IMPACT OF SISAL FIBER AS A REINFORCEMENT ON THE BEHAVIOR OF EXPANSIVE SOIL

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Abstract - *A large part of Madhya Pradesh is covered with black cotton soil, which is an expansive soil having swelling and shrinkage problems and extremely low CBR due to which it does not support any type of construction whether structural or pavement. In view to improve the shear strength parameter of expansive soil there are various ground improvement techniques. Soil reinforcement techniques are most prevailing one using several types of fibers including natural fibers. Among these fibers, sisal fiber can be used to improve the shear strength and bearing capacity of soil. Sisal fiber is a natural and biodegradable waste which is not harmful to environment or any living organism. The soil used is black cotton soil and the fibers are used at varying percentages (1%, 2%, 3%, 4%, 5% and so on) by dry weight of soil. The outcomes of this research indicate a reduction in the maximum dry density and the optimum moisture content of soil after the addition of sisal fiber. There is an improvement in the CBR value of soil after the addition of sisal fiber. The optimum CBR value is obtained for 1cm length of fiber with 4% fiber content.*

***Key Words*: Expansive soil, Sisal fiber, Stabilization, Compressive Strength, CBR.**

1. INTRODUCTION

Geotechnical engineers encounter the situation where they must provide foundation at site where soil is not suitable or unacceptable. In that case, property of the soil like shear strength, bearing capacity to carry the load is needed to be improved using different techniques. These techniques are called ground improvement methods. For this purpose, reinforcement of soil or stabilization of soil can be done using different kind of fibers like asbestos, steel, and glass, synthetic or natural. Among these Sisal Fiber (SF) can be used as a natural fiber to improve the shearing strength and bearing capacity of the soil and that would be a sustainable use of waste material. Sisal fiber is a natural biodegradable waste, it is available in abundance and at very low cost so it can be used as a reinforcing material that will increase the soil properties and reduces the disposal problem. The exceptional properties of Sisal such as its unique chemical composition, slow degradation rate, high tensile strength, thermal insulation, elastic recovery, scaly surface, and unique interactions with water and oils, has led to many diverse uses. Recently soil reinforcement with short, discrete, randomly oriented fibers is getting more attention from many researchers around the world.

Sisal fiber is one of the natural fibers that can be used for various industrial and construction purposes, the other fibers include bamboo, jute, coir etc. There have been many findings and research to find alternatives for plastics and polythene and these fibers are a great example of their alternatives which do not harm or prone any threat to the environment.

Sisal fiber is abundantly found in many parts of India including central India, north eastern region and Southern parts of India. It is also globally found in parts of east Africa, Brazil and Haiti.

Structure of Sisal Fiber:

- A healthy sisal fiber plant produces nearly 200 to 250 leaves.
- These leaves are composed of 1200 fiber bundle per leaf.
- This leaf contains 4 % fiber, 0.75 % cuticle, 8 % dry matter and 87.25 % of water.
- There are 3 fibers namely mechanical, ribbon and xylem in sisal leaf.

1.1 LITERATURE REVIEW

Following are some of the important literatures viewed related to reinforcing the soil with natural fibers.

- **Mr.Kilabanur Promod** et al **(2017)** studied effect of sisal fiber and cement on black cotton soil. Sisal Fiber was mixed in varying percentages and cement was kept constant at 5% by dry weight of soil.

- **Abhishek Ray (2016)** studied the properties of sisal fiber treated with an alkali (here KOH), there was a significant change in the surface of the fiber was observed.

- **S.Abhijith and T.Aruna (2015)** studied the impact of ground granulated blast furnace slag and sisal fiber on the on mechanical properties of black cotton soil.

- **Jyothi Swarup et al (2015)** studied the effects of percentage of sisal fiber and chemical on CBR value, UCC and Shear values of soil were additionally examined

independently to the ordinary soil. NaOH is utilized as an Alkaline compound alongside Fly ash as filler material.

- **John Engbonye Sani et al (2014)** studied behavior changes occurring in lateritic soils when treated with wood saw dust ash (WSDA) and Sisal Fiber treated with Sodium Borohydride ($NaBH_4$).Statistical analysis was carried out on the obtained results on XLSTART 2017 software and analysis of variance with the Microsoft Excel Analysis Tool Pack Software Package.

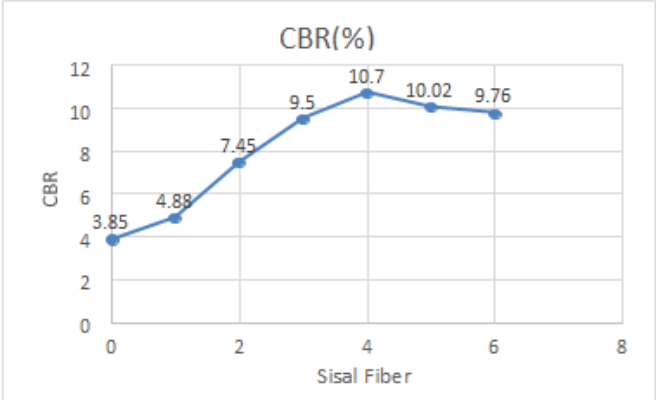
2. Research Outcomes

The properties of Black Cotton Soil are as follows

PROPERTIES	RESULTS
LIQUID LIMIT	59.34
PLASTIC LIMIT	35.23
PLASTICITY INDEX	24.11(CLAY)
PLASTICITY	HIGH PLASTICITY
SPECIFIC GRAVITY	2.35
COFFICIENT OF CURVATURE	1.25
COFFICIENTOF UNIFORMITY	6.23
OPTIMUM MOISTURE CONTENT	17%
MAXIMUM DRY DENSITY	1.4 g/cc
CALIFORNIA BEARING RATIO	3.85%

