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Investigating the effect of soil improvement by micropile method in marl soil: a case study of Bidboland, Khuzestan

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ABSTRACT: Based on a case study, the soil improvement operation under single foundations of a settled concrete structure has been presented using injected micropiles. Based on this, the effect of using micropiles in controlling the stress-deformation field created in the soil of the concrete structure has been studied. In order to evaluate the situation of the settlements, the necessary information was collected, including subsurface identification using geotechnical boreholes and settlement monitoring operations. The survey results before the soil improvement operations indicated the settlement of individual foundations and the continuity of the settlements. After the soil improvement operation, this trend reached zero. Using the Abaqus finite element software, a set of numerical analyses was performed on a concrete structure built on a loose foundation prone to destructive deformations in structural load-bearing members such as columns. In these simulations, in order to obtain the optimal performance of micropiles, the parameters of depth, diameter, and several micropiles were examined. The necessity of this research includes the decision to improve the soil of a settled concrete structure in the vicinity of the excavation based on the micropiles method or the destruction of the structure. The obtained results showed that the parameters of the length and number of micropiles have the greatest effect on the control of the deformation field and settlement of the structure. Also, the results show that the effect of the structure weight parameter on the interaction between the micropiles and the structure is significant.

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1- Introduction

One of the suitable methods to achieve the best soil improvement is to use micropiles elements. Micropiles are load-bearing elements that transfer loads, increase load capacity, and reduce bed settlements. These load-bearing elements are used today as a suitable method in the field of improvement, bed modification, and strengthening of structures, especially reinforced concrete structures, before and after the construction of structures [1, 2]. Based on the studies conducted by Tomasio et al., the use of micropiles as a solution to modify and strengthen the foundation of coastal concrete structures and breakwaters was investigated and analyzed. The obtained results clearly showed that the use of micropiles in this type of structure, which has specific geotechnical and geological conditions, will provide relevant results in the field of increasing the resistance of these types of structures and reducing the changes. Nevertheless, the researchers emphasized that the proper performance of these methods is highly dependent on ensuring the quality and implementation of this modification method [3]. In the research conducted by Duarte Correia, the effect of micropiles and injection under pressure on strengthening the foundation of old and traditional structures in Lisbon was investigated and studied. For this purpose and to choose the appropriate method, a series of analyzes and simulations were carried out using Plaxis software. The obtained results indicated the more appropriate performance of the micropiles method in modifying and improving the behavior of the foundations of structures and controlling the changes in locations and displacements created in the foundation of these structures [4].

2- Methodology

In this study, the foundation of a concrete structure in an industrial area excavated in its vicinity has been investigated. The choice of this structure is because, as a result of excavation and application of structural loads, the individual foundations, along with the joints of the building, have settled and reduced the bearing capacity. Figure 1 shows the concrete building with its adjacent excavation. This concrete building has one floor with six axes, A to F in the north-south direction and 4 in the east-west direction. In the southern part of this building, a 7-meter deep excavation was carried out; after the excavation, the foundations of the building deformed in the southern part.

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Fig. 1. The concrete construction near the excavation has suffered subsidence

The highest amount of vertical settlement is caused by excavation in the E1 foundation and is 120 mm. In order to identify the geotechnical conditions, two boreholes were drilled and laboratory tests and field tests were performed. The land on which the concrete skeleton structure is to be built is embanked in some parts. The thickness of the embankment made under and adjacent to this structure is at most 7 meters. This embankment contains clay particles along with coarse-grained stones, but the overall texture of the fine soil is made up of clay with low density. Based on the monitoring of mapping and progressing displacements, studies were conducted to improve the soil under and around the foundations. The necessary measures to prevent the process of progressive displacements include two stages preliminary measures and the final stabilization plan. In the initial steps, building a concrete retaining wall in the excavation area and filling the excavated space was suggested. The modeling performed in ABAQUS software requires the definition of the resistance characteristics of the soil, micropiles and foundations in order to simulate the pit and foundation soil. Also, based on the studies, the underground water level was not observed in any of the drilled boreholes. Therefore, the collected samples are dry and unsaturated.

