

Behaviour of Hybrid Fibre Reinforced Concrete with Partial Replacement of Fine Aggregate with Non Bio Degradable Plastics

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ABSTRACT: In the present paper the behaviour of Hybrid fibre reinforced concrete with partial replacement of fine aggregate with non bio degradable plastic wastes is studied. The usage of plastic is increasing day by day although many steps were taken to reduce their consumption. Disposal of plastics has become threat to the environment. A healthy and substantial reuse of these materials can offer advantages. Using the recycled plastics in hybrid fibre reinforced concrete can reduce the effect of waste plastics on environment to some extent. In this experimental investigation different proportions (0%, 0.25%, 0.50%, 0.75%, 1.00%) of hybrid fibres i.e.; combination of glass and polypropylene fibres and different percentages (0%, 5%, 10%, 15%, 20%, 25%) of waste plastics in the form of granules as partial replacement to fine aggregate are used in concrete to study the properties like compressive strength, split tensile strength, stress-strain relationships and flexural strength of hybrid fibre reinforced concrete. It was observed that at 1% of hybrid fibres (0.5% glass fibres and 0.5% of polypropylene fibres) and up to 10% of non bio degradable plastic wastes can be effectively used in concrete.

KEYWORDS: Hybrid fibre reinforced concrete, hybrid fibres, waste plastics, non bio degradable plastic wastes, compressive strength, split tensile strength, stress-strain relationships, flexural strength.

I. INTRODUCTION

In the present scenario, concrete has been a versatile material in the progress of construction industry. Due to its adroitness and expertness, concrete can be mould into any shape. Innumerable varieties of construction materials are available in the market and concrete with-stands the desirable engineering properties resulting in the proficient material. To acquaint with the profundity of concrete, various innovative materials were adopted in it. Enthusiasm of the researchers paved the way for fibre reinforced concrete which consists of the fibrous materials that not only increases its structural integrity but also enhances its mechanical properties by showcasing its crack arresting property. A fibre in the concrete resists sudden failure, reduces permeability and lowers bleeding of water. Further interest and experimental investigations in fibres leads to the story line of hybrid fibre reinforced concrete, which is obtained when two or more fibres were combined in the concrete in such a way that it work together to compensate the faults in them to the maximum extent. A hybrid fibre which consists of the combination of lower and highest modulus of fibres tends to lock the micro and macro level of cracks. Rapid increase in the population resulted in the huge garbage of plastics that leads to the humongous escalation to the surroundings, usage of non bio degradable plastics in the form of plastic granules in the concrete can reduce the accumulation of harmful plastics on earth this can be a new development in the construction world by satisfying the slogan-“let’s make the use of waste, to maintain eco-friendly environment in haste.”

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II. RELATED WORK

Renji Xavier(2016) studied the behaviour of hybrid fibre reinforced concrete with fixed proportions of steel and polypropylene fibres and varying percentages of plastic under varying temperature conditions, up to 8% of plastic can be replaced with fine aggregate and can retain up to 75% of strength when heated up to 400°C. Mohankar(2016) has done investigations on performance of hybrid fibre reinforced concrete with varying percentages of steel and polypropylene fibres and suggested that HFRC can be used to resist seismic effects in structure, the floors additionally act as foundation slab that is bracing and carrying the entire building load. Sudheer (2015) used combination of steel and polypropylene fibre as hybrid fibres in varying percentages in HFRC and concluded that as the percentage of fibres increases the strength of concrete increases. Hybrid ratio 1.5 % gives maximum results in all the strength parameters compare to other different hybrid ratios.

III. OBJECTIVES

1. To determine the optimum dosage of hybrid fibres (combination of glass fibres and polypropylene fibres) in concrete.
2. To determine the optimum dosage of non bio degradable waste plastic granules as partial replacement to fine aggregate in hybrid fibre reinforced concrete.
3. To study the effect of hybrid fibres with plastic granules in concrete by determining the compressive and split tensile strengths.
4. To study the flexural behavior of the hybrid fibre reinforced concrete with non bio degradable waste plastic granules as partial replacement to fine aggregate

IV. MATERIALS USED

Cement: Ordinary Portland cement of 53 Grade confirming to IS: 12269-2013 with a specific gravity of 3.11 was used in this study.

Fine aggregate: In this study locally available river sand of zone-II confirming to IS: 383-1970 which has a specific gravity of 2.29 was used.

Coarse aggregate: Crushed granite of size 20mm with specific gravity 2.85 which was procured from a local quarry was used in this work.

Water: Potable water with no impurities was used for mixing and curing in this work.

