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Shear Strength Enhancement of Sandy Soil Using Hair Fibre

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ABSTRACT: The use of various materials, both biodegradable and non-biodegradable, for enhancement of properties of soil is a wide field of research at present. Human hair fibre is one such waste material that can be utilised as a reinforcing material. It has a major advantage in being easily available at minimal cost. The main aim of this research work is to investigate the variation in shear strength parameters of sandy soils by the use of hair fibre as reinforcing material. It also involves the determination of optimum fibre content for maximum value of shear strength paramenter. The results showed that almost 11.5% enhancement in shear strength parameter is obtained on use of hair fibre reinforcement.

KEYWORDS: Sandy soil, Shear Strength, Human Hair Fibre, Direct Shear.

I. INTRODUCTION

Soil investigation is very important for any construction, because every structure requires foundation. Soil investigation helps determine properties of the soil, and based on this, the type of foundation required is assessed. Foundations are broadly of two types, namely, shallow and deep. If the soil just below the ground level is of good quality, but that at far depth is not good, then shallow foundations such as isolated, combined or raft footings are used. When the soil immediately below the soil is of inferior quality, but that at greater depths is of good quality then deep foundations are used.

Deep foundations, however, are a costly affair. Hence, they are preferred only for massive structures. There may be situations where the soil is of inferior quality even at greater depths. Also, in several projects, deep foundations may not be feasible from the economic perspective and in these situations; soil improvement becomes more economical as well as necessary, compared to deep foundations. Again, there are several situations wherein soil improvement is a necessity such as in case of underground bunkers and air bases, in tunnel construction for road and rail projects when a route has to be cut through soil below ground level and when the structure is to take larger loads over a comparatively small area. To put it in simple terms, it is not always possible that the soil available at the construction site is feasible for work. Also, there are situations where it may not be possible to replace soil as in case of several massive constructions. Hence, in all practicality, soil reinforcement is an important aspect of Geotechnical Engineering, and therefore, it has become a scope of great research in the present situation. The basic concept of soil reinforcement is that friction develops between the soil and the reinforcement due to which the loads built up in the soil mass are transferred to the reinforcement. This leads to the development of tension in the reinforcement under the impact of shear stresses due to loading of the soil mass.

Soil improvement to some extent is naturally done by the presence of plant fibres. The roots of plants and trees hold the soil together, and this improves the strength of soils and stability of slopes. This is why a lot of emphasis is given on the protection of trees and forests, or carrying out of afforestation. One famous example where soil reinforcement has been carried out by plants is the Great Wall of China. To go with this, there are several materials such as hair fibre that can be used as reinforcement. A lot of work has already done on the use of materials such as geosynthetics and geonets for soil reinforcement. Although the use of natural fibres for soil reinforcement has been proved long ago through various research works, the concept of randomly reinforcing the soil is, however, a relatively new concept. Natural materials such as hair fibre have a certain advantage in that it is highly abundant and the cost of obtaining these fibres is almost negligible.

The paper is arranged in the following manner. Section II describes the properties of the soil sample and the hair fibres. Section III describes the methodoly followed in carrying out the investigation. Section IV provides the data obtained during the course of the work. The interpretation of the results obtained is given in section V and the conclusion is in Section VI.

II. THE MATERIALS

A. SOIL SAMPLE

The sample considered for the tests is sandy soil. The sieve analysis of the sample was carried out. The sieve analysis performed is as per the provisions of IS 383-1970. The gradation provided that the soil specimen is of Zone IV, with a Fineness Modulus of 3.03.

B. HUMAN HAIR FIBRES

Human hair fibres are naturally obtained. The main sources of these fibres are the salons and parlours. Human hair fibres are waste materials of no value. They are also a cause of environmental problems due to their inability of decomposition. Hence, using them as reinforcing materials is a measure of putting to use materials that may otherwise lead to degradation of the environment. For ease of work, the fibres were collected from salons of the nearby surroundings. Fibres obtained are dried to remove any moisture. For the purpose of this research work, the fibres are dried by placing under the sun. In general, the length of the hair fibres can range from 10mm to 25mm. Following are the properties of hair fibres, obtained from study work:

Table 1: Properties of hair fibres

Property	Specifications
Length	10mm-25mm
Diameter	17µm-100µm
Protein Present	Keratin
Cross Section	Circular
Outer Covering	Cuticle

III. METHODOLOGY

Direct shear tests were performed on the soil sample. Initially, the test was performed without any reinforcing materials, at normal stresses of 0.5, 1.0 and 1.5 kg/cm². Next, direct shear test was performed using reinforcing materials. Hair fibre was used at 0.5%, 1% and 2% by weight of soil. The fibres were randomly mixed with the soil specimen. After carrying out all the required direct shear tests, the stress-strain curves were plot, from which the maximum shear stress was determined in each case. This was followed by graphs of maximum shear stress and normal stress to determine the value of angle of internal friction in each case. The variation of angle of internal friction with fibre content was studied and the optimum fibre content required for the maximum shear strength was evaluated.

