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A Study on Mechanical Properties of Concrete using Hair IBRE Reinforced Concrete

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Abstract : Fibre reinforced concrete offers a practical and economical method for Over Coming micro-cracks and similar type of deficiencies Fibres are usually use in concrete to control plastic shrinkage and dry shrinkage cracking and also to lower the permeability of concrete. It also reduces greater impact, abrasions and shatter resistances in concrete. It is an effective method of construction of light weight seismic resistant structures. 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 fibre reinforcement Material. Hair Fibre (HF), an alternate non-degradable matter, is available in abundance and at a very cheap cost. It also creates environmental problem for its decompositions. Present studies has been undertaken to study the effect of human hair on plain cement concrete on the basis of compressive, crushing, flexural strength and cracking control to economize concrete and to reduce environmental problems. For each combination of proportions of concrete three cubes are tested for their mechanical properties. By testing we found that there is an increment in the various properties and strength of concrete by the addition of human hair as fibre reinforcement.
Key Words : Machines, Partial Replacement of cement, Sand, Water, Human hair fibre, Reinforced Concrete.

1.0 Introduction

1.1general

Almost everybody has heard about the concrete and knows that it is something which is used in construction of structures. And also very few of us have heard about the fibre reinforced concrete. **Fibre Reinforced Concrete (FRC)** was invented by French gardener Monier in 1849 and patented in 1867. The concept of using fibres as reinforcement is not new. This can be proved by the following: Fibres have been used as reinforcement since ancient times. Historically, horsehair was used in mortar and straw in mud bricks. In the early 1900s, asbestos fibres were used in concrete, and in the 1950s the concept of composite materials came into being and fibre reinforced concrete was one of the topics of interest[4]. There was a need to find a replacement for the asbestos used in concrete and other building materials once the health risks associated with the substance were discovered. By the 1960s, steel, glass (GFRC), and synthetic fibres such as polypropylene fibres were used in concrete, and research into new fibre reinforced concretes continues today[2,3].

Fibre Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibres. Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibres. Fibres include steel fibres, glass fibres, synthetic fibres and natural fibres

1.2 Human Hair

Human hair is considered as a waste material in most parts of the world and is a common constituent found in municipal waste streams which cause environmental problems[3]. This particular topic has been first chosen as a method of finding the possibilities of hair rather than considering it as a non bio degradable waste material. Is also available in abundance and at a very low cost. It reinforces the mortar and prevents the spalling of concrete. The properties like high tensile strength, unique chemical composition, thermal insulation etc makes it suitable to be used as a reinforcing material.

1.3 Treatment of Hair Fibre

The hair needed for the preparation of concrete cubes was collected from salons and beauty parlours. It needs treatment before to be added in the concrete specimens.

1.4 Collection of Materials Required

The materials required for the preparation of concrete cube specimens are given in table

Table Details of necessary materials required

Mix Proportion	**M20**	**M25**
Quantity of cement (kg)	4.86	4.86
Quantity of sand (kg)	7.29	6.68
Quantity of coarse aggregate (kg)	14.58	13.36
Water cement ratio	0.5	0.55
Quantity of water (l)	2.43	3.67
Quantity of hair (kg) (1.5%)	0.073	0.1
Quantity of hair (kg) (2.0%)	0.097	0.134

2.0 Review of Literature

Concrete is weak in tension and has a brittle character[5]. The concept of using fibers to improve the characteristic of construction materials is very old. The fiber reinforced concrete was invented by French gardener Joseph Moniker in 1849 and patented in 1867. Early applications addition of straw to mud bricks horse hair to reinforce plaster and asbestos to reinforce pottery use of continuous reinforcement in concrete (reinforcement concrete) increase strength ductility, but requires careful placement and labor skill[2.4]. Alternatively, introduction of fibers in discrete from in a plain or reinforced concrete may provide a better solution

2.1 Methodology

The following tests are conductedon concrete specimens to analyse its mechanical properties like compressive strength, flexural strength etc.

i. Compressive Strength test
ii. Flexural Strength test

3.0 Compressive Strength Test (on Cubes)

The compressive strength of concrete is its ability to resist a crushing force. It is the ratio of load at failure to surface area of concrete specimen. Compressive strength test is the most common test conducted on hardened concrete as it is an easy test to perform and also most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

