AN INVESTIGATIVE STUDY ON CONCRETE REINFORED WITH STEEL-POLYPROPYLENE HYBRID FIBER OF M30 GRADE CONCRETE

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Abstract— **The massive constructions like bridges, high-rise buildings, tunnels linings, and irrigation structures etc need high strength of concrete like M30, M40, up to M80. We have different methods for producing high strength to the concrete like fiber reinforced concrete, use super plasticizers, additives etc in concrete. In this thesis we are using reinforced polypropylene as an additive To boost concrete strength, it is important to integrate polypropylene and steel fibres into the mix. Reinforcement resin is widely used in the building industry to add strength to cement-based materials. Having only a single type of fibre in concrete can boost its efficiency. In cases with two fibre types, hybrid fibre may compensate the drawback of these two fibres. This article addresses the influences of the properties of steel-polypropylene composite on the consistency of reinforced concrete. This mixture use two different forms of fibre which are steel and polypropylene. The optimum sum of steel and polypropylene is used in order to achieve the optimum value of 2 percent S & 0.30 percent P. The slump test was performed for each mix in the fresh state. In the hardened condition of steel fibre-reinforced concrete, break tensile strength and flexural strength of reinforced steel fibre concrete, polypropylene concrete and composite concrete as well as standard concrete were seen at about 21 days and with full strength at 28 days..**

Keywords— **Concrete, Steel fibers, Polypropylene fibers, Hybrid fibers, Compressive strengths.** ***Introduction***

I. INTRODUCTION

Commonly used in construction projects, concrete is a form of man-made building material. Using a specific kind of fibres attached to a certain kind of concrete transforms the material into a toolable and largely smooth concrete. It has been observed that reinforced concrete has been substituted with simple concrete, which is brittle stock, though it stays in effect for a long time, and that it can be regarded as an upgrade over the first one. Fibers may also be used in concrete, particularly for shrinking and cracking purposes. The general stages of an FRC is the Matrix and the Inclusion mechanism. For certain carpets, these are steel fibres, glass fibres, synthetic fibres and natural fibres. Fibre reinforced concrete can also be called reinforced concrete. These fibres will play a major role in designing and refining modern concrete technologies. Hybridization means mixing two or three fibres with each other. Thus, the components present in fibre environment influence the fibre.

Fiber-reinforced concrete (FRC) is a concrete made of a fibrous material which provides added structural integrity. Speckles carry short, random, uniform fibres all over their body. Fibers involve steel, glass, synthetic, and natural fibres – each adding different properties to the concrete. Besides, the composition of concrete concrete varies with evolving frameworks, fibre types, geometries, distribution, orientations, and densities.

1.1.1 Historical perspective

Asbestos, once a promising material, shows good suitability in the use of this manner. Fibers have been used as an insulator for a very long time. In the past, horse hair was a key ingredient in tile construction. During the 1960s, asbestos made its way into the construction industry. It was during the 1950s that the concept of composite frameworks and fiber-reinforced construction came into existence. As soon as the health risks connected with asbestos became more well known, there was a need to find a cure for the product in concrete and other type of building materials. In the 1960s, steel and glass were used to form the foundation of the modern day Concrete industry. Currently there is a quest taking place for new concrete formulation.

1.1.2 Effect of fibers in concrete

Fibers are commonly used particularly in the preparation of formwork to defend against cracking due to the effects of concrete drying shrinkage. They often minimise concrete's permeability and thereby decreases the flow of water. There are several types of fibres that have greater effects, abrasive and thermal ability in concrete. Generally, fibres do not impact concrete strength when they are used in concrete. In fact, certain fibres have reduced the building power. Fiber usage of concrete is defined as a volume percentage of concrete. It can range from 0.1% to 3%.

The aspect ratio is determined by measuring the fibre length by its diameter (d). We need to create an equal diameter of the cross section for the measurement of the aspect ratio. If the fiber's modulus of elasticity is greater than the concrete matrix, it then provides extra load-carrying power of the mixture.

Increasing aspect ratio of fibre typically increases the strength and resilience of the fibre. Plus, content that is so extensive is hard to deal with. Any experiments suggest that fibres do not influence the strength of concrete It is critical because reinforced concrete appears to be weaker than standard concrete. A significant finding in this study revealed that the use of micro fibres provides greater effect resistance than longer fibres.

1.2 Steel –Polypropylene Hybrid Fibers

1.2.1 Steel fibers

The mix is composed of hydraulic mix and asphalt with fine and coarse aggregates. The mix contains fine and coarse aggregates combined with one or two discontinuous steel fibres. Drawn wires are broken to receive steel fibres. Fibers may be crimped moulded in unusual fashion to enhance the mechanical integrity. Steel fibres are short, approximate length is discrete and aspect ratio is 20-100mm. As steel fibres are applied to the concrete mix evenly and arbitrarily. This is called steel concrete. Compared to plain concrete, stud-framed construction displays improved impact, power, durability, tensile strength and flexural strength properties. But the properties of steel were unchanged by the inclusion of steel fibres. SFRC performs a decent job at avoiding cracking and even increases impact and abrasion resistance. There are variety of uses of SFRC such as construction of blast resistant walls, tunnel linings, pavements and precast concrete units. These fibres could be a concern when used in high percentages or aspect ratios in concrete.

Fig.1.1 Steel Fibers

Table 1.1 Physical Properties of steel fiber

Property	Value
Type of steel fiber	Crimped
length of fiber	30mm
Diameter	0.5
Aspect ratio	60
Tensile strength(Mpa)	280-2800
Young's modulus(Gpa)	203
Ultimate elongation	0.5-3.5%
Specific gravity	7.8

1.2.2Applications of Steel Fibers

- Repairs and re-habitation of marine structures.
- Highway construction and repair.
- Precast panels.
- Dam construction and repair.
- Airport runways, taxiways, aprons.
- Slip formed cast in place tunnel lining.

