Effect of Sisal Fibre on Shear Strength Characteristics of Kuttanad Clay

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Abstract – *Kuttanad is one of the few places that still use unpaved roads for inland transportation in the rural areas of Kerala, India. Clay itself is dumped and compacted to make the roads. Since no further treatment is given and is subjected to adverse climatic conditions these roads need maintenance every year. Betterment of properties of this clay could help in reducing the yearly maintenance needed. Shear strength parameters helps in determining the shear strength of the clay, so shear strength parameters are selected for study in this research. Improvement of shear strength using locally available waste materials could be economical and ecofriendly. The effect of sisal fibre on dry density, moisture content and shear strength parameters is found out. The dry density was found to be decreasing while the optimum moisture content increased with respect to increase in percentage of sisal fibre added. Shear strength parameters also showed variation with addition of different percentage of sisal fibre. The effect of seven day curing is also studied.*

Key Words: Sisal fibre, Standard proctor compaction, Triaxial, shear strength parameters.

1. INTRODUCTION

Kuttanad clay is one of the most problematic soils, other than black cotton soil in Kerala. The main industries in Kuttanad consist of coir industry, textile industry, bag, mat industry etc. Among which sisal fibre is used in mat and bag industry. Thus trimmed sisal fibre is available in plenty as a waste material. Using of locally available waste material for improvement of shear strength is always an economical method. The increase in scarcity of usable land leads to the requirement of improving the available problematic soil. The main problems faced by the soil could be due to its origin, water content, environmental conditions etc. Rectifying the problems by using economical and ecofriendly methods is the most befitting method in the present scenario. The place selected for this particular study is having a lot of industries which is having waste materials that could be used for the betterment of the shear strength characteristics. Fibres added to soil usually provide reinforcement to the soil layers. And thus increases the shear strength. May it be any fibre, the reinforcing action is supposed to improve the shear failure resistance. Here sisal fibre is added in varying percentages and is kept for seven days to check effects of curing. Compaction is the process of increasing the density of soil by mechanical means by packing soil particles closer together with reduction of air voids and to obtain a homogeneous soil mass having improved soil properties.[7] Compaction is done for maximum dry density and optimum moisture content while Triaxial is done for shear strength parameters

1.1 Sisal Fibre

Sisal fibre is a promising reinforcement for use in composites on account of its low cost, low density, high specific strength.[1] Sisal fibre is obtained from Agava sisalana plant.[2] The fibres are extracted and used for many purposes like bag, mat industries. If to be imported then it would be of high cost. Since this plant could be seen in rural areas, promoting the plant growth would be better than importing. This could make it more economical and ecofriendly. Anyway since, only the waste from the industries using sisal fibre is considered in this work, this is already an economical method. Moreover it is helping the easy and beneficial reuse of the industrial waste which might have caused environmental problems on dumping or burning in that case.

Figure 1 : Sisal fibre pieces

India possesses a large chunk of wastelands and practically, one of the viable cultivation on such a dry ecosystem is sisal.[6]so considering sisal as a raw material and cultivating it and finding new applications for it could be recommended.

Many studies have already been done about the properties of sisal fibre. Physical and chemical properties of sisal fibre have been subjected to many experimental investigations.

Table 1 : Properties of Sisal [3]

Properties	Sisal fibre
Diameter (μm)	192.5(±26.3)
Apparent density (g/cm^3)	1.41(±0.12)
Apparent porosity (%)	76.21(±2.01)
Tensile strength (MPa)	887(±143)
Modulus of elasticity (GPa)	16.4(±2.5)

1.2 Kuttanad Clay

The clay selected for this research is Kuttanad clay took from 8m depth. Experimental studies were conducted in laboratory to find out the basic or initial properties of the clay selected so that it could be kept as a standard for comparison after the inclusion of sisal fibre.

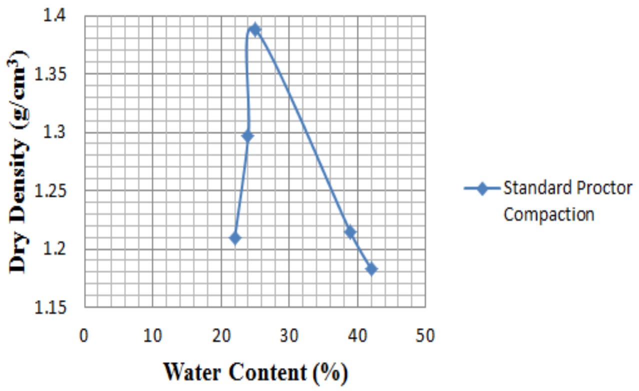

Chart 1: standard compaction curve

All the tests including Atterbergs limit, grain size analysis, compaction, triaxial etc. were conducted to get the results shown in Table 2. Proctor compaction curve from the standard proctor compaction is shown in Chart 1 from which optimum moisture content and maximum dry density of the clay selected is found out.

