Comparative Study of Soil Stabilization Using Human Hair and Lime

Tom Elias, Sreekumari T K, Sonia George, Abraham Zachariah, Saifudeen Sulfi, Sreedevi P S

Abstract— recent issues regarding solid waste disposal demands novel methods for their proper utilization. Environmental problems associated with Human hair fiber, a non- degradable matter can be minimized by using the same as a reinforcing agent in soil stabilization. Studies shows that Human hair fiber, as a cheap reinforcing agent, can be used for stabilizing clayey soil found in low lying areas of Kerala, India. Study is conducted to stabilize clayey soil using human hair fiber and to compare it with the classical method of lime stabilization. Human hair fibers randomly mixed in clayey soil samples were tested for its engineering property (Strength) by performing UCC tests on a number of samples by using different percentage of fibers and comparing the results with the non-reinforced soil and lime-stabilized soil. Human hair of length 4-40mm and of diameter 40-110µm were used. The test result reveals that the strength significantly improves with the inclusion of Human hair and it further improved when optimum percentage of both lime and human hair were added together. Thus soil properties of low-lying areas can be improved to a great extend while suggesting a solution to a major environmental issue of human-hair disposal.

Index Terms—Soil Stabilization, Human Hair Fibres, Lime Stabilization, Clay, Waste Disposal, Susatinable Material, Soil Improvement, Pollution

1 INTRODUCTION

Site feasibility study for geotechnical projects is of far most beneficial before a project can take off. Site survey usually takes place before the design process begins in order to understand the characteristics of subsoil. In the past, bearing capacity of subsoil played a major role in decision making on site selection. Once the bearing capacity of the soil was poor, possible solutions were to change the design to suit site condition, or remove and replace the in situ soil and to abandon the site.

Abandoned sites due to undesirable soil bearing capacities dramatically increased, and the outcome of this was the scarcity of land and increased demand for natural resources. In most geotechnical projects, it is not possible to obtain a construction site that will meet the design requirements without ground modification. The current practice is to modify the engineering properties of the native problematic soils to meet the design specifications. Soft clays can be improved to the civil engineering requirements.This, point out the need of soil stabilization, which is one of the several methods of soil improvement.

Stabilization in a broad sense incorporates the various methods employed for modifying the properties of a soil to improve its engineering performance. The most common application being in the construction of road and airfield pavements, where the main objective is to increase the strength or stability of soil and to reduce the construction cost by making best use of locally available materials. Stabilization is the process of blending and mixing materials with soil to improve certain properties of the soil. Soil stabilization aims at improving resistance to softening through bonding the soil particles together, water proofing the particles or combination of the two. The simplest stabilization processes are compaction and drainage (if water drains out of wet soil it becomes stronger). The other process is by improving gradation of particle size and further improvement can be achieved by adding binders to the weak soils. Soil stabilization was done by utilizing the binding properties of clay soils, cement-based products. As technology evolved, there have now emerged new types of soil stabilization techniques, many of which are classified as "green technologies". Soil stabilization also prevents road failure from water penetration or heavy frosts by helping in preventing water from soaking into the treated layer.

Human Hair Fibres can be added to soil as a stabilising agent. Hair as a cheap reinforcing agent is abundantly available as a waste product from saloons and is facing a major disposal issue.This study aims at comparing Hair stabilised soil with lime stabilized soil and to test the suitability of human hair as a sustainable source of soil stabilization.

2 EXPERIMENTAL INVESTIGATION

2.1 Materials Used

2.1.1 Soil

The soil used in the study is clayey soil collected from Kuttanad in Alapuzha district of kerala, India. Soil samples were collected manually from 1 meter depth and preserved in its natural water content. It is tested for various Index and Engineering properties using Indian Standard tests. Results are dicussed in table 1.

