Iranian Journal of Engineering Geology
Spring 2022, Vol.15, No.1

Investigation of the effect of diameter, distance and angle of micropiles on the stability of slopes under steady state seepage

F.Pirmohammadi Alishah *[1], M. Mohammadrezaei [2]

Abstract

In urban areas, due to space constraints, one of the most important issues in the stabilization of slopes is to choose a suitable method for the slope with technical and executive considerations. This choice requires a thorough knowledge of the methods of stabilization of slopes. Despite the proper design and execution of slopes, a variety of natural and artificial factors in a particular period may greatly affect their stability. In this study, the subject of which is to investigate the effect of micropiles on the stability of gables under the effect of steady-state seepage, seepage analysis was performed using Seep / W software and finite element method, assuming unsaturated saturation flow and in steady-state flow. Also, using Slope / W software, slope stability in different conditions including distance, diameter, and angle of micropiles has been investigated and the sensitivity of the results for permeability and soil resistance parameter has been investigated. The innovation of the present study is in the form of parts in the form of segments, which eliminates the common assumptions in the limit equilibrium method. Therefore, it is expected that this method will have less error in determining the reliability coefficient. According to the available results, it was observed that seepage in the slope, diameter, and distances of small piles has a great effect on the stability of the slope, which can be varied according to different conditions. As the distance between the micro piles increases, the slope reliability coefficient with different pitch diameters becomes closer to the slope reliability coefficient without decay and somehow converges to this reliability coefficient. Also, the amount of micropile angle will not have much effect on gable stability.

Keywords: *Sloping, Micropile, Seepage, Stability, Permeability, Friction angle coefficient.*

[1] Assistant Professor, Department of Civil Engineering, Shabestar Branch, Islamic Azad University, Shabestar, Iran.Petrofarhad@iaushab.ac.ir
[2] Assistant Professor, Department of Civil Engineering, Tasuj Branch, Islamic Azad University, Tasuj, Iran.
*** Corresponding Author**

Extended Abstract:

1. Introduction

Micropile is piles with a small diameter (less than 400 mm) that are often referred to as light steel reinforcement and injection of cement slurry and by transferring static and dynamic loads of the structure to more resistant layers of the ground, as load-bearing and impact-resistant element. Due to the small diameter of the micropile, a more percentage of load transfer occurs through friction between the micropile wall and the soil (AbdElaziz, 2012). A very important feature that has led to the increasing use of micropiles is the possibility of using them to increase the load-bearing capacity under the foundations of existing structures, while in such cases it is not possible to use concrete and steel piles. Another feature of micro piles is their effective operation in the presence of groundwater. Also, the implementation of thick concrete piles in arable soils, gravelly soils, and coarse-grained soils is faced with many problems and due to the need for items such as coating for drilling, is time-consuming and imposes a high cost on the project. Due to its small diameter and the way it is made, it is easy to implement and is superior to ordinary concrete piles. One of the significant advantages of this method in comparison with the application of concrete or steel piles is the performance of micropile loading tests with simple and cheap methods. In the loading test, it will be possible to investigate the behavior of the micropiles, the amount of loading, the elastic stresses, and the deformation of the residuals during loading. Thus, it will be possible to evaluate the accuracy of the design hypotheses and, as a result, modify and change the design according to the observation of the actual behaviour and their final load on the site (Guo, 2013). The purpose of this study is to investigate the effect of micropile on the stability of slopes under stable seepage, which using GeoStudio software and finite element method, assuming saturated-unsaturated flow and in steady-state flow, seepage analysis. The most important feature and innovation in this research is that in this method, drilling, installation, and injection of micro piles communities are performed simultaneously, which reduces the cost and time of project implementation. Also, due to the high injection pressure in this method, the wall resistance is much higher compared to other methods of performing small piles, which the results of loading tests show.

2. Materials and methods

In this study, a homogeneous slope of the soil stabilized by vertical and oblique micro piles is analyzed. The limit equilibrium approach has been used to analyze the slope stability, which has been performed using Seep / W software and finite element method and assuming saturated-unsaturated flow, in steady-state flow, seepage analysis. In the present study, a new limit equilibrium method is proposed that satisfies all equilibrium conditions. In the proposed method, the shape of the slip surface is considered as circular and non-circular and parts along the radius of the slip surface or lines that converge to a point. To calculate the reliability coefficient using the proposed method, a numerical model has been developed, which uses the iterative method (trial and error) to simultaneously satisfy the equilibrium equations of force and moment. The proposed method can also calculate the amount of vertical and shear forces between parts. Also, the shape of the parts is in the form of a segment, which eliminates the common assumptions in the limit equilibrium method. Therefore, it is expected that this method will have less error in determining the reliability coefficient. Also, using Slope / W software, slope stability has been investigated in different situations and conditions for micro piles.

