Behavior Of Geosynthetic Encased Sand Column In Soft Soil

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ABSTRACT:

The technique of sand columns to improve the mechanical properties of soft soil is well established. However, the use of sand columns is usually associated with excessive deformation due to lack of lateral support from the surrounding soil. The Sand columns are useful to improve the load carrying capacity of soft soil. It is difficult to install sand columns in soft soil due to bulging of sand columns after loading. So, the encased sand column with geosynthetic is found more convenient than ordinary sand columns during installation in soil bed. Geo-synthetics encased sand columns can be applied to increase in load carrying capacity & to reduce the settlement.

This paper presents the effect of encasement on sand columns of different diameters with different types of geosynthetic materials installed in clay bed in a typical square pattern. The geosynthetic material reinforcing all-round the sand columns having more initial tensile modulus was found more superior. The performance of reinforced sand columns of smaller diameters was superior to that of larger diameter sand columns because of mobilization of higher confining stresses in smaller diameter of sand columns. The behavior of geosynthetic encased sand columns during group loading test was encountered.

Keywords: *Geosynthetic encased sand column, Ordinary sand column, Group load test, Undrained cohesion, Relative density, Displacement method, Initial tensile modulus, Geosynthetic, Reinforcement*

1. INTRODUCTION

India has large coastline exceeding 6000kms.In view of the developments on coastal areas in the recent past, large number of ports and industries being built. This necessitated the use of land, which has weak strata, wherein the geotechnical engineers are challenged by presence of different problematic soils with varied engineering characteristics. Out of several techniques available for improving the weak strata, geosynthetic encased stone columns have been used to a large extend for several applications. The design of stone column is still empirical, based on past experience and needs field trials before execution.

Any soil type that does not respond to vibration alone is a candidate for stone columns. The carrying capacity of the stone columns or sand columns depends mainly on the lateral support. The lateral support is provided by the native soft soil and depends on its shear strength. The stiffness of the sand column also plays an important role in the increase of the stress concentration within the column, which leads to increase the bearing capacity of the improved ground. Thus, In case of group piles Bulging is the primary mode of failure. This drawback can be overcome by wrapping the individual sand columns with a suitable geosynthetic. The geosynthetic encasement helps in easy formation of the sand column and improves the strength and stiffness of the columns. By reinforcing sand columns by Geosynthetic, the ultimate bearing capacity of that column can be increased to considerable amount. Thus the geosynthetic encased sand column is the technique for reinforcement to improve the loading capacity of the ground.

Hence this paper investigates the improvement in load carrying capacity of sand columns in a square pattern after all-round reinforcement by geosynthetics. The effect of encasement over ordinary sand columns with different geosynthetics has been investigated. This paper also represents the influence of different diameters of the encased sand columns.

2. MATERIALS

2.1 Soil

The soil, taken from Vesu in Surat was sieved through 2mm sieve to remove the coarser fraction. To find the undrained cohesion of the soil sample, laboratory vane shear tests were carried out at 38% & 43% water content.

Table1. Properties of soil

Property	Value
Liquid limit (%)	48
Plastic limit (%)	18
Plasticity Index (%)	30
Specific gravity	2.50
Indian Standard soil classification	CI
Bulk unit weight at 43 % water content (kN/m^3)	17.25
Undrained cohesion at 43 % water content (kN/m^2)	9

2.2 Geosynthetic

Table2. Properties of geosynthetic

Types of geosynthetics	Initial tensile modulus (kN/m)
Soft grid	7.50
Non-woven geotextile	11.50
Woven geotextile	43.70

2.3 Sand

The clean river sand aggregates of a size less than 4.75mm was taken to form sand columns. The sand compacted to a density of 1.62 g/cm^3 & it was maintained constant throughout all the tests.

