OPEN ACCESS

International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8, Issue-1, May 2019

Comparitive Study on Effect of Diverse Geosynthetics and Their Spacing on Soft Clayey Soil

Ramya Krishna Vajrala, Raja VeerendraYenigalla

Abstract: Presence of soft clayey soil poses a problem for the construction of high load structures due to its low bearing capacity and high settlement.The soil should hence be stabilized to enhance its bearing capacity and decrease the settlement to make it suitable for construction. This study focuses on the behavior of geosynthetic reinforced-clayey soil and also the effect of different parameters contributing to their performance using laboratory model tests. The parameters investigated in this study are the type of geosynthetic reinforcement andthe number of reinforcement layers / vertical spacing between geosynthetic layers. Laboratory Tests were performed to examine the efficiency of geosynthetics and the effect of their spacing on the peak load bearing stress of soil. A series of model tests were conducted to investigate the behavior of the geosynthetic-reinforced clay under circular type of loading.Tests were conducted by preparing soil specimens reinforced with geotextiles, geogrids and geocomposites at various spacing and were tested for their load bearing capacity. The test results show an enhancement in load carrying capacity and depletion in settlement of soil when reinforced with the geosynthetics.Based on the results of the experimental program, the effect of spacing in increasing the load carrying capacity of clayey soil is established. The results of this study may be helpful in improving the bearing capacity of highly compressible soft soils and also in reduction of layer thickness in pavement design on soft clayey soil

Keywords: Geosynthetics,Soft Soil, Soil Reinforcement,Spacing

I. INTRODUCTION

Weak clayey and compressible soils with low strength characteristics cause serious construction problems resulting in failure of the structures constructed over them. Availability of good soil, for development of civil infrastructure is scarce due to the ever-increasing population. In such cases, it is required to enhance the strength properties of these weak soils. To enhance the strength properties, the soil can be stabilized either by chemical stabilization or mechanical stabilization. Chemical stabilization involves the utilization of chemicals and emulsions as stabilizing materials, which are injected/ mixed to soils to improve the properties of soils.

Revised Manuscript Received on 30 May 2019.

* Correspondence Author

Ramya Krishna Vajrala*, Former Masters Student, Department of Civil engineering, V.R. Siddhartha Engineering College, Vijayawada, AP, India,

Raja VeerendraYenigalla, Assistant Professor, Department of Civil engineering, V.R. Siddhartha Engineering College, Vijayawada, AP, India,

Lime stabilization (chemical stabilization) generally improves the engineering performance of these clayey soils. However, in some cases, lime has been reported to have an adverse effect on the soil (Sujith&Monowar, 2011). Lime stabilization has certain factors affecting the stabilization of soil such as lime content, curing time, curing temperature and soil mineralogy and they also added that an unclear behavior was noted for the permeability of soil-lime mixture when compared with the original soil; The disadvantages of lime-treated soil include carbonation, sulfate attack and environment impact (IbtehajTahaJawad et al, 2014). It is recommended that geotechnical engineers consider the reactive effects of chemical stabilizers on the soil matrix before making the choice of any chemical method of stabilization. Mechanical stabilization involves the improvement of soil properties by addition of reinforcement or non-reactive fibers to the soil. Mechanical stabilization has the advantage of having no reactive effects due to the inclusion of reinforcement in the soil. The addition of geo synthetics as a mechanical stabilization method has been proven to improve the mechanical properties of soil (Shukla and Yin, 2006). In this study, mechanical stabilization of soil is adopted and is achieved by introducing three non-biodegradabletypes of geosynthetics: geotextiles, geogrids and geocomposites. The usage of geosynthetic materials as a reinforcement can lead to an enhance in the bearing capacity of soil and also reduce the settlement in case of shallow foundations and also the use of geosynthetics can reduce the layer thicknesses of various layers constructed over a poor subgrade soil in case of pavement design. Previous studies done by researchers using the model tests conducted in the laboratory on geo-synthetics have shown that geosynthetics can be used as effective reinforcement in sandy soils or as a reinforced layer between clay and sand. P. K. Kolay et al (2013) studied the effect of geogrids used on two types of soil: silty clay and sandy soil. They have conducted several tests with a rectangular model loading with sand as the top layer and silty clay soil as the bottom layer reinforced with number of geogrid layers. The vertical spacing between successive geogrid layers is varied. From the results they concluded that the properties of soil were enhanced by the use of geogrids and by replacing silty clay soil at top with sand.

