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An Experimental Study of Human Hair in Concrete as Fiber Reinforcement

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Abstract:
Since the ancient times, many researches and advancements were carried to enhance the physical and mechanical properties of concrete. Fiber reinforced concrete is one among those advancements which offers 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 generally strong in tension; hence it can be used as a fiber reinforcement material. Human hair fiber is an alternative non degradable matter available in abundance and at cheap cost, it is also reducing environmental problems. Also, addition of human hair fibers enhances the alternative non-degradable matter available in abundance and at cheap cost. It also reduces environment problems. Also, addition of human hair fibers enhances the binding properties, micro cracking control, imparts ductility and also increases swelling resistance. The experimental finding in our studies would encourages future research in the direction for long term performance to extending this cost of effective type of fibers for use in structural applications. Experiments were conducted o concrete cubes, cylinder and beams of standard sizes with addition of various percentages of human hair fiber i.e., 0%, 0.5%, 1%, and 1.5% by weight of cement, fine & coarse aggregate and results were compared with those of plain cement cubes, three cylinders and three beams were tested for their respective mechanical properties at curing periods of 3,7, and 28 days, Optimum hair fiber content was obtained as 1.5% by weight of cement.

Keywords: Human Hair, Concrete, Fiber Reinforcement.

INRODUCTION:

Fiber Reinforcement concrete is concrete containing fibrous material which increases as structural and is gaining importance, it contains short discrete fibers that are uniformly distributed and randomly oriented. The concept of using fibers as reinforcement is not new, Fibers have been used as reinforced since ancient times, Historically, horsehair was used in mortar and straw in mud bricks, In the early 1900s asbestos fibers were used in concrete , and in the 1950s the concept of composite materials came into being and fiber reinforced concrete was one of the topics of interest, Later the use of asbestos for concrete reinforcement was discouraged due to the associated health risks, New materials like steel, glass and synthetic fibers replaced asbestos for reinforcement.

A fiber is a small piece of reinforcing material possessing certain characteristics properties, Addition of fibers to concrete influences its mechanical properties which significantly depend on the type, length and percentage of fiber, generally concrete is weak in tension and has a brittle characteristics of construction materials.

Fibers are usually used in concrete for the following reasons: -

1) To control cracking due to both plastic shrinkage and drying shrinkage.
2) They also reduce the permeability of concrete and thus reduce bleeding of water.
3) They produce greater impact, ductility, strength, abrasion and shatter resistance in concrete.
4) The fineness of the fibers allows them to reinforce the mortar fraction of the concrete, delaying crack formation and propagation.

This fineness also inhibits in the concrete, thereby reducing permeability and improving the surface characteristics of the hardened surface. But use of higher percentage of fiber is likely to cause segregation and harshness of concrete and mortar.

The fiber is often described by a convenient parameter called aspect ratio. The aspect ratio of the fiber is the ratio of its length to its diameter, its value varies for different fibers. Reinforced concrete with high aspect ratio was found to have improved effectiveness. The modulus of elasticity of matrix must be much lower than tough fiber for efficient stress transfer. The interfacial bond between the matrix and the fiber also determines the effectiveness of stress transfer, from the matrix to the fiber. A good bond is essential for improving tensile strength of composite. Basically, the hair thread has a cylindrical structure, highly organized formed by insert 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 flexible and mechanical resistance, Human hair has about 65-95% of its weight in proteins, 32% of water. lipid pigments and other components why human hair a fiber?

Hair is used as fiber reinforcing material in concrete for the following reasons

1) It has high tensile strength which is equal to that of copper wire with similar diameter.
2) Hair a non-degradable matter is creating an environment problem so it used as fibro reinforcing material can minimize the problem.
3) It also available in abundance and at a very low cost.
4) It reinforces the mortar and prevents it from spelling.

