

# “Human Hair Fiber” A Discrete Fiber To Improve Soil Subgrade Strength: A Review

Ujjwal Mishra

M.Tech (Transportation Civil Engineering),  
Lovely Professional University, Phagwara, Punjab, India

*Abstract: Except India, China, Japan and few other countries the human hair is supposed to be a material of garbage having no use, but the main objective of writing this paper is to attract the readers mind towards the fact that human hair is considered as a biological fiber and has some extraordinary properties which can be useful in many fields like-in the field of agriculture, material construction, and pollution control as well. Human hair fiber is shortly represented as HHF and this study paper is a research of necessity and usefulness of this waste material and what are the various effects which this material is going to leave on the strength of the subgrade of soft clayey soil. In this study we are going to use the 20 mm average length of particular fiber. The various test which are going to be considered or are necessary for this study are being shown in this paper with their results and with their effects and graphs made with the help of it.*

*Keywords: Human hair, Waste Material, Properties, Human hair fiber(HHF), UCC test, waste material, CBR test, clayey soil etc.*

## I. INTRODUCTION

Mostly the human hair fiber (HHF) is being dumped into the dustbin or garbage places as it can not be left openly in the environment as it can cause various respiratory related problems mainly in humans and animals as it is a non-biodegradable material which is a totally waste from any point of view and also generates affliction if not properly dumped in the atmosphere, but in this study we are going to use this material as a strong reinforced material which is used to enhance the strength of subgrade for clayey soil which is quite soft in nature. The human hair fiber is going to be used as a discrete fiber which is used in few varying percentages and the test which is going to be necessary to perform to prove this study helpful are the California bearing ratio test (CBR Test), as well as the Unconfined compressive strength of soil test. As we know that the particular quality of the subgrade of soil causes the best or worst performance of pavement. If we want to make our pavement durable we will surely need a subgrade of stabilized soil with ample pavement draining properties. The basic reason of pavement failures are being considered as the variation in the moisture and temperature, unpredictable traffic

behavior and due to use of some faulty road construction material. The Highway research board (HRB) has given one solution for this that we should use various chemicals for sub grade stabilization but use of natural fibers are more suitable idea in place of using others chemical used products.

## II. PROPERTIES OF HUMAN HAIR

There are so many properties of human hair like it's higher tensile strength, unique chemical composition, slow degradation rate, thermal insulation, scaly surface, elastic recovery, and it's interaction with the water and various oils is unique and it is also available in huge quantity and can get easily the variety of hair available varies according to five parameters-color, curliness or straightness, length, hair damage and contamination.

The various variations which found out in the particular area in human hair mainly depends on that region's culture hair style, ethnicity and the hair practice in that region. For an example a particular malnutrition affected area where several kind of chemical shampoos, dyeing, permanent waving are

generally used hair gets more damaged. Due to use of toxic dyes and chemicals in environment or food chain of that area causes chemical contamination [9].

### III. USES OF HUMAN HAIR

According to various properties and field of applications there are several uses of human hair in various industries and in various areas for numerous purposes as those uses are being list out which will provide the basic knowledge of the utilization of human hair which has either being considered as a waste material.

#### A. COSMETICS INDUSTRY, FASHION, THEATRE

In order to make various beauty accessories like Wigs, Hair extensions, Eyelashes, Beards, Artificial Moustaches etc. As there is a huge market demand of these products are generating due to various changes in the fashion, trends and today's need and mainly the youths are being very much influenced by this so to fulfill their all demands and needs these industries are being produced these products in a large quantity and the people who are working in the movies, plays, theatres are generally using these things mostly to impersonate the particular character of the play or theatre. So these are the basic causes of those people which requires and proves the need of human hair waste to make these Particular things.

#### B. AGRICULTURE

Human hair is used to make fertilizers as it contains the 16% of the nitrogen which is the highest nitrogen containing organic material in nature in spite of this it also contains sulphur, carbon and 20% other elements essential for plants [6]. The human hair decomposes at the slower rate in atmosphere but in presence of keratinolytic fungi and moisture present in the soil, sludge of sewage and animal manure can help to decompose it within few months [7]. By addition of human hair with cattle-dung can produce a vermicompost of a good quality within two to three months [8]. Whether it takes several years or months to decompose the human hair but it can also be decomposed by chemical hydrolyzing process within few hours at the particular high temperatures in a base or acid solutions which can be used in the form of the liquid fertilizer after it's neutralization [9]. This liquid fertilizer contains the amino acids with some fatty acids and nucleotides. It also helps to prevent the spreading the wilt disease in plants which caused by bacterium *Ralstonia solanacearum*. It has been experimented by the researchers on the plant of hot pepper and they found satisfactory results [10]. So it is also an essential component of the fertilizer via which we can enhance the productivity of our crops.

