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Utilization of Human Hair Fiber to Stabilize Black Cotton Soil

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ABSTRACT

Land pollution is one of the primary concerns of today. So, conservation of natural resources and utilization of solid waste materials is necessary to deal with the problems of disposal of solid waste. The solid waste can be utilized in the construction and development industries depending upon their suitability. Such A solid waste material is Human Hair Fiber (HHF). The main aim of this paper is utilization of human hair fibres as a soil stabilizer to modify the properties of black cotton soil. investigate the suitability of solid waste material such as human hair fibers in the process of soil stabilization. It is an analysis to study the influence of HHF on the characteristics of black cotton soil. It is used as a soil strengthening material which can enhance the properties of soil in the field of geotechnical engineering. In this study HHF is randomly mixed with these soils in the proportion of fiber (0,1,2,3 & 4%) by weight of soil. The properties such as specific gravity, index properties and strength were determined and compared with non-reinforced soil. The findings show an enhancement in the properties of soil with the inclusion of HHF.The soil sample were treated with different percentages of human hair. The strength of soil sample increased up to 1.2% and then it decreased.

***Keywords:** Human Hair Fiber (HHF), CBR, Unconfined Compression Test, Specific Gravity,Conservation.*

1. INTRODUCTION

Soil stabilization is a process by which the properties of a soil are transformed to provide permanent strength gains and enhanced engineering properties, especially with fine-grained soils. Expansive soils always pose challenge to foundation engineering. In India, these soils occupy around 20% of the total area. When geotechnical engineers are faced with swelling type of soils(i.e black cotton soil) , it is great challenge to Civil engineers. The design of foundations and pavements founded on swelling soils always involve a certain degree of risk and damage. Human hair fibre (HHF) is one of the waste materials which have an essential feature of developing friction with the soil which helps in transfer of forces from soil to the fibres. Thus, developing tensile strength in the fibres when the soil mass is subjected to shear. During current times human hair fiber(HHF) is considered as a waste material in most parts of world and it create many environmental problems however it have many known uses like randomly reinforced fiber in the present state of art and technology. Hair is a non biodegradable matter is creating an environmental problem so its use as a fiber reinforcing agent it can minimize the problem. It is also available in wide and economical. The characteristics that are of concern to the design engineers are permeability, ompressibility and durability. The test results such as Atterberg's limits, Compaction, California Bearing Ratio and Strength characteristics obtained in expansive soils admixed with human hair fiber at varying percentages of 0%, 1%, 2%, 3% and 4% of the expansive soil.The purpose of this study is to utilize HHF & modify the properties of black cotton soil also to investigate the influence of human hair fiber on the geotechnical properties of an expansive soil. This paper focus on experimental test plan was to investigate the effect of HHF on strength improvement of expansive soil. [1] Renju R. Pillai et al. investigated the influence of varying HHF on Kaolinite clay and they found that the inclusion of randomly distributed human hair fiber up to 2% in the soil significantly enhances the geotechnical properties of soil. [2] utt et al. observed that the optimum quantity is about 2% which enhanced the CBR and undrained shear strength of clayey soil. [3] Elias et al. concluded that the strength appreciably enhanced with the inclusion of HHF, and it further improved when optimum percentage of both lime and fibre were added together. [4] Mishra observed that optimum percentage of 0.1% HHF by weight of soil improves the unconfined compressive strength of soft clayey soil. [5] K. Shankar Narayanan and S. Mary Rebakh Sharmila conducted research on "stabilization of clay with human hair fiber". They studied to improve the shear strength parameters and found that uncompressive strength of soil was increased at 1.2% of HHF. The CBR value increased at 1.2% of HHF.[6] Renju R Pillai et.al studied on "Innovative technique of improving the soil using human hair fibers". They found that the engineering properties of soil increased by adding HHF.The liquid limit increased, plastic

