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Improvement of CBR using Jute Fiber for the Design of Flexible Pavement

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***Abstract*—In the present paper, the CBR value of the soil under consideration has been improved by introducing geo textured mat ie.jute fiber mat at different depths of the soil to enhance the CBR value. Further by considering the traffic and CBR value as the factors, the thickness of varying coat , sub-base and base courses are evaluated along with stresses and strains at the interface of each layer. When the thickness and stresses are compared with analytical values and IRC techniques, the reduction in the thickness by both methods are evaluated and the comparisons of the above techniques are done and presented.**

Key words—Jute fiber mat, Soaked CBR, Reinforced soil, Bitumen, Maximum dry density, CBR.

I. INTRODUCTION

The civil engineering problems which often encountered are multidisciplinary in nature. Soils of expansive nature are problematic to the structures because of their volume changes due to change in moisture content. This is the major threat in field of geo technical engineering. Reinforced soil is a composite material comprising frictional soil and tension resistant elements in the form of sheet, strips, nets or mats of metals, synthetic fabrics or natural fibers such as jute, coir, bamboo etc. arranged in the soil mass in such a way to suppress the tensile strain which develops under gravity and boundary forces. The performance of expansive soils can be substantially improved by introducing reinforcing elements in the direction of tensile strains in the same way as in reinforced concrete. The literature survey has suggested that inclusion of jute fiber increases the CBR value of the soil and the distribution of the fiber along with soil will become random because of non-uniform mixing. To overcome the above limitation in the present project an attempt has been made to spread the fiber in the form mat at different depth so as to attain the maximum CBR value. To avoid biodegradation of jute fiber mat especially in rainy season because of over saturation of water, geo-fiber mat dipped in bitumen are placed at effective depths and to reduce normal and tangential stresses at the interface of each layer so that the respective strains developed are kept with that of resistance of soil improving the durability of the pavement.

II. OBJECTIVE OF STUDY

The literature survey has suggested that inclusion of Jute fiber increases the CBR value of the soil and the distribution of the fiber with soil will become random because of non-uniform mixing. To overcome the above limitation in the present project an attempt has been made to spread the fiber in the form mat at different depth so as arrive the maximum CBR value Thus the objectives of the study are;

- To analyses the soaked CBR of the soil placing jute fiber mat at different level along the depth.
- To analyses soaked CBR for soil and fifty percent gravel placing jute fiber matrix in three layers at one-third depth interval.
- To evaluate required thickness by analytical method using three layer concept.
- To work out the cost economics for different increase percentage of CBR.

III. METHODOLOGY

The soil that is being stabilized is tested before validating for widespread usage in the field. The initial tests are mandatory that is confined to IS: 2720 prescribed in our country. The shear strength of soil is indirectly determined for natural soil placing geo synthetic mats at different depths and also stabilizing the soil by adding gravel with mat are analyzed for a kilometer length of Dudda stretch between Hassan and Arsikere. Based on CBR value and as well as traffic parameter wearing coat and base and sub base course thickness are designed as per IRC: 37-2001 reaffirmed in 2012. By applying elastic theory the stress at each interface are found out and comparison between the thicknesses by different technique are made and are presented in this paper.

A. Materials and properties.

1) Jute fibre: The Jute Geotextile sheet is starred of from the Jute bag available in the market. The diameter of the jute mat is equal to diameter of the CBR mould of 15cm.The thickness of jute mat was measured using slide-callipers which is having a thickness of 2mm-3mm and the colour being yellowish- brown. The views of the jute mat used for experiment are shown in figure 1.

Fig. 1. Jute fibre mat used as soil reinforcement.

2) Bitumen: Bitumen is used for coating the jute fibre to protect them from microbiological attack & degradation. Bitumen coating is done in a hot state at a temperature of 160°C. The grade of bitumen taken is 80-100, softening point is 65°C, and flash point of bitumen is 185°C with specific gravity of 1.06 kg /m^3.

3) *Engineering Properties of the soil under study:* The soil under study has physical characters such as color being brick red with specific gravity of 2.59 kg/m^3 and grain size distribution where in gravel is 16.10%, sand is 82.65% and fines is 1.25% in composition. The engineering properties possessed were MDD of 1.85 g/cc, OMC of 16% and soil being non-plastic in nature. Soil under study is shown in the figure 2.

Fig. 2. Soil under study.

