Investigation on Human Hair Fibre Concrete

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Abstract- *Fibre reinforced concrete (FRC) is Portland cement concrete reinforced with more or less randomly distributed fibres. In FRC, thousands of small fibres are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions. The concept of using fibres as reinforcement is not new.*

Fibres have been used as reinforcement since ancient times. FRC is cement- based composite material that has been developed in recent years. It has been successfully used in construction with its excellent flexural-tensile strength, resistance to splitting, impact resistance and excellent permeability and frost resistance. It is an effective way to increase toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar.

Fibre is a small piece of reinforcing material possessing certain characteristic properties. In the past, attempts have been made to impart improvement in tensile properties of concrete members by way of using conventional reinforced steel bars and also by applying restraining techniques. Although both these methods provide tensile strength of concrete members, they however, do not increase the inherent tensile strength of concrete itself FRC is gaining attention as an effective way to improve the performance of concrete

I. INTRODUCTION

Fibre reinforced concrete (FRC) is Portland cement concrete reinforced with more or less randomly distributed fibres. In FRC, thousands of small fibres are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions. The concept of using fibres as reinforcement is not new. Fibres have been used as reinforcement since ancient times.

In the past, attempts have been made to impart improvement in tensile properties of concrete members by way of using conventional reinforced steel bars and also by applying restraining techniques.

FRC is gaining attention as an effective way to improve the performance of concrete .The fibres are added to fresh concrete during the batching and mixing process to allow them to be equally distributed throughout the concrete.

Fibres are generally used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact abrasion, and shatter resistance in concrete.

OBJECTIVES

- Addition of the Human hair fibres to the concrete.
- Human Hair Fibres in different volumes has been added and the performances has been Compared.
- This project investigates the, compressive strength, Split tensile strength, Flexure strength, ultimate load, cracking characteristics of cubes, cylinders, prisms respectively, which are made up of Human Hair Fibre Concrete.

SCOPE OF THE PRESENT INVESTIGATION

This study mainly focus on the Compressive strength, Tensile strength and Flexure strength of Human Hair Fibre.

Reinforced Concrete (M20). Human Hair Fibres were added to the concrete in various proportions by weight starting from 0.1 % to 1%. Cubes, Cylinders, Prisms were casted and tested at 7 days and at 28 days. The various properties are measured during the test in order to explore the characteristics of the Human Hair fibre concrete.

NEED FOR THE STUDY

- Fibre reinforced concrete (FRC) offers a numerous advantages in comparison to normal concrete.
- The addition of human hairs to the concrete modifies various properties of concrete like tensile strength, compressive strength, binding properties, micro cracking control and also increases splitting resistance.

- Since human hairs are in relative abundance in nature and are non-degradable provides a new era in field of FRC.
- Various properties of hair made it suitable to be used as fibre reinforcement in concrete
- The quality and cost of effective the advanced concrete technology is needed to meet out such demands.
- Fibre reinforced high strength concrete is now widely used throughout the world on major infra-structure works under ground, rail ways, large structures.
- The fibre reinforced concrete is gaining attention as an effective way to improve the high performance of concrete.

IMPORTANCE OF FIBRES USING IN CONCRETE

Generally, Concrete is weak in tension and has a brittle character. Hence fibres are added to increase its tensile strength and improve the characteristics of construction materials. Addition of fibres to concrete makes it a homogeneous and isotropic material. When concrete cracks, the randomly oriented fibres start functioning, arrest crack formation and propagation, and thus improve strength and ductility.

Fibres are usually used in concrete for the following reasons:

i. To control cracking due to both plastic shrinkage and drying shrinkage.
ii. They also reduce the permeability of concrete and thus reduce bleeding of water.
iii. Some types of fibres also produce greater impact, abrasion and shatter resistance in concrete.
iv. The fineness of the fibres allows them to reinforce the mortar fraction of the concrete, delaying crack formation and propagation. This fineness also inhibits bleeding in the concrete, thereby reducing permeability and improving the surface characteristics of the hardened surface.

