Experimental Study on Influence of Natural Fibres on CBR Values of Soils Having Different Properties

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Abstract - The construction of roads in clayey soil has continuously been a challenging task for the engineers without any failure. The clayey soil has high shrinkage and swelling potential; thus, the strength of the soil is relatively low. Improving the properties of the soil in terms of strength can be done by stabilizing the soil. Different soil stabilization techniques including soil reinforcement have been adopted to improve the properties of the unsuitable soils. In this study, soils having different properties are collected and natural fibres are randomly distributed to improve the geotechnical property of the soil. Additionally, the biodegradable property of natural fibres may decrease the possibility of the long-term performance of geotechnical structures. So, this study aims at improving the repellent ability and the durability of natural fibres by coating fibres using some additives, such as bituminous materials. The aim of this paper is to study the effectiveness of natural fibres on soil sub-grade strengthening.CBR test were conducted on soil sample before and after addition of fibres. Fibres were added at 0.25%, 0.5%, 0.75%, 1% and 1.25%. Lengths of fibres were taken as 20 mm. The increase in CBR value leads in decrease in pavement thickness.

***Key Words*:** strength, reinforcement, natural fibre, bituminous coating, long-term performance, CBR test

1. INTRODUCTION

Soil is an accumulation or deposit of earth material, derived naturally from disintegration of rocks or decay of vegetation. The supporting soil beneath pavement and its special under courses is called sub-grade. Undisturbed soil beneath the pavement is called natural sub-grade. Sub-grade soils are an essential component of pavement structures, and inadequate sub-grade performance is the cause of many premature pavement failures. Clay sub-grades in particular may provide inadequate support, particularly when saturated. As the quality of a soil layer is increased, the ability of that layer to distribute the load over a greater area is generally increased so that a reduction in the required thickness of the soil and surface layers may be permitted. These types of soil quality improvement are referred to as soil modification or soil stabilization. The concept of reinforced soil with natural fibre materials originated in ancient times. Fibres are used for increase of tensile, compression and shear strength of soils. Most advantageous application of natural fibres in comparison with metal and polymer materials is that they are pollution free, easily available and cost effective.

The main objective of our study is to evaluate the effect of fibre inclusions on strength of parameters and CBR value of clayey soil and laterite soil. In order to achieve the objectives a detailed laboratory tests were conducted on virgin sample and fibre reinforced clay. Tests are performed by varying the fibre content in different proportions. The test results are tabulated and compared.

2. MATERIALS SELECTION

The materials required for the test are selected and then it is collected. In this study soils having different properties such as clayey soil and laterite soil , natural fibres such as coconut fibre and banan fibre and bitumen are selected and collected.

2.1 Soil

Samples of clayey soil and laterite soil are collected and tested for its initial properties and following results were obtained.

2.2 Natural fibres

Coconut fibre and banana fibre are selected as the reinforcing material for this study. Fibres are cut at 20 mm and fibre contents were selected as 0%, 0.25%, 0.5%, 0.75%, 1% and 1.25%.

2.3 Bitumen

The biodegradable property of coconut fibre and banana fibre may decrease the possibility of the long-term performance of geotechnical structures. Such important issues can be solved by improving the water repellent ability and durability of these fibres by coating the fibres with bitumen.

