Global journal of multidisciplinary and applied sciences

Available online at www.gjmas.com

©2014 GJMAS Journal-2014-2-3/76-79

THE EFFECT OF EXCAVATION METHOD ON THE STRESS IN TUNNELS (CASE STUDY: TUNNEL NO. 2 OF KURDISTAN)

Vahid Hosseinitoudeshki[1] and Mohammadreza Rajabi Khamseh[2*]

1- Department of Civil Engineering, Zanjan Branch, Islamic Azad University, Zanjan, Iran
2- Department of Civil Engineering, Urmia Branch, Islamic Azad University, Urmia, Iran

***Corresponding author*: Mohammadreza Rajabi Khamseh**

ABSTRACT: The excavation method of tunnels cause disturbing surrounding rocks of tunnels which it create stress relief in the rock masses. Therefore, condition of stress around tunnels depends on the amount of disturbance of rocks due to excavation. This study has been in the tunnel No.2 of Kurdistan in NW of Iran which is composed of shale rocks. In tunnel modeling, different disturbance factors (0 to 1) depends on excavation methods are analyzed using phase2 software and the amount of minimum stress and strength factor in around the tunnel is determined. The obtain results show that by increasing of disturbance factor, the minimum stress and strength factor around the tunnel has decreased and the most decrease has occurred in disturbance factors 0.8 to 1. Accordingly, using very poor quality blasting method will be caused that the minimum stress around the tunnel reduce to zero which it cause the extrusion of tunnel face and collapse of tunnel.

***Keywords*:** Excavation method, Disturbance factor (D), Minimum stress, Strength factor.

INTRODUCTION

When a tunnel is excavated in rocks, the stress field is locally disrupted and a new set of stresses are induced in the rock surrounding the tunnel. Depending on the amount of disturbance of rocks due to excavation, the induced stresses in the rock surrounding the tunnel will be different. The magnitudes and directions of these induced stresses are effective in tunnel excavation design because, in many cases, the strength of the rock is exceeded and the resulting instability can have critical outcomes on the manner of the excavations.

Damage and stress relief in the rock masses arise by excavation of tunnels and disturbance factor (D) which introduced by Hoek . (2002) is related to excavation method. According to Hoek . (2002) can be found that D= 0 to 2 is related to excavation by Tunnel Boring Machine or hand excavation in poor quality rock masses, D= 2 to 5 is related to excavation by other mechanical methods such as excavation by roadheader, D= 5 to 8 is related to excavation by good quality blasting and D=8 to 1 is related to excavation by very poor quality blasting. The most important point in relation to the estimation of the disturbance factor (D) is that this factor should not be applied to the entire rock mass surrounding the excavation. The disturbance factor (D) should only be applied to the actual zone of damaged rock (Hoek E, 2012).

The study area is located in in Sanandaj - Sirjan structural zone (Aghanabati, 2004) which has been affected regional convergence in the NE-SW direction. In the regional tectonic, Sanandaj – Sirjan zone is located in the Turkish-Iranian plateau (Allen ., 2004). It extends from eastern Anatolia to eastern Iran, and typically has elevations of 1.5–2 km.

In this paper numerical analysis are conducted to investigate the effect of excavation method on the stress in tunnels. The tunnel No.2 of Kurdistan with span of 12.5 meters will be excavated in shale rocks in this area is considered as case study.

THE PHYSICAL AND MECHANICAL CHARACTERISTICS OF THE SHALE ROCKS

The physical and mechanical properties of the shale rocks are determined from cores obtained of boreholes in a tunnel. The specific gravity of these rocks is equal to 2.65 and the minimum and maximum of UCS varies from 18 to 22 MPa, respectively, and the average value is equal to 20 MPa.

The rock mass properties such as the rock mass strength (σ_{cm}), the rock mass deformation modulus (Em) and the rock mass constants (mb, s and a) were calculated by the RocLab program defined by (Hoek ., 2002) (Fig. 1). This program has been developed to provide a convenient means of solving and plotting the equations presented by (Hoek ., 2002).

In RocLab program, both the rock mass strength and deformation modulus were calculated using equations of (Hoek ., 2002). In addition, the rock mass constants were estimated using equations of Geological Strength Index (GSI) (Hoek ., 2002) 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 excavation method was considered zero for the shale rocks in Fig. 1.

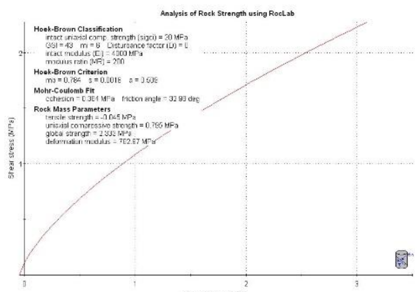

Figure 1. Rock mass parameters for zero disturbance factors

THE TUNNEL MODELING

For modeling of the tunnel in shale rock masses a finite element software (Phase2) for horseshoe tunnel with span of 12.5 meters are used. Phase2 is a two dimensional program which planned based on infinite elasto-plastic elements that used for calculation the stresses and displacements around the underground excavations. In this paper, the tunnel is simulated in shale rocks and with disturbance factor 0 to 1. Numerical analysis was based on two dimensional analyzing and plane strain. The external boundary of models is located in distance 5 times of tunnel diameter and graded meshes with 6 nodes are used in finite element meshing (Fig. 2).

