Experimental Investigation on Characteristic Strength of Hybird Fibre Reinforced Concrete

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Abstract— **Concrete with a single type of fiber may improve the desired properties to a limited level. A composite is termed as hybrid, if two or more types of fibers are rationally combined to produce a composite that derives benefits from each of the individual fibers. This paper focuses on the experimental investigation of high strength concrete with steel fibers and combination of steel and polyolefin fibers (hybrid) by testing of compressive strength, splitting tensile strength of cylinders and flexural strength of prisms. For this ACI 211-4R-93 guide line was followed to design the high strength concrete of grade M25 and M30. Each test the high strength concrete specimens were cast and treated as control specimens, other specimens were cast high strength concrete added with steel fibers at the volume fraction of 1.5%, and 2.0%. At each volume fraction Steel – polyolefin fibers were added at 80% - 20% and 60% -40% combinations. Test results showed that the compressive strength, splitting tensile strength and modulus of rupture improved with increasing volume fraction. Regression analyses were done to predict the values of compressive strength, splitting tensile strength and modulus of rupture of all parameters. The prediction values were matching with the experimental results.**

Keywords: High strength concrete, steel fibers, polyolefin fibers, hybrid fibers, Regression analysis.

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I. INTRODUCTION (*HEADING 1*)

Portland 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 Portland 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.

a. 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.
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.

b. ROLE OF FIBERS IN CONCRETE

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.
- 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.

- Further, the application of these fibers in construction increased largely because addition of fibers in concrete improves the tensile strength, flexural strength, toughness, impact strength and also failure mode of concrete.
- For effective performance, the recommended dosage rate of polypropylene fibers is 0.9 kg/m3, approximately 0.1% by volume.

II. NEED OF THE STUDY

- In recent decades many varieties of concrete is being developed due to various demands.
- Highly congested reinforcements in heavy structures demand several varieties of fiber reinforced Concrete.
- Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking .Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete.

III. SUMMARY OF LITERATURE

- These literature reviews are choosing a one grade of concrete with different proportion and find a optimum percentage of concrete. Replacement of steel and glass fiber. 2% of fiber in a concrete is suddenly reduced strength.
- So, the optimum percentage of fiber is 1.5%. So, I have choosing a two grade (M25 & M30) concrete with single proportion and adding of steel and polypropylene fiber. The properties of fresh concrete and hardened concrete such as compressive strength, split tensile strength, flexural strength and durability are studied.

IV. OBJECTIVE OF THE STUDY

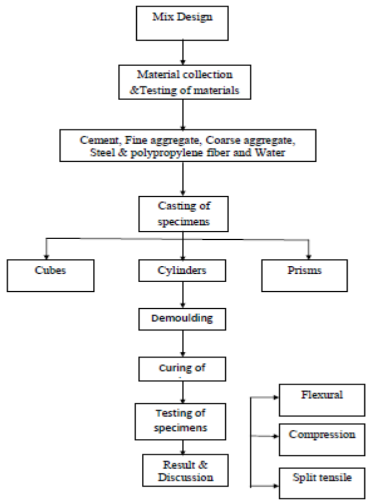
To prepare FRC with addition of polypropylene and steel fiber for grades of concrete such as M25 & M30.

- Testing the FRC for strength parameters.
- Testing the strength.
- 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.
- Comparing the results.

SCOPE OF THE STUDY

- To mixing of 0.5% of steel and polypropylene fiber in concrete.
- Compare the mechanical properties.

V. METHODOLOGY AND MATERIAL PROPERTIES



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VI. MATERIALS USED

GENERAL

Material properties are one of the important for the making of concrete. So the testing of materials are following

Cement

The cement used should confirm to IS specifications. There are several types of cements are available commercially in the market of which Ordinary Portland Cement is the most known and available everywhere. OPC 53 grade was used for this study.

Fine aggregate

Locally available river sand passing through 4.75mm sieve conforming to the recommendation of IS383-1970 is used.

S.No	**Characteristic**	**Experimental value**
1	Fineness modulus	2.89
2	Specific Gravity	2.54
3	Zone of fine aggregates	Zone II

Coarse aggregate
Coarse aggregates to be used for production of concrete must be strong, impermeable, durable & capable of producing a sufficient workable mix with minimum water cement ratio to achieve proper strength. Locally available coarse aggregate (basalt commonly known as blue metal) retaining on 4.75mm sieve is used.

