An Experimental Study on Concrete with Hybrid Fibres

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Abstract

Plain concrete has a very low tensile strength, limited ductility and little resistant to cracking. Internal micro cracks are present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, leading to brittle fracture of the concrete. In the past attempts have been made to improve the tensile properties of concrete by way of using reinforced steel bars and also by applying restraining techniques. Although both the two methods provide tensile strength to the concrete members but do not increase the tensile strength of the concrete. Then Steel fibres are used to increase the tensile strength of concrete. The cracks present in the concrete will be controlled by adding coir fibres to the concrete. The study aims to evaluate the properties of concrete using steel and coir fibres. This project presents adding steel and coir fibres to the percentage of 0.5, 1.0, 1.5, and 2.0% to the weight of the concrete. Physical and chemical properties of steel and coir fibres have been studied. A concrete mix has been designed to achieve the grade of M30 as required by IS 10262-2009.The investigation contains two phases. The phase one contains to study and determine the properties of the material. In the phase two contains to determine the Compressive Strength, Split Tensile Strength and Flexural Strength of the concrete at 7, 14 and 28 days by adding steel and coir fibres to the percentage of 0.5, 1.0, 1.5 and 2.0% to the weight of the concrete.

Keywords: Coir fibre, Compressive Strength, Flexural Strength, Split Tensile Strength & Steel fibre

I. INTRODUCTION

Fibre reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. Fibres include steel fibres, glass fibres, synthetic fibres and natural fibres. Within these different fibres that character of fibre reinforced concrete changes with varying concretes, fibre materials, geometries, distribution, orientation and densities.

Fibre reinforced concrete with mono fibre system provides limited enhancement of properties. Therefore for improved performance combining two different fibres at suitable proportion in concrete can offer more attractive engineering properties because the presence of one fibre enables the more efficient utilization of the potential properties of other fibre.

The fibres used are mainly steel fibres, coconut coir fibres. Among these fibres steel, polypropylene and polyolefin fibres have attracted most attention due to the outstanding toughness of concrete reinforced with them. But it has been found that steel fibrous concrete has more toughness by preventing and controlling the initiation and propagation of cracks. However, steel fibres in concrete contribute more in resisting flexural and impact loads and prevents propagation of cracks only after concrete is hardened and can stop the development of micro cracks due to drying shrinkage. The coconut coir fibres (low modulus fibres) have got big advantage in resisting impact loads, because they have longer elongation under a given load which means they can absorb more energy without fracture. They are very good in resisting shrinkage and temperature cracks in fresh concrete. Therefore the low modulus fibres can be combined with steel fibres advantageously.

II. MATERIALS USED

A. Steel Fibre

The Steel fibre is Collected from Kovai steel traders, Coimbatore.
Length-35mm
Thickness-0.6mm
Aspect ratio-58
Shape-Hooked end

B. Coconut Coir Fibre

The Coir fibre is collected from Velavan traders, kumaramangalam.
Average diameter of fibre measured from Vernier calliper is 0.296mm
The coir fibre is cut to the length of 35mm.
Aspect ratio-118
Shape-Straight tightly.

C. *Plasticizers Used*

Conplast SP430 is used.

Conplast SP430 is a chloride free, super plasticising admixture based on selected sulphonated naphthalene polymers. It is supplied as a brown solution which instantly disperses in water.

III. METHODOLOGY

Tested the material properties as per IS procedures.
Mix design for concrete proportion has been developed as per IS: 10262-2009.
Casted and cured the concrete specimens as per IS procedures.
The properties of fresh concrete was tested as per IS procedures.
The characteristic strength of hardened concrete specimen was tested as per IS procedures.

IV. LITERATURE REVIEW

A. *Mohammad Adnan Farooq & Dr. Mohammad Shafi Mir*

This study presents Steel Fiber Reinforced Concrete for varying Fiber Proportion. The addition of fibers not only enhances the requisite properties of reinforced concrete but also changes the characteristics of the material from brittle to ductile. The paper presents the work done to determine the influence of change in Fiber volume fraction and Fiber aspect ratio on workability property of green concrete as well as on the compressive, flexural and split tensile strength properties of hardened concrete. The study determines the optimum volume fraction and aspect ratio of fiber required for achieving maximum strength and desirable workability. The study reveals that compressive and split tensile strength show similar behavior for different fiber content and aspect ratio while flexural strength shows different behavior. The study determine the Compressive Strength, Split Tensile Strength, Flexural Strength of concrete by adding steel fibre to the percentage of 1.0, 2.0 & 3.0% to the weight of the concrete.

