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COMPARATIVE STUDY OF SOIL WITH AND WITHOUT HUMAN HAIR FIBER AS REINFORCEMENT

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Abstract: Accumulation of solid waste is another serious problem faced by the world for which huge area of land is required for its disposal. Alternatively, engineers try to utilize these solid waste materials in the civil engineering construction based on its feasibility or suitability on their performance. The main objective this study is to investigate the suitability of solid waste materials such as human hair fibers in the process of soil subgrade stabilization as a reinforcement which can replace conventional commercial fiber materials. The influence of reinforcement parameters i.e. fiber content on Kaolinite clay will observe through a series of laboratory tests such as consistency limit tests, compaction tests and unconfined compression tests.

This project concluded that the moisture content of soil without human hair fiber is found to be 18.75%. And the moisture content of soil with human hair fiber is found to be decreased as percentage of human hair increased. The specific gravity of soil without human hair fiber is found to be 2.769. And the specific gravity of soil with human hair fiber is found to be decreased as percentage of human hair increased. The free swell test value of soil without human hair fiber is maximum and it is decreased as percentage of human hair increased in soil. Hence degree of expansion is low and degree of severity is non-critical. The maximum dry density (MDD) in standard proctor test of soil without human hair fiber is found to be 1.534 g/cc, which is increased as percentage of human hair increased. Optimum moisture content (OMC) is found to be 10% in soil without human hair fiber and increased as percentage of human hair increased. From Consistency limits test, it is found that the effect of fiber inclusion on consistency limits were minimal, however it was observed that with the increase of human hair fibers content there was a slight increase in the liquid limit and slight increase in plastic limit thereby increasing the plasticity of soil.

Keywords: Soil, Soil Stabilization, Human Hair Fiber, Standard Proctor Test, etc.

I. INTRODUCTION

Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that together support life. All of these functions, in their turn, modify the soil and its properties. Soil is also commonly referred to as earth or dirt; some scientific definitions distinguish dirt from soil by restricting the former term specifically to displaced soil. The pedosphere interfaces with the lithosphere, the hydrosphere, the atmosphere, and the biosphere. The term pedolith, used commonly to refer to the soil, translates to ground stone in the sense fundamental stone. Soil consists of a solid phase of minerals and organic matter (the soil matrix), as well as a porous phase that holds gases (the soil atmosphere) and water (the soil solution). Accordingly, soil scientists can envisage soils as a three-state system of solids, liquids, and gases.

Soil is a product of several factors: the influence of climate, relief (elevation, orientation, and slope of terrain), organisms, and the soil's parent materials (original minerals) interacting over time. It continually undergoes development by way of numerous physical, chemical and biological processes, which include weathering with associated erosion. Given its complexity and strong internal connectedness, soil ecologists regard soil as an ecosystem. Most soils have a dry bulk density (density of soil taking into account voids when dry) between 1.1 and 1.6 g/cm^3, while the soil particle density is much higher, in the range of 2.6 to 2.7 g/cm^3. Little of the soil of planet Earth is older than the Pleistocene and none is older than the Cenozoic, although fossilized soils are preserved from as far back as the Archean. Soil science has two basic branches of study: edaphology and pedology. Edaphology studies the influence of soils on living things. Pedology focuses on the formation, description (morphology), and classification of soils in their natural environment. In engineering terms, soil is included in the broader concept of regolith, which also includes other loose material that lies above the bedrock, as can be found on the Moon and on other celestial objects.

Figure 1: Soil

1.1 HUMAN HAIR FIBER

Biological fibers have been already used some 3000 years ago in composite systems in the ancient Egypt, where straw and clay were mixed together to build the walls. In the last few years, biological fibers have become an attractive reinforcement for polymeric composites from economical and ecological point of view. There is an increase in the environmental awareness in the world which has aroused an interest in the research and the development of biodegradable materials. Biological/Natural fibers can be obtained from natural resources such as plants, animals or minerals.

With the increase of global energy crisis and ecology risk, the unique advantages of biological fibers such as its abundance quantity, non-toxic, non-irritation of the skin, eyes, or respiratory system, noncorrosive property, biological fiber reinforced polymer composites have attracted much interest owing to their potential of serving as alternatives reinforcement to the synthetic ones. The lower weight and higher volume of the biological fibers as compared to the synthetic fibers improve the fuel efficiency and reduced emission in auto applications. Hair is a protein filament that grows from follicles found in the dermis or skin. It is one of the defining characteristics of mammals.

