INFLUENCE OF GEOFABRICS IN THE CONSTRUCTION OF PAVEMENTS ON EXPANSIVE CLAYEY SUBGRADES

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ABSTRACT
Design and construction of pavements on weak soils pose lot of problems due to its low load carrying capacity. Roads cause rut formation due to the high axle loads of vehicle on expansive clayey subgrades. There are many techniques to modify the properties of such soils. Among them, soil reinforcement with geofabrics is more promising in improving the load carrying capacity of expansive subgrades. In this paper, emphasis is given to investigate the feasibility of using abundantly available indigenous resources, coir and jute in road construction. In addition to the above mentioned natural fabrics, geogrid, a synthetic material is also considered. The influence of varied number of reinforcing layers on CBR values is investigated. CBR method is employed for the design of flexible pavements in most of the design offices even though it is empirical in nature, since the method is simple and convenient to apply and the CBR value of the subgrade indirectly gives the strength of subgrade soil. The results are analyzed effectively by introducing two non-dimensional factors namely, Effective Depth Ratio (EDR) and Strength Benefit Ratio (SBR). It is found that both CBR and SBR values increases with increase in number of reinforcing layers. Based on the favorable results obtained, it can be concluded that expansive soil can be successfully stabilized using geofabrics.

KEYWORDS: *California Bearing Ratio, Effective Depth Ratio and Strength Benefit Ratio, Geofabrics, Expansive clay*

I. INTRODUCTION

Design and construction of roads on expansive soils is a difficult task because of its low load carrying capacity, high compressibility, high swelling and shrinkage. In United States, damage caused by expansive clays exceeds the combined average annual damage from floods, hurricanes, earthquakes, and tornadoes [1]. Documented evidence of the problems associated with expansive clays is worldwide, which occurred in countries like United States, China, Australia, India, Canada, and regions in Europe [2]. Changes in the moisture content of clay soils are generally accompanied by volume changes. On moisture uptake, there is generally volume increase and moisture loss is accompanied by shrinkage [3]. The properties of these soils can be improved by stabilization with admixtures and geofabrics. But, in stabilization using admixtures technique, it is necessary to select proper stabilizer and it is very difficult to stabilize huge quantity of soil in the field. With the advent of synthetic fibres, soil reinforcement is found to be dynamic in improving load bearing capacity of soft soils. The geofabric reinforcement system prevents the failure of the pavement due to penetration of road crust into subgrade soil or intrusion of soft subgrade soils into base course and inadequate drainage of subbase and base course by acting as separator as well as drainer within the pavement apart from reinforcing function. The geofabrics include synthetic fibres like geogrid and natural fibres like jute and coir. The thickness of the pavement is inversely proportional to the California Bearing Ratio (CBR) of a subgrade. The increase in CBR with the introduction of geofabrics results in reduction in pavement thickness and it is obvious that increase in number of layers will yield higher CBR values which results in further reduction in pavement thickness. But, with increase in number of layers, the ultimate cost of the pavement will go up and hence the experimentation is carried out by restricting the number of layers to four only. The effect of reinforcing layers on the CBR values of the subgrade soil is studied herein.

II. MATERIALS AND METHODS

Soil

The soil used in this study was obtained from Gajulamandyam near Tirupati. Disturbed but representative soil samples were collected from trial pits at a depth of about 2.0 m from ground level. The soil collected from the site was pulverized with wooden mallet to break lumps and then air-dried. Subsequently it was sieved through 2.36 mm IS sieve and then dried in an oven at 105°C for 24 hours .The soil falls under the CH category i.e., clay of high compressibility as per I.S Classification System [4]. The soil passing through I.S 425μ sieve has very high Liquid Limit and Plasticity Index. Based on Differential Free Swell Index, Liquid Limit and Plasticity Index, the soil comes under the category of high degree of expansiveness. The properties of soil are presented in Table 1.

Coir

The coir fabric is obtained from door mats which are uniformly woven. Coir fabrics of 15 cm diameter circular pieces were used for the present study.