Hybrid fibre: Alkali resistant glass fibres and polypropylene fibres were used in this study. These two fibres function together to form hybrid fibres. Alkali resistant Glass fibre of type-S as shown in Figure 1(a) The properties of glass fibres are tabulated in Table 1. Polypropylene fibre as shown in Figure 1(b) was procured from Reliance Industries, its properties are tabulated in Table 2. Nomenclature: H-F- Hybrid fibre, GF- Glass fibre, PPF- Poly Propylene fibre



Fig. 1 (a) Alkali Resistant glass fibres



Fig. 1 (b) Polypropylene Fibres



Fig. 1 (c) Plastic granules

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Table 1 properties of Glass fibre

Property	values
Tensile strength(MPa)	4028 to 4650
Elongation of break %	5.81
Diameter (micron)	10 μ m
Specific gravity	2.46
Length of the fibre	12-13mm
Nature	Sharp glassy
Crack resistor	excellent

Table 2 properties of polypropylene fibre

Property	values
Diameter	33-35 microns
Length	12-13mm
Tensile strength	6000kg/cm ²
Dispersion	Excellent
Acid resistance	Good
Nature	Cotton soft
Water absorption	Low

Plastic granules: Recycled linear low density polyethylene plastic granules as shown in figure 1(c) of size 2 to 4mm were used in this study. It was procured from a plastic recycling industry at Warangal.

V. EXPERIMENTAL WORK AND RESULTS

M30 grade of concrete with mix proportions 1:1.44:2.89 with a water cement ratio of 0.45 was designed as per the guidelines provided in IS: 10262-2009. The experimental work is carried out in two phases. Firstly in order to obtain the optimum dosage of hybrid fibres(combination of Glass and polypropylene fibres)in concrete Secondly in concrete with the fixed percentage of the hybrid fibre, fine aggregate is partially replaced by varying percentages (0%, 5%, 10%, 15%, 20%, and 25%) of plastic granules resulting in the plastic hybrid fibre reinforced concrete. Test specimens of standard size 150 mm x 150 mm x 150mm cubes for compressive strength and cylinders of diameter 150mm and height 300 mm for split tensile strength with combination of Glass and polypropylene fibres of varying percentages (0%, 0.25%, 0.50%, 0.75% 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 (0%, 5%, 10%, 15%, 20%, and 25%) of plastic granules were cast and cured for 28 days. The specimens were tested under compression testing machine to obtain the dosage of plastic granules to be used with hybrid fibres in concrete. Beam specimens of size 600 mm x 150mm x 100 mm with optimum dosage of the hybrid fibres and different percentages of plastic granules (0%, 5%, 10%, 15%, 20%, and 25%) were cast and cured for 28 days. The specimens were tested under Universal Testing Machine according to IS: 516-1979 to study the flexural behavior of hybrid fibre reinforced concrete.

a) Compressive Strength of Hybrid Fibre Reinforced Concrete:

The average compressive strength of hybrid fibre reinforced concrete with varying percentages of hybrid fibres(glass and polypropylene fibres) are shown in table 3 and graph 1, Maximum strength of 41.11 MPa was obtained at 1%(0.5% Glass fibres and 0.5% polypropylene fibres).

Table 3 Average compressive strength of the hybrid fibre reinforced concrete

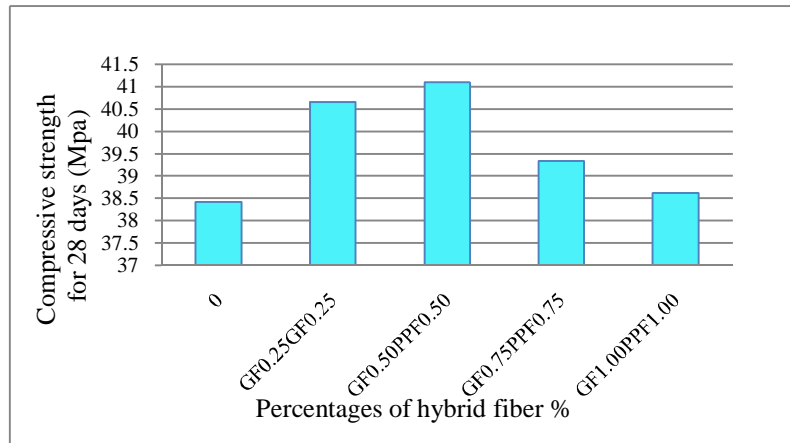
Percentage of hybrid fibre		AverageCompressive strength of hybrid fibre reinforced concrete for 28days (MPa)
Percentage of Glass fibre (GF) %	Percentage of Polypropylene fibre (PPF)%	
0.00	0.00	38.42
0.25	0.25	40.66
0.50	0.50	41.11
0.75	0.75	39.33
1.00	1.00	38.62