In this experimentally study, human hair fibers are incorporated into concrete at content of 0.5, 1 and 1.5% by weight of cement. Cubes, beams and cylindrical specimens are casted and cured properly for evaluating various mechanical properties. These specimens made of human hair fiber reinforced concrete are tested at 3,7 and 28 days and the change in mechanical properties when compared to plain cement concrete is observed.

LITERATURE REVIEW:

This chapter presents the background information on the issue to the consider in the presents research work and to focus the significance of the current study.

Dr Sinan Abdul Khaleq Yaseen, University of Salahaddin published a paper on “An Experimental Investigation into the mechanical properties of New Natural Fiber Reinforced Mortar in 2013.This paper highlights use of human hair fiber as reinforced material in cementitious material. Tests were carried to study the influence of fiber content on the compressive strength, splitting tensile strength, flexural strength and load deflection was presented for two w/c ratio (0.6 and 0.7). Energy absorption capacity and ductility factor were improved considerably with the fiber content increased , which makes using the HHF suitable

for seismic force resistant structures, Jain , D and Kothari , A, it is observed that there is remarkable increment in properties of concrete according to the percentages of hairs by weight of in concrete, When M20 concrete with 1% hair is compared with the plain cement concrete, it is found that there is an increase of 10% in compressive strength and 3.2% in flexural strength. When M20 concrete with 1% hair is compared with the plain cement concrete, it is found that there is no increase in compressive strength and 2% in flexural strength. When M20 concrete with 1.5% hair is compared with the plain cement concrete, it is found that there is an increase of 8.8% in compressive strength and 5.5% in flexural strength. When M25 concrete with 1% hair is compared with the plain cement concrete, it is found that there is an increase 4.6% in compressive strength and 3% in flexural strength. When M25 concrete with 1.5% hair is compared with the plain cement concrete, it is found that there is an increase of 11% in compressive strength and 4% in flexural strength.

Nila V.M. Rajjan K.J Susmitha Antony, Riya Babu M, Neena Rose Davis, 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 concrete. There was an overall increase of 1-12% in the compressive strength of concrete and up to 5% in the flexural strength of concrete test specimens by the addition of hair fibers in different quantities, it is well observed that the maximum increases are noticed in the addition of 2% hair fiber by weight of concrete in all the mixes. it is concrete mixes making the hair fiber reinforced concrete best suitable to u the application with those concrete mixes. Crack formation and propagation are very much reduced showing that FRC can have its application in seismic construction.

METHODOLOGY:

In this study mixes we are planned to make with fiber with varying proportion of 0.5% ,1% and 1.5% control mix was taken with 0% fiber.

A. Collection of Raw Materials:

The materials used in this study are ordinary Portland cement: 53 grade ACC Cement Human hair fiber, Human hair fiber collected from the salon shop in the Visakhapatnam district.

These fibers are chapped into 3.5cm length and washed these fibers in the acetone for washing or polishing purposes.

1. Water: Collected from the local fresh water sources.
2. Fine Aggregate: River sand passing through 4.75mm sieve size.
3. Coarse Aggregate: Aggregate size of 20mm
4. Basic Test Results of Materials

For all the materials used in the project following basic tests were conducted according to the IS specifications.

B. Basic Test Results for Cement

- Fineness of cement= 7.16%
-Specific gravity of cement=3.195
-Normal consistency of cement=31.5%
-Penetration depth for initial setting time=5mm
-Penetration depth for initial setting time=32mm

C.Basic Test Results for Fine Aggregate

-Sieve analysis for fine aggregate= zone-1
-Specific gravity of fine aggregate= 2.519
- Water absorption for fine aggregate= 0.2

D.Basic Test Results for Coarse Aggregate

-Seive analysis for coarse aggregate= table 2 of IS 383-1970
-Specific gravity for coarse aggregate= 2.707
-Water absorption for coarse aggregate= 1.689

IV EXPERIMENTAL WORK

A Mixes

Four mixes are planned by cement content with human hair in percentages of 0,0.5, 1, 1.5 by weight of cement material was incorporated in all the mixes. Plain concrete in which 0% human hair fiber was taken as control mix. For each mix 4cubes of 150 x 150 x150mm size and 3Cylinders of 150mm dia and 300mm length and 3 beams of 700mm x 150mm x 150mm sizes were casted.