3. METHODOLOGY

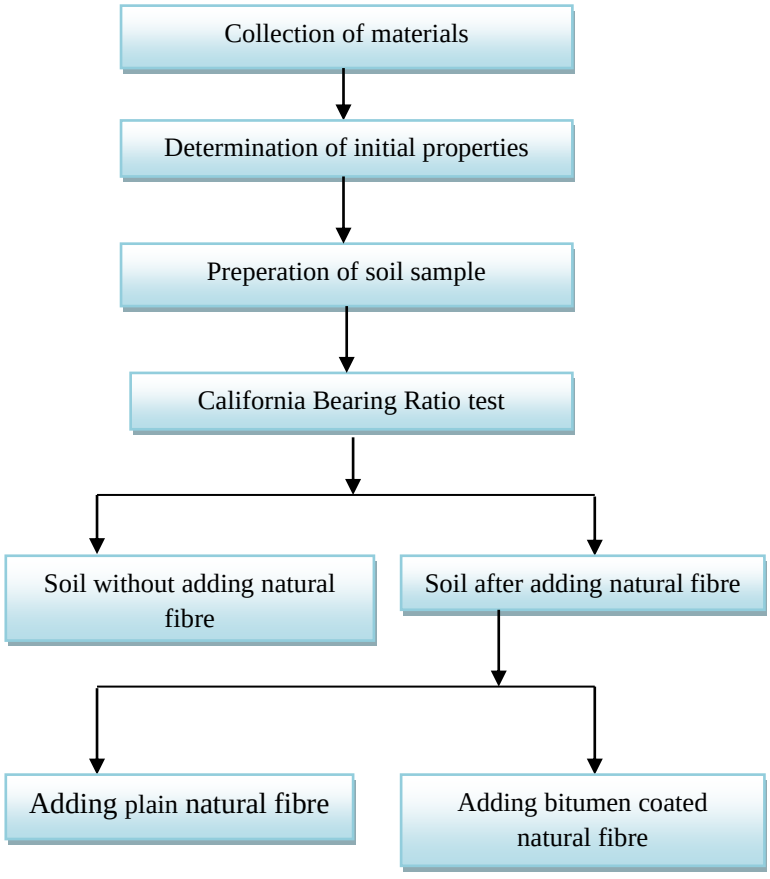

Fig 1: Flowchart showing methodology adopted

The values obtained from these tests are shown in table-1. After this CBR test was conducted for non reinforced, natural fibre reinforced and bitumen coated natural fibre reinforced soil samples at different fibre content percentages.

Table -1: Initial properties of clayey soil and laterite soil

Sl no.	Property	Test results	
		Clayey soil	Laterite soil
1	Specific gravity	2.27	2.4
2	Water content (%)	31.43	23
3	Effective size (mm)	0.017	0.14
4	Liquid limit (%)	49.5	27
5	Plastic limit (%)	33	23.33
6	Plasticity index (%)	16.5	1.67
7	Optimum moisture content (%)	11.25	15.42
8	Maximum dry density (g/cm^3)	1.95	1.663

4. CALIFORNIA BEARING RATIO TEST

The California Bearing Ratio test is a penetration test used to evaluate the sub-grade strength of roads and pavements. The results of these tests are used with the curves to determine the thickness of pavement and its component layers.

4.1 Test procedure

Water is mixed at optimum moisture content to the soil sample and is mixed. Compaction is given in 5 layers with 56 blows in each layer. Soil sample is tested in the CBR machine in which the penetration and load is noted down. Loads corresponding to 2.5mm and 5mm penetration are found out and CBR values are obtained. Same procedure was repeated at different percentage of fibre contents and fibre contents coated with bitumen and changes in values are noted down.

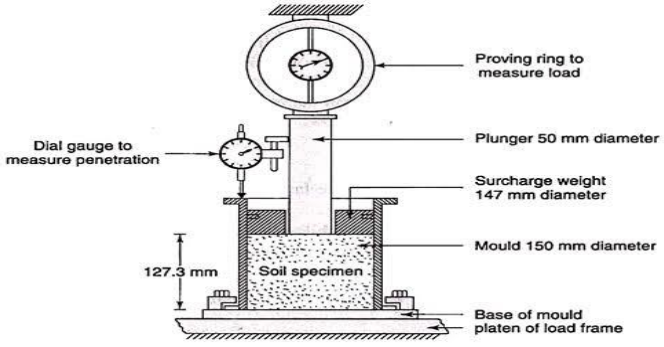

Fig 2: Experimental set up for CBR test

5. RESULTS AND DISCUSSIONS

CBR values of clayey soil reinforced with natural fibres and clayey soil reinforced with bitumen coated natural fibres are shown in table-2 and table-3.