Figure 2: Hair Fiber

The human body, apart from areas of glabrous skin, is covered in follicles which produce thick terminal and fine vellus hair. Most common interest in hair is focused on hair growth, hair types and hair care, but hair is also an important biomaterial primarily composed of protein, notably keratin. Keratins are proteins, long chains (polymers) of amino acids. In terms of raw elements, on an average, hair is composed of 50.65% carbon, 20.85% oxygen, 17.14% nitrogen, 6.36% hydrogen, and 5.0% sulphur. Amino acid present in hair contain cytosine, serine, glutamine, threonine, glycine, leucine, valine and arginine.

Table 1: Properties of Human Hair Fiber

Sr. No.	Properties of Human Hair Fiber	Remark
1	Cross-Section	Circular
2	Diameter	17-100 μm
3	Length	5-50 mm
4	Elongation	1.5 times its dry weight
5	Tensile strength	Around 1.6×10^{-9} N/m^2
6	Outer Covering	Cuticle
7	Protein Present	Keratin

Human hair is generally strong in tension; hence it can be used as a fiber reinforcement material. Human hair fiber is an alternative non-degradable matter available in abundance and at cheap cost. Also addition of human hair fibers enhances the binding properties; micro cracking control imparts ductility and also increases swelling resistance.

The lightweight, strength and deformation properties of human hair fibers make them effective materials in various foundation-engineering applications. They consist of fibers of varying length (4–40 mm) and diameter (40–111μm). Fibers as directly collected from barber shop are used for laboratory experiments to avoid processing cost. Properties of human hair fiber vary with age, colour, geographic location etc. These concerns are not considered in this study to avoid increment in cost because of extra processing.

1.2 Problem Statement

A developing country like India which has a large geographical area and population, demands vast infrastructure i.e. network of roads and buildings etc. Everywhere land is being utilized for various structures from ordinary house to sky scrapers, bridges to airports and from rural roads to expressways. Almost all the civil engineering structures are located on various soil strata. Soil can be defined as a material consisting of rock particles, sand, silt, and clay. Transportation of soil materials by wind, water and ice forms different soil formations such as those found in river deltas, sand dunes and glacial deposits. In India, soils are classified into six groups namely alluvial soil, marine soil, laterite and lateritic deposits, expansive soils, desert soil and boulder deposits.

Soil stabilization is the process which involves enhancing the physical properties of the soil in order to improve its strength, durability etc. by blending or mixing it with additives. The different types of methods used for soil stabilization are: Soil stabilization using cement, Soil stabilization using lime, Soil stabilization using bitumen, Chemical stabilization and a new emerging technology of stabilization that is stabilization of soil by using Geo textiles and Geo synthetic fibers. The above methods can be used alone or in combination. This thesis makes the use of hair fiber for soil improvement.

1.3 Aim of the Study

As more and more land becomes subject to urban or industrial development, good construction sites and borrows areas are difficult to find and the soil improvement alternatives becomes the best option, technically and economically. The aim of this research is to identify a fiber to understand and investigate the variation of the strength of the soil using human hair fibers randomly mixed with the soil samples. The main objective of this study is to investigate the suitability of soil such as human hair fibers in the process of soil improvement as a reinforcement which can replace conventional commercial fiber materials.

The study also includes a proposed protection method to increase the durability of the selected fiber, determination of the optimum reinforcement scheme in terms of fiber content and length. Moreover an environmental concern is also included by utilization of human hair fiber materials and they can be made useful for improving the soil characteristics and to solve problems related to the disposal of waste human hair fibers material.

1.4 Objectives of the Study

a) To study the behavior of soil with human hair fiber,
b) To analyze index properties of soil and engineering properties of soil,
c) To perform experiment on soil collaborate with fiber,
d) To compare engineering properties of soil with and without human hair fiber.

II. Methodology

The different phases of this project work are shown in the above diagram. The figure simply describes the experimental strategy of this study step by step.

a) Review of the existing literature on soil improvement techniques,
b) Selection of type soil sample type, (clay, soft soil, black cotton soil, etc.)
c) Selection of sources of human hair fiber,
d) To find out index properties of soil,
e) Comparative analysis of soil with and without human hair fiber,
f) Interpretation of results and conclusion.

