Experimental Studies on Hybrid Concrete Composites with Steel Synthetic and Natural Fibers

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Abstract ***For investigating the effect of addition of hybrid fibers in different proportions in concrete 6 different mix proportions with fibers of different volume fractions are added to concrete.Hybridfiber reinforced concrete with composition of steel, synthetic and natural fiber. Here three different type fibers are added to achieve better concrete strength compare to conventional concrete. The cubes of 100 x 100 x 100 mm size and cylinders of 100mm diameter and 200mm length were cast for compressive and split tensile test respectively. Disc of size 200mm diameter and 100mm height was cast for impact test. After confirming the characteristic compressive strength from optimum values were selected and tested for flexure on beam specimens of size 100 x 150 x 1200mm. Test results shows that the addition of thesefibers increases the compressive strength split tensile strength, imp act resistance and flexural properties of structure.***

Index Terms: micro steel fibers, polypropylene fiber,coconut fiber, hybridcomposition.

I. INTRODUCTION

1.1 General

Structural integrity of the concrete can be increased by addition of small discrete fibers in a randomly distributed manner. It contains short fibers of various aspect ratios that are randomly oriented and uniformly distributed. Addition of fibers helps in increasing the compressive strength,split tensile strength, energy absorption,flexural strength and ductility factor of concrete. By increasing the fiber volume fraction these properties will increase but only up to a certain volume that is from the previous studies it is concluded that the increase in fiber volume fraction up to 2% increases the above mentioned properties of fibers and beyond that there can be clogging of fibers that is there can be chances of balling effect. Using lesser fiber percentage avoid clogging effect. Random fiber mix produces better matrix building and in practical point of view also it is the more convenient procedure. In addition, there are various parameters which effect the character of fiber-reinforced concrete, parameters such as type of concrete, fiber type, aspect ratio, density, orientation and distribution.

Shrinkage cracks such as plastic shrinkage and drying shrinkage cracks can be avoided by the addition of fibers. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion and shatter–resistance in concrete. Generally fibers do not increase the flexural strength of concrete, and so cannot replace moment-resisting or structural steel reinforcement. Indeed, some fibers actually reduce the strength of concrete. Combination of both steel and polymeric fibers are can offer the advantaged of both the fibers and because of this it is widely used in construction industries; Steel fibers provides structural improvement and the resistance to explosive spalling and plastic shrinkage improvements provided by polymeric fibers.

Therefore, this study investigated the effect of addition of different types of fibers in different proportions on the compressive, split tensile, elastic modulus, and impact resistance of hybrid fiber reinforced concrete specimens. The Main objectives of this study include investigating the effect of fiber addition on the load carrying capacity in compression and elastic modulus in tension; the flexural strength and split tensile strength and impact resistance.

II EXPERIMENTAL PROGRAM

2.1 Materials and Mix Proportions

The mix proportion Concrete mixused in this study is listed in Table 1. Pozalana Portland cement of grade 53 procured from local suppliers was used for the investigation. The cement being a binder material helps to bind the fine and coarse aggregate together and also filling the voids between aggregates. Cement had a specific gravity of 2.8 with consistency 26% and initial setting time as 30 minutes and final setting as 600minutes the physical properties and chemical compositions ofwhich are listed in Table 2. River sand has been used as fine aggregate. The fineness modulus and specific gravity are zone I as per IS383:1970 and 0.721 respectively.Crushed coarse aggregate of size 10mm were collected from local quarries. The specific gravity is 0.78. The aggregates have been tested as per IS: 2386 (part 1)-1963[8] and surface quality description of the aggregate are classified as per IS: 383-1970. Detailed properties of the micro steelfibres used are listed in Table 3.Different Mix proportions of hybrid mixes are given I Table 4. After casting, the concrete is kept of curing for 28 days.

Revised Manuscript Received on May 06, 2019

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Table 1 Mixproportions

Cement Kg/m^3	Silica fume Kg/m^3	Flyash Kg/m^3	Sand Kg/m^3	Aggregate Kg/m^3	w/b	SP Kg/m^3
450	26.75	80.25	537	1035	0.24	2.65

Table 2 Table 2 Chemical Composition

Chemical Composistion	Cement	Flyash	Silica Fume
Sio2	21.9	52	35
Al2O3	6.9	23	18
Fe2O3	3	11	6
Cao	63	5	21
Mgo	2.5	-	-
So3	1.7	-	-
Density g/mm^3	0.00287	0.0013	0.006

Table 3 Properties of Fibres

Type	Micro steel	Polypropylene	coconut
Length	3mm	5mm	1 mm
Diameter	0.05mm	0.05mm	0.02mm
Aspect ratio	60	100	50
Density(g/cm3)	7.15	0.95	0.48
Tensile strength	1020MPa	22.06MPa	38.4MPa
Elastic Modulus	200000 N/mm²	1300 N/mm²	400000 N/mm²

Table4Different mix propositions of fibres.