Jute

Jute is prepared from jute bags like sugar bags, rice bags etc, of 1.5 mm thick. 15cm diameter circular pieces are cut from the jute bag. A jute geofabric of 3mm thick is prepared by joining two pieces of jute bag.

Geogrid

Geogrid used in this study is a product of Netlon. This is immune to corrosive, chemical and biological attack in soils. Geogrid of 15 cm diameter circular pieces were used for the present study.

Table 1 Properties of Soil

CHARACTERISTICS	VALUE
Specific gravity	2.69
Particle Size distribution a) Gravel (%) b) Sand (%) c) Silt+Clay (%)	 Nil 12 88
Liquid limit (%)	98
Plastic limit (%)	13
Plasticity index (%)	85
Differential Free Swell Index (%)	150
Classification of soil	CH
Maximum dry unit weight (kN/m^3)	17.99
Optimum moisture content (%)	14
Unconfined Compressive Strength (kN/ m^2)	145
Unsoaked CBR (%)	6.84

III. TESTS CONDUCTED ON UNREINFORCED SOIL

The compaction tests, unconfined compression tests and CBR tests on unreinforced soil were conducted in accordance with Indian standard codes [5, 6 and 7].

IV. TESTS CONDUCTED ON REINFORCED SOIL

The main emphasis in the present study is the influence of geofabrics on CBR values of expansive clays, since the thickness of pavement depends on CBR value. The thickness of the pavement is inversely proportional to the CBR of a subgrade. To achieve positive contribution of geofabric has to be placed at optimum depth below the surface of weak subgrade [8]. The increase in CBR with the introduction of geofabrics results in pavement thickness and it is obvious that increase in number of layers will yield higher CBR values which results in further reduction in pavement thickness. The effect of reinforcing layers on the CBR values of the subgrade soil is studied herein. The reinforcing materials employed are coir, jute and geogrid. The tests have been carried out for studying layer effect. The numbers of layers selected are one, two, three and four. The locations of fabrics for one layer is H/6, two layers are top and H/6, for three layers at top, H/6 and 2H/6, for four layers at top, H/6, 2H/6 and 3H/6. All the tests have been conducted for unsoaked condition since the studies on soaked and unsoaked soil specimens indicated that the percentage improvement of reinforced system remain almost same irrespective of soaking of the specimen.

V. RESULTS AND DISCUSSION

The results are analyzed effectively by introducing two non-dimensional factors namely, Effective Depth Ratio (EDR) and Strength Benefit Ratio (SBR). The Strength Benefit Ratio (SBR) is defined as the per cent increase in CBR value of soil due to the presence of reinforcement when compared to the CBR value of unreinforced soil.

$$\text{SBR} = \frac{\text{CBR}_{(\text{Reinforced})} - \text{CBR}_{(\text{Unreinforced})}}{\text{CBR}_{(\text{Unreinforced})}} \text{ X } 100$$

The Effective Depth Ratio (EDR) is defined as the ratio of depth of reinforcing layer from the top to total height of soil specimen.

$$\text{EDR} = \frac{\text{Depth of reinforcing layer from the top}}{\text{Total height of soil specimen}}$$

Figures 1, 2 and 3 represent load-penetration curves of the soil for single, two, three and four layers with coir, jute and geogrid respectively. The load- penetration curve of unreinforced soil is also shown in each of these figures. The CBR vales are presented in Table 2 for varied number of reinforcing layers with different geofabrics. Table 3 gives the SBR values obtained with different geofabrics for varied number of reinforcing layers for geofabrics like coir, jute and geogrid. Fig. 4 represents the variation of SBR values with number of reinforcing layers for geofabrics like coir, jute and geogrid. The above tables and figures show that both CBR and SBR are increasing with increase in number of reinforcing layers. It is inferred that coir is more effective than jute. The reason is that coir has more tensile strength and friction than jute. The solid structure of the coir fabric resulting in higher tensile strength contributes to the observed behaviour. The jute has fibrous structure of low tensile strength. It is also observed that geogrid results in less CBR values when compared to natural fabrics even though the geogrid has six to seven times more tensile strength natural fabrics. But, to develop full tensile stress within the geogrid, it should interlock with the aggregates. Otherwise, it will slip due to its smooth nature resulting in low CBR value.