#### C. PEST CONTROL

Human hair is also used to control problems which are being generated from various animals as well as insect pests, through various mechanisms, among big animals it has been used to stop rabbits, rodents & wild boar and deer respectively

in the countries Mauritius, India and USA [11]. Generally sniffing is the common phenomenon via which the rabbits, rodents and wild boar find their food and hair makes discomfort during sniffing by coming into their nostrils. Human hair is mainly used for deterring rhinoceros beetles in India [12,13]. The small balls of human hair has been made and placed at the nodes of the affected plants such as coconut trees which makes beetles to fringe out in the hair and unable to move. In Florida peasants were using human hair mats and able to save \$45,000 on pesticides on about one million trees in the year 2007 which they had got in the form of the savings of a particular labor and fertilizers's benefits [14].

#### D. ETHNOMEDICINAL USES

Numerous medicines are being prepared by using human hair as an chemical substituent. In china the human hair has being carbonized first and then they are being used in various renowned Chinese medicines for the treatment of diseases like- burns, wounds, hemorrhage, scars [15]. It is also being used to stop bleeding and promote urination [16]. In India it is mostly being used in many rural states like- chhatisgarh in the form of ash, as the hair ash is being applied on the wounds for immediate pain relief and for quick recovery [17]. In an another ethnomedicinal study of India shows that most of these state communities are using the different formulations made by the powdered hair, hair decoction and hair ash for the treatment of the various diseases like- asthma, anemia, piles, rat bite poisoning, urinary calculus, foot sprain, sexual problems and delivery pain [18]. In the preparation of these medicines the purity and the quality of hair has an special importance.

#### E. HYDROLIZED HAIR KERATIN

The hydrolyzed human hair keratin protein from human hair called generally as HHKP is used in various hair care products by many hair oil companies [19,20]. It is generally a mixture of polypeptids and aminoacids generally produced by hydrolysis process of keratin protein from human hair it has been supposedly reported as a good solution of hair damage problems by various hair experts as it contains the constituents which are very much similar to native hair protein. The extraction of HHKP needs uncontaminated hair for processing properly and without causing any problem.

#### F. COMPOSITE MATERIAL

The most important aspect of human hair is that it has the high tensile strength and friction coefficient it is been used for the construction of the reinforced based clay construction mostly it has been using in the India in Uttar Pradesh and Madhya Pradesh and in many other European countries [21]. Human hair is also used in various fields like in various clay mixtures, making wheels and lining ovens plastering house walls. The addition of human hair in the particular mixture generally reduces the various crackings and increases the design life of the structures. In clay structures it increase the thermal insulation capacity as well as the structural strength which has been shown by the researchers [22,23]. The use of

the reinforced human hair also reduces the various cracks in the cement mortar originated by plastic shrinkage upto 92% [24]. It also increases the fly ash/cement concrete over 3 times [25]. It is highly fracture-resilient and have the capacity of high pressure bearing structures like-bridges and petroleum wells. Mostly all kind of hair can be used in these phenomenon or process.

#### IV. SOURCES OF COLLECTION

##### A. BARBERS AND HAIR STYLIST'S SHOPS

Due to the large market value the human hair is been collected in large quantity through the various barbers and hair stylists shoper. Because the barbers shoper are the most suitable way to collect various quantities of human hair via various haircuts. In several countries including India and china, these shoper are providing the human hair into larger quantity for further processing for making the wigs. At some places like Chennai and New Delhi the hair is being collected at lower prices for making blankets, quilts, fertilizers and amino acids etc [26].

##### B. SPECIAL RELIGIOUS PLACES

At certain religious places in India like at Tirupati Balaji Temple situated in Andhra Pradesh and Kashi Vishwanath Temple at Varanasi Uttar Pradesh, a large number of people get tonsured due to their religious practices [27].

