

EFFECTIVENESS OF JUTE GEOTEXTILES IN FLEXIBLE PAVEMENT CONSTRUCTION

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ABSTRACT: Jute, the forerunners of the manmade fibers, is used as a soil erosion control in highway side slope protection and reinforcing section of new road on poor subgrade. The effectiveness of the jute geotextiles as subgrade soil reinforcement for a flexible pavement has been investigated in this study. A systematic laboratory investigation has been carried out on the sandy soil sample collected from an Integrated Development Project in Dhaka city. Here, a comparative study is performed for the CBR values of the subgrade soil sample with jute geotextiles and without jute geotextiles. The test results show that the CBR value increases significantly with the application of jute geotextiles in subgrade soil. Further investigation has been carried out by placing jute geotextiles at different layers to find out its influence over soil keeping the same dry densities. It is found that CBR increase ratio is higher when jute geotextiles is placed at the bottom layers i.e. away from the loading point. It is also found that in case of sandy soil, the use of jute geotextiles as subgrade reinforcement is less significant when larger compaction effort has been applied.

Keywords: Flexible Pavement, Jute Geotextiles, Subgrade, CBR, Dry Density

1. INTRODUCTION

In civil engineering, jute and jute products have widespread use for various purposes such as sand bags for concrete curing and protection, soil erosion control, highway side slope protection and reinforcing poor subgrade. The 'subgrade' is the in situ materials upon which the pavement structure is placed. It is typically characterized by its resistance to deformation under load i.e. bearing capacity or strength. Poor subgrade should be avoided since subgrade can often be the overriding factor in pavement performance. One of the methods of improving subgrade is installation of an additional layer above the subgrade which increases its strength. Jute Geotextiles (JGT) is a modern material in Geotechnical Engineering which can be used largely in this aspect.

Jute is eco-compatible and its superior environment friendliness can replace the use of synthetics in pavement construction. It is highly hygroscopic and helps to consolidate soil. However, due to its hydrophilic characteristics, untreated jute cannot be used in saturated environment for more than 6 to 9 months. This biodegradability of jute may be enhanced up to 20 years with different methods of treatment [2]. It has allowed jute products to be termed as 'Jute Geotextiles' (JGT) and opened up avenues to be applied as reinforcement of subgrade soil for flexible pavement construction.

The main focus of this research is to examine the feasibility of using JGT as subgrade soil reinforcement for flexible pavement design through laboratory tests. With this objective, an endeavour is made to test as well as compare the CBR values of soil sample with JGT and without JGT at different

compaction efforts. In addition, comparison among the CBR values of the soil sample using JGT at different layers is also within the purview of the study.

2. METHODOLOGY –CBR TEST

The soil was collected from a newly filled soil deposit on the subgrade of the proposed roadway of 'Hatirjheel Integrated Development Project' of Dhaka City. It was taken from three different spots at a distance of 50m meter apart and from 1 meter depth. Through sieve and hydrometer analyses, it was found that 97.3% of the soil sample consists of sand. The maximum modified proctor dry density was 1528.95 kg/m³ and the optimum moisture content was 15.15%.

For both uncompact and compact soil sample, three moulds of three layers each were prepared (Fig 1). Mould diameter was 6 inch, material passing 19.0 mm sieve. One of the moulds was prepared for the soil without JGT. The other two were with JGT where it was placed at two different layers, above and below 2nd layer. The moulds were prepared in accordance with the procedures given in test methods D698. Blows used per layer for compaction were 25 and 35. The uncompact soil sample was taken in oven dry condition and the test was performed in unsoaked condition. Conversely, the compact soil sample was allowed to take on water for 96 hours by soaking. Each specimen was then subjected to penetration by a cylindrical rod. Results of stress (load) vs. penetration depth were plotted to determine the CBR for each specimen. The stress required to penetrate 2.54mm was divided by 6.9 MPa and the load required to penetrate 5.08mm was divided by 10.3MPa to obtain the CBR value in terms of

percentage. The value corresponding 2.54mm penetration gives the CBR value. In any case if the CBR value corresponding 5.08mm penetration is greater, then the test was repeated and the higher value was considered as the CBR value (ASTM 1883-87).

