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An Experimental Study on Strength Properties of Concrete By Adding Human Hair Fibers

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ABSTRACT

This project is intended to analyze the Performance of Hair Reinforced Concrete. Fiber reinforced concrete can offer a convenient, practical and economical method for overcoming micro-cracks and similar type of deficiencies. Since concrete is weak in tension hence some measures must be adopted to overcome this deficiency. Human hair is strong in tension; hence it can be used as a fibers reinforcement material. Hair Fibers (HF) an alternate non-degradable matter is available in abundance and at a very cheap cost. It also creates environmental problem for its decompositions. This particular project has been undertaken to study the effect of human hair on plain cement concrete on the basis of its compressive strength, flexural strength, and Split Tensile strength tests. Experiments were conducted on concrete beams and cubes with various percentages of human hair fibers i.e. 0%, 0.5%, 1%, 1.5% by weight of Concrete. For each combination of proportions of concrete one beam and three cubes are tested for their mechanical properties. By testing of cubes and beams we found that there is an increment in the various properties and strength of concrete by the addition of human hair as fiber reinforcement.

KEYWORDS : *Human Hair fibers (HHF), Fiber reinforced concrete (FRC), Aspect ratio, Compressive strength test, Split Tensile Strength Test, Flexural Strength Test.*

INTRODUCTION

Definition & History of concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate (usually made from different types of sand and gravel), that is bonded together by cement and water. In 1756, British engineer, John Smeaton made the first modern concrete (hydraulic cement) by adding pebbles as a coarse aggregate and mixing powered brick into the cement. In 1824, English inventor, Joseph Aspdin invented Portland cement, which has remained the dominant cement used in concrete production. Joseph Aspdin created the first true artificial cement by burning ground limestone and clay together. The burning process changed the chemical properties of the materials and Joseph Aspdin created stronger cement than what using plain crushed limestone would produce.

MATERIALS

1. Cement
2. Coarse Aggregate
3. Fine Aggregate
4. Human Hair Fibers

METHODOLOGY

1. Initial and final setting time
2. Consistency test
3. Specific Gravity

Characteristics	**Test results**	**IS:12269-1897 specifications**
Initial setting time (minutes)	45 minutes	>30 minutes
Final setting time (minutes)	580 minutes	<600 minutes
Consistency	29%	-
Specific gravity	3.15	3.15
Fineness	4.9%	<10%

Table:Test results of cement

Property	**Test results**	**IS:2386-1963 Specifications**
Fineness modulus	3.4	-
Specific gravity	2.65	2.6-2.8
Bulk density	1475kg/m^3(untraded)	-
	1624kg/m^3(ridded)	-

Table: Properties of Fine Aggregate

Property	**Test result**	**IS:2386-1963 Specifications**
Fineness modulus	7	-
Specific gravity	2.7	2.6-2.8
Crushing value	22%	<30%
Bulk density	1483kg/m^3(untraded)	-
	1563kg/m^3(ridded)	-
Abrasion test	34%	40%

Table: Properties of Coarse Aggregate

Mix design:

For ordinary concrete: Mix design for M50

- For M50 mix design Cement: F.A.: C.A.: Water = 1: 1.472: 3.043: 0.35

Mix	Cement(Kg)	Fine aggregate(kg)	Coarse aggregate(kg)	Water (kg)	W/C
M50	422	621	1284	147.6	0.35

Table: Quantities of Ingredients

Mixes Adoptd:
M1-Nominal Concrete
M2-0.5%HHF added
M3-1.0%HHF added
M4-1.5% HHF added

RESULTS AND DISCUSSION

SLUMP CONE TEST - WORKABILITY

Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199 – 199 is followed. The apparatus used for doing slump test are Slump cone and tamping rod.

Slump cone dimensions:

Bottom diameter: 20cm
Top diameter : 10cm
Cone height : 30cm

The slump measured should be recorded in mm of subsidence of the specimen during the test. Any slump specimen, which collapses or shears off laterally, gives incorrect result and if this occurs, the test should be repeated with another sample. If in the repeat test also, the specimen shears, the slump should be measured and the fact that the specimen sheared, should be recorded.

S.NO	Concrete Type	Slump Value(mm)
01	M1 – Nominal mix	35
02	M2 – 0.5% HHF added	38
03	M3 – 1.0% HHF added	42
04	M4 – 1.5% HHF added	59

Table: Slump Cone test results

Compaction factor test

S.No	Concrete Type	Partially Compacted weight(kg)	Fully Compacted weight(kg)	Compacting factor
01	M1-Nominal mix	16.61	19.550	0.850
02	M2-0.5%HHF added	17.120	19.710	0.860
03	M3-1.0%HHF added	17.4416	19.820	0.880
04	M4-1.5%HHF added	17.790	19.910	0.890

