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An Innovative Ground Improvement Technique using Human Hairs and Sodium Polyacrylate

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Abstract

In this modern era of rapid development, solid waste has emerged as a great challenge due to its increased rate of generation. The accumulation of solid waste is very hazardous to the environment as well as human health. Disposal of solid waste is one of the serious global issues faced by the world. So, we have tried to utilize human hairs which form a part of solid waste, for improving the soil. Our main objective was to find whether solid waste materials such as human airs can contribute to construction industry based upon its suitability. It would prove to be an economical solution when used for reinforcing the soil replacing the conventionally used fibre products. The soil sample has been tested for Atterberg's consistency limits, compaction test and unconfined compression test. The laboratory tests show that inclusion of human hairs improved the engineering properties of soil. The test using chemical compound sodium polyacrylate with human hairs is not executed till now, but it is under process.

Keywords: *Ground Improvement, Human hair, Sodium Polyacrylate.*

1. Introduction

In general, stabilized soil is a composite material that results from the combination and optimization of individual constituent material properties. Hydraulic stabilization, mechanical stabilization, physical and chemical stabilization and stabilization by addition and containment are the main classifications. The last two approaches in these strategies are that we should use hazardous waste products successfully. It is highly desirable to replace natural soils, aggregates, and asphalt with solid industrial or natural waste. As these materials are low cost, if sufficient output can be achieved, it provides a desirable option.

Recently, many researchers around the world have given further attention to soil reinforcement with isolated and randomly directed fibers. Extensive experiments are being carried out using various chemicals such as lime cement, synthetic and natural fibres to strengthen soft clays and expansive clays. The effect of polypropylene fibre

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addition into the soil in the improvement of soil behaviour through a series of experimental investigations was established by many researchers [1, 2].

The consequence of fly ash mixed with a differing percentage of hair fibers studied by several researchers in the past [3, 4]. The strength of black cotton soil can be improved by means of soil reinforced with coir fibres [5]. However, reports on the use of hair and sodium polyacrylate in soil stabilization as a reinforcement have not yet been documented and are being reviewed in this study.

2. Material Used

2.1 Soil

The soil used in this study is black cotton soil. Various laboratory tests were conducted to determine various index and engineering properties of soil according to Indian Standard methods of testing. Table 1 compiles the various index and engineering properties of the soil.

Table 1. Properties of Soil sample

Property	Value
Specific Gravity	2.72
Liquid Limit	64 %
Plastic Limit	38 %
Plasticity index	26 %
Maximum dry density	1.62 g/cc
Optimum Moisture Content	19 %
% Clay	68 %
% Silt	32 %
% Sand	0 %

Figure. 1. Soil sample

2.2 Human hairs

In different soil stabilization engineering applications, the strength, deformation properties and light weight of hair make them effective material. Throughout the research, human hair was used to provide the soil with strength. Scanning Electron Microscope study was done to obtain the normal human hair diameter. Samples were prepared by

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adding 0.5 percent, 1.0 percent, 1.5 percent, 2.0 percent and 2.5 percent hair content to the soil sample by weight.

Figure 2. Human Hair

2.3 Sodium Polyacrylate

Sodium polyacrylate, also known as water lock, is a polyacrylic acid sodium salt containing the chemical formula $[-CH_2-CH(CO_2Na)-]_n$ and commonly used in consumer goods. The strength of this superabsorbent material is to contain 100 to 1000 times its water mass. An anionic polyelectrolyte with negatively charged carboxylic groups in the main chain is sodium polyacrylate.

Sodium polyacrylate is a chemical polymer that is widely used in a variety of consumer products for its ability to absorb several hundred times its mass in water. Sodium polyacrylate is made up of multiple chains of acrylate compounds that possess a positive anionic charge, which attracts water-based molecules to combine with it, making sodium polyacrylate a super-absorbent compound.

3. Sample Preparation

For this analysis, various hair content values of sodium polyacrylate were accepted for 0.5 percent, 1.0 percent, 1.5 percent, 2.0 percent, and 2.5 percent by soil sample weight. The mixing of dirt, when the sample would tie together and form small lumps, becomes very difficult above 2.5 percent. This has also contributed to the creation of low-density air pockets. So, at 2.5 percent hair content, it was decided to end the planning. At varying percentages, hair was applied to the saturated soil and the procedure was performed according to the codes. When hairs were mixed in dry soil segregation and floating occurred in the soil sample. All mixing was done manually and preparation of homogenous mixture on every stage of mixing samples. It was found that the hairs can get mixed in moist state more effectively than dry state.

