STUDY ON HUMAN HAIR IN CONCRETE AS A FIBER REINFORCEMENT

DR.A.S.KANAGALAKHMI[1], B.INDHUJA[2], U.RITHISRI[2], R.P.KOWSALYA DEVI[2]
[1]PROFESSOR, [2]STUDENT, DEPARTMENT OF CIVIL ENGINEERING.
PANIMALAR ENGINEERINGCOLLEGE, CHENNAI

ABSTRACT:-

In the modern era, recycling and reuse of waste to reduce environmental pollution is the main objective of sustainable development. Lots of researchers are running on innovative techniques and many of them were thinking for improvement in the field of concrete technology by utilizing the waste material in concrete to develop the physical and mechanical properties of the concrete. Fiber reinforced concrete is one which offers a convenient and practical and also economical method to overcome micro cracks and related types of deficiencies. In view of the fact that concrete is weak in tension therefore several measures are adopted to overcome this deficiency. Human hair fiber is used as a natural fiber to improve the strength characteristics of the concrete and as well as mortar. Human hair is normally strong in tension, for this reason it can be used as a fiber reinforcement material. Human hair is a non-degradable matter obtainable in greater quantity and also at the very cheap cost. Since human hair is non-degradable it creates environmental problems. By using human hair in concrete as fiber reinforcement it also reduces the environmental problems. Also, addition of human hair fibers in the concreteincreases the micro cracking control, binding properties, imparts the ductility and also increases the swelling resistance of the concrete. In this paper an effort has been made to review the works that have been already done in this field.

KEYWORDS

Fiber Reinforcement, Human Hair, mortar, Concrete.

I. INTRODUCTION

Fiber Reinforced Concrete is a concrete that contains fibrous material which increases the structural and its gaining importance. It has short separate fibers that are randomly oriented and equally distributed. The conception of using fibers as reinforcement is not a new method. Since ancient times fibers have been used as reinforcement. Historically, once horsehair was used in straw and mortar in mud bricks. In near the beginningof 1900s, asbestos fibers were used in the concrete and in the period of 1950s the idea of composite materials arise into existence and the fiber reinforced concrete was one of the most topics of interest. Later, in concrete reinforcement the use of asbestos was discouraged due to some of the associated health risks. Some new materials like glass, steel and synthetic fibers replaced asbestos for reinforcement.

Fiber, a small piece of reinforcing material in concretepossesses certain characteristics properties. Addition of fibers to concrete influences its mechanical properties which significantly depend upon the sort, length and percentage of fiber. Generally, concrete is weak in tension and features a brittle character. Hence fibers are added to extend its tensile strength and also improve the characteristics of the construction materials.

Fibers are usually utilized in concrete for the subsequent reasons:-

➢To control the cracking due to both plastic shrinkage and drying shrinkage.

➢They also reduce the permeability of the concrete thus it reduces the bleeding of water.

➢They produce ductility, greater impact, strength, shatter resistance and abrasion in concrete.

➢The fine quality of the fibers in the concrete allows them to strengthen the mortar fraction of the concrete, propagation and delaying thecrack formation.

Fig. 1 Example of an image of fiber reinforced concrete.

This fineness also obstructs bleeding within the concrete, thereby reducing the permeability and improving the surface characteristics of the hardened surface. But use of a larger percentage of fiber is probably going to cause segregation and harshness of concrete and mortar. The fiber is usually described by a convenient parameter called ratio. The ratio of the fiber is the ratio of its length to its diameter. Its value varies for different fibers. Reinforced Concrete with a high ratio was found to possess improved effectiveness. The modulus of the elasticity of the matrix must be much less than tough fiber for efficient stress transfers. The interfacial bond between the matrix and therefore the fiber also determine the effectiveness of stress transfer, from the matrix to the fiber. A good bond is important for improving tensile strength (lastingness) of combination. Basically, the hair thread features a cylindrical structure, highly organized, formed by inert cells, most of them keratinized and distributed following a really precise and pre-defined design. Hair forms a really rigid structure within the molecular level, which is in a position to supply the thread both flexible and mechanical resistance. Human hair has about 32% of water, 65-95% of its weight in proteins, lipid pigments and other components.

Fig. 2 A View of fibers in a concrete.

II. WHY HUMAN HAIR AS A FIBER?

Hair is employed as fiber reinforcing material in concrete for the subsequent reasons

➢Its high tensile strength (lastingness) is adequate to that of copper wire with similar diameter.