1.2.3 Advantages of Steel Fibers

- Reduced shrinkage control in concrete.
- Tensile strength, very strong flexural and shear.
- High fatigue strength resistance to impact, blast and shock loads.
- Temperature tolerance, High thermal.
- High strength wear and tear resilience of breaking.
- Earthquake conflict.

1.2.4 Polypropylene fibers

Infinitely thin polymer fibres in the form of fine fibres have significant effect on the given discourse. These fibres were observed to have high acid resistive property and high alkaline resistive property. Higher tensile strength was obtained for the nylon and polypropylene. They could be used to cut the metal because of their high elongation (15-25%). The low modulus decreases the power of the fabric. Ferrocene is also used for insulation of pile-shell structure. This unique plastic composite material is certainly an ideal replacement for steel reinforcement because it avoids material shipping and construction costs.

Fig.1.2. Polypropylene fibers

Table.1.2 Physical Properties of polypropylene fiber

1.2.5 Applications of Polypropylene Fibers

- Luxurious apartments, such as RCC homes, PCC homes,
- foundation ponds,
- paved roads, and
- Huge concrete panels render downtown business districts more appealing.

1.2.6. Advantages of polypropylene fibers

- PP is a light fiber
- Its cost is lower than polyester &nylon fiber
- When a standardised distribution of fibres is pumped onto the concrete mixture, the concrete becomes evenly blended everywhere.
- It also simplifies compact aquatic reduction
- Greater tolerance to effects.

- Restructure properties such as flexibility
- It is highly resistant to acid & alkalis
- It don't support the growth of fungi

As a consequence, a 50-70% decrease in rebound failure would save plenty of money, because the cost of these materials will not be needed, the process would not take as long as it had in the past, and less time would have been spent working.

It reduces crack formation during the plastic/hardening period.

The membrane is an effective way of preventing water seepage and corrosion and walls from condensation.

Plugs in to protect corners in precast slabs and concrete flooring. This tile has an increased abrasion tolerance of over 40%. So is the flooring that it is applied on. It decreases the amount of pitting floor standing.

1.2.7 Hybrid Fibers

As two separate elements are fused together in a particular matrix we call it as composite concrete. The fibres are picked based on their compatibility. If a certain kind of fibre is generally rigid and hard, then by taking advantage of its other traits, a different kind of fibre is created. By using this mixture of ingredients, we will create a better product, by creating a product that is expanded on upon until we reach it's absolute limit. Hybrid reinforced concrete has obtained excellent results at bridging between micro cracks, either in their form or in their place, and macro cracks by using appropriate fibres. The low modulus fibre would allow the stiffer material. On the other hand, any of these factors can trigger defects during the performance. Therefore, the type of fibre would be of paramount significance.

1.2.8 Advantages of Hybrid Fibers

On the basis of previous studies, the benefits of using steel-polypropylene fibres are that the size of the fibres can be used to monitor the magnitude of micro cracks and macro cracks. Inside the substance there are small fibres that are able to contract micro cracks and larger fibres that produce macro cracks. The proper controls of the micro & macro cracks will result the high tensile strength and hardness of the composite. The composite fibre reinforced with flexible and ductile fibre increases the first crack tension and eventually stress in the fibres. It has been shown that the presence of differing robust fibres in hybrid reinforced concrete has a substantial effect. The fibres that are longer fibres improve the resilience and strength relation after age. Meanwhile, the fibres that are short fibres help maintain the short efficiency of the composite materials that are used in transportation and installation. For steel-polypropylene fibres, raising the modulus of rupture (MOR) marginally decreases the unit area strain (UAS) compared to simple steel fibres, but improves the compressive strength compared to simple polypropylene fibres.

1.3 Objective of the Study

- To find the mechanical properties of steel fiber reinforced concrete with (0%,0.5%,1%,1.5%,2%,2.5%&3%) and polypropylene fiber concrete with (0%,0.15%,0.20%,0.25%,0.30%,0.35%&0.40%) and obtained optimum values of (2%S &0,30%P)hybrid fiber reinforced concrete for M30 grade of concrete.
- To measure Compressive Power, Split tensile strength and Flexural strength, on testing for 7 days. 14 days and 28 days.

1.4 scope of the study

It is organized into the following chapters:

- literature review is reviewed in chapter 2
- Experimental investigation is reviewed in chapter 3
- The findings and discussion of the data are outlined in chapter 4
- The week before Chapter 5 is dedicated to the conclusion and suggestions.

II. LITERATURE SURVEY

The study of behavior of Portland cement concrete had been taken up extensively by many authors since good olden days. A quick analysis of the current data on the action of parameters like: compressive strength, flexural strength, split tensile strength, and the methods used to collect the data was discussed.

Pragana.N.Javali ,S.Elavenil (2015), This thesis looks at the mechanical properties of concrete reinforced with steel-polypropylene hybrid fibres for M40 grade barrier concrete for . With a high polyurethane material, the fibres used are crimped steel fibres which have varying amounts of steel and polypropylene. Tensile experiments were administered first to obtain knowledge regarding the strength of these fibres. Then, the strength of the fibres within each mixture was tested using a compressive test. Based on laboratory experiments using 1 percent of steel fibre and 0.35 percent of polypropylene in hybrid concrete provides the optimum strength as compared with 1 percent steel fibre reinforced concrete and 0.3 percent polypropylene concrete.

Elavenil.S, Samuel Knight.G.M. (2006), a material model of dynamic behaviour of steel fibre reinforced concrete and RCC plates using finite element method was performed. The inclusion/fibrous composite material (inside the concrete), can be considered as a composite material with two stages, one being the concrete and the other being the fibrous materials. The most widely used parameter in defining the properties of fiber-reinforced composites is the volume fraction of inclusion.

