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Compare the amount of buffer required to stabilize the single and twin road tunnels constructed in jointed rock

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Abstract

To cross the high mountains and steep, rather long and winding path done a lot to reduce the slope length, can be used out of the tunnel. Road tunnel into two groups, depending on the direction of one-way and two-way tunnels are divided. Due to the number of lanes on the highway, tunnel consists of two types: twin tunnels (with two separate small schools with one-way flow) and single tunnel (with a large cross-section of two-way flow) is used. Costs mainly during tunnel construction, excavation level and appropriate support systems for stabilizing the wall they depend. The system required maintenance depends on the terrain and its geotechnical properties. The rock mass, fractures are one of the most important factors in determining the amount of buffer is considered. In this paper we investigate the number of joint sets in the stabilizers is required for single and twin road tunnels will be examined.

Keywords: joint, single tunnel, the tunnel twin, cross drilling, numerical modeling, system maintenance.

Introduction:

To cross the high mountains and steep, rather long and winding path curves done much to reduce the slope length, can be used out of the tunnel. With the construction of the tunnel, the distance between two given points of the route (on both sides of heights) are much shorter, additional arc and remove the dangers of avalanches (in the snow) and falling rock fragments and soil (in areas falling) has been resolved as well as maintenance and operation costs, greatly reduced. Road tunnel into two groups, depending on the direction of one-way and two-way tunnels are divided.

Due to the number of highway lanes, including two types of tunnels: tunnels Twin 1 (with two separate small schools with one-way flow) and 2 single tunnels (with a large cross-section of two-way flow) is used. Given that the tunnel construction costs compared with conventional methods is high, so it is important to choose the kind of tunnel. Costs mainly during tunnel construction, excavation and support systems suitable for stabilization period depend on their wall. The storage system 3 required depends on the type of land and its geotechnical properties. The rock mass, fractures are one of the most important factors in determining the amount of buffer is considered. Accordingly, the number of joint sets is more

likely that some will fall on the tunnel and on the contrary, by reducing the number of joint sets this probability decreases. In this paper we investigate the number of sets of 4 single and twin road tunnels in the buffer needed to be examined. For this purpose, the rock mass with stable characteristics is intended as a base. Assuming constant joint properties in all cases, several joints in rock mass base is in order. In order to view the impact of joint sets the parameters of the rock mass basis, the software is used RocLab. The analysis is based on rock mass was conducted for four items, including the existence of a joint sets, two sets, three sets and three sets, plus the occasional joint.

View tunnels

For single and twin tunnels we suppose sections intended vaulted tunnel will be constructed at a depth of 200 meters from ground level. The cross-sectional size should be selected that meet the minimum space requirements for traffic. Regulations in different countries, in order to select the minimum space required for different parts of the tunnel are made various recommendations. Sections considered in this study, based on a set of regulations designed to suburban highway. Profile of single and twin tunnels is shown in Table 1.

Table 1: The specifications of single and twin tunnels

Characteristic	Single tunnel	Twin Tunnels
Number of lanes	4	2
(m) Width of roadway	3.65	3.65
(m) Right shoulder width	1.85	1.85
(m) left shoulder width	1.85	0.50
(m) The middle bar width	0.70	-
(m)sidewalk The width of the right	0.70	0.70
(m)The width of the left sidewalk	0.70	-
(m) Free height	5.20	5.20

Twin tunnels position relative to the earth surface subsidence and severe effect on the distribution moment in the tunnel lining 5 [1]. and reducing the distribution moment in the tunnel lining.

Baseline characteristics of the rock mass

In this study, sandstone 6 with the number of joints low, as has been the base of the rock mass. It is assumed joint properties except in the category joints, remain constant in different situations. In various sets distance of one meter joints and angles of 70 and 130 degrees relative to the horizontal axis is in order. In Table 2 The mechanical properties of the rock mass and fractures [2,3, 4], and in Table 3 Q index for the base of the rock mass [4], is shown.

Table 1: The mechanical properties of the rock mass

Specifications	amount
(GPa) The elastic modulus of the rock mass	19.8
Poisson's ratio of the rock mass	0.20
(MPa) Bulk density Stone	2600
(MPa) The compressive strength of the rock mass	43
(MPa) Tensile strength of the rock mass	2.1
(Rock mass friction angle (degrees	46.4
(MPa) Adhesion of the rock mass	9.45
(Joint friction angle (degrees	20
(MPa) Adhesive joints	0.20
(Expansion joints angle (degrees	0

Table 3: Indicators Q for the base of the rock mass

Parameter	Description	amount
(RQD) Rock quality index	very good	100
(Jr) Number of joint sets	Low joints	0.50-1
(Jn) Number of joint roughness	Rough or irregular	1.50
(Ja) Joint alteration number	Little changed	2
(JW) Joint water reduction factor	Dry drilling	1

