STABILIZATION OF SOIL WITH FIBER HUMAN HAIR AND SURKHI FOR HIGHWAYS SUBGRADE - REVIEW

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Abstract - *Soil stabilization is the process in which, addition of material in soil done for enhances soil properties. Duty of an engineer is to utilization of waste materials in additive material so that waste disposes effectively with improvements in properties. Highways subgrade plays an important role to distribution of load of upper layers to lower soil safely. Human hair is waste whose dispose is not in our hand it is a non biodegradable material as in early years. It 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 be gave us a better option for us to use of human hair and surkhi for a better environmental conditions.*

Key Words: Soil, improvement, human hair, surkhi, stabilization and environment.

INTRODUCTION

The use of soil for engineering purposes dates back to prehistoric times. Humans have historically used soil as a material for flood control, irrigation purposes, burial sites, building foundations, and as construction material for buildings. First activities were linked to irrigation and flood control, as demonstrated by traces of dykes, dams, and canals dating back to at least 2000 BCE that were found in ancient Egypt, ancient Mesopotamia and the Fertile Crescent, as well as around the early settlements of Mohenjo-Daro and Harappa in the Indus valley. Foundation- related engineering problems, such as the 'Leaning Tower of Pisa', prompted scientists to begin taking a more scientific-based approach to examining the subsurface. When engineers are faced with cohesive clayey soils, the engineering properties of such soils are needed to be improved to make them suitable for construction. Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil. The main objectives of the soil stabilization are to increase the bearing capacity of the soil and its resistance to weathering process and soil permeability. The long-term performance of any construction project depends on the soundness of the underlying soils. Unstable soils can create significant problems for pavements or structures, therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially in case of soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil.

Many of the important engineering properties of clay soils are enhanced by the addition of Surkhi and human hair fiber. All the same, the properties of such treated soils vary and depend upon the character of the clay soil, the type and length of curing, and the method and quality of testing. Compared with the untreated sample, unconfined compressive strength and CBR of the treated samples increases significantly, depending on the content and curing period. It has been observed from the present investigation that long-term curing has profound influence on the gain in strength. Synthetic materials like geotextiles, geomembranes, geogrids, geocomposits, etc., have successfully been used in recent times for reinforcing the soil to improve their stability. The soil can be stabilized by introducing thin strips in it. In the reinforced earth, thin metal strips or strips of wire, hair or geosynthetics are used as reinforcement to reinforce the soil. The essential feature of the reinforced earth is that friction develops between the reinforcement and the soil. By means of friction the soil transfer the forces built up in the earth mass to the reinforcement and tension is developed in the soil mass.

LITERATURE REVIEW

Various researches for the stabilization of soils, which are related to my work, are as under:

1. Ranjan, et al., (1996) [1] carried a series of triaxial compression tests on cohesion less soils reinforced with discrete, randomly distributed fibers, both synthetic and natural, to study the influence of fiber characteristics (i.e., weight fraction, aspect ratio, and surface friction) soil characteristics and its density, and confining stress on shear strength of reinforced soils**.** The percentages of fibers used were 0.5%, 1%, 1.5%, 2%, 2.5% and 3%. Unreinforced sand attains a peak: stress at around 10% axial strain which then remains practically constant even up to 20% axial strain, whereas fiber reinforced sand samples do not exhibit any peak: stress. The stress-strain curves of reinforced sand indicate an increasing trend even at axial strain of 20%.The inclusion of fibers causes an increase in peak shear strength and reduction in the loss of post-peak stress. Thus, residual strength of fiber-reinforced soil is higher as compared to unreinforced soil. Shear strength increases approximately linearly with increasing amounts of fibers up to 2% (approximately) by weight, beyond which the gain in strength is smaller.

2. Consoli, et al., (1999) [2] conducted triaxial compression tests with internal measurement of deformation and scanning electron microscopy were carried out to evaluate the effect of randomly distributed glass fiber reinforcement and cement content on the response of a sandy soil to load. Cemented specimens were prepared with cement contents varying from 0%, 1%, 3% and 5% by weight of dry soil and cured for 7 days. The fiber length was 12.8 mm, varying in content from 0 to 3% by weight of dry soil. The cementation itself notably increased in stiffness and peak strength, while fiber inclusion increased both residual and peak strength and reduced stiffness, changing the behavior of the cemented soil from brittle to more ductile. Peak strength envelopes indicated that the friction angle was increased from 35 to 41^0 as a result of cementation and 46^0 as consequence of fiber inclusion. However, the peak cohesion intercept was unchanged after fiber addition, being a function only of cementation. Adding fibers changes the residual cohesion intercept from 0 to about 18 kN/m^2.