IMPORTANCE OF SELECTING HUMAN HAIR AS A FIBRE

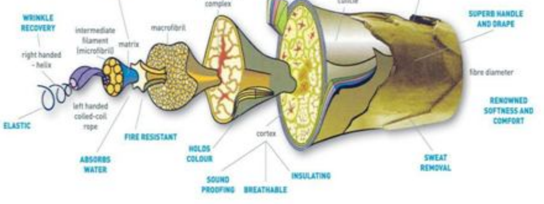


Fig: Schematic Representation Of Micro Structure Of Human Hair Fibre

Hair is used as a fibre reinforcing material in concrete for the following reasons:

- It has a high tensile strength which is equal to that of a copper wire with similar diameter.
- Hair, a non-degradable matter is creating an environmental problem so its use as a fibre reinforcing material can minimize the problem.
- It is also available in abundance and at a very low cost.
- It reinforces the mortar and prevents it from swelling.

Human Hair as innovation to the field of Fibre Reinforced Concrete, usage of Human Hair as a Fibre gained its importance. Chemically, about 80% of human hair is formed by a protein known as keratin, with a high grade of sulphur – coming from the amino acid cysteine – which is the characteristic to distinguish it from other proteins. Keratin is a laminated complex formed by different structures, which gives the hair strength, flexibility, durability, and functionality. Basically, the hair thread has a cylindrical structure, highly organized, formed by inert cells, most of them keratinized and distributed following a very precise and pre-defined design. Hair forms a very rigid structure in the molecular level, which is able to offer the thread both flexibility and mechanical resistance.

Human Hair fibre is composed by three main structures: cuticle, cortex and medulla. Proteins with α helix structure which are winded in the hair have long filaments of unknown micro fibres which link to each other to form bigger structures, in order to produce cortex cells. This enchained structure offers the capillary fibre more strength and elasticity. The main factor to be considered in the human hair is the high amount of the amino acid cistern, which may be degraded and afterwards may be re-oxidation under a disulphide bounding form. Hair is surprisingly strong. Cortex keratin is responsible for this propriety and its long chains are compressed to form a regular structure which, besides being strong, is flexible. The physical proprieties of hair involve: resistance to stretching, elasticity and hydrophilic power.

FACTORS CONTROLLING FIBRE REINFORCED CONCRETE

Properties of Concrete are affected by many factors like Properties of Cement, Fine aggregate and Coarse aggregate. Other than this Fibre reinforced concrete is affected by following factors:

Types of Fibre:

A good fibre should have good adhesion within the matrix and adaptable elasticity modulus. It must be compatible with the binder, which shouldn't be attacked or destroyed in the long term. It should be short, fine and flexible to permit mixing, transporting and placing and also strong enough to withstand the mixing process.

Aspect Ratio:

The fibre is often described by a convenient parameter called aspect ratio. The aspect ratio of the fibre is the ratio of its length to its diameter. Its value varies for different fibres.

Quantity of Fibre:

The amount of fibres added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and fibres) termed as volume fraction (V f). V f typically ranges from 0.1 to 1%. Also it can be taken as percentage by weight of cement, Fine & Coarse aggregate together that is used in preparing concrete. The increase in the volume of fibres, increase approximately linearly, the tensile strength and toughness of the composite.

Orientation of Fibre:

One of the differences between conventional reinforcement and fibre reinforcement is that in conventional reinforcement, bars are oriented in the direction desired while fibres are randomly oriented. It was observed that the fibres aligned parallel to the applied load offered more tensile strength and toughness than randomly distributed or perpendicular fibres.

Relative Fibre Matrix Stiffness:

The modulus of elasticity of matrix must be much lower than that of fibre for efficient stress transfer. The Interfacial bond between the matrix and the fibre also determine the effectiveness of stress transfer, from the matrix to the fibre. A good bond is essential for improving tensile strength of the composite.