S.no	MSF %	PPF %	CF %	TOTAL %
S1	0.6	0.2	0.2	1
S2	0.3	0.4	0.3	1
S3	0.5	0.1	0.4	1
S4	0.5	0.5	0.5	1.5
S5	0.7	0.7	0.1	1.5
S6	1	0.3	0.2	1.5

2.2 TEST SETUP

2.2.1 COMPRESSION TEST

Cube specimens having dimension of 150x150 mm was used for compression test according to IS 516-1959. Compressive strength of the specimens were measured for 7 days and 28 days in Compression testing machine (CTM) of load capacity 300Tons. Compression test setup is shown below in figure 1 .

Figure 1 Compression Test

2.2.2 SPLIT TENSILE TEST

Cylindrical specimens having dimension 100 diameter and 200mm length was used for split tensile strength test .Elastic modulus was measures using the stress strain graph obtained from the test.The specimens for split tensile strength was cast and kept for curing for 7 and 28 days and was tested in Universal Testing Machine (UTM) of 100 Ton capacity.

Figure 2 Split Tensile Test

2.2.3 IMPACT TEST

The impact values of the concrete was measures using the drop weight impact testing setup fabricated as per ACI Committee 544.2R-89 [5] .Circular disc of dimension 150 mm diameter and 50mm height has been subjected to impact loading. The impact testing machine setup contains a steel ball of some weight which is dropped over the specimen to be tested and it works on the mechanism such that it is connected to a steel wire and up and down movement is done by passing over a pulley. Discs with above mentioned specification were kept on the setup below the dropweight test. The impact test was carried out by dropping thesteel ball.it hits the disc at a height of 120mm. The number of blows required to cause failure was noted down to calculate the impact energy using equation (i).

Figure 3 impact Test

Energy absorption capacity = mgh x N…………..(i)

Where

m = mass of ball (2 kg)

g = acceleration due to gravity (9.81 m/s^2)

h = height of falling (120 mm) and N is the number of blows.

And the dynamic impact energy was calculated with the help of equation ii.

$E_{dynamic}$= ½x m x v^2x N……………………….. (ii)

Where,

E=Impact Energy (N-m)

m= drop hammer mass (19N)

v= impact speed (m/s)

N= no. of blows

h= height of drop (120mm)

v=g x t

m=$^{w}/_{g}$

h=$\frac{gXt^2}{2}$

III.RESULTS AND DISCUSSION

3.1 COMPRESSIVE STRENGTH

Compressive strength results were obtained by testing concrete cubes both conventional concrete and hybrid fiber reinforced concrete cubes and the obtained results are listed in table 5.

Table 5 Compressive Strength Results

specimen	Stress @ 7 days(MPa)	Stress @ 14 days (MPa)	Stress @28 days (MPa)
S1	21.53	27.7	45.4
S2	**23.23**	**28.9**	**46.8**
S3	23.19	28.1	45.8
S4	16.33	23.2	38.6
S5	18.25	25.7	41.1
S6	17.47	24.3	39.5
CS	29.08	32.69	41.45

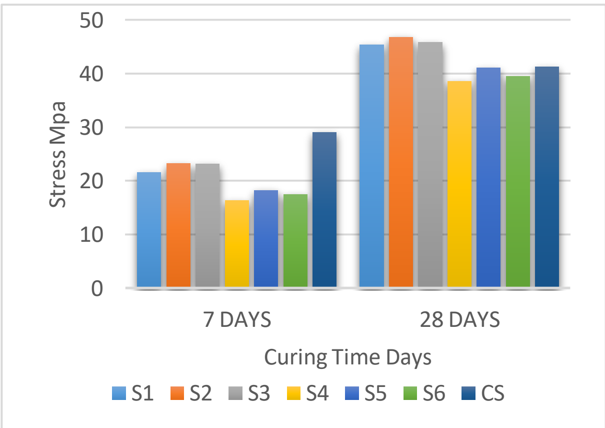


Figure 4 Compressive Strength Graph

From the above results it is clear that specimens with a total volume fraction of 1% shows increase in compressive strength. The mix S2 with 0.3% micro steel fiber, 0.4% polypropylene and 0.3% coconut fiber shows maximum strength compared to mix S3 and S1.

