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Mechanical Properties of Human Hair Concrete

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Abstract-*Fiber rein forced polymer compounds is the majorcategory of structural matter because of its many merits. Reinforcing the polymer should be either typical or engineered. Engineered fiber, for instance, polypropylene, glass etc. has superior specific features however their areas of application are limited because of its economic problems. Recently there is an increase in interest to ward ordinary compounds which are made by reinforcing the typicall fIber Human hair has hard ductile character rustics; therefore, it can beutIlize das a fiber reinforcing substance. It provides better feature sat easier cost of production. It also creates environmental problems because of its deterioration property (Non-degradable characteristic).To achieve this aim, we have triedtoinvestigatethepossibleusageofhuman hairwhichis not only cost effective but effortlessly availableinall over the country for manufacturing value added outcome. The aim of this research work is to find out the properties (mechanical) of hair fiber reinforced concrete. The effect of loading on fiber and the length of fiber on mechanical behavior like compression strength, tensile strength, flexural strength and toughness of resulting compounds is investigated. Testing was carried out on polymer compounds with distinct percentages of hair fiber added by weight of cementi.e.0%,2%,4%,6%, 8%, 10%andwithvaryinglengthofhair fiberi.e.0.5-2cm.Bytestingof resulting specimens ,it has been not iced that there is remark able effect of human hair fiber on the mechanical properties of resulting compounds.*

Key words- *Fiber, Human Hair, Concrete, Polymer Compounds, Mechanical Behavior.*

I. Introduction

Concrete is one of the most broadly utilizing material in construction industries; it is generally consisting of three main elements: cement, sand and Coarse aggregates, they are bonded together by cement and results in concrete which in fact an artificial stone. Its compressive strength is higher than tensile strength. To consolidate such weakness like tensile strength of construction materials like concrete, it is reinforced with fibers. Human hair waste and straw are used as natural fibers. With reinforcing fibers within the concrete not only its tensile strength but its flexural strength extremely increases. This composite has specific integrity, linkage and give suitable utilization of concrete as an elastic material to provide high levels of deflection resistant surfaces. Fiber used in concrete has high energy absorption and under direct application of loads it is not easily fracture [1,2].

The insertion of hair fiber in the concrete fine numerous properties of concrete such as tensile strength, flexural strength, compressive strength, control of micro cracking and increases resistance to the mortar from spalling. Human hairs are available in excessive amount in nature and its non-degradable property gives anewera in the sector of FRC [3].

With the increase in the volume of non-metallic fibers, while the crack outline remarkably enhances, concrete will lose its strength because of expansion and such expansion in concrete may cause a significant issue. This issue usually increases in volume of air which is trapped within concrete which will results in decrease in strength of concrete and life of the exploitable substances. Hair is a protein strand which originate from follicles found in the dermis or skin. It is one of the describing features of animals. The human body, aside from portion of glabrous skin, is protected in follicles which generate sturdy terminal and fine villus hair [4,5].

Major concern in hair is focusing on the growth of hair, types of hair and hair care, but hair is also a major biomaterial basically consists of protein, notably keratin. Keratins are proteins, lengthy chains of amino acids [6].

A very valuable procedure in controlling cracks which occur due to clay shrinkage is to reinforce the concrete with fibers. Fibers which are made from metals and polypropylene or characteristic fiber which are irregularly scatter create junction forces within cracks width and that would obstruct more formation of cracks. Fibers which are non-metallic such as glass, polyethylene and carbon fibers may lead to reduce the cracks width that are because of shrinkage which is caused in drying concrete. Crack may be defined as a “break, split, fracture, fissure, separation, cleavage or elongated thin opening that can be seen through normal human eye and which continues to extend from the surface into a masonry unit, mortar joint, interface between a masonry unit and adjacent mortar joint”. The cracks are categorized per its damage level for load bearing masonry structures. To repair cracks having a width not exceeding 5mm, then either steel wire mesh should be used or cement grout can be injected into the cracks. These fibers will act as an alternative reinforcement

in concrete and it will decrease the formation of cracks and its elongation. The bridging effect of such fiber will help to improve both the tensile and flexural strength [7,8].

The major part of the fibers in the concrete and cement mortar is subsidiary reinforcement by reorganizing the mechanical performance of the cementitious matrix. Precisely, the fibers mark for refinement of ductility of the compound and enhancing the mechanism for cracking [9].

One of the deficiency of concrete is that it has minor-cracks both at the surface and inside the material even before the application of load. The reason for such deficiencies and minor cracks are because of the presence of extra water which also results in bleeding, settlement in the plastic state, thermal and shrinkage strains and stress concentrations enforce by exterior constraints. Under the application of load, disperse minor-cracks generate combine and join with each other to form macro-cracks. When loads are furthermore magnified, state of the crucial fracture growth are accomplished at the tips of the macro-cracks and inconsistent and adverse collapse of the material will be happen [10,11].

