], Dr. G V V Satyanarayana [2]
M.Tech Student, Department of Civil Engineering, GRIET, Hyderabad [1]
Associate Professor, Department of Civil Engineering, GRIET, Hyderabad [2]

Abstract – Mechanical properties of hybrid fiber reinforced concrete were studied by Incorporation of multiscale fibers in M30 grade of concrete mix. Crack resisting is observed when glass and polypropylene fibers are uniformly distributed in the concrete. The inclusion of glass fibers varied from 0 to 1% with a variation of 0, 0.2%, 0.4%, 0.6%, 0.8% and 1% by weight of binder and the inclusion of polypropylene fibers varied from 1%, 0.8%, 0.6%, 0.4%, 0.2% and 0 by the weight of binder. The cement was replaced with flyash by 25% by weight of cement. The effect of hybrid fibers is seen considerably in compression and flexural behavior of concrete.

Index Terms – Hybrid Fibers, Hybridization, Glass Fibers, Poly propylene Fibers

1. INTRODUCTION

Hybrid fiber concept consists the addition of minimum two types of fibers which use the potential properties of fibers more efficiently. Fiber reinforced composites may be processed by conventional methods, such as compression moulding, and offer improvements in mechanical properties over unreinforced ones. Fibers act as a bond towards crack widening and increase the energy absorption capacity of the concrete. The earlier researchers on the characteristics of conventional concrete with hybrid fiber reinforcement were reported. In this present investigation, the effect of Hybrid Fiber Reinforcement consisting of Glass and polypropylene Fibers showed an improvement in the mechanical properties of HFRC. For this justification, investigation was made to examine the behavior of glass fiber reinforced concrete(GFRC), polypropylene fiber reinforced concrete(PFRC) and hybrid fiber reinforced concrete(HFRC) under axial compression and flexural. In this study, hybrid fibers are added by 1% to the weight of the binder, polypropylene fibers(PF) and glass fibers(GF) were added ranging from 1% to 0 and 0 to 1% respectively and at GF(0.6%)+PF(0.4%) the mechanical properties are observed to be maximum.

2. LITERATURE REVIEW

Vikranth S.(2012) worked on experimental studies on fibre combinations in reinforced concrete which demonstrate the maximum compressive strength and split tensile strength of hardened concrete in which the results shows that both compressive strength and tensile strength are of HFRC is greater than the conventional concrete He conclude that the study on the effect of hybrid fibres with different proportions can still be a promising work as there is always a need to overcome the problem of brittleness of concrete

M.D Koli (2013) worked on the flexural behavior of hybrid fibre reinforced concrete beams in which he used combination of polypropylene fibres and steel fibres with different proportions with aspect ratio of 30 and 50, and reinforced concrete beam of M-25 grade concrete were casted and tested under UTM.
He concluded that beam having same percentage of fibres shows better results for aspect ratio 30 than aspect ratio 50 and also concluded that the load carrying capacity of beam specimen is increasing at a constant rate for increase in fibre percentage upto 1 percent.
Selina Ruby G., Geethanjali C.(2014) are worked on influence of hybrid fibres on reinforced concrete of grade of M-40 and conducted tests to find the strength parameters of concrete cubes and concluded that HFRC performed good over normal conventional concrete. Different proportions of steel and polypropylene fibres are used and test data of samples are interpretated one over other.
They also concluded that the Combination of 75% of steel fibres and 25% of polypropylene are gave maximum compressive strength over other proportions because of high elastic modulus of steel fibres and low elastic modulus of polypropylene fibres.
R.H Mahankar (2016) worked on mechanical performance of hybrid fibre reinforced concrete of grade M-20 with combination of steel and polypropylene fibres in which compressive strength and flexural strengths of concrete cubes are tested and concluded that combination of steel and polypropylene fibres with proportion 1% are gave better results than the other proportions like 0.25%, 0.50%, 0.75%.
They also concluded that HFRC results in reduction of secondary reinforcement at some level and make structure economical.

3. EXPERIMENTAL PROGRAMME

3.1 Materials Used:

In this experimental investigation, Cement, fine aggregate, coarse aggregate, water, fly ash, glass fibers, polypropylene fibers and chemical admixture were used.

Cement: Ordinary Portland cement of 53 grade was used in this experimental investigation conforming to I.S-12269: 1987 the specific gravity of cement is 3.18 **Coarse aggregates**: Locally available 20mm size coarse aggregates were tested and the specific gravity value is 2.78.

Fine aggregates: The fine aggregates available from local sources and passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was 2.60, conforming toI.S. – 383-1970.