➢Hair, a non-degradable matter, is creating an environmental problem so it is used as fibro reinforcing material to minimize the matter.

➢It is also available in abundance and at a really low cost.

➢It reinforces the mortar and also prevents it from spelling.

In this study, human hair fibers are combined into the concrete at content of 0.5, 1 and 1.5% by the weight of cement. Beams, Cubes and cylindrical specimens are casted and then cured properly for estimating various mechanical properties. These specimens made from human hair fiber ferroconcrete are tested at 3, 7 and 28days and therefore the change in mechanical properties in comparison to plain cement concrete is observed.

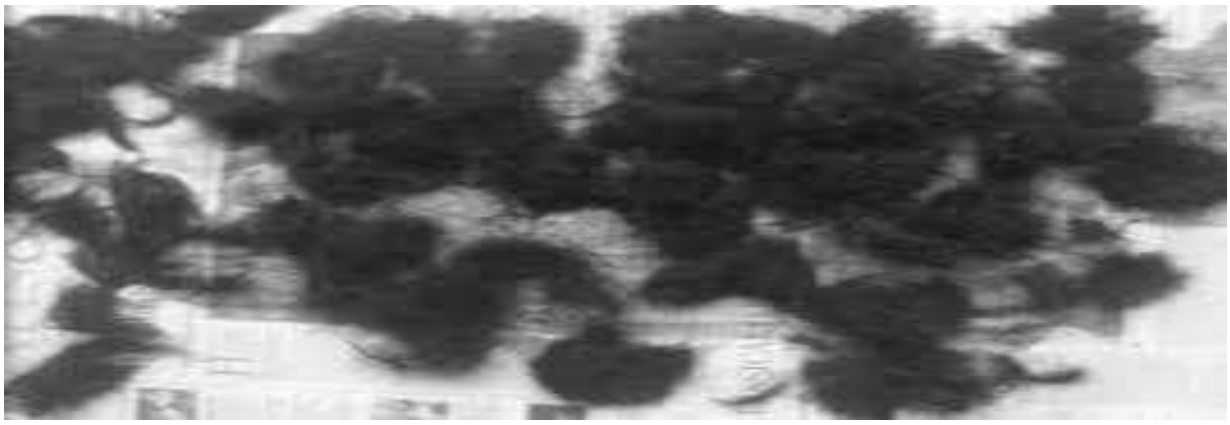

Fig. 3 Human hair fibers.

III. COMPOSITION AND PROPERTIES OF HAIR

The hair thread has a highly organized cylindrical structure which is formed by inert cells of keratin, following a very precise and pre-defined design. In terms of raw elements, on an average, hair is composed of 20.85% oxygen, 50.65% carbon, 17.14% nitrogen, 5.0% sulphur and 6.36% hydrogen. Keratin gives the hair flexibility, strength and durability. Cortex keratin is liable for this property and its long chains are compressed to form an even structure which, also being strong is flexible. And the physical properties of hair involve elasticity, resistance to stretching and hydrophilic power. The resistance to breakage is a role of the thickness of the thread, of the cortex condition. Hair fiber has an elastic characteristic, and it may go through enough stretching either dry or wet. When dry, the hair thread can stretch 20-30% of its length and in contact with water; this may reach up to 50%.

