AN EXPERIMENTAL INVESTIGATION ON HIGH STRENGTH CONCRETE USING ADMIXTURES

R. Vamsidhar Reddy[1], Mrs. B. Ajitha[2]
[1]M. Tech, Civil Engineering Department, JNTU Ananthapuramu, India
[2]Assistant Professor, Civil Engineering Department JNTU Ananthapuramu, India,

Abstract - To enhance the physical and mechanical properties of concrete, many researches and advancements were carried out. Fibre reinforced concrete is one among those developments that offers an appropriate, practical and economical method for overcoming micro cracks and similar type of shortcomings. Some measures must be adopted to overcome these shortcomings as concrete is weak in tension. Human hair is generally strong in tension, hence it can be used as a fibre reinforced material. Human hair fibre is an uncommon non-degradable matter available in abundance and at minimal cost. It also creates environmental problems. Experiments were conducted on concrete cylinders of standard sizes with addition of various percentages of human hair fibre i.e., 0.5%, 1%, 1.5% by weight of cement and results were compared with those of plain cement concrete of M60 grade. For each percentage of human hair added in concrete, 9 cylinders were tested for their respective mechanical properties at curing periods of 3 days, 7 days and 28 days. The change in mechanical properties of concrete is determined and analysed. The results obtained show us that the optimum content of human hair fibre to be added to M60 grade of concrete is 0.5%, 1%, 1.5% weight of cement fine and coarse aggregate together and consequently there has been a significant increase in mechanical properties of concrete. Also addition of human fibres enhances the binding properties, micro cracking control, imparts ductility and also increases spalling resistance. The 100% of concrete mix to the natural coarse aggregate in concrete with 150 mm dia*300 mm height were casted according to the design mix M60. Split tensile strength of cylindrical specimens at 3, 7, 28 days was tested and recorded.

***Index Terms* - High Strength Concrete, Split Tensile Strength, Fibre reinforced Concrete, human hair.**

I. INTRODUCTION

Concrete can be defined as highly heterogeneous material generated by the mixture of finely powdered cement, various sized aggregates and water with inherent physical, chemical and mechanical properties. At present, the researchers emphasizes on different types of admixtures to produce a new generation of concrete materials that could achieve sustainable concrete structures with more endurance and less economy. Evolution of materials is must for better performance for special engineering applications and modifying the bulk state of materials in terms of composition or microstructure. It has been one of the best routes for developing new mixtures. The most widely used construction material in India is Concrete. Classification of Concrete can be seen as Normal Strength Concrete (NSC), High Strength Concrete (HSC) and Ultra High Strength Concrete (UHSC). With the advancement of technology in the field of applications of concrete and mortars, the strength, workability, durability and other characteristics of the ordinary concrete need modifications to make it more suitable for any situation and any type of aggressive environment. Added to this it is replacement and necessity to combat the soaring cost and scarcity of cement. Under these circumstances, the usage of admixtures is a considerable alternative solution. Concrete as a construction material is grouped as Normal Concrete or High Strength Concrete based on its Characteristic Strength. The Characteristic Strength of Normal Concrete is less than 50MPa. The High Strength Concrete has Characteristic Strength above 50MPa. High strength concrete (HSC) may be defined as concrete with a specified characteristic strength between 60 and 100 N/mm^2, although higher strengths have been achieved and used. Strength levels of 80 to 100 N/mm^2. The methodology for producing high strength concrete is nearly as same as the methods required for normal strength concrete. 0.30–0.35 should be the range of water/cement ratio or even lower.