S.Elavenil, V.Chandrasekar (2007) in which they studied the resilience of strengthened beams made of ferrocement. there have also been several separate experiments performed on the impact unit, the specimen design, the specimen size and the research scheme each time.

S.Elavenil,G.M. Samuel knight (2007) There are criteria from an impact test of fibre reinforced concrete taken from a pair of plates, as well as the fibres of the plate itself, the The aspect ratio of the fibre should be another important parameter in selecting the length of the fibre. This means that the fibre is shaped like a cylinder that is fiber's long and slender.

SinghA.P.and Bajaji.v (2010) The effectiveness of the concrete reinforced steel fibre inane was measured using the tensile strength and bending resistance of polymer-infused fibrous concrete. The task of short fibres as secondary reinforcement is specifically intended to prevent the crack from progressing further, but is not to make this commodity fail prematurely. The aim of making different sized fibres is to monitor cracks occurring throughout the mesh.

Wu Yao, Jieli and Keruwu (2003), In a study performed on the mechanical properties of hybrid produced fibre reinforced concrete at lower steel content, the wide and powerful steel fibres regulated the large cracks. The softer and smaller fibres have a slight crack inhibitor. In addition, they often help in reducing the permeability of concrete, thereby minimising blood loss. Although certain components, including glass fibres, potentially lead to greater resilience and insensitivity in concrete.

Elhamrawy M .Landsaba.A.M (2007) They researched a fracturing energy of the composite fibre reinforced concrete. The hybrid mixture of metallic and non-metallic fibres will have the possible benefits of optimising concrete properties as well as reducing the total cost of concrete manufacturing.

Sivakumar.A and Santhanam.M (2007) Well observed and described the mechanical properties of high strength concrete strengthened with metallic and non-metallic fibres. Those fibres with an elastic modulus lower are required to maximise the energy production throughout the strength phase. moreover, the inclusion of hybrid fibres renders the concrete more homogeneous and isotropic thus it is converted from brittle to more ductile material.

Nataraj.C.Dhang.N and Gupta.A.P Scientists also proposed an algorithm to measure the influence of fibre on compressive strength of concrete in terms of a fibre reinforcing parameter. One illustration of simulation involves utilising concrete as a material to assess the strength properties of a material. Because concrete comes in sand" shape, the finer grains of sand appear to render the concrete brittle. However, steel fibres in concrete can offset this brittleness. This allows concrete more likely to withstand tensile pressure, unlike concrete which is brittle. They explored how they performed an experiment to see various configurations of steel fibres through findings showing the spectrum of 0.5% ,1.0% ,1.5% ,2.0% in their analysis.

K.Murahari,Rama Mohan Rao P(2013) A scientific analysis of the strength properties of concrete that incorporates polypropylene fibre and a class C fly ash of varying proportions. He finds that when the added content of polypropylene fibre rises steadily from 0.15 percent to 0.30 percent , the sample of concrete increases in compressive power.

MR Mehul J.Patel ,MRS.S.M.Kulkarni Sure, I looked at the effects of polypropylene fibres on the high strength concrete. The main aim of the inquiry programme would be to first to plan the concrete in the aggregate grade of M40 and then, in cooperation with the disposal authority, study the effect of various proportions (0.5% ,1% ,1.5 %) of polypropylene fibre in the mix in determining the optimal range of polypropylene fibre material (0.5% ,1% ,1.5%) in the mix.

III. MATERIALS AND PROPERTIES

3.0 General

The chapter on the scientific and physical particulars of materials also addresses the aspects of the investigation of materials. This covers the components to use, how to build the cylindrical frameworks and the various experiments performed on the various aspects of the concrete and see how it hardens.

3.1 Materials

Any of the properties and characteristics of different products that are used for the processing of research specimens are included below.

3.1.1 CEMENT

Cement is the main ingredient in manufacturing of concrete. The characteristics of concrete will be greatly affected by changing the cement content. The cement used in this project is Ordinary Portland cement of 53 grade confirming to IS 12269-1987.

Table 3.1Physical Properties of cement

S.No.	Property	Value Obtained Experimentally	Value as per IS: 1489-1991
1.	Normal Consistency	29	31%
2.	Fineness of cement	1.7	Min 0.2
3.	Setting time Initial setting time Final setting time	45min 359min	Min 31 minutes Max 600 minutes
4.	Specific gravity	3.13	3.15

3.1.2 Fine aggregate

So that the powder you choose to use for bone building applications, can be properly graded so that there is a minimal void percentage, free from deleterious products like clay and silt content and crisp and free from hazardous chemicals like chloride contents etc. For the optimal grade of fine aggregate to be used for HSC, it is calculated to be an influence on more water demand than physical packaging. Various reports made by the As to the properties of the lubricating oil e.g. void ratio, gradation, basic gravity, fineness modulus, free moisture content, specific surface and bulk density it has to be tested to design an optimal mix of it so as to move together with a mixture that is denser and has less water. Material taken from the location was used as fine aggregate in the concrete. A description of the physical properties finding of sand can be found in tables 3.2.

Table 3.2 Physical Properties of Fine Aggregate

S.No.	Property	Value Obtained
1.	Specific gravity	2.51
2.	Bulk density	1.5
3.	Fineness modulus	2.16
4.	Water absorption	1.8%
5.	Grading Zone	Zone II

3.1.3 Coarse aggregate

Aggregate of size more than 4.75mm are generally considered as Coarse aggregate. The maximum size of coarse aggregate used in this experimental work is 20mm. A good quality of coarse aggregate is obtained from nearest crusher unit. The coarse aggregate are selected as per IS-833 specifications.

