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Past Investigations on Mechanical and Durability Properties of Natural Hair Fibre Reinforced Concrete

Mr. N. Sureshkumar[1], B. Aishwarya[2], A. Anandhi[3], S. Sona[4]
Associate Professor, Department of Civil Engineering[1]
UG Students, Department of Civil Engineering[2,3,4]
Anjalai Ammal Mahalingam Engineering College, Kovilvenni, Tiruvarur, Tamil Nadu, India
Affiliated to Anna University

Abstract: *The construction industry is the largest manufacturing industry, which produces concrete and other related materials for construction of infrastructure around the world, after the food production industry. This industry requires a lot of natural resources like aggregates, limestone etc. to produce finished product such as concrete and cement. These natural resources are limited and have to deplete one day, so alternate to these resources are required. On the other hand, this industry produces a large amount of waste material that creates environmental pollution. In the present era, to recycle waste and to reduce environmental pollution is the main objectives of sustainable development. Sustainable development in structural materials is currently getting attention all around the world. Solid waste, building and demolition waste, natural resources, and their reuse are the most obvious strategies for achieving sustainability in the construction industry. Many researchers are working on new techniques and thinking for innovation in the field of concrete technology by utilizing the waste material in concrete. As a fiber reinforcement material, Human Hair Fiber (HHF), an alternate non-degradable matter, is available in abundance and at a very cheap cost. In this review of literature paper presents the quantitative analysis of HHF as natural fibers in cement concrete.*

Keywords: Human Hair Fibre, Cement composites, Strength properties, Mechanical properties, Durability properties.

I. INTRODUCTION

Fibre Reinforced Concrete (FRC) is concrete containing fibrous 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. Different types of fiber's have been used as reinforcement, since ancient time the most economic and environment friendly fiber is human hair fiber. Human hair has about 65% - 95% of its weight is proteins, more than 32% of water, lipid pigments and other components. Chemical about 80% of human hair is formed by a protein known as Kertin with a high grade of sulphur coming from the amino acid cysteine -which is the characteristic to distinguish it from other proteins. In general the physical properties consist of resistance to breakage is a function of the diameter of the thermal of the cortex conditions. 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. It 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. 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

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fineness also inhibits bleeding in the concrete, thereby reducing permeability and improving the surface characteristics of the hardened surface.

II. CRITICAL REVIEW ON THE INVESTIGATION OF HAIR FIBER REINFORCED CONCRETE

2.1 S. Pavankumar and A.B.S Dadapeer Concluded that,

Human hair waste can be effectively managed to be utilized in fibre reinforced concrete constructions.

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.

There was an overall increase of 1-16 % in the flexure strength of concrete . 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.

2.2 T. Naveen Kumar et.al investigated that

M-40 grade concrete with 1.5% human hair fibre shown an increase in compressive strength of 7.22%, 7.21% and 8.18% at curing periods of 7 days, 14 days and 28 days respectively when compared with the plain cement concrete.

Increase in the flexural strength was in the order of 27.60%, 20.93% and 23.56% for the same experimental conditions at curing periods of 7 days, 14 days and 28 days respectively.

Similarly the split tensile strength recorded an increase of 17.26%, 29.98% and 26.60% for the same experimental conditions at curing periods of 7 days, 14 days and 28 days respectively.

2.3Shaaqib. A. Mansuri et.al experimented on,

Human hair has a place in the field of cutting edge building materials science. Analysts have very much tried the achievability and appropriateness of the human hair as a composite fiber indifferent conditions and have discovered numerous accomplishments in their important fields.

Hair fibers are beneficial added substance to concrete, which diminishes the crack arrangement and builds the durability of structure thereby reducing the problem of disposal and deterioration of environment.

2.4 Ajna Manaf et.al Concluded that,

Hair is used as an additive in various percentage by weight of cement in concrete, there is an increase in compressive strength by 12% and 22% increase in flexural strength on addition of 1% hair fibre by weight of cement.

Addition of 1% hair fibre by weight of cement shows better result in strength as compared to other percentages. Further addition shows declination in result even though there is no loss less than the target strength.

2.5 Hande Sezgin and Ipek Yalcin Enis investigated that,

The huge amount of human hair causes environmental risk in open fields due to its non-degradable characteristic. These biological wastes are efficiently utilized in fiber reinforced composites for greener and cost-effective materials.

While polymer based human hair fiber reinforced composites can be used in sport equipment, furniture and automobile parts, the most promising end-use areas of cement based ones are civil constructions in seismic zones and in case of pavement constructions.

