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Experimental Study on Strength Properties of Randomly Oriented Short and Long Length Kerosene Coated Sisal Fiber Reinforced Soil

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Abstract:

Sustainable ground improvement techniques have led to the use of natural fibers to improve the shear strength properties of soil .The present work, evaluates the strength properties of subgrade soil of pavement by reinforcing with the sisal fibers randomly in the soil sample. The Sisal fibers were extracted manually and treated with kerosene in order to reduce the capacity of water absorption. Different percentage of sisal fibers 0, 0.5%, 1%, 1.5%, and 2% ,3% by weight of dry soil for fiber lengths of 10, 15, and 20 mm were used to study different parameters of compaction soaked California bearing ratio (CBR) and unconfined compression strength tests (UCS). From the work done it is observed, as the fiber content and length increased, the maximum dry density (MDD) of reinforced soil slightly decreased, whereas the optimum moisture content (OMC) increased modestly. The California bearing ratio (CBR) and unconfined compressive strength (UCS) both increased significantly with increasing fiber length and content and this increment is substantial at 15 mm fiber length of 1.5% fiber content. Therefore, it's concluded that 15mm sisal fiber length can be considered as a practical for enhancing the properties of weak subgrade soils. The present work revealed better bonding strength between soil and sisal fiber.

Keywords **—** Sisal fiber, subgrade, compacted soil, reinforcement, California bearing ratio, approach road..

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I. INTRODUCTION

Generally weak soil posses threat to structures and cause damages when water percolates them. When the beneath soils do not possess enough stamina to retain and revert back the applied loads then it is better to provide reinforcement after proper compaction of the soil else it may cause strength issues. Naturally weak soils can be strengthened using compaction, consolidation and by methods of soil stability using various means and methods. Strengthening of weak natural soils having matter like mudstone beneath which posses a characteristic strength of 1 MPa and can lose strength with the entry of water are a threat to the strength estimated hence soil characterization and various evaluations can be achieved with the aid of different materials and soil reinforcement is one among the techniques. Reinforcing soil mass have three primary purposes:

1. To increment its load bearing capacity and check sudden loss in overall strength,
2. To rise its stability along with time , and
3. To decrease settlements and lateral deformations this may impact the overall performance.

The reinforcement inclusion can be in the form of strips, bars, sheets, mats, or nets in a definite pattern (oriented distribution), or the mixing of discrete fibers randomly with the soil. The non uniform mixing of thin threads of naturally available or manmade fibers or threads in the sample soils or soils has more profit in reinforcing than complete mixing uniformly on the whole soils. This will reduce the material requirement and saves manpower energy along with cost savings. The mixing in random and non uniform ways has impact on its overall isotropy i.e. it limits the over stressing in all other directions and controls the limit while it forms any lumps in the soil if possible and reduces the formation of failure planes. By adding reinforcing elements to a soil mass, shear resistance can be increased. There has been widespread application of natural materials such as Jute, coir, sisal, banana and palm as reinforcing materials in the soil for a long time. Since long, the silk route is a knowledge centre along the centuries for many nations spread across the Asia content and sub Africa and Sahara routes. This knowledge passed through many continents and applied in many structures throughout the world. India and a few Asian countries is pioneer in the field of reinforcing soil through mats of natural fibers like bamboo and Kans. These vegetations have least impact on the natural resources and forms a attaching bond with the other building components apart from pavements. In china, threads of rattan are extensively used along the gigantic wall which can be still seen from the moon. This great wall is made of tree trunks and is reinforced along with other fibers too. Apart from that in Indonesia there are many proofs that fibers are used as reinforcement are seen in many empires for pavement improvement. In Bangladesh the jetties of docs are reinforced with fibers and many thread like formations are extensively used for locking and fixing the soils. The Chinese people used the bars of bamboo and rattan for tensile components along many bridges along with sisal and other fibers for fixing the loads applied along the structures. In ancient Greece and in ziggurats, the proofs of reinforced soils are still found. The pyramids of Giza and other locations are evident that they used reinforced soil before the eraction of very heavy structures; this is a clear indication that use of reinforced beds of soil in single or in multiple layers is not new, and has been used since times immortal. The ancient engineers and architects and planners used knitted mats of fibers and have conducted a tri axial experiment to assess the effect of randomly distributed sisal fiber on the mechanical properties of a silty clay soil**.** Since natural fibers are readily available and less expensive, soil can be reinforced with them. The soils generally weak and aside the rivers are well strengthen for application of load before being used and hence found as treated. The increment of fibers in them has strengthened the load absorption behaviour and has improved the weakness planes to a great extent. This improved soil now is a good bed for load application in multiple options. Likewise for heavy continuous loading or random loading along the wars along the regular movement of people. Thus entering the fibers inside the soils and those too naturally available fibers can impact the general and localized stamina of soil and controls the planes of weakness for any soil.