IV. RESULTS AND DISCUSSIONS

A. *Behaviour of different combination of soil and jute fibre mat.*

The increase in percentage of natural soil CBR with that of natural soil and three layer jute fiber mats may do suggest that the jute fiber mat which act as reinforcement place a vital role in improving the CBR value which may be due to improving the shearing action of the soil. This combination also attains the minimum requirement of CBR as per IS: 2720. Further adding jute fiber mat at three levels may prevent the water intrusion from top of the pavement from surface flow infiltration and rise in water level due to capillary action from the bottom.

TABLE I
BEHAVIOUR OF DIFFERENT COMBINATION OF SOIL AND JUTE FIBRE MAT.

Type of combination	$(\gamma_d)_{max}$ (g/cc)	OMC (%)	Volume of soil in (g)	Quantity of water to be added (ml)	Soaked CBR for 2.5mm penetration in %
NS	1.821	14.85	4022.46	597.33	0.652
NS+One LJFM	1.840	13.33	4064.37	541.78	1.285
NS+Two LJFM	1.895	13.15	4185.86	550.44	1.597
NS+ThreeLJFM	1.935	12.55	4274.22	536.41	2.18
50%NS+ 50% gravel	1.885	13.20	4163.77	549.61	1.402
50%NS+ 50% gravel+ Three LJFM	1.975	11.36	4362.50	495.58	4.285

NS- Natural soil, LJFM-Layer jute fiber mat.

B. *Compaction characteristics of natural soil with intrusion of jute fibre.*

To assess maximum dry density (MDD) and optimum moisture content (OMC), Standard Proctor compaction test is performed as per IS 2720:1980 Part8. A series of standard proctor's tests are carried out and results are tabulated and are presented in table II.

TABLE II
SHOWING THE RESULTS OF MDD AND OMC FOR DIFFERENT LAYER COMBINATION

Sl.No	Type of combination	$(\gamma_d)_{max}$ (g/cc)	% Increase in dry density	OMC (%)	% decrease in OMC
2	NS+One LJFM	1.840	1.043	13.30	10.43
3	NS+Two LJFM	1.895	4.063	13.15	11.44
4	NS+Three LJFM	1.935	6.260	12.55	15.488

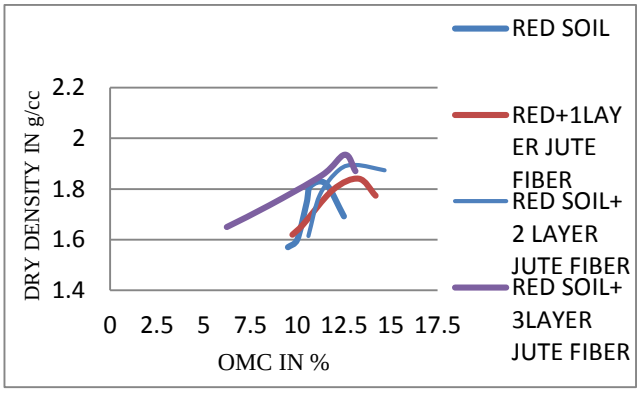

Figure 3. A line graph showing compaction curve for different layer combination

From the above graph it appears that natural soil with three layer jute fiber mat will provide higher density for smaller OMC value which may be due to jute fiber mat which is acting as barrier to improve density and to avoid infiltration of water.

C. Compaction characteristics of natural soil with intrusion of jute mat and 50% replacement of gravel by natural soil.

A series of standard proctor's tests are carried out on the soil sample with intrusion of jute fibre coated with bitumen along with 50% replacement of natural soil by gravel with and without jute mat. The trend of variation with dry density and percentage reduction in moisture content has been plotted and are presented in graph.

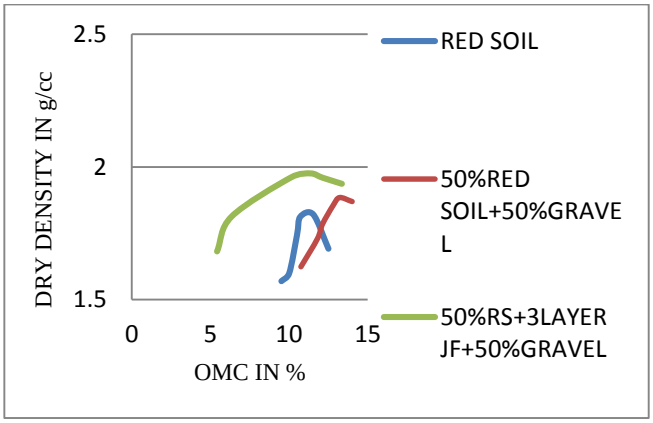

Figure 4. A line graph showing compaction curve for different layer combination.