By entering different joints in the rock mass basis, some of its mechanical properties will change. To view these changes from the application RocLab 7 is based on the criterion of Hoek & Brown. In RocLab GSI index is one of the parameters. Q system GSI index is obtained from the following equation [4,6]:

$$GSI = 9\left(\frac{RQD}{J_n} \times \frac{J_r}{J_a}\right) + 44$$

Where, RQD rock quality index, Jr number of joint sets, Jn number of joint roughness and Ja is a joint alteration number. Now, hold Jr, Jn and Ja, by applying different sets RQD value will change according to the following equation [4].

$$RQD = 115 - 3.3J_v$$

Where the number of joints per unit volume. So by changing the RQD, different values are obtained for the GSI. According to my values and the values proposed in RocLab, in different sets values for GSI has been set. Here the analysis was performed in rock mass base for four items, including the existence of joint sets, two sets, three sets and three sets, plus the occasional joint. Table 4 shows the properties of the rock mass shows in different situations.

Numerical modeling using DEM

Discrete element method was presented for the first time in 1971 by the Kandal 8. This method is also known as a solid block. From DEM to analyze the problems in static and dynamic rock mechanics is used. Unlike other methods, discrete element method for continuous ambient environment consisting of several blocks, but does not model considers separate. One of the key problems of rock mechanics, analysis of discontinuous rock masses that contains one or more joints and other discontinuities are. Therefore, in this study, according to a joint sets of discrete element method is capable of analyzing the behavior of discontinuous rock masses, in the form of software UDEC, is used.

The modeling process tunnels

- Create model geometry

Modeling first starts with the delimitation model. On the recommendation of the border should UDEC guide to five times the diameter of the tunnel it away? Crater and the crater is intended for the bottom border four times. After determining the overall dimensions of the issue, the cross-sectional geometry of the tunnel to be introduced to the program

Table 4: characteristic of rocks in different situations

Condition	Ja	RQD	GSI	C (MPa)	φ (degrees)	σ_c (MPa)	σ_t (MPa)	Em (GPa)
1	1	100	76.6	1.44	56.57	20.4	0.75	17.3
2	2	95	69.9	2.19	55.55	14.1	0.45	15.1
3	4	90	42.1	1.68	54.03	9.1	0.25	11.7
4	6	80	58.5	1.52	52.22	7.4	0.2	10

Roughly resolve issues associated with N 3/2 where N is the number of blocks [7]. So in a jointed, decide on the issue so that the program is able to reach a solution acceptable returns at the right time is very important. Actually applied (Figure 1) At the end of the meshed model is done with the command gen edge.

Determine the behaviors and characteristics of materials

Software UDEC able to model a behavioral model seven blocks and five types of behavioral model for joints [7]. Including block model can be, elastic model, mohr - coulomb model and the null model, and in the case of joint models Point contact, Area contact and Barton-Bandis noted. In this study, Blocks of Mohr and for joints, according to the model surface contact 9 more practical in rock mechanics issues, the model is used. Mohr each block in the model of behavior that are defined by six characteristics: density, bulk modulus, shear modulus, angle of friction, cohesion, angle of dilation and tensile strength. Also for joints six

Initial tensions

Information on the initial stresses through the trials here it comes in. When for some reason, do such experiments is not possible, the necessary parameters can be selected within a reasonable range and initial analyzes based on them. Hook and Brown, demonstrated the vertical stresses can be achieved with good approximation the following equation:

$$\sigma_{\upsilon} = \gamma h$$

In which the average specific weight of stone and h is the height of overhead. The introduction of initial stress model has the advantage that the initial convergence process accelerated program-binding. If you do not define the initial stress for the application, their amount in order to result in zero blocks.

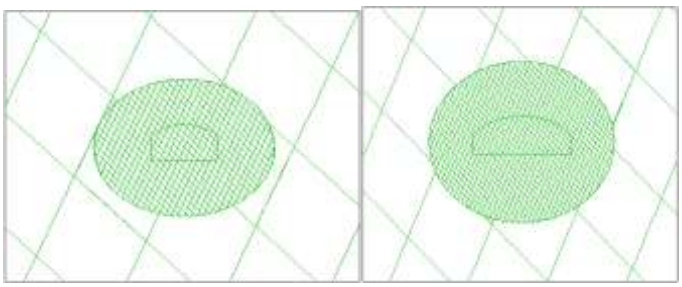
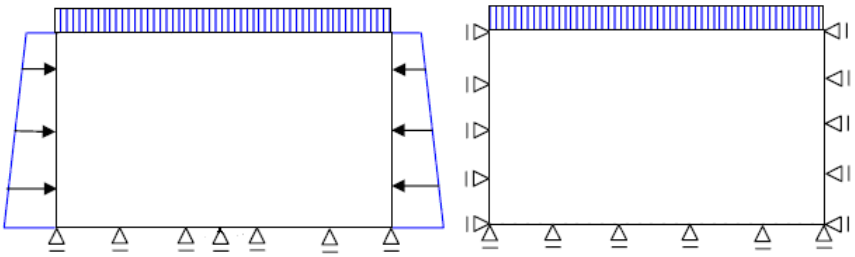


Figure 1: Range intended to apply joint spacing in real terms



(border tension) (Frontiers of Change location)

Figure 2: The boundary conditions imposed on modeling

Boundary conditions

After creating the model geometry and the determination of the initial stress Boundary conditions should be set for modeling. These issue usually two possible events: the borders shift and used the border tension (Figure 2).