Table 2: Properties of Clay

Initial water content	105%
Liquid limit	130%
Plastic limit	42%
Plasticity index	88%
Soil classification	CH – clay of high plasticity
Flow index	102%
Toughness index	0.863%
Maximum dry density	1.38 g/cm^3
Optimum moisture content	27%
Specific gravity	2.4
Cohesion	94.97 kN/m^2
Angle of internal friction	7°

The test results show that the clay collected belongs to CH in soil classification. That is clay of high plasticity. The initial shear strength parameters are cohesion 94.97kN/m^2 and angle of internal friction 7° thus giving initial shear strength of the clay selected as 95.47kN/m^2.

2. EXPERIMENTAL INVESTIGATION

As for the experimental investigation, sisal fibre was introduced in three different percentages 0.5%, 0.75% and 1% of weight of clay. The length of sisal fibre used ranges from 0.5cm to 1cm as they are trimmed waste of industries using sisal as a raw material. In addition to varying percentage, a study on effects of curing period was also done. Standard proctor compaction was done to get maximum dry density (M.D.D) and optimum moisture content (O.M.C) for the three percentages selected. Triaxial at these M.D.D and O.M.C were done to find out the shear strength parameters cohesion (C) and angle of internal friction (φ).

Table 3 : Standard Proctor Compaction Results

Percentage added	M.D.D (g/cm^3)	O.M.C
0.5%	1.35	22.14
0.75%	1.31	25.8
1.00%	1.28	29.46

With addition of sisal fibre the M.D.D shows decrement and O.M.C shows increment. Triaxial for 0.5%, 0.75% and 1% is done for which the samples were prepared at the O.M.C and M.D.D shown in Table 3. Shear strength parameters C and φ were obtained from triaxial experiment, from which shear strength is found out.

Table 4: Triaxial Test Results

Percentage Added	Zero day curing		Seven day curing	
	C	Φ	C	Φ
0.5	108.12	10^{0}	121.85	20^{0}
0.75	128.65	14^{0}	132.93	10^{0}
1.00	85	12^{0}	120	12^{0}

Triaxial test results are shown in Table 4. The effect of curing was checked by keeping the sample for curing for seven days.

The samples prepared at O.M.C and M.D.D were wrapped in aluminium foil and were kept inside zip lock air tight bag, so that the sample could retain its water content without subjecting to evaporation. The Figure 2 shows the picture of samples wrapped up in aluminium foil paper after seven days.

Figure 2 Samples wrapped up for Curing

Thus the sample is given a chance to undergo curing if possible. Since a fibre is added, no chemical reaction is expected to occur during the seven day curing period but a proper binding or reinforcing action is expected. Triaxial were done on both cured and uncured samples. Both the shear strength parameters showed increment when compared to initial values of samples without the inclusion of sisal fibre. Even though there is an increment in the values of angle of internal friction there are percentages which showed no change in values for angle of internal friction on curing. Cohesion shows increment and then decrement in values.

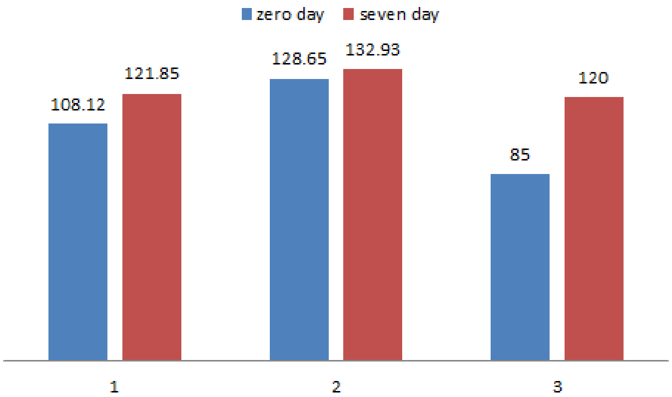

Chart 2: Effect of Curing on Cohesion

The 1, 2 and 3 in the Chart 2 represents the three set of percentages considered in this research. That is 0.5%, 0.75% and 1% of sisal fibre. At 1% addition of sisal fibre there is a decrement in cohesion both cured and uncured samples. But the angle of internal friction is not following a real pattern even though it's showing an increment when compared to the initial test results.

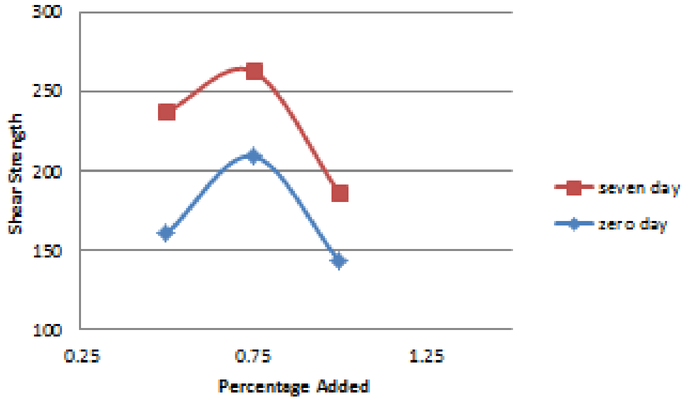

Chart 3: Shear Strength Behaviour of cured and uncured sample.

