International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-5, March 2020

Effect of Natural Fibers Composites as Soil Stabilizer on Flexible Pavement Design

P.Sribalaji, S. Banupriya, R.Ruthra

Abstract*: The primary function of road pavement is to distribute and transmit the wheel loads at the surface to a sufficiently large area of sub grade without failure or excessive deformation. The sub grade must be stable, unyielding, properly drained and free from volume changes due to the reasons such as structural, functional, or materials failure, or a combination of these. This project is being developed to be implemented in Perur – Ukkadam by-pass road of Coimbatore,Tamilnadu, India . It is around 2.2 Kms in length. In the study area, it is observed that the pavement failure is under the category of swelling and shrinkage characteristics of soil. To overcome this failure, its necessary to improve the bearing capacity of sub grade soil . For this purpose the Natural Fiber Composites (Coir & Sisal) were used in improving the soil bearing capacity and checked for CBR test to design flexible pavement. Thus this study shows the effectiveness of Natural Fiber Composites (Coir & Sisal) in improving performance characteristics of pavements.

I. INTRODUCTION

Soil mass is found in an infinite stretch which has different properties at different stretches. The presence of a site having weak soil is very common. Every Geotechnical engineer should make effective use of weak soil.

The addition of natural fiber composite reinforcement in soil is such ground improvement technique. Black cotton soil is usually, has a low load carrying capacity and as a huge volume changes capacity and moisture content changes. This makes the construction of roads a tough task necessitates periodic maintenance and relaying works. The construction of roads in clayey soil is a real tough task considering the volume change characteristics, compressibility characteristics, toughness, moisture content changes etc., The pavement design has to be taken a series note so that the maintenance and operation cost are

less. The pavement design mainly depends on the factor termed as California Bearing Capacity (CBR) of the soil. The CBR value of black cotton soil is very low. In this project we had increase the CBR value of the soil with natural fiber composite. The increment in the CBR values is visualized clearly when blended with the natural fiber composites.

Revised Manuscript Received on March 30, 2020.
***** Correspondence Author
Sribalaji P*, Assistant Professor, Department of Civil Engg, St Joseph's College of Engineering, Chennai, India. Email:psbalaji1992@gmail.com
Banupriya S, Assistant Professor, Department of Civil Engg, St Joseph's College of Engineering, Chennai, India. Email:banu10990@gmail.com
Ruthra R, Assistant Professor, Department of Civil Engg, St Joseph's College of Engineering, Chennai, India. Email: ruthraofficial@gmail.com @gmail.com

There are various methods are available to enhance the performance of road such as chemical stabilization, compaction, replacement if sub grade and soil reinforcement. CH soil is not suitable for compaction because it will become flexible under wet condition. That is, when the compacting roller moving in an area, the soil will displaced out from there. So it is difficult to get uniformly compacted soil with improved bearing capacity.

II. BACKGROUND

Perur by-pass road is about 2.2 km in length. It was found that, the sub grade consist of High Plasticity Inorganic Clay (CH). The behavior of this soil in climatic changes is worst. Because of its high swelling and shrinkage characteristics, the soil has been a challenge to the highway engineers. The soil is very hard when dry but loses its strength completely when in wet condition. Due to alternate wetting and drying process, vertical moment takes place in the soil mass. All this movements lead to failure of pavement, in the form of settlement, heavy depression, cracking and unevenness. To overcome these effects the sub grade should be stabilized.

The Coir and Sisal Fibre are used to improve the bearing capacity of High Plasticity Clay in Perur – Ukkadam by-pass road of Coimbatore.

The following are the objectives of the study

1. To Improve the Shear Strength of soil.
2. To prevent the penetration of sub base materials into the sub grade soil.
3. To reduce the pavement thickness compared to the conventional road type.
4. To Increase the life span of road.
5. For Less maintenance of road

III. MATERIAL S AND METHODOLOGY

The materials used in the study are Coir, Sisal Fibre and Epoxy resins. These material are used as a stabilizer to enhance the Shear Strength properties of High Plasticity Clay present in Ukkadam by-pass road of Coimbatore

EPOXY RESINS

Epoxy resins have excellent adhesive qualities with high tensile strength and will bond to nearly all construction materials. Compared to other thermosetting resins, epoxies have low autogenous shrinkage. Formulations are available in which effective linear shrinkage is as low as 0.001 percent. A thin coating of an appropriate epoxy system can provide a high degree of impermeability even when continuously inundated in water.

In the study, Epoxy resin is used as the adhesive material, to make the Coir and Sisal Fibres like reinforcement structure.

