International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 07 | July -2017 www.irjet.net p-ISSN: 2395-0072

Study on Geosynthetic Reinforced Stone Column with soft & stiff clay

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Abstract – *Rapid increase in population, economic and social development has forced to use soils which were unsuitable for construction earlier. Such soils include clay, peat soils, recent fills, marine clays etc. They raise various problems such as low bearing capacity, high compressibility and tendency for lateral flow. Stone column technique is considered as an efficient, cost effective and environmentally friendly for improving cohesive and cohesion less soils to sustain the foundations of light to moderately loaded structures; such as low rise building, storage tanks ,embankments, warehouses and bridge approaches are to name a few. This paper involves the simulation of Geosynthetic Reinforced stone column on layered soil using Plaxis Professional.*

Key Words: Bulging, Geosynthetic, Stone column, Encased Stone Column, Plaxis software.

1.INTRODUCTION

From the past few decades there has been an increase in infrastructural development which led to high increase in the prices of land and shortage of suitable land for development. Stone columns were used to provide higher bearing capacity, reduce settlements, speed up the consolidation settlement and reduce the liquefaction potential of cohesion less soils under seismic loading and to enhance the stability of natural and manmade slopes. The ground can be improved by many techniques which includes densification through Blasting, Vibration and compaction, pre-compression, electro-osmosis, drainage, drying, heating, freezing, addition of admixtures including lime and cement, installing of stiffening column and several other methods.

1.1 Ordinary Stone Column

During the mid 1930's vibrating probe was used for the densification of granular material by this technique of vibration the void ratio of granular material was reduced at certain spacing which led to the rearrangement of soil particles into closer state. Later it was found that in cohesive soils vibro-densification was not enough to obtain stiffer soil mass. Other deep foundation transfers the load of the structure to a rigid layer, however stone column improves the bearing capacity of composite soil mass at different layers. The column of stone aggregate is formed using a vibrating probe called Vibroflot. the shape of the vibroflot is torpedo and generally ranges from 300mm to 460mm (Ref: Greenwood and Kirsch 1983) and is between 2m and 5m long (Ref: McKelvey and Siva Kumar 2000).

1.2 Applications Of Stone Column

Stone columns are suited for improving the undrained shear strengths ranging from about 15KPa to 50KPa(Ref: McKelvey and Siva Kumar 2000).Below this strength the natural soil is not able to provide sufficient lateral confinement and thus the soil will fail in bulging. It may be noted that In published case studies indicates that stone column have been used in soil with undrained shear strength as low as 6kPa (Ref: Raju 1997).

2. GEOSYNTHETIC REINFORCED STONE COLUMN

Due to the limitation of an ordinary stone column where the failure occurs due to bulging lateral confinement is provided to the stone column by encasing an ordinary stone column with Geosynthetic which ultimately increases the load bearing capacity of the stone column and prevents bulging. There are various methods to reinforce the granular pile with suitable stiffness since there is a handful option available in the market. Stone columns can be fully encased or partially encased depending on the conditions and method of application. Detail research is being carried out through out the world since the effect of encasing the stone column on a stiffer layer makes no sense. Encasement is provided only to the soil layer with weak soil properties.

The application of the Geosynthetic Stone column is beneath the storage tanks, stability of embankment, slope stability, increase consolidation by creating vertical drains and reduce differential settlement

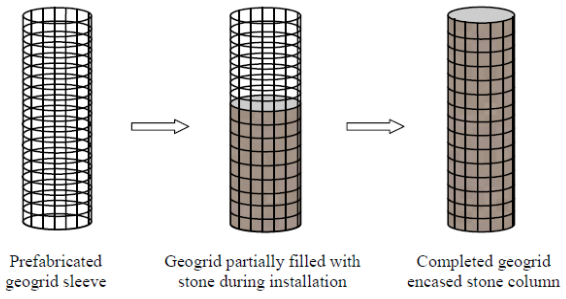

Fig -1: Installation of Geosynthetic Stone Column

2.1 Finite Element Analysis Of Critical Parameters In Plaxis

Plaxis is a finite element software package for the analysis of deformation and stability of Geotechnical Projects. The Advantage of the software is the simple graphical method of input for solving complex geometry problems. The most comprehensive part of using Plaxis in this paper for simulation of Geosynthetic Reinforced Stone Column RSCs and Ordinary Stone Column OSCs is that it provides detail representation of results the calculation is automated based on geotechnical techniques.

Table -1: Format material Properties of soft, stiff clay, Stone Column

Parameters	Soft Clay	Stiff Clay	Stone Column
Material model	Mohr-Coulomb		
Material type	Drained	Drained	Drained
Unsaturated unit weight(kN/m^3)	17	19	20
Saturated unit weight(kN/m^3)	17	19	20
Modulus of elasticity: E (kN/m^2)	250*C1	1000*C2	40000
Poisson's ratio:v	0.45	0.35	0.30
Cohesion:c (kN/m^2)	15(C1)	75(C2)	1
Angle of internal Friction Ø (degree)	2	2	40
Dilatancy angle:φ (degree)	0	0	$\emptyset - 30$

Table -2: soft clay & Stiff clay behaviour in Plaxis

Material	Diameter Of Stone column
10m- full length soft clay	0.8m
10m- full length stiff clay	0.8m

