Parametric and Numerical Study on Soft Ground Improvement using Stone Column Reinforced with Geogrid

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Extended Abstract

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Introduction

The design engineers usually follow a specific decision-making process for optimal selection of the type of required foundation and its design. In this state, in case the surface foundation is not appropriate for the project conditions, before making any decisions about the use of deep foundations, the proper methods for optimization of the liquefied soil should be evaluated in order to compare the advantages and disadvantages of each of them with those of deep foundation, in terms of efficiency, implementation problems, costs, and finally to select the best choice. One of the best methods of soil improvement is the use of stone columns. The rationale behind the use of stone columns is the high shear strength of materials and the provision of lateral grip by surrounding soil. Therefore, the stone column can receive the load from the structure, and transfer it to the resistant layers. In the soils with low shear resistance, the lateral constraint crated by the surrounding soils is not enough for preventing the sideway buckling of the column under which is subjected to the loads. Thus, special measures should be considered for the use of stone columns in these soils. One of these methods is the use of reinforcement shelves such as geogrid and geotextile. Investigating the previous studies, the lack of evaluation of the design parameters such as the settlement ratio of the soil improved by the reinforced stone column to the geogrid, and provision of design graphs in this regard, has been revealed. Therefore, by extension of the studies conducted by Chub Basti et al. in 2011, the design graphs were provided in this regard.

Material and methods

The PLAXIS V8 Software was used for mode~~l~~ling the soft soil improved by the stone column. For increasing the precision of the results, the 15-knot element was used in the current study. The fine mesh was used in the models made for the analysis of the problem. For simulation of the improved soft soil with the stone column in a single cell, the mode~~l~~ling was implemented in a two-dimensional environment in axial symmetry conditions. In the current study, it was assumed the rigid foundation is on the improved bed. Thus, for analysis of the simulated model, a vertical strain up to 2% of the soft soil height has been applied on the ground. Also, for simulation of the soil behavior, an appropriate model of soil and parameters proportional to the materials should be allocated to the construct geometry. The non-linear stress-strain of the soil in different levels of the problem can be simulated. The number of model parameters increases with the level of problem rupture. For precise simulation, we need the proper parameters of the materials. For modeling of soft soils and stone columns, elastic-plastic model with Mohr-Coulomb rupture criterion was used. In the current study, it was assumed the soft bed is located on a very hard layer of soil. Therefore, the vertical deformation was prevented on this horizontal boundary. Also, the horizontal deformation in two vertical edges was prevented and only deformation in vertical direction was allowed. The soft bed close to saturation was considered without the determined free water level. For models with stone columns, the element of interface between the stone column and soft soil, has been used. The reason behind using this element is that the stone column rupture is of shear form and due to this, a significant shear stress is created on the common surface between the stone column and soft soil. The percentage of the replacement area is defined as the ratio of the total area of the stone columns to the total area of the non-improved area. In the current study, the percentage of the replacement area is utilized between 10 to 30%, which is used in implementation. Also, the diameter of the stone columns is from 0.6 to 1.2, in the analyses.

Results and discussion

The results of the numerical study were compared with the existing theoretical relationships provided by Poorooshasb and Meyerhof (1997), and Pulko et al. (2011). Figure 1 shows the comparison of the replacement percentage (RP) and settlement ratio (SR) in the non-reinforced state in the current study as well as theoretical relationships proposed by the previous researchers. Based on this figure, there is a difference between the results of the current study and those of Poorooshasb and Meyerhof (1997), and Pulko et al (2011). Poorooshasb and Meyerhof (1997) calculated the settlement ratio in their proposed material with the assumption of linear elasticity of the materials without consideration for plastic settlement. Therefore, the settlement of the improved soft soil with stone column, calculated by Poorooshasb and Meyerhof, would not show the real amount. However, Pulko et al. (2011), with consideration for the elastoplastic behavior of the materials, the lateral expansion of the stone column, and the primary stress of the soil around the column, provided more realistic results that correspond closely with the present study. Also, for designing the stone column, the results of its reinforcement have been also provided in the graph presented in Figure 2. Thus, by the use of these graphs, the ratio of settlement reduction can be obtained for each distance between columns and with different percentages of alternatives.

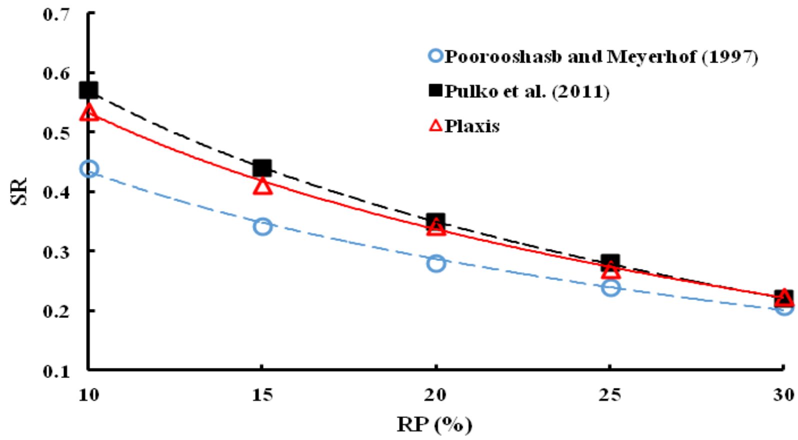

Figure 1. Comparision of SR in unreinforced stone column

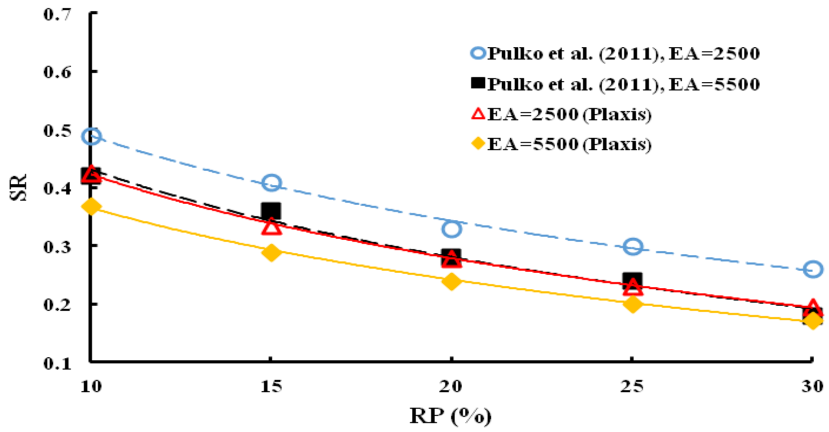

Figure 2. Comparision of SR in reinforced stone column

Keywords: soil improvement, stone column, geogrid coating, bearing capacity, settlement ratio.

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