Experimental Investigation on Performance of Concrete using Hybrid Fibers

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Abstract*: This project work represents the mechanical strength properties such as compression, splitting tensile and flexural strength of fiber reinforced concrete with addition of hybrid fibers. Steel and carbon fibers are added in fiber reinforced concrete at varying percentages of 3 % and 2 % at different ratios of (50:50) and (75:25) based upon the orientation. Carbon fibers are mixed all along with cement, aggregates, water and super plasticizers while mixing in the mixer machine because of its size whereas steel fibers are being sandwiched between the layers of concrete based on the orientation so that the fibers would be perpendicular to the point of application of load. The strength properties of fibers were tested by compression, splitting tensile, flexural and two point loading at 7, 14, and28 days. M40 grade of concrete is used as per IS1026: 2009. Workability of concrete is maintained by using super plasticizer. The test results are being noted in tables and compared with conventional concrete. From the obtained results it can be concluded that the strength of concrete is optimum when hybrid fibers steel and carbon are added at 3% (75:25) ratio.

***Index Terms*: Hybrid fibers, Fiber reinforced concrete, orientation, super plasticizer.**

I. INTRODUCTION

This paper shows the mechanical properties of fiber reinforced concrete such as compressive strength, split tensile strength, flexural strength with hybrid fiber based on the orientation of fibers [1],[3],[6]. Hybrid fibers such as steel and carbon fiber of two different sizes are used in this project, the reason for using hybrid fiber in concrete is to obtain both properties of fibers individually in concrete[2],[5]. The reason for using long and short fiber is, small fibers are small and thin and will be large in numbers and thus they help in arresting cracks and also bridges the micro cracks present [4],whereas large fibers are used to increase mechanical properties of concrete [6]. In this project carbon fibers are mixed along with cement, water, aggregate and super plasticizer and are randomly distributed within the concrete [4], where as steel fiber are not mixed along with concrete but they oriented as layers in concrete [7]. The reason for orienting steel fibers in layers of concrete is to obtain high strength, random distribution of concrete may cause distribution of fibers at different points and some places maybe crowded with fibers while other places maybe without fibers, so when fibers are oriented in layers the distribution of fibers will be even and arrangement of fibers in concrete will make proper utilization of fibers in concrete [8], [9]. The objective of this project is improving mechanical properties of concrete with incorporation of short and long hybrid fibers, and to achieve workability by addition of chemical admixture.

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II. MATERIALS AND METHODOLOGY

A. Material Properties

The materials used in this project includes ordinary Portland cement of 53 grade confirming to IS codes, natural river sand is used as fine aggregate, coarse aggregate of maximum size 20mm is used confirming to IS: 236- 1993 and steel fibers of 25mm length and 0.5mm diameter is used and carbon fiber of length 6mm length and 0.5mm diameter is used as hybrid fibers. The materials used are tested according to Indian Standards and results are tabulated below.

Table 1: Physical properties of cement

SI. No	Properties	Values
1	Consistency	31
2	Earliest Setting Time	50
3	Specific Gravity	3.09

Table 2: Specific gravity of fine aggregate

SI. No	Description	Sample(gms)
1	Weight of empty pycnometer (W1)	680
2	Weight of dry sample (W2)	1650
3	Weight of F.A + pycnometer + water (W3)	2099
4	Weight of pycnometer filled with water (W4)	1540
5	**Specific gravity of fine aggregate**	**2.27**

Table 3: Specific gravity of coarse aggregate

SI. No	Description	Sample (gms)
1	Weight of aggregate A	2
2	Weight of aggregate + wire basket in water B1	1.9
3	Weight of wire basket in water B2	0.6
4	Weight of saturated aggregate in water B= (B1-B2)	1.26
5	Weight of surface dried aggregate C	1.98

6	**Specific gravity of coarse aggregate**	**2.80**

Table 4: Physical properties of carbon fiber

SI. No	Properties	Values
1	Specific gravity	1.35
2	Length(mm)	6
3	Diameter(mm)	0.5
4	Tensile strength (Mpa)	650-780

Table 5: Physical properties of steel fiber

SI. No	Properties	Values
1	Specific gravity	7.5
2	Length (mm)	30
3	Diameter (mm)	0.5
4	Aspect ratio	70
5	Tensile strength (Mpa)	1050

Table 6: Physical properties of super plasticizer

Super plasticizer	Auro cast 270 M
Appearance	Liquid
Colour	Straw/ Brown
pH	6
Melting Point	0ºC
Solubility	Soluble in water
Specific gravity	1.12

B. Mix proportion

With the values obtained from the basic tests done for cement and aggregates, mix design for m40 concrete is designed as of IS 10262: 2009. The mix calculations and mix ratios for M40 grade of concrete are as follows.

