Strength Improvement Of Geotextile Encased Stone Columns Using Tyre Chips And Aggregates

Akhitha A.
M Tech Student, Geotechnical Engineering,
Marian Engineering College, Kazhakkuttom 695582
Thiruvananthapuram, India

Aswathy S.
Assistant Professor, Department of Civil Engineering,
Marian Engineering College, Kazhakkuttom 695582
Thiruvananthapuram, India

***Abstract*— Nowadays the availability of land is less for the proper development of infrastructure, roads, highways etc. This problem can be overcome by the effective use of available land, which may not be suitable for construction. So a proper ground improvement technique is needed. Out of various methods stone column is widely used. Here the shredded tyre chips and aggregates are used as stone column material. Plate load test is carried out to determine the load settlement behaviour of end bearing and floating stone column with and without geotextile encasement prepared in a cylindrical tank. Mixture of 70% stone + 30% tyre chips with geotextile encasement shows the higher load carrying capacity.**

Keywords- Tyre chips, Plate load test, Stone column

I. INTRODUCTION

The cost and availability of land is a major issue nowadays for the proper development. Effective use of available land which has weak strata, soils with very low shear strength and high compressibility is a suitable solution. Effective and economical way is the in situ ground improvement technique. Vibro compaction, vacuum consolidation, preloading, soil nailing are some of the recent techniques to improve the ground. Stone column is a technique in which a part of the soft soil is replaced with harder materials such as stones. Stone columns are extensively used in soft cohesive soils to improve bearing capacity of poor ground, stiffness of poor ground, shear strength of soil and to reduce the settlement of structure and liquefaction potential of soft ground. Stone columns can be end bearing or floating. If hard strata is unavailable for placing the stone columns, floating columns can be used.

The stone column technique is widely used to strengthen the ground to support embankment, oil tanks on poor ground, low-rise buildings, highway facilities, bridge abutments, air field applications etc. So it is necessary to find out a cost effective and environmental friendly technique. Mostly used stone column materials are crushed stone aggregates having size between 10 mm and 100 mm. But now the studies are going on to replace this costly material by alternate materials such as quarry waste, tyre chips, silica manganese slag etc. These materials are not only cost effective but also important in the point of view of environment. Use of waste materials will help to preserve nature and will provide a greater economy.

R. Ayothiraman et al., (2009) conducted an experimental study using shredded tyre chips as stone column material and they found that mix proportion of 20%T+80%S shows high load carrying capacity and mixture of 60%T+40%S and 40%T+60%S have load carrying capacity of stone column with only stone aggregates (100S). Combination of stone aggregates and tyre chips would give much higher load carrying capacity of stone columns due to higher interlocking of stone aggregates and tyre chips. Both materials are having same plastic deformation. This means that deformed or bulged stone columns does not regain its original shape during unloading even if tyre chips are used.

Tandel Y.K et al., (2012) conducted the experiment to compare the performances of an ordinary stone column and reinforced stone column. By reinforcement using geosynthetic ,sand columns are confined and the lateral bulging is minimized and the load capacity of the sand column can be increased and they also found that elastic modulus of the geosynthetic reinforcement plays an important role in enhancing the load carrying capacity of reinforced column due to the confining pressures.

Siva Gowri Prasad et al., (2015) conducted the experiment using silica manganese slag as stone column material with lateral reinforcement and found that Settlements are decreased when geotextile is used and the improvement in load carrying capacity of reinforced column also depends on the reinforcement depth. Maximum bulging has been found at half of the length of stone column for unreinforced column and for all reinforced columns, bulging is found just below the reinforcement depth.

S. Murugesan et al., (2010) studied the behaviour of single and group of geosynthetic reinforced stone column and found that there is clear improvement in the load capacity of the stone column due to encasement and the increase in the axial load capacity depends very much upon the modulus of the encasement and the diameter of the stone column due to the confining stresses generated. Encased stone columns will behave as semi rigid piles due to the increase in stress concentration with increase in modulus of encasement.

