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Study Of Clayey Soil Reinforced With Human Hair Fiber

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Abstract*—Clayey soil possesses threat for the construction of building due to its low shear strength and high swelling characteristics. Suitable ground improvement techniques need to be adopted on such soil. Soil reinforcement technique has been successfully used in recent times to improve the shear parameters of the marginal/weak soils. Among various reinforcing materials, Human Hair Fiber (HHF) can be used as a natural fiber to enhance the shear strength and bearing capacity of a clayey soil for sustainable use of waste materials and sustainable development of infrastructures in a rapid urbanization. Human hair fiber is a natural non-biodegradable waste material, which creates health and environmental problem if not disposed of in a scientific manner. This is available in abundance at a very low cost and can be easily used as a reinforcing material not only to improve poor/unsuitable construction sites for sustainable construction but also to avoid its disposal problems. Present research focuses towards the strength properties of clayey soil reinforced with HHF with average length of 4mm-40mm. The HHF randomly distributed in clayey soil samples were tested for its both Index and Engineering properties by performing consistency limit tests, compaction tests and unconfined compression tests on number of samples by using the different percentage of Human Hair fibers (0.5%, 1%, 1.5%, and 2%). Further, for obtaining the optimum dosage of HHF, UCS test was conducted for both reinforced and non-reinforced condition. The test results were compared with both Reinforced and Non-reinforced soil. The test results reveal that the inclusion of randomly distributed human hair fiber in soil significantly improves the engineering properties of soil.

***Keywords*— Human Hair fiber, Soil improvement, Compaction, UCS, Clay**

I. INTRODUCTION

Stabilized soil is, is generally a composite material that outcomes from mix and improvement of properties in individual constituent materials (Basha et al. 2004). The significant characterizations are mechanical adjustment, pressure driven adjustment, physical and substance adjustment and adjustment by consideration and control. The last two of these methods allow us to make use of solid waste materials in an efficient manner. It is highly desirable to replace cement, aggregates, and natural soils with solid industrial or natural waste. If adequate performance can be achieved, these materials are an appealing alternative due to their lower cost. Albeit the idea of haphazardly supported soil is moderately new in geotechnical designing yet the support of soils with normal filaments has been polished from the time of Pharaohs (Estabragh et al. 2011). Recently soil reinforcement with short, discrete, randomly situated strands is definitely standing out from numerous analysts all over the planet. Extensive studies were carried out on the stabilization of soft clays and expansive clays utilizing different added substances like lime, concrete, manufactured and regular filaments. Ranjan et al. (1994) investigated the behavior of Plastic Fiber Reinforced sand through a series of tri-axial tests. Unconfined compression tests were used by Maher and Ho (1994) to investigate the mechanical properties of a Kaolinite/fiber composite. Kaniraj et al. (2003) led an exploratory review to research the impact of randomly situated fiber incorporations on the geotechnical conduct of two Indian fly cinders. Akbulut et al. (2007) assessed the utilization of waste materials like scrap tire elastic, polyethylene, and polypropylene fiber to improve strength and dynamic behaviour of clayey soils.

Numerous researchers (Dall'Aqua et al.) were able to demonstrate, through a series of experiments, that the incorporation of polypropylene fibers into the soil improved soil behavior. 2010; Jiang et al. 2010; Senol, 2011). A clay soil reinforced with nylon fibers was the subject of an investigation by Estabragh (2011) into the effects of fiber on the soil's consolidation and shear strength behavior. Numerous studies demonstrated that natural fibers can be utilized effectively as reinforcement. Basha et al. (2004) directed concentrate on adjustment of lingering soils by artificially utilizing concrete and rice husk debris. Akhtar et al. (2008) investigated how a mixture of fly ash and lime containing varying proportions of human hair fibers affected the California Bearing Ratio values. Akhtar and Ahamad (2009) investigated how hair fiber affected the mechanical properties of hollow block made of fly ash for masonry structures. Ramesh et al. (2010) portrayed the compaction and strength conduct of black cotton soil (BC soil) built up with coir strands. Strength Behavior of Clayey Soil Reinforced with Human Hair as a Natural Fiber (Wajid Ali Butt et. al., 2015). An Innovative Method of Improving Subgrade Strength of Soft Soil using Human Hair Fibers as Reinforcement (Harini et. al., 2016). Characterization of Clay Soil Reinforced with Human Hair for Pavement Design (Sonu Singh et. al., 2018) Nonetheless, tracked down examinations on the utilization of human hair filaments in the adjustment of soils as support have not been accounted for up until this point, which is endeavored in this study.

