Stabilization of Expansive Soil by using Jute Fiber

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Abstract. The instability of structure lies mainly in the properties of soil under which it is constructed. For instance, if the soil is having weak engineering properties, there are chances of crack formation and settlement. One of the major problematic soils of this type are the Black cotton soils which are mainly classified as expansive soils. They are obviously a hindrance to the strength and stability of structures. The present study deals with the improvement of soil characteristics with the addition of Jute fiber sheet. A series of Triaxial and CBR tests were done on normal soil and Jute fiber reinforced one. The observed values indicate a significant contribution of strength improvement when fiber sheets were added.

1. Introduction

Soil can be considered as a complex material. The construction of any road or pavement consisting of number layers which includes subgrade, sub base, Base and Wearing course. Sub grade is very important in road construction. If subgrade soil is expansive soil or black cotton soil which as a tendency to swell or shrinkage characteristics. So the structures cannot be constructed on these types of soils without any stabilization. Stabilization means the process of improving the properties of soil by using suitable additives such as fly ash, cement, jute fiber, lime, plastic powder etc. In this investigation jute geotextile is used to stabilize the expansive soil or black cotton soil. The geo textile used for this investigation was Tossa jute. Jute fiber can be proved as a more superior compare to other fibers in terms of its stability or strength, functionality etc.

Black cotton soil is formed due to weathering of rocks. Black cotton soils are black in color due to the presence of titanium oxide. These soils are very hard in dry condition but losses its strength or stability in wet condition. Due to the presence of high content of montmorillonite makes the soil is more expansive. The property of high swell and shrinkage characteristics or volumetric changes the soil can be considered as dangerous in construction activities. In India these soils are found in many areas which include Andhra Pradesh, Madhya Pradesh, Maharashtra, Gujarat, Orissa etc. Enhancement in performance with the addition of Jute fibers were reported by [1-6]. In a comprehensive study by [4], it was observed that Jute fibers provide an efficient stabilization for expansive soils. It was also observed that Optimum moisture content decreased and dry density increased with the addition of Jute fiber [6].
2. Materials and Methodology

2.1 Clay

Generally clayey soils are fine grained soils, having particle size less than 2µ. Clayey soils (shown in Figure 1) are plastic in nature due to its size and geometry as well as moisture content, and these soils become hard, brittle and non-plastic upon drying. Table 1 lists the properties of clay.

![Figure 1 Photograph of Clay](https://example.com/image1.png)

Table 1 Properties of soil
2.2 Jute Fiber

Jute fiber is also called as Golden Fibre. The natural jute fiber reinforcement is shown in Figure 2.

| Property of soil                      | Value        |
|---------------------------------------|--------------|
| Liquid limit                          | 59%          |
| Plastic limit                         | 37.925 %     |
| Plasticity index                      | 21.075%      |
| Specific gravity                      | 2.125        |
| Optimum moisture content (OMC)        | 24.27%       |
| Maximum dry density (MDD)             | 14.915 kN/m³ |
| Cohesion                              | 54.96 kPa    |
| Angle of Internal Friction (degree)   | 6°           |
| CBR                                   | 1.05%        |

*Figure 2 Photograph of Jute Fiber*
2.3 Methodology

Basic tests were conducted for clay and after that a detailed elaborate study on the unreinforced and Jute fiber reinforced soil were conducted. CBR and Traxial were the main tests to identify the engineering behavior of soils. Jute fibers were laid in three layers to evaluate the performance characteristics. Triaxial and CBR tests were conducted for reinforced soil by inclusion of 1, 2 and 3 layers of jute fiber. For one layer, the fiber was placed at middle of the sample, for two layer it was at a distance of 1/3rd and 2/3rd of the sample and finally for three layer, jute fiber was located at a distance of 1/4th, 2/4th and 3/4th of the sample.

The soil samples of 38mm diameter and 76 mm height were prepared and tested under tri axial condition. Various tri axial tests were conducted on different samples with or without jute layer reinforcement.

3. Results and Discussion

A detailed and elaborate Triaxial and CBR tests were conducted to study the performance improvement. Stress strain graphs were plotted to find our C and Ø values of the samples. Table 2 shows the results of values obtained for reinforced and Jute fiber reinforced soil.

Figure 3 shows the results of Cohesion values with the addition of fiber. The results clearly shows an increase in shear strength properties of soil. This is mainly attributed to the multi-cellular structure of the Jute fiber, which effectively bonds and gives tensile strength to the soil. However, beyond two layers, cohesion value decreased. This clearly shows that optimum is already attained and adding of an additional layer may reduce the reinforcing effect.