The addition of steel fibers at 1.0% by volume causes a significant enhancement in early as well as long term compressive strength of concrete. The maximum improvement in 28-days strength was observed to be 29.15%. Hence 1% fiber content is optimum fiber content for 63 aspect ratio fiber from compressive strength point of view. The addition of steel fibers at 1% by volume causes a considerable improvement in early as well as long term split tensile strength of concrete. The maximum improvement in 28-days strength was observed to be 64.83%. Hence 1% fiber content is optimum fiber content for 63 aspect ratio fiber from split tensile strength point of view. The addition of steel fibers at 1% by volume changes the mode of failure from brittle to ductile and causes a considerable improvement in early as well as long term flexural strength of concrete. The extent of improvement in 28-days strength was observed to be 57.34% for 1% fiber content. However maximum strength improvement obtained was 93.3% with 2.5% fiber content which makes it optimum fiber content for fiber type of 63 aspect ratio for flexural strength.

B. *A.M.Shende, A.M.Pande & M.Gulfam Pathan*

This study presents Experimental Study on Steel Fiber Reinforced Concrete for M-40 Grade. Critical investigation for M-40 grade of concrete having mix proportion 1:1.43:3.04 with water cement ratio 0.35 to study the compressive strength, flexural strength, Split tensile strength of steel fibre Reinforced concrete (SFRC) containing fibers of 0%, 1%, 2% and 3% volume fraction of hook tain. Steel fibers of 50, 60 and 67 aspect ratio were used. A result data obtained has been analyzed and compared with a control specimen (0% fiber). A relationship between aspect ratio vs. Compressive strength, aspect ratio vs. flexural strength, aspect ratio vs. Split tensile strength represented graphically. Result data clearly shows percentage increase in 28 days Compressive strength, Flexural strength and Split Tensile strength for M-40 Grade of Concrete.

It is observed that compressive strength, split tensile strength and flexural strength are on higher side for 3% fibres as compared to that produced from 0%, 1% and 2% fibres. All the strength properties are observed to be on higher side for aspect ratio of 50 as compared to those for aspect ratio 60 and 67. It is observed that compressive strength increases from 11 to 24% with addition of steel fibres. It is observed that flexural strength increases from 12 to 49% with addition of steel fibres. It is observed that split tensile strength increases from 3 to 41% with addition of steel fibres.

C. *Shreeshail.B.H & Jaydeep Chougale*

This study presents effects of coconut fibers on the properties of Concrete. The testing of various material constituents of concrete was carried out according to the Indian Standard specifications. To identify the effects on workability and mechanical strength properties due to the addition of these coconut fibres, workability tests such slump, vee – bee, compaction factor test, Flow table tests, and the mechanical strength tests on standard specimens such as compressive strength, split tensile strength, modulus of rupture were conducted on the different aspect ratio. The standard cubes, cylinders and beams for conventional concrete and coconut fiber reinforced concrete were prepared and tested under compression testing machine and flexure testing machine respectively. The suitability of CFRC as a structural material is studied, in comparison with conventional concrete.

The compressive strength, Split tensile strength and Flexural strength has an increasing trend up to 2%. Later, strength decreased with the increase in fiber content. CFRC with 2% fiber content has higher compressive strength, Split tensile strength and Flexural strength as compared to that of PC. Optimum results were found when 2% of coir by weight of cement fibers were used, there was 6% and 13% increase in compressive strength as compared to normal concrete for 75AR and 125 AR

respectively. Split Tensile Strength increased up to 12% for 75 aspect ratio and 29% for 125 aspect ratio with 2% fibre. Modulus of Rupture increased up to 45% for 75 aspect ratio and 50% for 125 aspect ratio with 2% fibre.

D. Kshitija Nadgouda

This study presents coconut fibre reinforced concrete. Reinforcement of concrete is necessary to enhance its engineering properties. For this study, coconut fibres were used as they are freely available in large quantities. The study comprises of comparative statement of properties of coconut fibre reinforced concrete with conventional concrete based on experiments performed in the laboratory. The use of coconut fibres will also lead to better management of these waste fibres. The addition of coconut fibres improved the flexural strength of concrete by about 12%, they also formed good bonding in the concrete. The study found the optimum fibre content to be 3% (by weight of cement). Further work is required by changing the fibre content and aspect ratio to determine the optimum range of fibre content so that fibre reinforced concrete can be used where high flexural strength is required.

Coconut fibre being low in density reduces the overall weight of the fibre reinforced concrete thus it can be used as a structural light weight concrete.

By reinforcing the concrete with coconut fibres which are freely available, we can reduce the environmental waste. Flexural strength increases in case of 3% fibre mix. Thus, economy can be achieved in construction. Since, 5% & 7 % fibres do not show favorable results, it can be concluded that fibre content should not be used beyond 3%.