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II. MATERIALS AND METHODOLOGY

A. Materials

1) Expansive soil

In the present study soil is clayey in nature which is collected in Bellary region of Karnataka state. To investigate the engineering properties of the collected soil laboratory tests have been carried out according to IS methods of testing.

Fig. 1- Expansive Soil

Table 1: Properties of Clayey Soil

Sl. No.	*Properties*	*Experimental Value*
1.	Specific Gravity	2.85
2.	Liquid Limit (%)	59
3.	Plastic Limit (%)	28
4.	Plasticity Index (%)	20.00
5.	Maximum Dry Density(g/cc)	1.56
6.	Optimum Moisture Content (%)	27.89

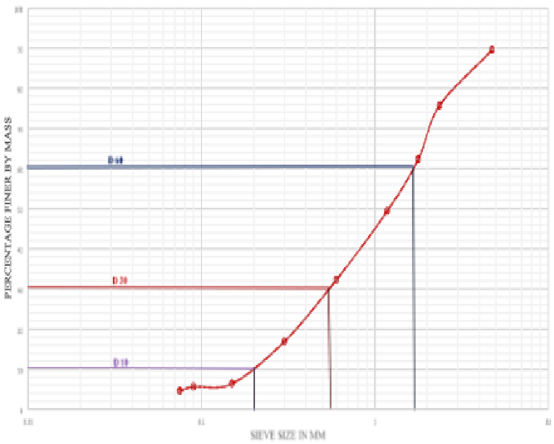

Fig. 2: Grain size distribution curve

2) Human Hair Fiber

The HHF was gathered from local sources. The main physical properties of the hair depend mostly on its geometry; the physical and mechanical properties of hair involve characteristics to improve elasticity, smoothness, volume, shine and softness due to both the significant adherence of the cuticle scales and the movement control as well as the easiness of combing, since they reduce the fibers static elasticity. The average composition of normal hair is composed of 45.68 % carbon, 27.9 % oxygen, 6.6 % hydrogen, 15.72 % nitrogen and 5.03 % sulphur (Choudhry and Pandey 2012)electing a Template (Heading 2).

Fig. 3: Human Hair Fiber

B. Sample Preparation

Different values of fiber content adopted for present study were 0.5%, 1.0%, 1.5% and 2.0% by weight of soil. The mixing of soil was felt very difficult beyond 2.0%, as the same stick together to form lumps. This also caused pockets of low density. So, it was decided to stop with 2.0% fiber content. Fibers were added to the moist mixture soil at different percentages and were tested as per IS specifications. When fibers were mixed in dry soil segregation and floating occurred. All mixing was done manually and proper care and time were spent for preparing homogenous mixture at each stage of mixing. It was found that the fibers could be mixed with soil more effectively in the moist state than in dry state.

C. Laboratory Tests and Program

Proctor's standard compaction test was carried out to determine the maximum dry density (MDD) and the optimum moisture content (OMC) of both unreinforced and reinforced soils. The soil mixtures, with and without fibers, were thoroughly mixed with various moisture content. The first series of compaction tests were aimed at determining the compaction properties of the unreinforced soils. Secondly, tests were carried out to determine the proctor compaction properties of the clay upon mixing with varying percentage of human hair fiber. Samples were prepared as described earlier. Unconfined compressive strength tests were conducted for various mix proportions of clay and human hair fibers compacted to their maximum dry density (MDD) and optimum moisture content (OMC). Cylindrical specimens with a slender ratio 2 (38 mm diameter × 76 mm length) were prepared by compacting compaction mould using round hammer in three equal layers. Ttest was carried out as per the IS standards. All the specimens were prepared at the MDD and OMC obtained from the compaction test respectively.

