

A Study on Stabilization of Subgrade Soil Using Natural Fibers (Coir and Jute)

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ABSTRACT: Soil stabilization has become the major issue in construction activity. Stabilization is a method of processing of locally available materials for the construction of low-cost road in the view of design and construction.. Two types of fibers were utilized in the study: Coir and Jute fibers. A study was conducted to investigate the influence of randomly oriented natural fiber reinforcement on soil strength parameter. Two types of naturally available fibers i.e., coir and jute fibers with different aspect ratios were used with varying dosages of fibers of about 0.25%, 0.5%, 0.75% and 1.0% by dry weight of soil. Laboratory tests are carried out to establish the magnitude of the strength properties of natural fiber reinforced soils. Characterization of soil which is used in the present investigation is carried out by conducting grain size distribution and soil classification. A series of compaction tests were carried out using standard compaction apparatus for different combinations of soil and fiber varying coir and jute fiber content. For stabilized soil, the Unconfined Compressive Strength test and California Bearing Ratio tests were carried out in accordance with the standard procedures for different combination of soil with coir and jute fibers individually. Fatigue load analysis was conducted on stabilized soil samples.

KEYWORDS: Stabilization, Coir, Jute, Aspect Ratio, Fatigue.

I. INTRODUCTION

In developing countries like India the biggest handicap to provide a complete network of road system is the limited finances available to build road by the conventional methods. Therefore there is a need to resort to one of the suitable methods of low cost road construction to meet the growing needs of the road traffic. The construction cost can be considerably decreased by selecting local materials including local soils for the construction of the lower layers of the pavement such as the sub-base course. If the stability of the local soil is not adequate for supporting wheel loads, the properties are improved by soil stabilization techniques. Thus the principle of soil stabilized road construction involves the effective utilization of local soils and other suitable stabilizing agents.

Soil stabilization is defined as the modification of native soil or aggregate in an effort to improve its engineering properties. While stabilization techniques have been used to modify soil for thousands of years, modern stabilization utilizing laboratory experimentation began around 1930. Since then, a variety of stabilizers have been investigated, including lime, Portland cement, coir, fly ash, blast furnace slag, lime-fly ash, bituminous products in various forms, road tar, calcium chloride and other salts, and several non-traditional additives.

The present investigation focuses on use of naturally available Coir and Jute fiber in providing soil-reinforcement for soil, they are expected to accelerate the process of improving stability and increase the strength of the soil. The use of natural materials such as jute, cotton, coir, sisal etc. as reinforcing materials in soil started in the early nineties. The main advantage of these materials is that they are locally available with practically little cost. They are biodegradable and hence will not create environmental problems. The ability of natural fibers to absorb water and to degrade with time is its prime property which gives them an edge over the synthetic materials.

The work in this paper is divided in five stages. 1) To evaluate the engineering properties of soil. 2) To compare the resistance offered by stabilized soil, when mixed with the different percentages of coir and jute fibers content by California Bearing Ratio (CBR) test and Unconfined Compression test (UCC). Thereby, determining the optimum percentage of coir and jute content by weight of soil as a stabilizing material. 3) To evaluate the performance of

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stabilized soil under Repeated / Fatigue loading. 4) To evaluate the effectiveness of stabilized soil under different stress ratios.

II. RELATED WORK

Singh et al (2013), in this study a number of experiments were conducted on soil reinforced with coir fiber. Soil samples for CBR value tests were prepared at its maximum dry density corresponding to its optimum moisture content in the CBR mould without and with reinforcement. The percentage of coir fiber by dry weight of soil was taken as 0.25%, 0.5%, 0.75% and 1.00%, corresponding to fiber content un-soaked and soaked CBR tests were conducted in the laboratory. Tests result indicates that both un-soaked and soaked CBR value of soil increases with the increase in fiber content. It was also observed that increase in CBR value of reinforced soil is substantial at fiber content of 1 %. Thus the significant increase in CBR value of soil due to coir fiber will substantially reduce the thickness of pavement subgrade. Based on the test results of the present investigation it is concluded that CBR value of soil increases with the inclusion of coir fiber for both soaked and un-soaked conditions. When the fiber content is increases, the CBR value of soil is further increases and this increase is substantial (200 %) at fiber content of 1 %. It was also found that preparation of identical soil samples for CBR test beyond 1 % of fiber content was not possible and optimum fiber content is found to be 1 % by dry weight of soil.

