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GEOTEXTILE REINFORCED TWO LAYER SOIL SYSTEM WITH KUTTANAD CLAY OVERLAIN BY LATERITE SOIL

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Abstract – *The use of geosynthetic for flexible pavement found on expansive soil subgrade is feasible and economic solution to minimize the pavement thickness. In the present study effect of inclusion of coir geotextile on California Bearing Ratio value of two layered soil system with kuttanad clay at bottom and laterite soil on top with different thickness configuration and geotextile on zig sag manner was studied by Dynamic Cone Penetration test (DCPT) on field. Thickness of pavement over two layered soil system with and without geotextile are evaluated by method suggested by Indian Road Congress (IRC). The reduction in thickness of pavement is achieved up to 18% depending upon the thickness configuration and type of geotextile used.*

***Key Words*: Soil reinforcement, Coir geotextile, California Bearing Ratio. Dynamic cone penetration.**

1. INTRODUCTION

Geosynthetics is the term of recent origin which includes materials that are used in addition with soil to improve its performance. Natural fibres can be used in many applications, its properties such as ability to absorb water and their biodegradability with time gives an edge over synthetic geotextiles. Due to their flexibility effect it allows them to conform closely to the terrain condition.

Kuttanad which is located in Alappuzha district of Kerala. It is an agricultural area and clay in this region is dark grey in colour in which kaolinite and illite are present. Clay in this region is characterized by its high compressibility and low shear strength. The low bearing capacity of this soil may lead to the foundation or embankment failures.

Reinforcement techniques is considered as an effective ground improvement method because of cost effectiveness, easy adaptability and reproducibility. The fibre selected for this method is not hazardous to the environment and it should be easily available and less expensive. Dynamic Cone Penetration test on field were conducted to investigate the effect of coir geosynthetic reinforcement on California Bearing Ratio value of two layered soil system with geotextile of zig sag arrangment. Thickness of soil layer over two layered soil system of different thickness configuration was estimated for unreinforced and reinforced two layered soil system using design charts developed by Indian Road Congress (IRC).

2. LITERATURE REVIEW

Vishwas N. Khatri et al., (2017) [1] study the bearing capacity of foundation with inclusion of dense sand layer over loose strata. Lower and upper bound finite element limit analysis in conjunction with second order conic programming was used in present study. Analysis is based on Mohr-Coulomb criterion and flow curve. Results are expressed in terms of efficiency factor.

Sushovan Dutta et al., (2016) [6] conducted model study on geocell reinforced fly ash bed overlying soft clay. Here the test beds were subjected to square rigid steel plate loading as footing. Series of test where conducted to study the effect of height and width of geocell mattress on the performance of the system in terms of pressure and settlement.

Vishwas N Khatri et al., (2015) [8] studied the shear strength behavior of clay reinforced with treated coir geotextile. The coir geotextile was treated with NaOH and CCl_4 solution. Compaction and triaxial test of reinforced clay with different percentage of coir and different deviated stress are evaluated.

Hedge et al., (2014) [10] study the use of bamboo in soft ground engineering and its performance comparison with geosynthetics. Laboratory investigation is carried out on clay bed reinforced with natural bamboo and commercial reinforcement material. Three dimensional cells and two dimensional grids are prepared using bamboo.

Neenu M. B (2016) [7] study the compaction characteristics and stress- strain behaviour of kuttanad clay stabilized with rice husk ash and lime. Physical property of rice husk ash and properties of kuttanad clay is found out. Proctor compaction, unconsolidated undrained triaxial test without pore water measurement are evaluated with varying percentages of rice husk ash and lime.

Kuo- HsinYang et al., (2016) [4] studied the behavior of geotextile reinforced clay with coarse material sandwich technique under unconsolidated undrained triaxial compression. Conducted series of UU triaxial test with different confining pressures and thickness of the sand layer. Results shows that shear strength increases with increase in geotextile layer.

M. Deivanai et al., (2015) [9] studied the effect of natural fibre on soil subgrade. In this study four type of natural fibre (coir, jute, bamboo, sisal fibre) with different percentages and evaluated by soaked and un-soaked California bearing ratio tests. Proctor compaction, UCS tests, CBR test where conducted with locally available soil which are reinforced with these natural fibres for strengthening the subgrade for pavement design. Series of laboratory CBR test where conducted on reinforced and unreinforced soaked and un-soaked samples which are compacted at optimum moisture content and maximum dry density.