The effect of using sisal fiber with black cotton soil is as follows

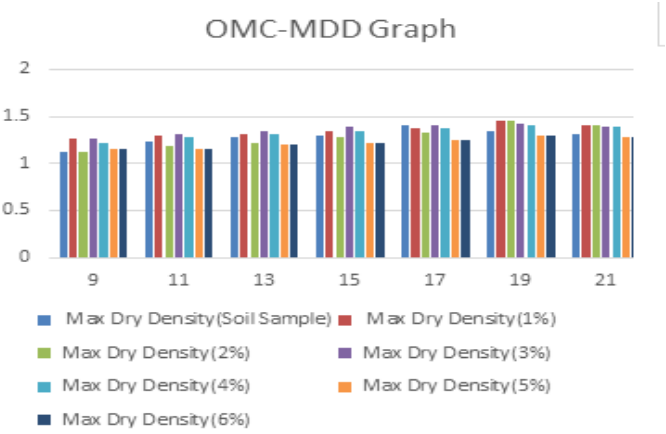
SISAL FIBER (%)	CBR (%)
0	3.85
1	4.88
2	7.45
3	9.5
4	10.7
5	10.02
6	9.76



Graphical Representation of CBR at Different Percentage of Sisal Fiber

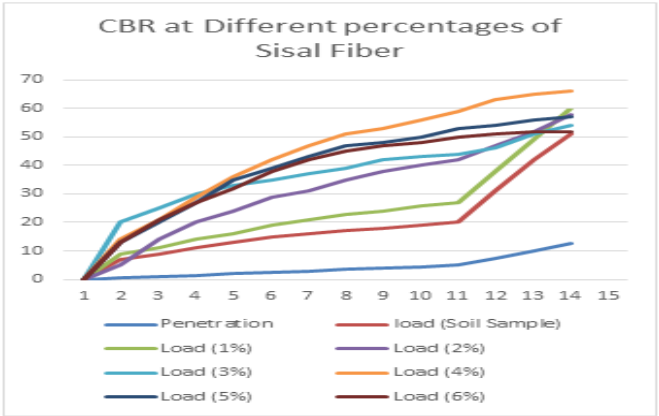
COMPARISON of OMC & MDD at DIFFERENT PERCENTAGE of SISAL FIBER

The following graph shows the variation in the Optimum Moisture Content and Maximum Dry Density when different percentage of sisal fiber is used with black cotton soil.



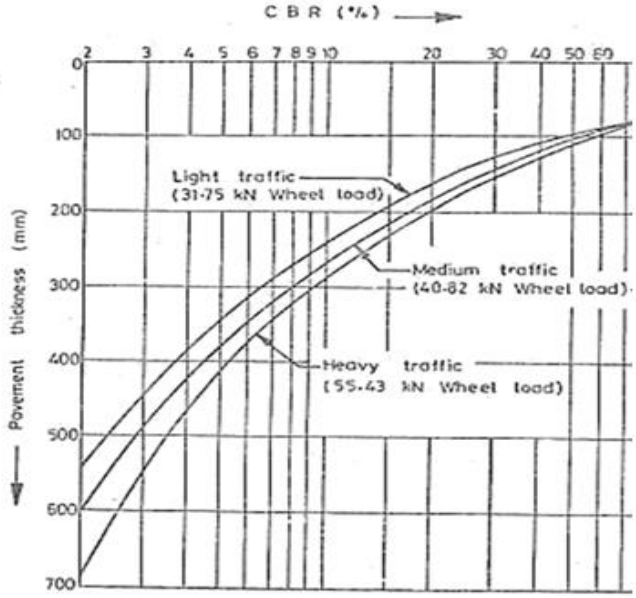
COMPARISON OF CBR VALUES AT DIFFERENT PERCENTAGE OF SISAL FIBER

The graph shows the comparison between different values of CBR calculated at different percentages of Sisal Fiber added.



Relationship between the Properties of Sisal Fiber, CBR Values and Thickness of Pavement

For the design of pavement empirical chart as shown in fig. above CBR-method-flexible-pavement-design-by-California-state-of-highways.
The pavement is design for heavy traffic loading as the soil sample is from state highway.
Thickness of the pavement according to the calculated CBR value is 260 mm when mixed with 4% sisal fiber.
Taking into account 3.5 mm width of lane with 105 cubic meter can be reduced for single lane in 1 km stretch.



Sisal Fiber %	CBR Value (%)	Thickness of Pavement(mm)
1%	4.88	425 mm
2%	7.45	350 mm
3%	9.50	325 mm
4%	10.70	260 mm
5%	10.02	280 mm
6%	9.76	290 mm

3. Conclusions

On the basis of experimental investigation & results obtained, following conclusion can be drawn –

- The optimum moisture content increases with the addition of sisal fiber at 1% but remains constant up to 6%, where it shows a slight increase in water content after which the soil tends to fail because of other physical properties.
- The maximum dry density decreases with the addition of sisal fiber and the value of maximum dry density is not constant it is continuously changing with respect to the addition of sisal fiber at different percentage.
- The CBR value of virgin black cotton soil obtained as 3.59%. CBR value of black cotton soil increases with the addition of sisal fiber & maximum value of CBR was found to be 10.7% with 4% sisal fiber.
- This soil cannot be used in foundation purpose, constructions of bridge piers because of high swelling properties and due to failing of UCS test.
- This stabilized black cotton soil can be used in the construction of embankments and pavement.
- The optimum dose of sisal fiber for CBR is 4% at 1 cm length.
- The thickness of pavement that will be laid down comes out to be 260 mm.

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