Harshita et al (2014), the present study attempts to understand the effectiveness of Jute fibers in controlling swelling behaviour of black cotton soil measured in the laboratory with and without use of random reinforced jute fibers in the black cotton soil. The influence of one parameters of random reinforced jute fibers, via, its amount, on the measured reduction of swelling behaviour is systematically studied, under controlled conditions. The objective of this study is to propose an alternative method to control the swelling behaviour of the expansive soil. In the present study soil samples containing 0%, 1%, 2% to 5% of jute fiber were prepared and the shrinkage limit, optimum moisture content, maximum dry density, California Bearing Ratio and unconfined compressive strength were conducted as per relevant IS code of practice. The test results showed significance decrease in the expansive behaviour of the black cotton soil. The shrinkage limit increase from 8.66% to 14.68%. There is a remarkable increase in California Bearing Ratio and unconfined compressive strength test results. The C.B.R. value increased from 1.8% to 4.1% and unconfined compressive strength values increased from 1.09 kg/cm² to 1.35 kg/cm². From the test results it can be concluded that the addition of jute fibers to black cotton soil decreases its swelling behaviour and increase the C.B.R. and unconfined compressive strength properties.

Qiu et al (1999), reports an extensive research effort relating to permanent deformation of subgrade soils. Repeated load testing was conducted on a subgrade soil. While most soil specimens were subjected to 10,00 to 100,000 load repetitions, one specimen was loaded to over 1 million application to verify the general trend of deformation accumulating various factors including moisture content, density, deviator stress, confining pressure, load frequency, freeze and age were investigated to determine their individual contributions to deformation accumulation.

III. PRESENT INVESTIGATIONS AND RESULTS

The experimental work was carried out in three stages. In the first stage basic tests like Wet Sieve analysis and Atterberg limits tests were conducted on soil obtained for investigation. Second stage consisted of determining Optimum Moisture Content of Soil samples. In the third stage California Bearing Ratio (CBR) test were conducted on the soil samples. After conducting all the above experiments the optimum aspect ratio for coir and jute fibers are fixed based on the higher strength obtained for the soil mix.

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Table 1 Physical and Engineering Properties of Coir

Sl. No.	Properties	Value
1	Specific Gravity	0.71
2	Cut Length	20-50mm
3	Diameter	0.20- 0.25mm
4	Colour	Brown
5	Aspect Ratio	100-250

Table 2 Physical and Engineering Properties of Jute

Sl. No.	Properties	Value
1	Specific Gravity	1.12
2	Cut Length	20-50mm
3	Diameter	2-3mm
4	Colour	Yellowish Brown
5	Aspect Ratio	10-25

Table 3 Results of Physical Properties of Soil

Colour	Red
Particle Size Distribution:	
Gravel, %	0.20
Sand, %	28.12
Silt, %	53.44
Clay, %	18.24
Atterberg's Limits	
Liquid Limit, %	36
Plastic Limit, %	16
Plasticity Index, %	20
Standard Compaction Test	
Maximum Dry Density, g/cc	1.888
Optimum Moisture Content, %	15.30
CBR, % (soaked)	1.91
CBR, % (un-soaked)	4.26
Unconfined Compressive Strength (kPa)	179.07