Dilip Kumar Talukdar (2014) [11] study the correlation between California bearing ratio value with other properties of soil. Sixteen number of samples were collected and particle size, consistency limits, compaction property and CBR value of the samples were calculated. Graphical analysis of soil property is done by the relation of CBR value with respect to the plasticity index, effect of maximum dry density and the effect of optimum moisture content. Compare the laboratory CBR value with CBR value obtained from mathematical computation.

Singh and Mittal (2014) [12] conducted experimental study on clay mixed with different percentage of coir fibre. California bearing ratio and unconfined compressive strength test were conducted in which the soil specimens are prepared using optimum moisture content and maximum dry density. Soaked CBR and UCS test is done on laboratory by using the percentage of fibre as 0.25%, 0.5%, 0.75%, 1%.

Summary of reviews;

Above literature reviews indicate that geotextile of various forms are used for increasing the strength of the soil layer. However investigation on two layer soil system with clay at bottom and laterite soil at top as a buffer layer, reinforced with geotextile in zig-sag way using Dynamic cone penetration test at field is not found on any literatures. So present study is to evaluate the properties of two layered soil system with geotextile in zig-sag arrangement.

3. MATERIALS

3.1. Clay

Soil used in the present study is collected from Kumaramkary, Kuttanad, in Alappuzha district. Samples are collected at a depth of 1m from the surface. Samples are collected and preserved in polythene bags and air dried before starting the experiments. The index and engineering properties of clay and laterite is evaluated using IS code methods. Properties of clay samples are given in table 1.

3.2. Laterite soil

Laterite soil is collected from local area in Kottayam district.. The index and engineering properties of laterite is evaluated using IS code methods. Properties are given in table 2.

3.3. Coir Geotextile

Natural fibres are extensively used for the eco-friendly behavior. Coconut fibre can give strength along with elasticity. Coir fibre is hardest natural fibre available because of its high lignin content. Coir fibre is collected from coir-fed Alappuzha.

Table -1: Properties of collected clay sample.

Properties	Values
Specific gravity	2.3
Percentage of clay	52
Percentage of sand	38
Percentage of silt	10
Liquid limit	64%
Plastic limit	47%
Shrinkage limit	6%
Plasticity index	17%
Toughness index	11%
Maximum dry density	1.45g/cc
Optimum moisture content	30%
California Bearing Ratio	2.01%
Unconfined compressive strength(kPa)	6.73

Table -2: Properties of collected laterite sample.

Properties	Values
Specific gravity	2.5
Percentage of clay	4
Percentage of sand	93
Percentage of gravel	3
Liquid limit	52%
Plastic limit	35%
Shrinkage limit	10%
Plasticity index	17%
Toughness index	11%
Maximum dry density	1.84g/cc
Optimum moisture content	19%
California Bearing Ratio	5.8%

Table -3: Properties of collected coir geotextile.

Properties	Values
Mass per unit area (g/m^2)	250
Thickness (mm)	8
Colour	Brown

4. METHODOLOGY

4.1. Dynamic Cone Penetration Test

Dynamic cone penetration test is a quick, simple, low cost test which is extensively used to measure the strength of compacted material with reasonable accuracy. Basic principle involved is measuring the resistance offered by pavement layers to penetration of standard cone with diameter 20mm driven by an 8kg hammer freely falling through height of 575mm. Amount of penetration of cone is generally reported in terms of average penetration per blow $DCPI_{60}$(mm/blow). Here DCPT is done on field by making a circular pit of diameter 1m and a depth of 2m. Holes are excavated manually and samples are filled depending on thickness configuration.

Table -4: Selected Mixes

Mix 1	Thickness configuration for A
Mix 2	Thickness configuration for B
Mix 3	Thickness configuration for C

The thickness configurations of soil layers is shown below.

