International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 11, November-2014

Stability Analysis of Kuttanad Clay Reinforced with PET Bottle Strips

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***Abstract*—Kuttanad clay spread over the Kuttanad region in the state of Kerala, India. These clays are characterized by high compressibility, low shear strength and high percentage of organic matter, which are unfavorable from the geotechnical point of view. Reinforced earth technique is considered as an effective ground improvement technique because of its cost effectiveness, easy adaptability and reproducibility. In this context, a detailed study is undertaken to study the effect of using waste plastic bottle (PET bottle) strips/chips as a reinforcement material in kuttanad clay. To study the effect of stabilization, on load- settlement properties of Kuttanad clay, analysis of foundation is done using PLAXIS software.**

Keywords—PET; Stabilization.

I. INTRODUCTION

Kuttanad clays are dark brown colored medium sensitive alluvial deposits spread over the Kuttanad region in the state of Kerala in India. This area lies 0.6-2.2 m below mean sea level and a major portion of the region is in submerged condition during the monsoon season in every year. These clays are characterized by high compressibility, low shear strength and high percentage of organic matter, which are unfavorable from the geotechnical point of view. A large number of embankment failures and foundation failures have been reported in this soil due to its poor shear strength and compressibility characteristics. Reinforced earth technique is considered as an effective ground improvement method because of its cost effectiveness, easy adaptability and reproducibility. Fibre selected must not be hazardous to the environment, and it should be easily available and less expensive.

The bottled water is the fastest growing beverage industry in the world. Recycling plastic wastes formed due to use of water bottles has become one of the challenges worldwide. The use of plastic waste in engineering applications reduces the problem of disposal of this non-biodegradable waste in the most environmental friendly way and it can be converted into a resource.

In this context, a detailed study is undertaken to evaluate the effect of using waste plastic bottle (PET bottle) strips/chips as a reinforcement material in kuttanad clay. To study the effect of stabilization, on load- settlement properties of Kuttanad clay, analysis of foundation is to be done using PLAXIS software.

II. MATERIALS

A. Reinforcement

For the present study, plastic strips were obtained from PET water bottles. The strips were cut into pieces of length 25 mm having average width 10mm. Strips are randomly mixed with soil in varying percentages (0, 0.25, 0.5, 0.6, 0.75, and 1) by dry weight of soil.

B. Soil

In this study, Kuttanad clay collected from Nedumudy, Alappuzha district, Kerala, India is used. Samples were collected from a depth of 1m from the surface. The properties of soil were determined by standard test procedures and tabulated as per provision of IS codes of practice. The properties of kuttanad clay are given in Table I.

TABLE I. PROPERTIES OF KUTTANAD CLAY

SL NO	Property	Value
1	Specific gravity	2.56
2	Particle size distribution	
	Sand (%)	11.57
	Clay (%)	21
	Silt (%)	67.43
3	Atterberg's Limits	
	Liquid Limit (w_L)	171 %
	Plastic Limit (w_p)	45 %
	Shrinkage Limit (w_S)	30%
	Plasticity Index (I_p)	126 %
	Soil classification	MH or CH
4	Unconfined compressive strength (kN/m^2)	5

	Cohesion(kN/m^2)	2.5
5	Triaxial test	
	Cohesion(kN/m^2)	5
	Angle of internal friction, Ø	3^o
6	Standard Proctor compaction test	
	Maximum dry density (g/cm^3)	1.31
	Optimum moisture content (%)	32
7	CBR Value (%)	2.97
8	Coefficient of consolidation, C_v (cm^2/s)	1.58 X 10^{-4}
	Coefficient of volume change, m_v (cm^2/kg)	0.0112

III. TEST ON REINFORCED SOIL

A. Preparation of Soil Fiber Mix

For the present study, plastic strips were obtained from PET water bottle. The strips were cut into pieces of length 25mm having average width 10mm. It is to be noted the that the mould diameter would be at least 4 times the maximum strip length, which ensures the sufficient room for the strip to behave freely and independent of mould confinement. Strips are randomly mixed with soil in varying percentages (0, 0.25, 0.5, 0.6, 0.75, and 1) by dry weight of soil.

Plastic reinforced soils were prepared manually by hand mixing. Oven dried soil after passing through 4.75 mm sieve was taken and water added and mixed uniformly. For a particular percentage of fiber content, the 1/3 rd of total amount of plastic strips were distributed evenly and mixed thoroughly with wet soil. After mixing the 1/3rd amount, another 1/3rd amount were mixed in the same way. Lastly the rest 1/3rd amount was mixed with the wet soil. The wet plastic-mixed soils were then used for various tests.

Standard Proctor test, CBR test, Unconfined compression test and Triaxial compression test were done in the laboratory to study the effect of fiber reinforcement on Kuttanad clay.

The properties of soil were determined by standard test procedures and tabulated as per provision of IS codes of practice. The properties of kuttanad clay reinforced with PET bottle strips are given in Table II.

TABLE II
Properties of Kuttanad clay reinforced with PET bottle strips

SL NO	Property	Clay + PET (0.6%)
1	Standard Proctor compaction test	
	Maximum dry density (g/cm^3)	1.323
	Optimum moisture content (%)	32.1
2	CBR Value (%)	8.92
3	Unconfined compressive strength (kN/m^2)	24.69
	Cohesion(kN/m^2)	12.345
4	Triaxial test	
	Cohesion(kN/m^2)	17.5
	Angle of internal friction, Ø	19^o

IV. ANALYSIS OF FOUNDATION USING PLAXIS SOFTWARE

A. Before stabilization

Settlement of a simple square footing placed on pure clay layer is done by using PLAXIS software. Size of footing 2m x 2m. Depth of footing is taken as 0.5 m. Distributed load is applied on the plate placed on pure clay layer of 10 m thickness and 20 m width and the displacement caused by the applied load is calculated.

