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Mechanical Properties of Hybrid Fiber Reinforced Concrete

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Abstract

Objectives: To evaluate the suitability of short coconut and PP fiber as a reinforcing agent in cement concrete. Mixing and casting of untreated coconut and PP fiber in RCC check the mechanical properties of HFRC. The experimental background is cited in the literature. **Methods/Statistical Analysis:** From the basic tested data a mix design for M20 grade concrete at a weight of cement fraction is 1%.For this work 12nos of cube (150 mm * 150 mm * 150 mm) and 12nos of beam (700mm *150 mm*150 mm) were casted by using different fiber proportion of polypropylene fiber & coconut fiber in the laboratory; along with one set of control sample were examined and compared with the HFRC. **Findings:** All the cube specimens were tested by UTM and beam specimens were tested in UTM by using two points loading as per IS 516-1959. The test result shows that the weight fraction of 1% with Polypropylene 0.75 – coconut coir 0.25 combination specimens improves compressive strength and flexural strength as compared with control specimen. **Applications/Improvements:** The use of hybrid fiber reinforced concrete in non-structural components like Walls & Surfaces of Septic Tank, Water Storage Tanks and Dams, Sports Grounds, Industrial, Residential Floors & Warehouses etc. The major contribution of fibers in crack resistance and crack control, improve ductility of concrete.

Keywords: Coconut Coir Fiber, Ductility, Hybrid Fibers, Polypropylene

1. Introduction

Now-a-days concrete made with Portland Slag based cement is commonly used as a construction material in the world wide. Due to increased production in the ferrous based industries, we found a huge stock of ground granulated blast furnace slag. By adding specified amount of slag with OPC the Portland slag cement is produce. But, matter of regret is that, the use of such cement makes the concrete inherently brittle in nature along with weak crack resistance in the field.

In that case, if we use [1]FRC in the concrete matrix containing short discrete fibers randomly & uniformly distributed throughout, would increase the structural integrity enhancing both the compressive and flexural strength comparatively.

In FRC fiber includes natural fibers, synthetic fibers, material fibers or glass fibers each of having their original properties. In a hybrid more than two different types of fibers are proportionally mixed with concrete to produce a composite material that having individuals benefits of the fiber in a synergetic manner. Hybridization of both natural & synthetic fibers can give potential advantages in improving concrete properties. Simultaneously it reduces the cost of concrete production.[2]Use of natural fibers in concrete mix will improve the quality & quantity of cultivation also. HFRC can be materialized in various fields of civil engineering applications. Hence, this experimental study proves the feasibility of HFRC with required grade of concrete at a weight of cement fraction of 1% in various fields of construction work in future.

Previous studies have shown that straw were used in reinforced brick, horse hair[3] was used to reinforce plaster & recently asbestos fiber are being used to reinforced Portland cement. In India for the first time used of composite material i.e. fiber reinforced plastics (FRP) started

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in 1962 for manufacturing roofing sheets Industries, Coimbatore[4].

In[5] studied on PFRC (Polypropylene Fiber Reinforced Concrete) and found that addition of low volume of PP increases its 28days compressive strength. But, higher value of PP in PFRC decreases by 3 % to 5% from its original value. However tensile strength increases up to 0.40% by volume and then after again decreases with increasing of PP fiber in PFRC.

In PFRC that PP fiber reduced the water permeability, plastic shrinkage & settlement, Carbonation depth etc. Higher volume of PP in PFRC decreases the workability of concrete. A good workability can be achieved by adding HRWR chemical admixture even with w/c ratio of 0.3.

In[6] researched on CFRC (Coconut Fiber Reinforced Concrete) and found that due to high material cost is the dominating factor of conventional construction material. It also made some problems to the environment cannot lead to proper disposal & also increasing impact on environment. In CFRC where coir fiber is a natural product which does not impact on the environment & also increase the strength of the concrete as compare to the conventional one.

In analyzed the time development of the shrinkage of polypropylene fiber reinforced high-performance concrete in the laboratory and his team found that the total shrinkage of FRC is less than the shrinkage of a control one. Again shrinkage of the FRC was considerably reduced, by increasing the content of the fibers up to 0.5% of the volume of the composite, whereas further increasing of the fiber quantity, the rate of shrinkage reduction became relatively insignificant. While considering both simultaneously the shrinkage & the workability of high performed fiber-reinforced concrete then the optimum volumetric content of polypropylene fibers range should be in between 0.25% to 0.50%.

2. Materials used

In this experimental study cement, fine aggregate, coarse aggregate[7] coconut coir fiber, polypropylene fibers were used.

2.1 Cement

Portland Slag based Cement (Brand-Ultra Tech) conforming to IS 455:1989.The various test result on cement are given in Table 1.

2.2 Coarse Aggregate

Locally available crushed granite stone of 20mm is used. The various test results on coarse aggregate are given in Table 2.

2.3 Fine Aggregate

Clean and dry river silica sand locally available was used. Sand passing through IS 4.75mm sieve [IS: 383:1970] was used for the specimens. The various test result on Fine aggregate in presented in Table 3.

2.4 Polypropylene Fiber

Fine fibrillated polypropylene monofilaments named as "Fiber Guard". The fibers were supplied by M/S Bajaj Reinforcement LLP Nagpur, Maharashtra, India. The various properties of Polypropylene fiber are given in Table 4.

2.5 Coconut Coir Fiber

Brown coconut coir fiber was collected from local market. The various properties of coconut fiber are presented in Table 5.