The test results show an increment in shear strength. Addition of 0.75% sisal fibre shows maximum increment. For zero days curing there is an increment of 54.33% in shear strength and for seven day curing there is an increment of 63.66% in shear strength. Both seven day and zero day curing test results shows maximum shear strength for 0.75% addition of sisal fibre.

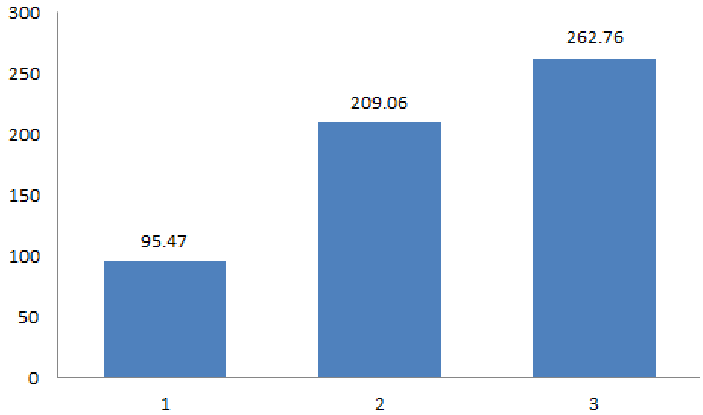

Chart 4 : Shear Strength Comparison

Shear strength parameter is an essential engineering property of soil which affects different aspects of soil.[6].The comparison of initial shear strength, shear strength at zero day curing after the inclusion of sisal fibre and shear strength at seven day curing after the inclusion of the sisal etc. are depicted in the Chart 4.

Unlike planar reinforcements, which are only placed in one dimension within the soil mass, fibers are randomly distributed within the soil mass and therefore are usually considered to have an isotropic effect on the soil behavior.[976] Here the pattern of variation of shear strength behavior shows that even without curing the inclusion of sisal fibre increases the shear strength. Effect of curing is also studied as seven day curing and testing is done. The curing results show that curing improves shear strength parameters and as a result the shear strength is also improved.

3. CONCLUSIONS

The addition of sisal fibre shows an increment in shear strength parameters cohesion and angle of internal friction, no matter what the percentage added. Among which the maximum increment is shown at the addition of 0.75% of sisal fibre. Both the cured and uncured sample shows maximum increment in shear strength for 0.75% addition of sisal fibre. Also the comparison of test results of cured and uncured sample shows that cured samples shows better results than the uncured samples. Even though the angle of internal friction is not following a particular pattern for increment, it is showing increment when compared to the initial test results. Cohesion increases up to 0.75% addition of sisal fibre and then shows a decrement at 1% of sisal fibre

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REFERENCES

[1] Li, Yan, Yiu-Wing Mai, and Lin Ye. "Sisal fibre and its composites: a review of recent developments." Composites science and technology 60.11 (2000): 2037-2055.

[2] Chand, Navin, and S. A. R. Hashmi. "Mechanical properties of sisal fibre at elevated temperatures." Journal of Materials Science 28.24 (1993): 6724-6728.

[3] Silva, Leandro José da, et al. "Micromechanical analysis of hybrid composites reinforced with unidirectional natural fibres, silica microparticles and maleic anhydride." *Materials Research* 15.6 (2012): 1003-1012.

[4] Freilich, B. J., C. Li, and J. G. Zornberg. "Effective shear strength of fiber-reinforced clays." *9th International Conference on Geosynthetics, Brazil*. 2010.

[5] Srinivasakumar, P., et al. "Sisal and its Potential for Creating Innovative Employment Opportunities and Economic Prospects." (1995).

[6] Kiran, Sushama, Bindhu Lal, and S. S. Tripathy. "Shear Strength Prediction of Soil based on Probabilistic Neural Network." Indian Journal of Science and Technology 9.41 (2016).

[7] Vinay, A., and Hemanth Yadav. "Study and comparison of soil compaction between laboratory and field to simulate field compaction for rural roads." (2015).

[8] IS: 2720(Part 2) – 1973 "Determination of water content."

[9] IS: 2720(Part 2) – 1973 "Rapid determination of water content with infra-red lamp torsion balance moisture meter"

[10] IS: 2720 (Part 4) – 1985 "Methods of test for soil grainsize analysis."

[11] IS: 9259 – 1979 "Specification for liquid limit apparatus for soils"

[12] IS: 10074 – 1982 "Specification for compaction mould assembly or light and heavy compaction test for soils."