limit decreased and moistur content increased and maximum dry density decreased due to the addition of HHF. The Unconfined compressive strength value increased upto 2 times that of unreinforced soil.. [7] Prakash Patil et.al studied on "Innovative method of improving subgrade strength of soft soil using Human Hair fibers as reinforcement" and concluded that by adding HHF the subgrade strength of clay soil was improved. They use fibers having average length of 20mm. The CBR value has increased at 0.1% of HHF. The compressive strength also attains maximum value at 0.1% of HHF.[8] Rohin Kaushik studied on Innovative technique of improving the CBR Value of soil using hair fiber and fly ash by using different proportions of humanhair fibers at 0.5, 1.0 and 1.5 by percentage and observe that there was increase in the bearing ratio of the soil, CBR value got increased at 1.5% of HHF. Wajid Ali Butt et.al studied on "Soil Sub-grade improvement using Human hair fiber" and concluded that the CBR value increased by adding HHF andattains maximum value at 2% of fiber.

2. METHODOLOGY

2.1 MATERIALS USED

2.1.1 Black Cotton Soil

Black cotton soil is inorganic clay formed in regions having poor drainage conditions. It contains varieties of mineral elements and is very sensitive to water or moisture. Its name stems from its ability to favor cotton crops grown on it. The Soil sample was collected from malkapur,Maharashtra, India.from 2 m depth belowthe natural ground level. The soil classified as 'CH' as per I.S.Classification (I.S: 1498- 1978).

Figure No.1: Black Cotton Soil

2.1.2 Human Hair Fiber

Human hair fiber is a natural non-biodegradable waste material which create health and environmental hazards, So there is need of proper disposal of them or utilize them. From nearby salons as shown in figure.The human hair was collected. It can be used as a reinforcing agent to minimize environmental problems. To obtain the average diameter of human hair fiber, Scanning Electronic Microscope (SEM) analysis was conducted. By adding fiber content of 0.5%, 0.7%, 0.9%, 1.2% and 1.5% by weight of soil, samples were prepared. Fig. 1.2 show fibers used in this study.

Figure No.2: Human hair fiber

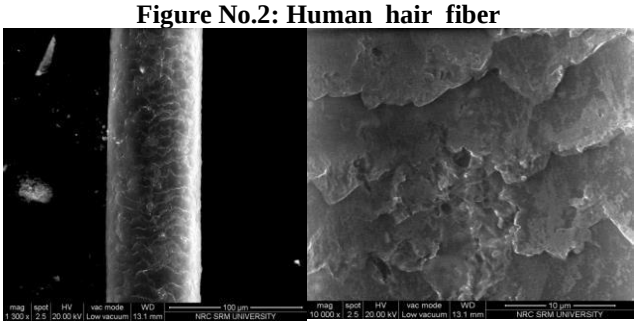

Figure No. 3: Electron microscopic image of hair

Table 1: Properties of Human Hair Fiber

S.N.	PROPERTY	SPECIFICATIONS
1	Length	8mm-40 mm
2	Diameter	40µm-90 µm
3	Protein present	Keratin
4	Cross section	Circular
5	Outer Covering	Cuticle

SPECIMEN PREPARATION

Soil sample is prepared using human hair fiber in 0.0, 0.5%,0.7%,0.9%,1.2% and 1.5% percentages by weight of soil sample. All samples are prepared at optimum moisture content (OMC) and maximum dry density (MDD). In air dried soil these percentages of human hair is mixed in random orientation. In order to obtain even distribution of fiber the quantity of fiber computedcorresponding to the above percentage directly mixed to soil before water adding to it.

3. TESTS PERFORMED

The various laboratory tests were performed on black cotton soil samples as per IS standard (IS:2720) to determine its Index and Engineering properties. The soil sample is then randomly mixed with various percentages of human hair fiber. Compactioncharacteristics i.e., Maximum Dry Density and OptimumMoisture Content were determined by Standard Proctor test results. Addition of fibers was done carefully and percentage is calculated by its weight. Following is the various test which was carried out on soil sample.

3.1 Moisture Content & specific gravity

The natural moisture content of soil sample is calculated by oven drying method it is found to be 22%.The specific gravity is determined by density bottle which is found to be 2.58.