2.1.2 Human Hair Fiber

Human hair fibres were used throughout this study to reinforce soil. They are considered as valueless solid which are being dumped to waste landfills. Fibres used in this study consist of varying length (4–40 mm). Average diameter of human fibre is known from Scanning Electron Microscope analysis and is found to be 40-110µm (Renju and Ayothiraman, 2012). The parameter concerning the fibre

selection was fibre content by weight of soil. Samples were prepared by adding fibre content of 0.5%, 1.0%, 1.5%, 2.0% and 2.5% by weight of soil (Renju and Ayothiraman, 2012).

TABLE 1
PROPERTIES OF PURE CLAY

Property	Value
Specific Gravity	1.9
Liquid Limit	65.8%
Plastic Limit	27.7%
Plasticity Index	38.1
Maximum Dry Density	0.97g/cc
Optimum Moisture Content	25%
Natural Water Content	130%
Percentage Clay	33.398%
Percentage Silt	66.602%

2.1.3 Lime

When adequate quantities of lime and water are added, the pH of the soil quickly increases to above 10.5, which enables the clay particles to break down. Silica and alumina are released and react with calcium from the lime to form calcium-silicate-hydrates (CSH) and calcium-aluminates-hydrates (CAH). CSH and CAH are cementatious products. They form the matrix that contributes to the strength of lime-stabilised soil layers. As this matrix forms, the soil is transformed from a sandy, granular material to a hard, relatively impermeable layer with significant load bearing capacity. The process begins within hours and can continue for years in a properly designed system. The matrix formed is permanent, durable, and significantly impermeable, producing a structural layer that is both strong and flexible. Addition of lime chemically transforms unstable soils into structurally sound construction foundation.

2.2 Sample Preparation

Two types of stabilizers has been used in the present study i.e. lime and human hair.

In case of soil amended with lime alone, a homogeneous mixture was obtained by blending the required amount of lime with the natural clay in a tray. In the present study lime is added to clay in its natural water content. Lime content was varied from 3%, 6%, 9%and 12% by weight of soil. Then To study the effect of curing, samples were made and allowed to cure for a period of 2, 4, 6, 8, 10, 14 and 28 days before testing. Cylindrical samples were prepared by filling clay at stages, in a mould of internal diameter of 38mm and a height of 75mm. After filling, the specimens were extruded from the mould and stacked for curing. These prepared samples were tied using polythene bags in order to prevent them from losing its natural water content. At least two samples of each percentage were prepared in order to avoid any cases of sample failure. Data sheets were prepared and recorded for calculation of dates, in which they have to be tested. These samples were properly placed in containers for ease of testing and were kept under moist condition to preserve its natural moisture. Samples were carefully taken and tested in Unconfined Compression Testing machine, on respective days.

In case of hair stabilization, human hair was added by hand to achieve a homogeneous soil-hair mix. The hair used in the present study were of length 4-40mm and it was added to the mix in varying percentages of 0.5%,1.0%,1.5%,2.0% and 2.5% by weight. Mixing was done to get a uniform distribution of hair throughout the above matrix. Since curing could not trigger any chemical reaction between soil and human hair, these soil samples need not be kept for curing for different days. The soils were statically compacted immediately after the mixing was over. Once the compaction is over, samples are immediately tested in Unconfined Compression Testing Machine.

2.3 Laboratory tests

A series of unconfined compression tests were conducted as per Indian standards specification IS 2720 (Part-10), 1991 to study the effect of random inclusion of lime and hair in the soil.

For the lime stabilised soil, lime content was varied from 3%, 6%, 9% and 12% by weight of soil. The optimum lime content is found out by a series of unconfined compressive strength tests. For human hair stabilised soil, the hair content was varied from 0.5%, 1.0%, 1.5%, 2.0% and 2.5% by weight of the soil. The optimum hair content is thus found out by a series of unconfined compressive strength tests. Finally at optimum lime content, optimum amount of hair is added and test is conducted. For all the possible combinations, tests were performed to compare lime and hair stabilization.