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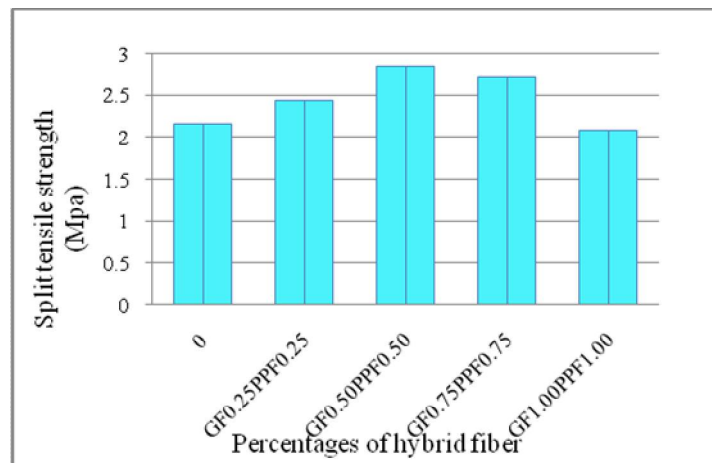
Graph 1 Average Compressive strength of cubes of hybrid fibre reinforced concrete for 28 days

b) Split Tensile Strength of Hybrid Fibre Reinforced Concrete

The average split tensile strength of hybrid fibre reinforced concrete with varying percentages of hybrid fibres (glass and polypropylene fibres) are shown in table 4 and graph 2. Maximum strength of 2.84 MPa was obtained at 1% (0.5% Glass fibres and 0.5% polypropylene fibres).

Table 4 Split tensile strength of the hybrid fibre reinforced concrete for 28 days

Percentage of hybrid fibre		Split tensile strength of hybrid fibre reinforced concrete for 28days (MPa)
Glass fibre (GF %)	Polypropylene fibre (PPF %)	
0	0	2.15
0.25	0.25	2.44
0.50	0.50	2.84
0.75	0.75	2.71
1.0	1.0	2.08



Graph 2 Average Split tensile strength of the hybrid fibre reinforced concrete for 28days

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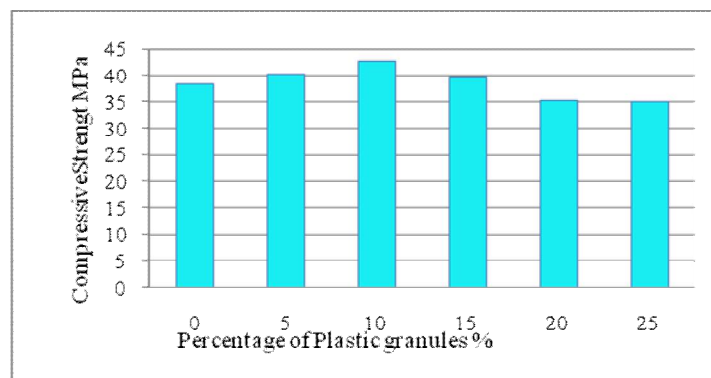
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c) Compressive Strength of Hybrid Fibre Reinforced Concrete With Plastic Granules:

The average compressive strength of hybrid fibre reinforced concrete with optimum dosage (0.5% GF and 0.5% PPF) of hybrid fibres (glass and poly propylene) along with varying percentages of plastic granules are shown in table 5 and the variation is shown in graph 3. Maximum strength of 42.75 MPa was obtained at 10% plastic granules.

Table 5 Average Compressive strength of the hybrid fibre reinforced concrete with plastic granules for 28 days

Percentage of plastic granules (%)	Average compressive strength after 28 days of age (MPa)
0	38.42
5	40.08
10	42.75
15	39.56
20	35.42
25	35.11



Graph 3 Average Compressive strength of hybrid fibre reinforced concrete cast with optimum dosage of hybrid fibres and varying percentages of plastic granules.

d) Split Tensile Strength of Hybrid Fibre Reinforced Concrete with Plastic Granules:

The average split tensile strength of hybrid fibre reinforced concrete with optimum dosage (0.5% GF and 0.5% PPF) of hybrid fibres (glass and poly propylene) along with varying percentages of plastic granules are shown in table 6. And the variation is shown in graph 4. Maximum strength of 2.54 MPa was obtained at 10% plastic granules.

