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Experimental and Investigation 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 of concrete mixture is studied in the present investigation. In 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.***

I. INTRODUCTION

Cement is a very commonly used construction material. Concrete made with this cement has certain characteristics. It is relatively strong in compression but weak in tension and tends to be brittle. Because of the load and environmental changes, a micro crack appears in cement products. Therefore cement based materials have low tensile strength and cause brittle failure. Cement mortar and concrete made with cement is a kind of most commonly used construction material in the world. These materials have inherently brittle nature and have some dramatic disadvantages such as poor deformability and weak crack resistance in the practical usage. Also their tensile strength and flexural strength is relatively low compared to their compressive strength. The weakness in tension can be overcome by the use of sufficient volume fraction of certain fibers. In order to improve the mechanical properties of concrete it is good to mix cement with fiber which have good tensile strength. Adding fibers to concrete greatly increases the toughness of the material. The use of fibers also alters the behavior of the fiber matrix composite after it has cracked, thereby improving its toughness.

1.1 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.

Fiber Reinforced Concrete is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers each of which lend varying properties to the concrete. In addition, the character of fiber reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation, and densities. In a hybrid, two or more different types of fibers' are rationally combined to produce a composite that derives benefits from each of the individual fibers.

The hybrid combination of metallic and non-metallic fibers can offer potential advantages in improving concrete properties as well as reducing the overall cost of concrete production. Basically fibers can be divided into following two groups

(i) Fibers whose moduli are lower than the cement matrix such as cellulose, nylon, polypropylene

(ii) Fibers with higher moduli than the cement such as asbestos, glass, steel etc.

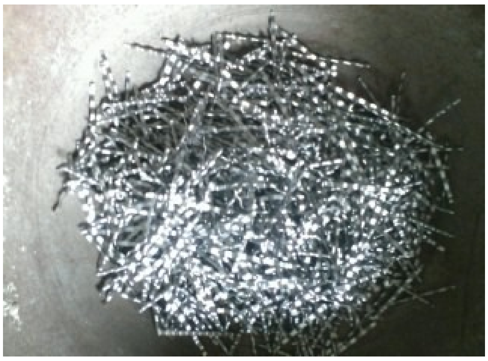
The fibers are able to prevent surface cracking through bridging action leading to an increased impact resistance of the concrete. The combination of two or more different types of fibers is becoming more common, with the aim of optimizing overall system behaviour. The intent is that the performance of these hybrid systems would exceed that induced by each fiber type alone.

We in ancient time fibers are used as reinforcements. In mortars horse hair is used and in mud, bricks straw is used. In 1950's fiber reinforced concrete got great importance. By 1960's fibers such as steel, glass, synthetic fibers such as polypropylene fibers, polyolefin fibers has got great importance. Fibers have great role to control cracking due to plastic shrinkage and due to drying shrinkage. Fibers such as polypropylene when added to concrete reduce the compressive strength, but increases both split tensile strength and flexural strength. They are more porous compared to the plain concrete. Moreover the bridging effect by this fiber leads to the improvement in the tensile and flexural strength. The fiber also improves the resistance to ion penetration which results in corrosion reduction of reinforcing bars.

1.2 Role of Fibers in Concrete

Fibers are available in different sizes and shapes. They can be classified into two basic categories, namely those having a higher elastic modulus than concrete matrix (called hard intrusion) and those with lower elastic modulus (called soft intrusion). High modulus fibers improve both flexural and impact resistance simultaneously where as low modulus fibers improve the impact resistance of concrete but do not contribute much to flexural strength.

Steel fiber reinforced concrete (SFRC) offers good tensile strength, ultimate strength, flexural strength, shock resistance, fatigue resistance, ductility and crack arrest. Some researches show that SFRC shows a slight tendency to reduce the young's modulus as the fiber content decrease. Some of the experimental results show that the beams reinforced with steel fibers shows a similar or even better post cracking behavior than beams with minimum amount of transverse reinforcement.. Steel fiber also reduce the width of shear cracks, thus improve durability. The surface corrosion of steel fiber reinforced concrete mostly depends on the cover and the water-cement ratio. In some other research the combined effect of silica flume and steel fiber improved the impact resistance and mechanical properties of concrete.



When fibers are added to concrete, it becomes homogeneous, isotropic and transforms it to a ductile material. These fibers will act as secondary reinforcement in concrete and reduces crack formation and propagation. Fiber reinforced concrete can be defined as a composite material consisting of cement, concrete and discontinuous, discrete, uniformly dispersed suitable fibers. If more than one fiber is used in concrete, it is called Hybrid Fiber Reinforced Concrete (HFRC). If the fiber used is large and strong, it will control crack formation and if it is small and soft, it reduces the crack formation and propagation. Researches shows that when the fibers are used in the hybrid form-steel and polypropylene, increases ductility. Steel fiber bridging across cracks in concrete mix will increase joint shear strength. The synthetic fiber increases the ductility and energy dissipating capacity.

