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Investigation on Hybrid Concrete Using Steel and Polypropylene Fiber

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***Abstract*— The effect of addition of hybrid fibers on the mechanical properties of concrete mixture is studied in the investigation. Steel fibers of 1% and polypropylene fibers 0.035% were added together to from hybrid concrete. Mechanical properties such as compressive strength split tensile test and flexural strength. Hybridization refers to combination of different types of fibers. The purpose of combining the fibers is to improve the multiple properties of concrete mixture. The behavioral efficiency of this composite material is far superior to that of plain and mono fiber reinforced concrete. The addition of fiber is helpful to improve the fracture properties of concrete. The hybrid fibers are comprehensively being used in rigid pavements, airfield pavements, flexible pavements, earthquake-resistant and explosive-resistant structures, mine and tunnel linings, bridge deck overlays, hydraulic structures, rock-slope stabilization, etc.**

***Index Terms*— Steel fiber, polypropylene fiber, hybridization, mono fiber.**

I. Introduction

Concrete is the most popular material in construction. Conventional concrete have good compression strength and it is very less or poor strength in tension as well as flexural strength. Fiber reinforced concrete (FRC) is concrete were the addition of fibers to concrete contains short discrete fibers that are uniformly distributed in concrete. Fibers include steel fibers, glass fibers, synthetic fibers and natural 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 behaviour of the fiber matrix composite after it has cracked, thereby improving its toughness. When two different fibers added to concrete to make the composite structure gives maximum strength to concrete that type of concrete is hybrid fiber reinforced concrete (HFRC).

The effect of strength and workability characteristics of waste plastic fiber reinforced concrete and found that the waste plastic fibers are very effective in controlling the cracks in concrete [1]. The addition of fiber is helpful to improve the fracture properties of concrete [2].The mechanical properties, impermeability, freeze-thaw resistance of fiber reinforced concrete have improved greatly compared with ordinary concrete[3]. Study on hybridization of different percentages of steel fibers and palm fibers and reported that the use of hybrid fiber in specimens increases notably the toughness indices and thus increases their flexural toughness and rigidity and enhance the overall performances of concrete[4]. The resistance of hybrid fiber reinforced self compacting concrete to elevated temperature is better than that of mono fiber reinforced self compacting concrete [5]. The initial crack, shrinkage can be resist by using of polypropylene and steel fiber is to increase the strength parameter[C].

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II. MEATRIALS COLLECTION

A. *Objective*

To develop a strong and ductile connection for precast concrete members in seismic zone and to increase the strength of joints used in the precast beam structure. Also study the effect of hybrid fiber concrete.

B. *Test Specimens*

Cube Specimens:

Cube which has the nominal size of 150mm x 150mm x 150mm are used for making samples using conventional concrete of Normal and HFR concrete specimens.

Cylinder Specimens:

Cylinders of 150mm diameter and 300mm height are used for making samples using conventional concrete of Normal and HFR concrete specimens.

Beam Specimen:

Beam size of 1500mm x 150mm x 100mm with 4 no.s of 10mm main reinforcement and 8mm distribution reinforcement @ 90mm spacing are used for making samples using conventional concrete of Normal and HFR concrete specimens.

C. *Mix Proportion*

Concrete mixes were prepared using water cement ratio of 0.5. Plain concrete (PC) and Concrete reinforced with combination of 0.035% Polypropylene + 1% of Steel fibers (HFRC). Concrete composition design is given in Table1.

TABLE I: CONCRETE COMPOSITION DESIGN

Index	Cement kg/m³	Water kg/m³	F.A kg/m³	C.A kg/m³	Steel fibe	PP Fibers
PC	377.6	188.8	591.6	1178	0	0
HFRC	377.6	188.8	591.6	1178	1	0.035

III. CONCRETE INGREDIENTS

A. Cement

Ordinary Portland Cement (53 Grade) cement was used for the present study and it is having a specific gravity of 3.14 and normal consistency 32% conforming to the requirements of IS: 12269-1987 specifications.