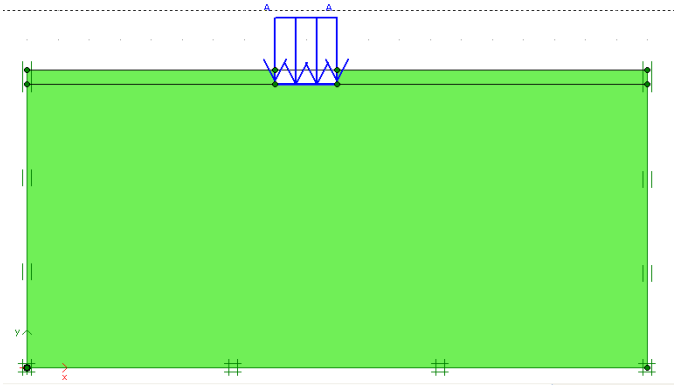

Fig.1. Plaxis 2d Model Of Pure Clay

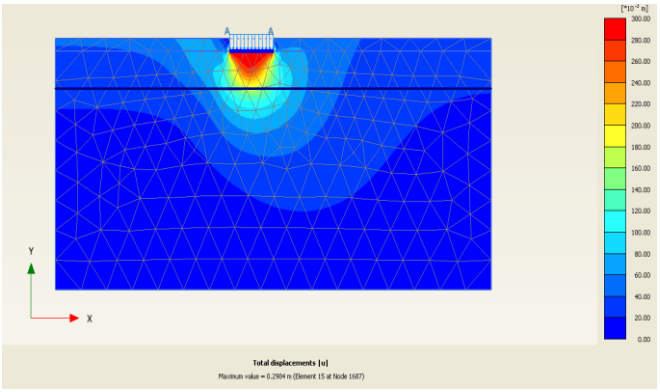

Fig. 2.Total displacement diagram of Pure Clay

Total displacement of Pure Clay at a load of 45kN/m^2 is found to be 0.2984 m.

B. After stabilization

Settlement of a simple square footing placed on reinforced clay layer is done by using PLAXIS software distributed load of 45kN/m^2 is applied on the plate placed on reinforced clay layer of 1 m thickness and the displacement caused by the applied load is calculated. Analysis result shows that the total displacement is 0.093 m. The procedure is repeated by increasing the thickness of reinforced clay layer by 0.5m and the displacement caused by the applied load is calculated.

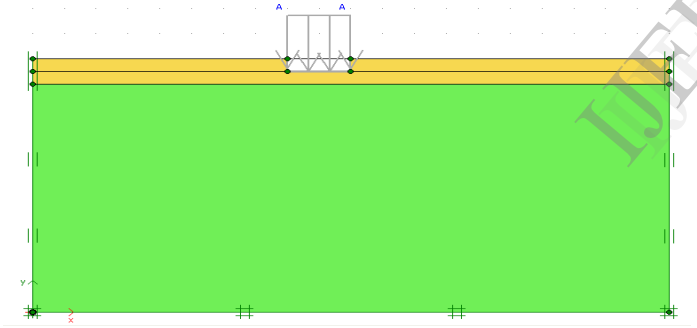

Fig.3. PLAXIS 2D Model of clay reinforced upto 1m depth

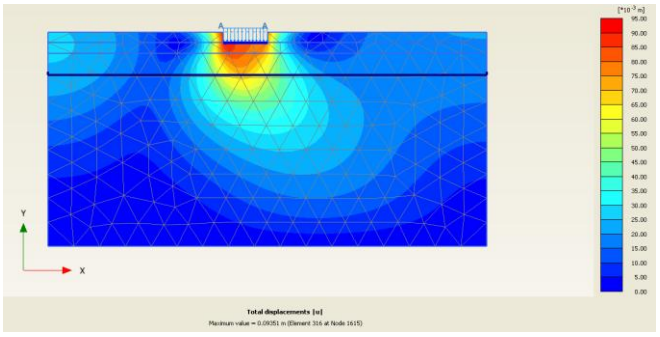

Fig. 4.Total displacement diagram of clay reinforced upto 1m depth

Total displacement of clay reinforced upto 1m depth, at a load of 45kN/m^2 is found to be 0.0935m.

V. CONCLUSION.

The following conclusions may be drawn from the present study:

1. Analysis of foundation using PLAXIS software show that the total displacement of foundation decreases from 0.2984m (before stabilization) to 0.0935m after stabilizing soil upto 1m depth at a load of 45kN/m^2
2. The maximum dry density increase with the increase in the strip content upto optimum strip content and then decreases.
3. CBR value increases with the increase in the strip content upto optimum strip content and then decreases. The optimum strip content corresponding to maximum improvement in CBR value is found to be 0.6%.
4. The unconfined compressive strength of the sample increase from 5 kN/m^2 (pure clay) to 24.69 kN/m^2, cohesion of the sample increase from 5 kN/m^2 (pure clay) to 17.5 kN /m^2 and the angle of internal friction (Ø) of the sample increase from 3^0 (pure clay) to 19^0.

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