Effects on mechanical properties of FRC addition of fibres to concrete influences its mechanical properties which significantly depend on the type and percentage of fibre. Fibres with end anchorage and properties and applications of Fibre Reinforced Concrete with high aspect ratio were found to have improved effectiveness. Below are cited some properties of FRC determined by different researchers.

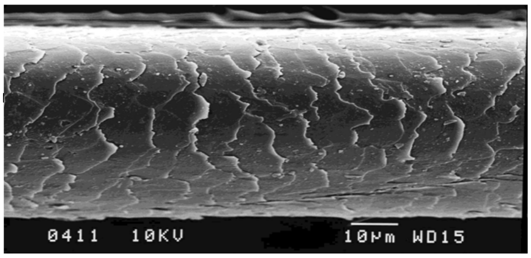


Fig :Microscopic image of human hair

EXPERIMENTAL INVESTIGATION
MATERIALS

In this investigation the Strength Concrete of 20 Mpa was used and it is designed as per the IS method.

PROPERTIES OF MATERIALS

General

The properties of materials used for preparing the concrete M20 will be described in the following sections.

Materials Used

Cement, fine aggregate, coarse aggregate , Human hair fibre, super plasticizer and water were used in this investigation. The following are the properties of the materials used.

Cement

Ordinary Portland cement of grade–53 conforming to Indian standard IS: IS: 8112-1989 has been used in the present study. The specific gravity of cement used is 3.15.

Table :Properties of cement

S. No	Physical properties of SANGHI OPC 53 cement	Result	Requirements as per IS: 8112-1989
1	Specific gravity	3.15	3.10-3.15
2	Standard consistency (%)	31.5%	30-35
3	Initial setting time (hours, min)	9 1 min	30 minimum
4	Final setting time (hours, min)	211 min	600 maximum
5	Compressive Strength N/mm² at 28 days	58 N/mm²	53 N/mm²

Fine aggregate

Fig: Fine aggregate

Aggregates are the important constituents on concrete. They give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is a good gradation of aggregates. Good grading implies that a sample fraction of aggregates in required proportion such that the sample contains minimum voids. Samples of the well graded aggregates containing minimum voids require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less water, which are further mean increased economy, higher strength, lower shrinkage and greater durability.

Coarse Aggregate

Fig: Coarse aggregate

The fractions from 20mm to 4.75mm are used as coarse aggregate. The coarse aggregates from crushed Basalt rock, conforming to IS: 383 is being used. The flakiness and elongation Index were maintained well below 15%

Water:

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully.

Human hair fibre

Human hair fibres were collected through near by saloon shops. The fibre is oftendescribed by a convenient parameter called aspect ratio. Typically aspect ratio ranges from 250 to 320. And the length of human hair fibre ranges from 6 mm to 50 mm.

Plasticizer

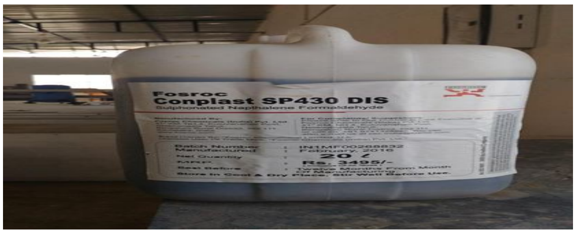


Fig :Plasticizer

Table : Quantities of plasticizer

S.NO	% OF HAIR FIBRE	WATER QUANTITY (l)	% OF PLASTICIZER	PLASTICIZER(ml)
1	0.10	27.75	0.30	83.25
2	0.20	28.56	0.60	171.13
3	0.30	29.37	0.90	264.33
4	0.40	30.18	1.20	362.16
5	0.50	30.99	1.50	464.85
6	0.60	31.80	1.80	572.40
7	0.70	32.60	2.10	686.60
8	0.80	33.41	2.40	801.84
9	0.90	34.22	2.70	923.94
10	1.00	35.03	3.00	1051.05

II. TESTS ON MATERIALS

Sieve analysis for grading of coarse aggregates [IS2368 (PART1)1963]

Pile up the bulk sample received in conical form till cone flattens. Obtain the sample for screening by method of quartering so that the sample is available. Air dries the sample at room temperature or by heating at 100-110C.Weigh the air dried sample. Place the set of sieves in descending order of their sizes of pan. Place the sample in top coarse sieve and fit the lid. Shake the whole assembly in all directions for not less than 2 minutes by hand movements on shaking platform. Remove the lid and weigh the residue carefully retained on each sieve. Tabulations are shown below.

