The Effect Of Releasing Stress In Tunnels On The Lining Of Adjacent Tunnels

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***Abstract*— The development of transportation requires the construction of new tunnels close to the existing ones. Since, the relative position of tunnels affects the soil movement and internal forces in the lining, it is better to study the influence of tunnels on each other. This paper presents numerical analysis of the effect of releasing stress in the new tunnel on the lining forces of the old tunnel in the shale rocks by means of elasto-plastic finite element method. In numerical analysis, a 2D finite element program with software Phase2 is utilized. First, a circular tunnel with a diameter of 8 meters is modeled and reinforced with lining. Then, a new tunnel is excavated at various distances from the first tunnel, and the effect of it on the lining forces of the old tunnel is investigated. The results of the evaluations show that by increasing the value of releasing stress in the new tunnel, the axial force, shear force and bending moment of lining in the old tunnel have increased and the maximum of these changes is related to axial force of lining. Furthermore, by increasing distance of tunnels, the changes of lining forces in the old tunnel has somewhat increased.**

Keywords— Releasing stress; tunnel; Lining; Axial force; Shear force; Bending moment

1. INTRODUCTION

Rock masses existing in depth of the earth, are affected by stresses called in-situ stresses. Main factors of in-situ stresses are layers weight and tectonic activities. After constructing the tunnel, stress condition gets disorganized and its condition around the tunnel gets a new formation which differs from its first condition. Produced stresses due to tunnel excavation are called induced stress [1]. Stress induced instability is one of major concerns for the safe construction and operation of tunnels. The high horizontal stress may play a crucial role in the stability of tunnels, which specially is true for tunnels situated close to the ground surface. During the tunnelling process, the support systems needs to be installed for the purpose of maintaining of rock masses in order to maximize supporting capacity and to create favorable development of the stress field within the rock mass.

In tunnel design, the interaction between the support system and the rock surrounding the tunnel are studied [2, 3]. One problem in tunnels design is the measurement and interpretation of stresses in the lining of tunnels, particularly when a new tunnel to be excavated in the vicinity of the old tunnel. In geo technic projects, different methods are used to calculate lining stresses [4]. 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 releasing stress in the new tunnel on the lining forces of the old tunnel in the shale rocks.

2. GEOMECHANICAL PARAMETERS OF SHALE ROCKS

The rock mass properties such as the rock mass strength (σcm), the rock mass deformation modulus (Em) and the rock mass constants (mb, s and a) are calculated by the Rock-Lab program defined by [5]. This program has been developed to provide a convenient means of solving and plotting the equations presented by [5].

In Rock-Lab program, both the rock mass strength and deformation modulus are calculated using equations of Hoek et al., 2002, and the rock mass constants are estimated using equations of Geological Strength Index (GSI) [5] together with the value of the shale material constant, mi. Also, the value of disturbance factor (D) that depends on the amount of disturbance in the rock mass associated with the method of excavation, is considered equal to 0.2 for the rock masses, it means these rocks would be disturbed slightly during blasting.

Finally, the shear strength parameters of the rock mass (C and φ) for the rock masses are obtained using the relationship between the Hoek–Brown and Mohr–Coulomb criteria [6]. The geomechanical parameters of shale rock masses is obtained and presented in Fig. 1.

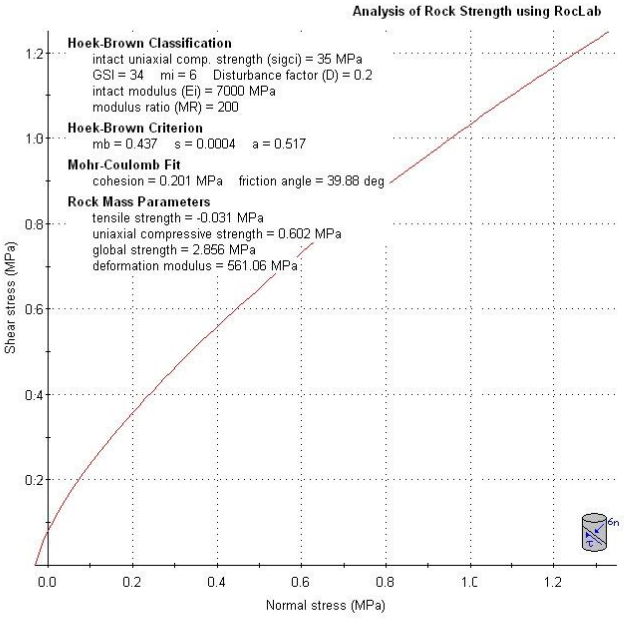

Fig.1. Geomechanical parameters of the shale rocks

3. Numerical analysis of the releasing stress in the tunnels

Numerical analyses of the releasing stress in the circular 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 in the rock masses. The geomechanical properties for these analyses are extracted from Fig. 1. The generalized Hoek and Brown failure criterion is used to identify elements undergoing yielding and the displacements of the rock masses in the tunnel surrounding.