The compression test is carried out on specimens cubical in shape of the size 150 × 150 ×150 mm. The test is carried out in the following steps, First of all the mould preferably of cast iron, issued to prepare the specimen of size 150 × 150 × 150 mm. Calculated quantity of hair fibre is evenly added into the concrete mix manually. During the placing of concrete in the moulds it is compacted with the tamping bar with not less than 25 strokes per layer After 24 hours the specimens are removed from the moulds and immediately submerged in clean fresh water. After 28 days the specimens are tested under the load in a compression testing machine The load is applied uniformly at the rate of 14 N/mm^2inthe compression testing machine. The specimen for the test is made following manner three cubes are each M15, M2O and M25 with 0%,1.5% and 3% hair by weight of cement. The results from the compression test are in the form of the maximum load the cube can carry before it ultimately fails. The compressive strength can be found by dividing the maximum load by the contact area of the test specimen.

Let, P = maximum load carried by the cube before the failure
A = contact area normal to the load 150*150mm2 = 22500 mm
$\sigma = P/A$ N/mm^2
σ = maximum compressive stress (N/mm^2)

Equals to the Compressive strength: Therefore the results of compressive strength and the corresponding compressive strength of specimen when M15 concrete with 1.5% hair is compared with the plain cement concrete, It is found that there is an increase of 8.5% in compressive strength and when M15 concrete with 2% hair is compared with the plain cement concrete, it is found that there an increase of 12% in compressive strength. When M20 concrete with 1.5% hair is compared with the plain cement concrete, it is found that there is an increase of 1% in compressive strength and when M20 concrete with 2% hair is compared with the plain cement concrete,

It is found that there is an increase of 6.3% in compressive strength. When M25 concrete with1.5% hair is compared with the plain cement concrete, it is found that there is an increase of 1% in compressive strength and when M25 concrete with 3% hair is compared with the plain cement concrete, it is found that there is an increase of 4.44% in compressive strength.

3.1 Methods of Compressive Syrength Test on Cylinders

Compressive strength of cylinders is always less than that of cubes due to the Following reasons contact area of a cube with the upper platen in the testing machine Is more which results in more confinement and it offers resistance to specimen against expansion resulting in more compressive strength

Studies have proven that there exists a ratio between the compressive strengths of cylinders to that of cubes and in normal case it ranges between 0-8 0-9By taking this ratio to be 0.8, the compressive strength of cylinders can be roughly calculated as shown below Compressive strength of cylinders also shows are markable improvement justifying the addition of hair into the concrete mix for enhancing the mechanical properties.

3.2 Methods On fluxeral Strength Test

A flexural test is the most common procedure used to measure the tensile strength of concrete[4.]Althoughconcrete is not designed to resist direct tension, The knowledge of tensile strength is of importance in estimating the load under which cracking develop. The test is very useful especially in relation to the design of road slabs and runways because the flexure tension is a critical factor in these cases. The system of loading used in finding out the flexural tension Is third-point loading method. In this method the critical crack may appear at any section, where the bending moment is maximum the test is carried out in the following steps: First of all the mould preferably of cast iron, is used to prepare the specimen of size 150 × 150 × 700 mm. During the placing of concrete in the mould it is compacted with the tamping bar with not less than 25 strokes perlayer. After 24hours the specimens are removed.

From the moulds and immediately submerged in clean fresh water. After curing, place the specimen in the machine in such manner that the load is applied to the uppermost surface along two lines spaced at a proper gauge length, at specified rate. Increase the load till the specimen fails. Note the appearances of the fractured faces of concrete. When M15 concrete with 1.5% hair is compared with the plain cement concrete, It is found that there is an increase of 4% in flexural strength and when M15concrete with 2% hair is compared with the plain cement concrete, it is found that there is an increase of 5% in flexural strength.

When M20 concrete with1.5% hair is compared with the plain cement concrete, it is found that there is not any appreciable increase in flexural strength and when M20 concrete with 2% hair is compared with the plain cement concrete, it is found that there is an increase of 3% inflexural strength. When M25concretewith 1.5% hair is compared with the plain cement concrete, it is found that there is not any appreciable increase in flexural strength and when M25 concrete with 3%hair is compared with the plain cement concrete, it is found that there is an increase of 3% in flexural strength.

