Effect of Shear Stress on Clay Reinforced with Encapsulated Geosynthetics

Y.S Ahalya
M Tech student,
Department of Civil Engineering,
Marian Engineering College,
Kazhakuttom-695582

V. Rani
Associate Professor,
Department of Civil Engineering,
Marian Engineering College,
Kazhakuttom-695582

Neema Therese
Research scholar,
Department of Civil Engineering
LBS Institute of Technology for Women,
Thiruvananthapuram- 695012

S. Naveen
Deputy Director,
LBS Centre for Science & Technology,
Thiruvananthapuram- 695033

J. Jayamohan
Professor,
Department of Civil Engineering,
LBS Institute of Technology for Women,
Thiruvananthapuram- 695012

Abstract— **The geosynthetics are used to improve the bearing capacity and settlement performance of embankment has proven to be a cost- effective system. This can be done by either reinforcing cohesive soil or replacing the poor soils with stronger granular fill in combination with geosynthetic reinforcement. Reinforced granular bed will improve the load bearing capacity of embankment and provide better pressure distribution on top of the underlying weak soils. This can be reducing the settlements. But the availability of granular soil is very less and it makes the reinforced soil technique uneconomical. There is a need for a technique which will improve the bearing capacity without excessive settlement of reinforced granular soil. One technique yet to be comprehensively studied is geosynthetic is encapsulated in thin of sand , 6mm chips and mixture of sand and 6mm chips, when used as reinforcement in clays. The large scale direct shear test is conducted to determine the shear parameters of different encapsulated thin layer of geosynthetics**

Keywords— Embankment, Geosynthetic, Bearing capacity, Shear parameters

I. INTRODUCTION

Highways and Railways are essential components of development and are vital for the economic growth of the country. The growing economy requires expansion of existing carriageways into multi-lane expressways and development of new road / rail routes(1). The concept of soil reinforcement is extensively used in many geotechnical structures including retaining walls, embankments, foundations, slopes, highway and airport pavements, and railway tracks(2). However difficult subsoil conditions along with high economic and social costs and dearth of good construction material coupled with environmental constraints pose major challenges to development of the road network. A typical road project has two major components; the embankment supporting the carriageway and the pavement/track. The construction of embankments over soft, compressible ground is increasing due to lack of suitable land for infrastructure and other developments. When constructing an embankment over very soft subsoil of low shear strength and high compressibility, the engineering tasks are to ensure stability of the embankment against possible slope failure and to control the subsoil deformation or settlement to within allowable limits. The design of high embankments on very soft soil normally requires the assessment of the following problems: bearing capacity failure, global slope failure, local instability, excessive lateral displacement, and intolerable total and/or differential settlements. A variety of techniques may be used to solve these problems, such as the use of lightweight fill, over-excavation and replacement by granular soil, vertical drains with preloading, horizontal reinforcement, and vertical reinforcement(1).

One promising technique is the geosynthetic layer and encapsulating it in a thin layer of different materials such as sand, 6mm chips and mixture of sand and 6mm chips when used as reinforcement. Large scale direct shear test have been carried out. It is observed that provision the geogrid encapsulated with thin layer of 6mm chips is very effective in improving the strength and deformation characteristics of saturated clay. The purpose of this project is to investigate the possibility of reinforcing the embankment having soft soil foundation with geogrid.

2 MATERIALS USED

Locally available clay and sand are used in this investigation. Biaxial geogrid is used as reinforcement. The properties of clay, sand, laterite and geogrid are presented in Tables 1, 2, 3and 4, respectively.

TABLE 1 PROPERTIES OF CLAY

Properties	Clay
Specific gravity	2.63
Optimum moisture content (%)	18.18
Dry unit weight (kN/m3)	15.61
Liquid limit (%)	58
Plastic limit (%)	22
Plasticity index	22
IS classification	CH
Friction angle (0°)	5
Cohesion (KPa)	25

TABLE 2 PROPERTIES OF MANUFACTURED SAND

Properties	M. Sand
Specific gravity	2.65
Effective grain size, D_{10} (mm)	0.13
D_{60} (mm)	0.90
D_{30} (mm)	0.34
Coefficient of Uniformity, C_u	6.92
Coefficient of curvature. C_c	1
Permeability (m/s)	$1.07x10^{4}$
Friction angle (0°)	31.2
Cohesion (KPa)	0
Void ratio	0.5

TABLE 3 PROPERTIES OF LATERITE

Properties	Laterite
Specific gravity	2.6
Optimum moisture content (%)	15.5
Dry unit weight (kN/m3)	18.84
Liquid limit (%)	49
Plastic limit (%)	36.39
Plasticity index	12.66
IS classification	SW
Friction angle (0°)	32
Cohesion (KPa)	13
D_{60} (mm)	1
D_{30} (mm)	0.425
Coefficient of Uniformity, C_u	6.67
Coefficient of curvature. C_c	1.2

TABLE 4 PROPERTIES OF 6MM CHIPS

Properties	6mm chips
Specific gravity	2.6
Permeability (m/s)	$2.07x10^{4}$
Friction angle (0°)	30.2
Cohesion (KPa)	0

TABLE 5 PROPERTIES OF GEOGRID

Properties	Values
Color	Black
Type	Biaxial
Tensile strength (kN/m)	30
Aperture size (mm)	26x20
Mass per unit area (g/m^2)	225

2.1 Large scale direct shear teat

Large scale direct shear tests in a shear box of dimensions 300 x 300 x 200mm are carried out to study the improvement in shear strength attained due to encapsulating geogrids in thin layers of sand. The figure of the setup is shown in Figure1 and photograph in Figure 2.