Table Sieve analysis for coarse aggregates

Sieve No	Weight of retained (gm)	Cum weight of retained	Cum % retained	Cum% of passing	As per IS
40 mm	0.00	0.00	0.00	100	100
20 mm	40.00	2.00	2.00	98.00	85 - 100
10 mm	1410.00	70.50	72.50	27.50	0 - 20
4.75 mm	541.00	27.50	99.25	0.45	0 -5
PAN	9.00	0.45	100.00	0.00	0.00
TOTAL	2000			225.95	

Fineness modulus for Coarse aggregate: - 225.95/100 = 2.2595

Fineness modulus Test

Take 1kg of aggregate from laboratory sample of 10 kg. Arrange the sieve in order of size numbers. Fix them in sieve shaker and sieve it. Find weight in each sieve. After this process calculate total of all % weight of retained on particular sieve and divide by 100.Hence, the value of fineness modulus which unit is in number. Which shows the number of sieve from bottom to top and that sieve size is the maximum size of aggregates.

Fig : Sieve analysis apparatus

Table . Sieve analysis for fine aggregates

Sieve No	Weight of retained, gm	Cum weight of retained	Cum% retained	Cum% of passing
4.75 mm	22	22	4.4	95.6
2.36 mm	0	22	4.4	95.6
1.18 mm	97	119	23.8	76.2
600 M	130	249	49.8	50.2
300 M	170	419	83.8	16.2
150 M	65	484	96.8	3.2
TOTAL	484			337

Fineness modulus for Fine aggregate: - 337/100 = 3.37

Shape test (Flakiness Index)

Fig : Flakiness Index apparatus

Table : Flakiness index test observations

Size of aggregate		
Passing through IS sieve,mm	Retained on IS sieve,mm	Thickness gauge (0.6 times the mean sieve), mm
1	2	3
63.00	50.00	33.90
50.00	40.00	27.00
40.00	25.00	19.50
31.50	25.00	16.95
25.00	20.00	13.50
20.00	16.00	10.80
16.00	12.50	8.55
12.50	10.00	6.75
10.00	6.30	4.89

Specific gravity of aggregates [IS: 2386-(PART-3)1963]

Wash thoroughly 2 kg of aggregate sample to remove fines, drain and then place in wire basket and immerse in water at temperature between 22-30 C with cover of at least 5 cm of water above the top of basket. Immediately after immersion , remove the entrapped air from the sample by lifting the basket containing it , 25 mm a above the base of tank and allowing it to drop 25 times at about 1 drop per second. Keep the basket and aggregate completely immersed in Water for a period of 2 hours afterwards. Weigh the basket and sample while suspended in water .

Fig : Pycnometer apparatus

Calculations

Weight of saturated aggregate suspended in water with the basket $=W_1$ gm=612.4 gm

Weight of basket suspended in water$=W_2$ gm=1124.4 gm

Weight of saturated surface dry aggregate in air$=W_3$ gm=1795.9 gm

Weight of water equal to volume of the aggregate $=(W_3\text{-}Ws)$ gm$=W_4$=1487 gm

1. specific gravity =dry weight of aggregate/weight of equal volume of water

$=(w_2\text{-}w_1)/[(w_4\text{-}w_1)\text{-}(w_3\text{-}w_2)]$ = (512/[(1487-612.4)-(1795.9-1124.4)] = 2.52