3.3 Reduction in Crack Formation

According to Grimm, 1988, a crack may be defined as a “break, split, fracture, fissure, separation cleavage or elongated narrow opening visible to thenormal human eye and extending from the surface and into a masonry unit, mortar joint, interface between a masonry unit and adjacent mortar joint The cracks are classified according to its damage level for load bearing masonry.

In order to repair cracks up to a width of 5mm, either cement can be used or steel wire meshes can be inserted into the cracks[3].Butit is found that when fibre reinforced concrete is used, crack formation and propagation is very much reduced since fibres can form a strong bond with the concrete mix and can bridge the cracks to some extent. Examining the concrete specimens after the tests, it is found that cracks were specimens with hair fibre when compared with concrete specimens without hair fibre content

4.0 Analysis

Self-compacting concrete was made of cement, sand, water, Hair and mineral admixture.

4.1 Materail used

4.1.1 Cement:

Ordinary Portland cement, 53Gradeconforming to IS: 12269 – 1987.

4.1.2 Fine aggregate:

Locally available river sand confined Grading zone II of IS: 383-1970.The sand was first sieved

Table properties of fine aggregate

Sl no	Characteristic	Value
1.	Type	River sand
2.	Specific gravity	2.6
3.	Water absorption	1.2%
4.	Fineness modulus	3.78
5.	Grading zone	II

4.1.3 Coarse aggregate:

Locally available crushed blue granite stones conforming to graded aggregate of nominal size 12 mm as per IS: 383 – 1970.

4.1.4 Hair:

Human hair waste product collected

Table properties of coarse aggregate

Sl no	Characteristic	Value
1.	Type	Crushed
2.	Maximum size	20mm
3.	Minimum size	16mm
4.	Specific gravity	2.70
5.	Water absorption	0.5%
6.	Fineness modulus	7.88

4.1.5 Water:

Water used was fresh, colorless, odorless and tasteless potable water free from organic matter of any type.

Table - properties of water

Sl no	Test particulars	Result obtained	Requirements as per IS 456-2000
1.	pH value	8.2	No less than 6
2.	Chlorine content	112.5mg/l	500mg/l
3.	Total hardness	105mg/l	200mg/l
4.	Total dissolved solids	150mg/l	-

4.2 Mix Properties

One control and eighteen HR C mixes with different replacements of polypropylene fiber were prepared and examined to quantify the properties of HRC. They are replacement of fly ash at 2%&4% of cement, The proportions for normal mix of M25 Normal Mix are as follows: - Cement: Sand: Coarse Aggregate: Water -1 : 1.50: 3.17 : 0.43

Table - Materials used for cube specimen

Mix	Hair	Coarse aggregate (g)	Fine aggregate (g)	Cement (g)
M0	0	977	751	320
M1	1.5%	903	1340	270
M2	2%	903	1340	250
M3	3%	903	1340	240

Table - Materials used for cylinder specimen

Mix	Super plasticizers 2%(of cement)	Coarse aggregate (g)	Fine aggregate (g)	Cement (g)
M0	0	1500	995	450
`M1	1.5%	1420	2103	412
M2	2%	1420	2103	404

Table - Details of specimen

Properties tested	Size in mm	Number of specimens
Cube compressive strength	150x150x150	9
Cylinder split tensile strength	300x150ϕ	9

4.3 Batching, Mixing and Casting

Careful procedure was adopted in the batching, mixing and Operations. The coarse Aggregates and fine aggregates were weighed first with an accuracy of 0.5 grams. The Concrete mixture was prepared by hand mixing on a watertight platform. The Hair and Cement was mixed dry to uniform color separately. On the watertight platform, the coarse and fine aggregates were mixed thoroughly. To this mixture, the required quantity of cement, (Hairby weight of cement 1.5%,2%3%) were added. These were mixed to uniform color. Then water was added carefully so that no water was lost during mixing. The top surface of the specimen was leveled and finished. After 24 hours the specimens were de molded and were transferred to curing tank where in they were allowed to cure for 7,14 and 28days.

4.4 Test Results and Discussion

4.4.1 Test on Fresh Concrete

Slump Flow:

The slump flow test is used to assess the horizontal free flow of FRC in the absence of obstructions. On lifting the slump cone, filled with concrete, the concrete flows. The average diameter of the concrete circle is a measure for the filling ability of the concrete. The time T50cm is a secondary indication of flow. It measures the time taken in seconds from the instant the cone is lifted to the instant when horizontal flow reaches diameter of 500mm.