Mahmoud Ghazavi et al., (2013) conducted the experiment to find out the bearing capacity of non woven polypropylene encased stone column. They found that mode of failure in single stone column is by bulging and for group of column is by the combination of bulging and lateral displacement. Ultimate load carrying capacity of soft soil can increase by using ordinary stone column and ultimate load carrying capacity and stiffness of the treated soil can be increased by reinforcement.

K.Balan et al., (2013) studied the behaviour of geosynthetic encased quarry waste column. The results obtained are Inclusion of quarry waste column increases the load carrying capacity of the soil by about 175% by densifying the soil and the load carrying capacity and stiffness of the stone column can be increased by lateral reinforcement of column using natural geotextile and the improvement in load carrying capacity of reinforced column also depends on embedment depth.

A.P.Ambily et al., (2004) conducted an experimental and theoretical evaluation of stone column in soft clay. The results obtained are when column area alone is loaded, the failure is by bulging of the column with maximum bulging at 0.5 to 1 times the column diameter below the top and the load settlement behaviour when entire area is loaded is almost linear and it is possible to arrive at the stiffness of the improved ground and the stiffness obtained from model test compares well with that obtained from the finite element analysis.

II. OBJECTIVES OF THE STUDY

The main objectives of the study include:

- To compare the load settlement behaviour of end bearing and floating stone column using tyre chips and aggregates
- To compare the load settlement behaviour of geotextile encased end bearing and floating stone column using tyre chips and aggregates

III. MATERIALS AND METHODOLOGY

The study was conducted on kaolinite clay. Clay was brought from English India Company, Veli, Trivandrum. Stone aggregates were collected from the quarry near varkala and tyre chips collected from tyre shredding unit, Attingal.Geotextile was brought from Alappuzha. Initial properties of soil and aggregates were tested. Here shredded tyre chips and aggregates were used as stone column material and plate load test was carried out to determine the load settlement behaviour of the stone column prepared in a cylindrical tank. The plate load test conducted for stone column constructed using stone alone, tyre chips alone,50%Stones(S)+50%Tyrechips(T),30%S+70%T, 70%S+30%T ,clay bed alone and for encased stone columns.

A. MATERIALS USED

Initial properties of soil, tyre chips and aggregates were tested.Physical properties of coir geotextile were obtained from manufacturer. Tyrechips of size 10 mm is used and stone aggregates of representative size 10 mm is used. The initial properties of Kaolinite clay were given in Table I. Properties of aggregates were given in Table II. Tyre chips have water absorption of 2% and specific gravity of 1.2.Woven coir geotextile is used as encasement in the test and properties were shown in Table III.

TABLE I. INITIAL PROPERTIES OF SOIL

SOIL PROPERTIES	VALUE
Plastic limit (%)	23.4
Plasticity index (%)	11.5
Liquid limit (%)	34.9
Shrinkage limit	15.5
IS classification	CL
OMC (%)	24
Dry density(g/cc)	1.43
% clay	53
% silt	42
% sand	5
Specific Gravity	2.61
UCC (kN/m^2)	71
Free swell index	0.52

TABLE II. INITIAL PROPERTIES OF AGGREGATES

PROPERTIES OF AGGREGATES	VALUES OBTAINED
Size	Passing through 12.5mm & retained on 10mm
Bulk density	1.626g/cc
Specific gravity	2.90
Water absorption	1.168%

TABLE III. PHYSICAL PROPERTIES OF COIR GEOTEXTILE

CHARACTERISTICS	VALUES
Mass (gms/m^2)	900
Thickness at 20kPa(mm)	6.5
Aperture size (mm)	4.2×5.2
Initial tangent modulus at 5mm deformation	65-75 kN/m
Trapezoidal Tear Strength (cross machine direction)	0.15N
Trapezoidal Tear Strength (machine direction)	0.50N

B.PREPARATION OF CLAY BED

In order to study the load settlement behaviour of stone columns, plate load test were conducted. Studies were conducted on tank of size 500mm height and 400mm diameter. The plate load tests were formed on a stone column of 50 mm diameter and 450 mm length placed at the centre of the clay bed having height of 450 mm. The columns were designed as end bearing and floating for the test. The load was applied through a 12 mm thick M S plate whose diameter is equal to twice the diameter of the column in order to get an area replacement ratio of 25% and a sand mat is also provided below the plate [1].