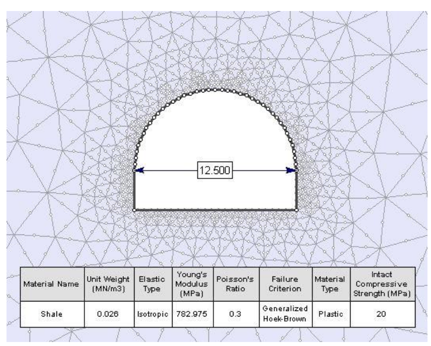

Figure 2. The modeling of tunnel with span of 12.5 m

Numerical analysis of the tunnel No.2 of Kurdistan includes analysis the minimum stress and strength factor around the tunnel in different disturbance factors.

THE MINIMUM STRESS AROUND THE TUNNEL

In order to surveying the minimum stress around the tunnel No.2 of Kurdistan, the amount of minimum stress in the roof of tunnel for different disturbance factors is determined (for example in Fig. 3) and is represented in diagram of Fig. 4.

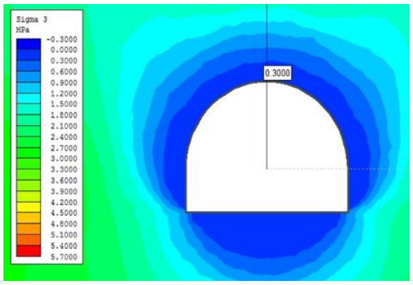

Figure 3. The amount of minimum stress in the roof of tunnel for zero disturbance factors

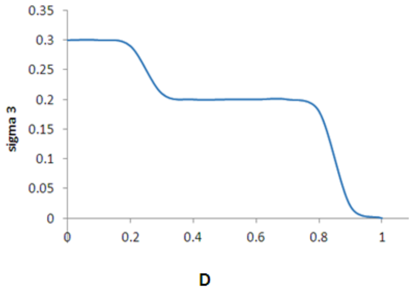

Figure 4. The amounts of minimum stress for different disturbance factors

Diagram in Fig. 4 shows that by increasing disturbance factor, the amount of minimum stress in the roof of tunnel decreases and the most decrease is in disturbance factors of 0.2 to 0.3 and 0.8 to 1, so that in disturbance factor of 1, the amount of minimum stress becomes zero. When the minimum stress is zero, the extrusion of tunnel face very increases and it causes collapse of tunnel. Therefore, very poor quality blasting method should not be used for excavation of the tunnel No.2 of Kurdistan.

STRENGTH FACTOR AROUND THE TUNNEL

To evaluate stability of the tunnel No.2 of Kurdistan, the strength factor in the roof of tunnel for different disturbance factors is determined (for example in Fig. 5) and is represented in diagram of Fig. 6.

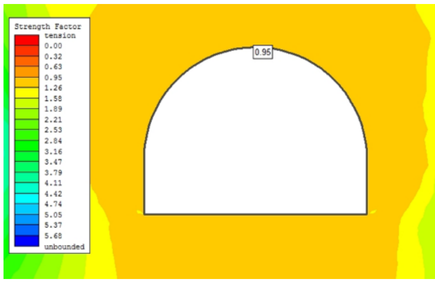

Figure 5. The strength factor in the roof of tunnel for zero disturbance factors

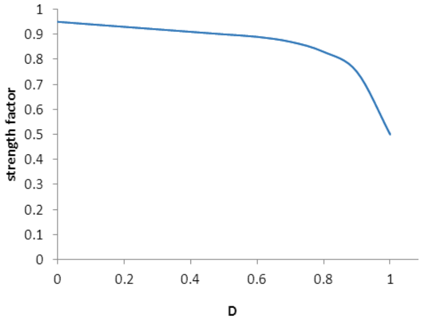

Figure 6. The amounts of strength factor for different disturbance factors

Diagram in Fig. 6 shows that by increasing disturbance factor, the strength factor in the roof of tunnel decreases and the most decrease is in disturbance factors of 0.8 to 1. The amounts of strength factor in the tunnel No.2 of Kurdistan imply instability of the tunnel without support system and also show that for excavation of this tunnel, the blasting method should not be used. The analysis of minimum stress and strength factor in the tunnel No.2 of Kurdistan represents that the mechanical excavation methods specially Tunnel Boring Machine method must be used only for excavation of this tunnel.

CONCLUSIONS

In this study that with purpose of investigating the effect of excavation method on the stress in the tunnel No.2 of Kurdistan is accomplished the following results have been obtained:

- By increasing the disturbance factor, the minimum stress and strength factor around the tunnel is decreased.
- The most of decrease of the minimum stress and strength factor is occurred in disturbance factors of 0.8 to 1.
- The obtained results imply that for excavation of the tunnel No.2 of Kurdistan, the blasting method should not be used and instead of, the mechanical excavation methods specially Tunnel Boring Machine method must be used.

REFERENCES

Aghanabati A. 2004. Geology of Iran. Geological Survey of Iran, 619 pp

Allen MB, Jackson JA and Walker R. 2004. Late Cenozoic reorganization of the Arabia-Eurasia collision and the comparison of short-term and long-term deformation rates. Tectonics, v. 23, art. no. TC2008, doi: 10.1029/2003 TC001530

Hoek E, Carranza-Torres CT and Corkum B. 2002. Hoek-Brown failure criterion-2002 edition. In: Proceedings of the fifth North American rock mechanics symposium, Toronto, Canada, 1: 267–273

Hoek E. 2012. Blast damage factor D, Technical note for Roc news. February, 2