Table 3.3 Physical properties of Coarse Aggregate

S.No.	Property	Value Obtained
1.	Type	Crushed
2.	Specific gravity	2.74
3.	Fineness modulus	6.03
4.	Water absorption	1.58%

IV. EXPERIMENTAL INVESTIGATION

4.1Introduction

Based on the incomplete investigation over the available place, an experimental investigation involving the possession of ultrasound transducers and washers is suggested.

- To achieve the blend proportions by grade for OPC concrete for M30
- To calculate the mix proportions of adding steel fibers such as 0%, 0.5%, 1%, 1.5%, 2%,2.5%and 3% with concrete.
- To calculate the mix proportions of adding polypropylene fibers such as 0.15%,0.20%,0.25%,0.30%,0.35%&0.40% with concrete.

Preparation of Testing Specimens

The prepared concrete specimens include cubes (150 x 150 x 150mm) to help with compressive strength, tubes (150 x 300mm) to help with broken tensile strength, and prisms (100 x 100 x 500mm) to help with flexural strength.

For the 7, 14, &28 days in the holding cabinet.

The mechanical properties of concrete, such as the compression force, the split tensile strength and the flexural strength of the concrete is measured.

To figure out the optimal values of steel-polypropylene hybrid blend, it was prepared at 30 modern size.

And to test the compressive power, the tensile strength, the flexural strength.

To assess and compare the results among them.

4.2 Method of Mix Design

For concrete mix design, the aim is to choose the right ingredients of concrete in the right ratios such as the weight of concrete, asphalt, concrete sand etc. for producing a concrete of any intensity and sustainability as inexpensive as possible. Combinations of two sets of test apparatus will be done, and validating each mixture of two using the IS 10262-2009 methods. In order to achieve standard M30 concrete, you can combine 1 part sand, 1 part portland cement and 2 parts water. See appendix for sample blend template.

4.3 Adding of cement with fibres

Calculated the mix proportion of steel-polypropylene hybrid fibres with various percentages

4.4 Preparation of Testing Specimens

Steel moulds are constructed with a set of openings that will enable the mould to be withdrawn without any harm to the specimen. Each mould is supplied with a metal base layer, on which occurs a smooth plane surface The plastic foundation is of such form and proportions as to support the pressing mould during the filling without leaking and it is ideally connected by electronic or mechanical springs or screws. When the pieces have been placed together they shape the parts of the mould to be kept together by bolts or by similar means, and in addition, to maintain quality protection, the parts thus encased must be installed and would be prior to filling.

In preparing the mould for usage, the joints between the parts of the mould, touch surface of the bottom of the mould and base plate are tiny covered with mould oil in order to guarantee that no water escapes throughout the filling? The surface of the closed mould must also be packed with mould release oil to keep the concrete from binding to the mould. A steel bar 16mm in height, 0.6m long and carved at the lower end functions as a jar that serves as an implement for tamping.

The stones are constructed of regular cubes (l50mm x 150mm x 150mm), standard prisms (100mm x 100mm x 500mm) and standard cylinders (l50mm x 150mm x 250mm)

4.4.1 Mixing

In this specific job, the mixing phase is taken up by the computer. In the ingredients, they are measured and combined together in the exact amounts to get the proper blend. After that, the combination is thoroughly blended in its dry state. The mixed concrete was instantly checked to see how ready or workable the fresh concrete mix was. In the case of adding the first component of fibres then combined with cement in dry state and then this was blended with aggregate.

Mixing of Concrete

4.4.2 Casting of the Specimens

Iron moulds are washed with a fine powder to prevent dust particles and are oiled on both sides until concrete is poured on to the moulds. There are the moulds mounted on a level base. The fabric of the green concrete will be applied to the rubber moulds, which will then be vibrated using an electric vibrator. A coating of waste concrete was separated from the foundation using a trowel. The floor is finished flat and smooth as per IS 516-1959.

Fig. 4.1 Casting of the specimens

4.4.3 Compaction of Concrete

The method of compaction of the concrete is the technique of expelling the entrapped air from the concrete. As an illustration, during the putting and mixing of concrete, air is likely to get entrapped in the concrete. If the concrete does not have a total void, it may lose its power. In order to obtain a complete solidification and optimum mass, a vibrating table is used in this experiment.

4.4.4 Curing of test specimens

Upon casting in the facility, the formed specimens are preserved in air-conditioned rooms for a maximum of 24 hours. After these times the specimens were withdrawn from the moulds and were in a curing tank which along with being clean and fresh freshwater, the tank was needed to stay in the cured condition for the permitted duration. This cure is equivalent to 7 days, 14 days, and even 28 days.

Fig. 4.2 Specimens in curing tank

4.5. Tests for Workability

4.5.1 Slump Cone Test

The slump cone or Choc cone examination is typically performed on concrete samples to decide whether it has the proper qualities for function. This research was performed in the laboratory with the concrete mix being used for M30 grade concrete.

4.5.2 Compaction Factor Test

This measure is used to assess the workability of concrete more reliably than the homologous series slump cone test and the explanation why is the homologous series slump cone test does not test the real workability of the concrete but instead it measures the workability of the mortar. This procedure is carried out as prescribed by IS 1199-1959.

The slump cone test and compaction factor test are also performed in order to assess the new properties of a concrete. The slump and compaction factor values for various blends of steel fiber(i.e.0 percent , 0.5 percent , 1 percent , 1.5 percent , 2 percent , 2.5 percent , 3 percent), polypropylene fibre (0.15 percent , 0.20 percent , 0.25 percent , 0.30 percent , 0.35 percent , 0.40 percent) and hybrid fibre (2 percent S & 0.30 percent P) are provided in the table 4.1 ,4.2 &4.3 below.