The terms "High Performance Concrete" and "High Strength Concrete" are often understood as same but they are not. However, as indicated, "high performance" strictly relates to a concrete that has been designed to have good specific characteristics, such as high resistance to chloride attack or high abrasion resistance. As a result, it may also have higher strength, but this is not under main analysis. High strength concrete has been used significantly throughout the world in the oil, gas, nuclear and power industries. The application of such concrete is increasing with time due to their prevailing structural performance, eco- friendly and energy conserving applications. These concretes are exposed to high pressures and temperatures for longer times in above mentioned industries apart from the usual risk of fire. Admixture is defined as a material other than cement, water and aggregates, which is used as an ingredient of concrete and is added to the batch immediately before or during mixing. Now a days, Concrete is being used for various purposes to make it suitable for different conditions. In these type of conditions ordinary concrete may not deliver optimum requirements such as quality performance or durability. To make it more suitable for any situation, admixtures are used to modify the properties of ordinary concrete. Some of the admixtures induce strength, improves quality and performance of concrete. In this experimental work, human hair was used as an admixture.

II. MATERIALS AND TEST METHODS

A. Cement - The Calcareous materials such as limestone or chalk, and argillaceous material such as shale or clay are the raw materials required for the manufacture of Portland cement. The raw materials used for the manufacture of cement consist of mainly of lime, Silica, alumina and iron oxide. To form more complex compounds, these oxides interact with one another in the kiln at high temperature. The hydration of cement can be defined as the chemical reactions that take place between cement and water. It is observed in two ways. The first is through solution mechanism in which cement dissolve to produce super saturated solution from which the hydrated products get precipitated. Second is that water attacks cement compounds starting from the surface to the interior of compounds with time. The reaction of cement with water is exothermic. The reaction liberates a considerable quantity of heat. This heat liberated is called the heat of hydration. In this study ACC OPC Grade 53 Cement is used. The properties of this type of cement are as following:

Table 2.1. Properties of cement

S.NO	Physical Characteristics of Cement	Results
1	Specific Gravity	3.16
2	Standard Consistency	31%
3	Initial Setting time	34 min
4	Final setting time	180 min

B. Aggregates – Aggregates are the important constituents in concrete. Aggregates reduce shrinkage, give body to the concrete, and influence economy. Aggregates are inert granular materials such as sand, gravel or crushed stone that are an end product in their own raw materials. For a good concrete mix, aggregates need to be clean, hard enough, strong particles free from chemical absorption or clay coatings and other fine materials that could cause deterioration of cement.

Aggregates are divided into two categories based on size factor:
i) Coarse Aggregate and
ii) Fine Aggregate.

i) Coarse Aggregate – Coarse aggregates are particles greater than 4.75mm but generally range between 9.5mm to 37.5mm in diameter. Either primary, secondary or recycled are the sources. With crushed stone making up most of the remainder, gravels also contains majority of the coarse aggregate used in concrete. In this study coarse aggregate of nominal sizes of 20mm, 12mm are used.

Table 2.2. Properties of Coarse Aggregates

S.NO	Physical Characteristics of Coarse Aggregates	Results	
		20 mm	12 mm
1	Specific Gravity	2.6	2.7
2	Total Water Absorption	0.12%	0.1%
3	Fineness Modulus	3.83	4.21

ii) Fine Aggregate - Fine aggregate are basically sand won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most percentage of particles passing through a 4.75mm sieve.

Table 2.3. Properties of Fine Aggregates

S. No	Physical Characteristics of Fine Aggregates	Results
1	Specific Gravity	2.519
2	Total Water Absorption	0.200

C. Human Hair – Hair is used as fibre reinforcing material. The tensile strength of human hair equals to the tensile strength of copper wire of similar diameter. Human hair fibre contains three main components: cuticle, cortex and medulla. In order to produce cortex cells, proteins with α helix structure that are winded in the hair have long filaments of unknown micro fibres which link each other forming larger structures. This enchained structure offers the capillary fibre more strength and elasticity Hair, a non-degradable matter is creating an environmental problem so it is used as fibro reinforcing material can minimize the problem. It is also available in abundance and at very low cost. It reinforces the mortar and prevents it from swelling. In this experimental study, human hair fibres are incorporated into concrete at range of 0.1 to 1% by weight of cement. Cylindrical specimens were casted and cured properly for evaluating tensile strength properties. These specimens made of human hair fibre reinforced concrete are tested at different curing periods (3, 7 and 28 days) respectively and the change in tensile strength properties when compared to plain cement concrete is observed.