In Fiber Reinforced Compounds (FRC) with less to average volume fragment of fibers, fibers will not increase the compression, flexural or tensile strength of the compound and advantages of fiber reinforcing material are restricted to energy absorption or toughness improvement in the post-cracking behavior only. However, for superior representation fiber reinforced with a high fiber quantity, advantages of fiber reinforcement have been not noticed to increase different mechanical properties at specific percentage but it is also lower than the plain concrete, strain-hardening reaction localization formerly and increased toughness after the crack localization [12,13].

For better potency, the fiber must have enough length to fortify that failure happen by entire pull-out of the fiber from the concrete mix or model before the fracture of the fiber because of the tensile forces. The critical rupture length of fibers in FRC compounds has been found to be between 18 and 24 mm. When a concrete sample which is reinforced with fiber is subjected to tensile load, at a specific strength the bond between the mix and fiber will start fracturing, the fiber from the sample starts to pull out [14,15].

II. Methodology

For this experimental procedure, the methodology adopted were further sub divided into three different classes as stated below.

A. Material Used

The material collected and utilized in this research procedure were ordinary Portland cement, Human Hair, Fine Aggregate (Sand), Coarse Aggregate (Crush) and Water.

i. Cement

Kohat cement which is manufactured locally in factory satisfying the ASTM Type I requirements were used for casting of Cylinder and Beam samples.

ii. Human Hair

Depending on the available local source, the collected hair often has other wastes such as cotton, blades, and household waste, which are first separated in almost all cases manually.

Figure 1: Prepared Specimen of Human Hair.

iii. Sand

Sand used in this research work were collected from local resources and after sieve analysis the result obtained was quite good. Sand has Fine Modulus of 2.40 in this investigation.

iv. Coarse Aggregate

After Sieve analysis of Coarse Aggregate, it's Fineness Modulus was 7.50. The Coarse Aggregate were also collected from local resources in Peshawar region.

Figure 2: Coarse Aggregate Washed

v. Water

Clean drinking water were used for the experimental work which was free from any suspended particles and color.

B. Mixing Proportion

The control mix was designed with the ACI standards. For making the mixes containing human hair waste, the amount of hair fiber using is calculated by volume method. The ratio used is 1:2:4 and water cement ratio (W/C) is 0.55 for all standard concrete mix. However, different percentage of Human hair fiber were to the mix ranging from0-10%.

C. Casting

The concrete samples were casted for different percentage of Hair fiber addition. And six distinct groups were made depending on the addition of Human hair fiber. For each group seven samples were casted using the reusable standard molds and after 24 hours of casting it was then removed. Water to cement ratio for all the groups were keep same (W/C=0.55).

Figure 3: Reusable Molds of Beams and Cylinders Properly oiled.

D. Curing

The samples were then placed in the water tank for the curing periods of 7 days, 14 days and 28 days. Each sample was marked with a specific recognition number.

E. Experimental Procedure

The three main tests which were carried out on the concrete reinforcing with varying percentage of Human hair fiber are Compression test, Split Cylinder test and Flexural test.

i. Compression test

The compression test for the Hair fiber reinforcing concrete cylinder specimen was carried out per ASTM C-39 requirements. Before testing of specimens, it was properly capped both on the top and bottom surface per ASTM C-617 requirements to overcome the unevenness of the surface of samples. The specimens were then tested under Universal testing machine (UTM) after curing period of 7 days, 14 days and 28 days. Mathematical expression to determine the compression strength is;

Compression Strength (fc) = P/A

Where,

fc = Compression Strength (MPa or Psi)

P = Ultimate Load (N or lb)

A = Cross section area (mm^2 or in^2)

Figure 4: Compressive Strength Test for Hair Fiber Reinforced Concrete Cylinder in UTM

ii. Split Cylinder Test

The tensile test for the Hair fiber reinforcing concrete cylinder specimen was carried out per ASTM C-496 requirements. There is no need of capping the cylinder samples in this test, the samples were then tested under Universal testing machine (UTM) after curing period of 7 days, 14 days and 28 days. Mathematical expression to determine the tensile strength is;

Tensile Strength (ft) = $2P/\pi DL$

Where,

ft = Tensile Strength (MPa or Psi)

P = Ultimate Load (N or lb)

D = Diameter of cylinder sample (mm or in)

L = Length of the cylinder sample (mm or in)

Figure 5: Split Cylinder Test for Hair Fiber Reinforced Concrete Cylinder in UTM

iii. Flexural Strength

Test were conducted on beams samples which was reinforced by Human Hair fiber to determine the flexural strength. The test was performed per ASTM C-1609 requirements. The samples were tested under universal testing machine (UTM) after 7 days, 14 days and 28 days of moist curing. Relation to determine the flexural strength is;