SISAL FIBRES

Sisal fiber is obtained from the leaves of the plant Agave Sisalana. It is one of the most extensively cultivated hard fiber in the world and it accounts for half the total production of textile fibers. The reason for this is due to the ease of cultivation of sisal plants, which have short renewing times, and is fairly easy to grow in all kinds of environments. The characteristics of the sisal fibers depend on the properties of the individual constituents, the fibrillary structure and the lamellae matrix.The importance of this material which form one of the abundantly available renewable resources in the world. The fibre is composed of numerous elongated fusi form fibre cells that tapered towards each end. The fibre cells are linked together by means of middle lamellae, which consists of hemicellulose, lignin and pectin. Table 1, shows the properties of Sisal Fibres.

Fig. 1 Sisal Fibre Composite

Table 1. Properties of Sisal Fibres

Properties of Sisal Fibres	Values
Specific gravity	1370 kg/m^3
Water absorption	110%
Tensile strength	347 – 378 MPa
Modulus of Elasticity	15 GPa
Density	1370 g/cm^3

COIR FIBRES

The coir is a versatile vegetable fiber extracted from the fibrous husk that surrounds the coconut. The fibers are tough, strong and extremely resistant to fungal and bacterial decomposition. Fiber length varies from 0.3 to 250mm, but to an average ranges from 100mm to 200mm. The usage of coir fiber materials in the civil engineering field has leads to the development of new techniques particularly in stabilizing the soils.Coir is an abundant, versatile, renewable, cheap, and biodegradable lingo cellulosic fibre used for making a wide variety of products. Coconut coir is the most interesting products as it has the lowest thermal conductivity and bulk density. The addition of coconut coir reduced the thermal conductivity of the composite specimens and yielded a lightweight product. Table 2, shows the properties of Sisal Fibres.

Fig. 2 Coir Fibre Composite

Table 2 Properties of Coir Fibres

Properties of Coir Fibres	Values
Specific gravity	1177 kg/m^3
Water absorption	93 %
Tensile strength	95 – 118 MPa
Modulus of Elasticity	8 GPa
Density	1177 g/cm^3

STUDY AREA

This project is being developed to be implemented in Perur – Ukkadam by-pass road of Coimbatore, Tamilnadu, India . It is around 2.2 Kms in length.

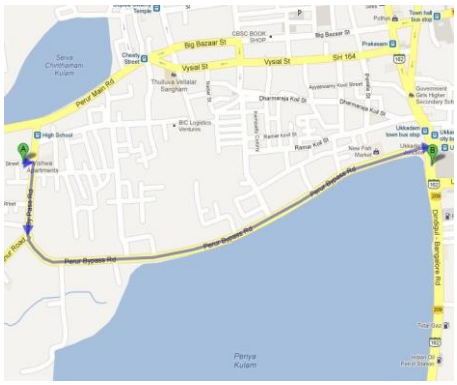


Fig.3 Perur – Ukkadam by-pass road of Coimbatore

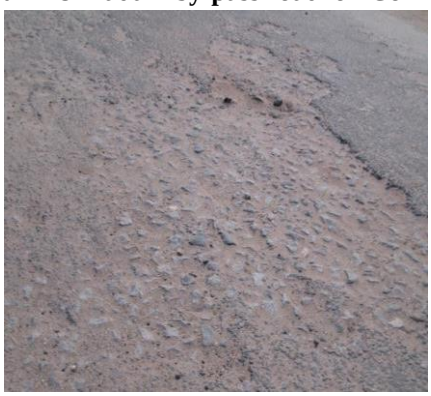


Fig. 4 Failure in the Pavement

METHODOLOGY

The soil samples were collected from the site and pulverized for conducting the laboratory tests. In order to determine the Soil Properties various laboratory tests like Specific gravity, Sieve Analysis,Atterbergs Limits, Standard proctor test ,Unconfined Compressive tests and CBR were done for Virgin Soil. Based upon the test tests results the Soil is classified. The Natural fibres (Coir & Sisal Fibres) were placed in the fabricated mould at various depth to find out the CBR values. For the various CBR value with Natural fibres , flexible pavement was designed and thickness is found.

IV. EXPERIMENTAL INVESTIGATION

Virgin Soil

The soil samples were collected and exposed to atmospheric temperature for drying. After the reduction in moisture content the samples are pulverized and stored for testing. The laboratory tests were conducted on collected clayey samples to find its Index and Engineering Properties and to classify it as per IS 2720. The following Table 3 shows the Properties of Virgin Soil Sample.