2.6 Akshay Patel and Abhay Srivastava discussed on,

Human hair waste is used in concrete of different percentage by weight of cement in concrete. Out of five sample of hair reinforced concrete, namely 0%,0.5%,1%,1.25% and 2%, the optimum percent of hair mix of the weight of cement is to be 2% for peak value of compressive strength.

Adding 2% of hair fibre by weight of cement the compressive strength was increased by 6.03 % at 28days. The workability of hair reinforced concrete is decreasing with the using human hair as a fibre.

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2.7 Er.P.Chinnadurai and R. Anuradha discovered 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.

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 wasstarted 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.

2.8 Khawar Ali et.al experimented on,

Workability of hair reinforced concrete initially increases then decreases by increasing the amount of hair fibers.

Compressive strength of concrete increases at 65 grams, 130 grams and 195 grams of hair fibers addition while it decreases at addition of 260 grams possibly due to decrease in the density of concrete.

Tensile strength of concrete increased at 65 grams, 130 grams, and 195 grams of hairs but decreased at 260 grams of hairs addition in the cement matrix. Tensile strength of hair reinforced concrete increased by 8.64% as compared to control mix.

2.9 Rohan Sandeep Ghatage and Sunil V. Anekar concluded that,

The first phase of experiment for utilization of human hair fibers in concrete as it is showing the maximum compressive strength and flexural strength for the cube and beam specimens for M-15, M-20 and M-25 grade after 28 days.

This new approach to fiber reinforced concrete will not only create new advancements in concrete technology but will also safeguard the environment form such hazardous waste materials.

2.10 Imran Ahmed Sheikh et.al investigated that,

The optimum percentage of human hair, Rice husk ash and copper slag, is 3 %, 4.5 % and 24 % in the Split tensile strength of the concrete .The maximum Split tensile strength test is achieved 3.568 in the mix of 3 % CF+ 1.5 % RF +18 % Steel Slag.

The Flexural strength of concrete increases by the addition of human hair, Rice husk ash and copper slag. The optimum percentage of human hair, Rice husk ash and copper slag, is 3 %, 18 % and 18 % in the Flexural strength of the concrete.

The literature study concludes that the1flexural strength and compressive strength increases1with the coir fibre and Recron fibre in the concrete. The cost of forming concrete can be reduced by using human hair, Rice husk ash and copper slag in it.

2.11 S. Manivel et.al investigated that,

The Compressive strength and split tensile strength of samples with 2% addition of hair fiber increased by 28.65% and 9.12% respectively when compared with that of the conventional specimens.

The flexural strength of beams tested with addition of 2% hair fiber and replacement of 20% GGBFS fared well against the conventional specimens.

2.12 Raghav Roshan et.al discovered that,

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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2.13 Hummaira kanwal et.al concluded that,

The following conclusions have been drawn from the experimental results .The workability of concrete with 0.5% of human hair is highest and for concrete with 1.5% human hair is lower.

The strength of concrete (M4) made with 1.5% of human hair is higher than the concrete (M3 and M2) made with 1.0% and 0.5% respectively. As the strength of M4 is highest so treated human hair can be used for mixing and curing of concrete.

2.14 J. M. R. I. Shohag et.al investigated that,

Human hair (male) with various percentages used as fiber reinforcement in plain concrete is applied and investigated efficiently in an appropriate approach.

The preferable properties, compressive strength and split tensile strength of concrete have been experimented after addition of a variety of percentages of male human hair used in plain concrete considering as fiber reinforcement.

Variation of compressive strength & split tensile strength of concrete have been found utmost for 2% & 1.5% mixing of human hair fibers at 28 days respectively.

2.15 Naraindas Bheel et.al discussed that,

This study presented sustainable composite development based on a novel use of human hair as fiber in concrete.

Workability of concrete containing no fiber was higher than that of the fibre reinforced mixture.

This was as a result of gripping effect by the network of fibers. As the proportion of hair increased, then there was a subsequent drop in workability values.

2.16 Zakaria Hameed Awadallah Ibrahim concluded that,

When M20 concrete grade with 1, 1.5 and 2.5% horse hair was compared with the plain cement concrete, it was found that there was an increase of 6.76, 14.49 and24.15% in compressive strength, 3.90, 5.85 and 6.58 in splitting tensile strength and1.48, 3.81 and 9.74% in flexural strength.

When M40 concrete grade with 1, 1.5 and 2.5% horse hair was compared with the plain cement concrete, it was found that there was an increase of 5.23, 9.52 and11,67% in compressive strength, 2.68, 2.76 and 5.51 in splitting tensile strength and1.89, 4.65 and 7.42% in flexural strength.