#### V. MATERIALS AND METHODS

##### A. MATERIALS

The soil which is going to be used in this research are being collected at the LPU-Phagwara region of the state of Punjab and the soil is quite soft in nature. To know the various engineering and index properties of soil laboratory test has been performed according to various methods made by IS testing and following properties are being noted down which is being given below in table no-I

Properties	Values
Specific gravity	2.48
Plastic Limit	24.70%
Liquid Limit	46.50%
Silt & Clay content	59%
Maximum Dry Density	1.8 g/cc
Optimum moisture content	18%
Plasticity Index	21.80%
CBR at OMC	3.20%
Classification	A-7-6

Table 1: Properties of clayey soil

Human Hair Fiber: Due to it's non -biodegradable property it is considered as that waste which is not going to be used in anywhere and also causes to be a major factor of atmospheric nuisance. This material has been collected through various resources which has been discussed in details above. Generally the basic length of HHF is found out to be somewhere between 20 to 25 mm mostly and can be get easily

over the least cost and access availability places. The various properties which a human hair consists is being given further in table no II



Figure 1: Human Hair Fibers

Property	Remark
Cross-section	Circular
Linear density (gm/cc)	1.25–1.40
Length	20-25 mm
Diameter	50µm
Tensile strength	About 400 Mpa
Elongation	1.5 times its dry weight
Absorption	Depends on physical process of surface tension
Friction	Depends on the cuticle geometry and on the physical-chemical status of the hair
Chemical reaction	Depends on Hair surface porosity. About 80 % of human hair is formed by a protein known as keratin

Table 2: Properties of human hair fiber

##### B. METHODS

###### SAMPLE PREPARATION

Using different fiber content percentages at OMC and MDD values the sample were prepared like 0%, 0.05%, 0.1%, 0.2%, 0.3%, 0.4% and 0.5%. These percentage were being calculated by weight and fibers were mixed to soil which was air dried or kept in oven.

###### TESTS IN LABORATORY

Sieve analysis (dry and wet), Modified procter test, Atterberg limits, Unconfined compressive strength, Specific gravity test and CBR test were performed which were necessary to extract out the readings from the plain soil. To calculate the Maximum dry density and UCC the Modified procter test was performed according to the procedure written in the code IS:2720 (part VII) and in these tests different percentages of fiber contents were used to determine MDD and OMC. For the condition that moisture content may not get lost the optimum content value were calculated and CBR test was performed because if once moisture is getting lost so it may cause to rearrange all the setups and may also cause the waste of time and resources as well.

## VI. MATERIALS AND METHODS

Due to the economical and faster processing the unconfined compression test is the most adoptable method for the testing purpose of shear strength of soil. For the cohesive and saturated soils mostly got from various sampling tubes having thin walls this method is generally adopted and 38 mm of its diameter and 76 mm specimen length has to be taken.

We got 0.349 kg/cm<sup>2</sup> UCC value with taking 0% of HHF and after addition of 0.1% of HHF it has been enhanced upto 0.591 kg/cm<sup>2</sup>. It indicates that for the road construction purpose it is quite suitable of adding the HHF in soil and it has been seen from the results of 0.1% HHF is determined as optimum quantity to increase the compressive strength of unconfined soil (Figure 3).

Due to enhanced interfacial adhesion between the soil particles and the fiber, which has been caused due to addition of HHF to clayey soil causes the increase in UCC values and it is also permissible to provide transference of stress along interface of fiber matrix easier and more efficiently. If the fiber-fiber interaction has been increased it can cause the optimum fiber content beyond decrease in UCC values. The poor dispersion of fiber in the matrix of soil is being caused due to improper alignment of fiber with soil matrix which also leads to lower efficiency of load transfer with fiber content increase. Many advantages such as high toughness, biodegradability, good strength properties, low cost are being provided by some optimum natural fiber content fiber as a potential reinforcement ingredient.

The major factors which affects overall performance of fiber depends on fiber matrix interface upto a large extent and it is governed by the surface topography of fiber, chemical composition of fiber and its resin properties.

To determine the optimum content of HHF the CBR test and UCC test were performed for both un-soaked and soaked conditions.

The CBR values are being considered and compared to other CBR values with 0% HHF CBR and with 0% HHF value which has been measured for soaked condition is 2.89% which has been enhanced to 4.82% when we have mixed 0.1% HHF in it as shown in Figure 4.