Table: Compaction factor test results

S.No	Degree of work ability	Slump test values		Compacting factor	Use for which concrete is suitable
		mm	In		
1	Very Low	0-25	0-1	0.748	Very dry mixes; used in road making. Roads vibrated by power operated machines.
2	Low	25-50	01-Feb	0.89	Low workability mixes; used for foundations with light reinforcement.Roads vibrated by hand operated Machines.
3	Medium	50-100	44288	0.92	Medium workability mixes; manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibrations.
4	High	100-175	44381	0.95	High workability concrete; for sections with congested reinforcement. Not normally suitable for vibration

Table: Suggested ranges of workability of concrete measured in accordance with IS 1199

STRENGTH TESTS ON CONCRETE:

Compressive strength test

According to Indian Standard specifications **(IS: 516-1959)**, the compression teston cubes of size 150mm X 150 mm X 150 mm were conducted. Compressive test is the most common test conducted on hardened concrete, partly because it is an easy test to perform and partly because most of the desirable characteristicsproperties of the concrete are qualitatively related to its compressive strength. Metal moulds preferably steel bar 16mm in diameter, 0.6m long and bullet pointed at the lower end serves as a tamping bar. The test cube specimens are made as soon as practicable concrete with neither segregation nor excessive laitance. The concrete is filled in to the moulds in layers approximately 5cm deep, each layer is compared by the tamping rod in 25 strokes. The test specimens are stored in a place free from vibration, in moist air of at least 90% relative humidity and at a temperature of 27℃ for 24 hours. After thus period the specimens are marked and removed from the moulds and unless required for test within 24 hours, immediately submerged in clean fresh wateror saturated lime solution and kept their until taken out just prior to test. The dried specimens are then tested on compressive testing machine.

Table: Test Results of Compressive strength(M50 Grades of concrete at 7,14 and 28 days)

S.No	Type of Concrete	Compressive strength (Mpa)		
	Number of days	7 days	14 days	28 days
01	M1 – Nominal mix	50.47	58.28	62.50
02	M2 – 0.5% HHF added	51.28	60.12	63.14
03	M3 – 1.0% HHF added	52.07	61.14	64.85
04	M4 – 1.5% HHF added	53.15	62.43	65.50

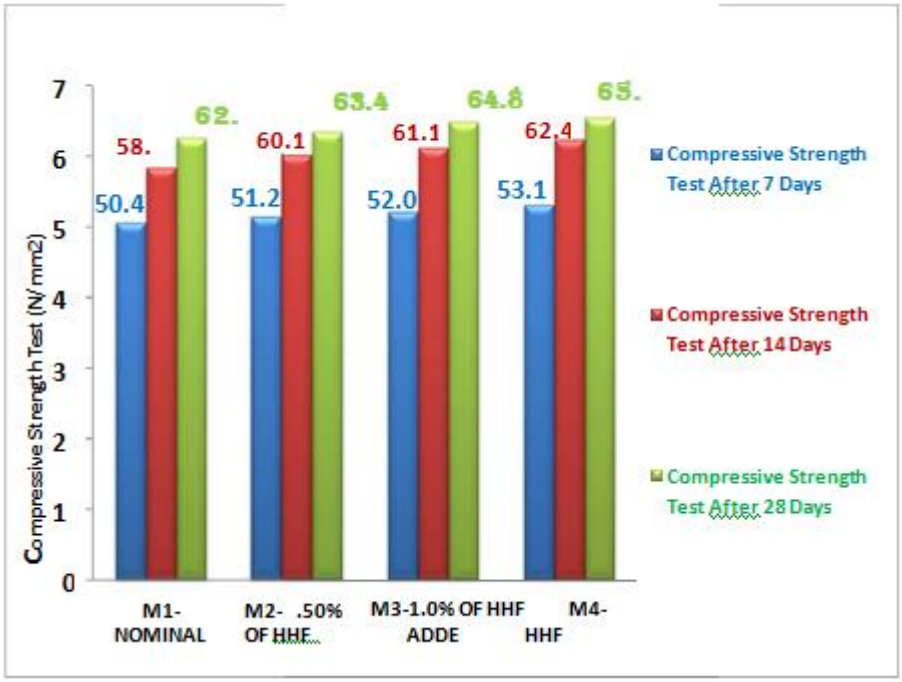

Fig : Graph Shows Different Compressive strengths of concrete (M1,M2,M3&M4)

In this section, the main concern is to study the compressive strength of concrete containing various percentages of hair fibers in combination. Control specimens are concrete with 100% cement which is compared with the strength performance of concrete containing 0.5% and 1.0% and 1.5% of human hair fiber. Cubes with the size of 150mm X 150 mm X 150 mm were tested at the ages of 7,14 and 28 days. The results of the compressive strength test are shown in Table Where each value from the results of the cubes.

From the graph shown in the Fig. specimens are concrete with 100% cement which is compared containing 0.5% ,1.0% and 1.5% of human hair fiber, (normal mix, 0.5% ,1.0% and 1.5% of human hair

fiber) has been observed as an optimal strength than other proportions at 7, 14 and 28 days.