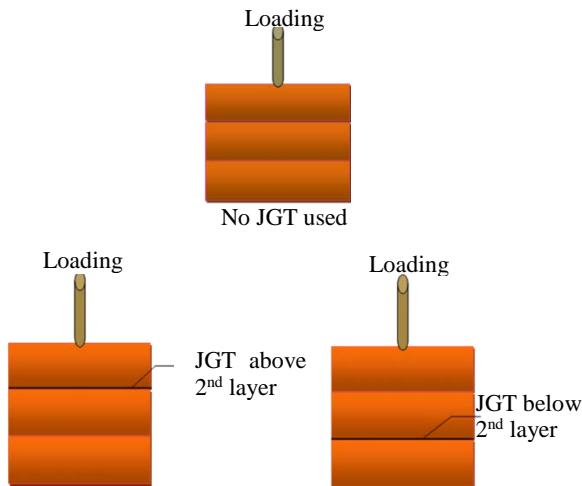


Fig. 1 Layers of soil and JGT in the moulds.

3. COMPARISON OF CBR VALUES AT VARIOUS JGT REINFORCEMENT CONDITIONS

3.1 Samples without JGT

Three samples of optimum moisture content, 15.15%, were prepared as follows:

- Mould#1: 3 layers without JGT reinforcement.
- Mould#2: 3 layers, reinforced with JGT above 2nd layer.
- Mould#3: 3 layers, reinforced with JGT below 2nd layer.

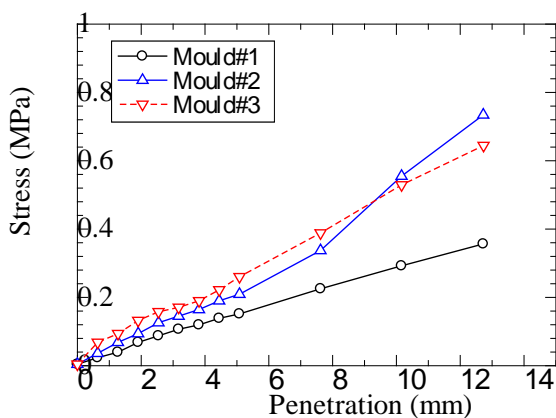


Fig. 2 Load-penetration curves for moulds 1 to 3.

Fig. 2 shows load-penetration curves for moulds number 1 to 3 without compaction. From the curves CBR values are calculated that are listed in Table 1.

Fig. 3 represents the relation of dry density with CBR for this condition. It is seen that CBR value increases with increasing dry density due to the application of JGT as a reinforced materials.

Table 1 CBR value of the sample at different dry densities and reinforcement conditions

Dry Density (kg/m ³)	Stress at 2.54 mm	Bearing ratio	Stress at 5.08 mm	Bearing Ratio	CBR
1290.5	0.087	1.27	0.151	1.47	1.27
1293.5	0.126	1.82	0.209	2.03	1.82
1295	0.158	2.29	0.261	2.52	2.29

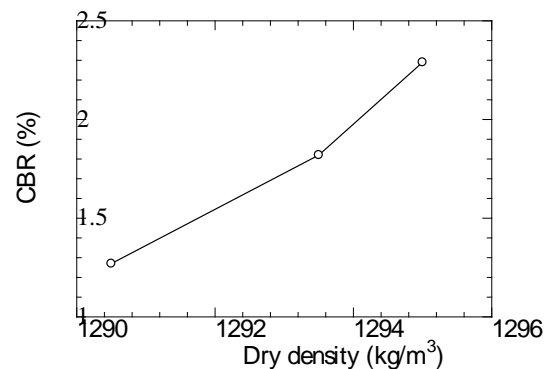


Fig. 3 Dry Density-CBR curve for Moulds#1-3

3.2 Samples with JGT with 25 blows

Three samples of optimum moisture content, 15.15%, were prepared as follows:

- Mould#4: Compacted in 3 layers by 25 blows of a 5.5 lbs hammer, not reinforced with JGT.
- Mould#5: Compacted in 3 layers by 25 blows of a 5.5 lbs hammer, reinforced with JGT above 2nd layer.
- Mould#6: Compacted in 3 layers by 25 blows of a 5.5 lbs hammer, reinforced with JGT below 2nd layer.