3- Results and Discussion

In this part of the article, the results obtained from simulations and numerical analyzes performed in ABAQUS software were discussed. As mentioned earlier, in order to investigate the effect of micropiles on the bearing capacity of the foundation, the length of micropiles, the diameter of micropiles and the number of micropiles were examined and evaluated as design parameters, and the results obtained for each of these parameters are presented below. The amount of difference related to sitting is available in different lengths. The results of this analysis indicate that the amount of settlement decreases by 18% in the front and adjacent part of the excavation and by 0.8% in the rear part compared to the excavation, with the increase in the length of the micropile from 8 meters to 12 meters. Also, the amount of settlement decreases by 25% in the front and adjacent part of the excavation and by 0.9% in the rear part compared to the excavation, with the increase in the length of the micropile from 6 meters to 12 meters. In fact, it is clear that the increase in the length of the micro-piles leads to the control of the settlement in the area of influence of the micro-piles, and outside this area, the soil-structure interaction will not be affected by the increase in the length of the micro-piles. By increasing the micropiles length, the foundation's bearing capacity is increased. As a result, the amount of plastic strains in the environment of the soil and the structure is significantly reduced. In other words, with the increase in the length of the micropiles in the soil bed, the number of plastic strains and, consequently, structural displacements will decrease significantly, which is similar to some results presented in previous studies [5-9]. The amount of settlement by increasing the diameter of the micropiles from 0.032 m to 0.051 m (a 60% increase in diameter) decreases only by 0.18% in the front part and adjacent to the excavation and by 0.16% in the rear part compared to the excavation.

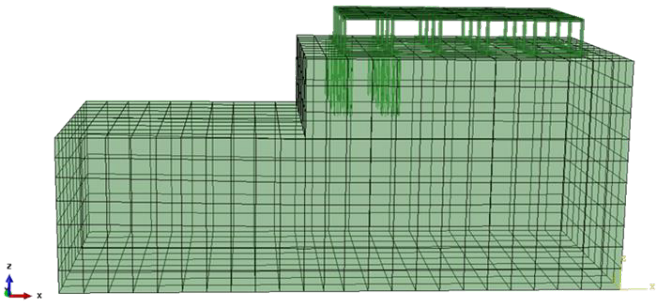

Fig. 2. Geometrical view of the concrete structure with excavation and micropiles

4- Conclusions

This article investigated the influence of micropiles on the amount of stress-strain, settlement, and displacement of the bed in a concrete structure in the vicinity of the excavation. The concrete structure had individual foundations, next to which excavation was carried out to a depth of 7 meters. With the start of excavation, the foundations of the structure began to settle, measured by monitoring the settlement amount and their displacement.

Then, soil improvement was made by combining the method of consolidation injection, contact injection, and the use of micropiles. In the studies, the length of micropiles 6, 8, and 12 meters were selected by default. The characteristics of the soil in terms of the standard infiltration number increased significantly from the depth of 7 meters onwards. For this reason and considering economic issues, 8-meter micropiles were used as the optimal length in the implementation. Since rubble had been poured at a distance of 0.5 meters below the foundations, grouting was done between these rubbles using contact injection to create cementation between them. Also, reinforcement injection with a diameter of 130 mm was performed around the individual foundations and outside the foundation.

References

[1] Budhu, M., Soil Mechanics and Foundations. 3rd edn, USA: John Wiley&Sons, (2011) 761.

[2] Byford, B., Hampton, M., Micropiles for re-support and lifting of two building under construction. International Foundations Congress and Equipment Expo. Orlando, Florida, United States, (2009) 383-389.

[3] Tumasio, R., Pinto, A., Pernao, J., Rehabilitation and Reinforcement of the Marina Expo Breakwaters, Lisbon, Portugal. Procedia Engineering, 143, (2016) 1511-1518.

[4] Duarte Correia, J, N., Reinforcement of building foundations. International Journal of Engineering & Applied Sciences, , 5, (2015) 1-8.

[5] Kumar, Jain Sanjaya, Mohammed Saleh Nusari, Dangol Purushotam, Acharya Indra Prasad, and Shrestha Rajyaswori, Effectiveness of geocell wall, geogrid and micropile anchors for mitigation of unstable slopes, Geoenvironmental Disasters 8, (2021) no. 1: 1-15.

[6] Malik, Bilal Ahmad, Mohammad Yousuf Shah, and Vishwas A. Sawant, Influence of micropile parameters on bearing capacity of footings, Environmental Science and Pollution Research : (2021) 1-10.

[7] Ying, Chunye, Xinli Hu, Sumi Siddiqua, Gehad Mohamed Hossam Makeen, Peng Xia, Chu Xu, and Qiang Wang. Model tests for observing the deformation characteristics of micropile boreholes during drilling in a soil-limestone mixture, Bulletin of Engineering Geology and the Environment, (2021) 1-21.

[8] Liu, Xueling, Jinkai Yan, Lei Liu, and Bing Han, Large-Scale Model Test of a Micropile Group for Landslide Control. Advances in Civil Engineering (2021).

[9] Lee, Seokhyung, Jin-Tae Han, Hyun-Sik Jin, and Seok-Jung Kim, 3-D Numerical Analysis for the Verification of Bearing Mechanism and Bearing Capacity Enhancement Effect on the Base Expansion Micropile, Journal of the Korean Geotechnical Society 37, (2021) no. 2: 19-31.

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