V. MATERIAL PROPERTIES

A. Cement

Cement used is a Dalmia cement 53 grade (OPC53). Setting time and specific gravity of cement is determined. Initial setting time of cement is 30 minutes and the final setting time of cement is 10 hours. The specific gravity of cement is 3.15.

B. Fine Aggregate

Specific gravity and sieve analysis of fine aggregate is determined. The specific gravity of fine aggregate is 2.76. By using sieve analysis test result the river sand confirming to Zone-2 as per IS 383-1970.

C. Coarse Aggregate

Specific gravity of coarse aggregate is determined. The specific gravity of coarse aggregate is 2.8.

D. Superplasticizer

In the marsh cone test, cement slurry is made and its flowability is found out. The dose at 1% of superplasticizers is optimum dose for that cement.

VI. MIX DESIGN

It is defined as the process of selecting suitable ingredients of concrete and determining their relative proportion with the objects of producing concrete of certain minimum strength and durability as economically as possible.

A. Mix Design Calculation

Mix design is prepared by using IS 10262-2009.

1) Water = 148 L/m^3
2) Cement = 370 kg/m^3
3) W/c ratio = 0.4
4) Aggregates

Coarse aggregate fraction = 0.64

Fine aggregate fraction = 1-0.64 = 0.36

5) Volume of concrete=1m^3

a) Volume of cement=370/3.15x1000=0.117 m^3
b) Volume of water=148/1x1000 =0.148 m^3
c) Volume superplasticizers=3.7/1x1000=0.0037 m^3
d) Volume of all in aggregate=1- (0.117+0.148+0.0037) = 0.731 m^3
e) Mass of coarse aggregate=0.731 x 0.64 x 2.8 x1000= 1309.95 kg/m^3
f) Mass of fine aggregate=0.731 x 0.36 x 2.76 x1000=726.32 kg/m^3

B. Mix Proportions

Table - 1
Mix proportion table

Water Content	*Cement (kg/m^3)*	*Fine Aggregate (kg/m^3)*	*Coarse Aggregate (kg/m^3)*
148	*370*	*726.32*	*1309.95*

0.4	*1*	*1.96*	*3.54*

VII. EXPERIMENTAL WORK ON CONCRETE

A. Slump Test

The slump values of concrete with various fibre proportions are tabulated.

Table - 2
Slump test table

S.NO	*Percentage addition of steel & coir fibre*	*Slump (mm)*
1	*0*	*22*
2	*0.5*	*18*
3	*1.0*	*16*
4	*1.5*	*14*
5	*2.0*	*12*

B. Compaction Factor Test

The compaction factor values of concrete with various fibre proportions are tabulated.

Table - 3
Compaction factor test table

S.NO	*Percentage addition of steel & coir fibre*	*Compaction factor*
1	*0*	*0.84*
2	*0.5*	*0.80*
3	*1.0*	*0.77*
4	*1.5*	*0.73*
5	*2.0*	*0.68*

C. Compressive Strength Test

The compressive strength values of concrete with various fibre proportions are tabulated.

Table - 4
Compressive strength test table

Percentage addition of steel & coir fibre	*Age at curing (days)*	*Compressive strength (N/mm^2)*
0	*7*	*21.58*
	14	*26.23*
	28	*32.81*
0.5	*7*	*22.35*
	14	*30.62*
	28	*34.33*
1.0	*7*	*27.94*
	14	*34.38*
	28	*38.65*
1.5	*7*	*25.98*
	14	*32.43*
	28	*36.02*
2.0	*7*	*24.43*
	14	*31.21*
	28	*34.91*