2.1 Tests on Soil

Following are the various types of soil tests to be taken in this study:

a) Moisture Content of Soil
b) Specific Gravity of Soil
c) Free Swell Test
d) Compaction Test – Standard Proctor Test
e) Liquid Limit Test & Plastic Limit Test

2.2 Identification of Samples

Table 2: Identification of Samples

Sr. No.	Sample Number	% of Human Hair Fiber
1	S0	0 % (Without Human Hair Fiber)
2	S1	0.5 %
3	S2	1 %
4	S3	1.5 %
5	S4	2 %
6	S5	2.5 %
7	S6	3 %

2.3 Summary of Test Results of Soil without Human Hair Fiber

Table 3: Test Results of Properties of Soil without Human Hair Fiber

Sr. No.	Properties	Values
1	Moisture Content	18.75 %
2	Specific Gravity	2.769
3	Free Swell Test	55 %
4	Maximum Dry Density (MDD) from SPT	1.534 g/cc
5	Optimum Moisture Content (OMC) from SPT	10 %
6	Liquid limit (W_L)	51.16 %
7	Plastic limit (W_P)	26.78 %
8	Plasticity Index (I_P)	24.38 %

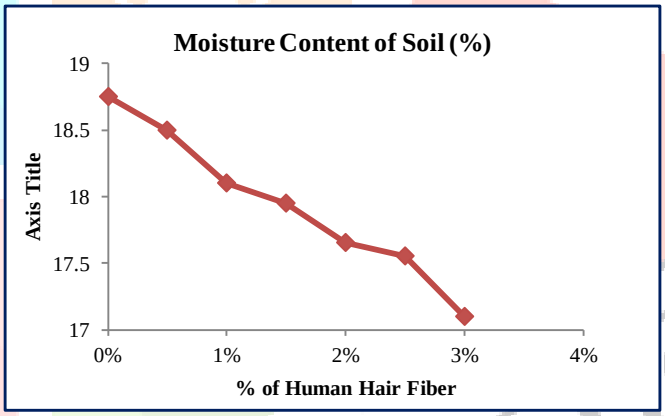
III. Results and Analysis

3.1 Test Results of Soil with Human Hair Fiber

3.1.1 Moisture Content of Soil

Table 4: Test Results of Properties of Moisture Content of Soil

Sample No.	% of Human Hair Fiber	Moisture Content of Soil (%)
S0	0 %	18.75
S1	0.5 %	18.50
S2	1 %	18.10
S3	1.5 %	17.95
S4	2 %	17.65
S5	2.5 %	17.55
S6	3 %	17.10

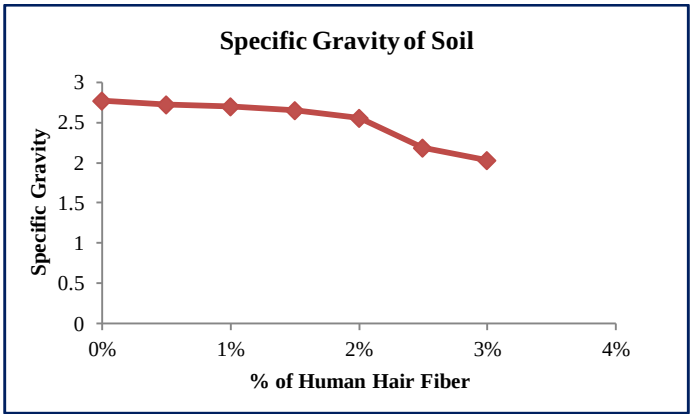


Graph 1: Comparative Test Results of Moisture Content of Soil with and without Human Hair Fiber

3.1.2 Specific Gravity of Soil

Table 5: Test Results for Specific Gravity of Soil

Sample No.	% of Human Hair Fiber	Specific Gravity of Soil
S0	0 %	2.769
S1	0.5 %	2.725
S2	1 %	2.695
S3	1.5 %	2.645
S4	2 %	2.558
S5	2.5 %	2.184
S6	3 %	2.028

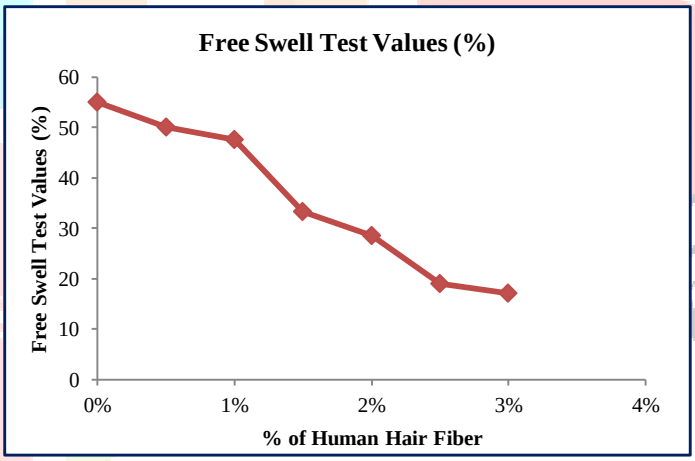


Graph 2: Comparative Test Results of Specific Gravity of Soil with and without Human Hair Fiber