Before the preparation of the clay bed oil was applied to the side wall of the tank in order to avoid the friction. Then centre of the tank was clearly marked and a PVC pipe having outside diameter 50 mm was placed at the centre and clay bed was formed around this pipe. For floating columns, after placing the first layer of clay bed then PVC pipe was placed at the centre. For geotextile encased stone columns, a geotextile was provided around the PVC pipe. Clay was filled at OMC to obtain maximum dry density. Clay bed was filled in 50 mm thick layers to obtain the desired height of 450 mm by compaction. After the completion of the clay bed reinforced portion was constructed. Stones and rubber chips were used in the stone column and they were carefully charged into the PVC pipe in layers after compacting each layer. Then this PVC pipe was removed. Then tank was covered with wet jute bag for 24 hours before the test.

IV. TEST RESULTS

Mixture of tyre chips and stones has better load carrying capacity than stone column using stones alone. This is because of the higher interlocking of the tyre chips and stones [2] .Mix proportion of 70%S+30%T shows better load carrying capacity and 50% replacement of stones with tyre chips also improved the load carrying capacity .Ordinary stone column and stone column using 70%T and 30%S shows similar performances. Results were shown in the Figure1. Efficiency of floating column can also improved by the use of tyre chips and aggregate mixture. This can be seen in the Figure 2.Here also 70%S and 30%T have the better load carrying capacity. So it can be inferred that mixture of tyre chips and stones can be used as stone column material.

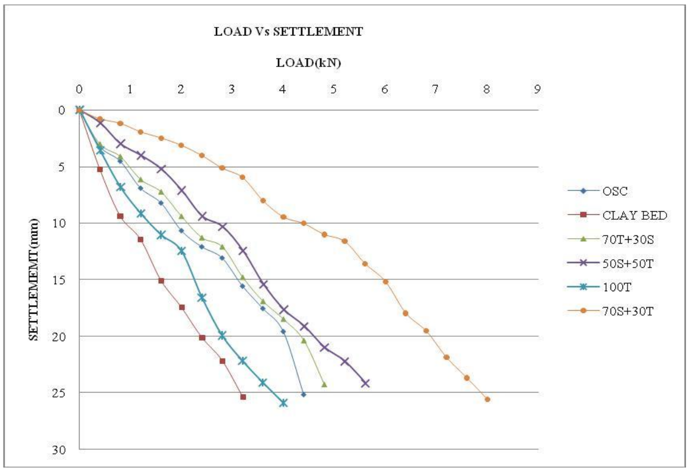

Fig.1 Test results for end bearing columns

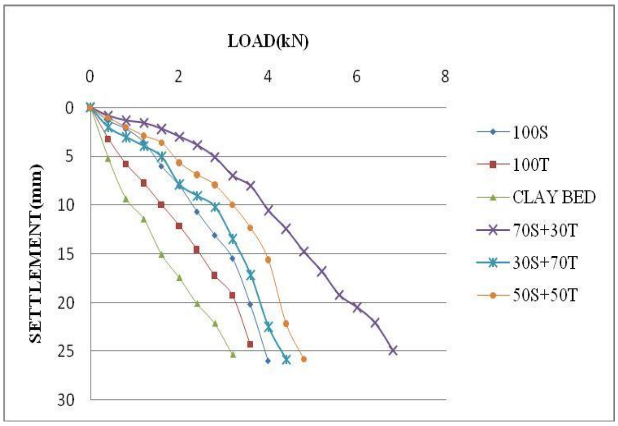

Fig.2 Test results for floating columns

Here the maximum load carrying capacity was obtained at 70%S+30%T for both end bearing and floating columns. So geotextile encasement was provided for this mix proportion and load settlement behaviour was studied. Comparison of test results for end bearing stone column with 70%S + 30%T with and without encasement were shown in Figure 3.Figure 4 shows the comparison of test results for floating stone column with 70%S + 30%T with and without encasement.