B. Fine Aggregate

River sand passing through IS 4.75 mm sieve was used as fine aggregate. The sand used having fineness modulus 3.237 and Water absorption of 1.93%.

C. Coarse Aggregate

The coarse aggregate of 20mm size was used in the study the aggregates were tested as per IS: 2386-1963 (I, II and III) specifications.

D. Normal Water

The water which if fit for drinking should be used for making concrete. The water should be clean and free from harmful impurities such as oil, alkali and acid etc.

E. Steel Fiber – Hooked End

Addition of steel fibers into the concrete improves the crack resistance (ductility) capacity of the concrete. Traditional rebar are generally used to improve the tensile strength of the concrete in a particular direction, whereas steel fibers are useful for multidirectional reinforcement.

TABLE II: PROPERTIES OF STEEL FIBER

Length of fiber	100mm
Diameter	1mm
Aspect ratio	100
Yield Strength	1100 – 1380 Mpa
Tensile strength	1.16 MPa

FIGURE I: HOOKED END

F. Polypropylene Fiber

The polypropylene fiber provides good bulk and lighter in weight. It is lighter than water and all other fiber. The melting point of polypropylene is about 165^0C and remains flexible at in the region of -55^0C.The water absorption of polypropylene fiber is about 0.3% after 24hr and it has no effect on the strength of polypropylene fiber.

TABLE III: PROPERTIES OF POLYPROPYLENE FIBER

Length of fiber	11mm
Specific Gravity	0.90 – 0.91 gm/cm^3
Yield Strength	1100 – 1380 Mpa
Tensile strength	392 – 588 kg/cm^2
Dosage Rate	900 g/ m^3 of Concrete

FIGURE II: POLYPROPYLENE FIBER

IV. EXPERIMENTAL TESTS

A. Compression Test

The cube specimens are tested for compressive strength at the end of 28days.

$$f = P/A \text{ N/mm}^2$$

The results of the compressive strength tests on concrete cubes are shown in Table IV.

TABLE IV: COMPRESSIVE STRENGTH OF CUBES AT THE END OF 28 DAYS

INDEX	COMPRESSIVE STRENGTH MPa			AVERAGE STRESS N / mm^2
	TRIAL 1	TRIAL 2	TRIAL 3	
PC	28.41	28.93	28.65	28.66
HFRC	33.12	33.20	33.32	33.24
AVERAGE INCREASE IN COMPRESSIVE STRENGTH				16%

From the above table it is clear that compressive strength of plane concrete greater than compressive strength of HFRC, it's by 16% increase.

CHART I: COMPRESSIVE STRENGTH TEST

B. *Split Tensile Test*

The cylinder specimens were tested for Split tensile strength at the end of 28days. The Tensile strength of the specimen was calculated by using the formula

$$\text{Tensile strength} = 2P/\pi LD$$

The results of the Split tensile strength tests on concrete Cylinders are shown in Table V.

TABLE V: SPLIT TENSILE STRENGTH OF CYLINDER AT THE END OF 28 DAYS

INDEX	SPLIT TENSILE TEST N / mm^2			AVERAGE STRESS N / mm^2
	TRIAL 1	TRIAL 2	TRIAL 3	
PC	3.11	3.12	3.13	3.12
HFRC	4.65	4.7	4.8	4.71
AVERAGE INCREASE IN SPLIT TENSILE TEST				51%

From the above Table it is clear that Split tensile strength of cylinder plane concrete greater than Split tensile strength of cylinder HFRC, it's by 51% increase.