3.1.3 Free Swell Test

Table 6: Test Results for Free Swell Test

Sample No.	% of Human Hair Fiber	Free Swell Test Values (%)
S0	0 %	55
S1	0.5 %	50
S2	1 %	47.62
S3	1.5 %	33.33
S4	2 %	28.57
S5	2.5 %	19.05
S6	3 %	17.10

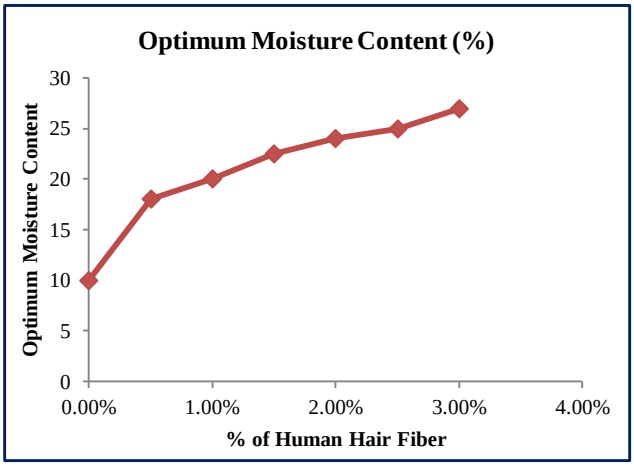


Graph 3: Comparative Test Results of Free Swell Test of Soil with and without Human Hair Fiber

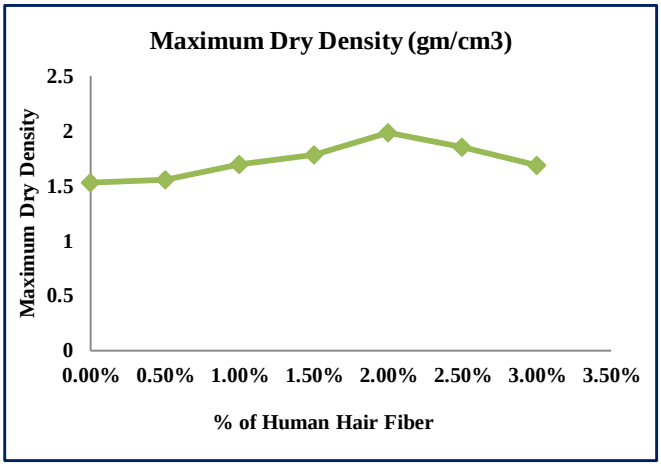
3.1.4 Compaction Test –Standard Proctor Test

Table 7: Test Results for Standard Proctor Test

Sample No.	% of Human Hair Fiber	Standard Proctor Test	
		OMC (%)	MDD (gm/cm^3)
S0	0 %	10	1.534
S1	0.5 %	18	1.556
S2	1 %	20	1.695
S3	1.5 %	22.5	1.786
S4	2 %	24	1.983
S5	2.5 %	25	1.855
S6	3 %	27	1.685



Graph 4: Comparative Test Results of Optimum Moisture Content of Soil with and without Human Hair Fiber



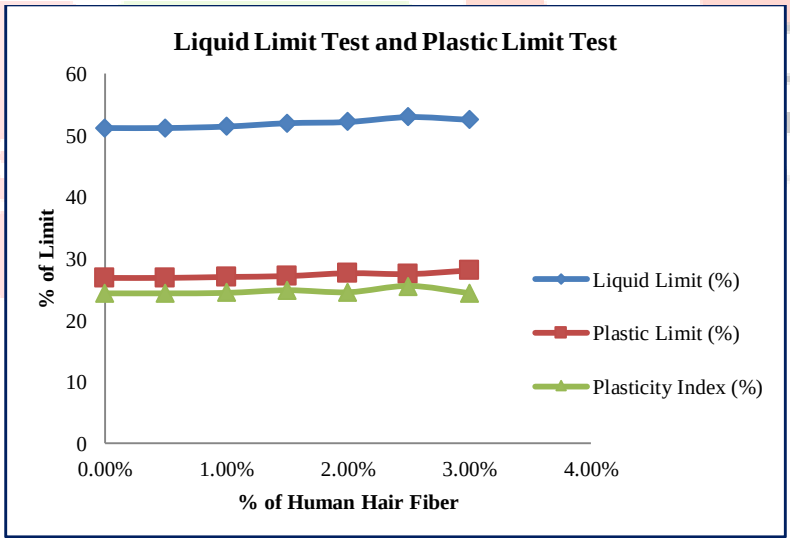
Graph 5: Comparative Test Results of Maximum Dry Density of Soil with and without Human Hair Fiber

