Journal of Multidisciplinary Engineering Science Studies (JMESS)
ISSN: 2458-925X
Vol. 2 Issue 4, April - 2016

The Effect Of Pretensioning In The Anchors On The Lining Of Tunnels

Vahid Hosseinitoudeshki[1], Amin Booryayei[2]
[1]Department of Civil Engineering, Zanjan Branch, Islamic Azad University, Zanjan, Iran
Corresponding e-mail address:
toudeshki@gmail.com
[2]Department of Civil Engineering, Zanjan Branch, Islamic Azad University, Zanjan, Iran
amin.booryayei94@gmail.com

***Abstract*—This paper present numerical analysis of the effect of pretensioning in the anchors on the lining forces of tunnels by means of elasto-plastic finite element method. In numerical analysis, a 2D finite element program with software Phase2 is utilized. First, a trench with depth of 20 meters and width of 15 meters is modeled and reinforced with anchors. Then, tunnels are excavated at various distances from the trench, and the effect of pretensioning in the anchors is investigated on the lining forces of tunnels. The results of the evaluations show that the value of pretensioning force in the anchors is effective on the axial force, shear force and bending moment of lining. Furthermore, by increasing distance of tunnels from trench, the maximum of pretensioning force of anchors that causes the highest changes of lining forces have increased.**

Keywords— Pretensioning; Anchor; tunnel; Lining forces

1. Introduction

Anchorage systems are used for supporting tunnels, mines and for retaining walls. The anchors are generally used in plain or reinforced concrete structures but also in structures in lightweight material, such as wood and brick. The anchors sustain axial loads and the load transfer from the reinforcement rod to the concrete mainly take place through shearing of lateral surfaces and interfacial tearing at the bottom of adhesive interlayer. The experimental investigation on mechanical and chemical anchors in masonry wall subject to pullout load and torque has been reported by [1]. The influence of the grout properties on the pull-out load capacity of fully cement-grouted rock bolts is investigated by [2]. The researchers such as [3] investigated the experimental studies concerning concrete are also coupled with theoretical formulations for predicting the ultimate tension load.

During the tunnelling process, the support systems needs to be installed for the purpose of maintaining of soils in order to maximize supporting capacity and to create favorable development of the stress field within the soils. The interaction between the support system and the soil surrounding the tunnel are studied [4, 5]. One problem in tunnels is the measurement and interpretation of stresses in the lining of tunnels, particularly when a trenching to be excavated in the vicinity of the tunnel and to be reinforced by anchor systems. Pretensioning of anchors can affect the lining forces. In geo technic projects, different methods are used to calculate lining stresses [6]. Therefore, tunnel design requires a proper estimate of pressures on the tunnel lining. Tunnelling may induce significant different magnitudes of deformation to the surrounding ground, resulting as well in different ground pressures on tunnel linings. For the design of the tunnel lining, the excavation and support sequence needs to be taken into consideration.

This paper attempts to evaluate the effect of pretensioning in the anchors on the lining forces of the tunnels.

2. Geomechanical Parameters of Soil

The geo-mechanical parameters of soil used for tunnel modeling are given in Table1. These characteristics are taken from Amirkabir tunnel in Tehran.

Table 1. The geo-mechanical parameters of soil

Initial Element Loading	Unit Weight (kN/m3)	Elastic Type	Young's Modulus (kPa)	Poisson's Ratio	Failure Criterion	Material Type	Friction Angle (peak) (deg)	Cohesion (peak) (kPa)
Field Stress and Body Force	19	Isotropic	72000	0.35	Mohr Coulomb	Plastic	33	35

3. Numerical Analysis of Pretensioning of Anchors

Numerical analyses of pretensioning in the anchors on the lining forces of the tunnels are done using a two-dimensional hybrid element model, called Phase2 Finite Element Program [7]. This software is used to simulate the three-dimensional excavation of a tunnel. In this finite element simulation, based on the elasto-plastic analysis, deformations and stresses are computed. These analyses used for evaluations of the tunnel stability. The geomechanical properties for these analyses are extracted from Table 1. The Mohr coulomb failure criterion is used to identify elements undergoing yielding and the displacements of the soils in the tunnel surrounding.

To simulate the excavation of trenches and tunnels in the soils, a finite element models is generated for a trench with depth of 20 meters and width of 15 meters that reinforced with anchors (Fig. 1). The outer model boundary is set on a scale of 100 and 200 meters and three-nodded six-angular elements are used in the finite element mesh. Then, the circular tunnel with diameter of 10 meters is modeled at a depth of 20 meters (Fig. 2). By run of model, the values of axial force, shear force and bending moment in the lining of tunnel is determined (Figs. 3, 4 and 5).