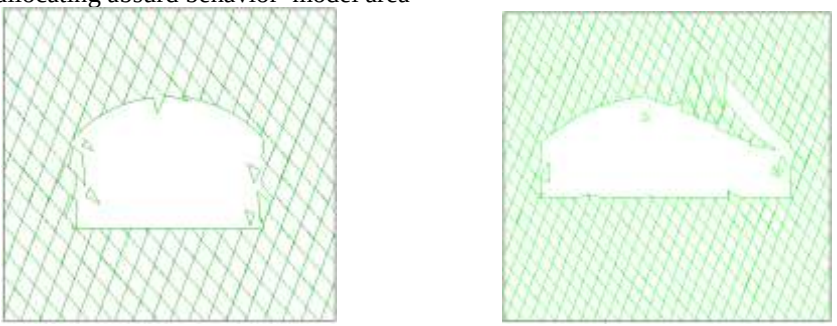
In the first case instead of applying external stress to the border, we shift zero at the nodal points. In the latter case the lateral boundaries limited by external forces and we will prevent it from moving. Given the importance of the impact of displacement on the stability of tunnel, select the appropriate boundary conditions plays an important role. Therefore, in this study the boundaries of tension to achieve primary balance are used.

Initial balance

After the models in order to balance the gravitational acceleration is of the order cycle n, where n is the number of steps taken to achieve primary balance issue. By executing this command the forces that were previously assigned to the nodes, moving nodes in order to force the equilibrium zone and tensions are created. After running this command with the convergence control, traction control and control of primary stresses, accuracy to reach equilibrium models examined in the original state takes.

Dig tunnels:

Tunnel dug by allocating absurd behavior model area



(Twin Tunnels) (single tunnel)

Figure 3: Mechanism digging the tunnel wall collapses all sections

Drilling, model unknown [7] Placed considerable drilling of all time, in different percentages of single and twin tunnels loss occurs in the discharge of tension. Figure 3 loss mechanism in single and twin tunnels dig up the entire cross-section of the show. Therefore, for a better understanding of the relationship between the displacement chambers discharge tunnels percent compared to the stress in their ground reaction curve (GRC) is drawing

Draw the characteristic curve (GRC)

To draw Characteristic curve Land in an underground excavation, As is customary analytical methods, Internal pressure must be equal to the tension in Enter place on earth to all points around the school During a gradual process to reduce the amount of pressure Has zero value.

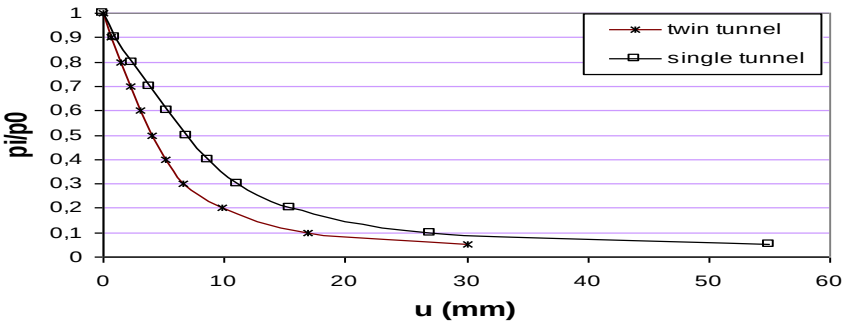


Figure 4: The Earth characteristic curve (GRC) for rock mass in (1)