III. TESTS AND RESULTS

1. Tests on Workability:

One of the important characteristics of Concrete is Workability. It is defined as the ease with which the concrete can be worked. Working includes mixing, placing, compacting, and finishing. These can be assessed by slump, compaction factor and Vee bee time test respectively. An increase in the amount of water used in making concrete increases its workability but reduces its strength because of w/c ratio. Thus, workability is the most predominant factoring determining the practicable lower bound of the water/cement ratio which can be used, implying that, it governs the maximum obtainable strength under given conditions of placing and compaction. For concrete mix designs, the required strength and workability are both specified. Where flow of concrete instead of its strength is the only or dominant criterion, such as in situations where concrete is to be pumped to greater distances, the workability of concrete should be very high.

Slump Cone Test - Slump can be summed up as, under the own weight of fresh concrete, vertical settlement of a standard cone of fresh concrete (actually frustum of the cone). The cone of concrete in a slump test may sometimes fail in shear, thus casting doubts on the stability of the concrete system. Lack of stability is termed as segregation. Slump Cone Test Values for various mix are as following:

Table 3.1: Slump Cone Test Values for various mix proportions

S.NO	Mix Notation	Percentage of Human hair	Slump Cone Results in cm
1	M0	0	10.5
2	M1	0.5%	10.2
3	M2	1%	9.2
4	M3	1.5%	8.5

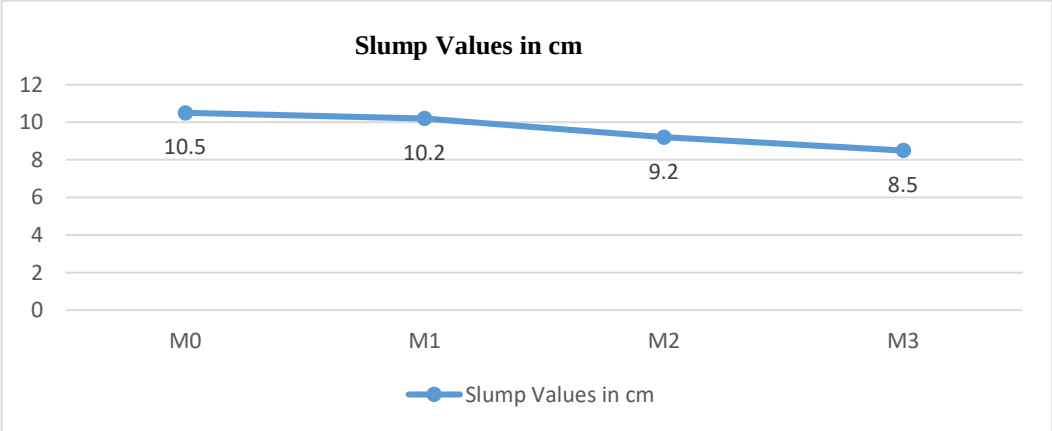

Fig. 3.1: Slump Cone Test Values for various mix proportions

Compaction factor Test - Compaction factor is a measure of the density of concrete to which a fresh concrete mix can be compacted for a standard input of energy corresponding to zero air content's theoretical maximum density. This theoretical maximum density can be estimated in the laboratory as that obtained by full of compatibility of fresh concrete. Compaction Factor Test Values for various mix are as following:

Table 3.2: Compaction Factor Test Values for various mix proportions

S.NO	Mix Notation	Percentage of Human hair	Compaction Factor Values
1	M0	0	0.930
2	M1	0.5%	0.916
3	M2	1%	0.900
4	M3	1.5%	0.870