Mix Proportions (M20 Grade, as per IS 10262-2009)

Material	water	Cement	Fine Aggregate	Coarse Aggregate
In kg/m3	186	294	724.888	1169.640
Ratio	0.5	1	2.466	3.978

Mix proportions for human hair fiber reinforced concrete blended with concrete (M20grade) Taking control mix proportions as reference mix proportions for other mixes were calculated. Here the mix proportions for the mix in which and 0.5% fiber was incorporated are given below.

Material	Water	Cement	Fine Aggregate	Coarse Aggregate
In kg/m3	186	294	724.888	1173.946
Ratio	0.5	1	2.466	3.992

Casting the specimens taking the control mix design as reference weights of materials are calculated as shown above. In all the concrete mixes human hair fiber was varied in the specimen of 0.5%, 1.0%, 1.5%, by the weight of cement material content was incorporated for the w/b ratio 0.5. Total 16 cubes (150 x 150 x 150mm), 12 cylinders (150mm dia and 300mm length) and 12 beams (700mm x 150mm x 150mm) for all the 4 mixes including control mix.

Mix 1: 0% fiber
Mix 2: 0.5% fiber
Mix 3: 1.0% fiber
Mix 4: 1.5% fiber

B. Workability

To determine workability of fresh concrete the following tests were conducted.

1) Slump cone test
2) Compaction factor test

C.Tests

To know the hardening properties of concrete the following tests are conducted on the specimens for 3,7 and 28 days from time of mixing the water to the dry materials.

1) Compaction strength test (Cubes)
2) Split tensile strength test(cylinders)
3) Flexural test(beams)

V RESULTS

A. Workability

Workability of human hair fiber reinforced is decreased than the control mixes due to the presence of human hair fiber. The results of workability are shown in the following Table-1

S.NO	Mix No	Slump value(cm)	Compaction Factor
1	**Mix 1**	**5**	**0.9**
2	**Mix 2**	**6**	**0.92**
3	**Mix 3**	**6**	**0.93**
4	**Mix 4**	**4**	**0.95**

Table 1: Results of workability of Mixes

B. Compressive strength

The compressive strength of concrete is determined by testing the cubes under compressive testing machine. The results of compressive strength are shown in the Table-2, Maximum compressive strength occurred at (1.5% fiber) and its nearer to the target strength.

S.NO	For Days	Compressive Strength in N/mm2			
		Mix 1	**Mix 2**	**Mix 3**	**Mix 4**
1	3	6.36	6.61	7.01	7.15
2	7	12.42	12.64	13.12	13.46
3	28	24.32	24.65	25.31	25.63