Cement = 330kg/ m³
Water = 132 kg/ m³
Fine Aggregate = 654.71kg/m³
Coarse Aggregate = 1317.62 kg/ m³
W/C Ratio = 0.4
Mix Ratio: 1:1.98:3.99:0.4(W/C)

III. EXPERIMENTAL WORK

A.Compressive strength test

Cubes of 150×150×150mm are used for casting. The inner layers of the moulds are oiled and then the cubes are being divided into 7 layers of 21.42mm where steel fibers will be placed in 6 layers. Each layer is filled with concrete and then a layer of steel fibers are placed and then the next layer of concrete is added to the mould and then the next layer of fiber is added, this is done until seven layers of concrete and six layers of steel fibers are placed in the mould, then the mould is left for 24hrs undisturbed and then tested for compression on 7th day, 14th day and 28th day. The test results are given in table. 7.

B. Splitting tensile strength test

Cylinders of dimensions 300×150mm are casted for splitting tensile strength test according to IS 516- 1956. The height of the cylinder is divided into 7 layers of 42.85mm where steel fibers will be placed in 6 layers. Similar to that of cube in cylinders too concrete is filled in layers and steel fibers are placed about each layer of concrete in the direction perpendicular to point of application of load. Steel fibers are sandwiched between the layers of concrete. Once the concreting work is done the moulds are left out for curing and demoulded after 24hrs and then placed in curing tank and tested for split tensile on 7th, 14th, and 28th day. The results are given in table.8.

C.Flexural strength test

Beams of 500×100×100mm are casted. Beam is divided into 4 layers of 25mm in which concrete is poured in each layer and steel fibers are placed over it and again the other layers of concrete is poured and fibers are placed over it resulting in 4 layers of concrete and 3 layers of fibers in the beam, once beam is casted it is left undisturbed for 24hrs and then demoulded and cured for 7th day, 14th day and 28th day testing.

D.Two point loading

Unreinforced beams of 1000×150×150mm are casted for tested for two point loading. This beam is divided into 4 layers similar to flexural beam of 37.5mm in which concrete is poured in each layer and steel fibers are placed over it and again the other layers of concrete is poured and fibers are placed over it resulting in 4 layers of concrete and 3 layers of fibers in the beam, once beam is casted it is left undisturbed for 24hrs and then demoulded and cured 28th day

IV. RESULTS AND ANALYSIS

A. Compressive strength

Cubes are loaded in axial compression direction for compression strength test. The test was carried out for all five mixes of concrete and the values are being noted down as shown in the table 7

Table 7: Compression strength of cubes

	Conventional Concrete	3% S,C(50: 50)	2% S,C(50: 50)	3% S,C(75: 25)	2% S,C(75: 25)
7 Day(N/ mm²)	29.82	31.07	30.35	32.43	32.11
14 Day(N/ mm²	45.88	47.80	45.99	49.99	48.65
28 Day(N/ mm²)	50.98	53.12	51.10	55.44	54.06

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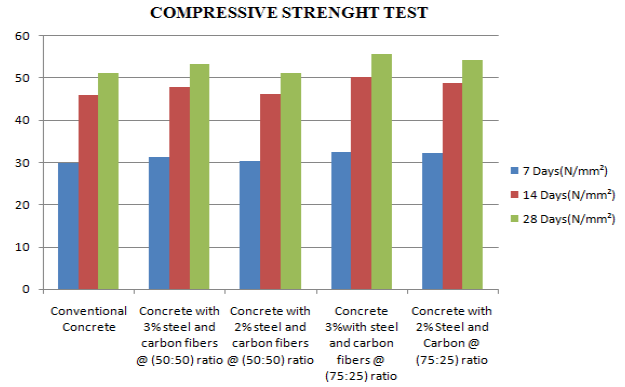

Fig 1: Graph on compressive strength of cubes

B. Splitting tensile strength

From table 8 it can be concluded that the splitting strengths of cylinders increases to optimum strength when steel and carbon fibers are added by 3% at (75:25) ratio. fig 2 shows the graphical representation of the strengths obtained by the cylinders of different mixes at 7, 14, and 28 days on split tensile.