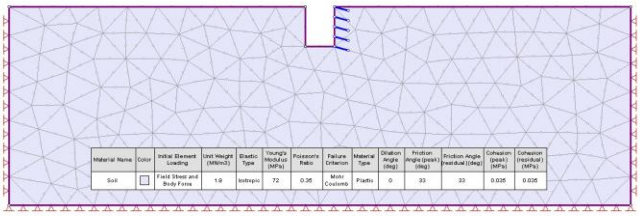

Fig. 1. The modeling of a trench with depth of 20 meters and width of 15 meters that reinforced with anchors

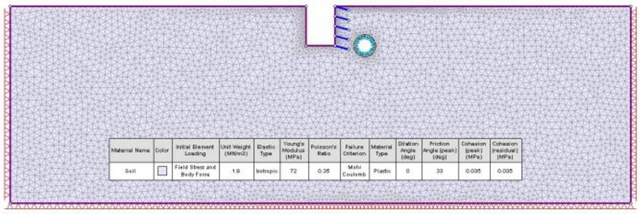

Fig. 2. The modeling of a circular tunnel with diameter of 10 meters and at a depth of 20 meters and at distance of 20 meters from the trench

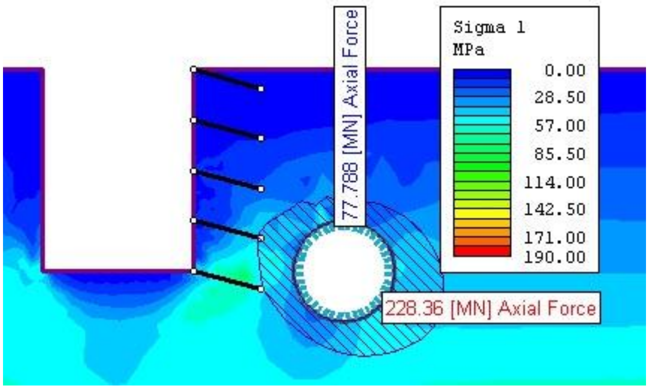

Fig. 3. The diagram shows the values of axial force in the lining of circular tunnel

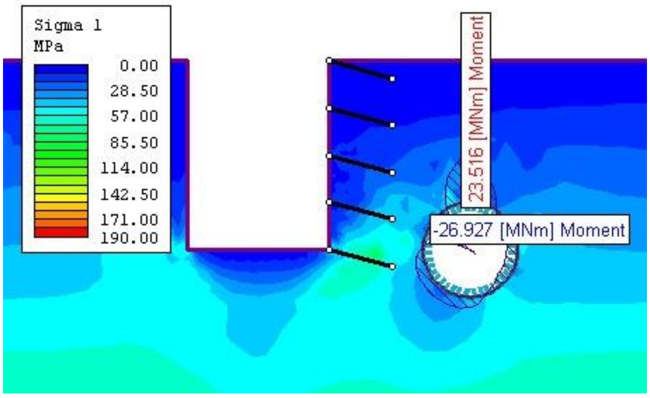

Fig. 4. The diagram shows the values of bending moment in the lining of circular tunnel

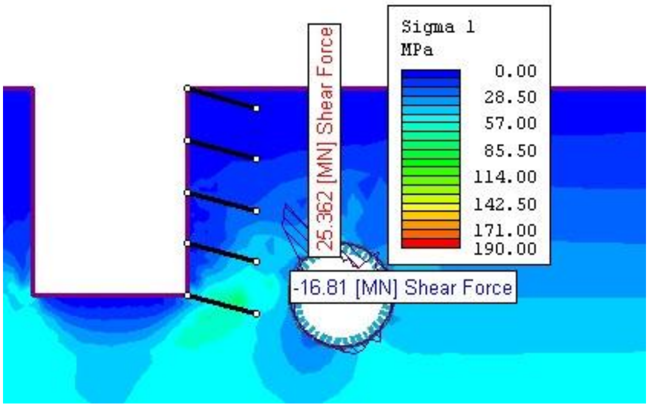

Fig. 5. The diagram shows the values of shear force in the lining of circular tunnel

In the next step, this circular tunnel is modeled at distances of 15, 30, 45, 60 and 75 meters from the trench. The pretensioning forces in the anchors are selected equal to 10, 20, 30, 40 and 50 KN, and the effect of it on the lining forces of the tunnel is investigated.

By run of models, the values of axial force, shear force and bending moment in the lining of tunnels for each pretensioning force is measured and the changes it is shown in Figs. 6 to 8.

