Stabilization of Soft Clay using Lime and Jute Fibres

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Abstract*: Growing urban developments have intensified the demand for housing and roads resulting in densification of land use. As a result, structures have been constructed in agricultural areas that have been converted as residential colonies. These soils popularly known as expansive soils pose several problems to the structures. Improvement of such soil has been observed by adopting various techniques like soil stabilization, adoption of reinforcement etc. In this project for making economical construction, jute and lime is used for improving the properties of soft clayey soil. Generally admixing technique in soil has an effective ground improvement because of its easy adaptability. It is well known that lime is an effective agent to be mixed with fine grained soils with high plasticity and it improves certain properties of the soil due to its chemical action. In order to reduce the brittleness of soil stabilized by lime only, a recent study of a newly proposed mixture of natural jute fiber and coated jute fibers for ground improvement is defined in this paper. The natural fibre reinforcement causes significant increase in tensile strength, shear strength and other engineering properties of the soil. The reinforcing material used in the study is jute fibers with different diameter and length. In this paper, an optimum value of percentage of lime to be added along with different proportions of jute to improve the properties of the soil is recommended. The effect of lime and fiber on the properties such as , Unconfined Compressive strength (UCC) and consolidation was studied on different samples. Soil samples were tested with 2 %, 4%, 6% and 8% natural jute fibers and coated jute fibers cut into 20mm and 40mm size by dry weight . For significant increase in strength the soil is first stabilized by adding lime and then reinforce with fibers. Here the soil samples were keep at its natural content and the laboratory tests were carried out. The effect of length of fibre is to be studied by using to different length 20 and 40mm, as well as the effect of diameter is also studied by using 3mm and 5mm diameter fibres. Based on the favorable results obtained, it can be concluded that the expansive soil can be successfully stabilized by the combined action of jute fiber and lime.

Keywords: Kuttanad soil, jute fibre, shear strength, UCC, consolidation, stabilization

I. INTRODUCTION

Growing urban developments have intensified the demand for housing and roads resulting in densification of land use. As a result, structures have been constructed in agricultural areas that have been converted as residential colonies. Theses soils popularly known as expansive soils pose several problems to the structures. Soils has been used as a construction material from ancient time itself. Reinforced soil is a composite material which is formed by the association of frictional soil and tension resistant elements in the form of sheets, strips, nets etc. Using fibres ranging from steel bars, polypropylene, poly-ester, glass fibres, and biodegradable fibres such as coir and jute, has been proven to be particularly effective for soil reinforcement.

Jute is one of the most valuable natural fibres produced extensively in India and Bangladesh. Under the product name soil saver, it is been an export commodity for many years. It is often called golden fibre in Bangladesh. The chemical composition of jute is Alpha cellulose, Hemi Cellulose, Lignin, fatty acids and waxy substances with some nitrogenous and mineral matter. Jute and kenaf are strong fibres but exhibiting brittle fracture and have only a small extension at break. They have a high initial modulus, but show very little recoverable elasticity. Tenacity measurements recorded in the literature vary widely, and although some of this variation is due to differences in the methods of measurement, a major part is due to variations in linear density of the fibres themselves. A good portion of this area lies below mean sea level and is submerged under water more than a month in every year during raining season. The soil in this region is black or grey marine clay, which has high organic content. The increase in population and the development of the area has demanded construction activities to be undertaken in Kuttanad region. A large number of foundation failures have occurred in this region due to very low shear strength of the clayey soil.

II. MATERIALS AND METHOD

A. Materials

1) Soil

The soil for this study was collected from kuttanad region in Aleppey district, Kerala. Representative soil sample were taken from a depth of 1m below riverbed.

Fig. 1. Collected Kuttanad Soil Sample

The natural properties of the soil and the particle size distribution curve are as shown in Table.1 and Fig.2 respectively.

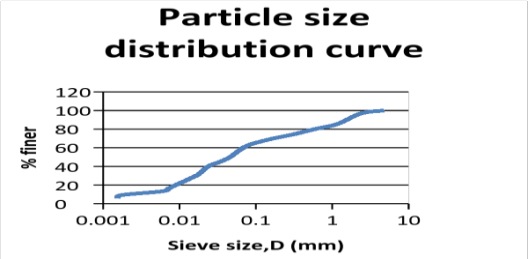

Fig. 2. Particle size distribution curve of Kuttanad Clay

TABLE 1 NATURAL PROPERTIES OF KUTTANAD CLAY

Specific Gravity	2.53
Insitu Water Content	160%
Colour	GREY
Plastic Limit	60.236%
Liquid Limit	105%
Shrinkage Limit	36.84%
Optimum Moisture Content	38.75 %
Dry Density	1.177 g/cc
% Of Clay	9.5
% Of Silt	52.3
% Of Sand	38.2

2) Reinforcement

The reinforcing material used in this study is jute fibers having diameter 3mm and 5mm. The length of fiber taken for this study is 20mm and 40mm.