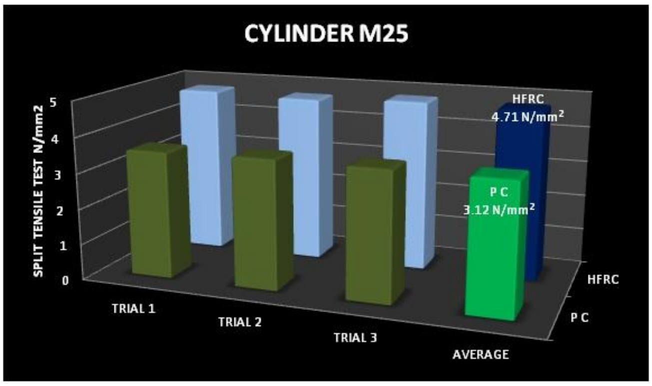

CHART II: SPLIT TENSILE TEST

C. *Flexural Strength*

The beam specimens were tested for Flexural strength at the end of 28days. The Flexural strength or modulus of rupture (f_b) of the specimen was calculated by using the formula

Flexural strength = PL/bd^2 (When a > 20.0cm for 15.0cm specimen or > 13.0cm for 10.0cm specimen)

Or

Flexural strength = $3Pa/bd^2$ (When a < 20.0cm but 17.0cm for 15.0cm specimen or < 13.3cm but > 11.0cm for 10.0cm specimen)

Where,

a= The distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen

b= Width of specimen (cm)

d= Failure point depth (cm)

L= Supported length (cm)

P= Maximum load (kg)

The results of the Flexural strength tests on concrete beam are shown in Table VI.

TABLE VI: FLEXURAL STRENGTH OF BEAM AT THE END OF 28 DAYS

INDEX	FLEXURAL STRENGTH TEST N / mm^2			AVERAGE STRESS N / mm^2
	TRIAL 1	TRIAL 2	TRIAL 3	
PC	3.57	3.62	3.61	3.6
HFRC	4.76	4.69	4.8	4.75
AVERAGE INCREASE IN FLEXURAL STRENGTH TEST				34 %

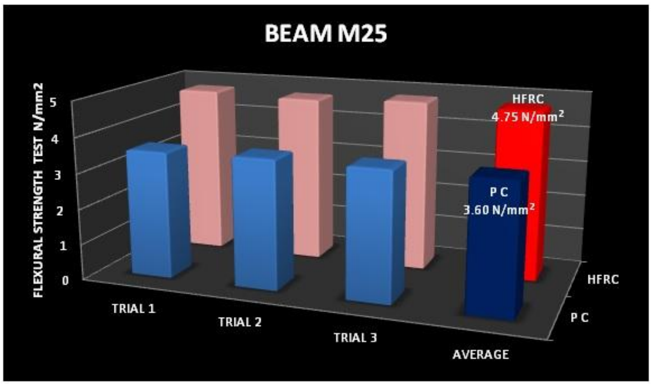

CHART III: FLEXURAL STRENGTH TEST

V. CONCLUSION

Following conclusions based on the experimental investigations concerning on the cube, cylinder and beam of its compressive strength, split tensile strength and flexural strength of concrete, by Normal Concrete or Plain Concrete and Hybrid Fiber Reinforced Concrete observations from the present study.

[1] In this Hybrid Fiber Reinforced Concrete the strength of concrete gets increase without adding any admixture or additives.

[2] Compressive strength of concrete of cube at the end of 28 days for Plain Concrete and HFRC are 28.66 N/mm^2 and 33.24 N/mm^2 respectively.

[3] The average increase in the compressive strength is 16%.

[4] Split Tensile strength of concrete of cylinder at the end of 28 days for Plain Concrete and HFRC are 3.12 N/mm^2 and 4.71 N/mm^2 respectively.

[5] The average increase in the Split Tensile strength of concrete of cylinder is 51%.

[6] Flexural strength of concrete of beam at the end of 28 days for Plain Concrete and HFRC are 3.6 N/mm^2 and 4.75 N/mm^2 respectively.

[7] The average increase in the Flexural strength of concrete of beam is 34 %.

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