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Experimental investigation of the mechanical properties of geogrid reinforced stone column groups

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Abstract

Increasing trend in the population density of the cities causes rising demand on high rise construction projects. High-rise structures bring high vertical loads on foundation soils. Especially in shallow foundations built on weak soils, large amounts of soil settlements may occur due to high vertical loads, which can cause varying levels of damages to the superstructural load bearing elements. In weak soils accommodating high liquefaction potential, settlement and stability problems, it becomes generally necessary to establish piled foundations or to use soil improvement methods under the building foundations since sole application of shallow foundations may not be sufficient to transfer superstructure loads to the soils. At this point, stone columns appear as one of the economical and efficient soil improvement solutions. Within this study, a physical modeling study were performed on small-scale stone column group models. The deformations and the pressure acting on the stone column group were monitored during the tests. The performance of ordinary stone columns was compared to those of the stone columns wrapped with geotextiles. It was observed that wrapped stone columns may handle higher foundations loads for the same deformation levels.

Introduction

Stone columns are considered as one of the important soil improvement methods in the field of geotechnical engineering. The stone column method was first used in France in 1830 and in the United States in 1972. The stone column technique was adopted in European countries in the early 1960s. In the following decades, it became more widespread [1]. The theoretical studies regarding the design of stone columns were performed in these years. In one of these studies, Han et al. developed a simplified theoretical closed form solution for the capacity and consolidation ratio estimation of stone column reinforced soils [2]. Rao et al. carried out loading tests for single and group stone columns. The results for the stone columns having a center to center spacing of 2 m indicated that the settlements were within good limits after the application. In the preliminary design phase, it is recommended to determine the amount of settlement in the stone columns and to determine the most effective interval in the design to increase the feasibility of the project and reduce the cost [3]. In a thesis study, physical model experiments were carried out to examine the loading behavior of the stone column reinforced clayey soils. Besides single stone columns, stone columns groups were also studied by model experiments. The length and diameter of the stone column and the distances of the stone columns to each other were changed to observe their effect on the bearing capacity [4]. In another study, it is seen that the longer stone columns behave more rigid when compared to shorter ones in terms of bearing capacity. When the behavior of stone column groups is compared, it is seen that long columns exhibit more rigid behavior when a vertical load higher than 820 kN is applied to the column top [5].

In this paper, the results of a study carried out on model stone column groups were reported. This study was funded by Mersin University Scientific Research Projects Office under project number 2021-1-TP2-4293. The equipment used in this project was integrated into Mersin University Geotechnical Engineering Laboratory as a result of extensive research and design processes. Within this study, the load-deformation characteristics of model scale stone column groups having different center to center spacing values were investigated. Loading tests were performed using a custom manufactured hydraulic loading press with a novel electronic speed controlled integrated in the test setup. Besides, the data acquisition system was also specifically manufactured for this study. Besides the center-to-center spacing values for the stone columns, the effect of geosynthetic wrap applied along the columns were investigated in this research. It was observed that there exists an optimal spacing for the stone column applications. The geosynthetic wrapping provides additions confining support for the stone columns which lead to smaller vertical deformations under the same loading.

Material and Method

Physical modeling tests of this study were performed in Mersin University Department of Civil Engineering Soil Mechanics laboratory. For the tests, a custom sand box was used to prepare the sand bedding for the stone column group.

For the filling of the bedding box, 856 kg granular sandy material with a relative density of 40% was utilized in such a way that the box was filled for every 10 cm lifts. Sand weighing 171.2 kg was weighed and firmly filled by hitting the steel plate 25 times. This process was repeated until a height of 50 cm sand fill was achieved. The experiments were carried out on wrapped and unwrapped stone column groups having a center to center spacing (s) value of 2×D, 3×D, 4×D distances where D denotes the diameter of the stone column. In order to form geogrid wrapped stone column groups with s=2×D, 3×D, 4×D spacing, a two-dimensional geogrid having 40mm×40mm spacing were brought into a cylindrical shape where it would be installed in a 100 mm diameter PVC pipe. The aggregate which will form the stone column body were poured into the PVC pipe where geogrid wrapping was present around the inner side of the PVC pipe. The geogrid material with a tensile strength of 10 kN/m was placed with the help of construction wire. Sand was compacted and placed in every 10 cm layer and at the same time, the aggregates were compacted and placed with the help of a hammer. When the 10 cm layers were completed, the guide was pulled up and the geogrid was ensured to completely surround the stone column. It was placed on the sand by means of a plumb line, centered on a 60x60 cm steel plate. It is fixed on it with the help of hydraulic piston. The 110 kN loading plate was slowly acted upon by the motor driver. The reading values were transferred to the data acquisition unit with LVDT and load cell to the computer environment. This section is shown in Figure 1.