II. SAMPLES COLLECTION

A. Black cotton soil is found throughout MP. The soil which is taken is from the locality of Patel nagar near raisen road in Bhopal area for the current work. BIS determine the strength, suitability, placement, property as generally available of the soil. Table 1 is displaying the lab results of sample. Grains distribution along the soil and the gradation is done by sieving as per the codes available and dry/wet sieve analysis and hydro meter analysis is displayed in figures along the work. Sisal leaves were collected from AMPRI, hoshangabad road area. The extraction process of manual method is displayed along the images. Sisal threads are kept dipped in chemical taken is kerosene oil for 23 to 24 hours to impact the absorption of moisture from soil, degradation, and microbial attack. Now the chemical loaded kerosene sisal threads are put to open air for dry for a sample time period of next one day. This matter is now dried and gently keeps mixing as per requirement. Physical properties as per the lab results are noted and indexed in table format as shown.

B. **I.S. Codes Used:**

- Classification and identification of soil for engineering purpose –I.S. 1498-1970
- Preparation and recording the sundried soil dry samples – I.S. 2720 (PART 1)-1972
- Determination of water content –I.S. 2720 – (PART II)-1973
- Determination of specific gravity –I.S. 2720-(PART III) -1974
- Grain Size Analysis –I.S. 2720 -(PART IV) - 1975
- Determination of Atterberg limits (liquid limit & plastic limit) –I.S. 2720 (PART V)-1970
- To find the moisture values and dry density relation using heavy compaction method I.S. 2720 -(PART -VIII) -1974

III. MATERIALS: SOIL PROPERTIES

TABLE I
SOIL PROPERTIES

Engineering Properties	Results obtained/type
Normal Moisture Content (%)	12.81
Specific gravity	2.69
Percent gravels found	0
Percent sand found	9.63
Percentage of silt	29.8
Percentage of clay	52.7
LL (%)	42
PL (%)	28
PI (%)	24
AASHTO classification of sample	A-6
USC system of sample	CL
Max.dry density of sample in (gm/cm3)	1.64
OMC (%)	18.61
CBR (%)	3.2
UCS (kPa)	86.2

C. SISAL PLANT FIBRES

TABLE 2 : PROPERTIES OF SISAL

Engineering Properties	Results/values
Color	White
Diameter (µm)	151
Density (gm/cm3)	1.38
Water Absorption Content of simple sisal thread (in percent)	89.29
Water Absorption value of kerosene dipped sisal thread (in percent)	49.17
Average tensile stamina found in thread of sisal (in Mega pascal)	426
Young's modulus (GPa)	10
Value of Elongated to break of fiber thread (in percent)	6