Table 2: Some Basic Properties of Black Cotton Soil

S.N.	Properties of soil	Values
1	Atterbergs limits:	
	➢ Liquid limit	55 %
	➢ Plastic limit	34 %
	➢ Plasticity index	21 %
2	Grain size distribution:	
	➢ Sand	19 %
	➢ Silt	17 %
	➢ Clay	72 %
3	IS Classification	CH
4	Specific Gravity	2.58
5	Compaction Characteristics (Light Compaction)	
	(a) Maximum Dry unit weight	1.62 g/cc
	(b)Optimum Moisture Content	22 %

3.2 Atterbergs Limits

For determining atterbergs limits (Liquid limit & Plastic Limit) Casagrande's apparatus is used. Black cotton soil has liquid limit of 55% and plastic limit of 34% and having plasticity index 21% as shown in table no.1From the results of liquid limit and plastic index the soil were classify as highly compressible soil containing high percentage of clay.

3.3 Proctor Compaction Test

Table No.3 represents the maximum dry densities and optimum moisture contents values determined by using standard proctor test apparatus. As the quantity of HHF increases, the MDD decreases as illustrated in figure 5. HHF is a lighter material which replaces heavier soil particles due to which there is a reduction MDD. With the inclusion of HHF, the OMC increases due to rearrangement of soil particles with the fibers and the ability of absorption of fibers. The variation of OMC is shown in figure 4.

Table No. 3: OMC & MDD of reinforced soil sample

% HHF	OMC %	MDD g/cc
0	22.4	1.84
1	24.8	1.62
2	25.2	1.42
3	26.0	1.38
4	28.2	1.35

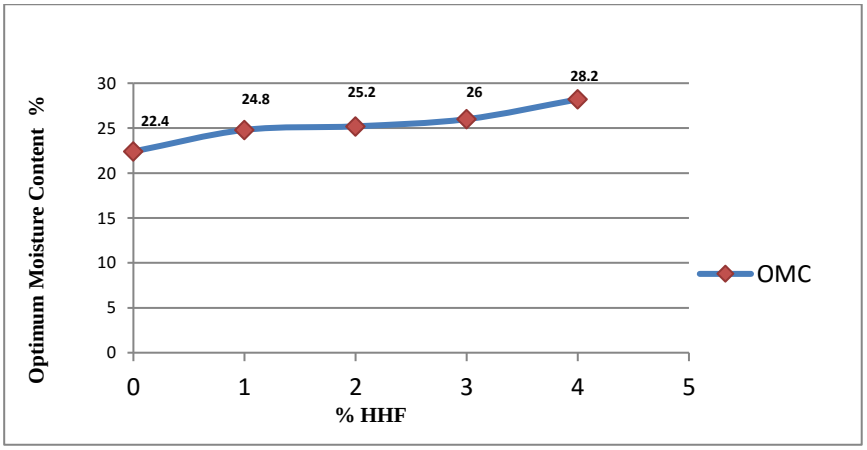

Figure 4. OMC of soil with varying HHF

Table 4. CBR Values of reinforced soil sample

	California Bearing Ratio	
% HHF	**CBR 2.5**	**CBR5**
0	0.731	0.7
1	0.832	0.72
2	1.43	1.15
3	1.88	1.8
4	1.23	1.32

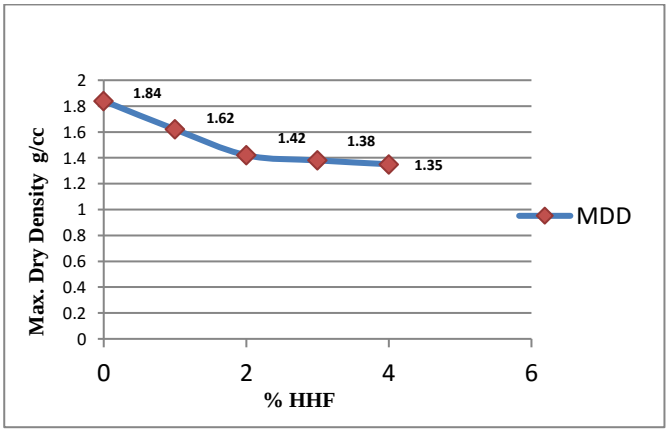

Fig 5:- MDD of soil with varying HHF

3.4 CBR Test

The CBRs of the reinforced soil sample is listed in table no.4 The CBR Values increases with the inclusion of HHF
upto 3% after that the value of CBR decreases.

