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Experimental Investigation on the Effect of Geometry and Reinforced Floating Stone Columns on Bearing Capacity

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1- Introduction

Using stone columns is one of the most effective ways to improve the bearing capacity of soft soils. The stone column increases the bearing capacity of soft soil, decreases settlement, increases drainage and finally demolishes the extra pore water pressure. Another asset of this method is its feasibility in construction and implementation. Van Impe pioneered the idea of using geosynthetic encasement for increasing the bearing capacity of stone columns. In fact, using geotextile surrounding the stone column increases the lateral pressure, and the geotextile prevents penetration of gravel material of the stone column into soft soil, thus, the bearing capacity significantly increases. Stone columns are divided into short and long groups. Actually, the stone column is considered to be long if its length to diameter ratio is more than 5. Practically, most stone columns are long. If the soft layer is thin, the end of the stone column is placed on the resistant layer; but in most projects, the height of stone columns is not that much to reach the resistant layer, so in most cases, the stone column is floating. In previous research studies, most stone columns were placed on hard bed, and the impact of the floating stone columns has been scarcely analyzed while stone columns are implemented in a floating type in most projects. Thus, in this study by the means of large-scale experiments, it was intended to measure the bearing capacity of floating stone columns in two reinforced and unreinforced states having different lengths and diameters. The lengths of stone columns determined in a way that the impact of the reinforcements on the two types of short and long stone columns in the floating state would be possible to be analyzed.

2- Experimental setup

In this research, a large test chamber with dimension of $90 \times 120 \times 120$ centimeters was used as the main reservoir. The loading system included the loading frame, loading inducing system, loading plate and data collection system. The data collection system included a computer, data registration system, 2 devices for measuring displacement and 2 load-cell devices. Loading was based on displacement control and its speed was selected as 1 millimeter/minute. The loading plate was 20 centimeters in diameter and 3 centimeters in thickness and it was made of hardened steel. All tests were done until the loading plate completely subsided 50 millimeters. Seven large scale experiments were carried out according to Table 1.

Table 1.Summary of experimental program

Test Description	Test Name
Without stone column	Clay
Ordinary stone column with 60mm diameter and 200mm length	OSC6-20
Ordinary stone column with 60mm diameter and 350mm length	OSC6-35
Ordinary stone column with 80mm diameter and 400mm length	OSC8-40
Encased stone column with 60mm diameter and 200mm length	ESC6-20
Encased stone column with 60mm diameter and 350mm length	ESC6-35
Encased stone column with 80mm diameter and 400mm length	ESC8-40

3- Results

According to Fig 1, by using stone columns OSC6-20 and OSC6-35, the bearing capacity in 50-millimeter settlement increased 11 and 22 percent, respectively, while the OSC8-40 sample showed a 38-percent increase. The bearing capacity increased in case of reinforcement of stone columns in a way that the samples ESC6-20, ESC6-35 and ESC8-40 had a respective increase in bearing capacity of 20, 38 and 69 percent in the state of 50-millimeter subsidence (Fig.2). In fact, the lateral pressure around the stone column increased by using geotextile encasement around it; and this reinforcement prevented penetration of the material of the stone column into the surrounding soft clay. In the state of 50-millimeter settlement, the percentage difference of increase in bearing capacity in the samples OSC6-20, OSC6-35 and OSC8-40 were 9, 11 and 31, respectively before and after reinforcement. Thus, it is considered that reinforcement of a stone column with a longer diameter is more effective than that of one with a longer length as the radial strain of the reinforcement agent increases by an increase in the diameter of the stone column.

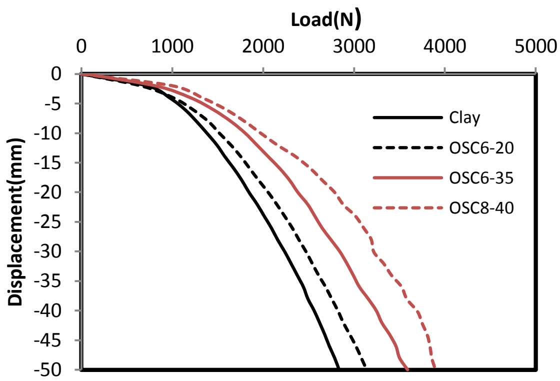

Fig 1. Load settlement variations of ordinary stone columns

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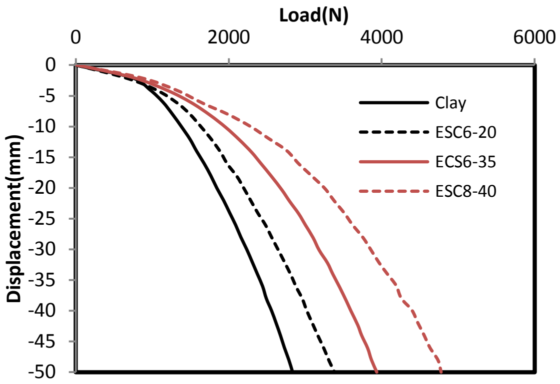

Fig 2. Load settlement variations of encased stone columns

4- Conclusin

In this study, by the means of large-scale experiments, it was intended to measure the bearing capacity of floating stone columns in two reinforced and unreinforced states applying different lengths and diameters. The following results were achieved:

1- The bearing capacity increased by using stone columns, and the efficiency of the stone column increased by an increase in its length and diameter.

2- While the samples OSC6-35 and ESC6-35 had a greater length-to-diameter ratio in comparison with similar samples with an 80-millimeter diameter, they had less bearing capacity. Thus, it is considered that an increase in the diameter of the stone column is more effective than an increase in its length.

3- The lateral pressure around the stone column increased by using geotextile encasement around it; and this reinforcement prevented penetration of the material of the stone column into the surrounding soft clay. Moreover, the bearing capacity increased.

4- The post-experiment observations demonstrated that the failure of the stone column OSC6-20 was due to being punched, and that of the stone columns OSC6-35 and OSC8-40 was due to lateral expansion (bulging).