To simulate the excavation of tunnels in the shale rock masses, a finite element models is generated for the circular tunnel (old tunnel) with diameter of 8 meters that reinforced with lining (for example Fig. 2). The outer model boundary is set on a scale of 100 and 200 meters and three-nodded triangular elements are used in the finite element mesh. The circular tunnel is modeled at a depth of 10 meters. By run of model, the values of axial force, shear force and bending moment in the lining of tunnel is determined (for example Figs. 3, 4 and 5).

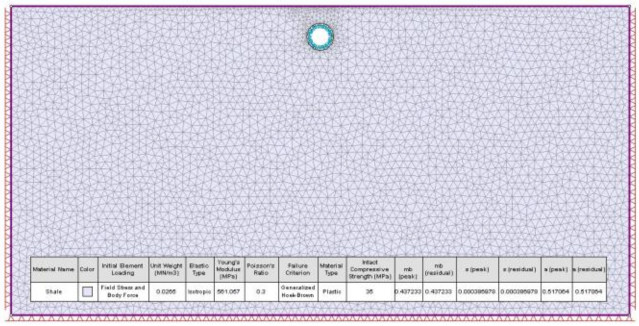

Fig. 2. The modeling of circular tunnel with diameter of 8 meters that reinforced with lining

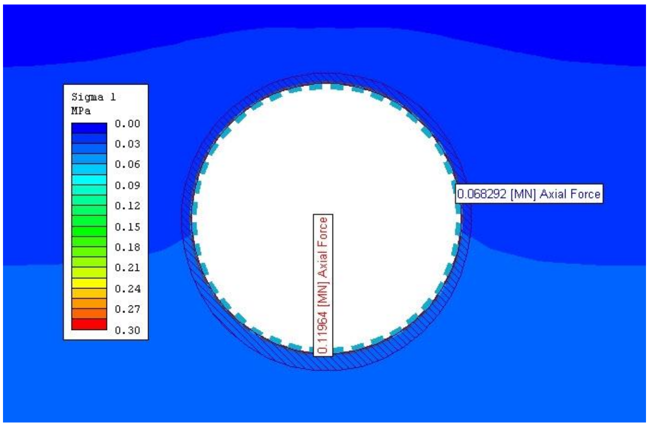

Fig. 3. The values of axial force in the lining of circular tunnel with diameter of 8 meters

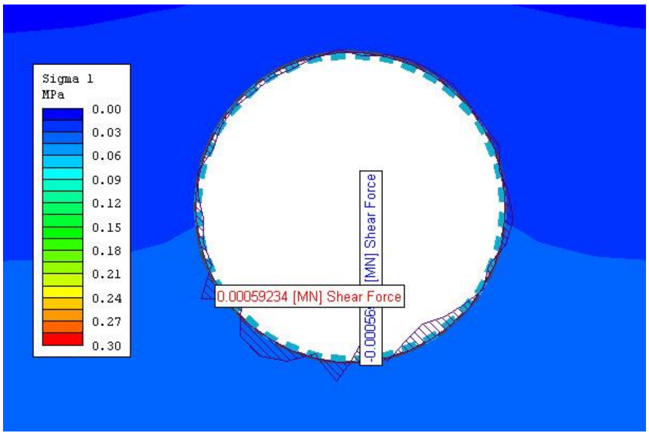

Fig. 4. The values of shear force in the lining of circular tunnel with diameter of 8 meters

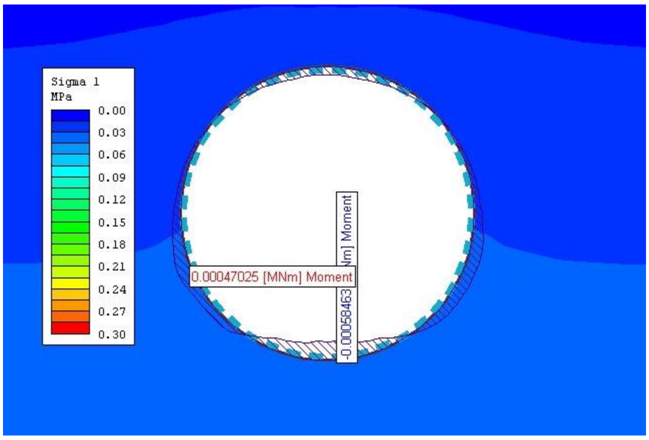

Fig. 5. The values of bending moment in the lining of circular tunnel with diameter of 8 meters

Then, a circular tunnel with diameter of 8 meters (new tunnel) is modeled at distances of 20, 30, 40 and 50 meters from the previous tunnel (for example Fig. 6). The induced stresses in new tunnels are released with the value of 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 percent, and the effect of it on the lining forces of the old tunnel is investigated.

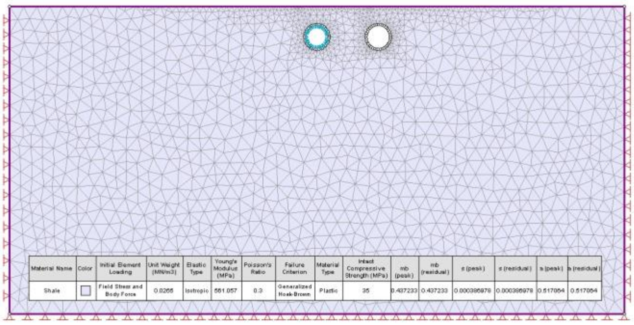

Fig. 6. The modeling of a circular tunnel (new tunnel) with diameter of 8 meters at a distance of 20 meters from the previous tunnel

By run of models, the values of axial force, shear force and bending moment in the lining of old tunnel is measured and the changes it is shown in Figs. 7 to 9.