It is quite obvious that much tensile stress will mobilize as more number of layers intercepts the effective pressure bulb. It is also observed that the rate of CBR value is high from one layer to two layers in case of natural fabrics such as coir and jute, whereas the rate of increase in CBR value is high from three to four layers in case of synthetic fabric i.e., geogrid. It is due to the presence of one of the layers at depth of H/6 from the top. Four layers proved to be more effective in improving the CBR values of the soil irrespective of type of fabric, as per this study. The maximum SBR i.e., at four layers for the soil with coir, jute and geogrid are of the order of 126.61%, 98.9% and 73.95% respectively.

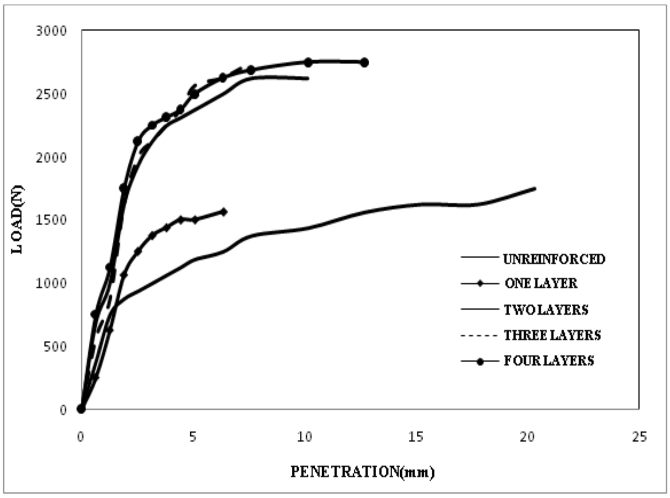

Figure 1 Load Vs penetration curves of soil reinforced with coir for varied number of reinforcing layers

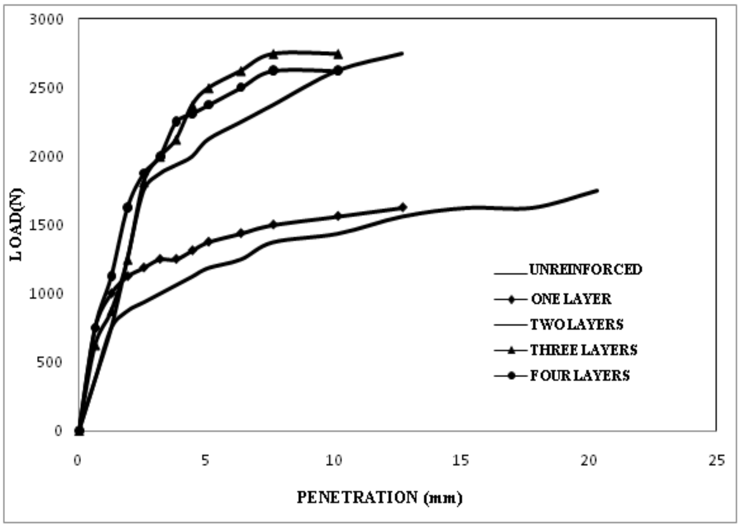

Figure 2 Load Vs penetration curves of soil reinforced with jute for varied number of reinforcing layers