From the above graph it appears that 50% natural soil is replaced by 50% gravel will provide higher density for smaller OMC value but fails to increase the CBR value of minimum 2% and in addition to the gravel and natural soil the jute fiber mat are placed in three layer will subsequently increase dry density and CBR with minimum OMC.

D. Compaction c of thickness obtained from IRC 37:2001and by analytical approach three layer concept.

Using the information available in article 4.6, and using equation 3.1 and 3.2 the thickness for natural soil and different material combination are worked out and are presented in the table 5.3. Also using the information from table 4.6, using equations 3.4to3.10 the thickness are evaluated for different combination and are presented in table III.

When thickness obtained by CBR method are compared with thickness obtained by three layer approach the percentage of reduction varies from 47.67% for natural soil, natural soil with one layer jute fibre mat, natural soil with two layer jute fibre mat and 50% natural soil and 50% gravel. For natural soil with three layer jute fibre mat the percentage of reduction in thickness is 38.77% and for 50% natural soil and 50% gravel with three layer jute fibre mat the percentage of reduction in thickness is 26.74%. In analytical technique for different combination the overall thickness obtained will be same because vertical, radial stress and strain at first and second interface obtained are within permissible limit not exceeding the stress 0.5MN/m^2 and deformation not exceeding 0.5cm.

TABLE III

SHOWING COMPARISON OF THICKNESS OBTAINED BY IRC-37:2001 AND ANALYTICAL METHOD

NS- Natural soil, LJFM-Layer jute fibre mat

Layer combinations	Over all thickness in (mm)	Percentage of reduction	Over all thickness by analytical approach(mm)	% of reduction
NS	860	No reduction	450	No reduction
NS+ one LJFM	860	No reduction	450	No reduction
NS+ two LJFM	860	No reduction	450	No reduction
NS+ three LJFM	735	14.53	450	No reduction
50%NS+ 50% gravel	860	No reduction	450	No reduction
50%NS+ 50% gravel +three LJFM	630	26.74	450	No reduction

V. CONCLUSIONS

1. When natural soil is reinforced with one layer of jute fiber from the base the CBR value as increased roughly around 38.31% which suggest that adding jute fiber mat there will be improvement in CBR.
2. when layer combination of jute fiber is made two layer both maximum dry density and soaked CBR value as increased .the percentage of increase in density with that of natural soil is 4.06% and that of CBR is 144.93% but it as fail to reach the minimum percentage value of CBR.
3. The percentage increase of natural soil and three layer combination with respect to original soil are 6.26% and 234.35%.the above value crosses the minimum requirement of CBR.to improve CBR of the natural soil economically without jute fiber mat another combination along with natural soil is tried having 50% replacement of natural soil with that of 50% gravel soil.
4. The improvement of increase in maximum dry density and CBR is 3.51% and 115.03% respectively but again failed to attain minimum 2% CBR. Hence for the same combination mentioned in the above three layer jute fiber mat is added and the density and soaked CBR value as increased to 8.455% and 557.20% which is very much appreciable improvement in other words the soaked CBR as crossed 4.285% which is roughly 6.572 times higher than the natural soil.
5. The increase in percentage of natural soil CBR with that of natural soil three layer jute fiber mat may do suggest that the jute fiber mat reinforcement place a vital role in improving the CBR may be due to improving the shearing action of the soil. Further adding jute fiber mat at 3 levels prevent the water intrusion from top of the pavement for surface flow infiltration and rise in water level due to capillary action from the bottom.

6. Here the same thickness for all combination means in case of analytical method vertical, radial stress and strain at first and second interface obtained are within permissible limit not exceeding the stress 0.5mm/m^2 and deformation not exceeding 0.5cm.
7. For all percentage of CBR vertical stress at first interface is more than the vertical stress at the second interface. This means as the thickness is approaching towards subgrade stress is becoming same as that of the soil. At first interface the radial stresses developed are same means there is no shearing action.

VI. REFERENCES

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