Here, M0 – M60 grade concrete

M1- M60 + 0.5% human hair

M2 - M60 + 1.0% human hair

M3 –M60 + 1.5% human hair

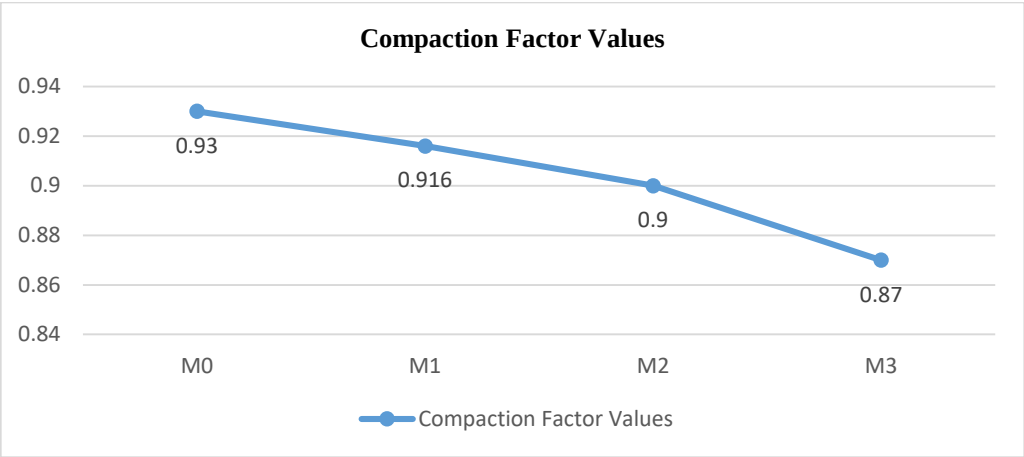

Fig. 3.2: Compaction Factor Test Values for various mix proportions

Vee Bee Time Test - The Vee Bee index is a time measure with a standard rate of energy input; the time required to force the fresh concrete to flow to a standardized extent is called the Vee bee time. It is measure of the mobility of the fresh concrete. Vee Bee Time Values for various mix are as following:

Table 3.3: Vee Bee Time Test Values for various mix proportions

S.NO	Mix Notation	Percentage of Human hair	Vee Bee Time in seconds
1	M0	0	8.1
2	M1	0.5%	9.0
3	M2	1%	10.3
4	M3	1.5%	11.1

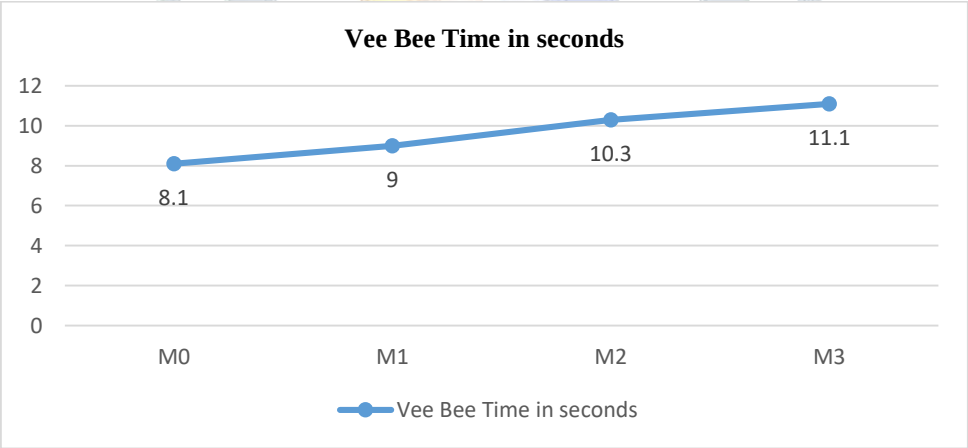

Fig. 3.3: Vee Bee Time Test Values for various mix proportions

2. Split Tensile Strength Test

One of the basic and important properties of Concrete is tensile strength. To determine the tensile strength of concrete, splitting tensile strength test on cylindrical specimen is the method. Due to its brittle nature, the concrete is very weak in tension and it is not anticipated to resist the direct tension. When subjected to tensile forces, concrete starts developing cracks at very minimal loads. Thus, it is prerequisite to govern the tensile strength of concrete to discover the load at which the concrete members may crack. With the longitudinal axis in horizontal direction between the plates of Compression testing machine, place the cylindrical specimen. Place narrow strip of a packing material such as plywood between the platens and cylinder surface. Load is applied at such a rate that tensile stress acting on the vertical diameter increases at a rate of 7kg/cm^2/minute. This test was conducted for cylinders with different percentages of human hair as the cement replacement. The Split tensile strength is calculated based on the below standard formula.