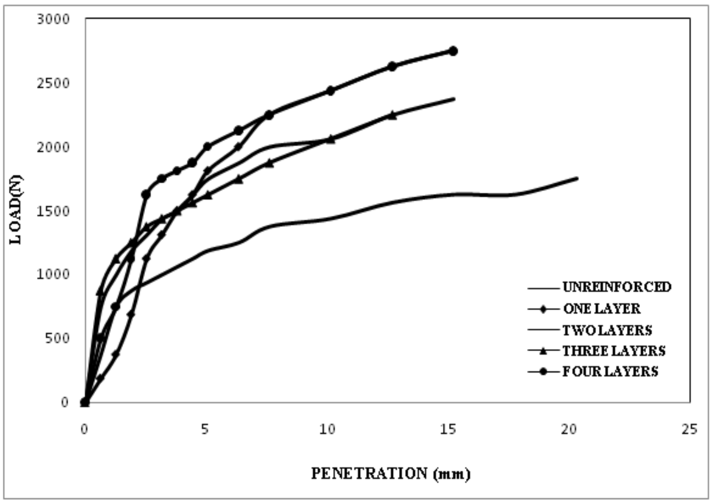

Figure 3 Load Vs penetration curves of soil reinforced with geogrid for varied number of reinforcing layers

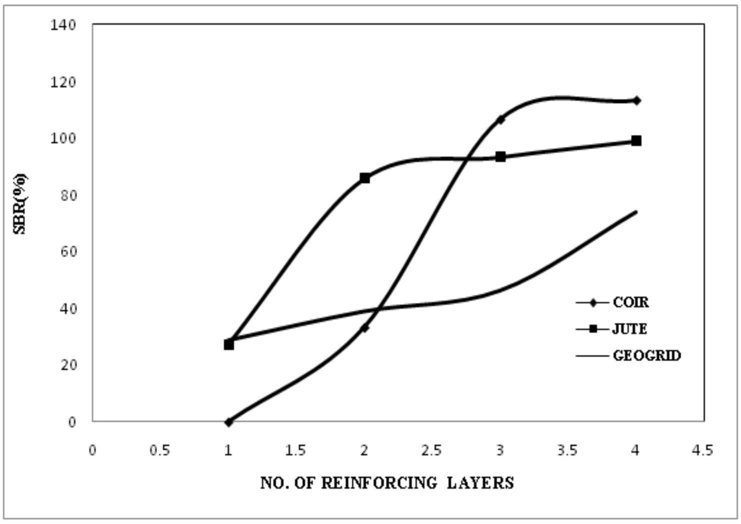

Figure 4 SBR(%) values for geofabrics with number of reinforcing layers

Table 2 CBR Values (%) for variation of reinforcing layers

Type of geofabric	CBR without geofabric	Geofabric at			
		One layer	Two layers	Three layers	Four layers
COIR	6.84	9.12	14.14	14.6	15.5
JUTE	6.84	8.7	12.7	13.22	13.7
GEOGRID	6.84	8.8	9.5	10	11.86

Table 3 SBR Values (%) for variation of reinforcing layers

Type of geofabric	Geofabric at			
	One layer	**Two layers**	**Three layers**	**Four layers**
COIR	33.33	106.73	113.45	126.61
JUTE	27.19	85.67	93.27	98.9
GEOGRID	28.65	38.88	46.2	73.95

VI. CONCLUSIONS

1. The CBR value increases with increase in number of reinforcing layers due to mobilization of more tensile strength as more number of layers intercept the effective pressure bulb.
2. The rate of increase in CBR value is high from one layer to two layers in case of natural fabrics such as coir and jute, whereas the rate of increase in CBR value is high from three to four layers in case of synthetic fabric i.e., geogrid.
3. The maximum SBR at four layers for soil with coir, jute and geogrid are of the order of 127%, 99% and 74% respectively.
4. The coir is more effective than jute in reinforcing action due to the fact that the coir has more tensile strength, friction and stiffness than jute.
5. Geogrid has less CBR value than natural fabrics in the conventional CBR test procedure.
6. For complete mobilization of tensile stress within the geogrid, it should interlock with aggregate. Hence, the conventional CBR test procedure should be modified by replacing the surcharge weight with the compacted aggregate with geogrid at zero EDR.
7. Geofabrics are more suitable for low load bearing soft soils. This may be due to the presence of higher percentages of clay fraction in soft soils which is responsible for greater mobilization of tensile strength.

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