Table 3 Properties of Soil Samples

S.No	Properties of soil	Values
1	Specific gravity of soil	2.68
2	Maximum Dry Density	15 kN/m^3
3	Optimum moisture content	25.50%
4	Plastic Limit	21.50%
5	Liquid Limit	52.50%
6	Shrinkage Limit	14%
7	Unconfined Compressive strength	200 kN/m^2
8	CBR values for 2.5 mm and 5mm penetration	10.5 and 9.7
9	Free Swell Index	5%

Stabilized Soil with Natural Fibres Composites

The Natural Fibres like Sisal and Coir Fibres were sandwiched with Soil sample individually at the Height of H, H/2 and H/3 in California Bearing Ratio Testing Load and tests were conducted to find the CBR values for 2.5mm and 5mm penetration. The Table 4 and Fig.5 shows the CBR testing value with and without reinforcement of Clayey Samples.

Table 4 CBR Values of Soil with Fibre as Reinforcement at Different Depth

Penetration	2.5 mm	5 mm
Without Fibres	10.5	9.7
Sisal at Height H/3	25.5	23.9
Sisal at Height H/2	25.26	23.8
Sisal at Height H	25.12	23.5
Coir at Height H	24.14	22.14
Coir at Height H/2	24.28	22.68
Coir at Height H/3	22.4	22.8

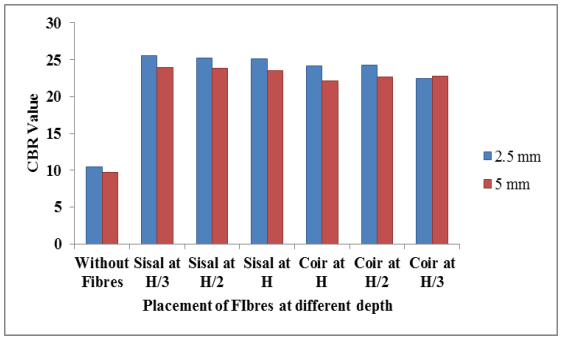


Fig 5 CBR Values of Soil with Fibre as Reinforcement at Different Depth

V. RESULTS AND DISCUSSION

Based on the CBR values obtained for 2.5mm penetration, the thickness of pavement were calculated using the below formula for Soil with and without reinforcements like Coir & Sisal Fibres. Table 5 and Fig 6 shows the Pavement Thickness values for reinforcement placed at different depth.

$$t = \sqrt{P}\sqrt{\left[\frac{1.75}{CBR} - \frac{1}{\pi p_c}\right]}$$

Where,

T= Pavement Thickness in cm
P= Wheel Load in kg
CBR= California Bearing Ratio
P_c = Tyre Load in kg/cm^2

Table 5 Pavement Thickness values for Fibres placed at different depth.

Description	Pavement Thickness in cm
Without Fibres	81.7
Sisal at Height H/3	47.57
Sisal at Height H/2	47.88
Sisal at Height H	48.06
Coir at Height H	49.37
Coir at Height H/2	49.17
Coir at Height H/3	49.01

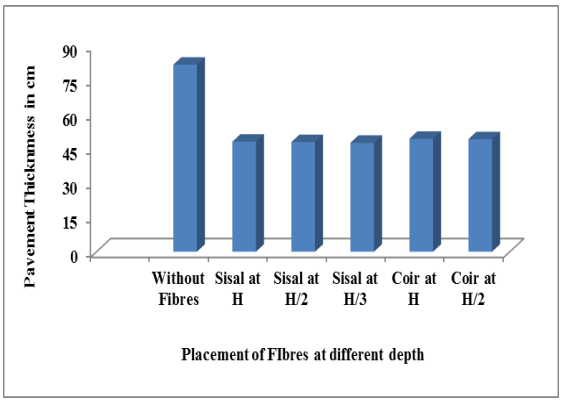


Fig 6 Pavement Thickness values for Fibres placed at different depth.