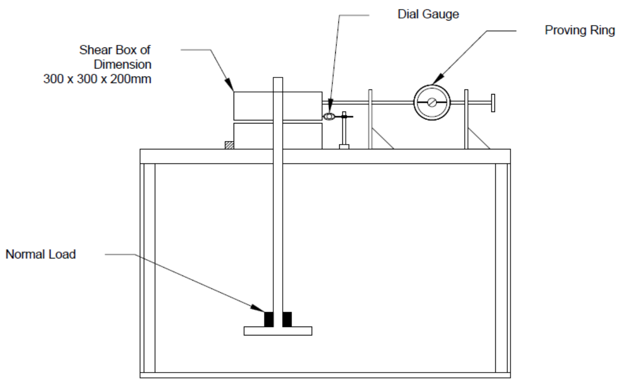

Fig 1 Large Scale Direct Shear Test Setup

Fig 2 Large Scale Direct Shear Test

Shear tests were carried out for various arrangements of soil layers and reinforcement. Specimens were prepared after thoroughly mixing measured quantities of clay and water corresponding to maximum dry density and optimum moisture content. Initially, the lower shear box was filled and compacted with clay or sand in three equal layers with the surface of each layer scarified after compaction to ensure good bonding. After placing the geogrid, the upper shear box was positioned and filled with clay or sand in a similar manner .The lower shear box was filled with clay up to the bottom of sand layer. Then sand was poured above the clay layer and up to the top level of lower shear box and compacted. Geogrid is positioned and clamped and the upper shear box is placed. Sand is poured for the required thickness and compacted by tamping. Then clay is filled and compacted for the remaining height in a similar manner. The next case the 6mm chips ware poured above the clay layer and up to the top level of lower shear box and compacted. Geogrid is positioned and clamped and the upper shear box is placed. 6mm chips is poured for the required thickness and compacted by tamping. Then clay is filled and compacted for the remaining height in a similar manner. The last case mixture of sand and 6mm chips were poured above the clay layer and up to the top level of lower shear box and compacted. Geogrid is positioned and clamped and the upper shear box is placed. The mixture of sand and 6mm chips are poured for the required thickness and compacted by tamping. Then clay is filled and compacted for the remaining height in a similar manner. After positioning the loading plate and setting the appropriate gauges, desired normal pressure was applied and testing commenced with no time allowed for the clay to consolidate. Tests were strain controlled.ss

3 RESULTS

3.1 Unreinforced Soil Sample

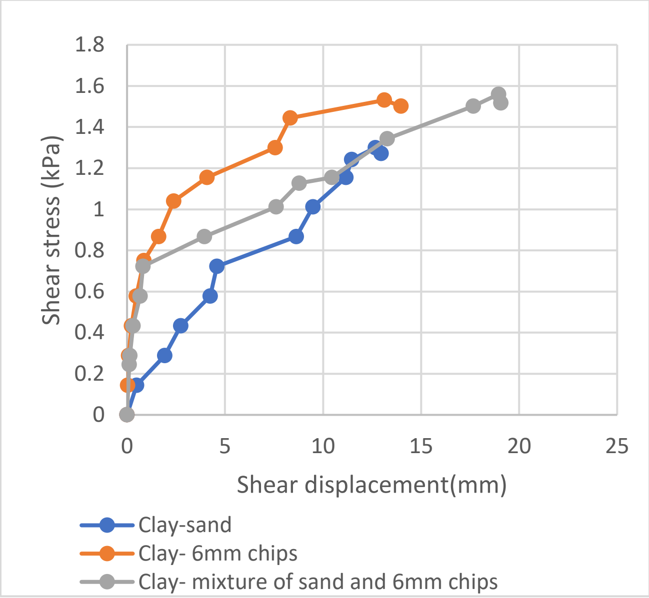

Fig 3 Variation of Shear stress with shear displacement (unreinforced)

Figure 3 shows the behaviour of clay-sand (clay in the lower half and sand in the upper half of shear box), clay- 6mm chips, clay- mixture of sand and 6mm chips. It is seen that shear stress is mobilised least in Clay since the shear strength developed is only due to cohesion. The shear stress mobilized in sand is due to friction and is observed to be more than that in clay. The mobilized shear strength in clay-6mm chips combination is observed to be more than that in other cases. In this combination even though shear failure occurs in sand, there will be relative movement at the clay sand interfaces also. Hence shear strength mobilizes is more. Maximum shear strength is observed to be mobilized in the clay-6mm chips combination. Here shear strength is developed due to both cohesion and friction since failure occurs at the 6mm chips-clay interface.