Where,

Soil (P) = laterite soil

Soil (Q) = clay sample,

A, B, C are the thickness configurations

T= total thickness (2m)

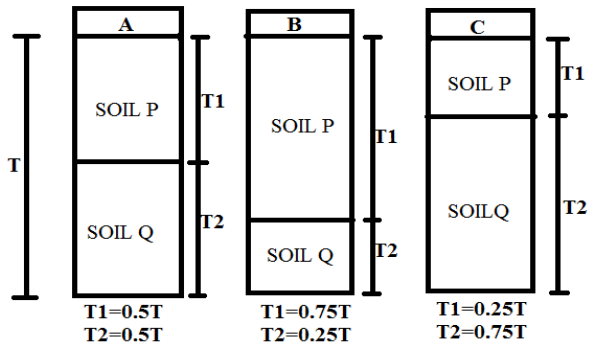

Fig 1: Thickness configuration of soil in CBR mould

5. RESULTS AND DISCUSSIONS

Effect of coir geotextile on two layered soil system by Dynamic cone penetration test was shown below;

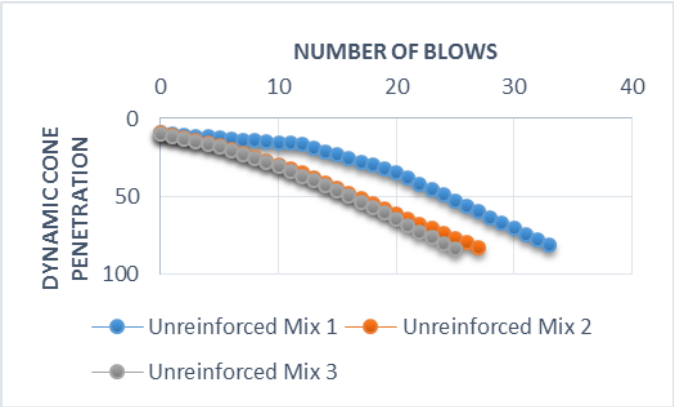

Chart 1: Variation of CBR value with number of blows without geotextile

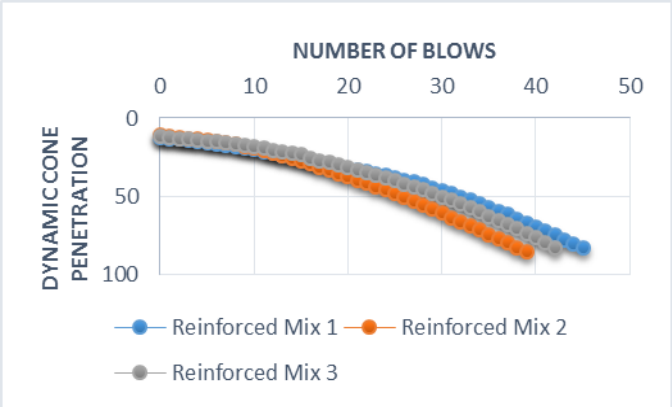

Chart 2: Variation of CBR value with number of blows with geotextile

From charts it can be observed that for reinforced and unreinforced soil system CBR is highest for thickness configuration B due to the combined effect of soil layers and the membrane effect of geotextile used.