3 RESULT AND DISCUSSION

Unconfined compressive strength is the maximum compressive stress which a cylindrical soil sample is able to carry when its side is not confined.UCC results of pure clay is discussed below.
Unconfined compressive strength =4.6kN/mm^2
Undrained cohesion=2.3kN/mm^2
Shear strength= 2.3kN/mm^2
UCC results after the addition of different percentage of lime is discussed in fig 1.

- *Tom Elias is currently pursuing Master of Technology in Coastal and Harbour Engineering in Kerala University of Fisheries and Ocean Studies kochi, India, PH-8907246776. E-mail: tomeliasbonded@gmail.com*
- *Sonia George is a Civil B.Tech graduate and third Rank holder, Cochin University of Science and Technology.*
- *Abraham Zachariah is a civil B.Tech graduate, Cochin University of Science and Technology*
- *Saifudeen Sulfi is pursuing Master of Technoloy in Structural Engineering, Sree Buddha College of Engineering, Pattoor.*
- *Sreedevi P S is a civil B.Tech graduate, Cochin University of Science and Technology*

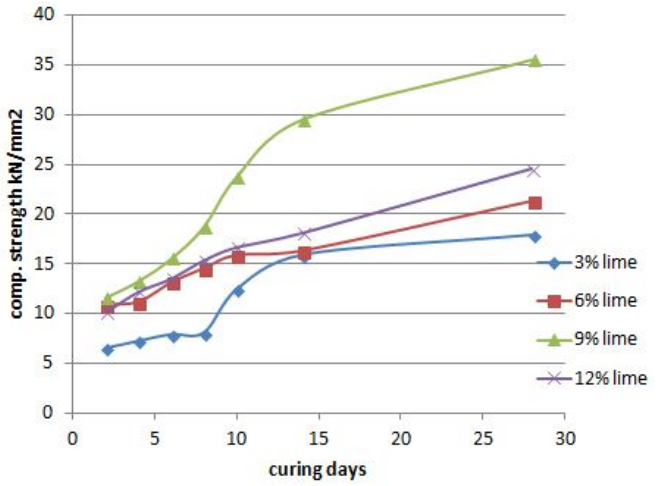

Fig. 1. Combined Graph for 3%, 6%, 9%, 12% lime

Fig1.Shows that samples with 9% lime achieves maximum strength. Close observation of the prepared graph reveals that the rate of strength achievement increases up to first 14 days tremendously and from 14 to 28 days the rate of strength achievement is slightly lower than the former. The slope of the above prepared graph supports the fact. Thus, it is evident that the strength achieved in 2-14 days is higher than that of 14 -28 days.

UCC tests were conducted for Hair stabilized soil with fibre content 0.5%, 1.0%, 1.5%, 2.0% and 2.5% by weight of soil. The mixing of soil was felt very difficult beyond 2.5%, as the same stick together to form lumps. This also caused pockets of low density. So, it was decided to stop with 2.5% fibre content.

TABLE 2
COMPRESSIVE STRENGTH, UNDRAINED COHESION AND SHEAR STRENGTH FOR DIFFERENT PERCENTAGES OF HAIR STABILIZED CLAY

Percentage of Hair	Compressive Strength kN/mm²	Undrained Cohesion kN/mm²	Shear Strength kN/mm²
0.5 %	6.42	3.21	3.21
1 %	7.8	3.9	3.9
1.5 %	8.51	4.255	4.255
2 %	6.8	3.4	3.4
2.5 %	5.86	2.93	2.93