2. Water absorption = Percent by weight of water absorbed in terms of oven dried weight of aggregates.

= (W3-W4)*100/W4 in % = (1795.9-1487)/1487x100 = 20.77%

Result:

Mean value of specific gravity=2.52

Mean value of water absorption=20.77%

Aggregate impact test

Fig :Impact test apparatus

Table :Aggregate impact test observations

S.NO	DETAILS	TRAIL NUMBERS		AVERAGE
		1	2	
1	Total weight of aggregate sample filling the cylindrical measure =W1 gm	1700	1600	1650
2	Weight of aggregate retained on 2.36 mm sieve after the test=W2 gm	2250	2150	2200
3	Weight of aggregate=W3	550	550	550
4	Weight of aggregate passing 2.36mm sieve after the test =W 4gm	100	100	100
5	Aggregate impact value=(W4/W3)*100	18.18%	18.18%	18.18%

Calculations

The aggregate impact value is expressed as percentage of fines formed in terms of the total weight of sample.

Let the original weight the oven dry sample be W1 g and the weight of the fraction passing 2.36mm IS sieve be W3 g.

As a aggregate impact value=(W3/W1)*100

Results

Aggregate impact value is to classify the stones in respect of their toughness property as indicated below.

Aggregate impact standard values

Aggregate impact values	Classification
<10%	Exceptionally strong
10-20%	Strong
20-30%	Satisfactory for road construction
>35%	Weak for road surfacing

Aggregate abrasion test

Fig : Abrasion test apparatus

Observations

Weight of sample W_1= 5000g
Weight of powder W_2= 350g

Calculations

Aggregate abrasion value = $[(W_2-W_1) / W_1]$ X 100
= 350/ 5000 x 100 =7 %

Results

Aggregate abrasion value = 7%

Aggregate crushing test

Weight of sample W_1= 2.7 kg
Weight of sample W_2= 40 kg
Aggregate crushing value= (W_1 / W_2) x 100
= 40 / 2700 x100 = 1.4 %

III. MIX DESIGN

Design stipulations

Characteristic compressive strength at 28 days	= 20 M Pa
Maximum size of aggregate	= 20 mm
Degree of workability	= 0.8
Degree of quality control	= good
Type of exposure	= mild

Test data for materials

Specific gravity of cement	= 3.15
Specific gravity of coarse aggregate	= 2.52
Specific gravity of fine aggregate	= 2.55
Water absorption for coarse aggregate	= 0.5%
Water absorption for fine aggregate	= 1%

Sieve analysis (confirming to IS 383-1970 , table-2)

Target mean strength of concrete

$$F_{ck} = f_{ck} + (t \text{ X } s)$$
$$= 20 + (1.65*4)$$
$$=26.6 \text{ M Pa}$$

Selection of water cement ratio

For preliminary calculation W/C ratio as given in IS 456-table no:5 for Different Environmental Conditions.

W/C ratio for M_{20} graded concrete should be 0.55 from IS code recommendations.

Selection of water and sand content

For 20 mm maximum size of aggregate , minimum water content for cubic meter of concrete is

w/c ratio	water content
0.6	186
0.35	180
0.55	?

= 180+ ((186-180)/(0.6-0.35)*(0.55-0.35))
= 184.8 litter (or) kg

Total Water content = 184.8+((1.5/100)*184.4)
= 188 litters

Determination of cement content

W/C ratio = 0.55

Cement = w/0.55

Cement = 188/0.55

Cement = 342 Kg/m^3

Determination of fine aggregate

V= (W+(C/S)+(1/P*(F_a/S_{fa}))*(1/1000)

To find P

P	w/c ratio
0.6	35%
0.35	25%
0.55	?