Table 4.1 Fresh properties of different mixes of steel fibers

Mix	Slump (mm)	Compaction factor
M1 (0% S)	40	0.91
M2(0.5% S)	40	0.91
M3(1.0% S)	50	0.92
M4(1.5% S)	55	0.93
M5 (2.0%S)	60	0.95
M6 (2.5%S)	62	0.96
M7(3.0% S)	64	0.97

From the above table, it is evident that the workability of concrete increases with the increase in the percentage of steel fibers. Hence (M7 3.0%) SFRC shows good workability as compared to normal concrete (M1 0%)

Table 4.2 Fresh properties of different mixes of polypropylene fibers

Mix	Slump (mm)	Compaction factor
M1 (0% P)	40	0.91
M2(0.15% P)	40	0.91
M3(0.20% P)	48	0.91
M4(0.25% P)	53	0.92
M5 (0.30%P)	58	0.93
M6 (0.35%P)	61	0.93
M7(0.40% P)	62	0.94

From the above table, it is evident that the workability of concrete increases with the increase in the percentage of polypropylene fibers. Hence (M7 0.40%) PPRC shows good workability as compared to normal concrete (M1 0%)

Table 4.3Fresh properties of hybrid fibers

Mix	Slump (mm)	Compaction factor
M1 (0% S&P)	40	0.91
M2(2.0%S &0.30%P)	65	0.97

From the above table, it is evident that the workability of hybrid concrete shows good workability when compared to normal concrete as well as SFRC & PPRC

4.6 Testing of specimens

A period cycle is maintained for evaluating all specimens, ensuring that they are checked for all of the required lab tests at the appropriate time. The mould used are very sensitive and need to be prepared as per normal practise just a few maintain that they are 'curing pond and cleaning them off the surface water'. Data are included in the spreadsheet.

4.6.1. Test for compressive strength

The specimens of 150 X 150 X 150 mm cubes were put in the compression testing machine so that the load was applied to the opposite sides of the cube as seen in fig 4.3. The axis of the cube was exactly parallel to the centre of the steel cylinder of the measuring unit. Pressure was steadily added to the specimen until it could no longer bear the application of pressure, and, when pressure was applied to the sample, the tolerance to more pressure decrease and the specimen could be supported no longer. Compression power (or compressive strength) is computed by dividing the maximum load (from the test) by the cross sectional region (of the specimen). As the average value determined from three test results of each specimens has been found to be adequate to determine the compressive intensity of the specimens, it is appropriate for these specimens.

Fig 4.3 compression strength test

4.6.2 Test for split tensile strength

For specimen cylinders of 150 mm in diameter, 300 mm in length, boney intervals were labelled in the stress testing unit, then the specimen cylinder was drilled off at the marks. A plywood strip was designed in the machine to position the specimen by aligning in such a way that the lines identified on the end of the specimen are truly vertical and balanced over the plywood strip. As a last move in securing the cylinder as a T-rest, another plank of plywood was spread over the top of the cylinder length-wise, and positioned as per the location marked for the end of the cylinder as pictured in fig.4.4. The failure load, or specimens with threw samples, was registered. Finally, the split tensile test was conducted for the specimen, as described in the following paragraph.

Split tensile strength=2P/πld

Where d = dia of the cylinder measured.

l = length of cylinder measured.

P = maximum load recorded.

The total value of the three specimens was measured as the split tensile strength. Adequate conformity was assured through statistical means to guarantee that the individual deviation on both specimens would not surpass 15% of the average split tensile strength.

Fig.4.4.Split Tensile Test

4.6.3 Test for flexural tensile strength (two point load test)

Test specimens (100x100x500 mm beams) exposed were placed in the Universal Testing Machine such that the load was applied to the upper most surface as laid in the mould along two parallel lines spaced at 133 mm apart as shown in fig 4.5. The load was applied gradually without any shock and before it hit it's full number. The maximum load added to the specimen during the test was reported (e.g. 5 Mpa). The gap between the fracture line and the closest support on the tensile side of the specimen was determined along with record keeping as to where the fracture line was placed. Then the flexural strength or modulus of rupture was computed by using the relevant equation out of the two as mentioned below basing on the value of ‘a’ which is the distance between the line of fracture and the nearest support.

(i) If a> 13.33 cm

(ii) If a< 13.33 cm

But a < 11.0 cm

Where b = measured width in cm of specimen.

d = length in cm of the span on which the specimen

L = length in cm of the span on which the specimen, and

P = maximum load in kg applied to the specimen

If a < 11.0 cm, the results of the test are discarded.

Fig.4.6.Flexural Strength Test

CHAPTER-5

TEST RESULTS AND DISCUSSION

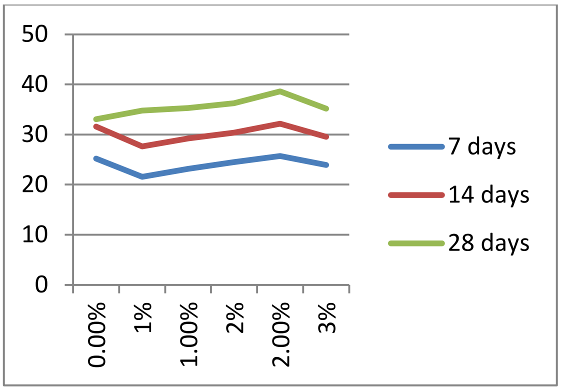
The tests were carried out to obtain compressive strength, split tensile strength, flexural strength of M30 grade concrete. The specimens are tested for 7,14& 28 days for 0%, 0.5%,1% 1.5%, 2%, 2.5% and 3% of steel fibers and 0.15%,0.20%,0.25%,0.30%,0.35%,0.40% of polypropylene and optimum values of steel at 2% and polypropylene at 0.30% of hybrid fibers.