Fibers and its properties

Fiber type	Steel	Polypropylene
Shape	Crimpled	Straight
Length (mm)	30	6
Diameter(mm)	0.6	1.0
Aspect ratio(L/D)	50	6
Tensile Strength(Mpa)	1100	550

VII. EXPERIMENTAL INVESTIGATION

a. *FRESH CONCRETE*

Slump cone test
The slump cone test is done to determine the workability of fresh concrete by slump test as per IS: 1199 - 1959.workability is the relative ease or difficulty of placing and consolidating concrete (fig 5.1 and fig 5.2). When placed, all concrete should be as stiff as possible, yet maintain a homogeneous, and void less mass. The slump test is performed on newly mixed concrete. To perform the test, you need a slump cone and a tamping rod.

b. TEST ON HARDENED CONCRETE

Testing hardened concrete plays an important role in controlling and conforming the quality of cement concrete works. The test methods should be simple, direct and convenient to apply.

Compression test on concrete cube
The test is done to determine the compressive strength of concrete specimens as per IS: 516 - 1959.Tests should be done at recognized ages of the test specimens, usually being 7, 14 and 28 days. The ages should be calculated (fig 5.3) from the time of the addition of water to the drying of ingredients.

Compression test is the most common test conducted on hardened concrete, partly because is an easy test to perform, and partly becomes most of the desirable characteristic properties of concrete are qualitatively related to is compressive strength. The compression test is carried out on specimens cubical or cylindrical in shape. The cube specimen should be in the size 150 × 150 × 150 mm,

Split tensile test on cylinder
After the curing period, the specimen is taken out from the curing tank and wipes it clean. Then the specimens are placed horizontally between the loading surface of the Compression testing machine (fig 5.5) and the load is applied till the specimens fails. The ultimate load at the time of the failure is noted down

Horizontal compressive strength = 2p/ ΠLD

FIGURE.5.5 – Cylinder Casted for determining Tensile Strength

FIGURE.5.6 –Tensile test on cylinder

Flexural strength of prism

The standard prisms of size 150 mm x150 mm x750 mm are used for flexural strength tests. Totally 8 prism are casted (fig 5.7) in which 2 prism were casted in each proportions. Their flexural strength is determined (fig 5.8) at the 28th days of curing. The flexural strength is calculated as follows IS: 516 (1959). The flexural strength of the specimen shall be expressed as the modulus of rupture fb,

$$fb = 3p \times a / bd2$$

where
b = measured width in cm of the specimen,
d = measured depth in cm of the specimen at the point of failure,
p = maximum load in kg applied to the specimen,

a = equals the distance between the line of fracture and the nearer support

FIGURE.5.7 – Prism Casted for determining Flexural Strength

VIII. DURABILITY TEST

a. Water Absorption Test
The Water absorption test is conducted as per ASTM C642 – 13 in the conventional concrete specimen as well as in the concrete specimen with addition of 0.5% 0f fiber. The concrete specimens of 150mm x 150mm x 150mm are casted

(fig 5.9) and they are kept for curing for 56 days, after which they are kept for dry in an oven at a temperature of 110°C for not less than 24 h. After removing each specimen from the oven, they are allowed to cool in dry air to a temperature of 20 to 25 °C and determine the mass. Then its first mass is determined and designated as “A”. Then the specimen, after final drying, cooling, and determination of mass, they are kept in water at approximately 21 °C for not less than 48 h and then the specimens are kept for surface drying by removing surface moisture with a towel, and then the mass is determined (fig 5.10)and designated as “B”.

FIGURE 5.9 Water absorption test

FIGURE 5.10Water absorption of curing

b. Acid Attack Test

For acid attack test concrete cube of size 150mm x 150mm x 150 mm are prepared for various addition of fibers. The specimen are casted in mould for 24 hours, after 24 hours, all the specimen are demoulded and kept in curing tank for 7-days. After 7-days all specimens are kept in atmosphere for 2-days for constant weight, subsequently, the specimens are weighed (fig 5.11) and immersed in 5% sulphuric acid (H2SO4) solution for 56-days. After 56-days of immersing in acid solution, the specimens are taken out and were washed in running water and kept in atmosphere for 2-day for constant weight. Subsequently the specimens are weighed and loss in weight and hence the percentage loss of weight was calculated.

IX. RESULTS AND CONCLUSION

SLUMP CONE TEST

The slump cone test have been conducted and the following slump value have been arrived.

w/c ratio	Percentage of addition	Initial height (mm)	Final height (mm)	Slump value (mm)
0.432	0%	300	270	32
0.432	0.5% steel and glass fiber	300	245	48

Slump Flow for M30 grade

w/c ratio	Percentage of addition	Initial height (mm)	Final height (mm)	Slump value (mm)
0.4	0%	300	268	30
0.4	**0.5% steel and glass fiber**	**300**	**252**	**45**

COMPRESSIVE STRENGTH RESULT

Totally 36 cubes are casted and the compression test are conducted on 7th, 14th and 28th day of curing period. The strength obtained in the compression test is tabulated below.