Table-2: CBR values of fibre reinforced clayey soil

Fibre type	Coconut fibre		Banana fibre	
Fibre content (%)	CBR value (%)	Increase in CBR value (%)	CBR value (%)	Increase in CBR value (%)
0	5.49	0	5.49	0
0.25	7.74	2.25	8.6	3.11
0.5	9	3.51	13.06	7.57
0.75	11.33	5.84	17.1	11.61
1	13.59	8.1	20.75	15.26
1.25	11.82	6.33	18.08	12.59

Table-3: CBR values of bitumen coated fibre reinforced clayey soil

Fibre type	Bitumen coated coconut fibre		Bitumen coated banana fibre	
Fibre content (%)	CBR value (%)	Increase in CBR value (%)	CBR value (%)	Increase in CBR value (%)
0	5.49	0	5.49	0
0.25	8.01	2.52	8.9	3.41
0.5	9.32	3.83	13.52	8.03
0.75	11.72	6.23	17.7	12.21
1	14.1	8.61	21.48	16
1.25	12.41	6.92	19.03	13.54

CBR values of laterite soil reinforced with natural fibres and laterite soil reinforced with bitumen coated natural fibres are shown in table-4 and table-5.

Table-4: CBR values of fibre reinforced laterite soil

Fibre type	Coconut fibre		Banana fibre	
Fibre content (%)	CBR value (%)	Increase in CBR value (%)	CBR value (%)	Increase in CBR value (%)
0	10.6	0	10.6	0
0.25	15.82	5.22	17.13	6.53
0.5	22.37	11.77	25.39	14.79
0.75	31.35	20.75	33.64	23.04
1	42.61	32.01	45	34.4
1.25	36.72	26.12	38.75	28.15

Table-5: CBR values of bitumen coated fibre reinforced laterite soil

Fibre type	Bitumen coated coconut fibre		Bitumen coated banana fibre	
Fibre content (%)	CBR value (%)	Increase in CBR value (%)	CBR value (%)	Increase in CBR value (%)
0	10.6	0	10.6	0
0.25	16.37	5.77	17.73	7.13
0.5	23.15	12.55	26.3	15.7
0.75	32.45	21.85	35	24.4
1	44.2	33.6	46.6	36
1.25	36.28	25.68	40.25	29.65