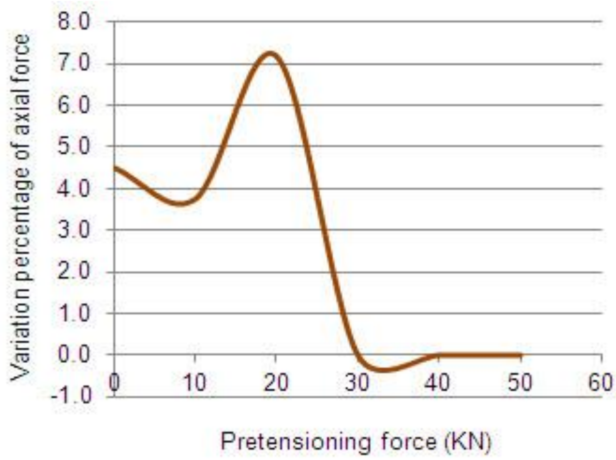

Fig. 6. The diagram shows the variation percentage of axial force of lining due to pretensioning force of anchors (distance of tunnel from trench is 45 meters)

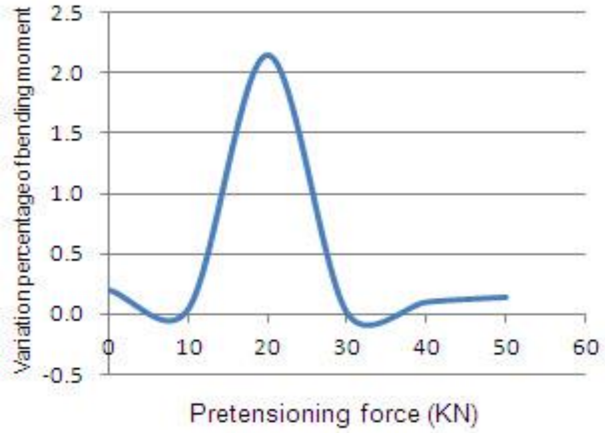

Fig. 7. The diagram shows the variation percentage of bending moment of lining due to pretensioning force of anchors (distance of tunnel from trench is 45 meters)

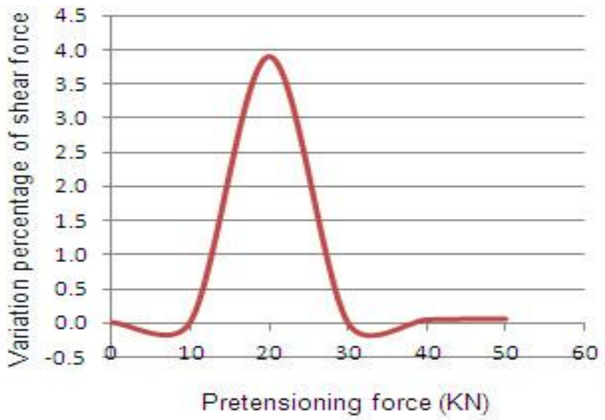

Fig. 8. The diagram shows the variation percentage of shear force of lining due to pretensioning force of anchors (distance of tunnel from trench is 45 meters)

Moreover, the maximum of pretensioning force of anchors that causes the highest changes of lining forces of tunnels is determined and shown in Fig. 9.

Fig. 9. The diagram shows the maximum of pretensioning force of anchors in terms of distance of tunnels from trench

As the above diagrams show, the value of pretensioning force in the anchors is effective on the axial force, shear force and bending moment of lining. The maximum changes of axial force, shear force and bending moment in the lining of circular tunnel at distance of 45 meters from trench is related to pretensioning force of 20 KN and the maximum of these changes is related to axial force of lining. Furthermore, by increasing distance of tunnels from trench, the maximum of pretensioning force of anchors that causes the highest changes of lining forces have increased.

4. CONCLUSION

This study provides an estimation of the effect of pretensioning in the anchors on the lining forces of the tunnels. The following conclusions could be noted:

- The value of pretensioning force in the anchors is effective on the axial force, shear force and bending moment of lining.
- The maximum of changes of lining forces of tunnels is related to axial force.
- By increasing distance of tunnels from trench, the maximum of pretensioning force of anchors that causes the highest changes of lining forces have increased.

REFERENCES

[1] H.M. Algin, "Investigation of masonry wall fixings subject to pullout load and torque." Constr Build Mater, 2007, 21, 2041-2046.

[2] A. Kılıç, E. Yasar, and A. Celik, "Effect of grout properties on the pull-out load capacity of fully grouted rock bolt." Tunn Undergr Sp Technol, 2002,17,355-362.

[3] A. Colak, "Estimation of ultimate tension load of methylmethacrylate bonded steel rods into concrete. " Int J Adhes Adhes, 2007,27, 653-660.

[4] M. Panet, and A. Guenot, "Analysis of convergence behind the face of a tunnel." Proceedings of the International Conference on Tunnelling, 197-204. Brighton: The Institution of Mining and Metallurgy,1982.

[5] M. Panet, "Le Calcul des Tunnels par la Méthode Convergence-Confinement." Paris: Presses de l'École Nationale des Ponts et Chaussées. 1995, (in French).

[6] M.A. Nunes, and M.A. Meguid, "A study on the effects of overlying soil strata on the stresses developing in a tunnel lining," Tunnelling and Underground Space Technology, 2009, (24), 716–722.

[7] Rocscience, "A 2D finite element program for calculating stresses and estimating support around the underground excavations," Geomechanics Software and Research. Rocscience Inc., Toronto, Ontario, Canada, 1999.