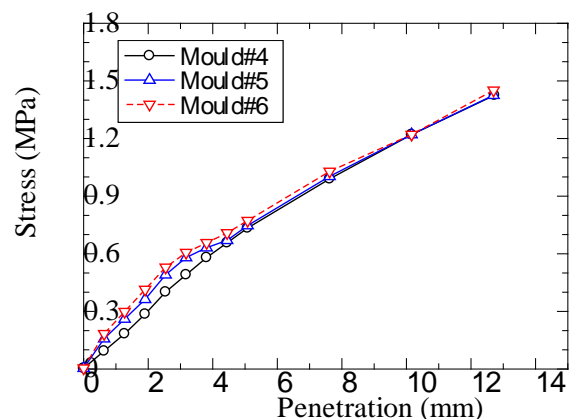


Fig. 4 Load-penetration curves for moulds 4 to 6

Fig. 4 shows load-penetration curves for moulds number 4 to 6 where samples are compacted by 25 blows. From the curves CBR values are calculated that are listed in Table 2. Fig. 5 represents the relation of dry density with CBR for this condition. It is seen that CBR value significantly increases with increasing dry density due to the application of JGT as a reinforced materials the same way as the conditions without compaction.

Table 2 CBR value of soil sample at different dry densities and reinforcement conditions

Dry Density (Kg/m ³)	Stress at 2.54m	Bearing Ratio	Stress at 5.08m	Bearing Ratio	CBR
1461.9	0.439	6.374	0.836	8.12	8.12
1471.3	0.581	8.415	0.875	8.49	8.49
1473.5	0.618	8.973	0.901	8.74	8.97

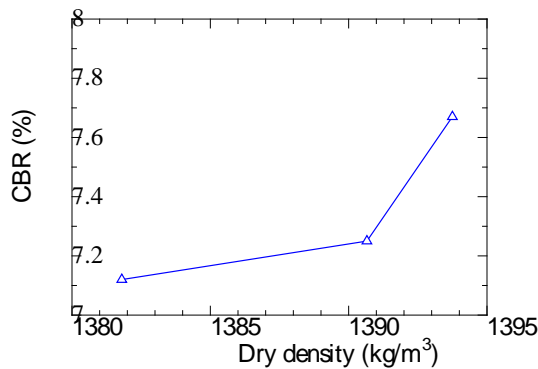


Fig. 5 Dry Density-CBR curve for Moulds#4-6

3.3 Samples with JGT with 35 blows

Three samples of optimum moisture content, 15.15%, were prepared as follows:

- Mould#7: Compacted in 3 layers by 35 blows of a 5.5 lbs hammer, not reinforced with JGT.
- Mould#8: Compacted in 3 layers by 35 blows of a 5.5 lbs hammer, reinforced with JGT above 2nd layer.
- Mould#9: Compacted in 3 layers by 35 blows of a 5.5 lbs hammer, reinforced with JGT below 2nd layer.

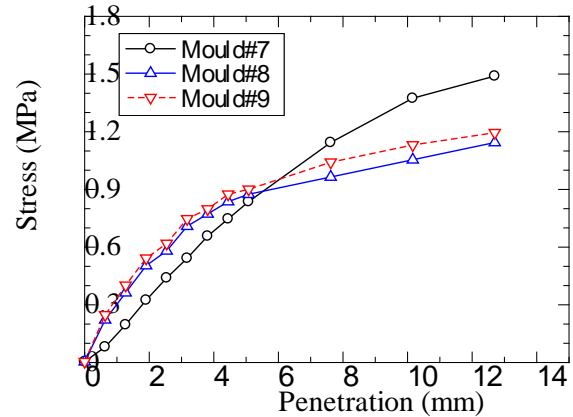


Fig. 6 Load-penetration curves for moulds 7 to 9

Fig. 6 shows load-penetration curves for moulds number 7 to 9 where samples are compacted by 35 blows. From the curves CBR values are calculated that are listed in Table 3. Fig. 7 represents the relation of dry density with CBR for this condition. It is seen that CBR value significantly increases with increasing dry density due to the application of JGT as a reinforced materials the same way as the conditions without compaction and compacted samples with 25 blows.

Table 3 CBR value of soil sample at different dry densities and reinforcement conditions

Dry Density (Kg/m ³)	Stress At 2.54 mm	Bearing Ratio	Stress At 5.08 mm	Bearing Ratio	CBR
1381.8	0.401	5.81	0.732	7.12	7.12
1390.66	0.490	7.11	0.741	7.25	7.25
1393.75	0.529	7.67	0.773	7.50	7.67