? = 25+((35-25)/(0.6-0.35))(0.55-0.3)

= 33%

P = 0.331-0.02

=(188+(342/3.15)+(1/0.33)*(fa/2.55))*(1/1000)

F_a = 575.105 kg/m^3

Determination of coarse aggregate

Ca = (1-p/p)*F_a*(S_{ca}/S_{fa})

= (1-0.33/0.33)*575.105*(2.52/2.55)

Ca = 1153.9kg/m^3

C	:	FA	:	CA
342	:	575.105	:	1153.9
1	**:**	**1.68**	**:**	**3.37**

Proportion for 1 cement bag

50kg : 84kg : 168.5kg

Water content in 50kg cement bag - 35 lt

0.55 - ?

w/c = 0.55

w = 0.55*c =

0.55*35

Water = 19.25 litters

Details of specimen

The programm consist of three types of specimens among those specimens one is concrete cubes and the other two specimens were beams and cylinders.

Table : Specifications of specimens

S. No	Specimen Name	Details	No's
1	Concrete cubes	Without fibre	6
2	Concrete cubes	Human hair fibres of percentages as 0.1%,0.2%,0.3%,0.4%,0.5%,0.6%,0.7%, 0.8%,0.9%,1.0%	60
3	Beams	Without fibre	6
4	Beams	Human hair fibres of percentages as 0.1%,0.2%,0.3%,0.4%,0.5%,0.6%,0.7%, 0.8%,0.9%,1.0%	60
5	Cylinders	Without fibre	6
6	Cylinders	Human hair fibres of percentages as 0.1%,0.2%,0.3%,0.4%,0.5%,0.6%,0.7%, 0.8%,0.9%,1.0%	60

Specifications of specimens

Dimensions of Concrete cubes	150 mm X 150 mm X 150 mm
Dimensions of Beams	500 mm X 100 mm X 100 mm
Dimensions of Cylinders	150 mm diameter, 300 mm height

TESTS ON CONCRETE MIX

Slump Cone Test on Concrete Mix With Addition of Human Hair Fibre

Fig :Slump cone test apparatus

REPORTING OF RESULTS

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

Table : Slump cone test values

S.NO	% OF HAIR FIBRE	SLUMP(MM)
1	0.00	25.00
2	0.10	29.54
3	0.20	34.08
4	0.30	38.62
5	0.40	43.16
6	0.50	47.70
7	0.60	52.24
8	0.70	56.78
9	0.80	61.32
10	0.90	65.86
11	1.00	70.40

COMPRESSIVE TESTS ON CUBES (150MM*150MM*150MM) WITH ADDITION OF HUMAN HAIR FIBRE

The compressive strength for different percentage of human hair added to concrete were tested at the end of 7 days and 28days using compressive strength testing machine as shown in figure 4.10 The percentage of human hair were taken as 0.1%, 0.2 %, 0.3 %, 0.4 %, 0.5 %, 0.6 %, 0.7 %, 0.8 %, 0.9 %, 1 %. Three cubes of each percentage of human hair are casted and the average of three test results is taken for the accuracy of the results. the concrete cubes were cured at room temperature. The values of compressive strength obtained are tabulated.

Fig : Compressive strength testing machine

S. No	% of fibre in concrete	VALUES @7DAYS		VALUES@28DAYS	
		Normal load(KN)	Normal stress(N/mm^2)	Normal load(KN)	Normal stress(N/mm^2)
1	0.00	370	16.44	610.66	27.40
2	0.10	380	16.92	630.45	28.20
3	0.20	390.05	17.34	650.02	28.90
4	0.30	370.25	16.56	620.10	27.60
5	0.40	400.01	17.82	660.83	28.70
6	0.50	420.40	18.73	700.50	29.23
7	0.60	440.40	19.78	740.18	29.97
8	0.70	460.23	20.55	770.06	31.25
9	0.80	430.50	19.35	720.50	30.26
10	0.90	410.20	18.17	680.15	30.19
11	1.00	390.92	17.70	670.50	30.01

SPLIT TENSILE TEST ON CYLINDERS (15CM dia, 30CM ht)

The split tensile strength for different percentage of human hair added to concrete were tested at the end of 7 days and 28 days using compressive strength testing machine as shown in figure 4.11 The percentage of human hair was taken as 0.1%, 0.2 %, 0.3 %, 0.4 %, 0.5 %, 0.6 %, 0.7 %, 0.8 %, 0.9 %, 1 %. Three cylinders of each percentage of human hair are casted. The concrete cylinders were cured at room temperature. The values of split tensile strength obtained are tabulated.