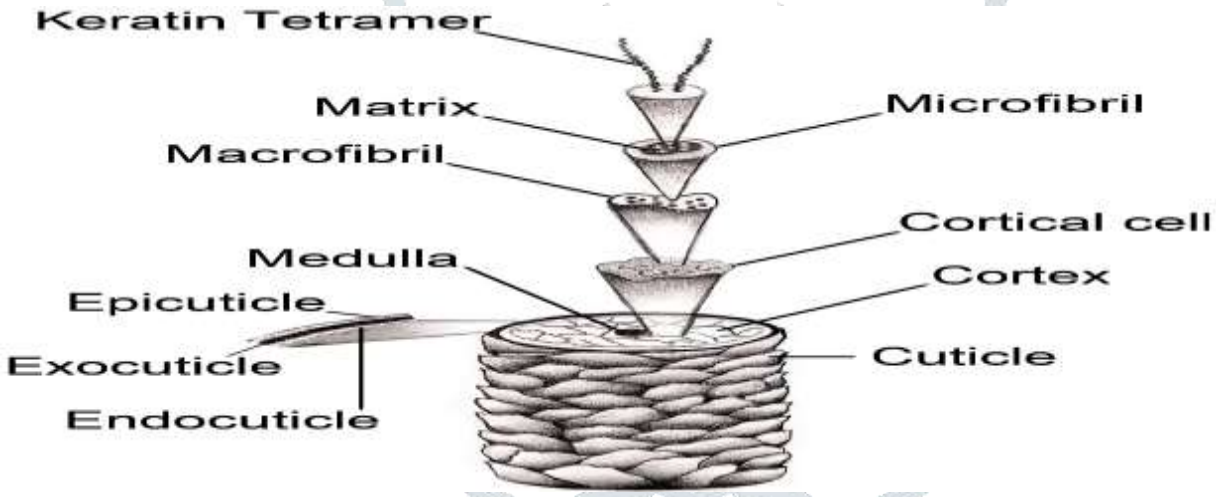

Fig. 4 Schematic of hair fiber structure.

IV. TREATMENT OF HAIR FIBER

The hair which is used for the preparation of concrete cubes was collected from beauty parlors and salons. It is to be treated before adding it to the concrete specimens. The following steps should be carried out

A. Separating: Separating hair from waste depending on the source, the collected hair may contain wastes. This has to be removed.

B. Washing: After separating, the hair is washed with acetone to remove the impurities.

C. Drying: Under the sun the hair is then dried. After drying, the hair can be stored without any concern for odor or decay.

D. Sorting: The hair is then sorted according to quality, color and length. The hair fibers are checked at random for its diameter and length.

V. PREPARATION OF MIX

Four mixes are intended by cement content with the human hair in the Percentages of 0, 0.5, 1 aand 1.5 by weight of the cement material was incorporated with all the mixes. In the Plain concrete, 0% of the human hair fiber was taken as a control mix. For each mix four Cubes of 150x150x150mm size and 3Cylinders of 150mm diameter and 300mm length and 3 beams of 700mm x150mm x150mm sizes should be casted.

VI. PREPARATION OF HAIR FIBER REINFORCED CONCRETE

First the quantity of hair fiber is calculated, calculated hair fiber is evenly added into the concrete mix manually. During placing of the concrete in the mould it should be 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 submerge in clean fresh water

VII. MATERIALS USED

A. Cement: The cement used for the present study is the Ordinary Portland Cement (OPC) having Grade 43 and the Specific Gravity of the cement used is 24kN/m2. The initial setting time of this cement is 45 minutes and final setting time is 600 minutes.

B. Fine aggregate: The fine aggregate used here is sand which is locally obtainable sand and has been obtained from grading Zone II. To make a right concrete the sand used here was first sieved through a 4.75 mm so as to eliminate any particle present with a size greater than 4.75 mm and after that the sand has been washed to clean any dust particle present.

C. Coarse aggregate: The coarse aggregates used for the present study are the crushed one and angular in shape. Here also the coarse aggregate is washed to remove any kind of impurity or dirt present. The size of aggregates used here is 12mm, 16mm and 20mm having a specific gravity of 2.74.Coarse aggregate particles used here are the one which retained on IS sieve No. 480(4.75MM) the size to be preferred for coarse aggregate depending upon the nature of the work to be carried out.

D. Human hair: 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 1

Table 1: Properties of hair

Property	Value
Hair diameter	100 to 120μm
Hair Length	60mm
Aspect Ratio	500-600
Tensile strength of human hair fiber.	380Mpa
Ultimate tensile strength	50.16%

E. Water: The water used for mixing and curing of the concrete is taken from the available local water source.

VIII.BASIC TEST RESULTS OF MATERIALS

For all the materials which are used in the project should have basic test results according to the IS specifications.

A. Basic Test Results for Cement

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

B. 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

C. Basic Test Results for Coarse Aggregate

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

IX. TEST TO BE PERFORMED

Various beams and cubes are tested and then examined for finding the effect of using human hair as fiber reinforcement. Theeffect of humanhairas fiber in the concrete is determined by conducting the following tests.

A. Compressive strength test

The test was to be conducted as per IS 516-1959. The test should be carried out on specimens cubical and cylindrical in shape of the size of 150mmx150mmx150 mm. Then Specimens should be placed on the bearing surface of the compression testing machine then a uniform rate of loading should be applied till the failure of the cube. The maximum load was then noted and then the compressive strength was calculated.