However, it was also observed that there was no clear variation in angle of friction as evident from the table. Several other studies from the literature [1-3] comply with the present study results.

| No. of layers jute fiber | C(kN/m²) | Ø(degrees) |
|--------------------------|----------|------------|
| 0                        | 54.96    | 6          |
| 1                        | 58.54    | 6.1        |
| 2                        | 153.52   | 6.3        |
| 3                        | 72.11    | 6.25       |
The California bearing ratio test is conducted for both unreinforced and reinforced soil with 2 layer jute fiber sheet. It has been noted that the CBR value is increased by 21% for 2.5mm penetration and 16.26% for 5mm penetration. This is mainly due to the strength and stiffness enhancement happened with the soil.

4. CONCLUSION

Various tests were conducted for both reinforced and unreinforced soil to determine the strength and stiffness characteristics. In this investigation jute fiber sheet were arranged in 1, 2 & 3 layers.

Based on the results obtained from this investigation, the following conclusions could be drawn:
CBR and Triaxial tests showed that placing of jute fiber reinforcement in layers have significantly enhanced the strength and stiffness characteristics of soil.

It was observed that placing of two layer jute fiber reinforcement is more effective compared to 1 & 3 layers.

The C and $\varnothing$ values of the plain soil are 54.96 kPa and 6°, whereas it is 153.52 kPa and 6.3° respectively when two layers of jute fiber sheet were inserted.

REFERENCES

[1] Yagya Sharma (2019), “Improvement of Soil Properties by Using Jute Fibre as Soil Stabilizer”, American Journal of Engineering Research (AJER), Vol 6, no 10, 123-129.
[2] Das T and Singh B, (2018), “Deformation and Strength characteristics of Jute Geotextile Reinforced Soils”. JERAD, Vol. 8 No. 04, PP. 987-995.
[3] Singh H.P (2018) “Strength and Stiffness of soil Reinforced with Jute Textiles”. IJCET, Vol.3, No.3, PP.1143-1146.
[4] BairagiHarshita, Yadav R.K and Jain R (2017), “Effect of Jute Fibres on Engineering characteristics of Black Cotton Soil”. International Journal of Engineering Sciences & Research Technology, Vol 8, PP.705-707.
[5] Gray, D.H., and Ohashi, H (1983) “Mechanics of fiber reinforcing in sand”. Journal of Geotechnical Engineering, 112 (8), 335-353.
[6] Aggarwal, P. and Sharma, B. (2010), “Application of Jute Fibre in the Improvement of Subgrade Characteristics” Geotextiles and Geomembranes., 28(1), 54–62.
[7] C. S., Shi, B., and Zhao, L. Z. (2010). “Interfacial shear strength of fiber reinforced soil”. Geotextiles and Geomembranes., 28(1), 54–62.
[8] Islam M, Iwashita K (2010), “Earthquake resistance of adobe reinforced by low cost traditional materials”. Journal of Natural Disaster and Science, Vol. 32, pp 1–21.
[9] Tera, S., and Reddy Jagannatha, H.P (2011) “International Journal of Innovation, Management and Technology, 2 (3), 186-191.
[10] Choudhary A, Gill K, Jha J; (2012), “Improvement in CBR of Expansive Soil Subgrade with a single Reinforcement layer”. ECU Publications, Preceedings of Indian Geotechnical Conference, Paper No. B-214, Delhi.
[11] Singh Pardeep, Gill K.S; (2012) “CBR Improvement of Clayey soil with Geo-grid Reinforcement”. IJETAE, Volume 2, Issue 6, PP. 315-318.
[12] Jagan B; 2016 “A Critical review on applications of natural Jute Fibers A Case Study”. (IJCIET) Volume 7, Issue 3, 2016, pp. 200–210.
[13] Lal D, Sankar N, Chandrakaran S 2017. Surface heave behaviour of coir geotextile reinforced sand beds. J Inst Eng India SerA, 98(1–2), 121–125.
[14] Lal D, Sankar N, Chandrakaran S 2017. Performance of shallow foundations resting on coir geotextile reinforced sand bed. Soil Mechanics and Foundation Engineering, 54(1), 60–64.
[15] Anzar Hamid (2017), “Subgrade Soil Stabilization Using Jute Fibre as a Reinforcing Material”, IJEDR.
[16] Yagya Sharma (2017), “Improvement of Soil Properties by Using Jute Fibre as Soil Stabilizer”, American Journal of Engineering Research (AJER), Vol 6, no 10, 123-129.