$$\text{Tensile stress} = \frac{2P}{\pi LD}$$

Where P = Maximum load in 'newton'

L = Length of Cylinder in 'mm'

D = Diameter of Cylinder in 'mm'

Table 3.4: Split Tensile Strength Test Values for various mix proportions for 3, 7 and 28 days of Water Curing

S. No	Mix Notation	Percentage of Human hair	Split tensile strength in MPa		
			3 days	7 days	28 days
1	M0	0%	3.28	3.612	4.213
2	M1	0.5%	3.47	3.67	4.48
3	M2	1%	3.60	3.73	4.92
4	M3	1.5%	3.36	3.61	4.32

It can be observed graphically as following,

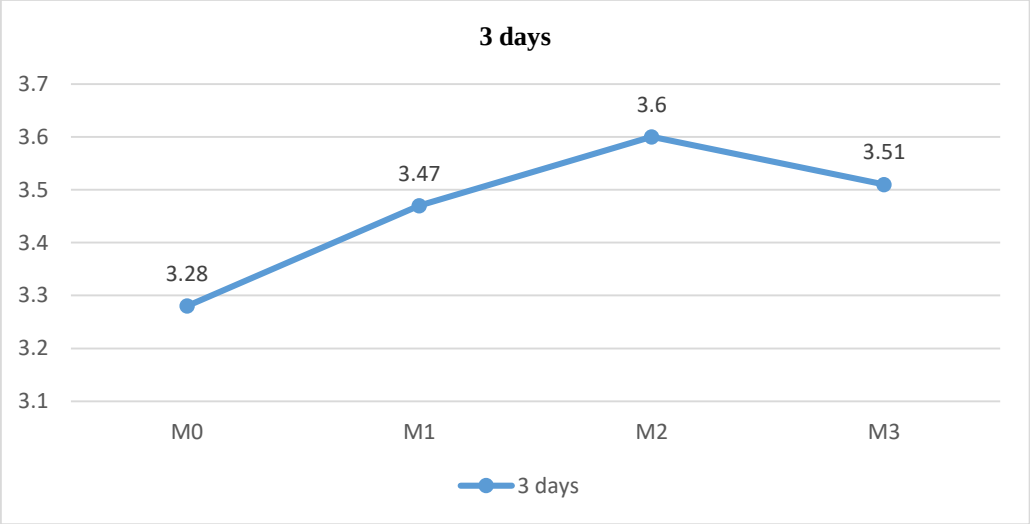

Fig. 3.4: Split Tensile Strength Test Values of various mix proportions for 3 days water curing