Fig.3 Comparison of end bearing columns with and without encasement

Fig.4 Comparison of floating columns with and without encasement

Here encased stone column shows better load carrying capacity than stone column without encasement for both end bearing and floating columns. Settlement also reduced due to the geotextile encasement. This is due to the confinement offered by the geotextile and the reduction in bulging. By comparing the geotextile encased end bearing and floating stone column, it is observed that end bearing column shows the better load carrying capacity .The results were shown in Figure5.

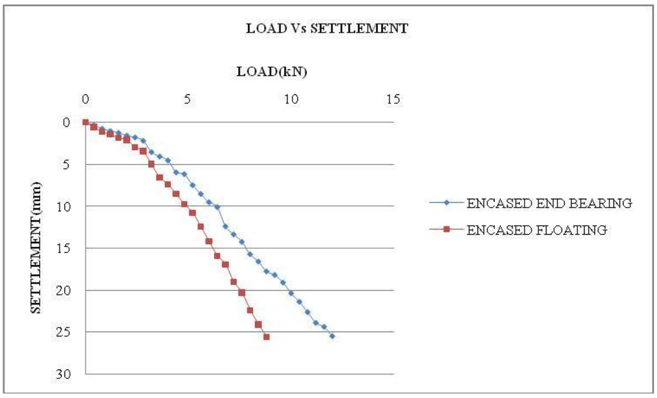

Fig.5 Comparison of encased end bearing and floating stone columns

V. CONCLUSIONS

In both end bearing and floating columns, mixture of 70%S and 30%T shows the better performance. From the analysis of results obtained from the end bearing and floating column, end bearing column with stone and tyre chips mix shows the better performance. On encasement, end bearing stone column shows the higher load carrying capacity. Reductions in amount of stone aggregate will lead to reduction in cost of stone column. Geotextile encased stone column using tyre chips and stone aggregates shows better performance than geotextile encased stone column with stone aggregates alone. Waste tyre chips from shredding plants can be used so this is an environment friendly technique also. This is very cost effective and efficient method which can be applied in the field.

REFERENCES

[1] IS 15284 (Part 1-Stone Columns), Design And Construction For Ground Improvement — Guidelines,2003

[2] R. Ayothiraman and Soumya — Use of shredded tyre chips as aggregates in stone column: an experimental study‖ Indian Geotechnical Conference,2009

[3] Tandel Y.K., Solanki C. H. and Desai A. K., ―Reinforced stone column: remedial of ordinary stone column‖International Journal of Advances in Engineering & Technology,Vol. 3, pp. 340-348, 2002

[4] S. Siva Gowri Prasad, Y.Harish and P.V.V.Satyanarayana ., ―Stabilization of Marine Clays with Geotextile Reinforced Stone Columns Using Silica-Manganese Slag as a Stone Column Material‖International Journal of Computational Engineering Research,Vol.05 ,pp.5-12,2015

[5] S. Murugesan and k. Rajagopal ., ―Studies on the behavior of single and group of geosynthetic encased stone columns‖ Journal of geotechnical and geoenvironmental engineering, ASCE,Vol.136(1),pp.129-139,2010

[6] Mahmoud Ghazavi and Javad Nazari A., ―Bearing capacity of geosynthetic encased stone column‖Geotextiles and geomembranes,Vol.38, pp.26–36,2013

[7] K. Balan, P. K. Jayasree and S. Thushara., ―Studies on natural geotextile reinforced quarry waste columns for soft soil stabilization‖ , Proceedings of Indian Geotechnical Conference,2013

[8] A.P. Ambily and S R Gandhi, ―Experimental and theoretical evaluation of stone column in soft clay‖, ICGGE,pp.201-206,2004