IV. RESULTS OBTAINED

After conducting the necessary tests, in each case, the graph for stress-strain relationship was designed, from which the value of maximum shear stress was obtained. Then, another graph for maximum shear stress and normal stress was designed, from which the value of angle of internal friction was obtained. The process was done for unreinforced soil, as well as for soil reinforced with hair fibre at various percentages. A final graph of the angle of internal friction vs fibre content was plot, from which the maximum value of angle of internal friction and the corresponding optimum fibre content was obtained.

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A. UNREINFORCED SOIL

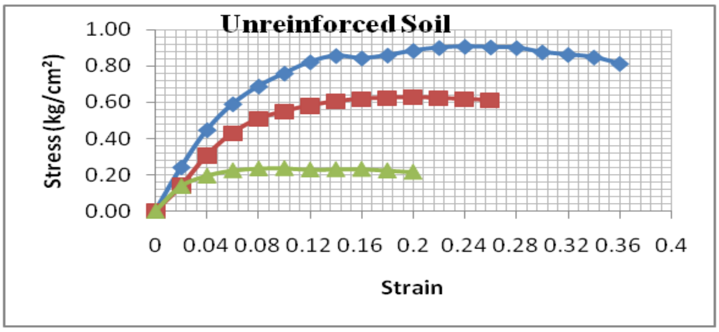

Fig 1. Stress-Strain Relationship for unreinforced soil

The maximum value of shear stress are 0.24 kg/cm², 0.63 kg/cm² and 0.91 kg/cm² at normal stresses of 0.5 kg/cm², 1.0 kg/cm² and 1.5 kg/cm² respectively.

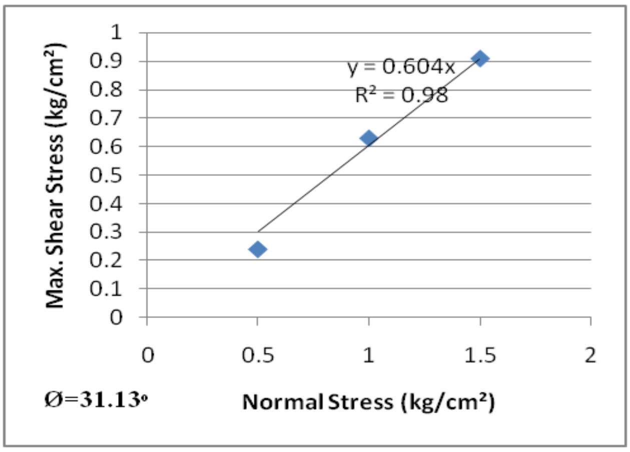

Fig 2. Maximum shear stress vs Normal Stress for unreinforced soil

The angle of internal friction obtained when soil is not reinforced is 31.13°.

B. HAIR FIBRE REINFORCED SOIL

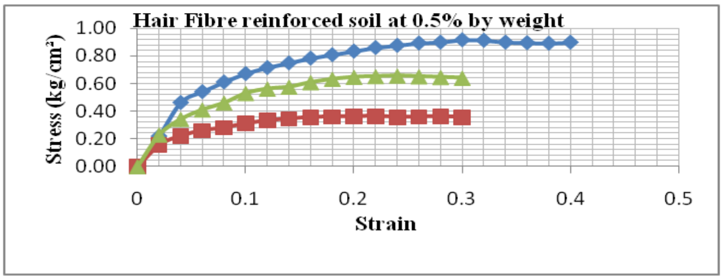

Fig 3. Stress-Strain relationship for soil reinforced at 0.5% by weight

The maximum value of shear stress are 0.37 kg/cm², 0.66 kg/cm² and 0.92 kg/cm² at normal stresses of 0.5 kg/cm², 1.0 kg/cm² and 1.5 kg/cm² respectively.

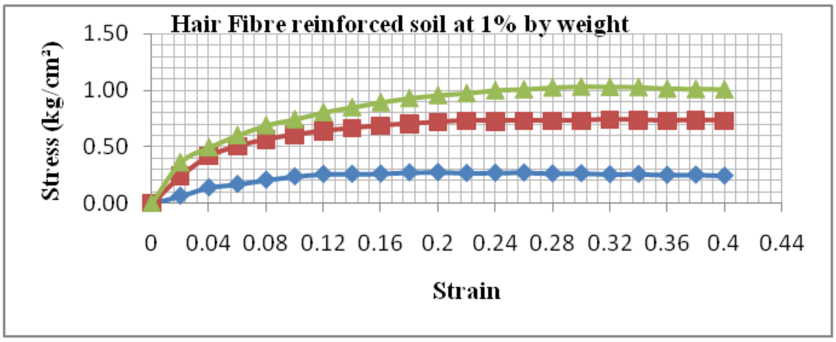

Fig 4. Stress-Strain relationship for soil reinforced at 1.0% by weight

The maximum value of shear stress are 0.28 kg/cm², 0.74 kg/cm² and 1.03 kg/cm² at normal stresses of 0.5 kg/cm², 1.0 kg/cm² and 1.5 kg/cm² respectively.