Further researches were done to study about the fracture properties and impact properties of hybrid fiber reinforced concrete. Other research works with steel and polyolefin show that they increase the compressive strength, flexure, modulus of rupture and ductility.

Polypropylene fibers are new generation chemical fibers. They are manufactured in large scale and have fourth largest volume in production after polyesters, polyamides and acrylics. About 4 million tonnes of polypropylene fibers are produced in the world in a year. Subsequently, the polypropylene fiber has been improved further and is now used as short discontinuous fibrillated material for production of fiber reinforced concrete or as a continuous mat for production of thin sheet components. These fibers are manufactured using conventional melt spinning. Polypropylene fibers are thermo plastics produced from Propylene gas. Propylene gas is obtained from the petroleum by products or cracking of natural gas feed stocks. Propylene polymerizes to form long polymer chain under high temperature and pressure. However, polypropylene fibers with controlled configurations of molecules can be made only using special catalysts.

Polypropylene fibers were formerly known as stealthe, these are micro reinforcement fibers and are 100% virgin homo polymer polypropylene graded monofilament fibers. They contain no reprocessed Olefin materials. The raw material of polypropylene is derived from monomeric C3H6 which is purely a hydrocarbon. For effective performance, the recommended dosage rate of polypropylene fibers is 0.9 kg/m3, approximately 0.1% by volume.

II. OBJECTIVE

The main objective of this research include

- To develop proper mix proportion for hybrid concrete.
- Testing the mixes of hybrid fiber reinforced concrete for compressive strength, split tensile strength and flexural strength.

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- Comparing the results and finding the optimum percentage of hybrid fibers.

III. MATERIALS

3.1 Cement:

Ordinary Portland cement of 53 grade was used in this experimentation conforming to I.S-12269 : 1987

3.2 Coarse aggregates:

Locally available, maximum size 20 mm, specific gravity 2.79

3.3 Sand:

Locally available sand zone I with specific gravity 2.28, water absorption 2% and fineness modulus 2.92, conforming to I.S. – 383-1970

3.4 Water:

Potable water was used for the experimentation.

3.5 Fiber:

The fibers used were steel and polypropylene fiber. Polypropylene fiber was straight and the steel fiber was crimpled type. Properties of fibers used are shown in the Table.1 below

Table.1 properties of fiber used

Fiber type	**Steel fiber**	**Polypropylene fiber**
Shape	Crimpled	Straight
Length(mm)	30	6
Diameter(mm)	0.6	1.0
Aspect ratio	50	6

3.6 Concrete Mix proportion:

In this study M25 and M30 grade of concrete was used. The concrete mix design was done using IS-10262:2009.The mix proportions are shown in Table 2 and Table 3.

Table.2 Concrete mix proportion for M25 grade

Material	**Quantity**	**Ratio**
Cement	428.26	1
Sand	1116.56	2.64
C.A	608.3	1.42
Water	198	0.45

Table.3 Concrete mix proportion for M30 grade

Material	**Quantity**	**Ratio**
Cement	413.3	1
Sand	669.45	1.61
C.A	1152.83	2.789
Water	198	0.45

3.7 Test specimens

Cube specimens of 150mmx 150mmx150mm were used for determining compressive strength. Cylinder specimens of size 150mm diameter and 300mm height were used for finding split tensile strength. Prism specimens of size 100mmx100mmx500mm were used for finding flexural strength of concrete.

IV EXPERIMENTAL METHODOLOGY

4.1 Compressive Strength Test:

For compressive strength test, both cube specimens of dimensions 150 x 150 x 150 mm were cast for M25 and M30 grade of concrete. The moulds were filled with 0% HFRC SO.5P0.5 fibers. Vibration was given to the moulds using table vibrator. The top surface of the specimen was leveled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank where in they were allowed to cure for 7 days, 14 days and 28 days. After 7, 14 and 28 days curing, these cube were tested on digital compression testing machine as per I.S. 516-1959.

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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.

4.2 Tensile strength test:

For tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 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 7, 14 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 as split tensile strength:

Tensile strength (MPa) = 2P / π DL, Where, P = failure load, D = diameter of cylinder,

L = length of cylinder

V EXPERIMENTAL RESULTS

5.1Compressive strength

Results of compressive strength for M25 and M30 grade of concrete cube specimen with 0%, HFRC SO.5P0.5 fibers are shown in table and graph below:

Table4: Results of Compressive strength using cubes specimen in M25 grade

S. No	Specimens	No of days	Compressive strength
1	Conventional concrete	7	5.70
		14	23.99
		28	25.57
2	HFRC S0.5P0.5	7	11.40
		14	26.81
		28	32.12