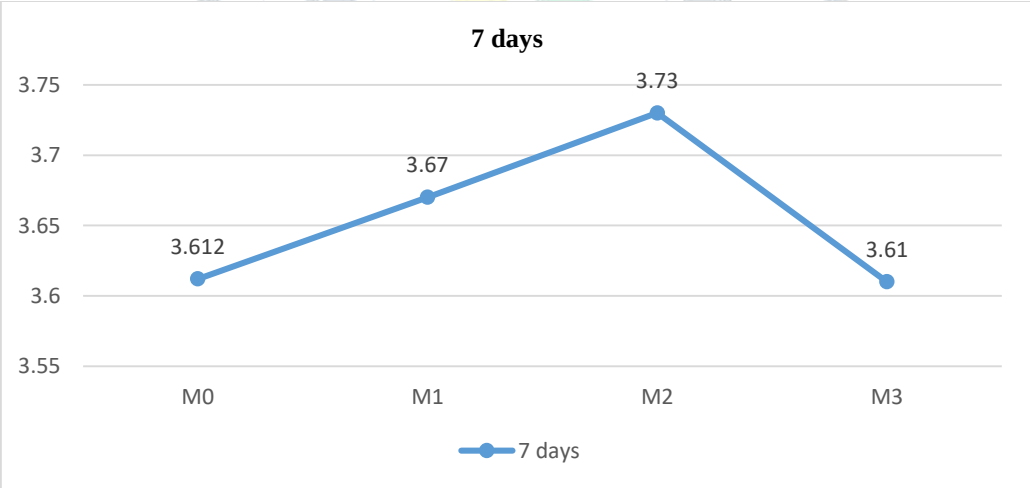

Fig. 3.5: Split Tensile Strength Test Values of various mix proportions for 7 days water curing

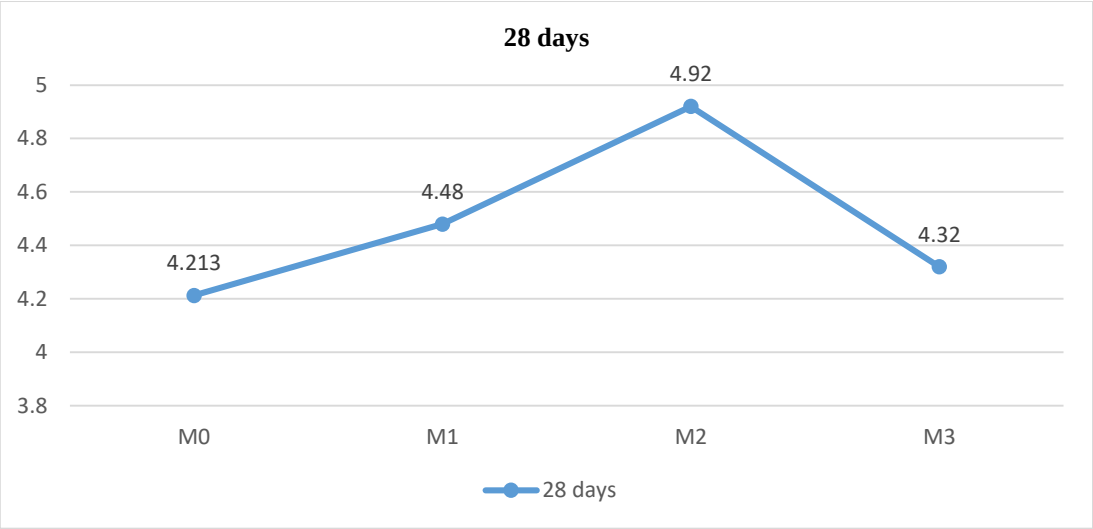

Fig. 3.6: Split Tensile Strength Test Values of various mix proportions for 28 days water curing