5.1 Effect of variation of steel fibers on Compressive Strength

Table 5.1 Compressive Strength of different mixes of steel fiber

S.No.	Steel Mix	Average Compressive Strength, MPa		
		7 days	14days	28 days
1	0%	25.21	31.55	33.02
2	0.5%	21.54	27.62	34.78
3	1.0%	23.17	29.22	35.28

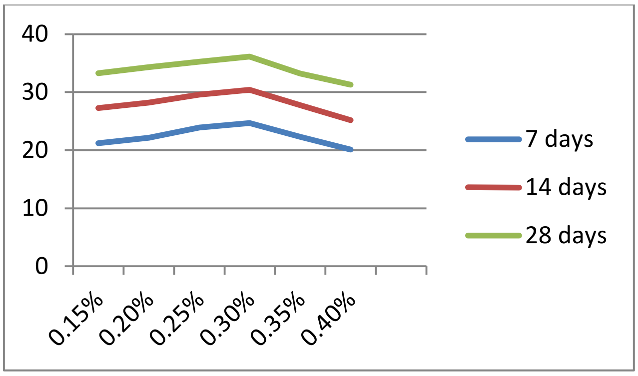
4	1.5%	24.48	30.35	36.23
5	**2.0%**	**25.69**	**32.15**	**38.61**
6	2.5%	23.93	29.53	35.13
7	3.0%	21.90	27.06	32.23



Graph 5.1 Compression strength of concrete vs. % of steel fibers

Table 5.2 Compressive Strength of different mixes of polypropylene fiber

S.No.	Polypropylene Mix	Average Compressive Strength, MPa		
		7 days	14days	28 days
1	0%	21.32	27.17	33.02
2	0.15%	21.23	27.24	33.25
3	0.20%	22.17	28.22	34.28
4	0.25%	23.89	29.56	35.23
5	**0.30%**	**24.69**	**30.40**	**36.12**
6	0.35%	22.31	27.77	33.23
7	0.40%	20.12	25.71	31.30



Graph 5.2 Compression strength of concrete vs. % of polypropylene fibers

Table 5.3 comparison Compressive Strength for hybrid concrete

S.NO	Name of the Concrete	% of steel	%of polypropylene	No of days		
				7 average	14 average	28 Average
1	Normal concrete(NC)	0%	0%	21.32	27.17	33.02
2	Polypropylene fiber reinforced concrete(PPFC)	-	0.30%	24.69	30.40	36.12
3	Steel fiber Reinforced concrete(SFRC)	2%	-	25.69	32.15	38.61
4	Hybrid fiber Reinforced concrete(HFRC)	2%	0.30%	27.53	33.86	40.19

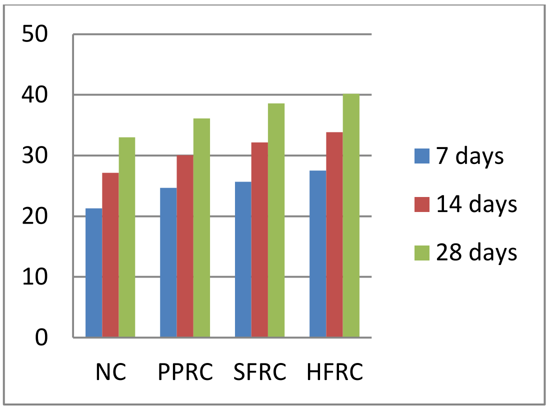


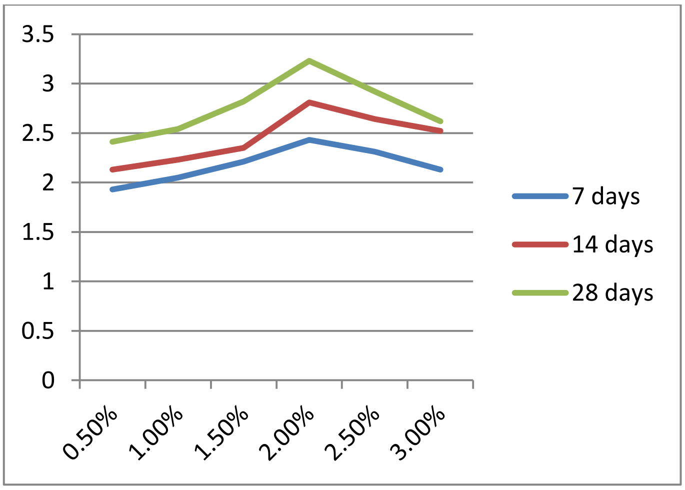
Figure-5.3 comparison of compression tests

5.2 Split Tensile Strength

After curing, cylinder specimens are tested to determine the tensile strength of concrete. The tensile strength of cylinder specimens after 7, 14, 28 days of curing are determined and given in the table below.

Table 5.4Split Tensile Strength of different mixes of steel fiber

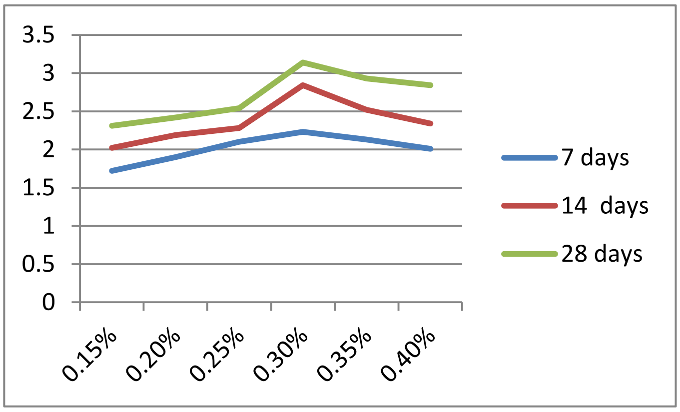
S.No.	Steel Mix	Average tensile Strength, MPa		
		7 days	14days	28 days
1	0%	1.71	1.98	2.27
2	0.5%	1.93	2.13	2.41
3	1.0%	2.05	2.23	2.54
4	1.5%	2.21	2.35	2.82
5	**2.0%**	**2.43**	**2.81**	**3.23**
6	2.5%	2.31	2.64	2.92
7	3.0%	2.13	2.52	2.62