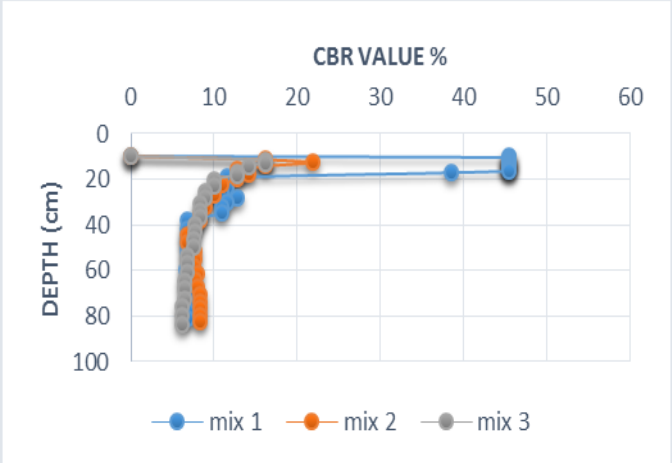

Chart 3: Variation of CBR value and depth by without geotextile

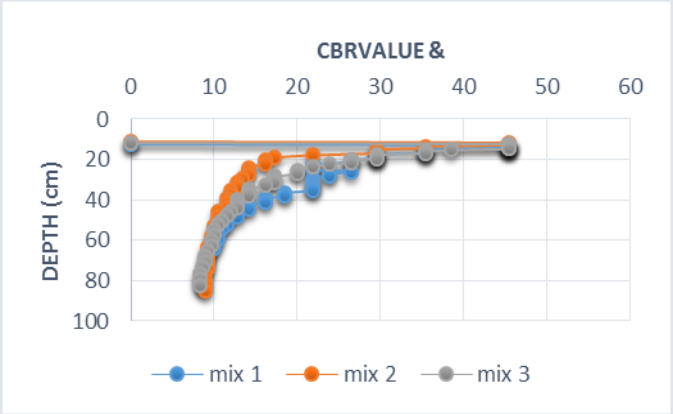

Chart 4: Variation of CBR value and depth by with geotextile

Table -5: Ratio of field California bearing ratio of reinforced soil to that of unreinforced soil.

SOIL SYSTEM	(CBR) r/ (CBR) ur
A	1.55
B	1.62
C	1.49

Where, r= reinforced soil layer, ur= unreinforced soil layer

6. FLEXIBLE PAVEMENT DESIGN

Design of pavement done by Indian Road Congress (IRC) method, first soaked CBR value of soil C(%) is determined in laboratory. Then appropriate design curve is chosen for design chart, depending on wheel load and traffic. CBR test should performed on remoulded soils in laboratory. Specimens are prepared by static compaction at desired density or by dynamic compaction.

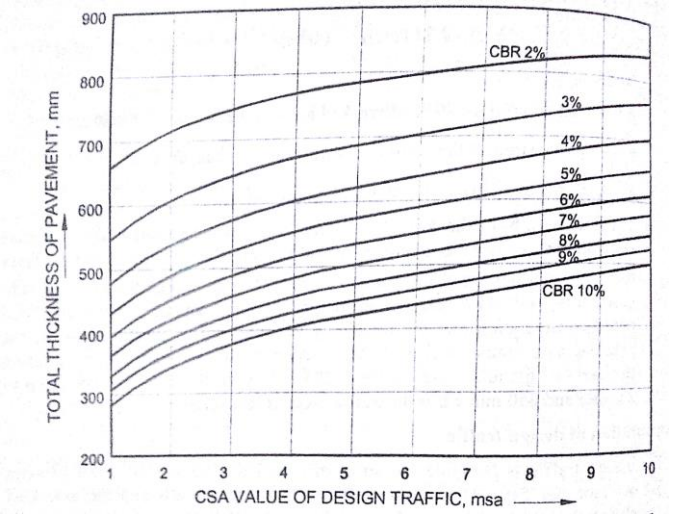

Chart 5: CBR design chart for determination of total pavement thickness for traffic with CSA 1 to 10 msa

The design chart is useful to design flexible pavement roads with low to moderate flow of heavy vehicles for design CSA (cumulative standard axle) values of 1 to 10 msa. CSA values are plotted in X axis thickness on Y axis and total pavement. CBR design chart is given above;

Table -6: Thickness of pavement for field CBR values by CBR design chart without geotextile.

Thickness configuration	Thickness of granular layer required over two layered soil
A	440mm
B	380mm
C	480mm

Table -7: Thickness of pavement for field CBR values by CBR design chart with geotextile.

Thickness configuration	Thickness of granular layer required over two layered soil
A	390mm
B	360mm
C	380mm

7. CONCLUSIONS

Based on the test results and their analysis the following conclusions are drawn;

- California bearing ratio of two layered system is increased due to the addition of coir geotextile at the soil layers.
- Improvement in CBR value is a function of thickness configuration of soil layers and tensile strength of geotextile.
- In field analysis CBR is highest for thickness configuration B due to the membrane effect of geotextile and soil layers. For unreinforced sample CBR is 8.49% and it increased 9.13% for reinforced soil layer.
- Mix 2 gives better results in dynamic cone penetration on field.
- Based on IRC method of design of flexible pavement the reduction in thickness of pavement is highest for thickness configuration B and is least in thickness configuration C.
- The highest reduction in thickness is 18% for thickness configuration B for field CBR value.

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