Flexural Strength (fbt) = PL/bd^2

Where,

fbt = Flexural Strength or Bend Strength (MPa or Psi)

P = Ultimate Load (N or lb)

L = Span of the beam between supports (mm or in)

b = Width of the beam (mm or in)

d = Depth of the beam (mm or in)

Figure 6: Flexural Test for Hair Fiber Reinforced Concrete beams in UTM

III. Analysis and Results

The graphical test results are briefly discussed in the below section.

a. Compression Strength Test

The compressive strength result which are obtained after testing the samples are given in the Figure. The samples were tested after 7 days, 14 days and 28 days. It is obvious from the figure that with the addition of human hair to the concrete results in the decrease of the compression strength.

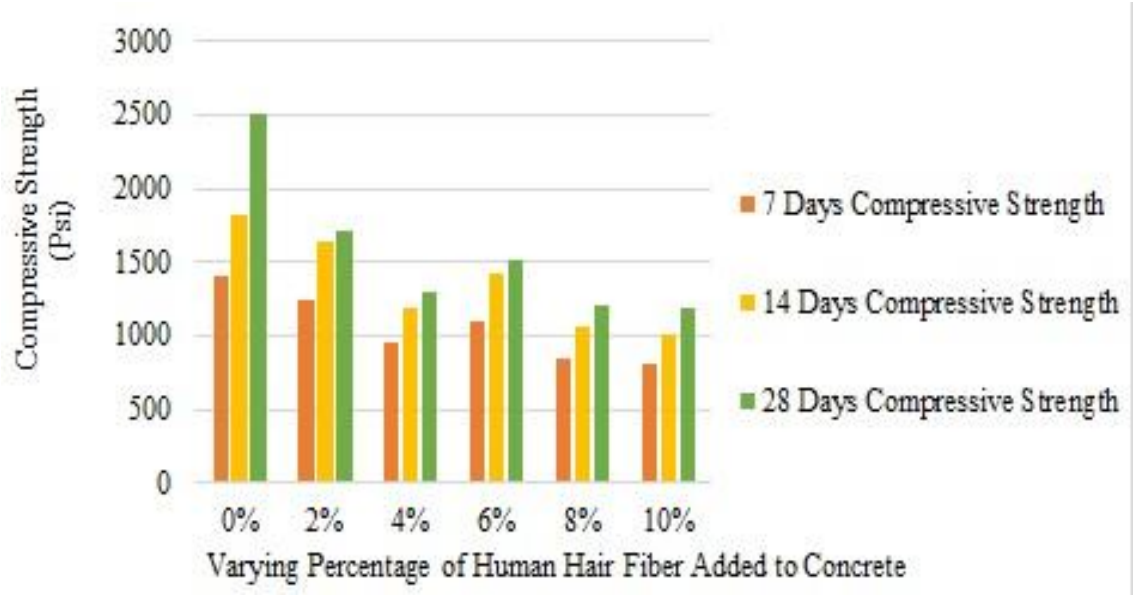

Figure 7: Average Compressive Strength of Hair Fiber Reinforced Concrete.

It is clear from the results that with the addition of the hair fiber in concrete the strength goes on decreasing. The result in the strength is due to the stress concentration. Also, the water absorption capacity of Human hair is about 30% of its own weight. So, as a result the percentage of unhydrated cement increases which results in lower concrete strength. Since the hair fibers are in the form of lumps because of which the coarse aggregate will not reach to the required places creating the voids in the concrete results in lower concrete strength.

b. Split Cylinder Test

The tensile test was conducted on the standard samples of the concrete which is reinforced with human hair fiber after 7 days, 14 days and 28 days. The result obtained was shown in the figure below. It is clear from the figure that with the addition of hair fiber will result in decreasing the tensile strength of concrete.