GRAPHICAL RESULT OF COMPRESSION TEST

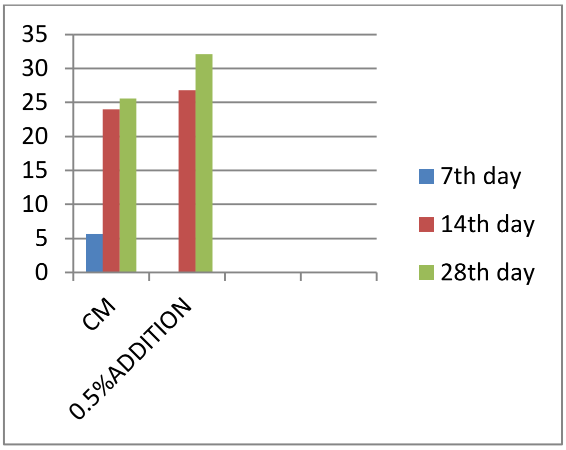
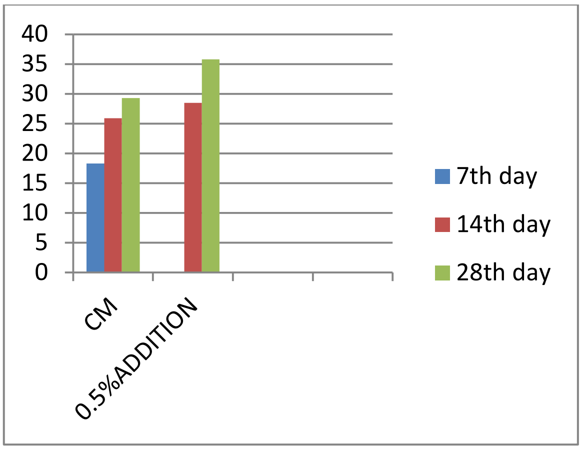


Table5: Results of Compressive strength using cubes specimen in M30 grade

S. No	Specimens	No of days	Compressive strength
1	Conventional concrete	7	18.26
		14	25.92
		28	29.28
2	HFRC S0.5P0.5	7	23.86
		14	28.50
		28	35.76

GRAPHICAL RESULT OF COMPRESSION TEST



5.2 Tensile strength

Results of splitting tensile strength for M-25 grade of concrete with 0%, HFRC SO.5P0.5 fibers are shown in table and graph below:

Table6: Results of Tensile strength using cylinder specimen in M25 grade

S. No	Specimens	No of days	Compressive strength
1	Conventional concrete	7	4.2
		14	4.42
		28	5.08
2	HFRC S0.5P0.5	7	4.52
		14	5.18
		28	8.15

GRAPHICAL RESULT OF TENSILE TEST

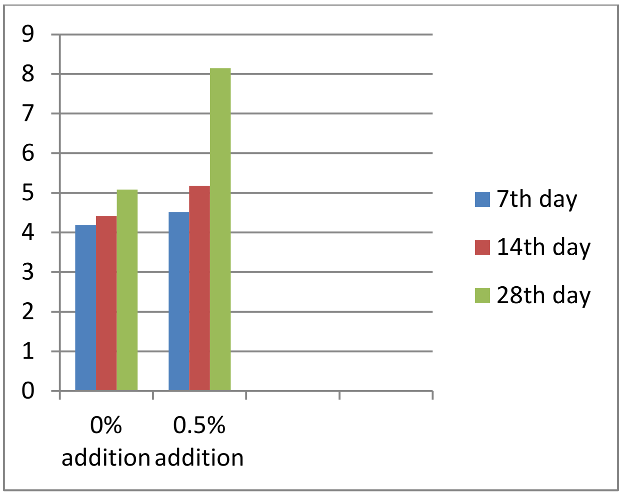
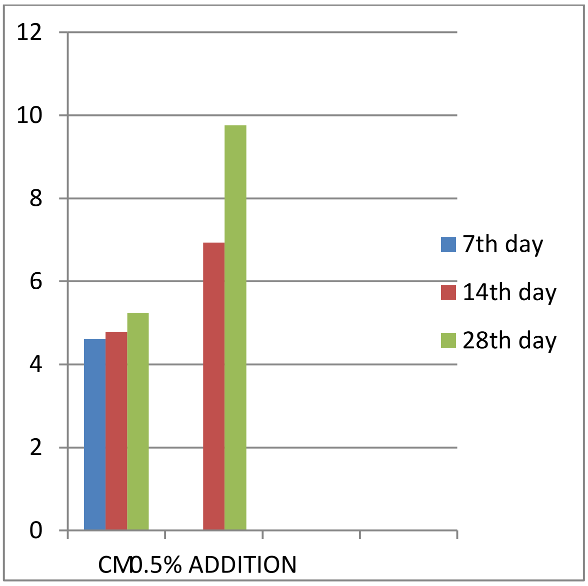


Table7: Results Tensile strength using cylinder specimen in M30 grade

S. No	Specimens	No of days	Compressive strength
1	Conventional concrete	7	4.6
		14	4.78
		28	5.24
2	HFRC S0.5P0.5	7	4.78
		14	6.93
		28	9.76

GRAPHICAL RESULT OF TENSILE TEST



VI 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 conclusions could be drawn from the present investigation-

1. Compression strength

We conclude that the compressive strength between conventional and HFRC S0.5&P0.5 is increase.

2. Split tensile strength

S0.5&p0.5 is gives it a high strength.

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