3.2 SPLIT TENSILE STRENGTH

The split tensile strength values of different Mixes are given in Table 6.Stress can be calculated from the formula

T=$\frac{2P}{\pi ld}$

T=Stress in N/mm^2

P=Load in N

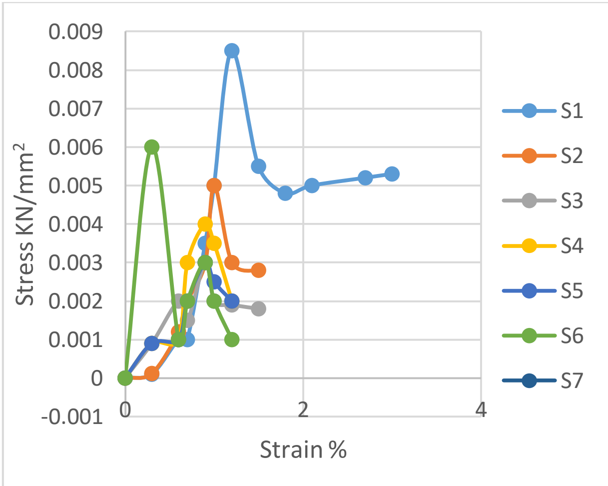
L= Length of specimen in mm

D=diameter of specimen in mm

Table 6 Split Tensile Strength Values

Specimen	Stress N/mm2	Load kN
S1	2.04	64.350
S2	1.35	41.200
S3	1.48	46.250
S4	1.358	42.650
S5	2.01	63.200
S6	1.38	43.550
Cs	1.36	42.520

From the split tensile strength values it is clear that maximum tensile strength is for S1 and S5 mixes. In that the mix with 1.5% volume fraction has more tensile strength compared to 1% volume fraction mix. Stress strain graph obtained from the test results are given below in figure 5.



The stress strain graph obtained from Computerized UTM is plotted above and in that maximum stress value is for S1 mix and maximum strain is obtained for the same that is with 1% volume fraction and the specimen with maximum amount of steel fibers.

3.3 IMPACT TEST

Impact resistance of the specimen was determined after 28 days curing period. The impact strength was determined for both static and dynamic condition from equations i and ii. For that the number of blows required for the failure of the specimen was noted down in both the cases.The results obtained is plotted in table 7.

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Table 7 Impact test Results

S.no	Specimen	Fiber Vol Fraction	No. Of Blows x	No. Of Blows y	IMPACT ENERGY (N-M) Dynamic	IMPACT ENERGY (N-M) Static
1	S1	1	5	7	239	156
2	S2	1	5	8	274	178
3	S3	1	5	7	239	156
4	S4	1.5	4	6	205	134
5	S5	1.5	5	7	239	156
6	S6	1.5	5	7	239	156
7	CS	1.5	4	5	171	111

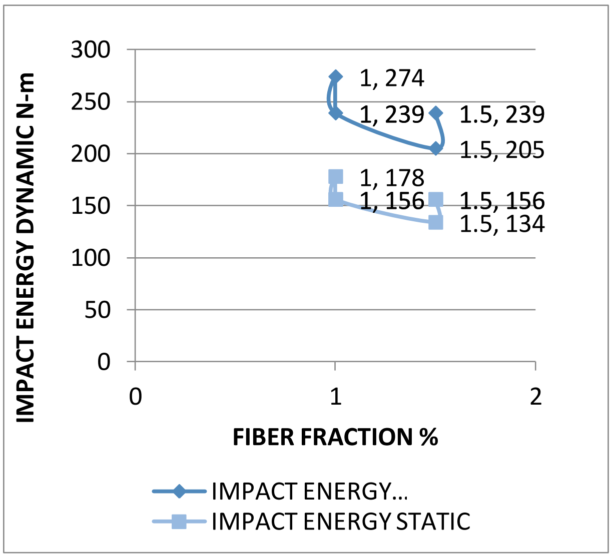

Figure 6 Dynamic and Static Impact Energy Chart

IV CONCLUSION

It is concluded that incorporation of different types of fiber influences different properties of concrete .3 tests have been conducted and from the results we can conclude

i. In case of compressive strength the addition of hybrid fibers cause an increase in the compressive strength by increasing up to 12% compared to Normal Mix.
ii. The mix with 1.5% Volume fraction with high % of micro steel fiber and shows slight decrease in compressive strength due to clogging.
iii. In case of Split Tensile strength both maximum and minimum strength obtained for specimen with 1% volume fraction.
iv. It showed an increase in 30% in strength compared to the normal mix.
v. In case of Impact testing addition of micro steel fibers increases the impact energy of the mix.
vi. Addition of hybrid fibers increase impact strength 40% compared to the nominal mix.

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