Table3. Properties of sand

Property	Value
Specific gravity	2.74
Maximum unit weight (kN/m^3)	18.0
Minimum unit weight (kN/m^3)	15.0
Compacted unit weight (kN/m^3)	16.20
Relative density (%)	45
Uniformity coefficient	3.50
Coefficient of curvature	0.73

3. METHODS

The laboratory tests were conducted on two different diameters 50mm and 75mm of sand columns in order to predict the influence of sand columns during group load test. The other parameter, the initial modulus of the geosynthetic was varied by using three different types of geosynthetics as woven geotextile, non-woven geotextile & geogrid for the encasement. The sand columns were installed in the soil bed with a typical square pattern.

3.1 Preparation of soil bed

The laboratory vane shear test resulted to the undrained cohesion of soil 9 kN/m^2 at 43% water content. The proper mixed soil mass with corresponding water content was placed at each 5cm up to the full height of 40cm in the tank of size 50cm × 50cm × 45cm.The surface of each 5cm layer was provided with uniform compaction up to the full depth of soil layer in the tank.

3.2 Installation of sand columns

The sand columns of four in numbers were installed up to full depth of soil layer in a square pattern of spacing 25cm centre to centre of each sand column in the tank.

The sand columns in the experimental work were installed by displacement method using a casing pipe having an outer diameter equal to the diameter of the sand column. The encased sand columns were installed by wrapping the geosynthetic around the casing pipe. The casing pipe along with a base plate was pushed into clay bed vertically at the specified location in the clay surface till it reaches the bottom of the tank. The base plate is to prevent the surrounding clay from entering into the pipe during the lowering of casing pipe. The displaced clay was taken out and the surface of the soil was trimmed to its original level.

The quantity of the sand aggregate required to form the stone column was pre measured and charged into the casing pipe in layers of 5cm thickness up to the full height of sand column. The relative density of sand was maintained at 45% for the installation of each sand column.

3.4 Load Test on Sand column group

After installation of sand columns the entire tank set up is placed in the loading frame & the loading is applied through strain controlled displacement of loading plate at a constant strain rate of 1.2 mm/min. The settlement in the sand column group was measured with the help of LVDT.

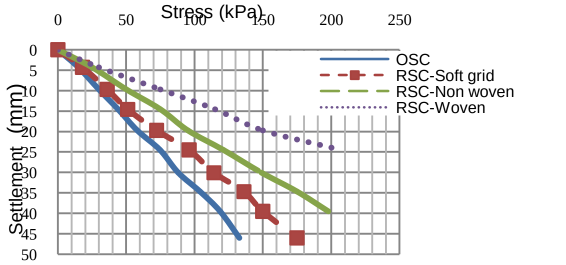
4. RESULTS & DISCUSSION

4.1 Effect of geosynthetic reinforcement

By the stress settlement response of 50 mm diameter sand columns, it can be seen that for a given settlement of 20mm, the RSC-Soft grid has 14% more stress than OSC, the RSC-Non woven has 34% more stress than OSC & the RSC- woven has 60% more stress than OSC.

For a given stress of 100 kPa, the RSC-Soft grid has 29% less settlement than OSC, the RSC-Non woven has 43% less settlement than OSC & the RSC-woven has 63% less settlement than OSC.

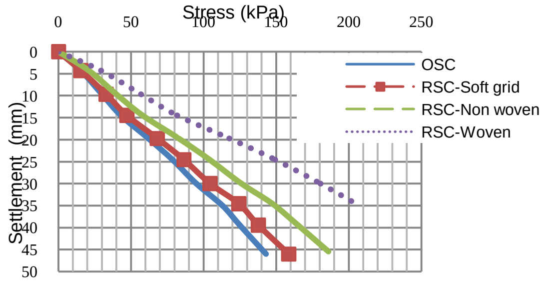
Figure1. Stress-settlement response of 50mm diameter sand columns



By the stress settlement response of 75mm diameter sand columns, it can be seen that the RSC –Soft grid has 14% more stress than OSC, the RSC-Non woven has 26% more stress than OSC & the RSC- woven has 54% more stress than OSC for a given settlement of 20mm.