M Rama Krishna et al (2015) used geogrids, woven geotextiles, non woven geotextiles and geocomposites and tire powder as a stabilization material for sandy soil and conducted CBR test to observe the change in behavior of soil property. Reinforcement was provided as a single layer at H/5, 2H/5, 3H/5, 4H/5 depths. From the results, they concluded that the soil reinforced with geogrids has more CBR value in case of sandy soil, where as soil with woven geotextile obtained more value at depth 2H/5, than at other depths. Soil with non woven geotextile and soil with geocomposite obtained more value of CBR at depth H/5, compared to other depths. ArghadeepBiswas et al (2016) used geogrid and geocells as reinforcement for different layered foundation systems of soils i.e.
clay and sand, clay and sand with geogrid, clay and sand with geocell and clay and sand with both geocell and geogrid. From obtained results, it was concluded that, placing sand on top of stiff clay enhanced the bearing capacity. With further increase in the thickness of sand layer on top of the stiff clay, the bearing capacity was reduced. By placing geocell and planar geogrid at base increased the bearing capacity by more than 300% than for homogenous bed. The conclusions from several laboratory model tests reported in the literature reiteratesthat the ultimate bearing capacity of shallow foundations on sand reinforced with several layers of geogrid and geotextiles has improved. For the shallow foundations it is also essential to evaluate the improvement in the bearing capacity of foundations for a particular settlement. From the findings of various researchers, it can be concluded that the bearing capacity of soil has changed with diverse factors like type of soil, reinforcing materials used, number of reinforcement layers provided and the ratios of different parameters of reinforcing material. Most of these studies on the use of geosynthetics as soil reinforcement were focused on either sandy or sand with clay soils. This study focuses on the use of geosynthetic reinforcementforhighly compressible clay.The present study concentrates on the use of geotextiles, geogrids and geo-composites as reinforcement for improvement in the characteristics of soft clayey soil properties. Tests were done to examine the effectiveness of geo-synthetics and the effect of their spacings on the peak load bearing stress of soil.

II. MATERIALS

A.Test Soil

The soil used for this study was obtained from Poranki Village, Krishna District of Andhra Pradesh, India. The region is part of the Krishna delta region consisting of compressible soft alluvial soil. The natural moisture content of the soil was found immediately after collection of the soil sample and then the samples were safely packed in polyethylene and transported the lab. Index properties of the soil were found as per BIS 2720 parts 2, 3.1, 4, 5 and the soil was classified as CH (Highly Compressible Clay) as per Indian standard soil classification system (IS 1498:1970).The properties of the soil are presented in table 1.

Table 1: Properties of soil used in the study

Property	Test Result
Specific gravity	2.63
Liquid limit (%)	94
Plastic limit (%)	38.66
Plasticity index (%)	55.34
Optimum moisture content (%)	23.5
Maximum dry density (kN/m3)	16.03
Indian standard soil classification	CH
Differential free swell (%)	90

B. Geotextile

The geotextile adopted in the study is a woven geotextile made of polypropylene fibers. In this process, monofilament yarn is weaved in a uniform pattern with well-defined and significant openings. The properties of the geotextile used, as specified by the manufacturer, are mentioned in table 2.

Table 2: Properties of woven geotextile used in this study

Properties	Values
Mass per unit area (g/cc)	165
Tensile strength (wrap/weft kN/m3)	35/30
Elongation at specified strength (wrap/weft %)	25/25
Puncture strength (N)	450
Aperture opening size (mm)	75

C. Geogrid

The geogrid used in this work is a biaxial geogrid. The biaxial geogrid is manufactured by extrusion process. The properties of geogrid, as specified by the manufacturer, are mentioned in table 3.

Table 3: Properties of biaxial geogrid used in this study

Properties	Values
Aperture size (mm)	38*38
Tensile strength @ 2.0% kN/m	11.0
Tensile strength @ 5.0% kN/m	21.6
Ultimate tensile strength kN/m	30
Joint efficiency %	>95
Minimum rib thickness mm	1.5

D. Geocomposite

Though geocomposites are readily available in the market, they can also be manufactured through available materials at the site by binding, knitting, weaving, joining and attaching as they are made in proven methods.