Hardened Concrete Test Results (M25)

Percentage of replacement	Compressive strength (N/mm²)		
	7th day	14th day	28th day
Replacement	12.72	21.999	24.629
0.5% of steel and polypropylene fiber	13.407	26.815	29.673

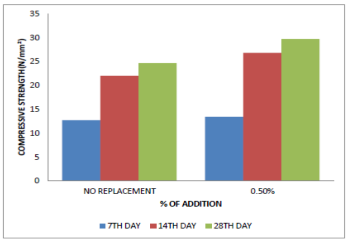

Figure 6.1Comparison of compressive strength M_{25}

SPLIT TENSILE RESULT

Totally 36 cylinders are casted and the split tensile test are conducted on 7th, 14th and 28th day of curing period. The strength obtained in the tensile test is tabulated below.

Tensile strength of cylinders (M25)

Percentage of replacement	Tensile strength N/mm²		
	7th day	14th day	28th day
Replacement	1.7	1.92	2.38
0.5% of steel and polypropylene fiber	1.78	2.33	2.59

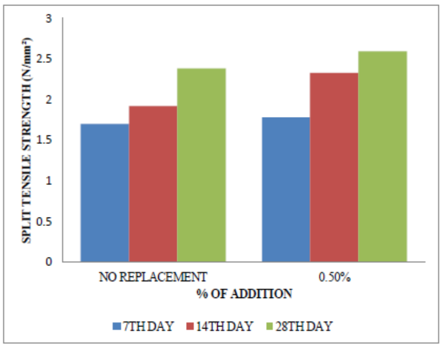

FIGURE 6.3 Comparison of tensile strength M_{25}

From the above result Fig 6.3 it is clear that the tensile strength is getting increased with the addition level of 0.5% Steel fiber & 0.5% polypropylene fiber.

Tensile strength of cylinders (M30)

Percentage of replacement	Tensile strength N/mm^2		
	7th day	14th day	28th day
No Replacement	2.69	2.73	3.12
0.5% of steel and polypropylene fiber	2.76	2.90	3.99

From the above result Fig 6.4 it is clear that the tensile strength is getting increased with the addition level of 0.5% Steel & 0.5% polypropylene fiber.taining the Integrity of the Specifications.

FLEXURAL STRENGTH

Totally 12 prisms with and without replacement are casted and the flexural test are conducted on 28th day of curing period. The strength obtained in the tensile test is tabulated below.

Percentage of replacement	Flexural strength N/mm^2 at 28th day
No Replacement	4.8
0.5% 0f steel and polypropylene fiber	5.99

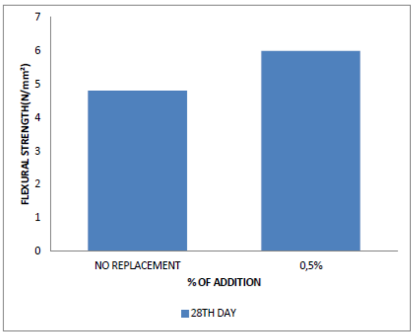

Figure 6.5 Comparison of flexural test result M_{25}

From the above results Fig.6.5 it can be observed that the flexural strength is increased with o.5% Steel fiber & 0.5% polypropylene fiber addition.

Flexural Strength of Prism (M30)

Percentage of replacement	Flexural strength N/mm^2 At 28th day
No Replacement	6.2
0.5% 0f steel and polypropylene fiber	6.56

From the above results it can be observed that the flexural strength is increased with o.5% Steel fiber & 0.5% polypropylene fiber addition.

WATER ABSORPTION RESULT

Mass of oven-dried specimen with 0.5% of steel and polypropylene fiber, A = 6452 g
Mass of specimen after immersion in water, B = 6790 g
Absorption after immersion, % = [(6790 – 6452) / 6452] x 100
= 5.23%

ACID ATTACK TEST

Percentage of Replacement	Weight of Specimen Before Immersion (g)	Weight of Specimen After Immersion (g)	Weig ht loss (g)	Weight loss (%)
No Replacement	6695	6350	345	5.15
0.5% of steel & polypropylene fiber	6590	6385	205	3.11

X. CONCLUSION

From the results obtained from the previous chapters, the following conclusions were made,

- The main aim of this entire project was to improve the compressive strength of conventional concrete. By conducting various test on the concrete specimens, the strength obtained is quite high when compared to normal concrete specimens.
- The workability of the concrete increases with the percentage of addition of fibers increase, which is witnessed by the results of slump cone test.
- The compressive strength and split tensile strength of the cubes and cylinders increases when the addition of fibers.
- In 27.5% increment in the compressive strength is found at 0.5% of addition fibers.
- In addition 18.5% increment in the split tensile strength is found at 0.5% of addition of fibers.
- In 9.97% increment in the flexural strength is found at 0.5% of addition of fibers.
- From the results obtained in water absorption test, it increased when compared with the conventional concrete.
- From the results obtained in acid attack test, it increased when compared with the conventional concrete. It also enhances the durability properties of concrete.

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