## VII. CONCLUSION

- ✓ From UCS test performed at optimum moisture content 0.35 kg/cm<sup>2</sup> compressive strength was found for un-reinforced soil and with mixing of 0.1% of HHF it is then increased to 0.59 kg/cm<sup>2</sup> indicating an increase in strength of 71.3%.
- ✓ Optimum percentage of 0.1% reinforcing material is considered to be adoptive form results of tests.

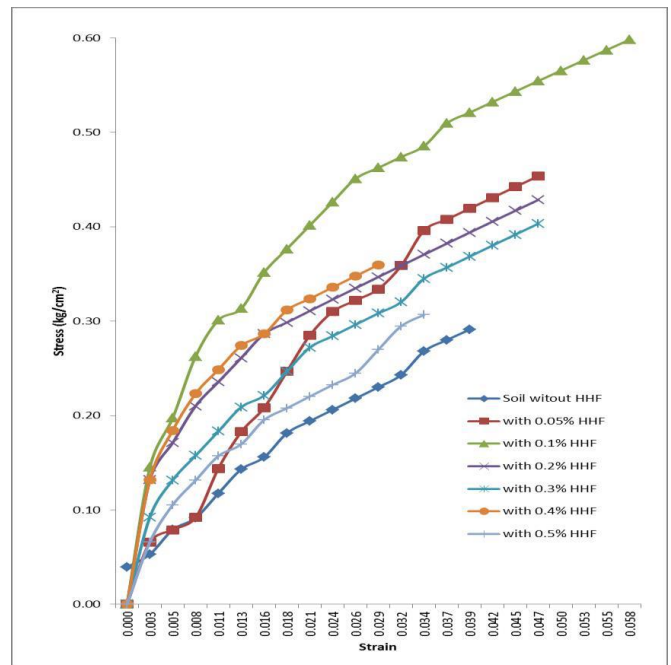


Figure 2: UCC curve for varying percentages of HHF

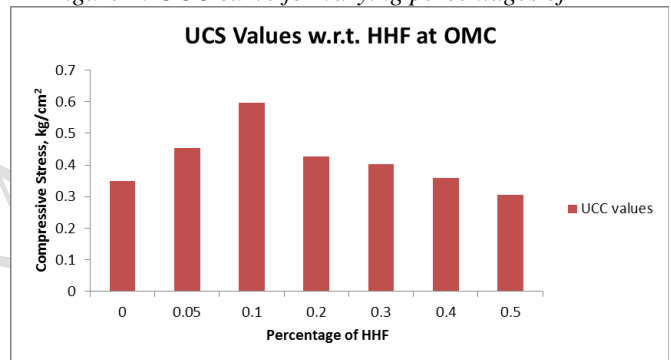


Figure 3: Variation of strength with varying percentage of HHF

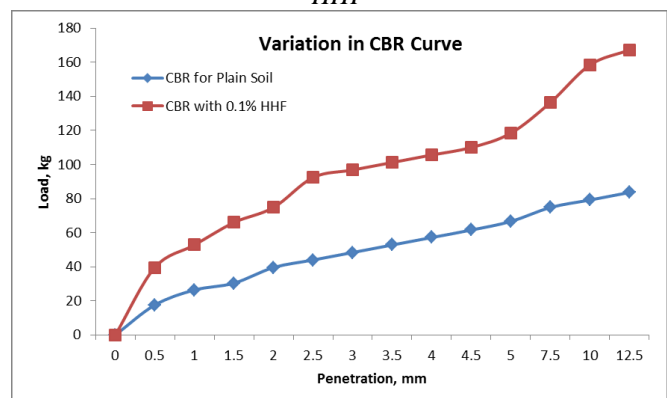


Figure 4: CBR Values with and without reinforcement of HHF

- ✓ For un-reinforced soil the CBR value at OMC was 2.89%. Later with the addition of 0.1% of HHF we got 4.82% value tends to increase in strength in soaked condition upto 66.78%.
- ✓ The results extracted from various experiment shows that with very low percentage use of HHF as reinforcement leads to strength increased in clayey soil.
- ✓ It has been occurred due to absorption of moisture in hair fibers.

For the purpose of slopes stability the Human hair fibers can also be used as a reinforcement material.

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