Graph 5.4 split tensile strength of concrete vs. % of steel fibers

Table 5.5split tensile Strength of different mixes of polypropylene fiber

S.No.	Polypropylene Mix	Average tensile Strength, MPa		
		7 days	14days	28 days
1	0%	1.71	1.98	2.27
2	0.15%	1.72	2.02	2.31
3	0.20%	1.90	2.19	2.42
4	0.25%	2.10	2.28	2.54
5	**0.30%**	**2.23**	**2.84**	**3.14**
6	0.35%	2.13	2.52	2.93
7	0.40%	2.01	2.34	2.84



Graph 5.5 split tensile strength of concrete vs. % of polypropylene fibers

Table 5.6 comparison split tensile Strength for hybrid concrete

S.NO	Name of the concrete	Percentage of steel	Percentage of polypropylene	Avg.Split Tensile Strength (MPa)		
				7 Days	14 Days	28 Days
1	Normal concrete(NC)	0%	0%	1.71	1.98	2.27
2	Polypropylene fibre reinforced concrete (PPRC)	-	0.30%	2.23	2.84	3.14
3	Steel fibre reinforced concrete (SFRC)	2%	-	2.43	2.81	3.23
4	Hybrid fibre reinforced concrete (HFRC)	2%	0.30%	2.53	3.02	3.43

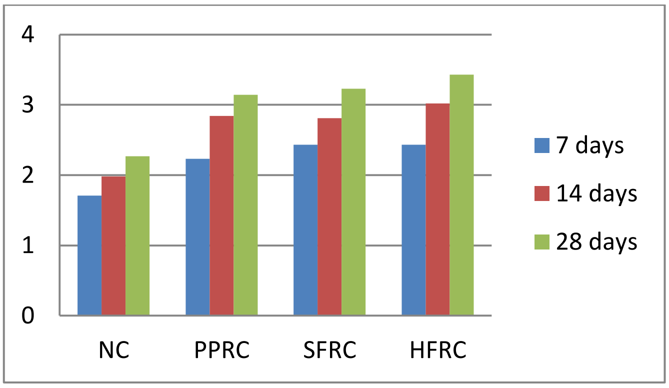


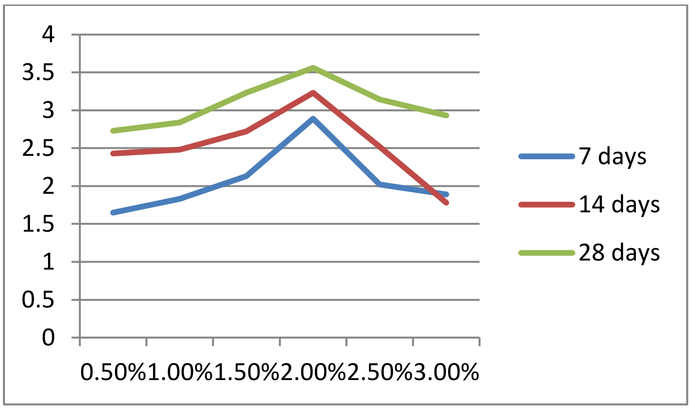
Figure-5.6 comparison of split tensile strength

5.3 Flexural Strength

After curing, prism specimens are tested to determine the flexural strength of concrete. The flexural strength of prism specimens after 7, 14, 28 days of curing are determined and given in the table below.

Table 5.7Flexural Strength of different mixes of steel fiber

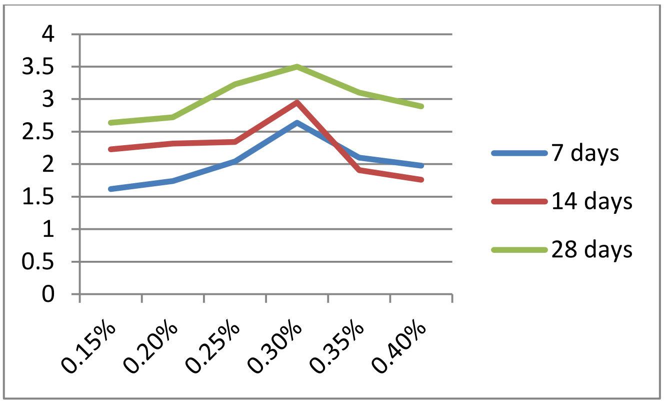
S.No.	Steel Mix	Average flexural Strength, MPa		
		7 days	14days	28 days
1	0%	1.56	2.24	2.56
2	0.5%	1.65	2.43	2.73
3	1.0%	1.83	2.48	2.84
4	1.5%	2.13	2.72	3.23
5	**2.0%**	**2.89**	**3.23**	**3.56**
6	2.5%	2.02	2.52	3.14
7	3.0%	1.89	1.78	2.93



Graph 5.7 flexural strength of concrete vs. % of steel fibers

Table 5.8 flexural Strength of different mixes of polypropylene fiber

S.No.	Polypropylene Mix	Average Flexural Strength, MPa		
		7 days	14days	28 days
1	0%	1.56	2.24	2.56
2	0.15%	1.62	2.23	2.64
3	0.20%	1.74	2.32	2.72
4	0.25%	2.04	2.34	3.23
5	**0.30%**	**2.64**	**2.95**	**3.50**
6	0.35%	2.10	1.91	3.10
7	0.40%	1.98	1.76	2.89