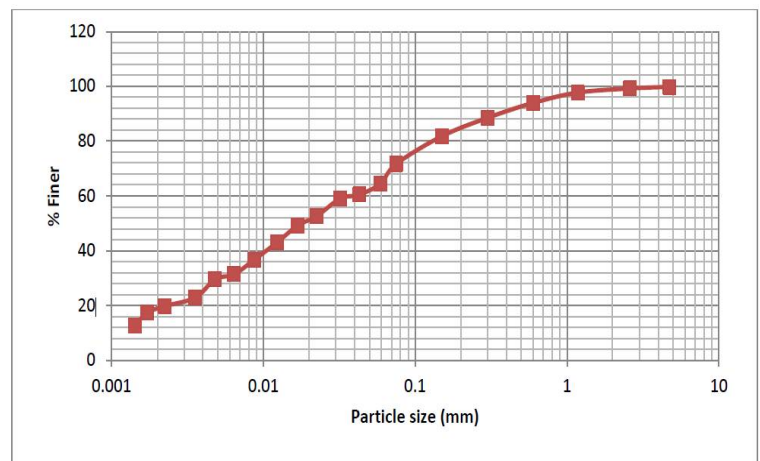


Figure1. Particle Size Distribution Chart

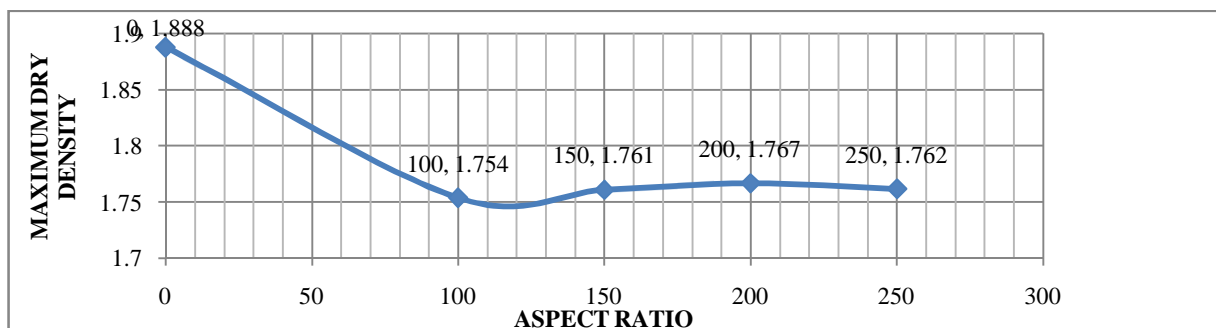


Figure 2 : Comparison of Maximum Dry Density for Varying Aspect Ratios of Coir Fibers

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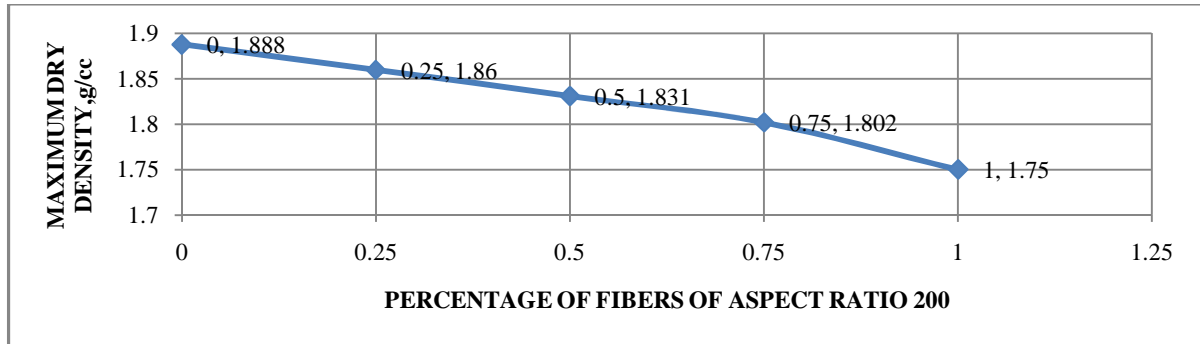