With the addition of 0.5% of hair an increase in 7% of compressive strength is observed in the study and a further addition of 0.5% increases it to 12.8%. With the further increase the strength reduces. The results are shown in Table 2.

Table 2:Average Compressive Strength of Hair Fiber Concrete

SI. No	% Hair	Compressive Strength (N/mm2)
1	0	26.6
2	0.5	28.4
3	1	30
4	1.5	26
5	2	22

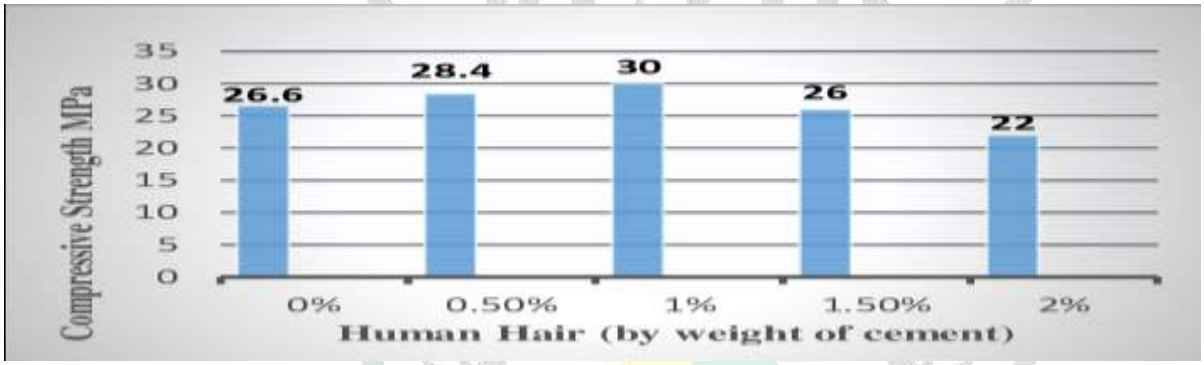

Fig. 5 Variation of compressive strength with % hair

B.Flexural Strength Test

Flexural Strength test should be carried out as per IS 516-1959 specifications. Human hair reinforced concrete beams and normal concrete beams of the size 150mm×150mm× 700mm should be tested using a flexure testing machine. The prepared specimen is to be simply supported on the two rollers of the flexure testing machine which are of 600mmat a distance with the bearing of 50 mm from the each support. The load should be applied on the beam from the two rollers that are placed above the beam having a spacing of 200mm. The load is then applied at a uniform rate therefore the extreme fibers stress increases at 0.7N/mm2 /min that is the rate of the loading shall be 4kN/min. The load should be gradually increased till the specimen fails. Note down the maximum value of the load applied.

With the addition of 0.5% of hair an increase in 2% of flexural strengthwas observed and a further addition of 0.5% increases it to 22%.

Table 3: Average Flexural Strength of Hair Fiber Concrete

SI. No.	% Hair	Flexural Strength (N/mm2)
1	0	4.67
2	0.5	4.77
3	1	5.7
4	1.5	5.72
5	2	5.68