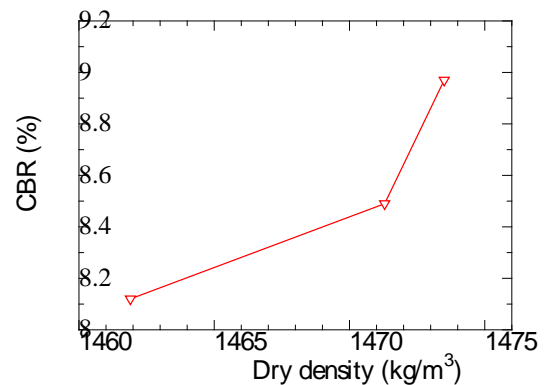


Fig. 7 Dry Density-CBR curve for Moulds#7-9

4. COMPARISON OF CBR VALUE OF SOIL MASS AT SAME COMPACTION EFFORT

From the results of analysis, it is worth speculation that in the range of similar compaction

efforts, the growth of CBR value has followed a definite path. The potential strength has been found to have increased gradually from no reinforcement, through reinforcement at upper layers to reinforcement at lower layers until a considerable level of bearing capacity is attained. On attaining such a level of bearing capacity, the soil mass has gained such strength as sufficient to prevent any deformation. However, the investigations were carried out using a soil sample which is sandy, should also be kept in mind for any further research.

Table 4 Comparison of CBR value at same compaction effort in different conditions

Compaction Effort	CBR Value (%)			Increase Ratio	
	Without JGT	JGT above 2nd layer	JGT below 2nd layer	JGT above 2nd layer	JGT below 2nd layer
No compaction	1.27	1.82	2.29	1.43	1.80
25 Blow	7.13	7.25	7.67	1.01	1.07
35 Blow	8.12	8.49	8.97	1.04	1.10

Table 5 Comparison of CBR value at same compaction effort in different reinforcement conditions

Compaction effort	CBR Value (%)		
	Without JGT	JGT above 2nd layer	JGT below 2nd layer
No compaction	1.27	1.82	2.29
25 Blow	7.13	7.25	7.67
35 Blow	8.12	8.49	8.97

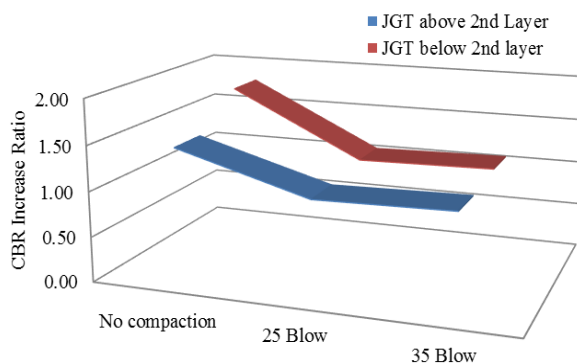


Fig. 9 Trend of CBR increment with increase of compaction effort

4.1 Trend of CBR Increase Ratio

The CBR Increase Ratio is given by the following equation (Eq.1).

$$\text{CBR Increase Ratio} = \frac{\text{CBR (\%)} \text{ with JGT}}{\text{CBR (\%)} \text{ without JGT}} \quad (1)$$

The increase ratio has decreased with increment in compaction effort in most cases in the study. Although there were a few deviations, the general trend of increase ratio confirms the deduction.

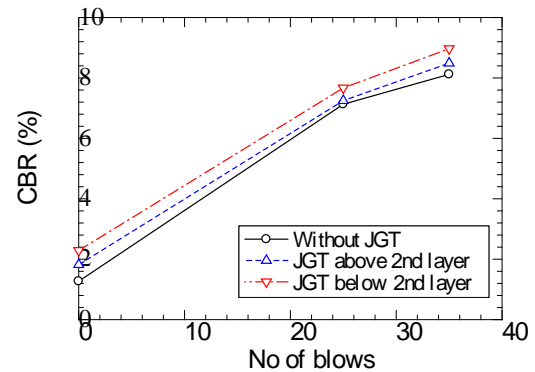


Fig. 8 Comparison of CBR in different compactions

5. CONCLUSION

A series of CBR tests were performed on sandy soil with and without JGT at the laboratory in order to study the effect of JGT on CBR values of soil samples. The CBR value of the soil with JGT is always found to be higher than that of without JGT at all corresponding dry densities. It is also found that at higher dry densities where larger compaction effort has been used, the rate of increment of CBR value decreases. The CBR increase ratio at an average is approximately 1.4.

Based on the experimental results, JGT at different layers of soil sample, it is found that CBR increment rate of subgrade soil is slightly higher when the JGT is used at bottom layers than using it in upper layers. The increment of CBR value is significant when the layer of JGT is away from the loading point. The CBR increase ratio is 1.23 when JGT is used above 2nd layer. At the same time the increase ratio is 1.38 when JGT is below 2nd layer. It can be illustrated that ensuring adequate long term durability through existing appropriate treatments jute geotextiles can be envisaged as a potential material for subgrade soil reinforcement applications.

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