In this study, the geocomposite is manufactured by binding the above-mentioned geotextile and geogrid. The geotextile was firmly attached to the geogrid by joining them through the interstices of the geogrid with a binding wire and is shown on fig.1. Both geogrid and geotextile act as reinforcement so by combining them it gives variable results.

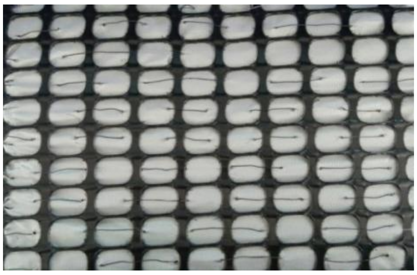

Figure 1: Geocomposite prepared by joining geogrid and geotextile

E. Model Test Mould

Based on the model tests conducted by the several researchers (Ahad&Mahmoudi, 2018; P. K. Kolay et al, 2013; M Rama Krishna et al, 2015) a model test mould was prepared with dimensions of length (L) 400mm, width (W) 400mm and depth (D) 400mm and a circular loading plate of diameter 130 mm was used for loading so as to prevent the lateral thrust on the walls of the mould during loading. The mould was made of 2mm thick iron plates to prevent deformations while applying the load and welded together. Inside the mould, wooden plates of 5mm thick are fixed so as to reduce the friction between soil and iron plates and also to prevent the deformation of mould during the compaction of soil. Metallic strips were attached to two sidewalls of the tank to reduce the lateral deformation of the mould while lifting and placing the tank during the load test.

III. EXPERIMENTAL PROGRAM

A.Preparation of Soil Sample

To prepare the soil sample, the soil collected was first dried and pulverized. Water was added uniformly to the soil to reach its optimum moisture content so as to achieve the maximum density by compaction. For each layer, the required volume of soil was calculated, mixed with water and placed in the tank. The compaction was done by the use of drop hammer and the soil is compacted up to the maximum degree of compaction by giving the same number of blows for all layers in all samples preparation. After completion of each layer, the surface of layer was scratched by trowel to get sufficient bond with the next layer. The layer was covered with plastic sheets to diminish the moisture loss until the next layer of soil is placed. Regulating the moisture content and compaction affect, fairly uniform soil beds were prepared.

For load test without reinforcement, the soil is placed in three layers and for the load tests with reinforcement, soil was compacted in 3, 4 and 5 layers in the mould with layer thicknesses of 13.33 cm, 10 cm and 8 cm, depending on the spacing of the geotextiles/ geogrids/ geocomposites. The reinforcement was provided between each layer of the soil subsequent to the compaction of the layer.

3.2.Load Tests

The geo-synthetics used in the study were placed at three different spacing: 13.33cm spacing where two geo-synthetics were placed, 10cm spacing where three geo-synthetics were placed and 8cm spacing where four geo-synthetics were placed. The placement of geo-synthetics in the mould at various spacing is shown with the help of line diagrams below in figure 2.

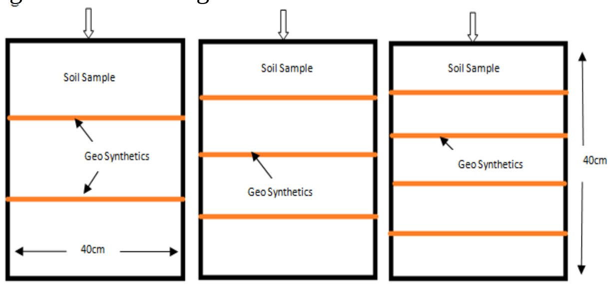

Figure 2: Line Diagrams showing placement of geo-synthetics at spacing of 13.33 cm, 10cm and 8 cm respectively