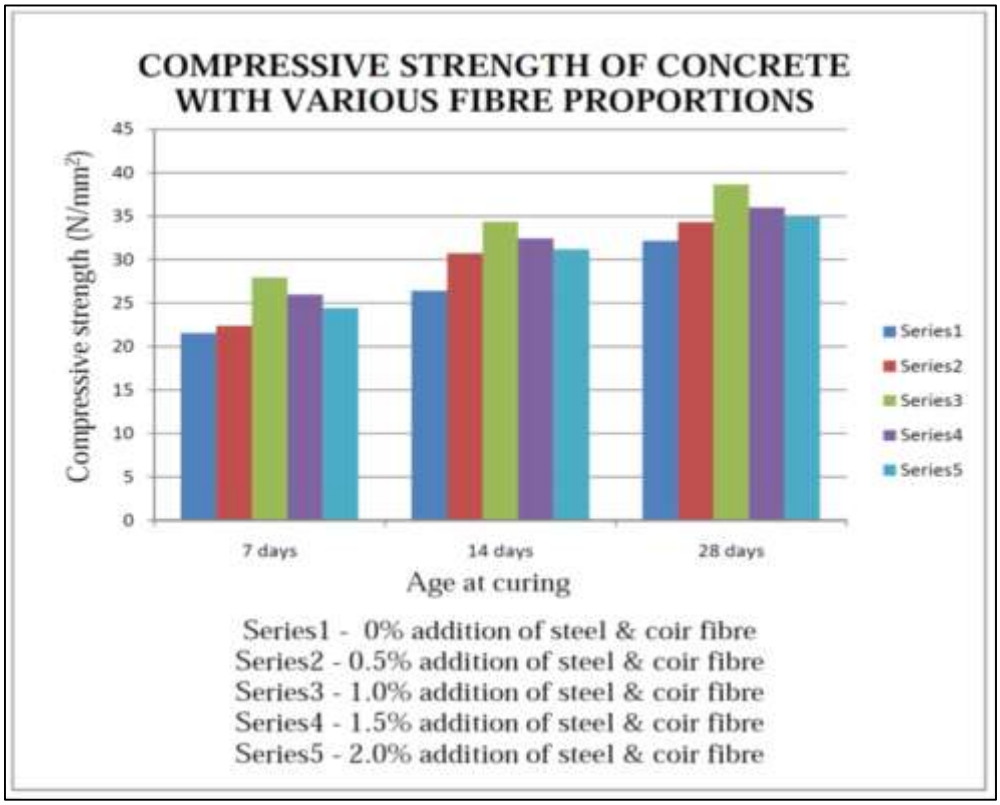

Fig. 1: Compressive Strength Test Graph

D. Split Tensile Strength Test

The split tensile values of concrete with various fibre proportions are tabulated.

Table - 5
Split Tensile Strength Test Table

Percentage addition of steel & coir fibre	*Age at curing (days)*	*Split tensile strength (N/mm^2)*
0	*7*	*1.56*
	14	*1.89*
	28	*2.61*
0.5	*7*	*2.12*
	14	*2.68*
	28	*3.33*
1.0	*7*	*2.42*
	14	*3.27*
	28	*3.85*
1.5	*7*	*2.21*
	14	*2.99*
	28	*3.51*
2.0	*7*	*2.04*
	14	*2.72*
	28	*3.21*

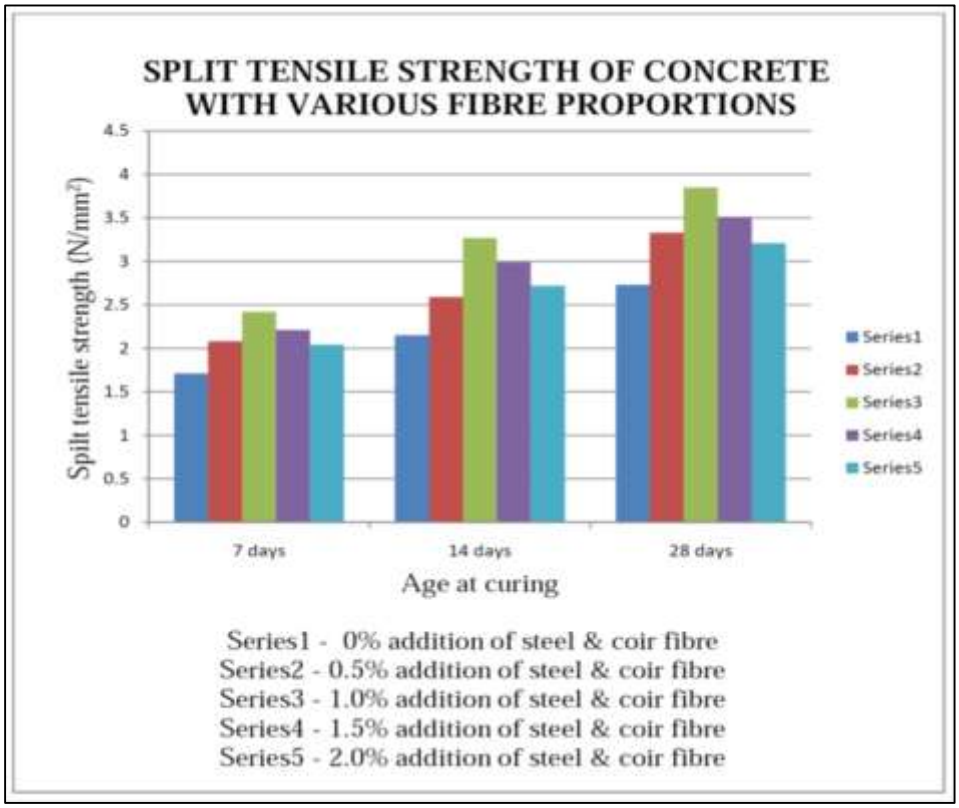

Fig. 2: Split Tensile Strength Test Graph

E. Flexural Strength Test

The flexural strength values of concrete with various fibre proportions are tabulated.