Figure 3: Compaction Characteristics for Varying Percentage of Coir Fibers

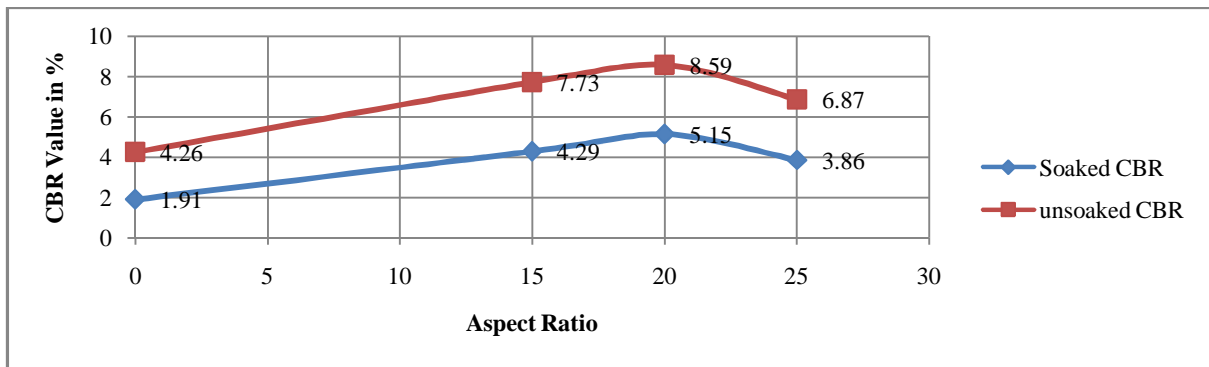


Figure 4: CBR for Varying Aspect Ratio of Coir Fibers

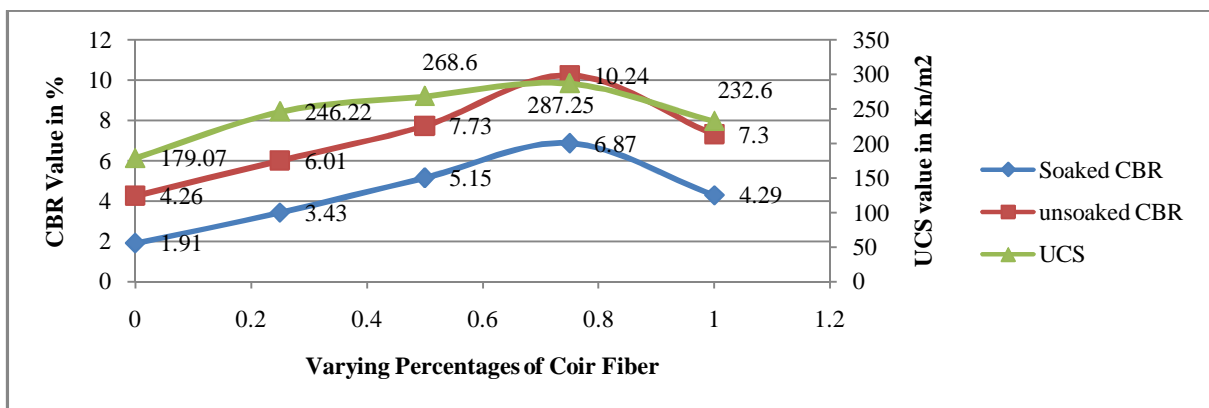


Figure 5: CBR and UCS Values for Varying Percentage of Coir Fibers

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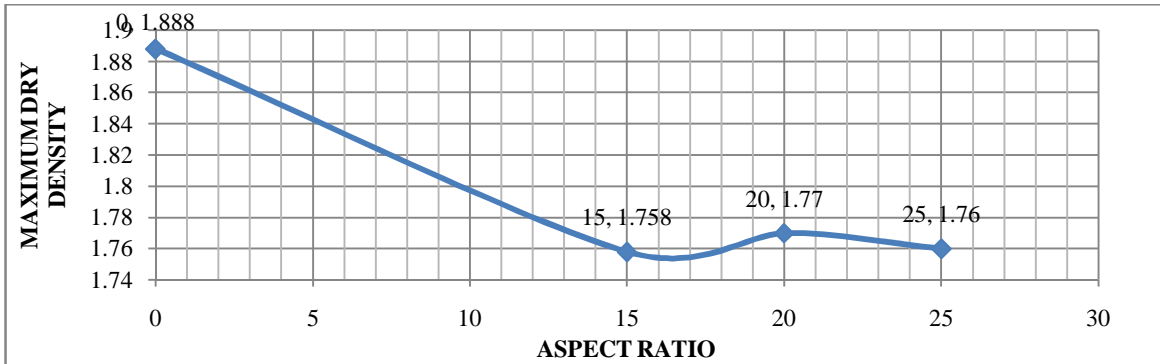