Table 2: Results of Compressive Strength

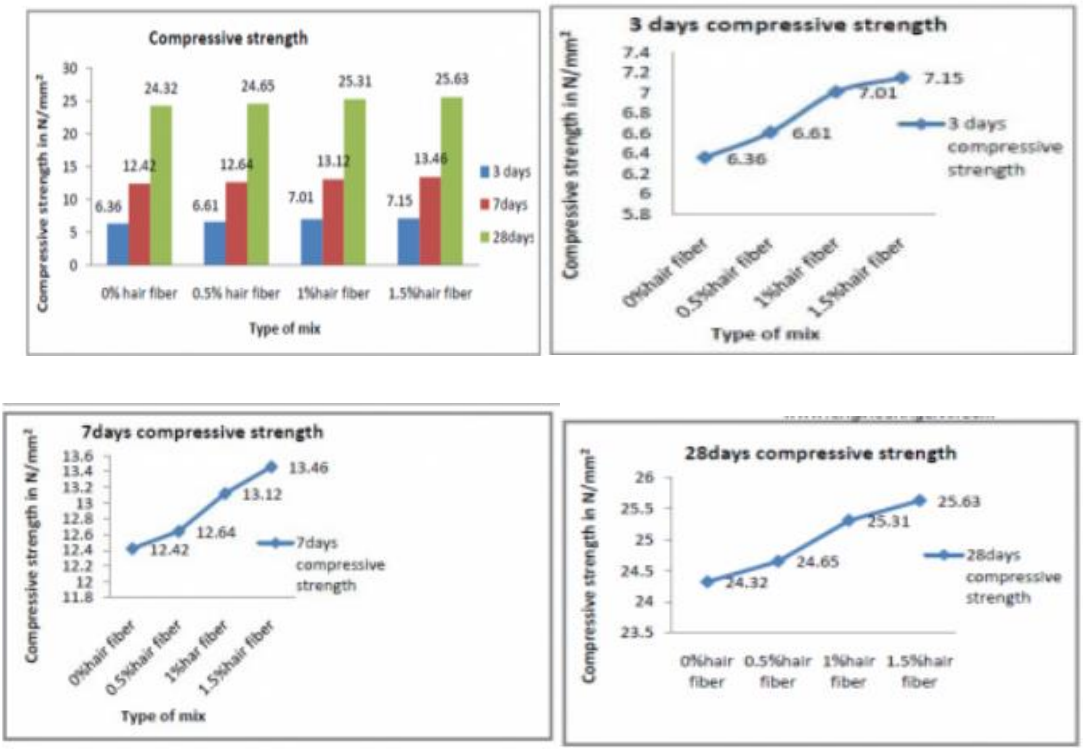
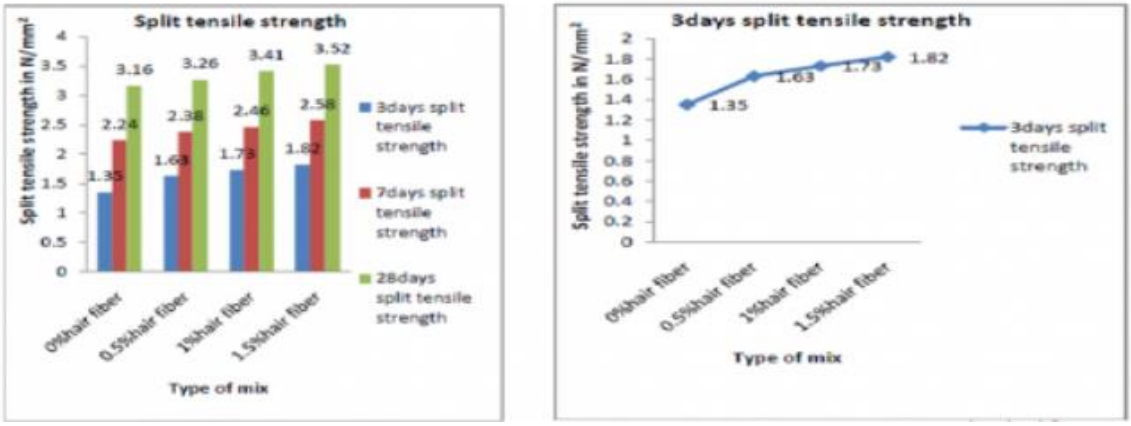


Fig 4: Variation of Hair Fiber Content v/s Compressive Strength at 3,7, and 28 days

Split tensile strength split tensile strength test was conducted for the cylinders of 150mm dia and 300mm length. The obtained values are tabulated in Table 3, Compared to conventional concrete crack width is for this fiber reinforced concrete. Splitting of specimens into two pieces can be controlled completely with this fiber.

