Physical Modeling of the Effect of Stone Column Location on the Behavior of Strip Footing near Soft Soil Slope

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Extended Abstract

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Introduction

Bearing capacity is very important in geotechnical engineering, which depends on factors such as footing shape, stress distribution under footing and failure mechanism of soil. Construction of the footing near a slope affects the behavior of footing and reduces the bearing capacity. Also, construction of structures on soft soil usually involves problems such as excessive settlement, deformation and stability problems. In order to increase the bearing capacity, especially in soft soils, one method is adding stone columns to soils. In this method 15 to 35 percent of unsuitable soil volume is replaced with appropriate material. In this research, the bearing capacity and settlement of a strip footing on a clayey slope reinforced with stone columns is investigated. For this purpose, a series of small-scale model tests was performed on the slope reinforced with both types of ordinary and vertical encased stone columns. The effects of length of stone column and location of stone column on the behavior of footing was studied and the optimum length of column and best location for column were determined. Also, some tests were performed on the effect of group stone columns on the footing and the efficiency of columns was investigated.

Material and methods

In order to determine properties of clay soil, stone column and encasement material, some preliminary standard tests were performed. The stone column material was selected with aggregate size ranging from 2-10 mm considering the scale effect. The performance of stone column depends on the lateral confinement provided from the surrounding soil and this lateral confinement represents undrained shear strength of the soil. In very soft soils (cu<15 kPa), the lateral confinement is not adequate and the stone column cannot perform well in carrying the required bearing capacity. For this reason, a series of undrained shear strength standard tests were carried out on clay samples with different water contents. According to these tests, the amount of water content of clay related to cu-15kPa was equal to 25%; while the natural water content of the clay was 4%. Therefore, the additional amount of water was weighted and added to clay. The apparatus of this research was consisted of two main parts including a test box and a hydraulic loading system. The test box dimensions should be such that for all states of the tests, the stress in the soil applied from the loading would be almost zero at all boundaries of the box. Thus, a box was built to accommodate the clay slope with 150 cm×120 cm×30 cm dimensions. The test box was built using steel material and steel belts were welded around it to prevent the deformation at high loads. The front side of the box was made from two pieces of tempered glass and a 10 cm×10 cm grid was drawn on them, for making the slope during construction and observation of deformations during the loading easier. The model strip footing dimensions were 29 cm length, 10cm width and 4cm height and it was made from steel to have no deformation during the loading. The displacement of the footing was measured using two dial gauges with accuracy of 0.01 mm.

The clay was filled in the test box in 5 cm thick layers and compacted with a special 6.8 kg weight tamper. All model stone columns were constructed using the replacement method. In this method, a 10 cm diameter open ended steel pipe was inserted into the soil and the clay within the pipe was excavated. Then the stone column material charged into the hole in 5 cm layers and each layer was compacted using a 2.7 kg special circular steel tamper with 10 blows. The 5cm compactions were repeated until the construction of ordinary stone column was completed. For construction of vertical encased stone columns, the cylindrical encasement mesh should be constructed first. Then, after excavating the hole, the prepared encasement mesh was placed inside the hole and the aggregates were charged into the hole in 5 cm layers and compacted.

Results and discussion

The loading method used in all tests was a stress control method. Bearing capacity values were determined from pressure-displacement diagrams using tangent method. All test results show that when any type of stone columns was added to slope, the bearing capacity of adjacent footing was increased. Vertical encasing of stone columns leads to a further improvement in the behavior of the footing. Influence of length of ordinary stone columns on the behavior of strip footing near clayey slope, was studied for four different lengths. Results show that, the optimum length of stone columns giving the maximum performance is about 4 times their diameter. Also, the location of column for both ordinary and vertical encased stone columns was studied using a series of laboratory tests and results show that the best location for the stone column is right beneath the footing. Also, group stone column tests resulted that for both ordinary and vertical encased types of stone columns, the group of two columns had a better efficiency than the group of three columns.

Conclusion

In this investigation, some model tests with 1/10 model scale on a strip footing near a clayey slope reinforced with stone columns were performed and the effects of different parameters such as stone column length and location were studied. Based on results from experiments on different states of stone columns, the following concluding remarks may be mentioned:

- The maximum encasement influence was observed when the encased stone column is placed under the footing.
- The optimum length of ordinary stone columns which are placed beneath the strip footing gives the maximum performance more than 4 times to their diameter.
-Bulging failure mode governs when the stone column is placed under the footing. When stone column is not beneath the footing, the failure mode was lateral deformation.

- Comparing the different locations of stone columns in the slope shows that for both ordinary and vertical encased stone columns, the best location having the most influence on the strip footing is under the footing and with increasing the spacing between column and footing, the bearing capacity is reduced.

Keywords: Encased stone column, bearing capacity, strip footing, slope, clay

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