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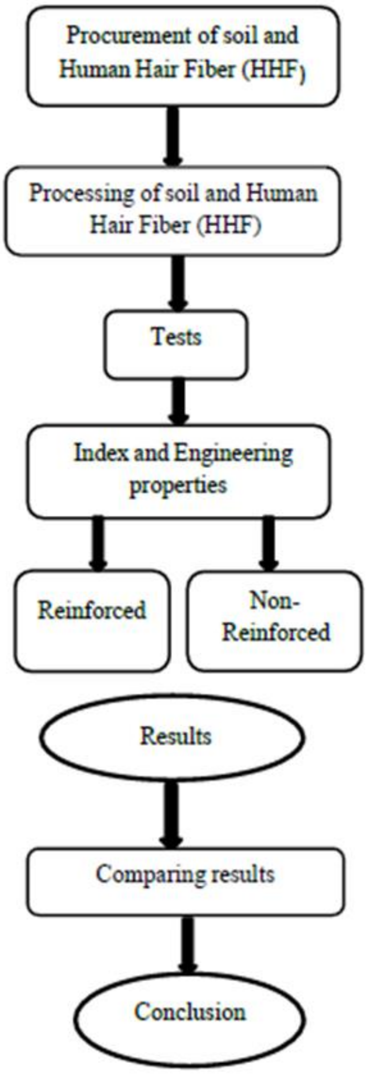


Fig.4 Schematic representation of methodology adopted

III. RESULTS AND DISCUSSION

A. *Effects on Compaction Characteristics*

Proctor compact tests were conducted in order to find the moisture content-density relationship for both unreinforced and reinforced clayey soil. The effect of inclusion of hair fibers in the clay was found out by adding various amount of fiber content (0.5-2.0% by weight). The standard Proctor tests were conducted with an initial target moisture content of 18% with an increment of 5%. Two trials of test for each composition were conducted in order to get more reliable results for comparison. The effects of fiber inclusion on the compaction behavior for clay are shown in Figure 4. It has been observed that addition of randomly distributed hair fiber to Kaolinite clay with different percentages reduces OMC and increases MDD.

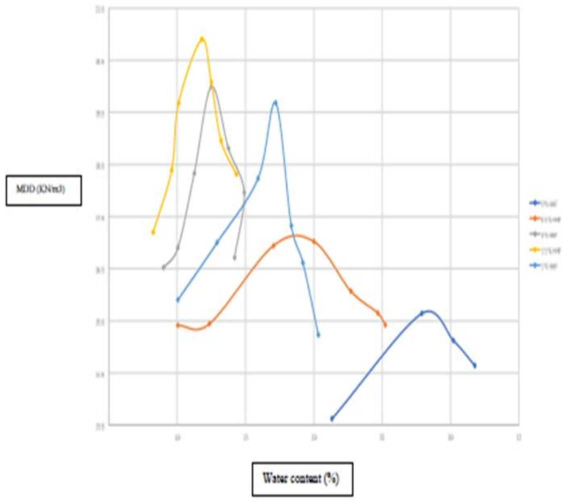


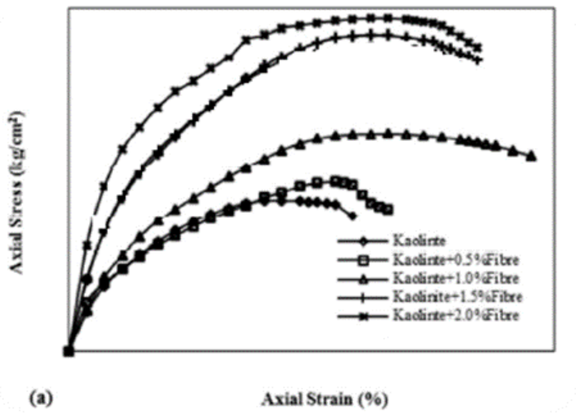
Fig. 5: Effects of fiber inclusion on the compaction behavior for clay