$CBR_{2.5}$ = CBR Value at 2.5mm penetration

CBR_{5} = CBR Value at 5.0 mm penetration

4. RESULTS & DISCUSSION

4.1 Effects on Compaction Characteristics

Table No.3 presents the maximum dry densities and optimum moisture contents. From Fig.4 & 5 as % of HHF increases the decrease in dry density, With the inclusion of HHF, the OMC increases due to rearrangement of soil particles with the fibers and the ability of fibers of absorption.

4.2 Effects on California Bearing Ratio

It was observed that from the Fig.6 & 7, CBR value of soil samples at 2.5mm & 5mm admixed with HHF increase with increase in percentages of HHF upto 3% and it was found that the excess of HHF more than 3% causes decrease in CBR value.

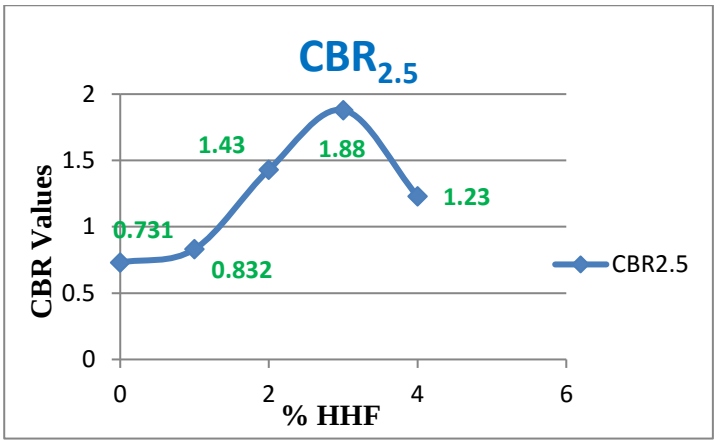

Fig 6:- CBR @ 2.5mm Penetration of soil with varying HHF

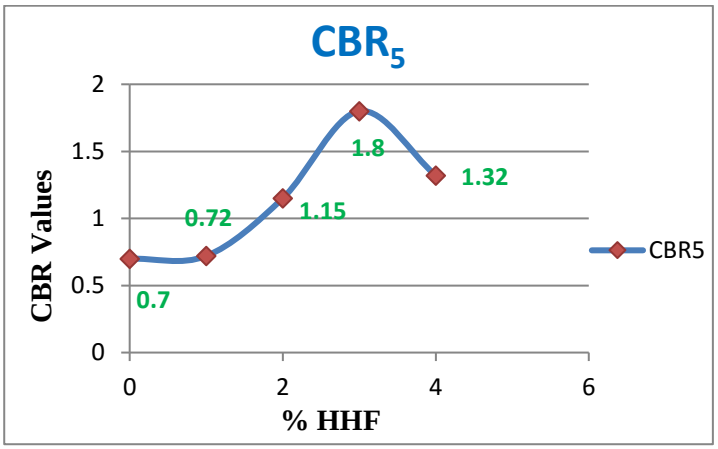

Fig 7:- CBR @ 5mm Penetration of soil with varying HHF

5. CONCLUSIONS

The following conclusions are drawn from the investigations:

- As the quantity of HHF increases, the MDD decreases due to its light weight.
- With the inclusion of HHF, the OMC increases due to rearrangement of soil particles with the fibers
- The addition of HHF up to 3% shows a significant increment in California bearing ratio.
- CBR value of soil samples at 2.5mm & 5mm mixed with HHF increases with increase in percentages of HHF upto 3% and it was found that the excess of HHF more than 3% causes decrease in CBR value.

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