Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 50(6) (2019) 337-340
DOI: 10.22060/ceej.2018.12789.5269

Experimental Study of Single and Groups of Stone Columns Encased by Geotextile

S. H. Lajevardi*, S. Enami, H. R. Shamsi, M. Hamidi

Department of Civil Engineering, Arak Branch, Islamic Azad University, Arak, Iran

ABSTRACT: Stone columns are one of soil improvement methods that helps to increase the bearing capacity of soft soils. Therefore, finding ways to enhance their workability can be considerable. Bulging, known as the most important columns failure, can be dealt with by using suitable encasements. In this paper, single and group of stone columns were studied with and without geotextile encasement. Single stone columns with diameters of 63 and 82 mm and length to diameter ratio of 5 were tested. Results showed that by using geotextile, the bearing capacity of columns increased. Also, stone columns were tested in groups and their bearing capacities are compared.

Review History:

Received: 19 April 2017
Revised: 26 November 2017
Accepted: 1 January 2018
Available Online:12 February 2018

Keywords:

Stone Column
Geotextile
Experimental Study
Soil Improvement

1- Introduction

The bearing capacity and the settlement are considered two main criteria for columns designing. Constructing structures on soft soils causes destructive settlement and structure instability. Therefore, developing the soil improvement procedures have been considered by engineers. Stone columns are environment-friendly ways to improve soft clay, silt, silty sands and so on. The main role of stone columns is reducing the pore pressure and the load transferred to the soft soil. Using stone columns was begun from Europe around 1960. Failure is the main reason of columns failure due to loading. This, results in reducing the bearing capacity. The process of bulging [1], shear failure [2] and deflection and punching [3] as a failure state were already explained by different researchers.

In 2010 a series of tests were performed to compare shear strength of encased stone columns [4]. Results have shown that the bearing capacity of the stone columns increased by using geotextile encasement.

Small-scale experimental studies are mostly focus on analyzing the load-settlement behavior of stone columns [5]. Also different failure modes of stone columns are studied by some researches [6]. Some of these tests are performed with triaxial loading [7]. Furthermore, in 2005 different experimental studies with centrifuge method performed [8]. Tests on stone columns which are made in large boxes are presented the best simulation in laboratory [9].

In this paper, stone columns are studied in a large box test. Effectiveness of increasing the diameter and using geotextile encasement for single stone column were investigated. Furthermore, some tests have been performed on group of stone columns to investigate the effect of different columns numbers and formations and their encasement. Changes in the bearing capacity of stone columns which aren't placed under the loading plate were analyzed, as well.

Corresponding author, E–mail: sh-lajevardi@Iau-arak.ac.ir

2- Methodology

Properties of clay are achieved from different tests such as triaxial and Atterberg Limits tests. To select the moisture content corresponding to undrained shear strength of 13 kPa, a series of unconfined compressive tests were performed on specimens with different moisture. Results have shown that the moisture content of 21 percent is necessary to achieve shear strength of 13 kPa.

Stone columns were filled with sands with the maximum and minimum particle diameters of 2 and 11 mm, respectively. Also some tests were performed on sand to investigate its properties.

In some tests geotextile with secant stiffness of 16.5 kN/m was used as the encasement. Based on the law scale [10] the stiffness scale of geotextile in laboratory equals to laboratory scale power two which is 1:100.

2- 1- laboratory model

The large box (90×120×120 cm^3) was filled with a clay with moisture of 21 percent and bulk unit weigh of 19 kN/m^3. Then a stone column with the bulk unit weigh of 15.5 kN/m^3 was constructed in the box. The total number of tests in this paper are 10 (Table 1).

Table 1. Properties of experimental studies

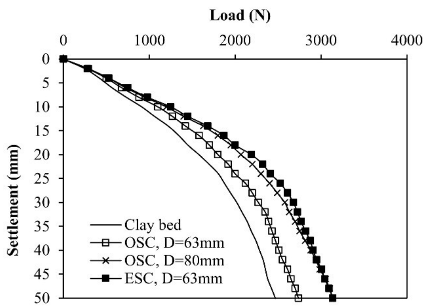
Test description	Stone column diameter (mm)		Diameter of loaing plate (mm)	Distance of stone columns center
	63	80		
Clay bed	1	180	180	-
Osc	1	1		-
Esc	1	-		-
Group of 7 oscs	1	-		
Group of 3 oscs	1	-	270	
Group of 12 oscs	1	-		
Group of 12 escs	1	-		
Triaxial group of 4 oscs	1	-		1.7 d
Square group of 4 oscs	1	-		

Note: osc= ordinary stone column, esc= encased stone column

Loading continued on to reach the settlement of 50 mm. All tests were controlled to have the fix speed of 2 mm/min. In addition, scale of all columns were 1:10 and length to diameter ratio of stone columns were 5. To ensure results accuracy all tests were performed twice.