Table : Split tensile strength test values.

S. No	% of fibre in concrete	VALUES @7DAYS		VALUES@28DAYS	
		Normal load(KN)	Normal stress(N/mm^2)	Normal load(KN)	Normal stress(N/mm^2)
1	0.00	148.365	2.10	219.721	3.11
2	0.10	153.310	2.17	225.373	3.19
3	0.20	158.962	2.25	231.025	3.27
4	0.30	165.321	2.34	235.264	3.33
5	0.40	170.266	2.41	242.329	3.43
6	0.50	173.092	2.45	248.688	3.52
7	0.60	181.570	2.57	259.992	3.68
8	0.70	187.929	2.66	270.095	3.823
9	0.80	183.690	2.60	265.644	3.76
10	0.90	180.864	2.56	262.111	3.71
11	1.00	175.215	2.48	260.698	3.69

LOAD DEFLECTION TEST ON PRISMS (50CM*10CM*10CM)

The flexure strength for different percentage of human hair added to concrete were tested at the end of 28 days using universal testing machine as shown in figure 4.12 The percentage of human hair was taken as 0.1%, 0.2 %, 0.3 %, 0.4 %, 0.5 %, 0.6 %, 0.7 %, 0.8 %, 0.9 %, 1 %. Three prisms of each percentage of human hair are casted. The concrete prisms were cured at room temperature. The values of flexure strength obtained are tabulated.

Fig 3.12 Load deflection testing machine

Table : Flexure strength values for HHF Concrete

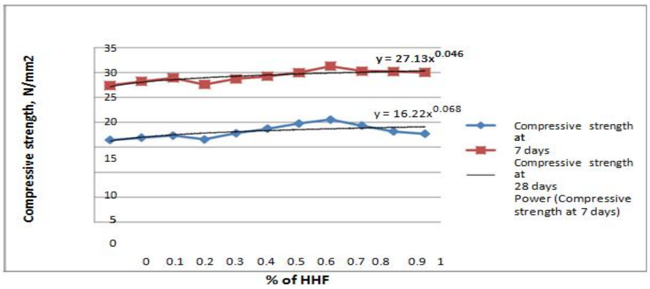
SL NO	% OF HAIR FIBRE IN CONCRETE	PEAK LOAD (KN)	DISPLACEMENT (mm)	Flexure strength (N/mm^2)
1	0.00	38.00	0.60	3.23
2	0.10	38.50	0.60	3.28
3	0.20	38.90	0.50	3.33
4	0.30	39.40	0.30	3.38
5	0.40	39.80	0.50	3.43
6	0.50	40.50	0.50	3.52
7	0.60	40.60	0.40	3.60
8	0.70	41.20	0.60	3.59
9	0.80	41.70	0.50	3.64
10	0.90	41.30	0.55	3.69
11	1.0	42.00	0.50	3.75

IV. RESULTS AND DISCUSSIONS

After a detailed study we have obtained the following results for compression, split tensile and flexure strengths.

COMPRESSIVE STRENGTH TEST ON CUBES (150MM*150MM*150MM) WITH

ADDITION OF HUMAN HAIR FIBRE



Graph : Compressive strength Vs % of HHF

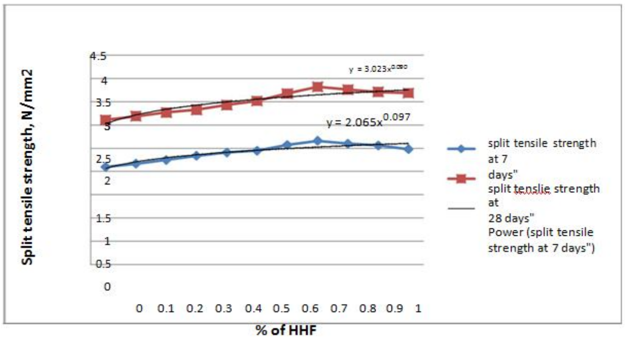
1. According to tests performed the compressive strength for the cubes of normal concrete is 16.44 Mpa at 7 days and 27.40 Mpa at 28 days.

