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An Experimental Investigation on the Strength Properties of Hybrid Fiber Reinforced Concrete

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Abstract:
Concrete is most widely used in construction material in the world. Fiber reinforced concrete (FRC) is a concrete in which small and discontinuous fibers are dispersed uniformly. The fibers used in FRC may be of different materials like steel, carbon, glass, polypropylene etc. The addition of these fibers into concrete mass can dramatically increase the compressive strength, tensile strength, flexural strength and impact strength of concrete. The effect of addition of mono fibers and hybrid fibers on the mechanical properties this paper hybrid fiber with crimped steel and polypropylene were used in concrete matrix to study its improvements in strength and durability properties. This paper addresses the compressive strength, split tensile strength, flexure behavior of hybrid fiber reinforced concrete. The specimens incorporated steel and polypropylene fibers in the mix proportions of 0.5% of use of M25and M30 grade of concrete.

Keywords: Polypropylene Fiber, Crimped Steel Fiber, Split Tensile Strength, Flexural Strength.

1. INTRODUCTION

Construction is a major part of development plan of developing countries including India to meet the large demand for infrastructure development, maintenance and life Enhancement of structures is very important. Concrete is the most widely used man- made construction material. Micro cracks in concrete are formed during its hardening stage a discontinuous system exists even before the application of any external load when the load is applied micro cracks start developing along the planes which may experience relatively low tensile strains, at about 25-35% of the ultimate strength in compression. Further application of the load leads to tensile crack propagation in turn results in a low fracture toughness, and limited resistance to impact and explosive loading. Hybrid fiber reinforced concrete may be defined as composite material made with Portland cement, aggregate and incorporating discrete discontinuous fibers. Pavements made of concrete by using hybrid fiber provide durable service, life and has remarkable application under heavy traffic loading. If the hybrid fibers are sufficiently strong, sufficiently bonded to material, and permit the HFRC to carry the significant stresses over a relatively large strain capacity in the post cracking stage. Hybrid fibers of different sizes and types may play important roles in resisting cracking at different scales to achieve high performance. It has been proven that incorporating fiber in to cementatious materials can effectively improve their toughness and ability of resisting crack, and a lot of research work has been carried out on fiber reinforced cementations composites the hybridization of fibers provides improved specific or synergistic characteristics not obtainable by any of the original fiber acting alone. Three types of hybrid fibers have been used they are 1.Galvanized iron fiber,
2. Waste plastic fiber and
3. High density polyethylene fiber.

1.1 Hybrid Fiber Reinforced Concrete

Fiber reinforced concrete is a concrete mix that contains Short, Discrete Fibers that are Uniformly distributed and randomly oriented. The characteristics of fiber reinforced concrete are changed by the alteration of quantities of concretes, fiber substances, geometric Configuration, dispersal, direction and concentration. The addition of fibers to the conventional Concrete is varying from 1 -2 % by volume depending on the geometry of fibers and type of application

2. MATERIALS USED

Cement: Ordinary Portland cement of 43 grade was used in this work. It was tested as per IS 8112-1989 recommendation. The chemical composition and properties of cement are tabulated as below.

Figure.1.Cement

Fine aggregates: Natural sand confirming to IS 383-1970 of Zone II is used. Specific gravity, moisture content and absorption capacity of fine aggregate is calculated according to the procedures confirming to IS 2386 and results obtained comply with the code specifications

Figure.2. Fine aggregates

Coarse aggregates: Locally available crushed aggregates confirming to IS 383-1970 are used in this work. Specific gravity, Bulk density and water absorption capacity of coarse aggregate is calculated according to the procedures confirming to IS: 2386

Figure.3. Coarse aggregates

Water: Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, alkalis, vegetables or other organic impurities. Soft waters also produce weaker concrete.

Super plasticizer /Water reducing agents: CONPLAST SP 430 is a super plasticizing admixture is used in this experimentation. CONPLAST SP430 has been specially formulated to give high water reductions into 25% without loss of workability and produce high quality concrete of reduced permeability.