3- Results and Discussion

In laboratory, two tests were performed on single stone columns without geotextile encasement and diameters of 63 and 80 mm. One test is also conducted on geotextile encased stone column with diameter of 63 mm. Figure 1 illustrates the bearing capacities of different tests with settlement variations.



Note: osc= ordinary stone column, esc= encased stone column

Figure 1. Load-settlement behavior of single stone columns

According to Figure 1, the bearing capacities of columns increased when the diameter of columns were raised. Using geotextile encasement also increases the bearing capacity. In addition, some tests were performed on group of columns to investigate the effect of columns located at the periphery of a column in the center (with different formations) plus effect of geotextile encasement. Square and triangle formations were also used. Figure 2 shows seven-column formation as an example.

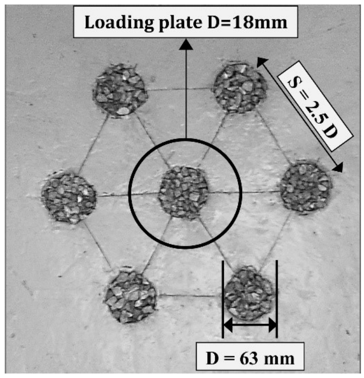


Figure 2. Arrangement of groups of seven stone columns

4- Conclusions

In this study some tests were performed on single and group of stone columns with changes on some effective factors of them. Some results can be considerable:

- Bearing capacity of stone columns increased by using geotextile encasement and rising the diameter. This increase for columns with the diameter of 63 mm is 14.62 %.
- Placing other columns around a single stone column caused a bearing capacity increase of 6.3 % which is less than the effectiveness of geotextile encasement.
- When loading on group of stone columns, those which are not under loading plate caused an increase of 8% on the bearing capacity. This increase is more than the same state for single stone columns.
- In group of stone columns, the same as single columns, using geotextile cases an increase on the bearing capacity. This increase for group of columns is achieved 29.7 %.
- Square formation in group of stone columns increases the bearing capacity more than 5% compared with triangle formation.

Reference

[1] J.M.O. Huges, N.J. Withers, Reinforcing of cohesive soils with stone columns. Ground Eng, (1974) 7 (3) 42-49.

[2] M. Madhav, P. Vitkar, Strip footing on weak clay stabilized with a granular trench or pile. Canadian geotechnical journal, (1978) 15(4) 605-609.

[3] H. Aboshi, E. Ichimoto, K. Harada, M. Emoki, The composer—A method to improve the characteristics of soft clays by inclusion of large diameter sand columns. Proc., Int. Conf. on Soil Reinforcement. E.N.P.C., 1, Paris, (1979) 211-216.

[4] S. Murugesan, K. Rajagopal, Studies on the behaviour of single and group of geosynthetic encased stone columns. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 136(1) (2010) 129-139.

[5] H. Yung-Shan, W. Cho-Sen, Y. Yi-Sheng, Model tests on geotextile-encased granular columns under 1-g and undrained conditions. Geotextiles and Geomembranes, 44(1) (2016) 13-27.

[6] J.F. Chen, L.Y. Li, J.F. Xue, S.Z. Feng, Failure mechanism of geosynthetic encased stone columns in soft soils under embankment. Geotextiles and Geomembranes, 43(5) (2015) 424-431.

[7] V. Sivakumar, DKNM. Jeludine, A. Bell, DT. Glyn, P. Mackinnon, The pressure distribution along stone columns in soft clay under consolidation and foundation loading. Geotechnique, 61(7) (2011) 613-620.

[8] BI. Kim, SH. Lee, Comparison of bearing capacity characteristics of sand and gravel compaction pile treated ground. KSCE Journal of Civil Engineering, 9(3) (2005) 197-203.

[9] M. Ghazavi, J.N. Afshar, Bearing capacity of geosynthetic encased stone columns. Geotextiles and Geomembranes, 38 (2013) 26-36.

[10] S. Lai, Similitude for shaking table tests on soil structure fluid models in 1g gravitational field. Soils and Foundations, 29(1) (1989) 105-118.

Please cite this article using:

S. H. Lajevardi, S. Enami, H. R. Shamsi, M. Hamidi, Experimental study of single and groups of stone columns encased by geotextile, *Amirkabir J. Civil Eng.*, 50(6) (2019) 1053-1060.

DOI: 10.22060/ceej.2018.12789.5269