The above line diagrams indicate the numbers of layers of reinforcement and the spacing they were placed. The orange line (▬▬) indicates the position of reinforcement material i.e., geogrids, geotextiles, geo composite at various depths. The prepared soil samples were then tested in a 100T Universal Testing Machine. The UTM has arrangements to record both load and displacement through an attached computer. A Plate of 13cm diameterwas placed at the top, in the center,with no eccentricity in application of the load. The load is applied hydraulically and the strain rate was kept constant in each test. The load and corresponding settlement of the soil model were measured. The load tests were repeated for:

i. Geotextiles placed in 3, 4 and 5 layers in the mould with layer thicknesses of 13.33 cm, 10 cm and 8 cm respectively
ii. Geogrids placed in 3, 4 and 5 layers in the mould with layer thicknesses of 13.33 cm, 10 cm and 8 cm respectively
iii. Geocomposites placed in 3, 4 and 5 layers in the mould with layer thicknesses of 13.33 cm, 10 cm and 8 cm respectively

IV. RESULTS AND DISCUSSIONS

A. Test on Unreinforced Soil

The load test was performed on unreinforced soil. The soil was compacted in three layers and is then mounted onUTM. From the test results, the peak stress taken by the soil was found to be 965.61kN/m2.

B. Effect of Geotextile Reinforcement on Clayey soil

After placing the Geotextile as reinforcement material in soil there is a notable increase in the peak stress of the soil. The results obtained while the soil is reinforced with geotextiles are shown in figures3&4.

For geotextile reinforcement with layer spacing of 13.33cm, the increase in the peak stress is 38% and for a spacing of 10cm, the increase in peak stress is 110% when compared with unreinforced soil. Further decrease in spacing of the geotextile reinforcement layer to 8 cm, caused a reduction in thepeak stress takenby the soil. There is only an increase of 13% compared to unreinforced soil.

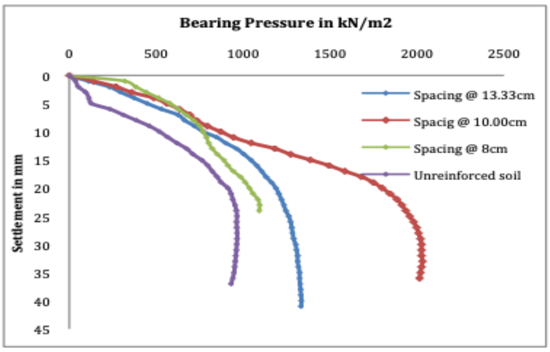

Figure 3: Graph showing Bearing Pressure vs. Settlement of soil reinforced with Geotextiles and unreinforced soil

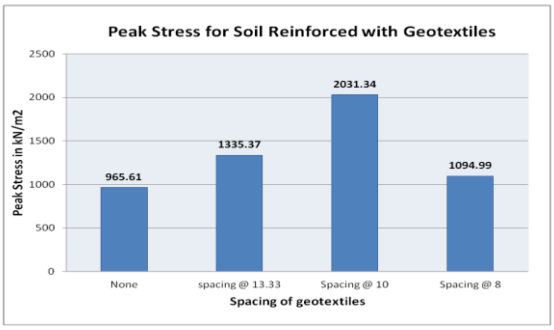

Figure 4: Graph showing peak stress of soil reinforced with Geotextiles compared to unreinforced soil

C. Effect of Geogrid Reinforcement on Clayey soil

Similarly by placing geogrid as reinforcement material in the soil, there is an increase in the Peak stress of soil for all spacing. For a spacing of 13.33cm, there is an increase in peak stress of 22.47% and for the spacing of 10cm the increase in peak stress is 82% as compared to unreinforced soil. Further decrease in the spacing, the peak stress increased by 48% as compared to unreinforced soil. The load test results for reinforced soil with geogrids as reinforcement are shown in figures5 & 6.

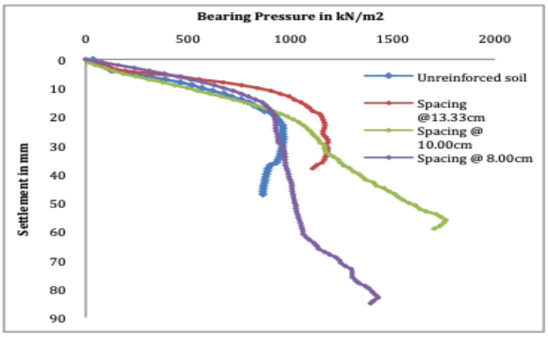

Figure 5: Graph showing Bearing Pressure vs. Settlement of soil reinforced with Geogridsand unreinforced soil