Table -Acceptance criteria for FRC

Test	Range	Result
Slump flow	650-800	715mm
V-Funnel (sec)	6-12	7.1sec
U-Box value (h1/h2)	0-30	26
L-Box(h1/h2)	0.8-1.0	0.94

4.4.2 Test on Hardened Concrete

Compressive strength test:

The compressive strength of concrete is one of most important properties of concrete in most structural applications. for compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm and cylindrical specimen of size 300 x 150 mm were cast forM25 grade of concrete. After curing, these cubes were tested on compression testing machine as shown in. the failure load was noted. in each category three cubes were tested and their average value is reported. the compressive strength was calculated as follows, Compressive strength (MPa) = Failure load / cross sectional area.

Table - Compressive strength for concrete cubes

Type of concrete	Cube	Compressive strength (N/mm^2)	Average Compressive strength (N/mm^2)
M20 with 0.0%	A1	26.55	26.55
	A2	26.88	
	A3	26.58	
M20 with 1.5%	B1	28.65	27.96
	B2	27.96	
	B3	28.75	
M25 with 3%	C1	36.21	35.64
	C2	35.64	
	C3	36.47	

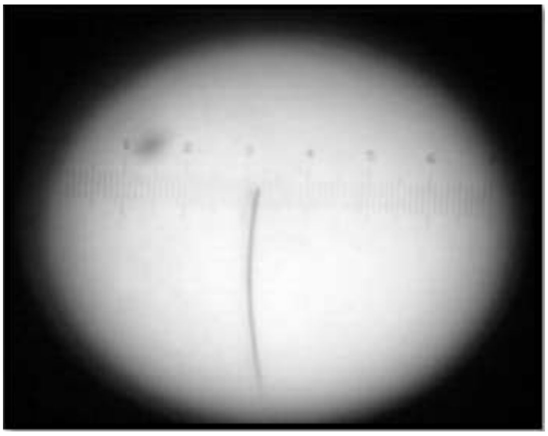
Split Tensile Strength of Concrete

The cylinder sizes were 150mm x 300 mm. Test being conducted using the compressive strength machine. the spilt tensile strength (Ft) is calculated using the following expression. $Ft=2P/3.14*D*L$ Where,

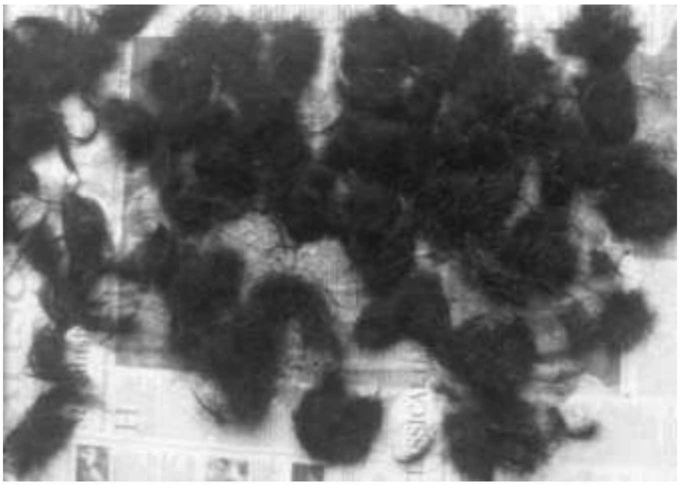
Ft = spilt tensile strength in N/mm2,P = applied load in N
D = diameter in mm ,L = length in mm

Table - Split tensile strength for concrete cylinders

Type of concrete	Cylinders	Split tensile strength (N/mm^2)	Average split tensile strength (N/mm^2)
M20 with 0.0%	A1	3.81	3.81
	A2	3.92	
	A3	3.86	
M20 with 1.5%	B1	4.08	4.02
	B2	4.02	
	B3	4.11	
M25 with 3%	C1	4.67	4.58
	C2	4.58	