The optimum human fiber content was taken as 2% of cement content. The addition of horse hair fiber gives the better mechanical properties of concrete strength than horse hair fibers.

2.17Sandeep Yerabati et.al investigated that,

There is increments as well as decrements in properties of M-40 grade of concrete according to the percentages of Rubber by weight of coarse aggregate (1.5% hair fixed). it is found that the optimum content of Rubber to be added to M-40 grade of concrete is 3%.

When M-40 concrete mixed with 3% Rubber (1.5% hair is fixed) is compared with the plain cement concrete, it is found that Increase in tensile strength and compressive strength.

2.18 Shailja Sharma and Er. Neeraj Studied that,

Strength and durability test were conducted on hair fiber reinforced concrete and theresults show that there is a 3.59 increase in flexural strength on addition of 2% (M25) hair fiber by weight of cement.

Strength and durability test were conducted on hair fiber reinforced concrete and the results shown that there is a 3.44 increase in split tensile strength on addition of 2% (M25) hair fiber by weight of cement.

Strength and durability test were conducted on hair fiber reinforced concrete and the results shown that there is a 34.63 increase in compressive strength on addition of 2% (M25) hair fiber by weight of cement.

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2.19 DR. A. S. Kanagalakhmi et.al concluded that,

Human hair waste can be effectively managed to be utilized in the fiber reinforced concrete constructions. According to the study performed it is observed that there is a remarkable increment in properties of concrete according to the percentages of hairs by weight of cement in concrete.

There was an overall increase in the compressive strength of 1-12% in the concrete and up to an increase of 5% in the flexural strength of the concrete test specimens by the addition of the hair fibers in different quantities. Also Crack formation and propagation are very much reduced showing that the fiberre inforced concrete can have its applications in seismic resistant constructions.

2.20Rohini B. Borkar et.al investigated that,

The expansion of human hairs to the solid not just adjusts different properties of solid like rigidity, compressive quality yet in addition improves the coupling properties, smaller scale breaking control and furthermore increments spalling opposition. The break width is diminished to a more prominent degree.

Crack arrangement and engendering are especially lessened demonstrating that hair fiber strengthened cement can have different applications in seismic safe and break safe developments, street asphalt developments and so forth.

2.21 M. Kumanachakravarthi and Dr. M. Sivaraja concluded that,

When 5% hair were added to the mix, then maximum compressive and flexural strength were noted. Compressive strength increased more than Flexural strength when compared with conventional concrete.

It was noted that a maximum of improvement in strength of concrete can be achieved by adding human hair as fiber reinforcement in concrete mix. Its has been noted that on an average the increment in the compressive strength of FRC is about 9% & that of flexural strength is 6.50% when compared with Plain cement concrete (PCC).

2.22 S Kaleem A Zaidi et.al discovered that,

In replacement range of 0-20% rice husk ash, the compressive strength of concrete increases at 5% Rice husk ash for the second mix with 0, 0.75 & 1.5% human hair fiber. It increases by 22.2, 28.9 & 25.64% respectively than 0% Rice husk ash content.

There is a remarkable increment in the addition of 1.5 % human hair fiber in compressive strength in all the mixes. The compressive strength of concrete increases with 0.75 and 1.5% of human hair fiber at 10 and 15% Rice husk ash content by 4.34 & 2.85%.

There has been a gradual increase in the compressive strength up to 1.5 % of human hair fiber and the optimum replacement level of Rice Husk Ash is found to be to 10% for M45 grade of concrete after which the strength starts decreases.

2.23 Dipshi Kapoor and Nirbhay Thakur studied that,

The concrete of M35 grade was prepared by the ratio 1:1.6:2.9. The optimum and maximum addition for compressive strength is 1.5% by the weight of cement. With very little change in compressive strength. The optimum and maximum addition of fibers for flexural is 1.5% of cement weight.

The increment of strength is 21%, the optimum and maximum addition of fibers for Split tensile strength is 2% of cement weight. The increment of strength is 29%. The high volume of fiber restricts the bond formation between concrete and fibers.

The combination of human hair and coconut fiber was found to be good in an increase in the flexural and split tensile of the concrete. Due to the high volume of natural fibers i.e coconut fiber the workability decreases because natural fibers abso

2.24 P. Sai Mahesh Reddy et.al concluded that,

Slump flow is decreasing with increase in fibre content. Replace 0.25%, 0.5%, 0.75%, 1% of fibre content in SCC mix, for 0.25%, 0.5% and 0.75% hair fibre mixes, slump flow is within limits of SCC and for 1% hair fibre mix, time exceeds the limit of SCC.