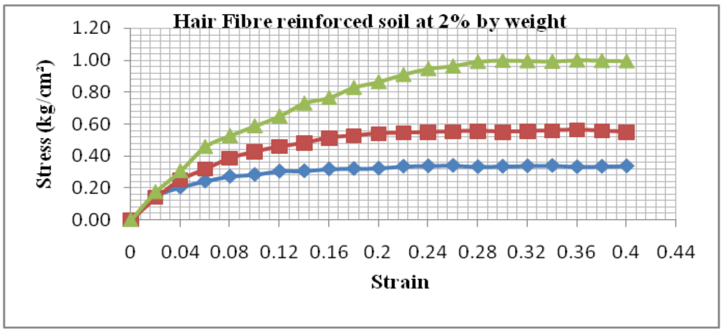

Fig 5. Stress-Strain relationship for soil reinforced at 2.0% by weight

The maximum value of shear stress are 0.34 kg/cm², 0.56 kg/cm² and 1.00 kg/cm² at normal stresses of 0.5 kg/cm², 1.0 kg/cm² and 1.5 kg/cm² respectively.

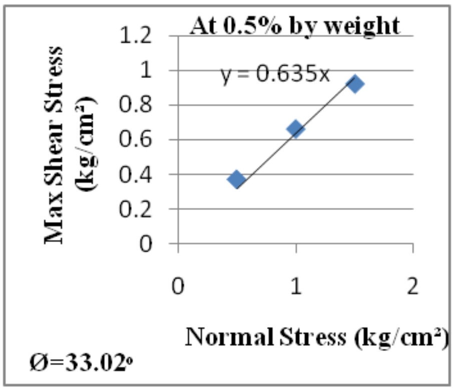

Fig 6. Maximum Shear Stress vs Normal at 0.5% by weight

The angle of internal friction obtained when soil is reinforced with fibres at 0.5% by weight is 33.02°.

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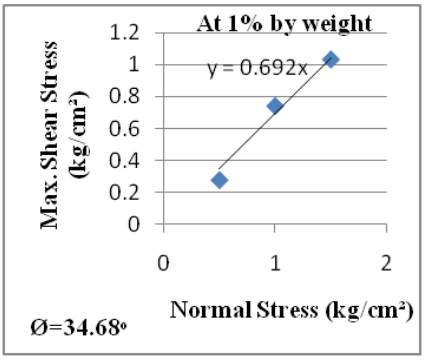

Fig 7. Maximum Shear Stress vs Normal at 1.0% by weight

The angle of internal friction obtained when soil is reinforced with fibres at 1.0% by weight is 34.68°
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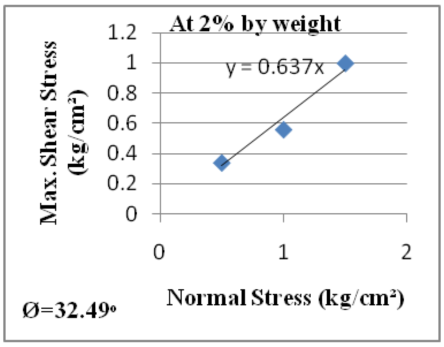

Fig 8. Maximum Shear Stress vs Normal at 2.0% by weight

The angle of internal friction obtained when soil is reinforced with fibres at 2.0% by weight is 32.49°

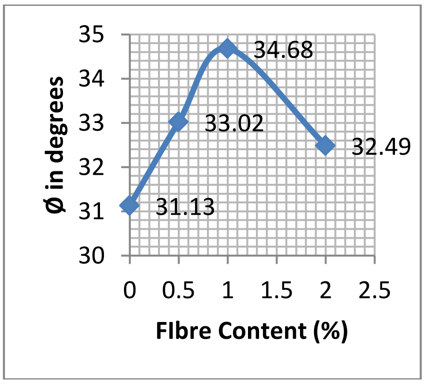

Fig 9. Angle of internal friction vs Fibre Content

Maximum Angle of Internal Friction=34.68°
Optimum Hair Fibre Required=1.00%

V. RESULTS AND INTERPRETATION

It has been observed that on application of hair fibres, an increase in the shear strength parameter of soil is obtained. The rise in strength can be attributed to the fact that without the use of any reinforcement, soil shows brittle failure which is responsible for lower strength but the use of fibres provides ductility to the soil. The main concept behind soil this increase is that friction is developed between the soil and the reinforcing material. This leads to transfer of the load that is built up in the soil mass to the reinforcement. It is also witnessed that shear strength parameter rises upto a certain value, and then reduces with the increase in percentage of fibre content. The optimum value of hair fibre content for maximum value of shear strength parameter is obtained as 1% for Ø=34.68°.

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VI. CONCLUSION

This paper has evaluated the effect of hair fibres on the shear strength paramenter of sandy soil. An increase in the paramenter has been obtained on utilisation of hair fibre. This increase is upto an optimum value of fibre content, beyond which, shear strength parameter reduces in value. Further research can be conducted on efficient methods of random placing of the fibre in soil so as to obtain better results. Thus, it can be concluded that human hair fibre can be utilised for enhancing the shear strength parameter of sandy soils, and considering the low cost and easy availability of the material, it can prove to be an efficient means of soil reinforcement.

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