Table 8: Split Tensile Strength of Cylinders

	Conventional Concrete	3% S,C(50:50)	2% S,C(50:50)	3% S,C(75:25)	2% S,C(75:25)
7 Day (N/mm²)	2.70	2.824	2.7202	3.243	2.872
14 Day (N/mm²)	4.167	4.341	4.182	4.989	4.419
28 Day (N/mm²)	4.63	4.29	4.65	6.16	4.91

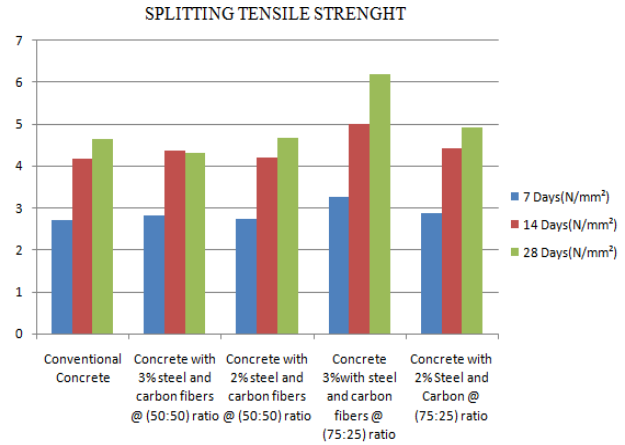

Fig 2: Graph on split tensile strength of cylinders

C. Regression analysis

Regression analysis is a set of statistical processes for estimation of relationship between the two variables, where the focus is on relationships between dependent variable and one or many independent variables. Regression analysis helps in understanding in what forms typical values of the dependent variable changes when any of the one independent variable is being varied, whereas other independent variables are being fix. Estimation of conditional exceptions of dependent variables, given that independent variables – average value of dependent when independent variables are fixed. The regression analysis for optimum value for compression strength and splitting tensile strength is given in fig 3and the regression analysis for optimum value for compression strength and flexural strength is given in fig 4.

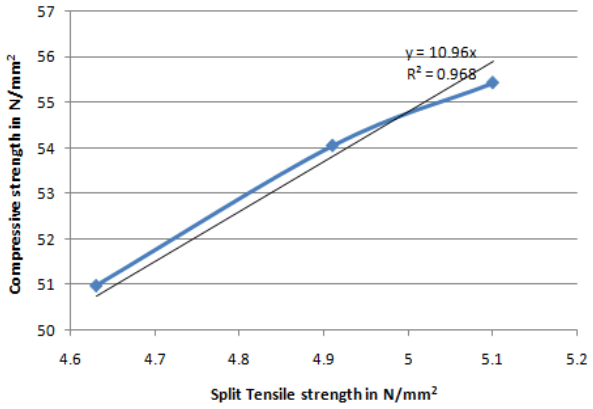

Fig 3: Graph on regression analysis

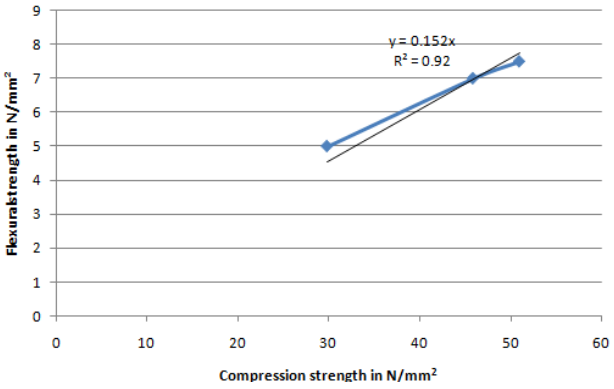

Fig 4: Graph on regression analysis

D.Flexural strength

From table 9 it is concluded as the flexural strength of beams increases to optimum strength when steel and carbon fibers are added at 3% (75:25) ratio. fig 4 shows the graphical representation of the strengths obtained by the beams of different mixes at 7 14, and 28th days on flexural strength.