2. It has been found that maximum compressive strengths, that is 31.25 Mpa and 20.55 Mpa was attained on addition of 0.7% of HHF to concrete at 28 and 7 days respectively.

3. For 7 days , 28 days curing period 25 % , 14.04 % increment in compressive strength of HHF concrete was found.
4. Compressive Strength was found improved on addition of HHF upto 0.7% then gradual declination was recorded on addition of HHF beyond 0.7%.

SPLIT TENSILE STRENGTH TEST ON CYLINDERS (15CM dia, 30CM ht)

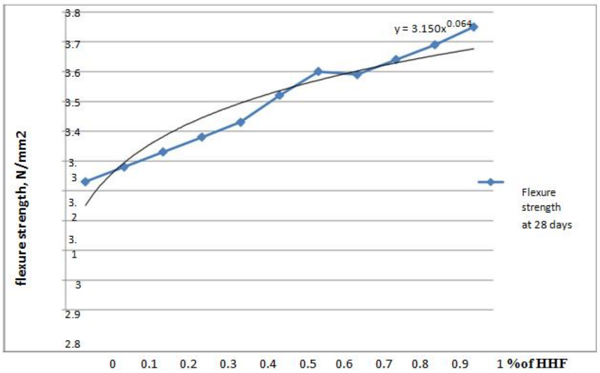
1. Split tensile strength for the conventional concrete is 2.10 Mpa at 7 days and 3.11 Mpa at 28 days.
2. Maximum split tensile strength was recorded when the addition of 0.7 % HHF to the Concrete. 2.66 Mpa , 3.823Mpa at 7 days and 28 days respectively.
3. For 7 days curing period 26.66 % increment in split tensile strength of HHF concrete was found when compared with conventional concrete.
4. For 28 days curing period 22.92 % increment in split tensile strength of HHF concrete was found when compared with conventional concrete.
5. Split Tensile Strength was found improved on addition of HHF upto 0.7% then gradual declination was recorded on addition of HHF beyond 0.7%.



4Split tensile strength Vs % of HHF

FLEXURE STRENGTH TEST ON PRISMS (50CM*10CM*10CM)

1. Flexure strength for the conventional concrete is 3.23 KN/mm2
2. Flexure strength for the HHF concrete is 3.75 KN/mm2.
3. 16% increment in Flexure strength was noted on addition of 1 % HHF
4. There is gradual increase in Flexure strength on addition of 0.1 % HHF to 1% HHF.



Graph : Flexural strength Vs % of HHF

V. SUMMARY AND CONCLUSIONS

Based on the experimental results, the following conclusions are drawn.

1. Human hair waste can be effectively managed to be utilized in fibre reinforced concrete constructions.
2. According to the test performed it is observed that there is remarkable increment in properties of concrete according to the percentages of hairs by weight of cement in concrete.
3. The human hair fibre concrete has the high compressive strength compared to the normal Concrete
4. Better split tensile strength was achieved with the addition of the human hair in concrete. The strength has increased when compared to that of the conventional concrete specimen.
5. There was an overall increase of 1-25% in the compressive strength of concrete and up to 26 in the split tensile strength of concrete test specimens by the addition of hair fibres in different quantities.
6. There was an overall increase of 1-16 % in theflexure strength of concrete .
7. It is well observed that the maximum increase is noticed in the addition of 0.7 % hair fibre, by weight of concrete, in all the mixes.
8. The human hair fibre concrete beam exhibit greater reduction in displacement at all load levels when compared to the control beam.

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