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Technical Note

Numerical Study of the Impressionability of Ground Settlement due to Excavation of Tabriz Metro Tunnel, Line 2, from the Coefficient of Lateral Earth Pressure (K0)

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Keywords

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Finite Differences Method
Real Settlements

English Extended Abstract

Summary

In this research, ground settlement due to mechanized excavation of the Tabriz metro tunnel, line 2, has been studied and the effect of the K0 parameter, coefficient of lateral earth pressure, has been discussed using finite difference method and modeling with FLAC 2D software considering different values of K0 parameter (0.25, 0.5, 0.75 and 1). The results of numerical model were verified according to real settlements measured simultaneously with tunnel excavation. The results show that in general, ground settlements due to tunneling decreases exponentially with increasing of the K0 value.

Introduction

Ground settlement is one of the inevitable consequences of excavation of shallow tunnels (both mechanized and NATM) in soft materials such as soils. This phenomenon has taken place due to the disruption of the initial stress distribution of the ground, which occurs because of the removal of materials during the tunnel excavation. Predicting the amount of the settlement and its extension is of great importance in terms of possible damage to surface structures and subsurface infrastructures and facilities. According to the risk of this phenomenon, it should be carefully evaluated. The amount and extension of settlements are widely influenced by some factors that the geological and the geotechnical characteristics of soil are among the most significant of them. In addition, the tunnel geometry and its depth, the excavation method, the workmanship and management quality are the other parameters affecting the ground settlements caused by the excavation of shallow tunnels. The coefficient of lateral earth pressure (K0) is one of the most important geotechnical parameters of the soil mass. This parameter is defined as the ratio of the horizontal in-situ stress over the vertical in-situ stress, (σ′h /σ′v) and its effect on ground settlement due to tunneling was analyzed by several authors. Estimation of the initial stresses with an accurate value of K0 is one of the most important issues in geotechnical engineering. K0 is greatly influenced by geological factors such as the soil type, the groundwater configuration, the overburden thickness (tunnel depth), etc. According to researches, the initial stress distribution in the ground is mostly unknown and quite a number of factors such as tectonic movements, thermic, creep or weathering can influence it.

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Vol. 13, No. 36, Fall 2023, Pages 31-46

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Methodology and Approaches

Several methods have been suggested to study and evaluate the amount of the settlement occurred due to tunneling such as: Semi-empirical, Analytical, Numerical and etc. Numerical methods are more paid attention because of extend utilizing of the geotechnical characteristics of host materials. In this study, a numerical parametric study on the effect of K0 on the ground settlements due to tunneling is presented. For this purpose, at first, real settlements obtained from studied section of the Tabriz metro tunnel, line 2, are used to validate numerical models. Then the effect of K0 on ground settlement due to the excavation of the tunnels is investigated using numerical method done by FLAC 2D.

Geotechnical properties of the soil layers and the location of the groundwater level were determined through site investigations included borehole and test-pits drilling, performing in-situ tests, and laboratory tests. Fig. 1 and Table 1 show the engineering geological profile of the tunnel in studied section and the geotechnical properties of soil units, respectively.

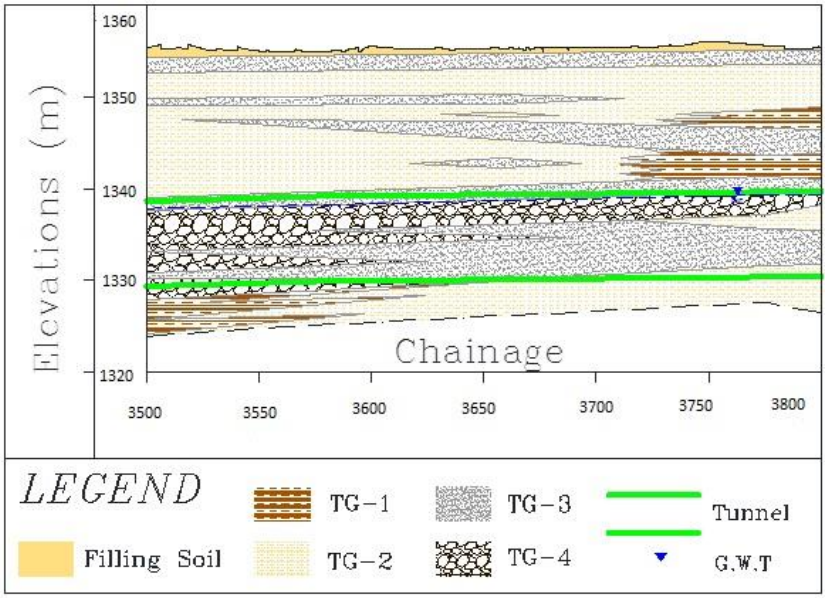

Fig. 1. Engineering Geological profile of tunnel and the categorized soil units

Table 1. Geotechnical parameters of soil types

Unit	C (kPa)	C_{cu} (kPa)	Φ (degree)	$Φ_{cu}$ (degree)	E (MPa)	ν	γd (kN/m3)
Fill	2-5	5-10	20-22	5-7	10-14	0.35	15-16
TG-1	10-20	40-70	19-23	0-5	15-25	0.35	15.7-16.5
TG-2	7-15	30-40	21-27	0-5	25-35	0.33	16.5-17
TG-3	3-9	8-15	28-32	28-30	30-40	0.31	15.4-17.5
TG-4	2-7	6-12	33-36	30-32	45-55	0.3	16.8-17.6

