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An Experimental Study of Human Hair in Concrete as Fiber Reinforcement

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Abstract: Since the traditional times, several researches and advancements were carried to reinforce the physical and mechanical properties of concrete. Fiber concrete is one in all those advancements that offers a convenient, sensible and economical technique for overcoming small cracks and similar sort of deficiencies. Since concrete is weak in tension therefore some measures should be adopted to beat this deficiency. Human hair is usually sturdy in tension; therefore it are often used as a fiber reinforcement material. Human hair Fiber is another non-degradable matter obtainable in abundance and at value|low-cost} cost. It additionally reduces environmental issues. additionally addition of human hair fibers enhances the binding properties, small cracking management, Imparts plasticity and additionally will increase swelling resistance.

Keywords: Human Hair, Concrete, Fibre Reinforcement.

I. INTRODUCTION

Fiber Reinforced Concrete (FRC) 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 character. Hence fibers are added to increase its tensile strength and improve the characteristics of construction materials. This fineness also inhibits bleeding 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 determine 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 inert cells, most of them keratinized and distributed following a very precise and pre-defined design.

II. OBJECTIVES

1) To develop sutaible mix design by using human hair in M20 grade concrete.
2) To determine the Compressive strength of Cubes of containing of human hair.
3) To determine the Split lastingness of Cylinders of containing of human hair.
4) To determine the Flexural strength of beams of containing of human hair.

III. EXPERIMENTAL WORK

A. Proportioning of Mix:

Four mixes are planned by cement content with human hair in percentages of 0, 0.5, 1, 1.5 by weight of cement (M 20)

-- Plain concrete in which 0% human hair fiber was taken as control mix.

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-- For each mix 4 Cubes of 150x150x150 mm size and
-- 4 Cylinders of 150mm dia and 300mm length
-- 4 beams of 700mm x150mm x150mm sizes were casted.
Mix Proportions (M20 Grade, As per IS 10262-2009)

Table1: Proportion of ingredients

Material	Water	Cement	Fine Aggregates	Coarse Aggregates
In kg/ m^3	186	294	724.888	1169.640
Ratio	0.5	1	2.466	3.978

B. Mix Design Ratio:

Casting the specimens taking the control mix design (i.e. 0% fiber) as reference weights of materials are calculated as shown above. In all the concrete mixes human hair fiber was varied in the percentages of 0.5%, 1.0%, 1.5%, by the weight of cement material content was incorporated for the w/b ratio 0.5. Total 4 Cubes (150x150x150mm), 4 Cylinders (150mm dia and 300mm length) and 4 beams (700mmx150mmx150mm) for all the 4mixes including control mix.

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

C. Collection of Materials:

The various materials collected for the manufacturing are
1. Cement
2. Fine Aggregate
3. Coarse Aggregate
4. Human hair fiber
5. Water

(1) Cement:

The Portland Pozzolana cement (PPC) of 43 grade of ACC Cement are used.

Pozzolana is a natural or artificial material which contains silica in the reactive form. Portland Pozzolana Cement is cement manufactured by combining Pozzolanic materials. This cement comprises of OPC clinker, gypsum and pozzolanic materials in certain proportions. The Pozzolanic materials include fly ash, volcanic ash, calcined clay or silica fumes. These materials are added within a range of 15% to 35% by cement weight. The strength of PPC is good than OPC in long terms. The hydration process is slower than OPC resulting low heat of hydration. Therefore, it is suitable for mass concreting. It has low percentage of sulphate alkalis, chlorides, magnesia and free lime in its composition, which makes the concrete durable. Show greater resistance to aggressive weather. PPC is available in any specific grades.

Table 2: Properties of Cement

Property	Result
Fineness of cement	2%
specific gravity of cement	3.1…..(This value is taken from IS 2720 Part 3)
Normal consistency of cement	31%
Initial setting time of cement	40 minutes
Final setting time of cement	400 minutes

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Figure 1: Cement.

2) Fine Aggregate:
River sand passing through 4.75mm sieve size.