Figure 6: Comparison of Maximum Dry Density for Varying Aspect Ratios of Jute Fibers

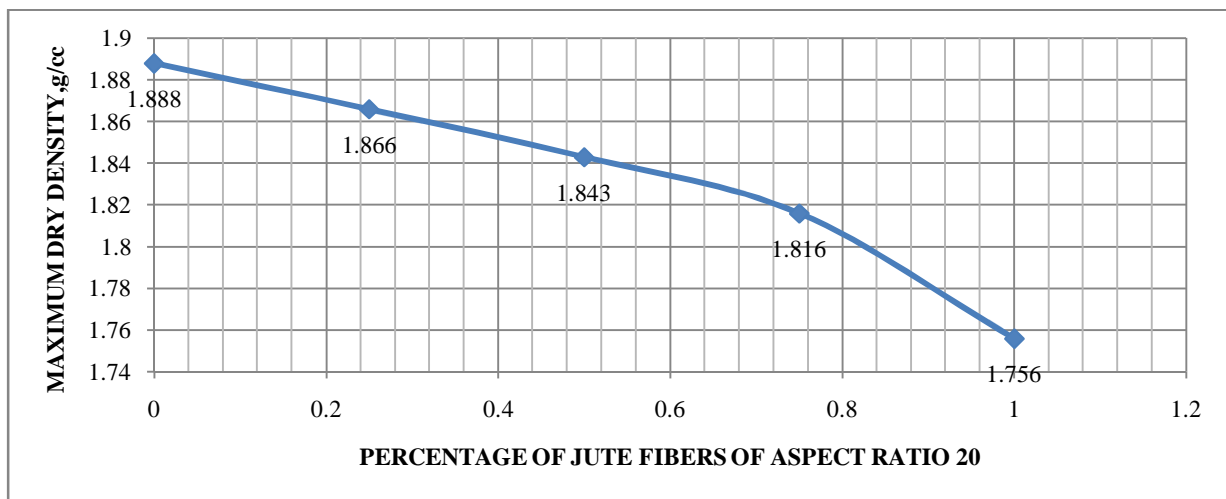


Figure 7: Compaction Characteristics for Varying Percentage of Jute Fibers

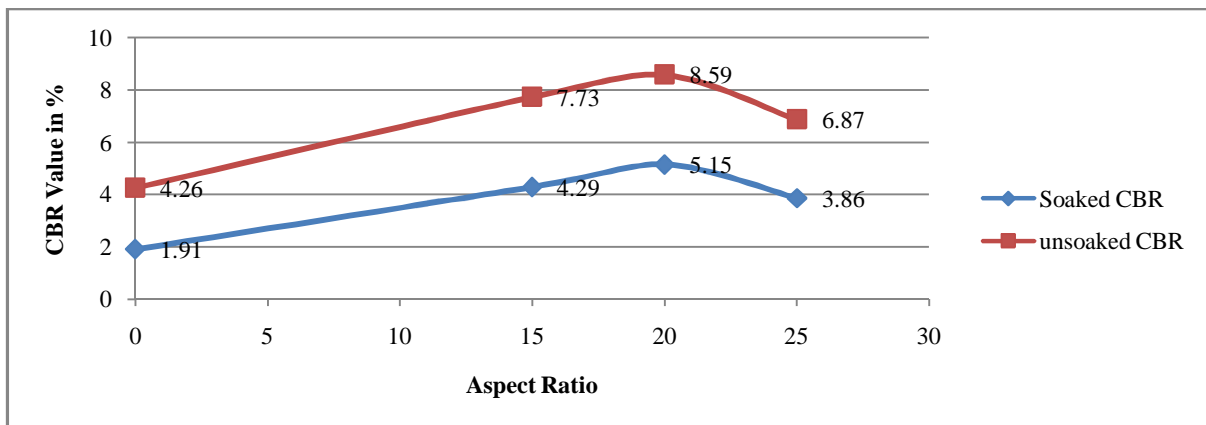


Figure 8: CBR and UCS Values for Varying Percentage of Jute Fibers

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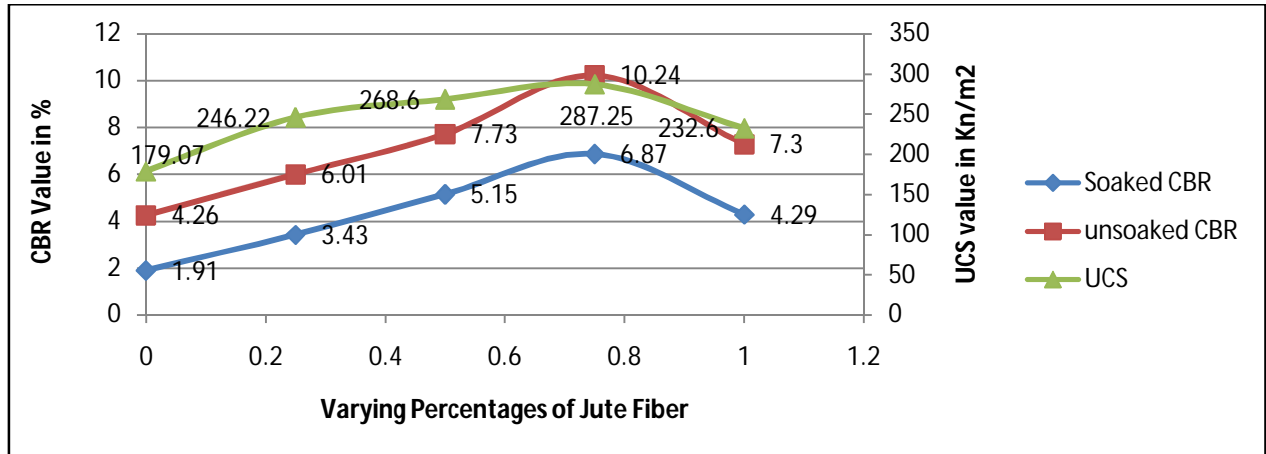


Figure 9: CBR and UCS Values for Varying Percentage of Jute Fibers

FATIGUE/REPEATED LOAD TEST

The effect of repeated load on the strength properties of stabilized soils has been studied in this paragraph. The test setup has a computer- interfaced data acquisition system which is used to control the nature, magnitude and frequency of loading and to collect data from different sensors. Repeated load tests were conducted on specimens prepared in the same manner as those for unconfined compressive strength tests. From the CBR test results it is observed that the higher strength to subgrade soil is achieved with addition of 