Table 6 split tensile strength of the plastic hybrid fibre reinforced concrete for 28 days

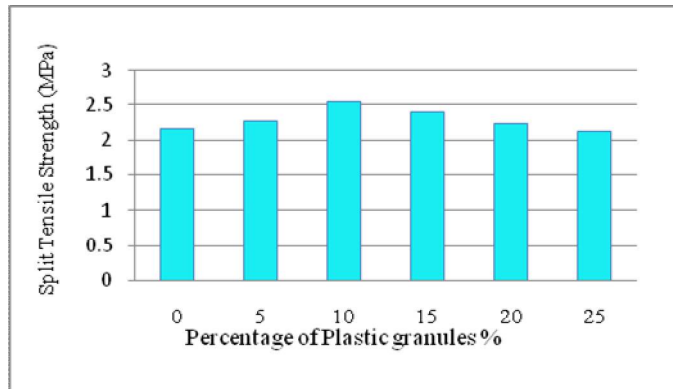
Percentage of plastic granules (%)	Average split tensile strength after 28 days of age (MPa)
0	2.15
5	2.26
10	2.54
15	2.40
20	2.22
25	2.12

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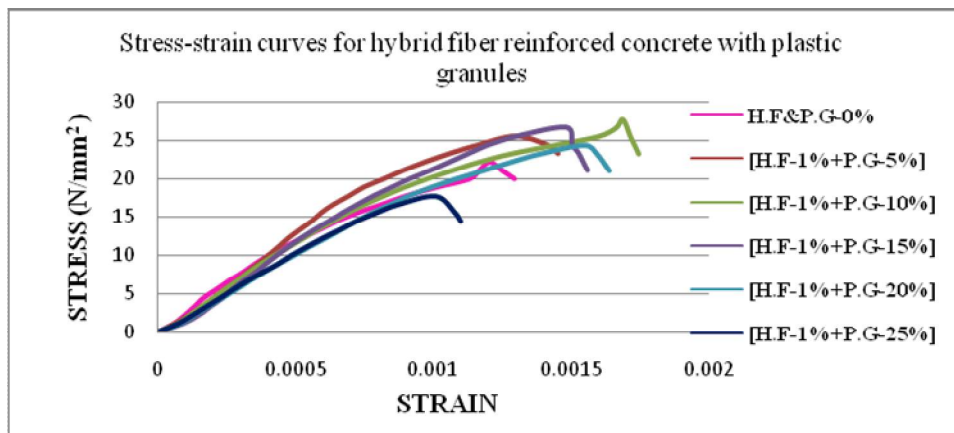
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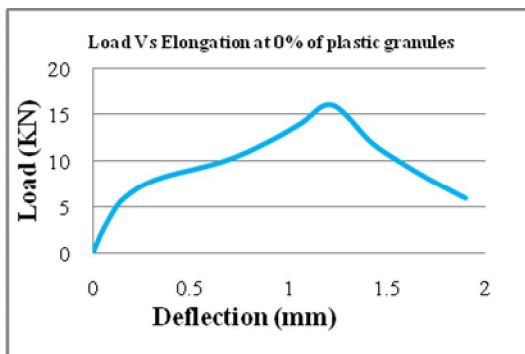
Graph 4 Average Split tensile strength of the cylinders for plastic hybrid reinforced concrete for 28 days

e) Stress-Strain Curves of Hybrid Fibre reinforced concrete with plastic granules:

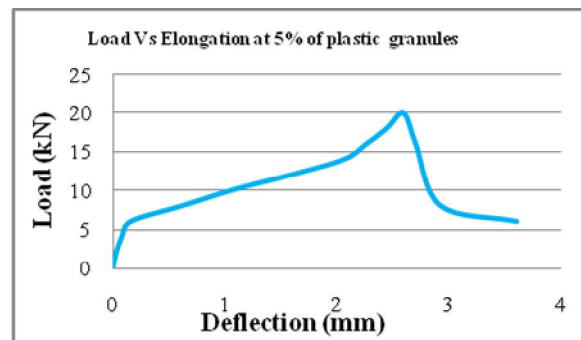


Graph 5 Stress Vs strain for various percentages of plastic hybrid fibre reinforced concrete

f) Load Vs Deflection curves



Graph 6 Load Vs Deflection of hybrid fibre reinforced concrete with no plastic granules



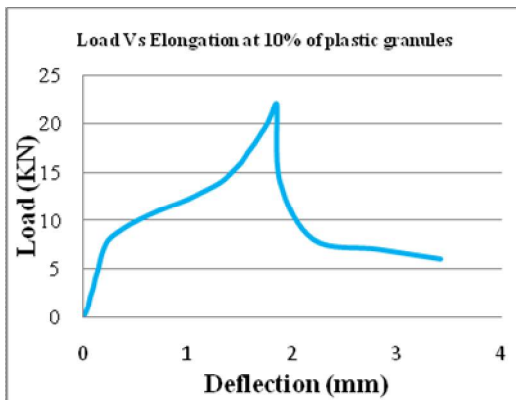
Graph 7 Load Vs Deflection of Hybrid Fibre reinforced concrete with 5% of plastic granules