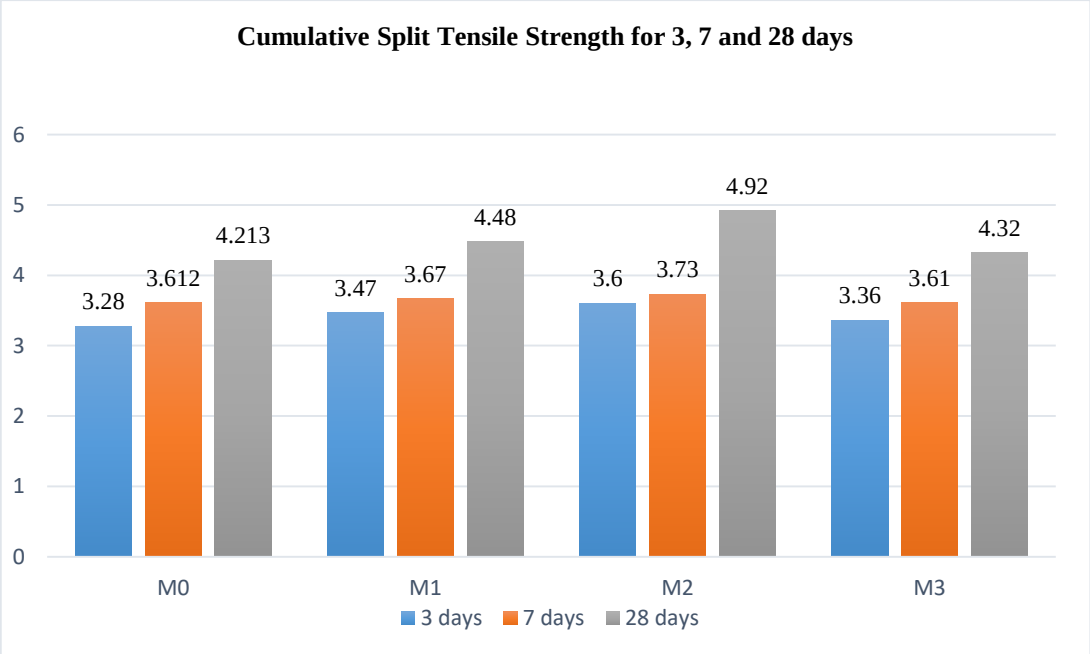

Fig. 3.6: Split Tensile Strength Test Values of various mix proportions for 3, 7 and 28 days water curing

From the above observations and graphs plotted, we can say that clearly the Split Tensile Strength of M60 Concrete increases after addition of admixtures. The optimum point of Split Tensile Strength occurs at 1.0% human hair. It is 16.78% higher compared to plain concrete M60 (mix M0). A cumulative graph can also be seen above for further more clarity

IV. CONCLUSIONS

- In fibre reinforced concrete constructions, human hair waste can be masterly managed to be utilized.
- According to the tests 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
- Though the workability results shows that it is affecting workability of concrete slightly, but it can be neglected as it is very less in comparison.
- The human hair fibre concrete has higher Split Tensile Strength compared to the Normal Concrete. With the addition of the human hair in concrete, finer split tensile strength was achieved. When compared to that of the conventional concrete specimen, the strength got increased.
- It is well observed that the maximum increase is noticed in the addition of 1% hair fibre, by weight of concrete, in all the mixes
- There was an overall increase of 16.78% in the split tensile strength of concrete at optimum point of 1% human hair cement replacement.

- Crack formation and propagation are reduced significantly showing that fibre reinforced concrete can have its applications in seismic resistant constructions.
- The human hair addition to the concrete not only enhances various properties like tensile strength, compressive strength but also improves the binding properties, micro cracking control and also increases spalling resistance. To a greater extent, the crack width was reduced.

V. REFERENCES

1. Majumdar A.J., Fibre cement and concrete - A Review, Garston: Building Research Establishment (1975)
2. Shah Sarendra P., Balaguru Perumalsamy N., Fibre Reinforced cement composites, McGraw Hill International Editions (1992)
3. Johnston Colin D., Fibre reinforced cements and concretes, Advances in concrete technology vol. 3 – Gordon and Breach Science publishes (2001)
4. Neville A.M., Properties of Concrete, (2005)
5. Gambhir M.L., Concrete Technology, (2009)
6. Shetty M.S., Concrete Technology, (2009)
7. Ahmed S., Ghani F., Hasan M., Use of Waste Human Hair as Fibre Reinforcement in Concrete, IEJ Journal, Volume 91 FEB, Page no 43, (2011)
8. Banthia N., Fibre Reinforced Concrete
9. Pickering,K.L.Properties and Performance of Natural Fibre Composites. Woodhead Publishing in Materials.2008
10. Falkner, T.W. Falkner, Fibre Reinforced Concrete, The technical advisor, June 1993.
11. Naaman, A.E., “Fibre Reinforcement for Concretes”. Concrete international: Design & Construction, Vol.7, Mar. 1985, pg No. (21-25).