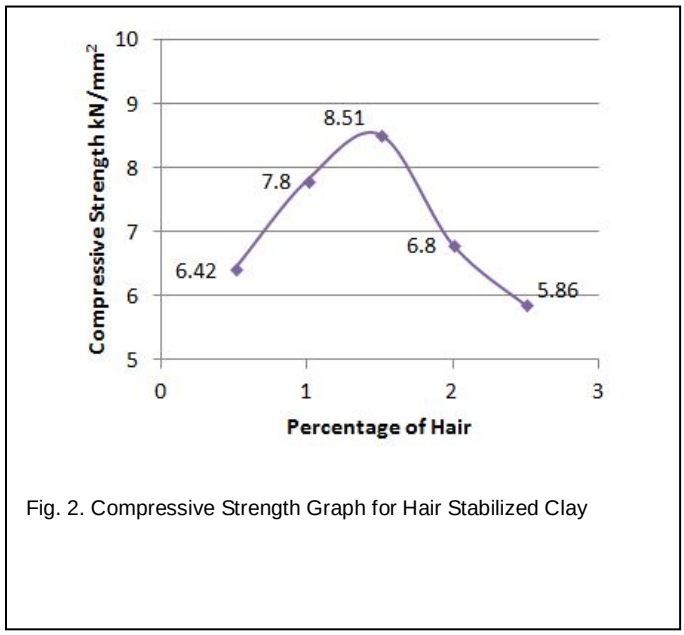

Fig. 2. Compressive Strength Graph for Hair Stabilized Clay

From table.2 and fig.2 it is evident that maximum compressive strength is attained by clay sample, stabilized by addition of 1.5% of Human Hair Fiber.

Clay samples were then created with 9% lime and 1.5% human hair and tested. It is evident from fig.3 that the addition of optimum percentage of both lime and hair yields a marginal difference in the compressive strength. So it is advisable to use the perfect combination of lime and hair to get a good stabilised soil.

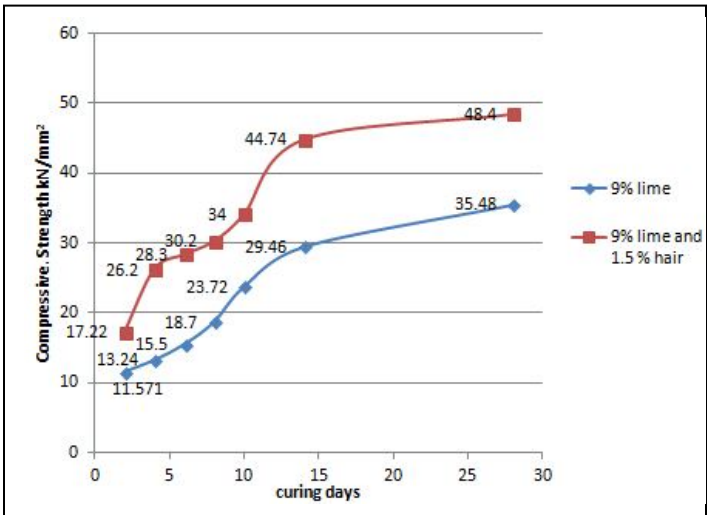

Fig. 3 Comparison of 9% lime with mixture of 9% lime and 1.5 % hair.

4 CONCLUSION

From this work we could conclude that Lime and Human Hair can be fruitfully utilised for stabilising clayey soils. Residual Human Hair from saloons and Beauty parlours poses a serious waste disposal issue and this can be effectively solved to a greater extend by using the same for stabilising clayey soil, that is found in different parts of our country .

After performing all the necessary tests and calculations on Kuttanad clay using lime, Human hair and the combination of both, we came to the following major conclusions:-

- The optimum percentage of lime and human hair that should be added in kuttanad Clay so as to make it properly stabilised is 9%, 1.5% respectively.
- It has been concluded that when pure clay is mixed with 1.5% of human hair a compressive strength increase of 45.9% is observed
- When 9% of lime is added to pure clay, a compressive strength increase of 87% is observed
- And when 9% lime and 1.5% hair is mixed together, a compressive strength increase of 90.4% is observed.

Through close observation we also came to a remarkable conclusion that, the rate of strength increment by addition of lime follows a specific pattern. Rate of strength achievement in 2-14 days of lime curing is higher than that of 14 -28 days.

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