0.50% of coir fiber of length 3cm and 0.75% of jute fiber of length 4cm. Hence repeated load test was conducted on soil with addition of 0.50% of coir fiber of length 3cm and 0.75% of jute fiber of length 4cm.

TABLE 4 LOAD APPLIED FOR FATIGUE TEST

SL NO.	PARTICULARS	UNCONFINED COMPRESSIVE STRENGTH (UCS), kN/M ²	FREQUENCY IN HZ	APPLIED LOAD DURING THE TEST, KG		
				STRESS RATIO 55%	STRESS RATIO, 60%	STRESS RATIO, 65%
1	SOIL	179.07	2	106	116	125
2	SOIL + 0.50% COIR	330.16	2	190	207	224
3	SOIL + 0.75% JUTE	287.25	2	177	193	209

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TABLE 5 FATIGUE TEST RESULTS

STRESS RATIO	FOR UN STABILIZED SOIL				SOIL + 0.50% OF COIR FIBER				SOIL + 0.75% OF JUTE FIBER			
	NO. OF REPETITIONS FOR FAILURE				NO. OF REPETITIONS FOR FAILURE				NO. OF REPETITIONS FOR FAILURE			
	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE
55%	206	182	190	193	1894	1960	2018	1957	1470	1672	1628	1590
60%	98	114	104	105	1234	1178	1196	1203	1088	1098	1144	1110
65%	48	52	42	47	590	634	568	597	380	380	428	396

