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Improvement of Soft Clay Using Geosynthetic Encased Stone Columns, Considering Pre-bulging

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Abstract

The use of geosynthetic encased stone columns as a method for soft soil treatment is extensively used to increase the bearing capacity and reduce the settlement of raft foundations and the foundation of structures like embankment. Pre-bulging is an effect occurring during stone column installation due to the compaction of the material in the column. The present study uses Plaxis to present a numerical analysis of the soft clay bed reinforced by geosynthetic encased stone column and the pre-bulging action in the encased column during installation has been considered in the analysis. The results of the analysis show that improved stiffness of the encased stone column is not only due to confining pressure offered by geosynthetic after loading; but the radial expansion of the stone column occurred during installation also contributes to the enhancement stiffness of the stone column and the reducing settlement.

Keywords: Stone columns, Geosynthetic encasement, Unit-cell model, Hoop tension force, Pre-bulging

1. INTRODUCTION

Some problematic soils like soft clay deposits, peat soils, recent fills, marine clays, etc. posses problems in construction because of low bearing capacity, high compressibility, tendency for lateral flow, etc. These grounds need treatment for improving their engineering behaviour as per the design requirements of the structure. One common approach for treating soft clay soil is stone columns installation. The beneficial effects of stone columns are increased stiffness, reduced settlements, increased time rate of settlements, increased shear strength, and reduction of the liquefaction potential of soft ground (Barksdale and Bachus,1983). When the stone columns are installed in extremely soft soils, the lateral confinement offered by the surrounding soil may not be adequate to form the stone column and the bulging of stone columns will be more leading to larger surface settlements rendering the efficacy of the stone columns to very low. This is a major limitation of the stone column technique especially in very soft soils. One method for improving the performance of the stone columns installed in such soils is wrapping the ordinary stone column by a suitable geosynthetic (geogrid or geotextile) in a tubular form. This type of encasement by geosynthetic imparts addition lateral confinement and makes the stone columns stiffer and stronger. In addition when the stone columns are encased in geosynthetic, it promotes the vertical drainage function of the stone column by acting as a good filter to prevent fines from mixing with the stone material. Expansion of stone material and consequently lateral bulging of the stone columns due to vertical loading, will induce a hoop tension force in the encasement and develop additional confining stress to the stone columns which helps in increasing the bearing capacity of the stone column and decreases the rate of the settlement (Deshpande and Vyas 1996). However, for very soft soil, the generation of this force requires a high radial expansion of the stones, which in turn means high axial deformation of the stone column and it depends on the vertical pressure over the bed, which can be small. In low vertical pressure, little expansion is occurred and encasement has no significant effect on improving the stone column performance. To enhance the performance of the geosynthetic encased stone columns in low surcharge, the stone column stiffness must be increase. The compaction of the stones and consequent radial strain of the stone column with the prefabricated geosynthetic cage to its final diameter will pre-strain the geosynthetic encasement (lo et al. 2009).

As pointed out by Christoulas et al. (1997), distributions of fill load depend on the relative stiffness of the stone columns and the soil between their spacing. The stiffness of a stone column is affected by the selection of its material and the pre-confining stress of the geosynthetic, if it is geosynthetic encased. The stiffness of a soil is affected by its initial properties and its disturbance during stone column installation. These influencing factors, in total, determine the relative stiffness of stone columns and the soil between their spacing. lo et al.