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T50CM slump is increasing with increase in fibre content. For 0.25%, 0.5% and 0.75% hair fibre mixes, time for 50cm slump is within limits of SCC and for 1% hair fibre mix; time exceeds the limit of SCC.

2.25 G. Ajaya Kumar et.al concluded that,

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.

2.26 Sakshi Gupta, Aakash Sharma et.al concluded that,

The maximum increase in strength is noticed when 2% hairs are used in concrete among all the set of cubes. It has also been observed that using human hairs not only increases compressive strength bust also improves binding property of concrete as well as formation of micro cracks is reduced.

In this experimentation they also tried using 10% of human hairs by weight of cement but while mixing it was observed that the materials were not binding properly and were falling under segregation further making it impossible to cast the cubes with 10 % hair.

Therefore it can also be concluded that using higher % of hairs is also not feasible. Usually fibre reinforced concrete finds application in managing the formation of micro cracks and even turns out to be practical and an economical method.

2.27 Ramya.T and Tamilamuthan. B et.al investigated that,

When M 35 concrete with 0.5% of hair is compared with the plain cement concrete, it is found that there is an increase of 1.34 N/mm2 in compressive strength.

When M 35 concrete with 1% of hair is compared with the plain cement concrete, it is found that there is an increase of 1.48 N/mm2 in compressive strength.

When M 35 concrete with 1.5% of hair is compared with the plain cement concrete, it is found that there is an increase of 2.67 N/mm2 in compressive strength.

When the percentage of human hair added in concrete the workability of concrete can be increased which has been analysed by slump cone test. From the study it was found that the percentage of human hair increases, the workability also increases.

2.28 Kumar Shakti Srivastava et.al concluded that,

The compressive quality of the concrete having 1.5% of HHF with 50 mm length provides maximum strength to the concrete.

An about 40% increase in impact strength can be observed up to an addition of 1.5% human hair fiber for the entire length range. At an increase of 2% HHF, the strength tends to decrease in comparison with the other percentages. However, in comparison with thenormal concrete, the addition of human hair fiber provides significant strength.

The split tensile strength of the concrete having 1% of HHF with 50 mm length proves togive better strength than other additional levels. An about 21% increase in tensile stress can be observed using HHF when compared to the controlled concrete.

2.29 Narain Das Bheel et.al investigated that,

At 0.25% human hair when used in concrete then there is an increment of 10.71% and 3.65% in cubical compressive and splitting tensile strength respectively at 1:2:4 mix ratio with 0.50 water-cement ratio.

At 0.50% human hair when used in concrete then there is an increment of 1.77% in cubical compressive strength and 7.84% decrement in splitting tensile strength at 1:2:4 mix ratio with 0.50 water-cement ratio.

At 0.75% human hair when used in concrete then there is decrement of 8.97% in cubical compressive and 5.67% in splitting tensile strength at 1:2:4 mix ratio with 0.50 water-cement ratio.

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2.30 Adhul Prakash, Harsh S et.al concluded that,

Hair is used as an additive various percentage by weight of cement in concrete. Strength and durability tests were conducted on hair fiber reinforced concrete and the results shows that there is an increase in compressive strength by 12% and 22% increase in flexural strength on addition of 1% hair fibre by weight of cement.

Increase in flexural strength indicates the reduction in micro-cracks, which is a threat durability. Addition of 1% hair fibre by weight of cement shows better result in strength as compared to other percentages. Further addition shows declination in result even though there is no loss less than the target strength.

2.31 Vishal Gadgihalli, Ramya M S et.al concluded that,

It can be observed that M20 grade concrete with hair as admixture greater than 10cm length withstands less compressive strength 21.53 compared to the hair as admixture using hairs of length greater than 5cm 22.1.This clearly states that approximately 0.5MPa of compression withstanding capacity has decreased.

Flexural strength than can be withstand by human hair as fiber reinforcement concrete greater than 10cm length, present study reveals that using human hair greater than 10cm as fiber reinforcement admixture takes 6.79MPa comparatively to using human hair greater than 5cm as using human hair greater than 5cm as fiber reinforcement admixture 7.04MPa, that is approximately 0.25MPa decrement in flexural strength in M20 grade of concrete.

Hence it says that the compressive strength &flexural strength goes on decreases as increasing the length of human hair dipped in salt water and oven dried used as fiber reinforcement admixture.