3.2 Unreinforced encapsulated soil sample

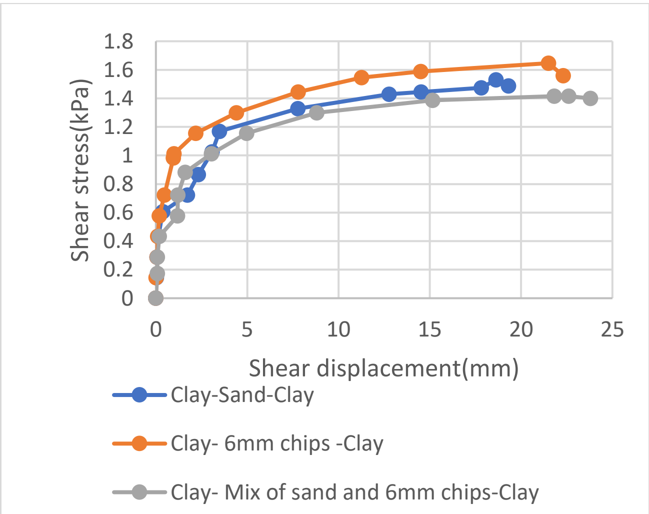

Fig 4 Variation of Shear stress with shear displacement (unreinforced encapsulated)

Figure 4 shows the behaviour of clay-sand-clay , clay- 6mm chips-clay, clay- mixture of sand and 6mm chips-clay. It is seen that shear stress is mobilised least in Clay since the shear strength developed is only due to cohesion. The shear stress mobilized in sand is due to friction and is observed to be more than that in clay. The mobilized shear strength in clay-6mm chips-clay combination is observed to be more than that in other cases. In this combination even though shear failure occurs in sand, there will be relative movement at the clay sand interfaces also. Hence shear strength mobilizes is more. Maximum shear strength is observed to be mobilized in the clay-6mm chips-clay combination. Here shear strength is developed due to both cohesion and friction since failure occurs at the 6mm chips-clay interface.

3.3 Reinforced encapsulated soil sample

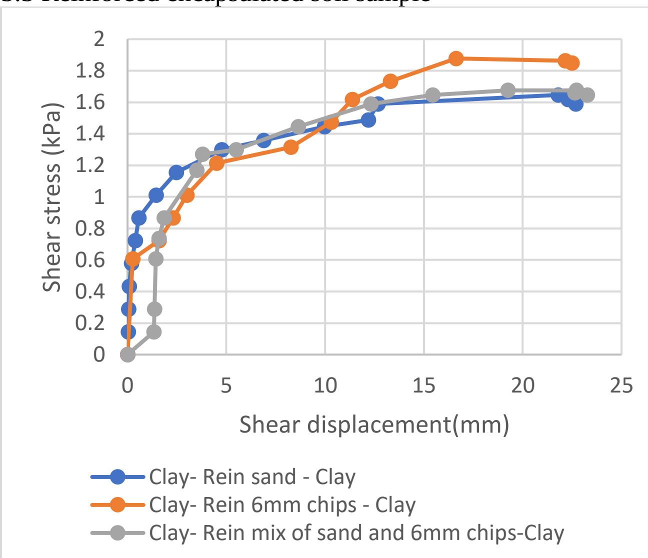

Fig 5 Variation of Shear stress with shear displacement (reinforced encapsulated soil sample)

Figure 5 shows the behaviour of clay-reinforced sand -clay, clay- reinforced 6mm chips-clay, clay- reinforced mixture of sand and 6mm chips-clay. It is seen that shear stress is mobilised least in Clay since the shear strength developed is only due to cohesion. The shear stress mobilized in sand is due to friction and is observed to be more than that in clay. The mobilized shear strength in clay-reinforced 6mm chips-clay combination is observed to be more than that in other cases. In this combination even though shear failure occurs in sand, there will be relative movement at the clay sand interfaces also. Hence shear strength mobilizes is more. Maximum shear strength is observed to be mobilized in the clay-reinforced 6mm chips- clay combination

4 CONCLUSION

The behaviour of clay reinforced with geogrid encapsulated in sand has been studied by carrying out large scale direct shear tests. The parameters studied are effects of geometric parameters of reinforcement and encapsulating different soil sample layer on the shear strength of reinforced clay and improvement in strength of embankment. Based on the results observed, the following conclusions are drawn

- Reinforcing clay with geogrid encapsulated in thin layer of 6mm chips considerably improves the shear strength of soil.
- The improvement in shear strength due to reinforcing clay with geogrid encapsulated in thin layer of 6mm chips is almost 100%.

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