Water: Water plays a vital role in achieving the strength of concrete. It is practically proved that minimum water-cement ratio of 0.4 is required for conventional concrete. Water, when added to cement forms a cement paste which binds with coarse and fine aggregates. If excess water is added, concrete suffers segregation and bleeding and becomes weak, but here most of the excess water will be absorbed by the fibers. **Fly ash**: Fly ash of Class F conforming to IS: 3812: Part-II-2003 obtained from Ramagundam thermal power plant (India) with a specific gravity of 2.18.

Chemical Admixture: Super Plasticizer- G / lenium B233.

Glass fiber: the properties of glass fibers used in this investigation are appearance = white, length = 18mm, dia = 0.014mm, aspect ratio = 1285, density 2.7gm/cm³, odorless and insoluble in water.

Polypropylene fibers: the properties of polypropylene fibers used in this study are appearance = white, length = 12mm, dia = 0.04mm, aspect ratio = 300, odorless and insoluble in water.

Table 1. Different proportions of fibers used

Notation	**Glass fibers by weight of the binder (%)**	**Polypropylene fibers by weight of binder (%)**
GF(0.2)+PF(0.8)	0.2	0.8
GF(0.4)+PF(0.6)	0.4	0.6
GF(0.6)+PF(0.4)	0.6	0.4
GF(0.8)+PF(0.2)	0.8	0.2
GF(1) +PF(00)	1	0
GF(00)+PF(1)	0	1

3.2 Mix Proportions of Concrete

M30 grade of concrete was obtained as per I.S.10262:2009 with w/c 0.4. Mix proportion for M30 grade concrete for tested material as follows

Materials	**Quantities (Kg/m³)**
Cement	300
Fly ash	100
Water	160
Coare aggeregate	1202.9
Fine aggregate	737.2
Super plasticizer	6

4. WORKABILITY:

Slump test is the most commonly used to determine the workability and consistency of fresh concrete. It is not suitable method for very wet or very dry concrete. it is used conveniently as a control test and gives a indication of the uniformity of concrete from batch to batch. The performance of all fiber reinforcement is dependent in deed of a homogeneous distribution of the fibers in the concrete, their interaction with the cement matrix, and the ability of the concrete to be successfully cast or sprayed. Essentially, each individual fiber needs to be coated with cement paste to provide any benefit in the concrete. Regular users of fiber reinforcement concrete will fully appreciate that adding more fibers into the concrete, particularly of a very small diameter, results in a greater negative effect on workability and the necessity for mix design changes. The slump changed due to the different type of fiber content and form. The reason of lower slump is that adding two different fibers can form a network structure in concrete, which restrain mixture from segregation and flow. Due to the high content and large surface area of fibers, fibers are sure to absorb more cement paste to wrap around and the increase of the viscosity of mixture makes the slump loss (Chen and Liu, 2000).

Table 2. Slump values

Dosage of glass and polypropylene fibers	Slump(mm)
Controlled concrete	98
GF(0.2)+PF(0.8)	89
GF(0.4)+PF(0.6)	82
GF(0.6)+PF(0.4)	78
GF(0.8)+PF(0.2)	69
GF(1) +PF(00)	66
GF(00)+PF(1)	72

5. EXPERIMENTAL METHODOLOGY

5.1 Compressive Strength Test

For compressive strength test, both cube specimens of dimensions 100x100x100 mm were casted for M30 grade of concrete. The moulds were filled with controlled concrete,
HFRC GF(0.2%) + PF(0.8%), HFRC GF(0.4%) + PF(0.6%), HFRC GF(0.6%) + PF(0.4%), HFRC GF(0.8%) + PF(0.2%), HFRC GF(1%) + PF(0%) and HFRC GF(0%) + PF(1%) fibers. The moulds are vibrated using table vibrator and the top surface of the specimen was leveled and finished. The specimens were demoulded. After 24 hours and were shifted to curing tank where in they were allowed to cure for 3 days, 7 days and 28 days. After 3, 7 and 28 days curing, these cube were tested on compression testing machine. The failure load was noted. In each category, three cubes were tested and their average value is reported.
The compressive strength was calculated as follows: Compressive strength (MPa) = Failure load / cross sectional area.

5.2 Tensile Strength Test

For split tensile strength test, cylinder specimens of dimension 100 mm diameter and 200 mm length were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 3, 7 and 28 days. These specimens were tested under compression testing machine. In each category, three cylinders were tested and their average value is reported. Tensile strength was calculated as follows
Split tensile strength:
Tensile strength (MPa) = 2P / π
DL, Where, P = failure load,
D = diameter of cylinder,
L = length of cylinder.

5.3 Flexural Strength Test

Prisms were casted for 3, 7 and 28 days to obtain flexural strength as per IS: 516 –1959 the size of the specimens are 100 mm x 100 mm x 500 mm were casted. The samples were demoulded after 24 h from casting and kept in a water tank for 3, 7 and 28 days curing. The specimens were placed in UTM and tested for flexural strength in three point method.