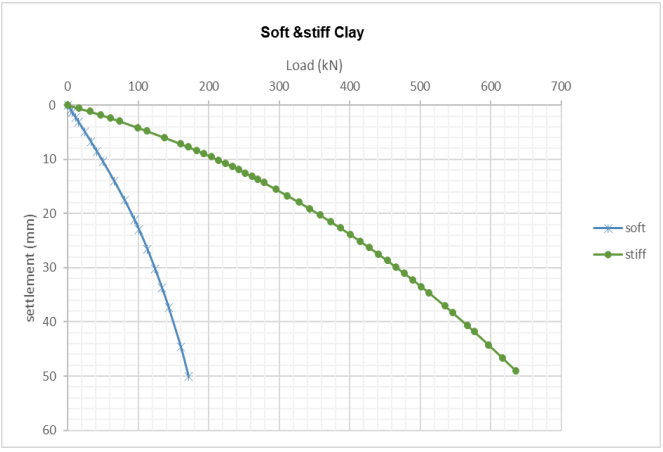

Fig -2: Load Vs settlement graph for surrounding Soft Clay & Stiff Clay

The load Vs settlement Graph shows that the behavior of Stone column in surrounding weak soil is poor. This simply means the lateral confinement of stone column is affected by surrounding soil. the above graph shows that the bearing capacity of soft clay is 171.48KN ,while in stiff clay it is 636.22KN.This results are to show comparative data that Reinforcing weak layers of soil is important to increase bearing capacity The failure mechanism of Ordinary Stone column is by bulging the above graph shows that if the surrounding soil layer is weak column will bulge more this was compared with soft and stiff clay. However the failure mechanism is experienced in the top layers only. The bulging of soft clay is 12.663724mm at a depth of 0.159732m from top. While in stiff clay bulging is 0.30281667mm at a depth of 0.3194639m.

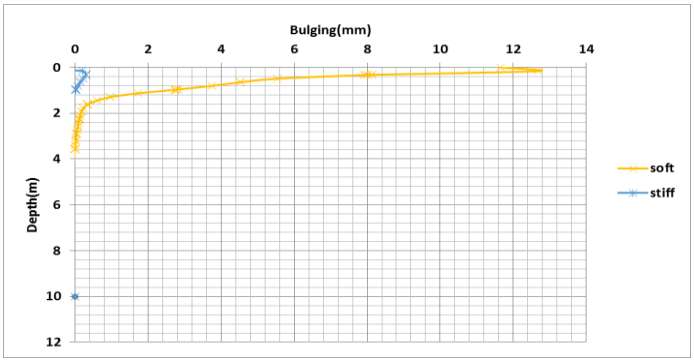

Fig -3: Bulging of Soft and Stiff Clay

2.2 Influence Of Geoxetile Reinforcement

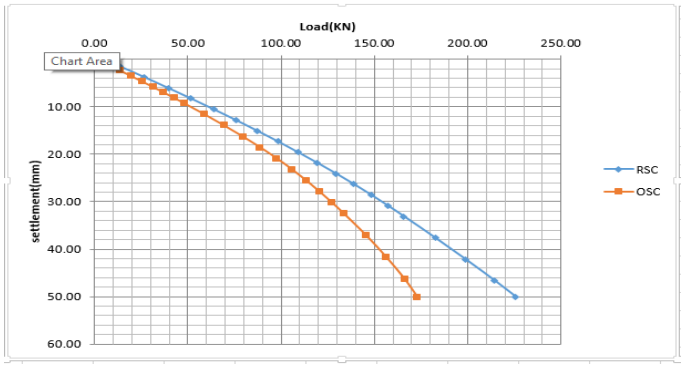

Fig-4: The graph is for layered stiff & soft clay (Load VS settlement Graph)

The influence of geotextile reinforcement is studied by comparing the stress-settlement curves of OSC with RSC for 0.40 m diameter in Figures it can be seen that with the use of geotextile reinforcement load carrying capacity of the OSC increased remarkably. It is clearly seen that soil without treatment and soil treated with OSC fail while RSC do not fail at large settlement. The increase in the load carrying capacity of the RSC is due to increase amount of additional lateral confinement provided by the reinforcement material. The

amount of increase in load carrying capacity at the initial stage is low but after this the load carrying capacity is increased rapidly. This phenomenon may be due to initial adjustment of stone particles of column.

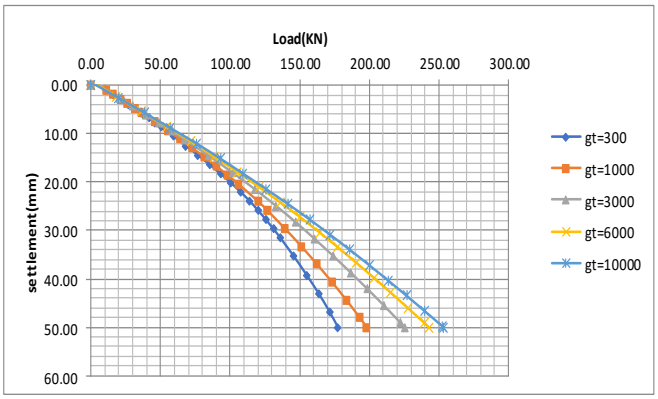

Fig -5: Load Vs Settlement Graph for Increased Stiffness of the stone column which improve bearing capacity of soil

3. CONCLUSIONS

The following conclusions can be derived from the study of soft and stiff clay surrounding stone column:

- An ordinary Stone column will eventually fail but the depth of failure depends on the surrounding soil which provides lateral confinement to the stone column.
- Stone column surround by weak soil such as soft clay will bulge more since lateral confinement to hold soil is less.
- Stone column surround by stiff clay will eventually bulge but minimum bulging is seen.
- The weak layers of the soil can be reinforced to increase its axial load carrying capacity and minimize bulging.
- Further improvement can be done by increasing the stiffness of the geogrid which increases the load bearing capacity of the soil.

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