To investigate the effect of droplets on the stability of slopes under leakage, models in GeoStudio software have been prepared and analyzed. The models used include a slope with a height of 30 meters and micro piles with 90, 10- and 20-degrees angles, taking into account 3 diameters of 10, 20, and 30 cm for micro piles and also with three different distances of length 1, 2 and 3 meters. The dimensions of the models used are chosen so as not to effect of results and the pore water pressure distribution (Huang, 1983). The boundary conditions considered for the numerical model are also consistent with the standard boundary conditions. Numerical model meshing is done automatically by the software (Moharrami et al., 2014). For this purpose, the software uses square elements. Numerical modelling has been done in such a way that the answers obtained from numerical solutions are accurate enough. For this purpose, several stages of numerical analysis have been performed by considering different dimensions for elements to the extent that the maximum dimensions of finite elements of the model are determined so that the problem error is acceptable and convergence to the solution of the problem is achieved. Based on this, the dimensions of the constituent elements up to one meter have been selected (Wei and Cheng, 2010). The slope in this study has a constant adhesion and coefficient of friction and soil permeability coefficient is also considered variable. Also, the angle of the micro piles, their diameter, and distance are considered as variables. In this analysis, Mohr-Columbus behaviour is the basis of modelling to study stability (Sivakumar and Singh, 2010). In the models related to the steady-state of leakage, 3 angles of micro piles and 3 different diameters in 3 different distances have been prepared to study the stability. To study the sloping seepage in the materials used, a semi-saturated model was used so that if a part of the material was out of the saturation range, the amount of pore water pressure would be as close to reality as possible. Before starting the analysis of slope stability, the slope must be permeated, therefore, the boundary conditions are defined upstream and downstream of the slope (Vandamme and Zou, 2013). Water molecules flow in porous soil environments due to their potential energy. Water gradually loses its energy along the way in a porous environment with the presence of friction and will have adverse effects such as loss of water stored behind the soil structure, creating pore pressure, and reducing effective stress. Each of these issues can reduce shear strength, apply increasing pressure, cause erosion and leakage force and have a negative effect on gable stability.

Finally, the results of slope stability analysis in the case of stable seepage in 3 different angles for vertical angles of 10 and 20 degrees and considering 3 diameters for the of 10, 20, and 30 cm and also with 3 different distances in length 1, 2 and 3 m were obtained. Also, the results of slope stability analysis for 20 cm diameter and 2 m length, 3 different friction angles of 25 °, 30 °, and 35 °, and with 3 different angles of micro piles were studied and analyzed.

3. Results and discussion

In this section, the results of sensitivity analysis for the performance of droplets on slopes under stable seepage conditions are investigated. For this purpose, different conditions have been considered for micropile angle, micropile distance, micropile diameter, soil strength characteristics, and soil permeability, and finally, for each case, the amount of reliability has been studied and analyzed. Considering the distance between the droplets by 2 meters, it is observed that by increasing the diameter of the droplets from 10 to 20 cm, the reliability value increases by 11%, and also by increasing the diameter of the droplets from 20 to 30 cm, the reliability value increases by 22%. Considering the diameter of the micropile, it is considered to be 0.2 meters. By increasing the distance between the micro piles from 1 to 2 meters, the reliability value is 13%, and also by

increasing the distance between the micro piles from 2 to 3 meters, the reliability value decreases by 4.5%.

4. Conclusion

The results of the study of the effect of micropile on the stability of the canopy under the effect of stable seepage show that considering the distance of micropile is considered to be 2 meters, with increasing the diameter of micropile, the number of reliability increases. Also, considering the diameter of the micropile, it is considered to be 0.2 meters. By increasing the distance between the micropile, the reliability decreases. The angle of incidence does not have much effect on the amount of confidence, and with the angle of incidence, the coefficient of confidence decreases slightly. This decrease in soil stability reliability at different angles of micropile seems to be relatively significant when the diameter of micropile is larger. The effect of internal soil friction coefficient on the amount of slope reliability in stable seepage is almost linear and it can be said that these changes are also parallel in different states.

References:

Abd Elaziz, A.Y. 2012. Performance of hollow bar micropiles under axial and lateral loads in cohesive soils. Ph.D. thesis, Department of Civil and Environmental Engineering, Western University, London,

Guo, W. D. 2013. Pu-based solutions for slope stabilizing piles. International Journal of Geomechanics, 13 (3), 292-310.

Huang Y.H. 1983. Stability analysis of earth slopes, van nostrand reihold Co., New York.

Moharrami A, Hassanzadeh Y, Salmasi F, Moradi Gh, Moharrami Gh. 2014. Performance of the horizontal drains in upstream shell of earth dams on the upstream slope stability during rapid drawdown conditions. Arabian Journal of Geoscience 7:1957-1964.

SivakumarBabu G.L. and Singh P.S. 2010. 2D Numerical Simulations of Soil Nail Walls," Geotechnical and Geological Engineering, 28(4), pp. 299-.903.

Vandamme J and Zou Q. 2013. Investigation of slope instability induced by seepage and erosion by a particle method. Computers and Geotechnics 48: 9-20.

Wei, W. and Y. Cheng. 2010. Soil nailed slope by strength reduction and limit equilibrium methods.Computers and Geotechnics.