For a given stress of 100 kPa, the RSC-Soft grid has 10% less settlement than OSC, the RSC-Non woven has 25% less settlement than OSC & the RSC-woven has 50% less settlement than OSC.

Figure2. Stress-settlement response of 75mm diameter sand columns

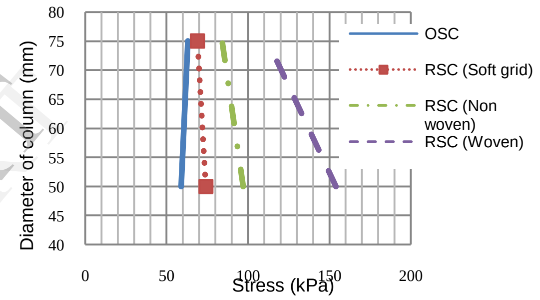


So, it is clear that for both the diameters of sand columns, the loading capacity of RSC-woven is found 50 to 60 % more than OSC. Again, in case of RSC-woven, there is significant reduction in settlement. In the present study, failure of the RSCs was not observed. In the case of RSCs the compression of the sand column was due mainly to the elongation of the geosynthetic reinforcement.

4.2 Effect of diameter of sand column

Plotting the variation of stress corresponding to the 20mm settlement with the diameters of 50mm and 75mm, it can be observed that for OSC, as the diameter increases, the stress also increases. Whereas in case of RSC (Soft Grid), RSC (Non-Woven), & RSC (Woven) geotextile the pattern is opposite, that is with increase in diameter stress is decreasing, the only thing is that in case of RSC (Woven) geotextile the diameter is more dominant.

Figure3. Variation of stress corresponding to 20mm settlement with diameter of sand columns



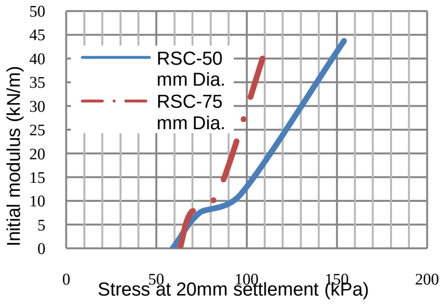
From the present study, it is found that the performance of smaller diameter sand column is superior to that of bigger diameter sand column. The reason for this is the development of larger additional confining stresses in smaller diameter reinforced columns.

4.3 Effect of initial tensile modulus of reinforcement

The effect of initial modulus of the geosynthetic reinforcement on the load carrying capacity of the reinforced sand column for 50mm and 75mm diameter has been discussed in this section. The vertical stress corresponding to 20mm settlement in the sand column reinforced in various geosynthetics is plotted against the modulus of the geosynthetic. It can be seen that the stiffness of the reinforced sand columns increases with an increase in the initial modulus of the geosynthetic used for reinforcement.

The improved performance is possible due to the reinforcement which attributes to enhancement of the overall stiffness of the columns because of the larger confining stresses developed in the sand columns.

Figure4. Influence of modulus of encasement on performance of reinforced sand column



5. CONCLUSION

a) The encased sand column behaves like elastic, semi-rigid flexible piles.
b) By geosynthetic reinforcement, it is found that the sand columns are confined and the lateral bulging is minimized.
c) The geosynthetic reinforcement prevents the soil from penetrating into the aggregate. This non-contamination of sands will result in better performance of the sand columns.
d) The loading capacity of the sand column can be increased by all-round reinforcement by geosynthetic.
e) There is significant reduction in settlement with geosynthetic encasement of sand columns in soft soil.
f) The performance of ordinary sand columns of larger diameter is superior to that of smaller diameter sand columns, but the performance of reinforced sand columns of smaller diameters is superior to that of larger diameter sand columns.
g) The elastic modulus of the geosynthetic reinforcement plays an important role in enhancing the load carrying capacity of the reinforced columns. The confining pressures generated in the sand columns are higher for stiffer reinforcements.

5. REFERENCES

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