Effects of Geometric and Mechanical Parameters on the Behavior of Stone-Columns- Numerical Investigation

Abstract:

Soil improvement has a key role in solving geotechnical problems, especially when construction has to be done in problematic soils. A variety of techniques have been developed to enhance the soil characteristics, among which using stone-columns has proved to be a practical and cost-effective method. Researches and practical experiences revealed that replacing the soft soil with stone columns, enhances the mechanical properties of the ground, which results in smaller settlements and larger bearing capacity. In addition, stone columns can effectively increase the rate of consolidation and mitigate the liquefaction susceptibility of saturated granular soils. The key advantages of this method are the availability of materials, simplicity of installation, and short construction time. Stone-columns can be used for various ground improvement purposes including the foundations used for supporting water and fuel storage tanks.

Many analytical, numerical, and experimental researches have been performed for studying the behavior of stone-column improved grounds. In spite of the researches conducted in recent decades, the influence of geometric and mechanical parameters on the settlement reduction still needs more investigations. In this thesis, the effects of various geometric, material, and loading parameters related to stone-column improved grounds are investigated using a numerical approach. In this context, the governing differential equation of the problem is obtained and it is solved using a finite difference numerical method. The major parameters that are studied in this thesis are the diameter and spacing of the columns, relative stiffness of the columns and the soil, bearing capacity of the soil and stone-columns, and shear resistance of the granular bed. Another major parameter that is explored is the nature of loading. For this purpose, various types of static and dynamic loadings are applied to the models, and the major differences between the static and dynamic behaviors are highlighted.

The obtained results show that using stone-columns, leads to transfer of stress from soil to column and has a notable impact in reducing the ground settlements. Several parameters such as bearing capacity, shear strength of the granular bed, column spacing and diameter, and relative stiffness of column to soil can significantly affect the performance of the stone-columns. Among these parameters, the relative column-soil stiffness has larger impact on the stone-column improved ground performance. Furthermore, it is observed that the stone columns can increase the consolidation rate significantly. The major result obtained regarding the dynamic response, is the importance of space to diameter ratio. It is found that the trend of settlement in various locations

below the foundation subjected to dynamic loading is not predictable, and the space to diameter ratio of the stone-columns should be selected carefully considering the project goals.

Keywords: soil improvement; stone-column; dynamic behavior; numerical modeling; finite difference method