Graph 5.8 flexural strength of concrete vs. % of polypropylene fibers

Table 5.9 comparison flexural Strength for hybrid concrete

S.NO	Name of the concrete	% of steel	%of polypropylene	No of days		
				7	14	28
1	Normal concrete(NC)	0%	0%	1.56	2.24	2.56
2	Polypropylene fiber reinforced concrete(PPFC)	-	0.30%	2.64	2.95	3.50
3	Steel fiber Reinforced concrete(SFRC)	2%	-	2.89	3.23	3.56
4	Hybrid fiber Reinforced concrete(HFRC)	2%	0.30%	2.91	2.95	3.58

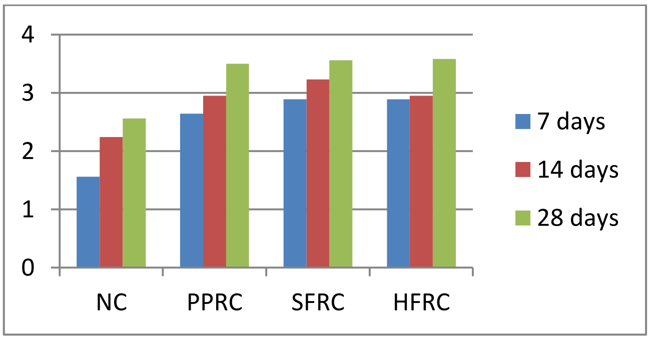


Figure-5.9 comparison of flexural strength

5.4 DISCUSSION OF TEST RESULTS

5.4.1 Compressive strength test

Compressive strength test is done by the 15cm×15cm×15cm cubes. By conducting compressive strength test on NC, SFRC, PPRC & HFRC and the test carried out the curing durations of 7, 14and 28 days. The compressive strength of NC at 7 days is 25.21MPa, 14 days is31.55MPa, and 28 days is 33.02MPa. The maximum compressive strength of 2% SFRC at 7 days is 25.69MPa, 14 days is32.15MPa, and 28 days is 38.61MPa. The maximum compressive strength of 0.30% PPRC at 7 days is 24.69MPa, 14 days is30.40MPa, and 28 days is 36.12MPa. The compressive strength of HFRC at 7 days is 27.53MPa, 14 days is33.86MPa, and 28 days is 40.19MPa

5.4.2 Split tensile strength test

Split tensile strength test is done by the (150mm dia×300mm ht) of NC, SFRC, PPRC& HFRC cylinders were casted and test carried out the curing durations of 7, 14and 28 days. The split tensile strength of NC at 7 days is 1.71MPa, 14 days is1.98MPa, and 28 days is 2.27MPa. The maximum split tensile strength of 2% SFRC at 7 days is 2.43MPa, 14 days is2.81MPa, and 28 days is 3.23MPa. The maximum split tensile strength of 0.30% PPRC at 7 days is 2.23MPa, 14 days is 2.84MPa, and 28 days is 3.14MPa. The split tensile strength of HFRC at 7 days is 2.43MPa, 14 days is 3.02MPa, and 28 days is 3.43MPa

5.4.3 Flexural strength test

Flexural strength test is done by the (50cm×10cm×10cm) of NC, SFRC, PPRC& HFRC prisms were casted and test carried out the curing durations of 7, 14and 28 days. The flexural strength of NC at 7 days is 1.56MPa, 14 days is2.24MPa, and 28 days is 2.56MPa. The maximum flexural strength of 2% SFRC at 7 days is 2.89MPa, 14 days is3.23MPa, and 28 days is 3.56MPa. The maximum flexural strength of 0.30% PPRC at 7 days is 2.64MPa, 14 days is 2.95MPa, and 28 days is 3.50MPa. The flexural strength of HFRC at 7 days is 2.89MPa, 14 days is 2.95MPa, and 28 days is 3.5MPa

VI. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the experimental investigation carried out, the following conclusions are made. Maximum compressive strength of SFRC is 38.61Mpa achieved at 2% adding of concrete by steel fibers (M30 grade). When compared to normal concrete it increases.16.9%. Maximum compressive strength of PPRC is 36.12Mpa achieved at 0.30% adding of concrete by polypropylene fibers (M30 grade).

When compared to normal concrete it increases.11%. Compressive strength of HFRC is 40.19Mpa is achieved at(2%S&0.30%PP) adding of concrete (M30grade) .when compared to normal concrete it increases 21.7%.

Maximum split tensile strength of SFRC is 3.23Mpa achieved at 2% adding of concrete by steel fibers (M30 grade). When compared to normal concrete it increases.42.2%. Maximum split tensile strength of PPRC is 3.14Mpa achieved at 0.30% adding of concrete by polypropylene fibers (M30 grade). When compared to normal concrete it increases 38.3%. Split tensile strength of HFRC is 3.43Mpa is achieved at(2%S&0.30%PP) adding of concrete (M30 grade) .when compared to normal concrete it increases 51.1%. When compared to SFRC it increases 6.1%. When compared to PPRC it increases 9.2%.

Maximum flexural strength of SFRC is 3.56Mpa achieved at 2% adding of concrete by steel fibers (M30 grade). When compared to normal concrete it increases.39.06%. Maximum flexural strength of PPRC is 3.50Mpa achieved at 0.30% adding of concrete by polypropylene fibers (M30 grade). When compared to normal concrete it increases 36.7%. Flexural strength of HFRC is 3.58Mpa is achieved at (2%S&0.30%PP) adding of concrete (M30 grade) .when compared to normal concrete it increases 39.8%. When compared to SFRC it increases 0.56%. When compared to PPRC it increases 2.2%. When compared to normal concrete mono fibers give maximum resultant. When compared to mono fibers hybrid fibers give maximum resultant.

6.2 Scope for Further Study

For use of fibers as a structural material, it is necessary to investigate the behavior of reinforced fiber under flexure, shear and the same exposed to an elevated temperature. Some tests relating to durability aspects such as water permeability, resistance to penetration of chloride ions durability in marine environment etc. need investigation.

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