3.1.5 Liquid Limit Test and Plastic Limit Test

Table 8: Test Results for Liquid Limit Test and Plastic Limit Test

Sample Number	% of Human Hair Fiber	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
S0	0 %	51.16	26.78	24.38
S1	0.5 %	51.56	26.90	24.40
S2	1 %	51.40	26.95	24.45
S3	1.5 %	51.95	27.10	24.85
S4	2 %	52.15	27.60	24.55
S5	2.5 %	52.95	27.45	25.50
S6	3 %	52.50	28.10	24.40

With increase in % of human hair fiber, Plastic Limit gives higher values as compared to Liquid Limit.



Graph 6: Comparative Test Results of Liquid Limit Test and Plastic Limit Test of Soil with and without Human Hair Fiber

3.2 Summary of Test Results of Soil with and without Human Hair Fiber

Table 4.13: Test Results of Properties of Soil with and without Human Hair Fiber

Sr. No.	Properties	0 %	0.5 %	1 %	1.5 %	2 %	2.5 %	3 %
1	Moisture Content (%)	18.75	18.50	18.10	17.95	17.65	17.55	17.10
2	Specific Gravity	2.769	2.725	2.695	2.645	2.558	2.184	2.0258
3	Free Swell Test (%)	55	50	47.62	33.33	28.57	19.05	17.10
4	MDD - SPT (g/cc)	1.534	1.556	1.695	1.786	1.983	1.855	1.685
5	OMC - SPT (%)	10	18	20	22.5	24	25	27
6	Liquid Limit (W_L)	51.16	51.56	51.40	51.95	52.15	52.95	52.50
7	Plastic Limit (W_P)	26.78	26.78	26.95	27.10	27.60	27.45	28.10
8	Plasticity Index (I_P)	24.38	24.38	24.45	24.85	24.55	25.50	24.40

IV. CONCLUSION

Based on test results and experiments conducted on soil sample the following conclusion were given,

1. The moisture content of soil without human hair fiber is found to be 18.75%. And the moisture content of soil with human hair fiber is found to be decreased as percentage of human hair increased.
2. The specific gravity of soil without human hair fiber is found to be 2.769. And the specific gravity of soil with human hair fiber is found to be decreased as percentage of human hair increased.
3. The free swell test value of soil without human hair fiber is maximum and it is decreased as percentage of human hair increased in soil. Hence degree of expansion is low and degree of severity is non-critical.
4. The maximum dry density (MDD) in standard proctor test of soil without human hair fiber is found to be 1.534 g/cc, which is increased as percentage of human hair increased. Optimum moisture content (OMC) is found to be 10% in soil without human hair fiber and increased as percentage of human hair increased.
5. From Consistency limits test, it is found that the effect of fiber inclusion on consistency limits were minimal, however it was observed that with the increase of human hair fibers content there was a slight increase in the liquid limit and slight increase in plastic limit thereby increasing the plasticity of soil.

V. FUTURE SCOPE

1. Use of human hair fiber with sheep wool fiber will be added new innovation in soil engineering.
2. Fiber-reinforced concrete (FRC) is one of those advances which offers a convenient, practical, and cost-effective method to overcome microcracks and similar deficiencies. Use of naturally available chopped human hair as fibers in concrete to enhance the performance of concrete. Human hair is non biodegradable material existence in nature.
3. Use of human hair fiber with jute fiber will also be added new innovation in soil engineering to increase properties of soil.
4. Human hair is waste whose dispose is not in our hand it is a non biodegradable material as in early years. Its utilization is very effective/essential for a better environmental conditions. Subgrade is mandatory for all types of pavements i.e. flexible or rigid. This study shall also be give us a better option for use of human hair and surkhi for a better environmental conditions
5. Using sheep wool as fiber reinforcement as concrete admixture will give good percentage of increment in both compressive strength and flexural strength of concrete.
6. The large quantities of human hair, unfortunately, are not always well managed or utilized. These wastes can be recycled, such as by incorporating in brick-making. This way the fly ash bricks are made a 'greener' building material and the discarded natural wastes can be re-utilized, avoiding otherwise wasteful landfill and harmful open incineration.

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