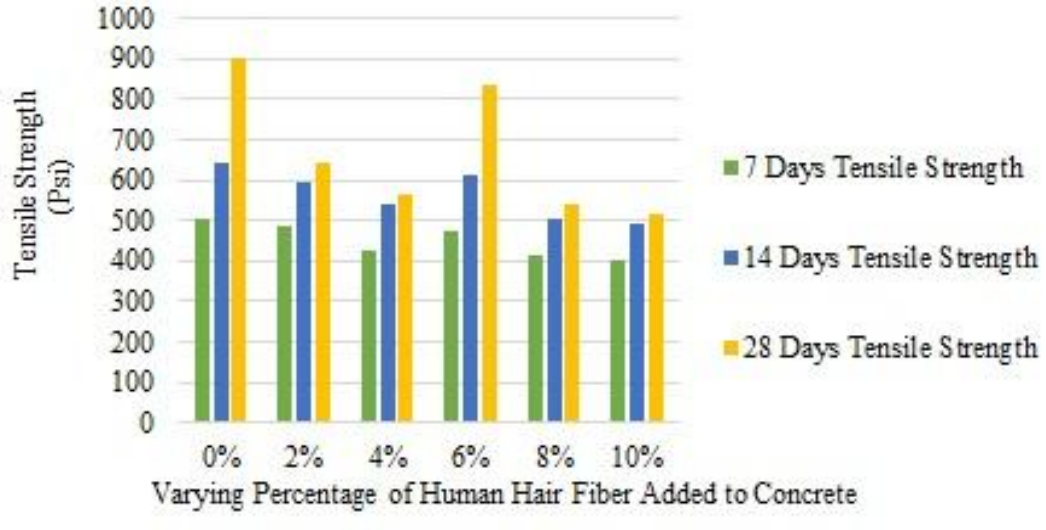

Figure 8: Average Tensile Strength of Hair Fiber Reinforced Concrete.

c. Flexural test

This Test was carried out on beam samples whose dimensions are breadth=0.5 feet, height=0.5 feet and length=2.5 feet casted from different amount of Human Hair Fiber added as percentage by weight of cement. The values of Flexural strength obtained were shown in the figure below.

It is clear from the Figure that with the addition of Human Hair, the Flexure strength of concrete decreases. The decrease in Flexural strength is about 42.9%.

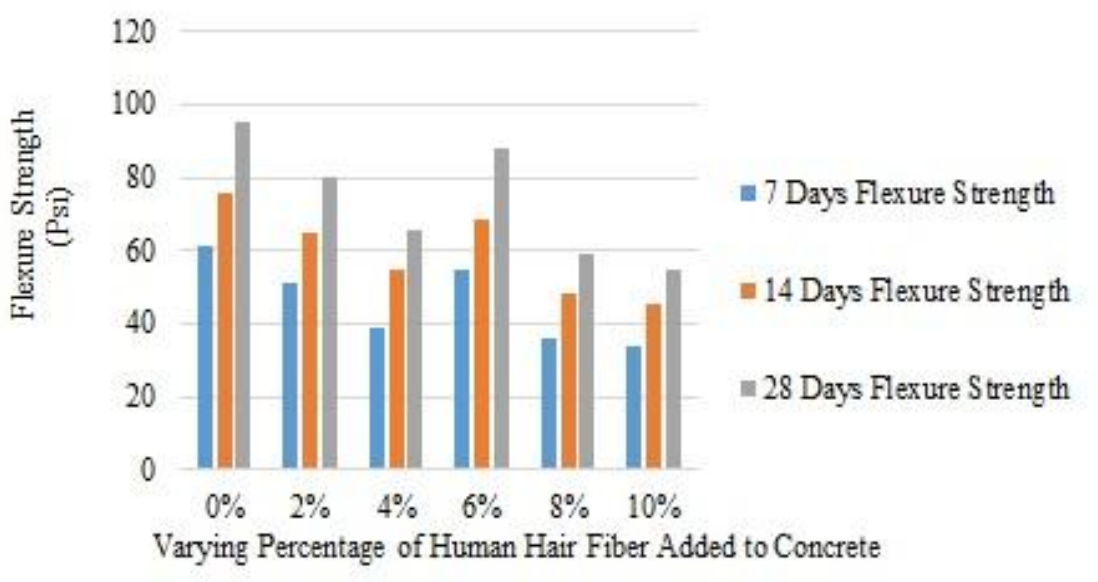

Figure 9: Average Flexure Strength of Hair Fiber Reinforced Concrete.

IV. Conclusion and Recommendations

Below are the conclusions that can be drawn from the research based on the studies and the test results.

1. The utilization of human hair fiber not only in engineering industries but also in medical and other fields is the best way to deal with such type of waste instead of throwing it to the waste streams.

2. From the result, it is shown that with the addition of 6% of hair fiber in concrete show satisfactory results.

3. Compressive strength of the concrete decreases upto 53% when the addition of hair fiber is 10%.

4. Tensile strength of the concrete decreases to 43% when the hair fiber added was 10%.

5. Flexure strength of the concrete decreases to 55% with the addition of 10% of hair fiber.

6. During utilization of the hair in the concrete mix, the problem of uniform scattering of the hair is of main concern.

7. It is clear from the results that the addition of Human Hair Fiber in the concrete has no effect on the ductility and toughness as far as the increment in strength is of concern.

From the conclusion of the test results, there are some recommendations which are stated below;

1. The study of admixtures and super plasticizer which could properly distribute the hairs without affecting the properties of concrete.

2. The research can be further enlarging to study the effect of Human hair on the physical and thermal properties of hardened concrete.

3. Influence of Animal Hair should also have to be checked for different properties of concrete.

4. Effect of Hair fiber as nano fabric in the modern field of nano technology in concrete.

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