S.No	For Days	Compressive Strength in N/mm2			
		Mix 1	Mix 2	Mix 3	Mix 4
1	3	1.35	1.63	1.73	1.82
2	7	2.24	2.38	2.46	2.58
3	28	3.16	3.26	3.41	3.52

Table 3: Results of Split Tensile Strength



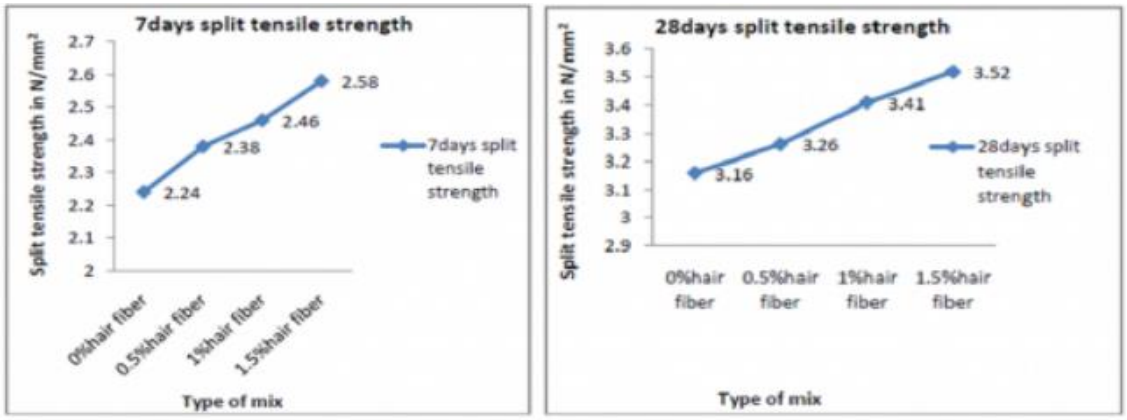
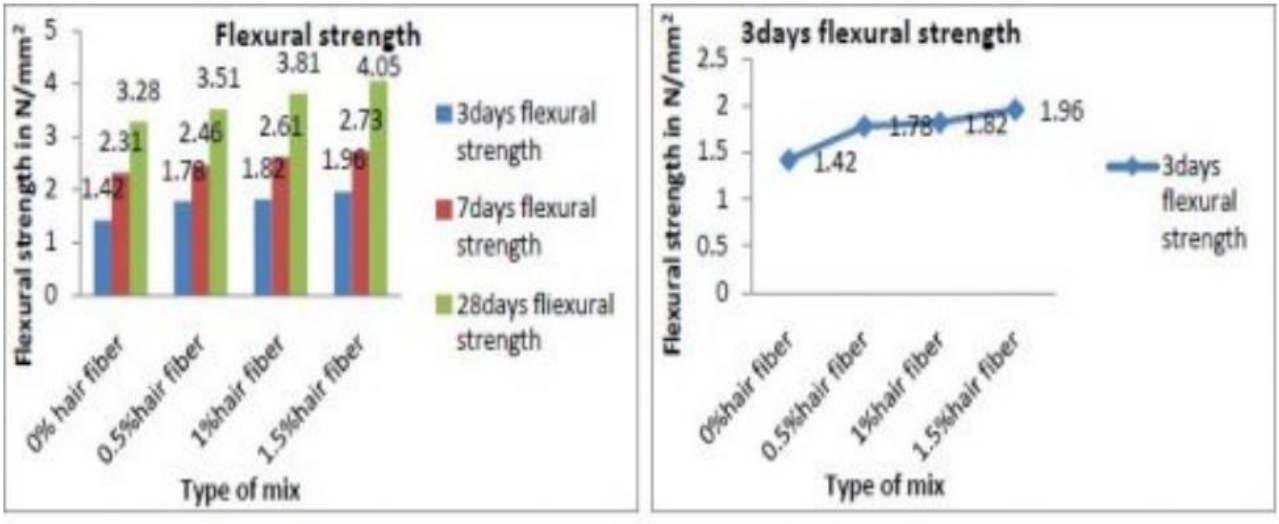