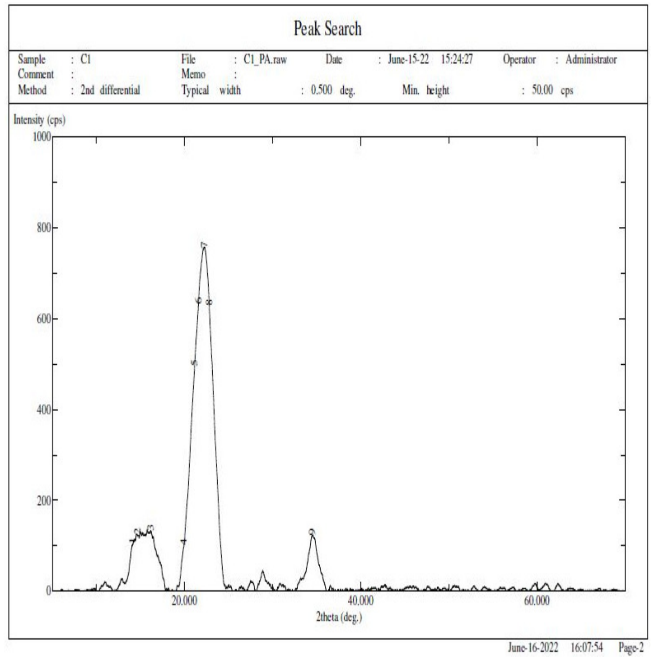

Figure 1: XRD of sisal fibers

IV.LAB PROCESSING AND TESTS BEING DONE

In the lab various experiments carried out namely Compaction tests Max. Dried density & Optimal Moisture Content, soaked CBR test and uncompression Compression Strength lab tests are performed in the laboratory as per the codes defined it. These lab tests are conducted for the sample at normal conditions of the soil and correlated with the obtained values. Then the soil is mixed with the sisal threads and conduction of test is again done. The soil is now being supplied with kerosene aided fiber threads and hence will affect the moisture ranges also hence done very carefully. Here the fibers threads are taken as per the process defined. Taken as in percentages , and in length of fibers threads. The mass of the sisal threads are carefully weighted and recorded. In the first iteration lying of the threads are done as per length and this is predetermined as 10 millimetres. This case is regarded as constant thread content case of the sisal, means percentage is same for the sample as per 10 millimetres. Now again the fiber threads are cutted from the whole thread in pieces of 15 millimetres and same percent mass is kept. And then again this is done for fiber threads length of 20 millimetres cut from the whole fiber threads. In the second iterations the thread mass percent is varied. The changing percent are 0.50 percent, 1 percent and finally 2 percent with dried soil mixed homogeneously taking the length of the threads as defined above. In this work only dried sample of soil is taken and mixed with threads thoroughly. When more than defined percent fibers 3 or 4 percent sisal threads are taken it is very difficult to mix them as they are creating lumps and mass of sisal-soil-water and this is affecting the overall mixing process and discarded in these ratios. These lumps are making small ball like spheres and creating a low compressive balls having mass but lowest strength and other features hence totally now discarded. The same samples are now taken with threads of even more length cut from the whole thread of the sisal and taken as of 25 to 30 millimeters. When again the same mixing is done they too are creating big lumps and mixing is disturbed and hence not suggested. The water is mixed as per the optimum values we got in the earlier test and then through mixing is done for uniform consistency. The proctor kit is well lubricated to reduce the impact of sticking of the soil and easy removal. The proctor kit is employed to make the sample of soil and then thoroughly compacted with the rammer of defined mass and plunger of defined mass as per the test conditions. The sample after the performed test is carefully ejected and tested for strength as quoted in the test. Here the standard conditions of height 11.40 centimeters are followed and mould diameter is 5.70 centimeters. This ejected sample is now adjusted over the frame of the instrument and testing for strength and bearing capacity determination. The load is laid constantly at a rate of 1.25 millimetres in one minute.

Figure 2 : mixing sisal fibers in soil

Figure 3 : compacting soil for MDD and OMC

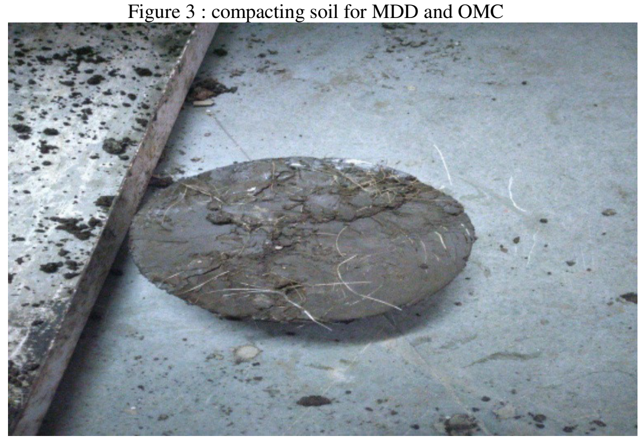

Figure 4 : sisal nailed soil sample

TABLE 3 : MDD of the nailed soil

Sisal thread dimension at length taken(mm)	Percentage mix taken of sisal fiber	Max. Dry Density (gm/cm3)
0	0%	1.689
10	0.5%	1.680
10	1%	1.671
10	1.5%	1.65
10	2%	1.62
15	0.5%	1.678

15	1%	1.659
15	1.5%	1.644
15	2%	1.612
20	0.5%	1.625
20	1%	1.601
20	1.5%	1.592
20	2%	1.582

TABLE 4 OMC OF THE NAILED SOIL

Sisal thread dimension at length taken(mm)	Percentage mix taken of sisal fiber	Optimum moisture content (%)
0	0%	19.85
10	0.5%	20.12
10	1%	20.34
10	1.5%	20.49
10	2%	20.97
15	0.5%	20.46
15	1%	20.87
15	1.5%	21.03
15	2%	21.34
20	0.5%	20.79
20	1%	21.23
20	1.5%	21.48
20	2%	22.14

TABLE 5 CBR VARIATIONS

Sisal thread dimension at length taken(mm)	Percentage mix taken of sisal fiber	C B R values obtained at this range (%)	% increment in CBR
0	0%	3.8	-----
10	0.5%	4.7	23.68%
10	1%	6.2	63.16 %
10	1.5%	9.9	160.53%
10	2%	8.7	128.95%
15	0.5%	5.1	34.21%
15	1%	6.9	81.57%
15	1.5%	13.7	260.53%
15	2%	11.2	194.74%
20	0.5%	5.8	52.64%
20	1%	9.6	152.64%
20	1.5%	11.9	213.15%
20	2%	8.4	121.05%