Fig.3. raw jute fibers

3) Procedure of coating jute fibers

The jute fibers were soaked in NaOH solution at desired concentration. The fibers were soaked in the alkali solution for 24 hour. The fibers were then dried at room temperature for 7 days.

4) Preparation of soil sample

Fiber reinforced soil sample were prepared at field condition. Samples were prepared by adding jute fibers 2%,4%,6% and 8% by weight of soil. Fibers were randomly mixed in soil to form homogenous mixture. Moist soil fiber mix was transferred to the mould and compacted.

5) Lime

The properties of lime used for study is shown in Table 2. The lime was collected from local market.

Fig.4. lime

TABLE 2 PROPERTIES OF LIME

Components	Amount (%)
Calcium hydroxide	90
Specific gravity	3.06
Silica	1.5
Ferric oxide	0.5
Magnesium oxide (MgO)	1.0
Alumina	0.2
Carbondioxide	3.0

B. Method

1) Unconfined Compression test

Unconfined compression tests were carried out in accordance with IS 2720 Part 10-1973. Initially the test was conducted in natural sample. For tests on fiber admixed samples, the amount of fiber added was calculated based on the dry weight of the soil sample. Unconfined compression tests were conducted on samples treated with varying percentages of cement ranging from 2% to 10%. This was done to fix the range of fiber content effective in imparting the strength.

III. RESULTS AND DISCUSSION

A. Test On Natural Sample Without Adding Fiber

The unconfined compressive strength test conducted under natural conditions it was observed that the soil sample doesnot take any load. Therefore the sample was kept for air drying for 24 hours. The dried sample gave a very low unconfinedcompressive strength of 1.56kPa at a water content of 95%.

Fig.5. UCC soil sample in natural condition

B. Effect of lime in plain soil

When lime is added to soils, it reacts with soil particles, which leads to the improvement in was greatly improved after lime treatment. Soil stabilization is a procedure where natural or manufactured additives or binders are used to improve the properties of soils. There are several methods that have been used to minimize or eliminate the harmful

effects of expansive/soft clayey soils on structures. These methods include chemical stabilization. Quicklime treatment on soft clayey soil improves stability and bearing capacity of soft clay. Lime treatment increases unconfined compressive strength, preconsolidation pressure and coefficient of consolidation of soft clay**.** The strong alkaline conditions with pH of 12.4 were able to release silica and alumina from the clay mineral and eventually to react with lime to form new cementitious products. The success of lime treatment process is highly dependent on the available lime content, curing time, soil type, soil pH and clay minerals. In this study lime is added at different percentages such as 2%, 4%, 6% and 8%.