Table 2: Optimum moisture content (OMC) and maximum dry density (MDD) with varying percentage of HHF by weight of clayey soil

Human hair fiber (%)	Optimum moisture content (%)	Maximum dry density (gm/cc)
0.0	27.89	15.94
0.5	20.00	17.32
1.0	12.50	20.29
1.5	11.80	21.20
2.0	17.21	19.98

B. *Effects on Compressive Strength*

The typical stress-strain behaviour of unreinforced clay and reinforced clay measured from unconfined compression test out for reinforced and un-reinforced soil was carried out. Fiber inclusion affected the stress-strain relationship of Kaolinite clay under static load by increasing the peak compressive strength, reducing the post-peak reduction in compression resistance, and increasing the absorbed strain energy (ductility). From the failure pattern it is observed that unreinforced specimens failed in shearing thorough a plain at 45° i.e. brittle failure and reinforced specimens failed in compression with bulging of specimen. The unconfined compressive strength (UCS) of unreinforced and human hair fiber-reinforced clay for different mix proportions determined from the stress-strain curve for various trials are presented in Table-3.



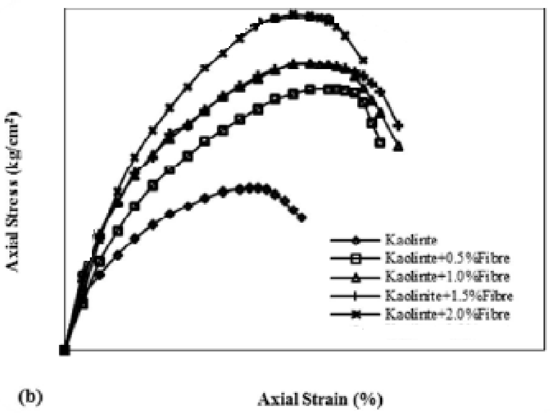


Fig. 6: Stress-strain relationship of human hair fiber reinforced and unreinforced black cotton soil.

Table 3: Unconfined compression test results

Percentage of Hair Fiber	Average UCS (kg/cm2)	Peak Axial Strain (%)	Avg. Cohesion, c (kg/cm2)	Increase in Strength (%)
0	1.18	7.46	0.59	NA
0.5	1.59	9.87	0.79	34.83
1	1.77	10.09	0.89	50.35
1.5	2.09	9.87	1.05	77.55
2	2.0	10.05	1.02	69.45

It is seen that the average UCS of the mixture reinforced with the hair fiber reaches its maximum strength almost at 1.5 % inclusion. The average improvement in strength was 34.83%, 50.35%, 77.55%, 99.79% and 89.45% corresponding to fiber inclusion ratio from 0.5 – 2.5% (Table 2). Similarly the peak axial strain of reinforced clay increases with increase in percentage of hair fiber, which proves the reinforced mixture, tends to behave in a ductile manner compared to that of unreinforced clay.

IV. CONCLUSION

By conducting Standard Compaction Test on both Reinforced and Non- Reinforced soil, the MDD for Reinforced soil is 1.5% of HHF and a gradual decrease is in the MMD with the further increase in percent of HHF. OMC is obtained in soil Reinforced with 1.5% HHF and further increase in the percentage of HHF increases the OMC. On comparing the results of the Standard Compaction test we came to know that MDD of Non- Reinforced soil is 15.94 kN/m³ and for the Reinforced soil is 21.2 kN/m³. On comparing the OMC of both soils, we came to know that the OMC of Non- Reinforced soil is 27.9% and Reinforced soil is 11.8%. By conducting Unconfined Compressive Strength Test, we came to know that the UCS of Non-Reinforced soil is 1.18kg/cm2 and for soil Reinforced is 2.09kg/cm2 which shows an increase in strength. From the result of the UCS test, we can conclude that, the soil with HHF reinforcement has more strength than the non-Reinforced soil.

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