Fine aggregates are small size filler materials in construction. Fine aggregates are the particles that pass through 4.75 mm sieve and retain on 0.075 mm sieve. River sand or machine sand, crushed stone sand, crushed gravel sand are the major sources of fine aggregate The surface area of fine aggregates is higher. The voids between the coarse aggregate are filled up by fine aggregate. Fine aggregates are used in mortar, plaster, concrete, filling of road pavement layers, etc. River sand is found in the river bed in-plane area. Grains of river sand is round in shape. This sand is clean and free from salt encrustations. No organic impurities are noticed. This sand is commonly for construction work.

Table 3: Properties of Fine Aggregate

Property	Result
Sieve analysis for fine aggregate	2.87
Specific gravity of fine aggregate	2.98
Water absorption for fine aggregate	0.30%


Figure 2: Fine Aggregate.

3) Coarse Aggregate:
Aggregate sizes of 20mm.

Coarse aggregates are larger size filler materials in construction. Coarse aggregates are the particles that retain on 4.75 mm sieve. Brick chips (broken bricks), stone chips (broken stones), gravels, pebbles, clinkers, cinders etc. are used as coarse aggregate in concrete. Dolomite aggregates, crushed gravel or stone, natural disintegration of rock are the major sources of coarse aggregate. The surface area of coarse aggregate is less than fine aggregates. Coarse aggregate acts as inert filler material for concrete. Coarse aggregates are mainly used in concrete, railway track ballast, etc.

Table 4: Properties of Coarse Aggregate

Property	Result
Sieve analysis for Coarse aggregate	7.30
Specific gravity of Coarse aggregate	2.70
Water absorption for Coarse aggregate	1.68%

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Figure 3: Coarse Aggregate.

4) Human hair fiber:

Human hair fiber collected from the saloon shop in the Vita city. These fibers are chapped into 3.5cm length and washed these fibers in the acetone for washing or polishing purposes.Human hairs have been used as a fiber here and they have been washed to remove any dust particles or any unwanted impurities present and after washing hairs are properly dried either under in oven or sun and preferably should be sorted such as they have uniform length in order to maintain and have an uniform and equal distribution of hairs while mixing the concrete. After drying, hair can be stored without any issue of decay or odor. The properties of human hair is given in a table 3.5

Table 5: Properties of Human Hair Fiber

Property	**Value**
Hair diameter	100 to 120μm
Hair length	60mm
Aspect ratio	500-600
Tensile strength of human hair fibre	380Mpa
Ultimate tensile strength	50.16%

Figure 4: Human Hair Fiber.

5) Water:
Collected from the local fresh water sources.

D. Tests & Results on specimen:

Workability:

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability, nor it is always representative of the placeability of the concrete. It indicates the characteristic of concrete in addition to the slump value. If the concrete slumps evenly it is called true slump. If one half of the cone slides down, it is called shear slump. In case of a shear slump, the slump value is measured as the difference in height between the height of the mould and the average value of the subsidence.

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Fig 5: Slump cone test.

Table 6: Results of Workability of Mixes

Sr.No	Ratio of concrete mix design	Percentages of Human Hair Content	Slump Value (cm)	Compaction Factor
1	1: 1.5: 3	0%	5	0.9
2	1: 1.5: 3	0.5%	6	0.92
3	1: 1.5: 3	1.0%	6	0.93
4	1: 1.5: 3	1.5%	4	0.95

Compressive strength test (15-516-1959):

Concrete cubes of size 150mm X 150mm X 150mm were cast with and without copper slag. During casting the cubes were mechanically vibrated using a table vibrator. After 24 hours, the specimens were demoulded and subjected to curing for 28 days in portable water. After curing the specimens were tested for compressive strength using compression testing machine of 2000KN capacity. The maximum load at failure was taken. The average compressive strength of concrete and mortar specimens was calculated by using the following equation.

Compressive Strength (N/mm^2) = Load / Cross-sectional Area

The tests were carried out on a set of four specimens and the average compressive strength values were taken.

Fig 6: Compressive strength test on Cubes.