3. Pillai, and Ramanathan, (2012) [3] observed the influence of reinforcement parameters i.e. fiber content on kaolinite clay through a series of laboratory tests such as consistency limit tests, compaction tests and unconfined compression tests. Fiber content of 0.5%, 1.0%, 1.5%, 2.0% and 2.5% by weight of soil was added. From Consistency limits test, it was 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 reduction in plastic limit thereby increasing the plasticity of soil. Inclusion of human hair fibers marginally affects the dry density-moisture content relationships of Kaolinite clay. Maximum dry density intially reduces lightly due to addition of light weight hair fiber and then practically remains same. Optimum moisture content increases marginally due to moisture absorption of hair fibers. With addition of 2.0% fibers by weight, the unconfined compressive strength increased up to 2 times that of unreinforced soil. The average improvement in strength was 34.83%, 50.35%, 77.55%, 99.79% and 89.45% corresponding to the fiber inclusion ratio of 0.5%, 1.0%, 1.5%, 2.0% and 2.5%.

4. Butt, et al., (2014) [4] conducted tests like CBR, maximum dry density, optimum moisture content to see the effect of incorporating human hair fibers of different length and equivalent diameter with aspect ratio ranging from 295 to 500 into soil sub-grade. The different percentages of human hair fiber used were 0%, 0.5%, 1%, 1.5%, 2% and 2.5%. They found that at 0.25% of the fiber maximum dry density increases and optimum moisture content decreases, further on increasing the human hair fiber content percentages, maximum dry density decreases and optimum moisture content increases. CBR value at 0.5% fiber content is much less than unreinforced soil. But after increasing the fiber content percentage CBR value increases up to 2% of fiber, then again starts decreasing at 2.5% fiber content.

5. Elias, et al., (2016) [5] conducted a study to stabilize clayey soil using human hair fiber (fiber content ranging from 0.5%, 1.0%, 1.5%, 2.0% and 2.5% by weight of soil) and to compare it with the classical method of lime stabilization (lime content was varied from 3%, 6%, 9% and 12% by weight of soil) . Human hair fibers randomly mixed in clayey soil samples were tested for its engineering property (Strength) by performing unconfined compressive strength 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 revealed that the optimum percentage of lime and human hair that should be added in kuttanad Clay so as to make it properly stabilized 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 was added to pure clay, a compressive strength increase of 87% was observed. And when 9% lime and 1.5% hair was mixed together, a compressive strength increase of 90.4% was observed.

6. Narayanan, and Sharmila, (2017) [7] replaced some portion of soil with different percentages of human hair fiber (0.5%, 0.7%, 0.9%, 1.2% and 1.5%). Compaction characteristics i.e., optimum moisture content and maximum dry density were determined by standard proctor test results. Strength characteristics (unconfined compressive strength and CBR) for corresponding optimum moisture content and maximum dry density for the soil sample. The California Bearing Ratio (CBR) of virgin soil sample is 5.41. With the addition of 1.2% of human hair fiber the CBR value increased to 8.83. Strength of the soil was increased to around 56.6% when compared to virgin soil sample. The unconfined compressive strength of virgin soil sample was 12.58 N/$mm^{2.}$ With the addition of 1.2% of human hair fiber, the unconfined compressive strength value increased to 20.92N/mm^2. It decreases when adding above 1.2% of human hair fiber. The maximum strength of the soil is achieved by the addition of 1.2% of human hair fiber to soil sample**.**

7. Singh, and Dwivedi, (2018) [9] reinforced clayey soil with human hair (percentage ranging from 0%, 0.5%, 1%, 1.5%, 2% and 2.5%) and studied its effect on maximum dry density, optimum moisture content, CBR value. Triaxial tests were conducted. They reported that maximum dry density initially reduces slightly due to addition of light weight hair fiber and then practically remains same. CBR value increases with inclusion of human hair fiber in clay soil. CBR value of unreinforced clay soil is 4.92 and with the optimum percentage of human hair fiber of 1.0%, CBR value is 7.70. At 25 kPa confining pressure peak stress of unreinforced soil was 175.98 kPa and with human hair fiber of 1.0%, peak stress obtained was 200.15 kPa.

8. Anjanadevi, et al., (2019) [10] described the effect of jute (0%, 0.5%, 1% and 1.5%) and human hair fiber (0.5%, 1%, 1.5% and 2%) in soil stabilization and conducted tests viz., unconfined compressive strength, CBR, optimum moisture content, maximum dry density and Atterberg's limits. The maximum dry density of marine clay was found to be increased by adding jute and hair fiber. The Maximum dry density of parent soil was 1.250g/cc. Maximum dry density of combined jute and hair fiber mixed soil was 2.40g/cc, obtained at the range of 0.5% jute and 1% hair. The percentage increased by 92%. The corresponding moisture content was 24% which shows that optimum moisture content of soil decreased. The liquid limit of marine clay was 45.5% which was not suitable for construction purpose. By the addition of 1.5% hair and 1% jute, the liquid limit was decreased up to 28.932%. The unconfined compressive strength of parent soil is 0.30KN/cm^2. From the result, it shows the unconfined compressive strength of marine clay increased to 0.854 KN/cm^2. When the content of fibers was increased, the CBR value of soil increased and this increase was remarkable at fiber content of 1.5% hair and 1.5% jute. The increment of CBR value was from 5% to 9.98%.