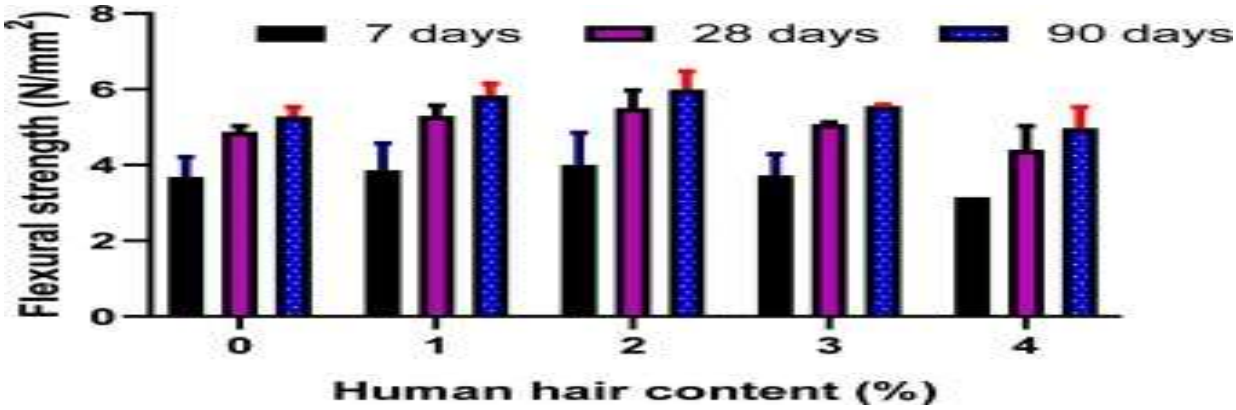

Fig. 6 Variation of flexural strength with % hair

C) Rebound Hammer Test

Rebound hammer test is usually done to show the concretes compressive strength by using the rebound hammer as per IS 13311(part 2)-1992. Rebound hammer test should be conducted on beams and cubes at twenty five selected points, with the instrument in the vertically downward direction and in the horizontal direction. In order to take the readings in the horizontal direction, corresponding to 20% of the design strength a load was applied. In cubes, the points were marked on the each of its face. In case of the beams, three sections were selected therefore A, B and C and then the points were marked on each face along with the length of the beam.

From the test done vertically downwards, the compressive strength was found from the rebound hammer test. This result will prove that the addition of hair does not affect the strength of concrete.

Sl. No	% Hair	Compressive strength (N/mm2)	Rebound number
1	0	34	33.2
2	0.5	35	34.4
3	1	37	35.28
4	1.5	37	35.56
5	2	38	36.64

D) UPV Test

UPV test is practiced to evaluate the concrete quality by ultrasonic pulse velocity (UPV) method as per IS 13311(part 1) – 1992. The fundamental principle of this test is the way of measuring the time of travel of an ultrasonic pulse passing through the concrete should be tested. Relatively higher velocity is obtained when the quality of the concrete is good in terms of uniformity, density and homogeneity.

Ultrasonic pulse velocity test (UPV) shown an increase in pulse velocity with the increase in percentage of human hair fiber in the concrete. This UPV test shows that the internal structure of the concrete is good with the increase in human hair fiber.

Table 5: UPV of hair fiber

Sl. No.	% Hair	Ultrasonic pulse velocity (28 days)
1	0	4121
2	0.5	4237
3	1	4298
4	1.5	4491
5	2	4237

Fig. 7 UPV test on concrete

E) Water Absorption Test

Three full size blocks should be completely immersed in the clean water at the room temperature for 24hours. Then the blocks should be removed from the water and then allowed to drain for one minute by placing the block on a 10mm or the coarser wire mesh then the visible surface water on the block should be removed with a damp cloth, the saturated and surface dry blocks should be weighed immediately. After weighing all the blocks should be dried in the ventilated oven at 100C to 1150C not less than 24 hours of time until two consecutive weighing at the intervals of 2hours which shows an increment of the loss not greater than the 0.2 % of the last formerly determined mass of a specimen.

If the water absorbed by the concrete percentage gets increases then the durability of the concrete gets decreased. From the water absorption tests it is observed that amount of water absorbed is decreased with addition of human hair as reinforcement in concrete. The minimum value of 2.67 percentages is obtained when adding 0.5 percentage of human hair by the weight of cement.

Table 6: Percentage of water absorption

SI. No	% Hair	Dry weight (kg)	Wet weight (kg)	% absorption
1	0	8.388	8.652	3.14
2	0.5	8.160	8.378	2.67
3	1	8.160	8.386	2.76
4	1.5	8.392	8.631	2.83
5	2	8.394	8.640	2.94

F) Sulphate Attack Test

The resistance to the sulphate attacks by the concrete was studied by determining thevariation in the compressive strength or the loss of compressive strength of concrete cubes which are immersed in the sulphate water having 5 percentagemagnesium sulphate (MgSO4) and 5 percentage of sodium sulphate (Na2SO4) by the weight of thewater and those which are not get immersed in the sulphate water. The concrete cubes of size 150mm after the periods of28days of curing and dried for 1 day were immersed in 5 percentage of MgSO4 and5 percentage of Na2SO4. The sulphate water concentration was maintained through the full period. After 28days of the immersion period, from the sulphate water the concrete cubes were removed and then water should be wiped out and the girt from the surface of the concrete cubes should be tested for the compressive strength by following the procedure given in IS 516-1959.

In Sulphate attack test, the percentage of strength loss and the percentage of weight loss will get decreased with the increase in the percentage of human hairfiber. From the observation and the study it is found that the minimum percentage ofweight loss and strength loss is obtained for 1% and 1.5% of hair fiber by the weight of cement respectively.