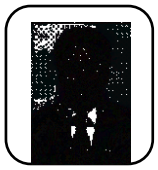
VI. CONCLUSION

The fast moving world requires innovative technologies to produce good quality of pavement construction in Earth. The role of Geotechnical engineering is to enhance available soil properties in field that can be satisfied by new technologies like ground improvement techniques. This techniques can be implemented by using the natural available and low cost materials .The pavements laid in black cotton soil is difficult , require periodic maintenance and carry fewer loads comparatively to other soils. Therefore the soil reinforcement can be adopted to improve the properties of soil instead of using traditional methods like lime stabilization or using admixtures. By using the natural fibres the cost is low and its naturally available material. In Lime stabilization we have to adopt proper types of Lime and proportion which is difficult to find out in compare with soil reinforcement and implementation in site also its quite complicated. On using sisal fibre composite, the CBR values are obtained as follows. The composite material is kept at a height H of the soil and gives the CBR value as 25.12. Similarly at heights H/2 and H/3 the CBR values are 25.26 and 25.5 respectively and corresponding pavement thickness are 48.06cm,47.88cm and 47.57cm. On using coir fibre composite, the CBR values are obtained as follows. The composite material is kept at a height H of the soil and gives the CBR value as 24.14. Similarly at heights H/2 and H/3 the CBR values are 24.28 and 24.4 respectively and corresponding pavement thickness are 49.37cm, 49.17cm and 49.01cm. Therefore, on comparing the results, the sisal fibre reinforcement placed at height H/3 gives greater CBR value and less pavement thickness, than coir at height H/3. Hence an effective measure has been taken to improve the engineering properties of the black cotton soil.

REFERENCES

1. ASTM D1883:87 (1987) "Standard Test Method for CBR (California Bearing Ratio) of Laboratory- Compacted Soils.", Annual Book of ASTM Standards.Behavior of Sands Mixed Randomly with Natural Fibers.
2. Bhasin, N.K., Goswami, N.K., Panchana Oil, Narinder Krishan and Lal, N.B. (1985). “Utilization of Waste Materials in Construction of Roads in Rural Areas.” *Seminar on Road and Rural Transport in Rural Areas*, pp. 260–267.
3. Bueno, B.S., Lima, D.C. Teixeria, S.H. and Reiberio, N.J. (1996). “Soil Fibre Reinforcement: Basic Understanding”.Proc. 3rd Int. Symp. on Environmental Geo Technology, Vol. 1, 878– 884.Gray, D. H. and Ohashi, H. (1983) "Mechanics of fiber reinforcement in sand".
4. Journal of Geotechnical and Geo-environmental Engineering, *ASCE*, 109(3), 335-353.
5. Gopal, Ranjan and Charan, H. D. (1998) "Randomly Distributed Fiber Reinforced Soil—the State of the Art.", Journal of the Institution of Engineers (India), Vol 79.
6. Gosavi, G., Patil, K. A. and Saran, S. (2004) "Improvement of Properties of Black Cotton Soil Sub grade through Synthetic Reinforcement", Department of Civil Engineering, IIT Roorkee.
7. Gosavi, Meenal, Patil, K.A., Mittal, S., and Swamisaran (2003), “Improvement of properties of black cotton soil subgrade through natural reinforcement,” Proc. IGC- 2003, Geotechnical Engineering for Infrastructural Development, Roorkee, December 18-20, pp. 379 – 383.
8. Rao, Venkatappa G., Dutta, R. K., and Ujwala, D. (2005), “Strength characteristics of sand reinforced with coir fibers and coir geotextiles,” (Vol. 10, 2005).
9. Indian Jute Industries Research Association (2005), “Application of jute geotextile in civil engineering,” IJIRA.
10. Pal. M, Majumdar, K, Barman, M and Sarkar, D (2010), “Study of Strength, CBR, Resistivity and Conductivity of Soil-Jute Mixture”, Indian Highway, IRC, 38(8).

AUTHORS PROFILE



P. Sri Balaji, pursued B.E in Civil Engineering from KPR Institute of Engineering and Technology and M.E in Integrated Water Resources Management, Centre for Water Resources, College of Engineering, Guindy. Fellowship member of collaboration of Saci-waters and IDRC- Canada in the PG Coursework. Started career in the field of teaching from the year 2017. Had mentored the Project which has been selected for the final round of Smart India Hackathon- Hardware Edition. Presented paper in the 2 National Conferrences and 2 International Conferrence.

S.Banupriya, pursued B.E in Civil ngineering from V.L.B Janakiammal College of Engineering,Anna University, Coimbatore. And in M.E ,Soil Mechanics and Foundation Engineering from College of Engineering,Guindy Campus. Started career in teaching field in 2016 and Published two papers in reputed Journal. One of the Project selected for Final presentation for INAE Award during 2019. Area of Interest is Concrete Technology and Geotechnical Engineering for Research.

Ms. Ruthra R, holds B.E in Civil Engineering from Jeppiar SRR Engineering College,Chennai and aslo Masters of Technology in Coastal Management from College of Engineering Guindy. Currently Working as an Assistant Professor, Department of Civil Engineering, St.Joseph’s College of Engineering,Chennai. Started career in the field of teaching from the year 2017. Had mentored the Project which has been selected for the final round of Smart India Hackathon- Hardware Edition. Presented paper in the 2 National Conferrences and 5 International Conferrence. Area of interest is Coastal management, Remote Sensing and GIS , Environmental Impact Assessment..