6. MECHANICAL PROPERTIES

6.1 Compressive Strength

Results of Compressive strength for M-30 grade of concrete on cube specimen with 0%, HFRC GF(0.2%) + PF(0.8%), HFRC GF(0.4%) + PF(0.6%), HFRC GF(0.6%)+PF(0.4%), HFRC GF(0.8%) + PF(0.2%), HFRC GF(1%) + PF(0%) and HFRC GF(0%) + PF(1%) fibers are shown in table below:

Compressive strength has marginally increased with inclusion of both fibers at 0.6% of glass and 0.4% of polypropylene fibers to the binder.

Percentages of fibers used	3 days N/mm²	7 days N/mm²	28 days N/mm²
Controlled concrete	20.64	28.9	38.70
GF(0.2)+PF(0.8)	21.3	30	38.23
GF(0.4)+PF(0.6)	22.2	31.8	41.86
GF(0.6)+PF(0.4)	23.73	33.28	44.64
GF(0.8)+PF(0.2)	21	28.9	39.63
GF(1) +PF(00)	20.68	29.1	38.92
GF(00)+PF(1)	20.66	28.96	36.71

6.2 Tensile Strength

Results of splitting tensile strength for M-30 grade of concrete on cylindrical specimen with 0%, HFRC GF(0.2%)+PF(0.8%), HFRC GF(0.4%)+PF(0.6%), HFRC GF(0.6%)+PF(0.4%), HFRC GF(0.8%)+PF(0.2%), HFRC GF(1%)+PF(0%) and HFRC GF(0%)+PF(1%) fibers are shown in table and graph below:

Percentages of fibers used	3 days N/mm²	7 days N/mm²	28 days N/mm²
Controlled concrete	2.47	2.9	5.03
GF(0.2)+PF(0.8)	2.57	3.75	4.48
GF(0.4)+PF(0.6)	2.73	3.91	5.15
GF(0.6)+PF(0.4)	3.084	4.42	5.803
GF(0.8)+PF(0.2)	2.49	3.47	3.77
GF(1) +PF(00)	2.688	3.783	4.825
GF(00)+PF(1)	2.47	3.475	4.404

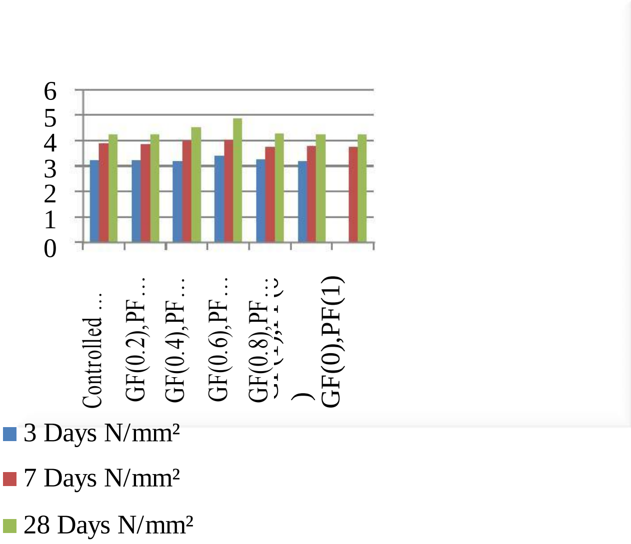
Split tensile strength has marginally increased with inclusion of both fibers at 0.6% of glass and 0.4% of polypropylene fibers to the binder.

6.3 Flexural Strength

Flexural strength also known as modulus of rupture or transverse rupture strength is a property of the material, defined as the stress in a material just before it yields in a flexural test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield. It is measured in terms of stress.

Percentages of fibers used	**3 days N/mm²**	**7 days N/mm²**	**28 days N/mm²**
Controlled concrete	3.21	3.9	4.25
GF(0.2)+PF(0.8)	3.24	3.85	4.24
GF(0.4)+PF(0.6)	36.32	3.98	4.54
GF(0.6)+PF(0.4)	3.409	4.04	4.87
GF(0.8)+PF(0.2)	3.25	3.75	4.29
GF(1) +PF(00)	3.183	3.776	4.264
GF(00)+PF(1)	3.181	3.767	4.240

Flexural Strength



7. CONCLUSION

The study on the effect of hybrid fibers with different proportions can still be a promising work as there is always a need to overcome the problem of brittleness of concrete. The following co nclusions could be drawn from the present investigation.
We conclude that the compres sive strength is increased as compare to other interval and is optimum at GF(0.6)+PF(0.4) Split Tensile Strength and flex ural strength at GF(0.6)+PF(0.4) Gives High Strength as Compare to other Combinations

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