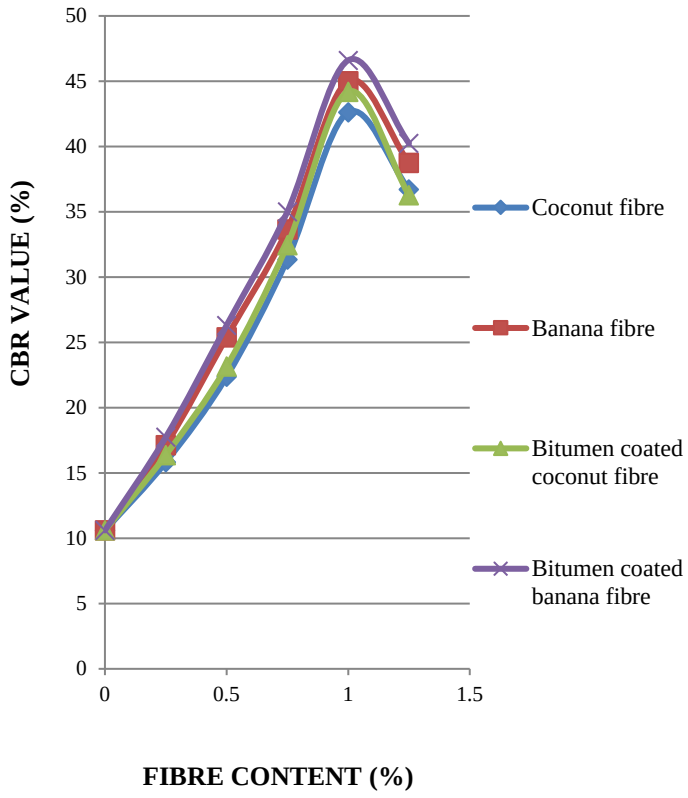

Fig 3: CBR value of fibre reinforced clayey soil

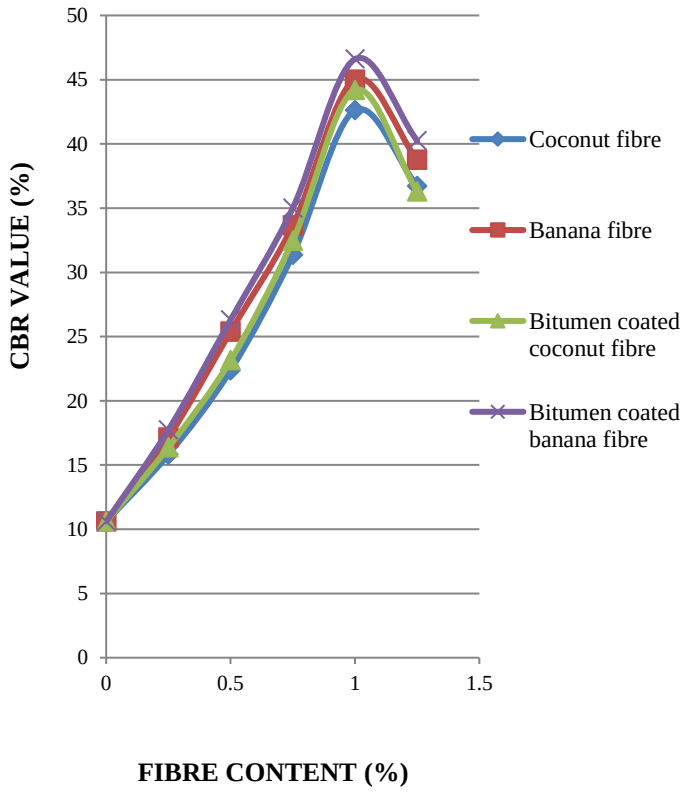

Fig 4: CBR value of fibre reinforced laterite soil

Based on the test results it was found that CBR value increases with increase in the fibre content at different percentages and shows a substantial increase at 1% fibre content thereafter it is decreased. When compared with plain clayey soil the CBR value of uncoated coconut fibre and banana fibre reinforced clayey soil shows an increase of 8.1% and 15.6% respectively and the CBR value of bitumen coated coconut fibre and banana fibre reinforced clayey soil shows an increase of 8.16% and 16% respectively. When compared with plain laterite soil the CBR value of uncoated coconut fibre and banana fibre reinforced laterite soil shows an increase of 32.01% and 34.4% respectively and the CBR value of bitumen coated coconut fibre and banana fibre reinforced in laterite soil shows an increase of 33.6% and 36% respectively.

6. CONCLUSION

On the basis of laboratory investigation on California Bearing Ratio of laterite and clayey soil with natural fibre reinforcement the following conclusions are drawn:

- CBR value of both clayey soil and laterite soil increases with the inclusion of both the Banana and Coconut fibre.
- CBR value increases with increase in the fibre content at different percentages and shows a substantial increase at 1% fibre content thereafter it is decreased.
- The banana fibre reinforcement is more suitable for both clayey soil and laterite soil.
- Banana fibre reinforcement shows an increase of 15.6% and 34.4% in CBR value for clayey soil and laterite soil respectively.
- Bitumen coated banana fibre reinforcement shows an increase of 16% and 36% in CBR value for clayey soil and laterite soil respectively.
- When bitumen coated fibres are added to the soil there was a slight increase in CBR value when compared with uncoated fibre reinforced soil.
- Bitumen coated banana fibre shows the best result.

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