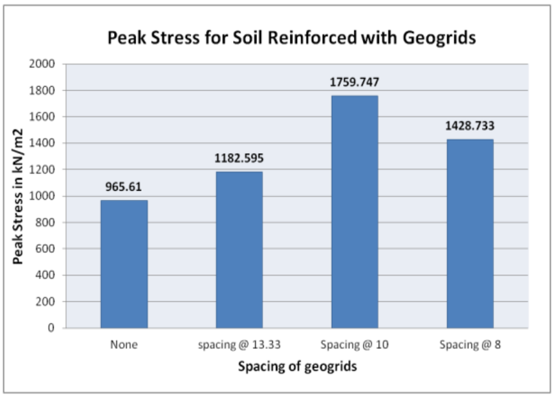

Figure 6: Graph showing peak stress of soil reinforced with Geogrids soil compared to unreinforced soil

D. Effect of Geocomposite Reinforcement on Clayey soil

Geocomposite layer acts as a double reinforcing material in the clayey soil, hence it gave better results when compared to geotextile and geogrid. The results obtained are shown in the figures 7&8. The increase in peak stress for spacing 13.33cm is 104% than unreinforced soil and the increase in peak stress for spacing 10 cm is 168% as compared to unreinforced soil. Further decrease in the spacing, the peak stress increased by 40% as compared to unreinforced soil.

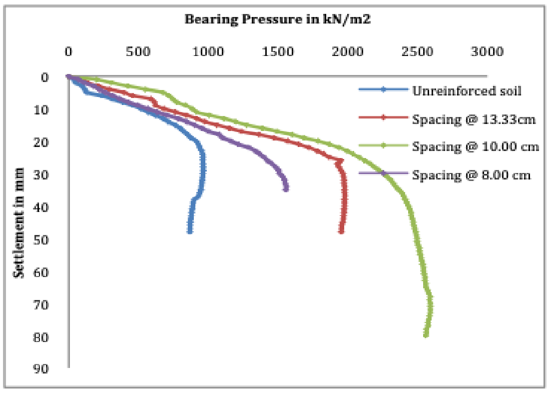

Figure 7: Graph showing Bearing Pressure vs. Settlement of soil reinforced with Geocomposites and unreinforced soil

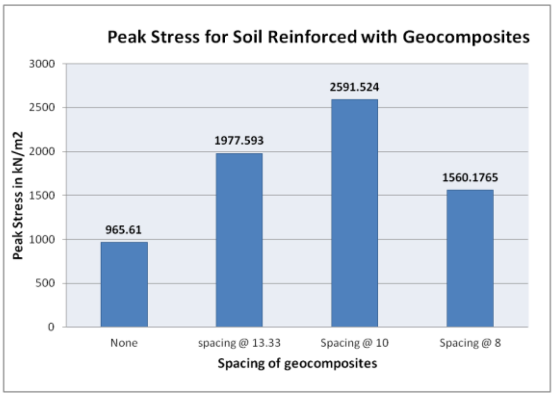

Figure 8: Graph showing peak stress of soil reinforced with Geocomposites compared to unreinforced soil

The peak stress results for all the load tests conducted are shown in figure 9 below. The conclusions are drawn from these test results and are presented.

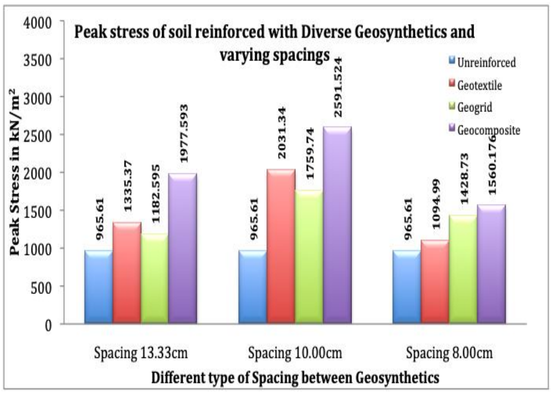

Figure 9: Graph showing peak stress of soil reinforced with Diverse Geosyntheticswith varying spacing compared to unreinforced clayey soil

V. CONCLUSIONS

The present study investigates the effect of geosynthetics on highly compressible clayey soil towards the increase of load carrying capacity. A number of laboratory model tests were conducted to calculate the load-carrying capacity of CH soil with insertion of geosynthetics at various depths from the base of the footing. Based on the model tests, the following conclusions were drawn.