Table - 6
Flexural Strength Test Table

Percentage addition of steel & coir fibre	*Age at curing (days)*	*Flexural strength (N/mm^2)*
0	*7*	*3.03*
	14	*3.88*
	28	*4.91*
0.5	*7*	*3.64*
	14	*4.71*
	28	*5.63*
1.0	*7*	*4.83*
	14	*5.78*
	28	*7.02*
1.5	*7*	*4.27*
	14	*5.22*
	28	*6.26*
2.0	*7*	*3.87*
	14	*4.91*
	28	*5.86*

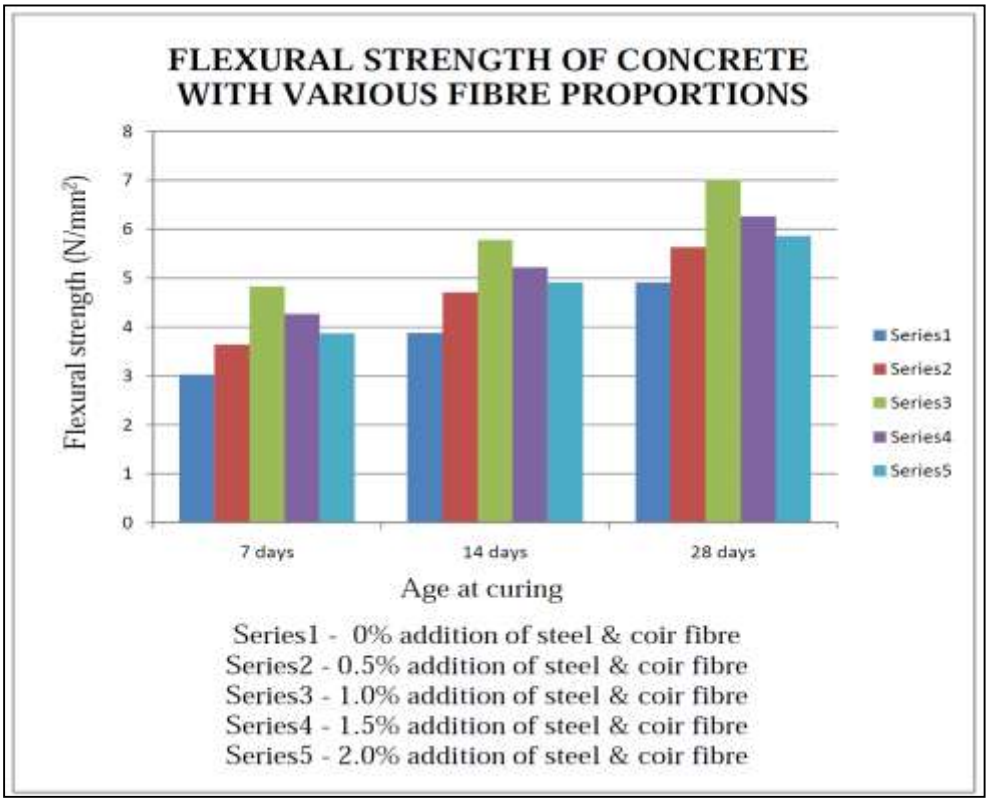

Fig. 3: Flexural Strength Test Graph

Fig. 4: Compressive Strength Test

Fig. 5: Split Tensile Strength Test

Fig. 6: Flexural Strength Test

VIII. CONCLUSION

1) The 1% addition of steel and coir fibres gives high compressive strength compare to other mixes. The maximum improvement in 28 days strength was observed to be 38.65 N/mm2.
2) The 1% addition of steel and coir fibres gives high tensile strength compare to other mixes. The maximum improvement in 28 days strength was observed to be 3.85 N/mm2.
3) The 1% addition of steel and coir fibres gives high flexural strength compare to other mixes. The maximum improvement in 28 days strength was observed to be 7.02 N/mm2.
4) From the compressive strength test, split tensile strength test & flexural strength test the 1% addition of steel and coir fibres gives high strength compare to other mixes.
5) If fibres added more than 1% then the strength decreases. It is to be concluded that the fibre content should not be used beyond 1%.

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