V. RESULTS

It is interpreted that California bearing ratio of the nailed soil is raised to a greater extent continuously, this growth is visible upto the 1.5 percent sisal content and again is lowered for 2 percent sisal content. The maxi. Increment is found to be 260 percent almost 3. 6 times as compared to the unnailed soil sample, this range is being 15 millimeters and 1. 5 percent sisal thread cuttings result. When the results are carefully evaluated then the normal soil sample is displayed a 23.68 percent values almost 1.23 times which being least for the overall soil taken and this being the 0.5 percent composition 10 millimeters sisal enabled soil. Hence results are clear and sound in favor of nailed soil.

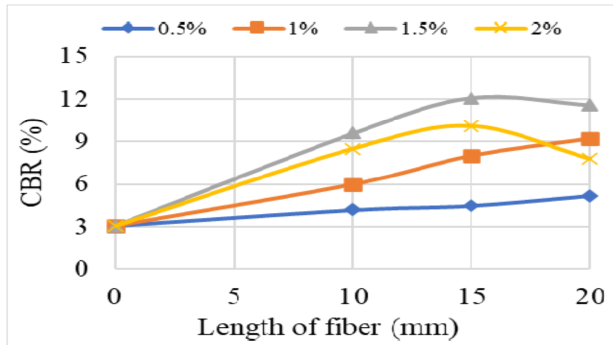

FIGURE 5 VARIATIONS IN CBR WITH SISAL NAILING

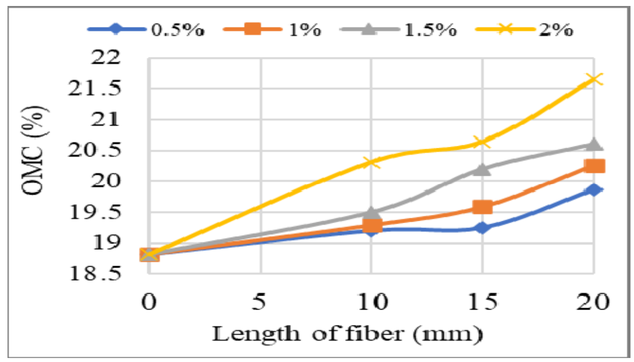

FIGURE 6 OMC VS LENGTH OF SISAL

As the sisal threads are added in random order composition between fiber and soil is having a particular sequel, soil particles occurs through friction and interlocking. This interlocking transmits the stress among both sisal and soil sample and enhances the better load-deformation criteria. Hence, sisal reinforcement performs well at rubbing that is friction and bear tensional behaviour also.

According to BIS California bearing is taken as from 8% up to 21% are specified for sub grades. Lab values is displayed a maxi. Bearing value 13.7 % when fifteen millimeters sisal thread with a optimal percentage of 1.5 percent is taken. Decrement in bearing values is found for a percent of two as the length is already taken of sisal threads as ten, fifteen or twenty millimeters then also the bearing is lowered. Localized sisal threads have disturbed the isometrics of the soil and are generated localized impact over the overall soil causing poor bonding feature. Hence after 1.5 percent the sisal is creating the overall localized impact making it difficult for the sisal to mix beyond that range. Sisal threads are sticking altogether after that ratio and creating a adhere condition for the soil to mix properly and impacting the overall behaviour of the soil mass system.

IV. CONCLUSIONS

When changes along the % mixing and sisal fiber length is studied carefully with the whole nailed soils and unnailed samples, as sisal mixed in a randomly order on Clayey soils of Low compressibility soil taken from Patel nagar and testes performed which being the California bearing ratio test, and the unconfined compression test the main conclusions can be drawn as following.

The maximum dry density and the optimum moisture content are changed a bit with sisal mixing with the soil. Maximum dry density reduced a bit, and optimum moisture content rose a bit with increment of sisal threads in both percent form and in length form.

California bearing ratio of the nailed samples is detected incremented while adding sisal threads to sample. With addition of more sisal the California bearing ratio increased more and this increment is very good at sisal thread mixture value of 1.50 percent. When the sisal threads are added in % more above 1.50 percent, decrement is detected continuously whatsoever length of sisal is taken. Hence length impacted the performance along the molded soil.

The California bearing ratio of molded nailed sample also varied upon the change in sisal fiber length being smaller to longer until twenty millimeters. The maximum California bearing ratio obtained is 13.70 % at 1.50 percent sisal mixture having fifteen millimeters threads whereas the unnailed soil value by then is just least and it rose by 3.60 times (260.53%).

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