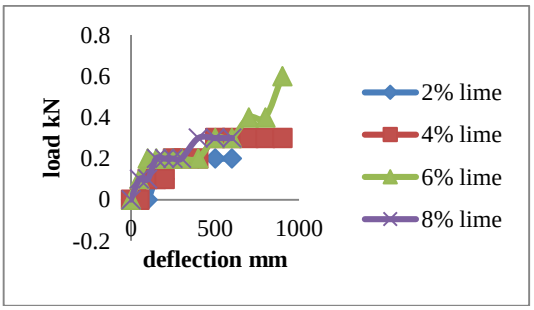

Fig.6. Load deflection graph after 3 Hrs

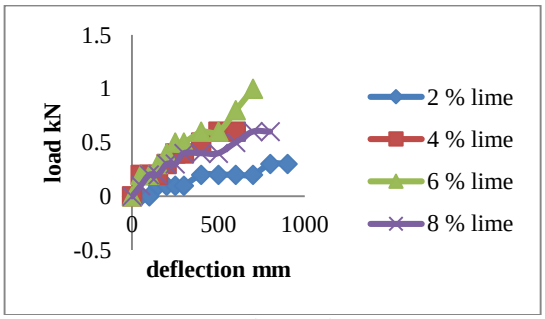

Fig.7. Load defection after 3 days

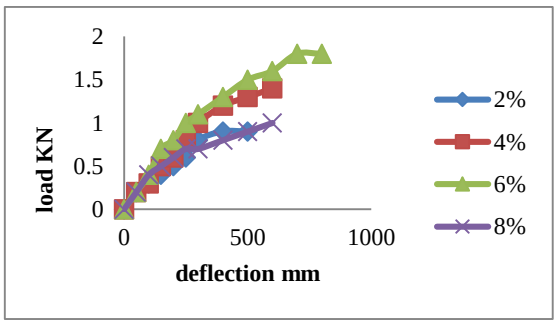

Fig.8. Load defection after 7 days

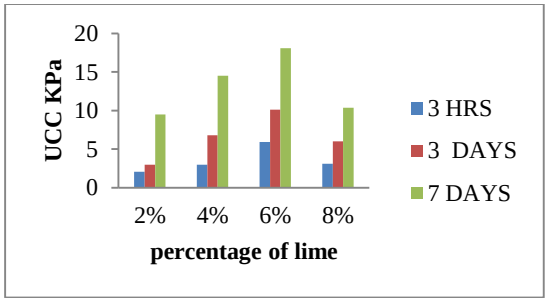

Fig.9. UCC strength variation

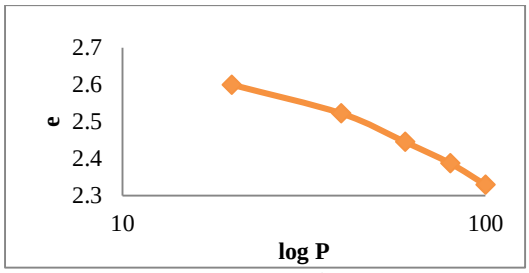

Fig.10. e log p graph of plain soil

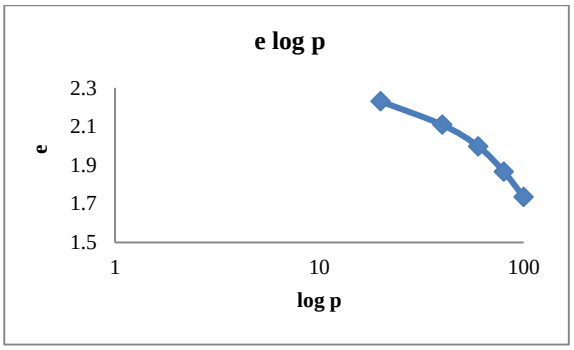

Fig.11. e log p graph of lime stabilized soil

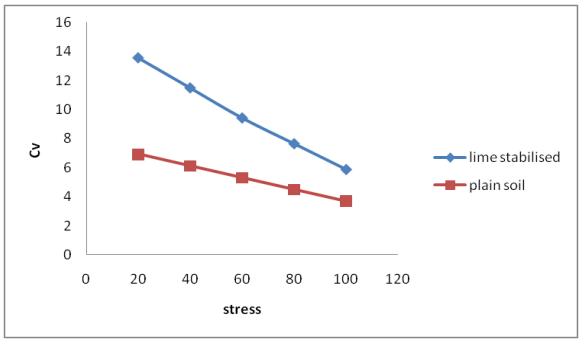

Fig.12. Cv variation with lime

C. Test On Natural Sample Reinforced With Jute Fibers

1) Effect of fiber content

A number UCC tests are performed on the soil reinforced using jute fibers having diameter and length. The test results are shown in figures and table given below.

a) Fibers having Diameter = 3mm and Length = 20mm

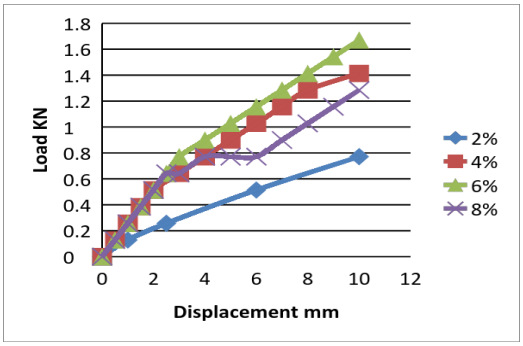

Fig.13. load- displacement graph obtained when soil reinforced with fiber having diameter 3mm and 20mm length

TABLE 3 VARIATION OF COMPRESSION STRENGTH WITH INCREASE IN PERCENTAGE OF FIBER HAVING DIAMETER 3MM AND LENGTH 20MM

UCC strength (Kpa)	% of fiber
5.83	2
10.517	4
12.15	6
9.0829	8

b) Fibers having Diameter = 3mm and Length = 40mm

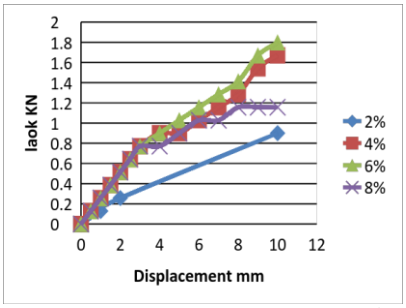

Fig.14. load- displacement graph obtained when soil reinforced with fiber having diameter 3mm and 40mm length