Figure 1. The test setup used in this study

Results

Load-displacement curves for stone column graphs having different characteristics were depicted in Figure 2. It was observed that the wrapped type stone columns are providing the best load carrying capacity under the same deformation. Besides it is observed that, the center to center spacing of the stone columns are also an important factor in determining the load bearing capacity of the stone columns. At the end of the tests, the granular sand material around the columns were partially removed. As an example, the deformation in geogrid-wrapped stone columns at the end of a typical tests were shown in Figure 3.

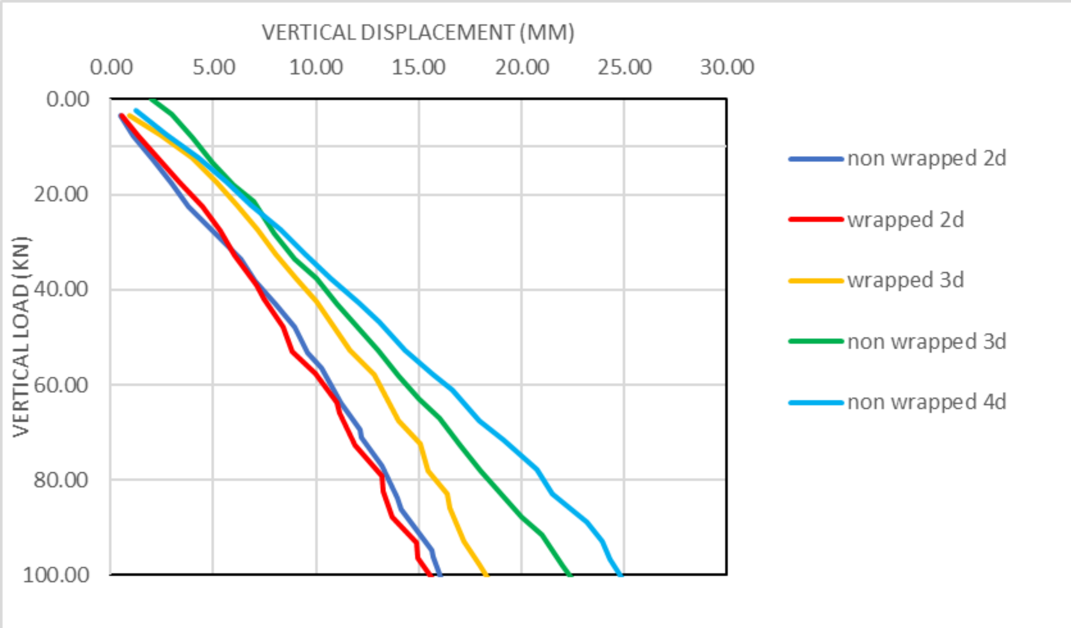

Figure 2. Load-displacement behavior for stone column groups having different characteristics

Figure 3. The bulging effect in geogrid-wrapped stone columns

Conclusion

Results of the tests indicated that there is a significant improvement in the load carrying capacity of the stone column groups when a geogrid wrap is used along the column surface. Since the geogrid layer is serving a confining material, it decreases the typical budging type deformation of the stone columns. Eventually, under high loads, the geogrids are also yielding and the bulging type deformation occurs. Considering a vertical load of 100 kN , it is observed that displacements up to 14.45 mm occurs for the unwrapped stone column groups having 2×D center to center spacing. For the wrapped stone column groups having 2×D center to center spacing, a displacement of

15.68 mm was observed under the same load. When the stone column groups having 3×D center to center spacing were compared for the unwrapped and wrapped type, it was observed that 22 mm deformation was occurring for the unwrapped whereas 18.2 mm deformation is occurring for the wrapped stone columns. This will translate into an additional load carrying capacity of 18%. The center to center spacing for the stone columns in the group is observed to be a very important parameter in the response and this effect is more pronounced for the unwrapped type stone column groups. A comparison of the unwrapped stone columns groups having 3×D and 4×D center to center spacing presents around 18 mm deformation for the first case and 25 mm deformation for the second case. This translates into 39% reduction in the load carrying capacity of the group.

References

1. Ambily, A. P., & Gandhi, S. R. (2004). Experimental and theoretical evaluation of stone column in soft clay. *ICGGE-2004*, 201-206.
2. Han, J., & Ye, S. L. (2002). A theoretical solution for consolidation rates of stone column-reinforced foundations accounting for smear and well resistance effects. *The International Journal Geomechanics*, *2*(2), 135-151.
3. Rao, L., & Madhira, M. (2010, December). Evaluation of optimum spacing of stone columns. In *Indian Geotechnical Conference. GEOtrendz. December* (pp. 16-18).
4. Sarıcı, T. (2014). *Geosentetik ile güçlendirilmiş taş kolonların taşıma kapasitesinin analizi* (Master's thesis, İnönü Üniversitesi Fen Bilimleri Enstitüsü).
5. Kanmaz H. (2014) Performance of Rigid Columns in Different Soil Environments (Master’s thesis, Istanbul Kultur University, Institute of Science and Technology).