Table 9: Flexural strength of beams

	Conventional Concrete	3% S,C (75:25)
7 Day (N/mm²)	4	5
14Day(N/mm²)	6	7
28 Day (N/mm²)	6.5	7.5

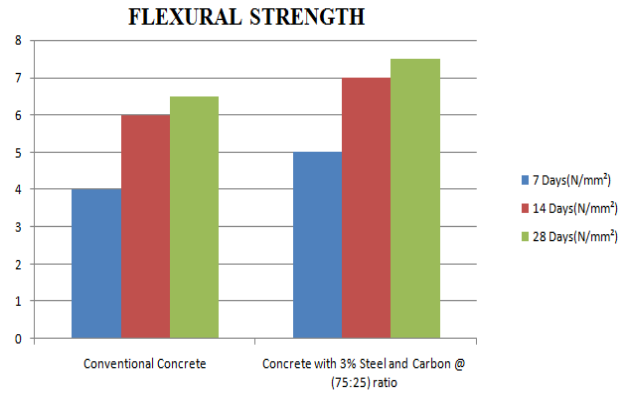

Fig 4: Graph on flexural strength of beams

E. Two point loading

Beams are marked with 100mm on both sides and mid- point of the beam is marked for applying load and then two point loads are placed in position from mid- point. A central deflectometer is placed at the mid -point to note the deflection for each loading applied. Once setup is done load is applied at intervals and deflections are noted down. From the values of loading vs deflection for conventional concrete and concrete with 3% steel and carbon fibers t (75:25) ratio which is given in table 10. From the table it can be concluded that the maximum deflection for conventional concrete is 0.98 at ultimate loading of 1.6 tons and for concrete with 3% steel and carbon fibers t (75:25) ratio is 2.46 at 2.8 tons. The main factor to be considered here is the ductility factor. Ductility factor may be defined as the ratio of elastic strength demand imposed to inelastic strength.

Table 10: Load vs deflection

Load (Ton)	Central deflection for conventional concrete	Central deflection for concrete with 3% steel and carbon fibers t (75:25) ratio
0.4	0.24	0.22
0.	0.49	0.45
1.2	0.76	0.71
1.6	**0.98**	0.92
2.0	1.18	1.15
2.4		1.32
2.8		**1.54**
3.0		1.69

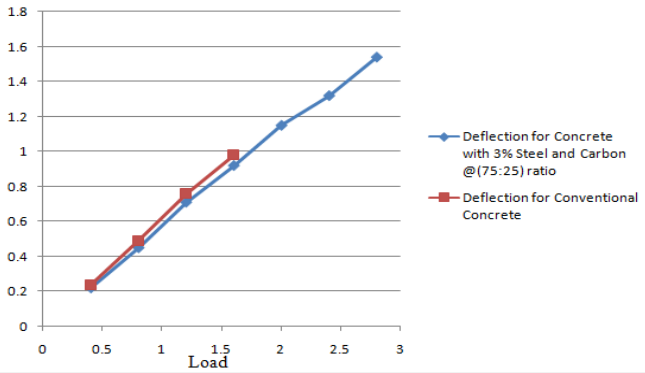

Fig 5: Load vs deflection graph

V. CONCLUSION

This experimental study concludes that the hybridization by addition of steel and carbon fiber in concrete with unidirectional fiber orientation increases the strength of concrete when compared to conventional concrete. The optimum strength in compression is 55.44N/ mm², splitting tensile strength is 6.16 N/ mm², and flexural is 7.5 N/ mm², achieved when steel and carbon fibers are added at 3% at (75:25) ratio, where as the other combinations of fibers shows light decrease in strength when compared. The mix with steel and carbon fibers 3% at (75:25) offers the maximum deflection with the same applied load when compared with conventional concrete.

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