9. Mishra, and Verma, (2019) [12] investigated the effect of surkhi and polypropylene fibers on geotechnical properties of expansive soil. They carried out tests to determine water content, Atterberg's limit test, standard proctor test and unconfined compression test. The different percentages of surkhi used were 0%, 0.5%, 1% and 1.5%. Polypropylene fibers were added to different proportion (0.35%, 0.40% and 0.45%) to the sample having optimum surkhi content. It was observed that with the inclusion of surkhi, the maximum dry density increased up to 40% surkhi addition and then decreased. On inclusion of 40% surkhi with soil, the optimum value of maximum dry density was obtained. On addition of polypropylene fiber (0.30%, 0.35% and 0.40%) to this optimum percentage of surkhi, it was observed that the maximum dry density increased for the sample containing 0.35% polypropylene fiber and 40% surkhi while it decreased for the sample containing 5% polypropylene fiber and 20% surkhi. The maximum value of maximum dry density was obtained for a soil sample containing 20% surkhi and 2.5% polypropylene fiber by dry weight of the soil sample. The outcomes of unconfined compressive strength test indicated that the unconfined compressive strength value increased upon inclusion of surkhi. Further polypropylene fiber was added to the soil sample containing 40% surkhi and 60% soil. The CBR value increased with addition of 0.35% polypropylene fiber and 40% surkhi to 60% soil. The maximum value of CBR was obtained for a soil sample containing 60% soil+40% surkhi+0.35% polypropylene fiber. For the stabilization of black cotton soil, the optimum quantity of surkhi and polypropylene fiber was found to be 40% and 0.35% for 60% soil. The proctor density was increased from 1.41 g/cc to 1.78 g/cc. The CBR value increased from 102.3 Kpa to 350.2 Kpa.

10. Balasubramanian, et al., (2020) [13] used combination of surkhi and granite dust to stabilize the soil. Surkhi was added to the soil at range of 30%, 35%, 40%, and 45% and granite dust was added at range of 5%, 10%, 15%, and 20%. Direct shear test, Atterberg's limits, CBR test and unconfined compressive strength test were conducted. It was found the optimum percentage of granite dust as 20% and the optimum percentage of surkhi was found to be 40% for engineering properties. The liquid limit of soil decreases when surkhi and granite dust is added which causes reduction in thickness of diffuse double layer around the soil particles. The plasticity index decreases with increased surkhi and granite dust content and eventually reaches zero. The Direct shear value increases with addition of surkhi and granite dust. The unconfined compressive strength value increases with addition of surkhi and granite dust when added with soil it significantly increases the shear strength characteristics by 38%.The CBR value increases with addition of Surkhi and granite dust. With addition of surkhi with granite dust, the CBR value further increases and 5.21% was achieved when 40% surkhi and 20% granite dust was added. Though a number of researches have been conducted to stabilize the soils using different materials, the combination of these two materials will make my research a novel to work upon.

MATERIALS TO BE USED

A brief outline of the materials to be used for the project is given in the following sections:

Soil: The soil sample to be used is any locally available soil. The soil sample is collected by excavating the ground surface. All the requisite physical and mechanical properties are to be determined as per relevant standard tests (IS: 2720).

Human Hair Fiber: 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.

Surkhi: Surkhi is artificial pozzolanic material made by powdering bricks or burnt clay balls. From a number of researches conducted, surkhi is proven to have binding properties and other engineering properties which enhance the soil properties.

OBJECTIVES OF THE STUDY

Main objectives of the project are mentioned below:

- To compare the various properties of virgin soil and modified soil sample by conducting various tests as per IS codes.
- To investigate the suitability of solid waste materials i.e., human hair fibers and surkhi in soil stabilization for highway sub-grade.
- To use various waste materials, thus making the research eco-friendly and economical.

IMPORTANCE OF THE STUDY

The two materials I have chosen that is surkhi and human hair fiber are found in abundance in our surroundings with non-revenue nature and also detrimental if left exposed to the environment. I came to know from various research papers that these materials have properties that can enhance the engineering properties of our soils; therefore their use to enhance or strengthen the soil is quite appreciable. By stabilizing the soil with any waste products, we can reduce the waste in our environment and also side by side can improve the soil properties to support pavement and foundations like in roadways, parking area, site development projects, airports and many other situations where soil is not suitable for construction.

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