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Figure 3. Reinforced Soil Sample with Human Hairs

4. Laboratory Testing Program

The Atterberg's consistency limits i.e. liquid limit and plastic limit was found as per IS code procedure using Casagrande's apparatus. The test was conducted using Oven-dried soil sample. The tests were carried out on the soil sample with different proportions of human hair and sodium polyacrylate. Proctor's standard compaction test was performed to determine the maximum dry density (MDD) and the optimum moisture content (OMC) of both unreinforced and reinforced soil sample after and before adding human hair and sodium polyacrylate. The soil mixtures, with and without hairs and sodium polyacrylate, were mixed thoroughly with various moisture contents. The first level of compaction tests was focused on determining the compaction properties of the unreinforced soil sample. Later, tests were performed to determine the proctor compaction properties of the soil upon mixing with varying percentage of hairs and sodium polyacrylate. Samples were prepared as described previously. Unconfined compressive strength tests were performed for various mix proportions of black cotton soil and human hairs and sodium polyacrylate 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 the sample in Harvard miniature compaction mould using spring hammer in three equal layers by giving 25 blows per layer. Axial strain rate of 0.5 mm/min was taken in order to complete the test within 10 minutes to prevent loss of water content during test. All the specimens were set at an average MDD and OMC of 1.7 g/cc and 22.3 % respectively since the MDD and OMC of various mix proportions do not vary considerably and for comparison purpose. Hence the effects due to differences in the dry density and water content of the unreinforced and reinforced samples were thus avoided.

5. Result and Discussion

1. Effects on the Consistency Limits

Owing to the inclusion of human hairs and sodium polyacrylate, which refers to the fact that human hairs consume moisture content within the saturated soil, it was shown that there was a minor rise in the liquid limit. Also, it was observed that there was a slight decrease in plastic limit with the addition of reinforcement. In this sense, the increase in human hair plasticity and the minimal volume of sodium polyacrylate reinforced soil are demonstrated as consequence of an increase in LL and a decrease in plastic limits.

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Although the effects of human hair and sodium polyacrylate addition on quality limits is much smaller.

2. Effects on Compaction Characteristics

In order to find the moisture content-density relationship for both unreinforced and reinforced soil, a Proctor compact test was conducted. The MDD and OMC were found to be 1.84 g/cc and 20.54 percent respectively, from the unreinforced soil survey. By applying varying amounts of all the sample material, the result of adding human hair and sodium polyacrylate to the clay was noticed (0.5-2.5 percent by weight).

The regular Proctor experiments were carried out with an initial moisture content goal of 17 %, with an initial increase of 4%, accompanied by a peak density increase of 1%. In order to achieve more satisfactory results for comparison, two research trials for each formulation were conducted. The effects of the incorporation of human hair and sodium polyacrylate on the compaction actions of black cotton soil have been noted. It has been found that addition of randomly distributed human hair and sodium polyacrylate to soil with different percentages reduces MDD and increases OMC. In the case of soil specimens fortified with human hair and sodium polyacrylate, the decrease in MDD and increase in OMC is attributed to the fact that lighter content substitutes hard soil mass and therefore decreases MDD due to rearrangement of particles with reinforcement. With the growing content of both human hair and sodium polyacrylate, except for 2.5 percent, the pattern that was observed in both OMC and MDD was declining.

3. Effects on Compressive Strength

For two tests, the standard stress-strain activity of unreinforced soil and reinforced soil determined from an unconfined compression test was examined. By increasing the peak of compressive power, reducing the post-peak in compression resistance, and increasing the absorbed strain energy, human hair and sodium polyacrylate addition influenced the stress-strain relationship of soil under static load.

Table 2. UCS Test Results

% Hairs and sodium polyacrylate	Average UCS (kg/cm^2)	Peak axial strain (%)	Average Cohesion (kg/cm^2)	Increase in strength (%)
0.5	1.62	8.32	0.66	35.76
1.0	1.83	8.56	0.74	52.87
1.5	2.14	9.12	0.88	79.35
2.0	2.36	9.74	1.02	99.59
2.5	2.21	9.66	1.14	88.78

It was observed from the failure sequence that the unreinforced sample failed to shear through a plain at 45^0 i.e. slight failure and the strengthened sample failed to compress with human hair and sodium polyacrylate bulging. Unconfined compressive strength (UCS) of unreinforced and human hair with strengthened sodium polyacrylate soil for various blend proportions calculated for different studies from the stress-strain curve and its variation with human hair and sodium polyacrylate percentage. The average UCS of respective percentage of human hair and sodium polyacrylate was found. The average UCS of the hair and sodium polyacrylate reinforced mixture has been shown to achieve its full strength at almost 2.0 percent. The average strength increase was 35.76 percent, 52.87 percent, 79.35 percent, 99.59 percent and 88.78 percent, equivalent to the 0.5-2.5 percent ratio of human hair and sodium polyacrylate addition. Similarly, with an increase

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in the proportion of human hair and sodium polyacrylate, the peak axial strain of reinforced soil increases, showing that the reinforced mixture continues to act in a ductile way.

6. Conclusion

Based on the test results obtained following conclusions can be drawn:

- Liquid limit significantly increased along with somewhat reduction in plastic limit, thereby increasing Plasticity of soil.
- Optimum moisture content of soil increased due to inclusion of human hairs in the unreinforced soil sample.
- It is found that Unconfined Compressive Strength of soil increased after reinforcing it with Human Hairs.

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