Table 7: Sulphate attack of hair fiber concrete

SI. No	% Hair	Weight loss (%)	Strength loss (%)
1	0	1.3	14.3
2	0.5	1.2	14
3	1	1.18	12
4	1.5	1.21	11.5
5	2	1.2	13

X. ADVANTAGES OF HAIR FIBER REINFORCED CONCRETE

➢It is used in the structures where the corrosion is to be avoided at the maximum level.

➢It is better suited to minimize the cavitation erosion damage in the structures where the high velocity flows are encountered.

➢In earthquake prone areas the use of fiber reinforced concrete would certainly minimize the human dead.

➢Fiber reduces the internal forces by locking the microscopic cracks from forming within the concrete.

➢Studies have been confirmed that the fiber reinforced concrete is found to improve the mechanical properties of concrete such as Compressive Strength, Splitting Tensile Strength, Toughness, and Impact Resistance.

XI.DISADVANTAGES OF HAIR FIBRE REINFORCED CONCRETE

➢The fibers which are added to the concrete should be uniform. This is found to be the difficult process and it consumes more time.

➢If this limitation has been overcome by the new and effective methods of the fabrication then the fiber reinforced concrete is found to be the more adaptable method for common concreting works.

XII. APPLICATIONS

A.CRACK RESISTANT STRUCTURES

Crack may be defined as a split, break, fracture, separation, cleavage, and fissure or elongated narrow opening which is visible to the normal human eye. Cracks are classified according to its damage level for the load bearing masonry. In order to repair the cracks up to a width of 5mm either cement grouting or the steel wire meshes can be inserted into the cracks. But it is found that when the fiber reinforced concrete is used crack formation and propagation is greatly reduced. Since fibers can form a strong bond with the concrete mix and it can bond the cracks to some extent. Observing the concrete specimens after the tests it is found that only the hairline cracks were formed after the compressive strength tests. When fibers are added to the concrete it becomes isotropic, homogeneous and converts it to a ductile material. These fibers will act as secondary reinforcement in the concrete and reduce the crack formation and propagation. The bridging effect by these fibers leads to the improvement in the flexural and tensile strength.

B.SEISMIC RESISTANT STRUCTURES

Safety against the seismic forces is a combination of both adoption of suitable construction techniques and structural stabilities. It is well known that the earthquake does not kill the people but the collapse of the structures can cause the disaster. Light weight construction systems have its application in this circumstance. If the structure is light in weight and stable in structural integrity the problems which are caused by the collapse of buildings can be reduced. From the experimental results it is clear that the hair fiber reinforced concrete can be used for the ordinary concreting works. For reinforced cement concrete the amount of the steel reinforcement can be reduced by adopting the required percentage of the hair fiber reinforcement which makes the section light weight. Studies have been advancing the possibility of partial replacement of cement with fibers in fiber reinforced concrete. If it is practicable the section will be economical without compromising the strength of the section.

C.ROAD AND PAVEMENT CONSTRUCTION

Several studies have been conducted to find the effects of human hair additives in the compressive strength of the asphalt cement mixture as the potential binder in the road pavement and those have proved that adding cement and human hair to the asphalt mixture greatly increase the strength of the mixture and making it a good material for the construction of road pavements. Adding both the cement and the human hair fibers to the asphalt mixture improves the load bearing capacity of the mixture. Hence the hair fiber reinforced concrete has its application in the construction of pavements also.

D. WATERPROOF CONSTRUCTIONS

By adopting the hair fiber reinforced concrete the formation of minute cracks in the section can be limited which also reduces the leakage problems, making it suitable for the water proof constructions.

XIII. CONCLUSIONS

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. The human hair fiber concrete has the high compressive strength compared to that of the normal Concrete. Also Better split tensile strength was attained with the addition of the human hair in concrete and the strength of the concrete is also increased. 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 fiber reinforced concrete can have its applications in seismic resistant constructions. The addition of human hairs to the concrete not only alters various properties of concrete such as compressive strength, Tensile strength but also enhances the micro cracking control, Binding properties and also increases the spalling resistance. The crack width is also reduced to the greater extent. It is well observed in the study that the maximum increase

in strength is noticed in the addition of 2% hair fiber by the weight of the concrete in all mixes. Therefore use of hair as a fiber in a concrete enhances the properties of concrete. Hair fiber is also available in abundance at a really low cost. Using hair fibers is also an eco-friendly idea.