Split Tensile Strength Test:

Split Tensile Strength, TSP = 2P/πDL

Where P = applied load

D = diameter of the specimen

L = length of the specimen

S.No	Type of Concrete	Split Tensile Strength (Mpa)		
Number of days		7 days	14 days	28 days
01	M1 – Nominal mix	2.70	3.150	3.80
02	M2 – 0.5% HHF added	3.00	3.30	3.99
03	M3 – 1.0% HHF added	3.15	3.80	4.20
04	M4 – 1.5% HHF added	3.43	4.10	4.80

Table: Test Results Of Split Tensile Strength Test (M50 Grades of concrete at 7,14 and 28 days)

In this section, the main concern is to study the Split Tensile strength of concrete containing various percentages of steel fibers in combination. Control specimens are concrete with 100% cement which is compared with the strength performance of concrete containing 0.5% and 1.0% and 1.5% of human hair fiber.

The Cylinder consist of 150 mm diameter and 300mm Long were tested at the ages of 7,14 and 28 days. The results of the Split Tensile strength test are shown in Table Where each value from the results of the Cylinders.

From the graph shown in the Fig.. specimens are concrete with 100% cement which is compared containing 0.5% and 1.0% and 1.5% of human hair fiber., (0.5% and 1.0% and 1.5% of human hair fiber.) has been observed as an optimal strength than other proportions at 7,14 and 28 days.

Flexural Strength Test

It is the ability of a beam or slab to resist failure in bending. It is measured by loading un-reinforced 5x5 inch (10 x 10 cm) concrete beams with a span three times the depth (usually 18 in.). The flexural strength is expressed as “Modulus of Rupture” (MR). Flexural MR is about 12 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used. However, the best correlation for specific materials is obtained by laboratory tests for given materials and mix design.

The testing machine used is UTM (universal testing machine). The permissible errors shall be not greater than ± 0. percent of the applied load where a high degree of accuracy is required and not greater than ± 1. percent of the applied load for commercial type of use. The bed of the testing machine shall be provided with two steel rollers, 38 mm in diameter, on which the specimen is to be supported, and these rollers shall be so mounted that the distance from center to center is 50 cm for 1.0 cm specimens or 40 cm for 10.0 cm specimens. The load shall be applied through two similar rollers mounted at the third points of the supporting span that is spaced at 20 or 13.3 cm center to center. The load shall be divided equally between the two loading rollers, and all rollers shall be mounted in such a manner that the load is applied axially and without subjecting the specimen to any tensional stresses or restraints.

$$f_s = Pl/bd^2$$

Where

b = measured width in cm of the specimen,

d = measured depth in cm of the specimen at the point of failure,

l = length in cm of the span on which the specimen was supported, and

p = maximum load in kg applied to the specimen.

S.No	Type of Concrete	Flexural Strength (Mpa)		
Number of days		7 days	14 days	28 days
01	M1 – Nominal mix	5.50	5.90	6.80
02	M2 – 0.5% HHF added	5.60	6.00	6.99
03	M3 – 1.0% HHF added	5.70	6.50	7.20
04	M4 – 1.5% HHF added	5.85	6.90	7.89

Table: Test Results Of Flexural Strength Test (M50 Grades of concrete at 7,14 and 28 days)

In this section the main concern is to study the flexural strength test of concrete containing various percentages of steel fibers in combination. Control specimens are concrete with 100% cement which is compared with the strength performance of concrete containing 0.5% and 1.0% and 1.5% of human hair fiber.

The size of specimen shall be 10 × 10 × 50 cm tested at the ages tested at the ages of 7,14 and 28 days. The results of the Split Tensile strength test are shown in Table Where each value from the results of the beams.

From the graph shown in the Fig specimens are concrete with 100% cement which is compared containing 0.5% and 1.0% and 1.5% of human hair fiber., (0.5% and 1.0% and 1.5% of human hair fiber.) has been observed as an optimal strength than other proportions at 7,14 and 28 days.

CONCLUSION

Fiber reinforced concrete and high strength concrete are being widely used as important constructional materials due to their excellent properties. An extensive knowledge of the properties is necessary in order to make best and economic use of the material. In this context, present experimental investigation aims to find the different strength characteristics of high strength HFRC. (M50)

Crack formation and propagation are very much reduced showing that hair fibre reinforced concrete can have various applications in seismic resistant and crack resistant constructions, road pavement constructions etc.

- During our research work we also faced the problem of uniform distribution of hair in the concrete. So an efficient method of mixing of hair fiber to the concrete mix is to be found out.
- A wide study on partial replacement of cement by using hair fibre is to be carried out.
- Applications fiber on other properties of composites such physical, thermal properties and appearances.
- Addition of hair fiber to conventionally reinforced beams increased the fatigue life and decreased the cracks width under fatigue loading.

HFRC have more strength in compression ,tension and Flexural Strength test

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