University of Tabriz

Journal of Civil and Environmental Engineering
Volume 52 (2023), Issue 4 (Winter), 191-201

EXTENDED ABSTRACT

The Effect of Arching Soil on the Stability and Deformation of Deep Urban Excavation

Saeed Ghaffarpour Jahromi *, Yasaman Dehghan Banadaki

Faculty of Civil Engineering, Shahid Rajaee Teacher Training University, Tehran 1678815811, Iran

Received: 28 January 2017; **Accepted:** 07 April 2021

Keywords:
Excavation, Soil modeling, Stability analysis, Deformation, Arching soil.

1. Introduction

With the development of urbanization and the increasing development of high-rise structures, there is a definitive need for excavation with higher depths. The important matter to be considered in such cases is providing stability of the excavation to prevent any probable risk in the urban environments. Because of excavation, the soil as a bearing system removed, and consequently, the equilibrium of in-situ stresses in the soil mass and the between-granular stresses are disrupted. If this stress change exceeded the tolerance limit of the soil, the soil would be unstable and, the excavation collapse will be inevitable. Hence, one of the aims of engineers in the assessment of excavation is the stability analysis so that the safety factor must always be above one. In addition to stability analysis and due to the effect of excavation on the surrounding area, deformation and settlement analyses are also necessary for the urban areas (Chen et al, 2020).

2. Methodology

Soil nailing means the passive strengthening of the ground without applying pre-stress loads, which performed by the installation of steel elements or nails. Generally, it is recommended to drive nails into the soil with angles of 10 to 20 degree to the horizontal to use their maximum tensile capacity. To make continuity and involvement between soil and steel elements (nails), it used from cement grouting. A shotcrete layer is also sprayed on the excavation surface to prevent local falling of soil. Commonly, this technique is widely used in urban excavations (Fig. 1).

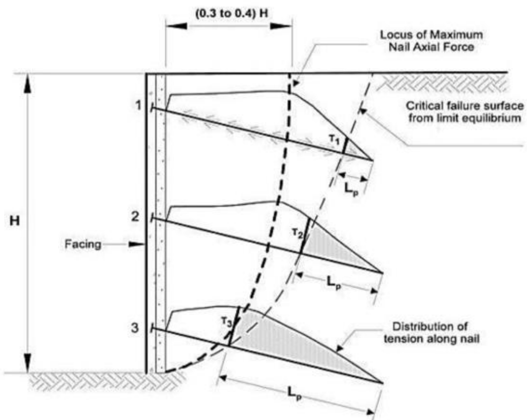

Fig. 1. The details of stabilization with soil nailing method

* Corresponding Author
E-mail addresses: saeed_ghf@sru.ac.ir (Saeed Ghaffarpour Jahromi), y_dehghan_b@yahoo.com (Yasaman Dehghan Banadaki).

On the expressing of the criterion of material failure at a certain level, in 1900 Coulomb had proposed a simple but very practical criterion that is a function of normal stress in the failure plane. In soil mechanics, this theory is expressed based on the theory of friction strength between soil particles and cohesion. For the expression of linear elastic behavior and plastic behavior of materials in the Mohr-Coulomb (MC) model, five main variables used. This model uses the combination of Hook's law and Coulomb failure criterion (Lai et al, 2018).

Hardening soil (HS) model is a powerful constitutive model to simulate the behavior of soft and hard soil types. From the main features of this model, it could mentioned the presence of two types of shear and compressive hardening as well as the non-constant failure surface of the model and its change with the increase in the plastic strains. As one of the main differences of the HS model with the MC model, the stiffness corresponded to stress level can mention. The main idea for the model's relations is the hyperbolic relation between axial strain and deviatoric stress in triaxial loading (Fig. 2).