1. Based on the laboratory tests, geosynthetic reinforcing materials in highly compressible soil have shown an improvement in the strength properties of the soil. Hence, geosynthetic reinforcement can be used for clayey soil making it suitable for construction of structures and also as sub grade for pavements
2. The maximum increase in peak stress is observed at a spacing of H/4, for all the three Geosynthetic reinforcements in clayey soil.
3. The maximum increase in peak stress is obtained when geotextile-geogrid geocomposite was used as reinforcement. Use of geocomposites has shown the maximum increase in peak stress at all spacing
4. For spacing of H/3 and H/4, it was observed that the increase in peak stress is more when geotextiles were used as reinforcement compared to when geogrids were used as reinforcement.But for a spacing of H/5, use of geogrids has shown more increase than use of geotextiles.

REFERENCES

1. AthiraUnni, Mithrathmajan A.K, SruthyRajkumar, V.Meril, Neenu M.B (2017) “Efficacy of Geosynthetics in Subgrade Stabilization- A comparative Study in Laterite Soil”.International Journal of Innovative Research in Science, Engineering and Technology, Volume 6, Issue 4; DOI: 10.15680/IJIRSET.2017.0604087
2. ArghadeepBiswas, A. Murali Krishna, Sujit Kumar Dash (2016) “Behaviour of geosynthetic reinforced soil foundation systems supported on stiff clay sub grade”, International Journal of Geomechanics, Vol. 16, Issue 5, https://doi.org/10.1061/(ASCE)GM.1943-5622.0000559
3. Dash, Sujit Kumar and MonowarHossain (2011), “Lime Stabilization of Soils-A Reappraisal”, Journal of Materials in Civil Engineering, doi:10.1061/(ASCE)MT.1943-5533.0000431
4. IbtehajTahaJawad,MohdRaihanTaha,ZaidHameedMajeed andTanveer A. Khan, (2014), “Soil Stabilization Using Lime: Advantages, Disadvantages and Proposing a Potential Alternative”, DOI: 10.19026/rjaset.8.1000
5. M Rama Krishna, B Naga MalleswaraRao, (2015) “Evaluation of CBR Using Geosynthetics in Soil Layers”, International Journal of Research in Engineering and Technology, Volume: 04 Issue: 05
6. P.K. Kolay, S. Kumar, D. Tiwari (2013) “Improvement of bearing capacity of shallow foundation on geogrid reinforced silty clay sand”, Journal of Construction Engineering, http://dx.doi.org/10.1155/2013/293809
7. Shukala, S.J., Yin, J.H., (2006). “Fundamentals of Geosynthetic Engineering”. CRC Press.
8. Magdi M. E. Zumrawi, NehlaMansour (2016) “Laboratory evaluation of geogrids used for stabilizing soft sub grades”, International Journal of Civil and Environmental Engineering, Vol:10, No:3, 2016
9. RishiSrivastava, ShalineeShukla, R.P. Tiwari, AyushMittal (2016), “Effect of woven polyester geotextile on the strength of black cotton soil”.International Journal of Innovative Research in Science, Engineering andTechnology, Volume 5, Issue 7;DOI: 10.15680/IJIRSET.2016.0507048
10. Fannin RJ, Sigurdsson O (1996),“Field observations on stabilization of unpaved roads with geosythetics”. J Geotech Eng ASCE122:544–553
11. AhadOuria, ArsamMahmoudi (2018), “Laboratory and numerical modeling of strip footing on geotextile- reinforced sand with cement-treated interface”, Geotextiles and Geomembranes, http://dx.doi.org/10.1016/j.geotexmem.2017.09.003 IS 1498: 1970
12. Robert M. Koerner, Bao-Lin Hwu, Mark H. Wayne (1987) “Soft soil stabilization designs using geosynthetics”, Geotextiles and Geomembranes, Volume 6, Issues 1–3, 1987, Pages 33-51