2.1 Fibers

Galvanized iron fibers (GI fibers): Galvanized iron is coated in a layer of zinc to help the metal to resist corrosion. When metal is going to be used in an environment where corrosion is likely, it is often galvanized so that it will be able to withstand the conditions. Even with galvanization however corrosion will eventually start to occur especially if conditions are acidic. GI fibers were procured from locally available material. Round GI wire of 1mm diameter was cut to the required length of 50 mm giving an aspect ratio of 50. The ultimate strength and density of fibers was found to be 395 MPa and 7850 kg/m^3 respectively. These low tensile strength fibers are commercially available and are generally used for electrical work.

Figure.4. Galvanized iron (GI) fibers

Waste plastic fiber: Waste plastic fibers were obtained by cutting waste pipes and cans. The thickness, breadth and length of this fiber were 2mm, 3mm and 50mm respectively, thus making the aspect ratio as 50

Figure.5.Waste plastic fiber

High density polyethylene fibers (HDPE): High density polyethylene fibers are procured from cutting HDPE oil cans. Fibers are cut to a length of 50 mm and width of 2 mm obtaining aspect ratio of 50. Density of HDPE fiber was found to be 941 kg/m$^{3.}$

Figure.6. High density polyethylene fibers

Mix Design for M20 grade concrete

The concrete mix is designed as per IS 10262-1982and IS 456-2000 for the conventional concrete..

Table.1. Mix proportion for M 20 Grade concrete

Sl. No	Grade of concrete	Cement	Fine aggregate	Coarse aggregate	W/C
1.	M 20	1.00	1.81	3.38	0.40

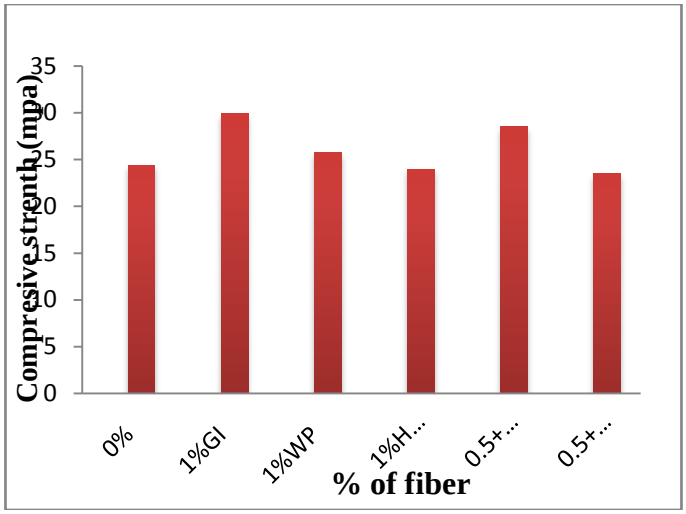
3. TABULATION AND CALCULATION OF RESULTS

3.1 Compressive Strength Tests Results

The following table gives the overall final results of compressive strength tests results of hybrid fiber reinforced concrete for different percentage of fiber.

Table.2. 7)Overall results Compressive strength for 28 days

Percentage of fiber	Compressive Strength(MPa)
0	24.416
1 (GI)	29.930
1(WP)	25.720
1(HDPE)	23.980
0.5+0.5(GI+WP)	28.558
0.5+0.5+(GI+HDPE)	23.540



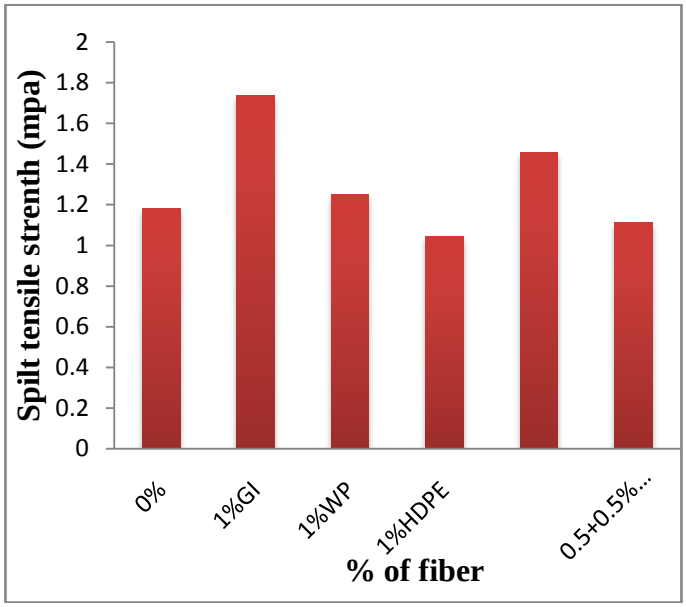
Graph.1. Compressive strength V/S percentage fiber.