The parameter of K0 (Coefficient of Lateral Earth Pressure) is one of the most important geotechnical properties of the soil and has an essential influence on the design of the tunnel, especially in designing of segmental lining. Numerical modeling is usually adopted to evaluate the ground settlement induced by shallow tunneling. In this study, the finite difference method base program of FLAC 2D, was used to model

Vol. 13, No. 36, Fall 2023, Pages 31-46

Journal of Analytical and Numerical Methods in Mining Engineering

Journal home page: http://anm.yazd.ac.ir/

the excavation of studied tunnel and investigate on the effect of K0 on ground settlement due to tunneling. To aim the purpose, a conceptual model was built based on the geotechnical and geometrical characteristics of the studied section of the tunnel and ground settlement was evaluated in several amounts of K0 equal to 0.25, 0.5, 0.75 and 1. This range of K0 value is usually observed in reality.

Results and Conclusions

The final findings of this study are shown in Fig. 2. The results show that the amount of ground settlement decreases generally with an increasing value of K0, and the changes follow an exponential function. According to Fig. 2, The relation between these two parameters follows an exponential function which can be expressed using the following equation:

$$S_{max} = Ae^{-BK_0}$$

Where A and B are coefficients that are dependent mostly on the soil type, geometrical characteristics of the tunnel (depth and diameter). For this study, the amount of A and B parameters which are index of settlement reducing with increasing of K0, were determined respectively as 41.69 and 1.39 via numerical modeling. It was predicted that the changes of K0 causes a change in the magnitude and direction of the stresses developed in the soils surrounding the tunnel and consequent change in the displacement induced in the soil surrounding and finally leads to settlement of the ground surface.
changes.

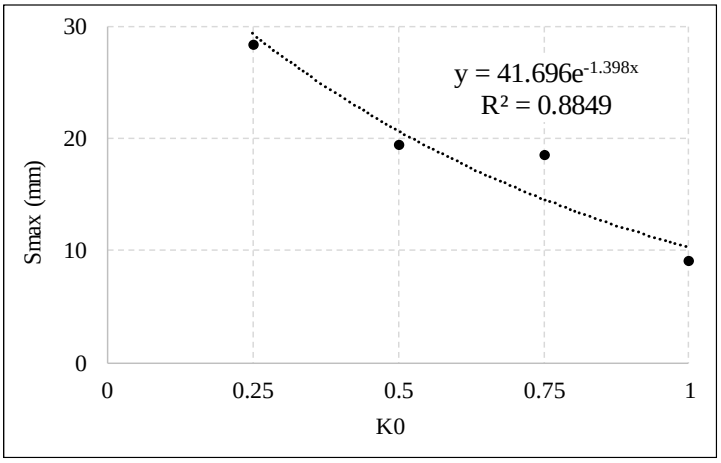

Fig. 2 . Impressionability of Ground Settlement from the Coefficient of Lateral Earth Pressure (K_0)

Table 2. Determination of A and B parameters for studying tunnel

Tunnel	D*	$(\frac{C}{D})$**	A	B
Tabriz Metro, Line2	9.49	1.65	41.69	1.39

*Tunnel Diameter (m)

**Ratio of Overburden to Diameter

References

[1] Peck, R. B. (1969). Deep excavation and tunneling in soft ground. Proc. Of the 7th int. Conference on soil Mechanics and Foundation Engineering. State of the art Volume. Socieded Mexicnan de Mecanica de Suelos, A. C. pp 225–290.

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Vol. 13, No. 36, Fall 2023, Pages 31-46

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[2] Baghban Golpasand, M.R., Nikudel, M.R., Uromeihy, A. (2016). Specifying the real value of volume loss (VL) and its effect on ground settlement due to excavation of Abuzar tunnel, Tehran. Bulletin of Engineering Geology and Environment. 75(2) 485-501.

[3] Franzius, J.N., Potts, D.M., Burland, J.B. (2005). The influence of soil anisotropy and K0 on ground surface movement resulting from tunnel excavation. Geotechnique. 55(3) 189–199.

[4] Muller, M. (2006). Tunnel induced settlement and structural forces in lining. Doctoral Thesis. Stuttgart university

[5] Baghban Golpasand, M.R., Do, N.A., Dias, D., Nikudel, M.R. (2018). Effect of the lateral earth pressure coefficient on settlements during mechanized tunneling. Geomechanics and Engineering. 16(6) 643-654.

[6] Mousazadeh, S., Goshtasbi, K., Ghzvinian, A. (2013). Comparison of Numerical Methods in Stability Analysis of masjed-Soleyman Power House Cavern. Journal of Analytical and Numerical Methods in Mining Engineering, 3(5), pp. 89-98. (In persian)

[7] Franzius, J.N., Potts, D.M., Burland, J.B. (2005). The influence of soil anisotropy and K0 on ground surface movement resulting from tunnel excavation. Geotechnique. 55(3) 189–199.

[8] Muller, M. (2006). Tunnel induced settlement and structural forces in lining. Doctoral Thesis. Stuttgart university