2.32 M. Manjunatha et.al investigated that,

The use of human hair in concrete reduced the development of microcracks and pores and makes concrete good in tension. Ultrasonic pulse velocity test results reveal that the use of human hairs in concrete improves the quality criteria of concrete up to 2.5% dosage; after that, the quality of concrete decreases for 3% dosage.

Mechanical properties of concrete like flexural strength, compressive strength & split tensile strength test results reveal that the optimum use of human hair as a fiber in concrete is 2–2.5%for structural application.

Durability aspects of concrete such as sorptivity and water absorption specifies that the use of human hair ass a fiber in concrete decreases the development of microcracks and pores up to2.5% dosage.

As a sustainable approach to overcome, the environmental issues and problems of human hairs can be used in concrete to make more durable, strong and economical human hairs can be effectively utilized in structural application of concrete up to 2.5% dosage.

2.33 Muhammad Akbar, Tariq Umar et.al concluded that,

Using human hair in concrete enhances the ductility of the material by minimizing the formation of macro cracks by crack bridging effect. Test results suggest that using 2% human hair fiber and replacing 15% of the cement with SF produces the best flexure, compression, and split tensile strengths. The optimum fiber and SF dosages were found to be 2% and 15%, respectively, based on experimental and RSM results. Due to the amalgamation of fibers, the results atlarger dosages were conflicting.

2.34 Nila V. M, Raijan K.J et.al investigated that,

It is well observed that the maximum increase is noticed in the addition of 2% hair fibre, by weight of concrete, in all the mixes.

It is to be 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 construction.

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2.35 Yogendra Patil, Ishwar Pati et.al investigated that,

The main aim of the study is to obtain the suitability of Hair Fibre in addition with OPC in concrete. It may be observed from the results that the properties of can be maintained withHair fibre in addition with cement in concrete up to 2% by weight of cement.

2.36 Rakesh Kr. Saini et.al concluded that

With help of fiber compressive strenth is increased upto 33%. It can revolutionised area of pavement construction.
It can be used in area where reinforcement requirement is low. Also it is eco-friendly as well as it solves the problem of solid waste.

2.37 Geeta Batham et.al investigated that,

On the basis of current study reviewed here and significant observations by various researchers in the field of human hair concrete it was observed that 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 spalling resistance.
Hence it can be concluded that human hair fibres give ideal choice of fibres in concrete if used in correct proportion and manner and human hair fibre has other advantages like it is completely biodegradable, renewable and easily available at negligible cost.

2.38 Shanker Lal Meghwar et.al investigated that,

The splitting tensile strength increases to 15% and 4.2% in 1:2:4 and 1:1.5:3 mix ratio at 1% addition of HSH respectively. And it decreases at other percentages of hair fibers.
The flexural strength of HSH fiber concrete increases to 7.4% and 6% in 1:2:4 and 1:1.5:3mix ratio respectively at 2% addition of hair fibers. It decreases at other percentages of HSH fibers.
Comparatively, higher value in both strengths was recorded at 1:2:4 mix ratio
rather 1:1.5:3 mix ratio at the same water cement ratio.
Workability in terms of slump value decreases with an increasing percentage of HSH; lower value is recorded at 3% of HSH. Comparatively, higher values of a slump are observed at 1:1.5:3 mix ratio.

2.39 Jain.D and Kothari.A et.al studied that,

By adding 1% & 1.5% of human hair as a reinforced fibre in concrete it increases the compressive strength and flexural strength in the grade of M15,M20,M25 concrete. Compared to plain cement concrete.

2.40 Saddy Ahmed and Aqsa Jamil investigated that,

The concrete mixes provided strength at 28 days higher than the design strength. The strength gain was nearly forty percent strength after 3 days, sixty five percent after 7 days, ninety percent at 3 days, 7 days and 14 days, respectively, as compared to the strength at 28 days.
The rate of increase of modulus of rupture (thirty seven percent) and compressive strength (thirty two percent) was higher as compared to split tensile strength (twenty three percent) and modulus of elasticity (nine percent).
The reduction in strength after 1.5 percent of HHFs addition may be due to water absorption property of human hair which may go beyond forty percent of its weight. This reduces waterrequired for the hydration process of cement.

III. CONCLUSION

This current literature review focused on significant observations by various researchers in the field of human hair fiber concrete. Based on the review of literature, it can be concluded that human hair fibres give ideal choice of natural fibres in concrete. If human hair fiber used in correct proportion and manner there will be a significant improvement of various properties of concrete such as splitting tensile strength, flexural strength, micro cracking control and also increases spalling resistance. The human hair has other advantages like it is completely biodegradable, renewable and easily available at negligible cost.

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