Table 1. Properties of Cement

Properties	Values
Fineness of Cement	3.5%
Soundness of cement	1 mm
Specific Gravity	3.10
Initial Setting time	50 min
Final Setting time	320 min
Consistency limit	32%

Table 2. Properties of Coarse Aggregate

Properties	Values
Specific Gravity	2.95
Fineness Modulus	6.97
Bulk Density	1.636 g/Cm^3
Impact Value	25.37%

Table 3. Properties of Fine Aggregate

Properties	Values
Specific Gravity	2.67
Fineness Modulus	5.17
Zone	II

2.6 Water

Portable drinking water was used for this experiment.

3. Design Mix

Concrete mix design has been adopted as per IS 10262:2009 for M20 grade concrete. The various constituents of concrete mix and quantity of mix are given in Table 6 and 7 respectively.

4. Experimental Methodologyt

4.1 Compressive Strength Test

It is determined that in compression testing machinet as specified IS 516-1959. Cubes of 150 mm size were subjected to a uniformly rated compressive load of 140 Kg/cm^2 per minute until failure at age of 28 days. Average of three results is obtained. Compression testing machine is shown in Figure 1.

Table 4. Properties of Polypropylene fiber

Specification	Values
Length (mm)	20
Diameter (mm)	0.1
Specific Gravity	0.91
Water absorption	Nil

Table 5. Properties of Coconut coir fiber

Specification	Values
Length (mm)	6 mm – 24mm
Diameter (mm)	0.29mm -0.83mm

Table 6. Quantities of materials

Materials	By weight
Cement	372 Kg/m^3
Fine Aggregate	833 Kg
Coarse Aggregate	1125 Kg
Water	186 Kg/m^3

W/C ratio: 0.50 % ratio 1:2.23:3
Hybrid: - 1 % weight of cement.

Table 7. Quantity of fiber uses

Mix	Marking	PP(Kg/m^3)	CC(Kg/m^3)
CM	S-0	-	-
P0.25 C0.75	S- 1	0.93	2.79
C0.50 P0.50	S- 2	1.86	1.86
P0.75 C0.25	S -3	2.79	0.93

4.2 Flexural Strength Test

Concrete also have some tensile property. Tensile strength is very much similar to flexure value. Among the two method of tensile strength test we go for flexural strength test by using two point loading frame method in UTM. A beam having 700 mm length, 150 mm breadth, 150 mm height was casted in cast iron form work. After that I allowed the beam for normal curing in room temperature for the age of 28 days. By using two points loading method, applied a load rate of 400 Kg / Min. & noted the ultimate facture load and by calculating with respect to area we can find out the flexure strength of the concrete. Averages of three sample test results are considered as flexure strength. The flexural testing machine and hybrid fiber reinforced beam is shown in Figure 2 and 3 respectively.

Flexural strength = $\frac{3}{2}\frac{pl}{bd^2}$

b: breadth of the tested beam (mm)
p: Ultimate cracking load (N)
l: length of the support span(mm)
d: depth of the tested beam(mm)

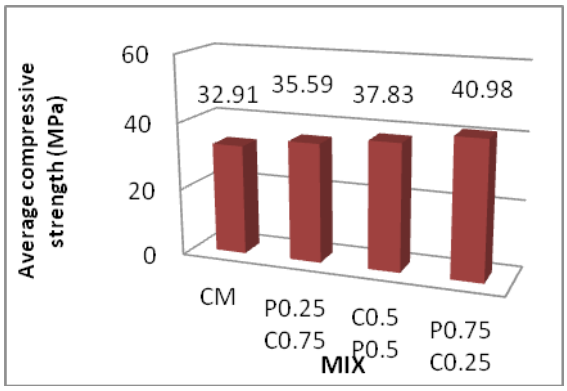
Figure 1. Control cube after compressive test.
Compressive strength = Load / Area (Mpa)

Figure 2. Test setup for flexural strength test.

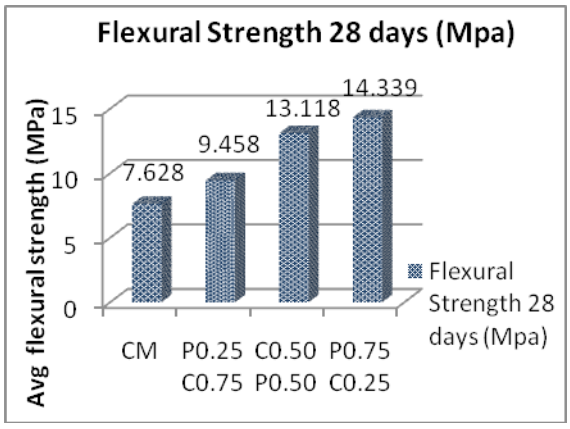
Figure 3. Hybrid fiber reinforced beam after flexural test.

Table 8. Results

Marking	Compressive strength 28 days (Mpa)	Flexural Strength 28 days (Mpa)
S-0	32.91	07.628
S- 1	35.59	09.458
S- 2	37.83	13.118
S -3	40.98	14.339



Graph1. Compressive strength at 28 days.



Graph2. Flexural strength at 28 days.

5. Results

Results of compressive strength and flexural strength test for M20 grade concrete with 0%, P0.25C0.75, P0.50C0.50, P0.75C0.25 are shown in the Table 8.The Different compressive strength vs different mix are presented in graphs 1 and 2 respectively.

6. Conclusion

The maximum compressive strength reaches in the S- 3, P 0.75C 0.25 i.e. 75% PP fiber and 25% CC fiber of weight of cement. Whereas flexural strength of HFRC containing weight fraction of 75% PP fiber and 25% CC fiber is higher than other hybrid form. Observed that cracks occur in microstructure due to axial load and fiber controls the growth of the cracks further. Hence, it is concluded that HFRC of both synthetic and natural can be used in concrete hence forth. It is limited to use as a reinforcing agent in the non-structural components.

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