TABLE 4 VARIATION OF COMPRESSION STRENGTH WITH INCREASE IN PERCENTAGE OF FIBER HAVING DIAMETER 3MM AND LENGTH 40MM

UCC strength (KPa)	% of fiber
6.92	2
12.636	4
13.608	6
8.64	8

c) Fibers having Diameter = 5mm and Length = 20mm

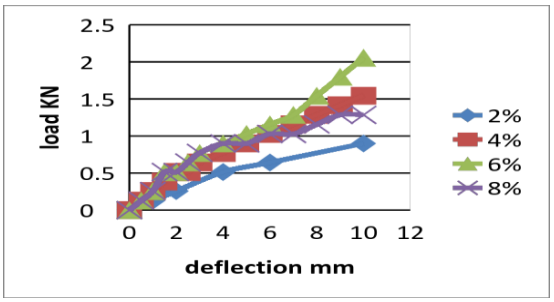

Fig.15. load- displacement graph obtained when soil reinforced with fiber having diameter 5mm and 20mm length

TABLE 5 VARIATION OF COMPRESSION STRENGTH WITH INCREASE IN PERCENTAGE OF FIBER HAVING DIAMETER 5MM AND LENGTH 20MM

UCC strength (Kpa)	% of fiber
6.835	2
11.523	4
15.103	6
9.277	8

d) Fibers having Diameter = 5mm and Length = 40mm

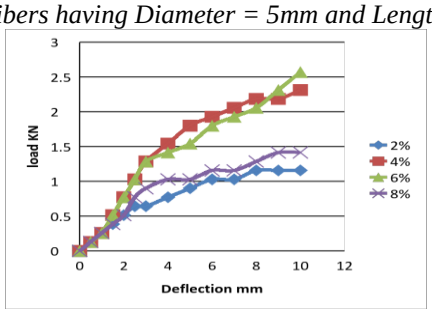

Fig.16. load- displacement graph obtained when soil reinforced with fiber having diameter 5mm and 40mm length

TABLE 6 VARIATION OF COMPRESSION STRENGTH WITH INCREASE IN PERCENTAGE OF FIBER HAVING DIAMETER 5MM AND LENGTH 40MM

UCC strength (Kpa)	% of fiber
9.08	2
17.87	4
19.205	6
10.7419	8

Based on the results obtained it can be concluded that the inclusion of NaOH coated jute fibers increases the compressive strength of clayey soil. 2%,4%,6% and 8% of fiber by dry weight of soil is added. The optimum amount of fibers added is 6%. When optimum amount of fiber is added the compressive strength increased by 13%.

2) Effect of diameter of fibers

From the above results it is the increase in percentage of fibers improve the strength characteristics of soil. To study

the effect the diameter of fibers, fibers of diameter 3mm and 5mm is taken. Here the length of fiber is 40mm. Results shows that the strength of soil increased with increase in diameter.

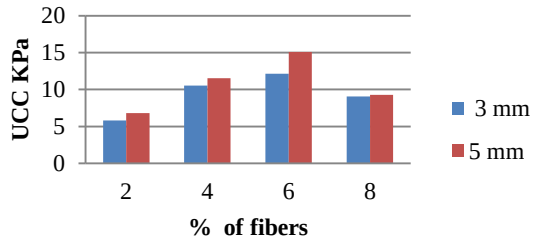

Fig.17. graph showing the effect of diameters as the percentage of fiber added increases

3) Effect of length of fibers

It is clear that from the results that greater the length of fibers larger will be the shear strength. For studying this fiber with constant diameter(5mm) with length 20mm and 40mm.

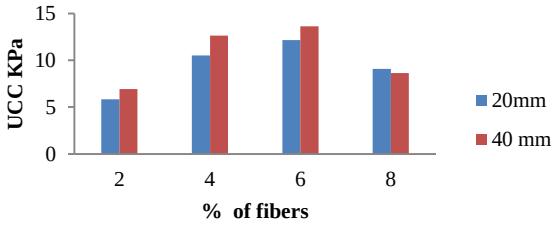

Fig.18. graph showing the effect of length as the percentage of fiber added increases

IV. CONCLUSION

Based on the above results, it is concluded that optimum fiber content is 6 % that is the fiber content beyond this causes reduction in strength. It is also found out that the diameter and length of fiber influences the strength of soil. As the diameter and strength increases the compressive strength of the soil also increases. When lime is added to the soil at different percentages such as 2 %, 4%, 6% and 8% the shear strength also increases. As lime content increases upto 6% the shear strength also get increased after that a decrease in strength were noticed. So the optimum amount is 6%.Lime is a puzzolonic material as time increases they will undergo chemical reaction. So the curing effect is also noticed. In 7 days, the shear strength is increased by 36%.When lime is added to the soil, the compressibility of the soil decreases, the Cv value decreases and Cc value increases.

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