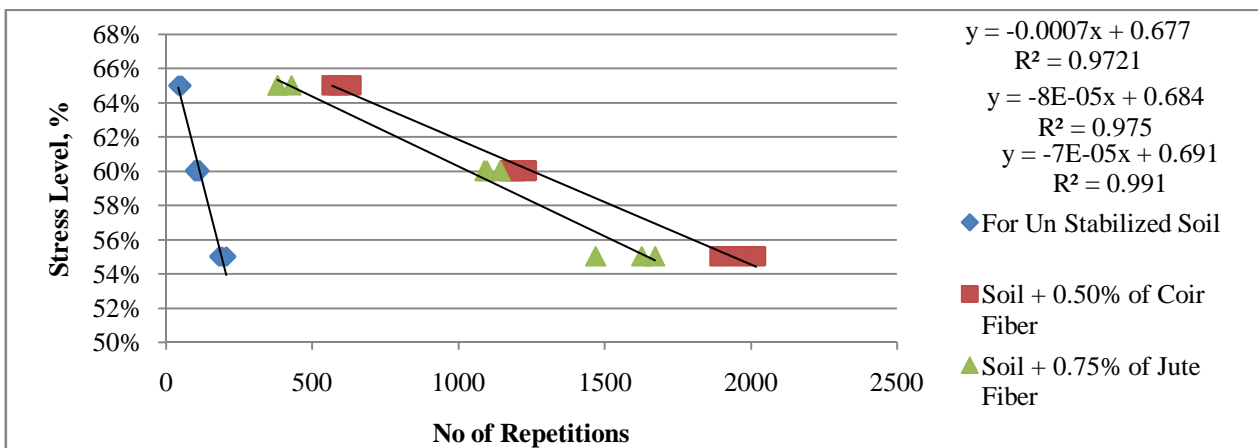


FIGURE. 10 COMBINED S-N CURVE FOR UNSTABILIZED SOIL AND STABILIZED SOIL

IV. DISCUSSIONS

1. The grain size analysis of soil selected for the studies is found to be 0.20 % of gravel, 28.12 % of sand, 53.44 % of silt and 18.24 % of clay. By conducting detailed laboratory investigation of Atterberg limits on soil, it is found the liquid limit and plasticity index of soil is found to be 36 and 20 respectively. The unconfined compressive strength of untreated soil sample is 179.07 kN/m².
2. The MDD of the soil decreases when fiber is added and this may be due to the lower density of fiber when compare to that of the soil alone. The increase in the OMC value of soil fiber mix may be due to absorption of water by fibers.
3. The increase in CBR value of stabilized soil may be due to reason that inclusions of randomly oriented discrete fibers into soil mass, improves the load deformation behaviour by interacting with the soil particles mechanically through surface friction and also by interlocking.
4. The decrease in strength value after further increase in the percentage of fiber may be due to the localization of the fibers in the soil and thus creating poor bonding between the soil and the stabilizing fiber material.

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5. Table 5, presents results of repeated load test performed on untreated soil, 0.50% coir and 0.75% jute stabilized soil. The repeated load experiment are conducted for 55%, 60% and 65% stress ratios of their corresponding unconfined compressive strength at frequency of 2Hz.
6. When the coir and jute fiber is added to soil the increase in fatigue life are 10.14 and 8.45 times respectively for a stress ratio of 55% compared to untreated soil.
7. Similarly, for a stress ratio of 60% and 65% the fatigue life of coir and jute stabilized soil is increased by 11.46, 10.64 times & 12.70 and 8.53 times respectively compared to untreated soil.

V. CONCLUSIONS

1. According to IS code 1498:1970, Indian Soil Classification the type of soil is medium compressible clayey soil (CI).
2. The MDD of soil decreases with increase in coir and jute content, and OMC increases with increase in coir and jute content.
3. The result of laboratory investigation shows that, the addition of coir and jute fiber to the soil, improves the strength characteristics of soil.
4. Soil stabilized with 0.50% of coir fiber with aspect ratio of 150 gives higher strength when compared with other combination of soil and coir fibers.
5. Soil stabilized with 0.75% of jute fiber with aspect ratio of 20 gives higher strength when compared with other combination of soil and jute fibers.
6. In terms of CBR value, soil stabilized by jute fibers gives higher strength when compare to that of coir fibers.
7. The Fatigue life of soil increases with addition of stabilizer and decreases with increase in stress ratio.

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