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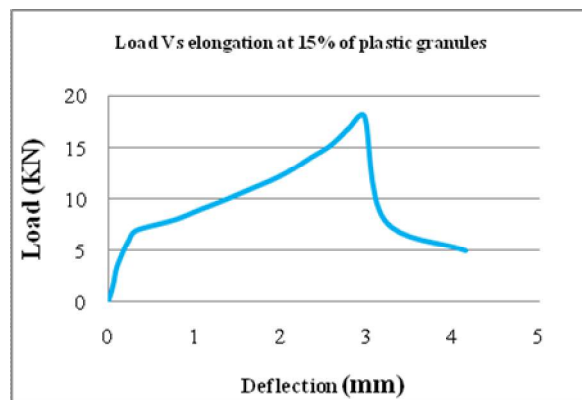
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Graph 8 Load Vs Deflection of Hybrid fibre reinforced concrete with 10% of plastic granules



Graph 9 Load Vs Deflection of Hybrid fibre reinforced concrete with 15% of plastic granules

g) Flexural Strength:

Flexural strength specimens were tested under two point loading over an effective span of 500mm. The details of the test set up with loaded specimen are shown in fig 3. The test specimens were simply supported on rollers and two point loads were applied at equidistance from both the supports between them. Loading was applied through a hydraulic jack arrangement to cause downward deflection. The load was given through the jack in small increments, to measure the deflection, a dial gauge was arranged. The loading was continued till the ultimate failure of the specimens was reached.

Modulus of rupture is the ultimate strength determined in a flexure test which is determined using the following equation.

$$R = \frac{PL}{bd^2}$$

Here, R= Modulus of Rupture, P = Ultimate Load, L= Length of specimen, b = width of specimen, d = depth of specimen.



Fig. 3. Details of the test set up with loaded specimen

Table 7 Flexural strength of the plastic hybrid fibre reinforced concrete for 28 days

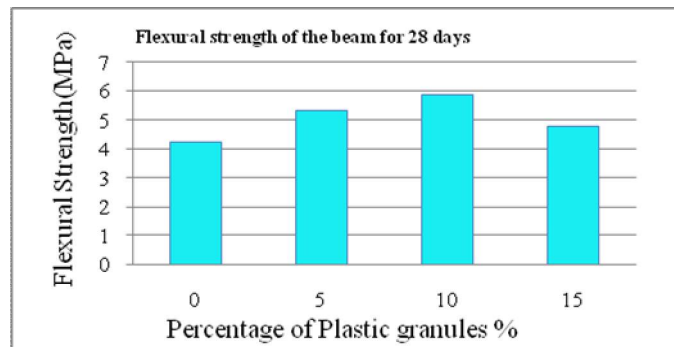
Percentage of plastic granules in hybrid fibre reinforced concrete %	Flexural strength after 28 days of age (MPa)
0	4.266
5	5.33
10	5.86
15	4.8

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Graph 10 Average Flexural strength for plastic hybrid fibre reinforced concrete

VI. CONCLUSIONS

- The highest compressive strength and split tensile strengths of the hybrid fibre reinforced concrete for 28 days were found to be 41.1 MPa and 2.84 MPa respectively, which are greater than conventional concrete.
- The optimum dosage of the hybrid fibres in concrete were found to be 1% i.e., summation of 0.50% of polypropylene fibre and 0.50% of Glass fibres.
- The highest compressive strength (42.75 MPa) and split tensile strengths (2.546 MPa) of hybrid fibre reinforced concrete cast with optimum dosage of hybrid fibres was achieved at 10% replacement of fine aggregate by plastic granules which are 11.27% and 18.1% greater than conventional concrete.
- From stress-strain graphs, up to 10% replacement of plastic granules in fine aggregate with 1% addition of hybrid fibres (GF0.50P.P.F0.50) resists a load of 450 KN within the limiting values of strain.
- The highest flexural strength was recorded at 10% replacement of plastic granules in fine aggregate with 1% addition of hybrid fibres (GF0.50P.P.F0.50) was 5.86 MPa which is 37.36% greater than conventional concrete.
- Availability of hybrid fibres has reduced the crack formation. And up to 10% of the plastic granules can be partially replaced or used in hybrid fibre reinforced concrete with 1% hybrid fibres.

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