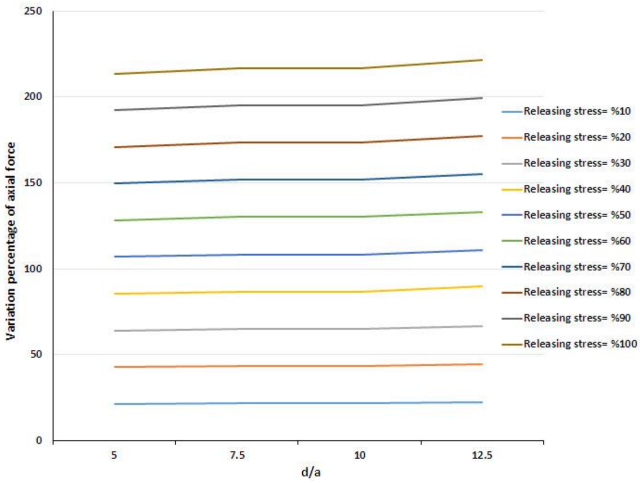

Fig. 7. The diagram shows the effect of releasing stress in the new tunnel on the axial force of lining in the old tunnel (d=tunnels distance; a=tunnel radius)

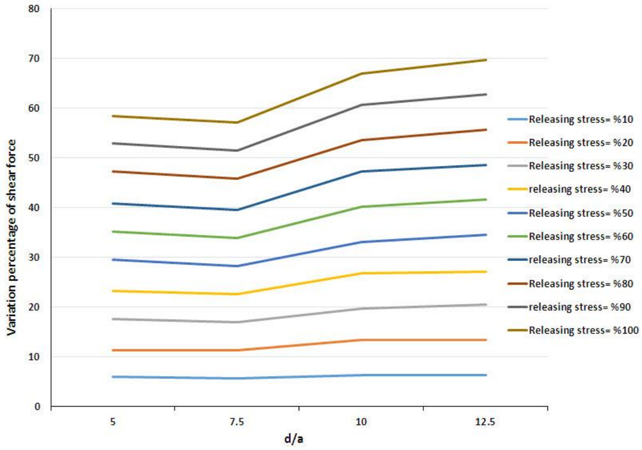

Fig. 8. The diagram shows the effect of releasing stress in the new tunnel on the shear force of lining in the old tunnel (d=tunnels distance; a=tunnel radius)

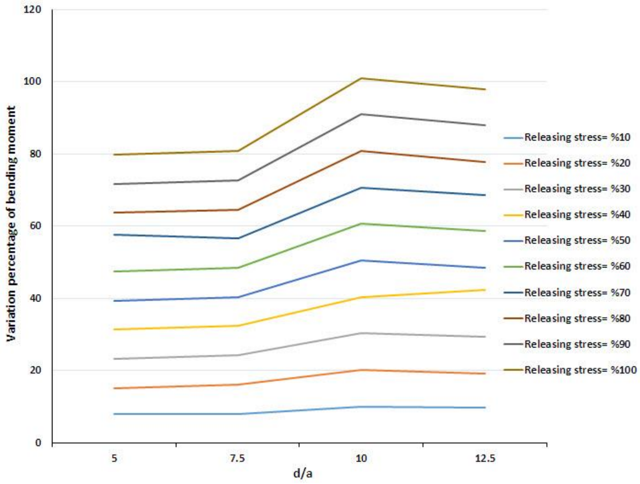

Fig. 9. The diagram shows the effect of releasing stress in the new tunnel on the bending moment of lining in the old tunnel (d=tunnels distance; a=tunnel radius)

As the above diagrams show, by increasing the value of releasing stress in the new tunnel, the axial force, shear force and bending moment of lining in the old tunnel have increased and the maximum of these changes is related to axial force of lining. When all stress is released in the new tunnel, the maximum changes of axial force, shear force and bending moment in the lining of old tunnel is equal to 223, 70 and 102 percent, respectively. Furthermore, by increasing distance of tunnels, the changes of lining forces in the old tunnel has somewhat increased and these changes are more in high level of releasing stress. However, the axial force changes with increasing distance of tunnels is less than the rest of forces.

4. CONCLUSION

This study provides an estimation of the effect of releasing stress in the new tunnel on the lining forces of the old tunnel in the shale rocks. The following conclusions could be noted:

- By increasing the value of releasing stress in the new tunnel, the axial force, shear force and bending moment of lining in the old tunnel have increased.
- The maximum of changes of lining forces in the old tunnel is related to axial force.
- By increasing distance of tunnels, the changes of lining forces in the old tunnel has somewhat increased and these changes are more in high level of releasing stress.

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