3.2 Split Tensile Strength Results

The following table gives the overall final results of split tensile strength tests results of hybrid fiber reinforced concrete for different percentage of fiber

Table.3.14) Overall results Split tensile strength for 28 days

Percentage of fibre	Split tensile Strength(MPa)
0	1.181
1 (GI)	1.734
1(WP)	1.248
1(HDPE)	1.042
0.5+0.5(GI+WP)	1.456
0.5+0.5+(GI+HDPE)	1.112



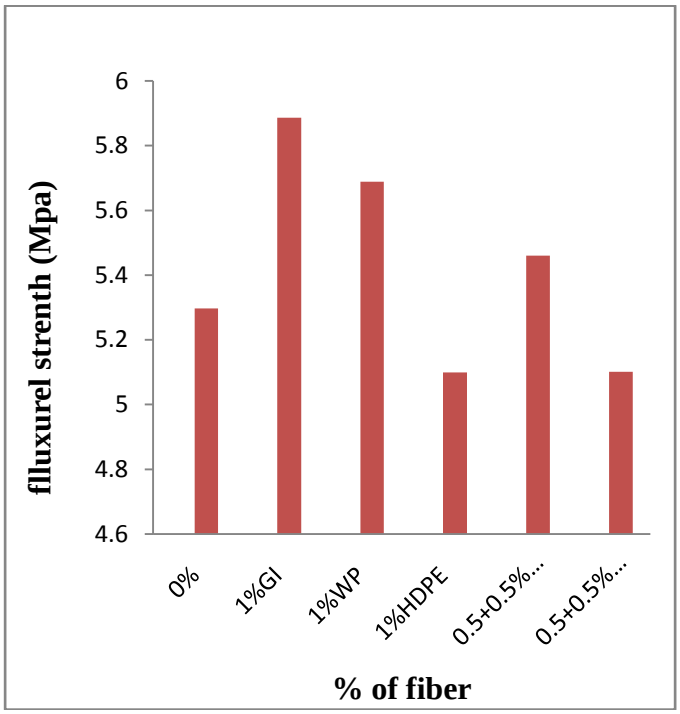
Graph.2. Split tensile strength V/S percentage fiber

3.3 Flexural Strength Results

The following table gives the overall final results of flexural strength tests results of hybrid fiber reinforced concrete for different percentage of fiber.

Table.3. 21) Results Flexural strength for 28 days

Percentage of fiber	Flexural Strength(MPa)
0	5.297
1 (GI)	5.886
1(WP)	5.689
1(HDPE)	5.099
0.5+0.5(GI+WP)	5.460
0.5+0.5+(GI+HDPE)	5.101



Graph.3. Flexural strength V/S percentage fiber

4.

5.

4. CONCLUSION

1. By the experimental results obtained the compressive, split tensile and flexural strength of normal concrete are 24.416 Mpa, 1.181Mpa and 5.297Mpa.
2. The compressive strength, split tensile strength, flexural strength of GI fiber reinforce concrete increases as compared to normal concrete.
3. The compressive strength, split tensile strength, flexural strength of WP fiber reinforce concrete increases as compared to normal concrete.
4. The compressive strength, split tensile strength, flexural strength of HDPE fiber reinforce concrete decreases as compared to normal concrete.
5. By comparing the results obtained we concluded that GI fiber rein concrete gives more strength than WP and HDPE fibers rein concrete.
6. The compressive strength, split tensile strength, flexural strength of hybrid concrete i.e. (GI+WP) FRC increases as compared to the normal concrete, HDPE fiber reinforced concrete ,where as it decreases when compared to GI and WP fiber reinforced concrete.
7. The compressive strength, split tensile strength, flexural strength of hybrid concrete i.e. (GI+HDPE) FRC decreases as compared to the normal concrete ,GI, WP and HDPE fiber reinforced concrete.

8. By comparing the results obtained we concluded that hybrid concrete i.e. (GI+WP) fiber gives more strength than hybrid (GI+HDPE) fiber rein forced concrete.

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