After 28 Days Results:

Table 5.1.2: Results of Compressive Strength Test

Sr.No	Ratio of concrete mix design	Percentages of Human Hair Content	Compressive Strength (N/mm^2)	Average compressive strength (N/mm^2)
1	1: 1.5: 3	0%	24.32	24.98
2	1: 1.5: 3	0.5%	24.65	
3	1: 1.5: 3	1.0%	25.31	
4	1: 1.5: 3	1.5%	25.63	

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Split tensile strength test (IS-5816-1999):

Concrete cylinders of size 150 mm diameter and 300mm length were cast with incorporating copper slag as partial replacement of sand and cement. During casting the cylinders were mechanically vibrated using a table vibrator. After 24 hours, the specimens were demolded and subjected to curing for 28 days in portable water. After curing, the cylindrical specimens were tested for split tensile strength using compression testing machine of 2000kN capacity. The ultimate load was taken and the average split tensile strength was calculated using the equation.

Split tensile strength (N/mm^2) $=2P/\pi LD$

Where,

P- Ultimate load at failure (N).

L- Length of cylindrical specimen (mm).

D- Diameter of cylindrical specimen (mm).

The tests were carried out on a set of four specimens and the average split tensile strength values were taken.

Fig 7: Split tensile strength test on Cylinder.

After 28 Days Results:

Table 5.1.3: Results of Split Tensile Strength Test

Sr.No	Ratio of concrete mix design	Percentages of Human Hair Content	Split tensile Strength (N/mm^2)	Average of Split tensile strength (N/mm^2)
1	1: 1.5: 3	0%	3.16	3.34
2	1: 1.5: 3	0.5%	3.26	
3	1: 1.5: 3	1.0%	3.41	
4	1: 1.5: 3	1.5%	3.52	

Flexural strength test (IS-516-1959):

Concrete specimen of size 700mm X 150mm X 150mm is cast in metal mould. The metal should be of sufficient. Test specimens are stored in water before testing. The bearing surface of support and rollers are wiped, cleared and any loose sand or other material is removed.

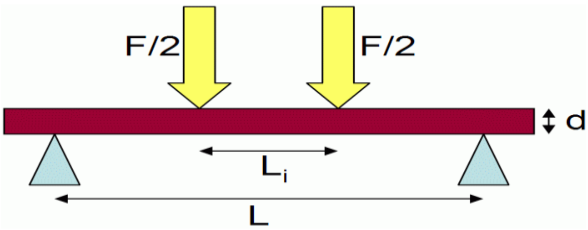

Fig 8: Position of load on Beam.

For the 4 pt bend setup, if the loading span is 1/2 of the support span (Le L=1/21 in Fig):

Flexural strength **(**f_b**)** = pl/bd^2

Where,

F- is the load (force) at the fracture point.

L- is the length of the support (outer) span.

b- is width

d- is thickness

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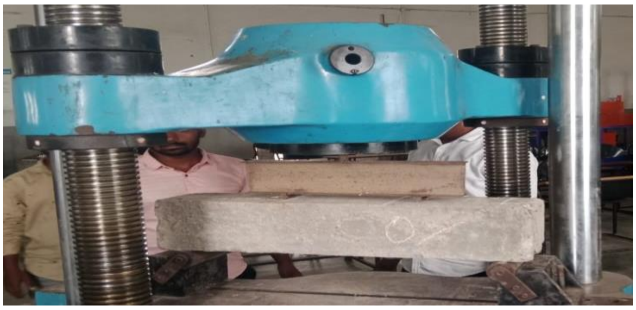

Fig 9: Flexural strength test on Beam.

After 28 Days Results:

Table 5.1.4: Results of Flexural Strength Test

Sr.No	Ratio of concrete mix design	Percentages of Human Hair Content	Flexural Strength (N/mm²)	Average of Flexural strength (N/mm²)
1	1: 1.5: 3	0%	3.28	3.66
2	1: 1.5: 3	0.5%	3.51	
3	1: 1.5: 3	1.0%	3.81	
4	1: 1.5: 3	1.5%	4.05	

IV. 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 percentages 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.
• 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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