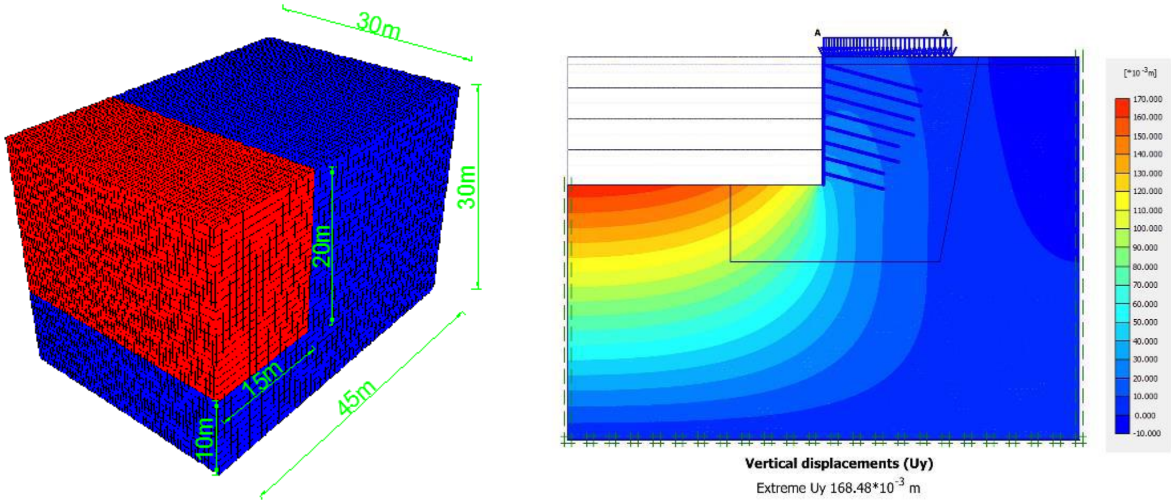

Fig. 2. Two-dimensional and three-dimensional modeling geometry

3. Validation of numerical model with case study

In the present study, the results of monitoring deformation using a micro-geodesy instrumentation during the excavation process and up to three months after the completion of excavation are available, which is used in validating this numerical analysis. In geodetic method, for monitoring a structure in two or more periods of time, a network of fixed points around the excavation is created. Then observations of length and angle used to determine the exact coordinates of these points.

Residual results from geodetic monitoring in urban excavations show that displacement is a nonlinear function of excavation depth, stabilization method and soil specification. Comparison of the results of numerical analysis with the track monitoring values for two points of harvesting in the fringe of the hole, which were stably steerable, as well as two points of harvest on the opposite front, which was stabilized by the Berlin wall method. The alignment of this point of withdrawal is at the zero level of the project and at the top of the track. This comparison shows that at all points of view, the results of numerical analysis with hardening behavior for soil are always closer to reality and better match with the results of monitoring (Fig. 3).

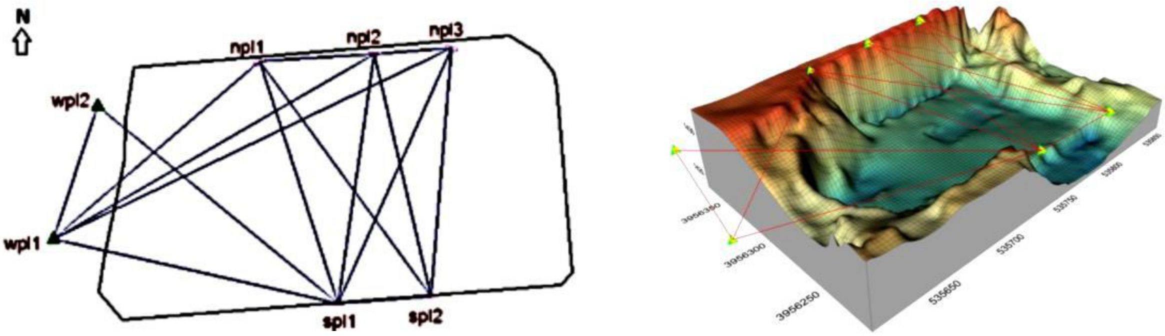

Fig. 3. Monitoring network points around the excavation and monitoring network points and observations (Ashourzadeh and Rostami, 2015)

4. Conclusions

Displacement analysis and deformation depend on various factors such as excavation geometry, soil properties, structure of stabilization and modeling method. In this paper, we try to analyze the displacement and stability of excavation in two different projects (case study) to investigate the effect of soil arching soil effect in different conditions. Also, the results of two-dimensional modeling are compared with the three-dimensional mode in simulated arching effects. FLAC3D, PLAXIS2D and GEOSLOPE software were used to analyze the stability and deformation of the excavation. The results show that a radius curvature in the wall of the excavation can increase the stability, reduce the deformation and by distributing stress and strain can effect on the coverage range of excavation.

5. References

Ashurzadeh Y, Rostami A, "Using the geodetic method to monitor and investigate the horizontal and vertical displacement of the excavation wall", Scientific-Promotional Journal of Mapping and Spatial Information Engineering, 2015, 9-18.

Chen G, Zou L, Wang Q, Zhang G, "Pile-spacing calculation of anti-slide pile based on soil arching effect", Advances in Civil Engineering, 2020, 5 (6), 221-243.

Lai HJ, Zheng JJ, Zhang RJ, Cui MJ, "Classification and characteristics of soil arching structures in pile-supported embankments", Computers and Geotechnics, 2018, 98, 153-171.