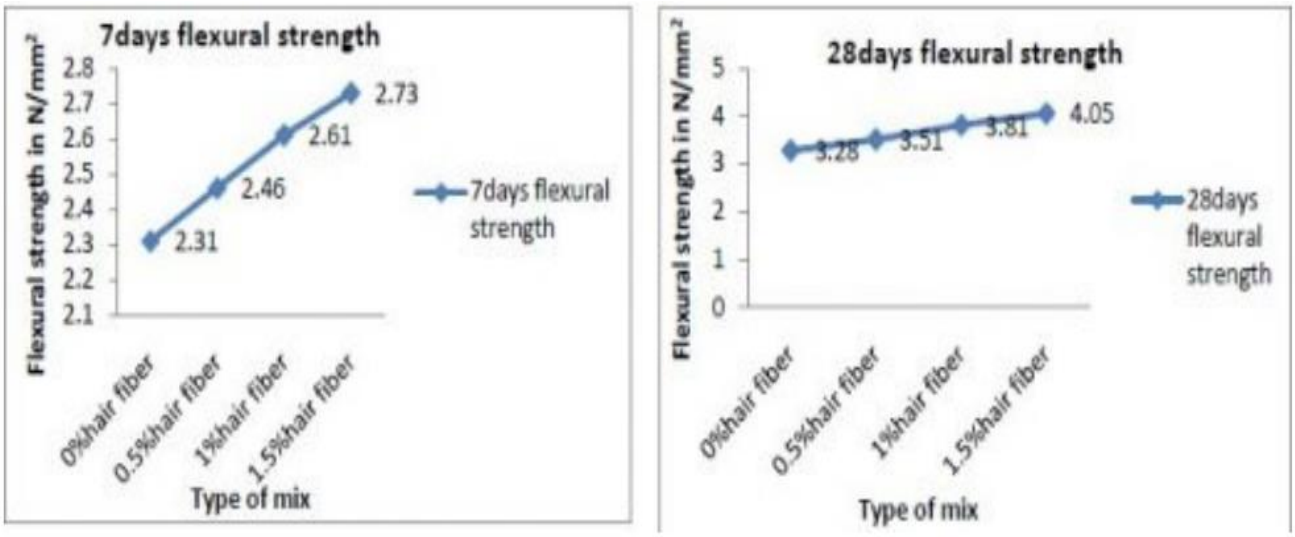
Fig 5: Variation of Hair Fiber Content v/s Split Tensile Strength at 3,7 and 28 days

Flexural strength: This test was conducted for the beams of 700mm length, 150mm wide and 150mm depth. The obtained values are tabulated in Table-4

S. No	For Days	Compressive Strength in N/mm2			
		Mix 1	Mix 2	Mix 3	Mix 4
1	3	1.42	1.78	1.82	1.96
2	7	2.31	2.46	2.61	2.73
3	28	3.28	3.51	3.81	4.05

Table 4: Results of Flexural Strength





Variation of Hair Content v/s Flexural Strength at 3, 7 and 28 Days.

CONCLUSION:

- Human hair waste can be effectively managed to be utilized in fiber reinforced concrete constructions.
- According to the test performed it is observed that there is remarkable increment in properties of concrete according to the percentage of hairs by weight of cement in concrete.
- The human hair fiber concrete has the high compressive strength compared to the normal concrete.
- 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.
- It is well observed that the maximum increase is noticed in the addition of 1.5% hair fiber by weight of concrete in all the mixes.
- Crack formation and propagation are very much reduced showing that FRC can have its applications in seismic resistant constructions.
- The addition of human hairs to the concrete not only modifies various properties of concrete like tensile strength, compressive strength but also enhances the binding properties, micro cracking control and also increases spalling resistance. The crack width is reduced to a greater extent.

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