REFERENCE

[1] "A review on natural fibers in the concrete" International Journal of Advanced Technology and Engineering, vol1 1(1) pp 32-35, 2017.
[2] Nila V. M, Raijan, International Journal of Research in Advent technology.
[3] An Experimental study on mechanical properties of Human hair fiber reinforced concrete (M-40 Grade)," Journal of mechanical and Civil engineering Vol 12(4), T. Naveen Kumar, Komershetty Gautami, 2015.
[4] International Journal and Magazine of Engineering, Technology, Management and Research, AnkaiahSiddharth.
[5] "Effect of randomly oriented hair fiber on mechanical Properties of fly ash based hollow block for low height Masonry structure" Asian Journal of Civil Engineering (Building and Housing), vol 10 (2), Akhtae J. N., Ahmad S. H., 2009.
[6] "Hair fiber reinforced concrete," Research Journal of Recent Science, vol 1, pp. 128-133. Jain D and Kothari, 2012.
[7] "Experimental investigation of shrinkage of Nano hair Concrete," Iranica Journal of Energy and Environment, Vol 4 (1), pp. 68-72, Yadollah Batebi, Alireza Mirzagoltbar, 2013.
[8] "Human hair as fiber reinforced in concrete: An Alternative method of waste management and its Application in civil construction," International Journal Of Current Research, vol 7 (10), pp. 21205-21210, .Nila VM, Raijan, K. J., 2015.
[9] International Journal of Modern Trends in Engineering Research L. B. Pawar and Y. L. Bhirudhh, 2015.
[10] International Journal of Innovative and Emerging Research in Engineering, vol. 2 (5), KhanSaheb, 2015.
[11] "Effect of human hair additives on compressive strength Of Asphalt Cement mixture," International Journal of Advanced Science and Technology, vol 67, pp. 11-22. Tomas U Ganiron, 2014.
[12] Use of Human hairs in concrete," International Journal For Scientific Research and Development, vol 4 (6), pp. 80-82, Jain Alok and Abhinav kumar Hindoriya 2016.
[13] "A concept of improving strength of concrete using human hair as fiber reinforcement," International Journal of Innovative Research in Science, Engineering And Technology, vol 5 (5), pp. 11358-11364., Agrawal Achal and Shrivastav Abhishek, 2016.
[14] "Human hair as fiber reinforcement in concrete", International Journal of Engineering, Science and Computing, vol 7(5), pp. 11-22G. Sreevani, Smt B Ajitha, 2017.
[15] "Performance of hair reinforced concrete" International Journal of Applied Research, vol 3 (1) pp. 582-586 Kumar shantaverayya and SugunashreeS. M., 2017
[16] "A study on mechanical properties of concrete using hair Fiber reinforced concrete," International Journal of ChemTech Research CODEN (USA), vol 10 (8), pp 167-176, Chinnadurai P and Anuradha R, 2017
[16] T. Naveen Kumar1, (2015), "An Experimental Study on Mechanical Properties of Human Hair Fiber Reinforced Concrete" IOSR Journal of Mechanical and Civil Engineering, Vol. 12, pp. 65-75.

[17] Akarsh Verma1, V. K. Singh1, S. K. Verma and Anshul Sharma, (2016)," Human Hair: A Biodegradable Composite Fiber", International Journal of Waste Resources, Vol. 6, Issue 2.

[18] Ashish Kumar Dwivedi, Dr. Arvind Saran Darbari, Vinod Kumar Verma, (2015), "Compressive strength evaluation of Human hair and Polypropylene fabricated reinforced composite", The International Journal of Engineering and Science (IJES), Vol. 4, pp-2319-1805.

[19] Sameer Ahmad, (2014), "Preparation of Eco-Friendly Natural Hair Fiber Reinforced Polymeric Composite (FRPC) Material by Using of Polypropylene and Fly Ash: A Review", International Journal of Scientific & Engineering Research, Vol.5, Issue 11.

[20] Hamidullah Naik, Nissar Ahmad Naikoo, Sahil Ayoub Dar, Mir Showket4, Sheikh Abbas Muhamm, (2015), "Use of horse hair as fiber reinforcement in concrete", International Journal of Advanced Research, Vol. 3, pp-1569-1572 [21] Yadollah Batebi, Alireza Mirzagoltabar, Seyed Mostafa Shabanian and Sara Fateri (2013), "Experimental Investigation of Shrinkage of Nano Hair Reinforced Concrete", IJEE an Official Peer Reviewed Journal of Babol Noshirvani University of Technology, Vol.2, pp.- 68-72