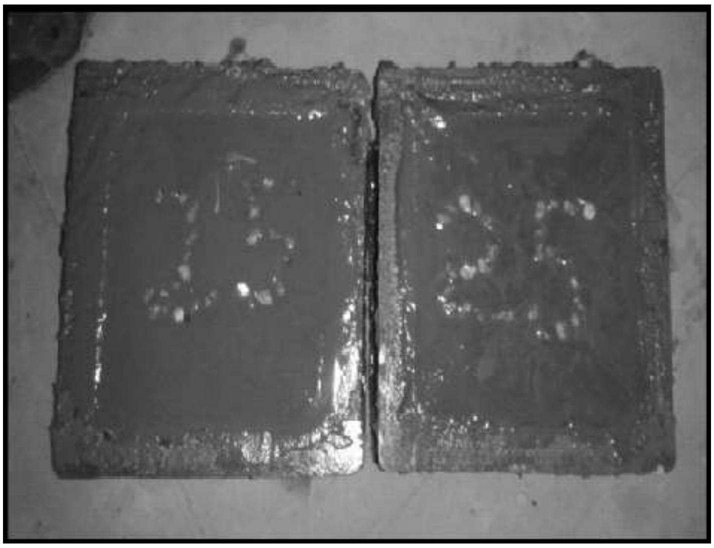


Picture of Microscopic image of hair



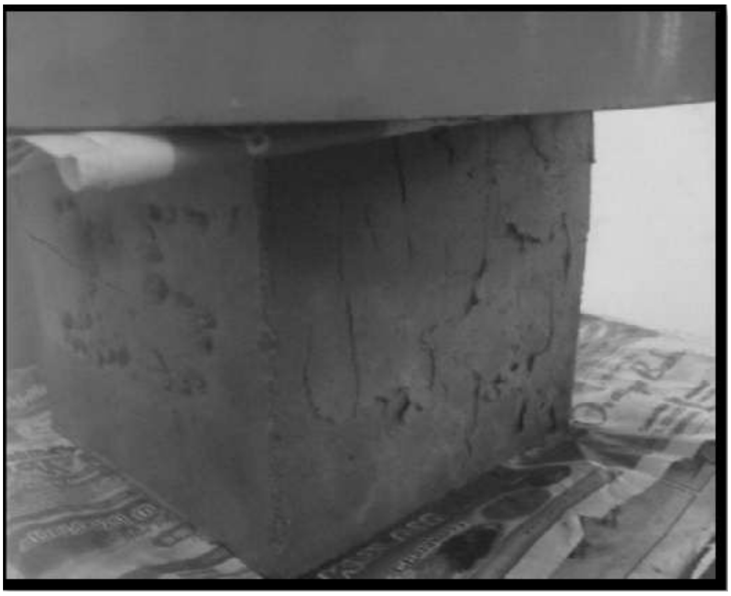
Picture of Image of Human hair

Picture of Cleaning Hair using Acetone



Picture of Concrete Cube Specimens

Picture of Cube specimen



Picture of Compressive testing machine

5.0 Conclusion

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. There was an overall increase of 1 to12% in the compressive strength of concrete and upto 5% in the flexural strength of concrete test specimens by the addition of hair fibres in different quantities.

It is well observed that the maximum increase is noticed in the addition of 1.5%3% hairfibre, by weight of concrete, in all the mixes. It is noted that maximum increase in the compressive strength is observed for lower concrete mixes,making the hair fibre reinforced concrete best suitable to the applications with those concrete mixes crack formation and propagation are very much reduced showing that FRC can have its applications in seismic resistant constructions. 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 fibre to concrete mix is to be found out.

A wide study on partial replacement of cement using fine hair fibre out applications of hair fibre reinforced concrete in the construction of seismic resistant structures. The distribution matrix of hair in concrete since the resultant matrix could affect the properties.

The study of admixtures and super plasticizer which could distribute the hairs without affecting the properties of concrete. The research can be further extended to study the influence of hair fibre on other properties of composites such physical, thermal properties and appearances

According to the test performed it is observed that there is increment in strength in concrete by increased the percentage of hair by weight of cement 0% to 3%. And at 3.5% the concrete strength was started decreasing. So the hair 3% is the mean value for adding of hair percentage by weight of cement, after adding of 3% of hair it was failure. The results are similar in compression test and splitting tensile test, i.e. compression

Test and splitting tensile test 3% of hair by weight cement is mean point to failure of concrete.

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