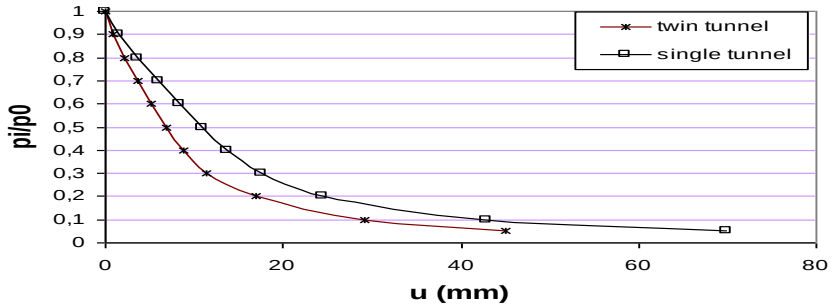


Figure 5: the characteristic curve (GRC) for rock mass in (2

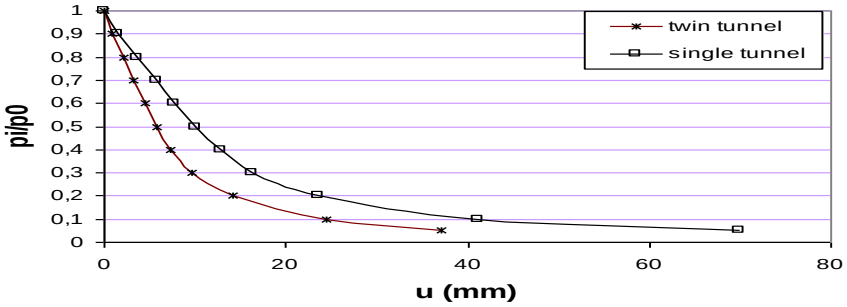


Figure 6: ground characteristic curve (GRC) for rock mass in (3)

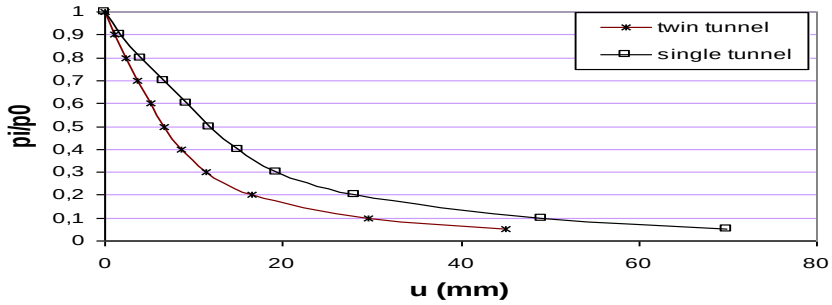


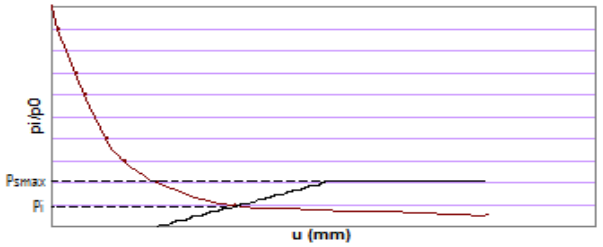
Figure 7: ground characteristic curve (GRC) for rock mass in (4)

Sustainable tunnel

One of the main issues in tunnel design specifications Saprtha is. In most tunneling projects of rock bolts, shot Crete, made of metal and concrete used. Here for sustainable tunnel in different situations, the hybrid system has been used rock bolt and shot Crete whose characteristics are shown in Table 5. [4,7].
Table 5: Profile rock bolts to stabilize the tunnels In this study, they compared the amount of support the single and twin tunnel is considered in a number of different sets, Assumed to tunnels in different situations, Saprtha clearance in 80% of the initial tension mounted. Also to More reasonable comparison,

Saprt tunnels in various positions chosen so that almost have the same confidence. Accordingly confidence Saprtha according to Figure 8 obtained from the following equation: (4)

$$F \cdot S = \frac{P_{s\max}}{P_i}$$



Where confidence Saprt, maximum pressure and the pressure at the point of intersection of the two curves Saprt. Saprt by determining the amount required stabilizing the tunnel, the curve of the Earth system interactions holder for single and twin tunnels have been drawn in different situations (see Figures 9, 10, 11, 12). Based on the analysis occur, the rock bolt and shot Crete required for stabilization of tunnels in different conditions were determined that their values are shown in Tables 6 and 7.

Table 5: characteristic of the rock bolt and shot Crete

(mm) Diameter	25
(kg/m3) Density	7500
(GPa) Modulus of elasticity	200
(kN) Tensile strength	240
(GPa/m/m) Shear stiffness slurry	5
(kN/m) Adhesive strength grout	300

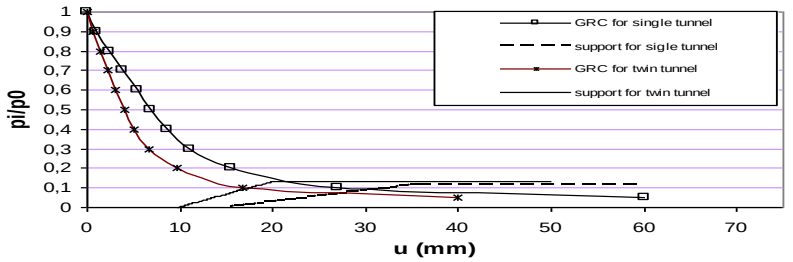


Figure 9: Interaction curve of the earth and holder system (1)

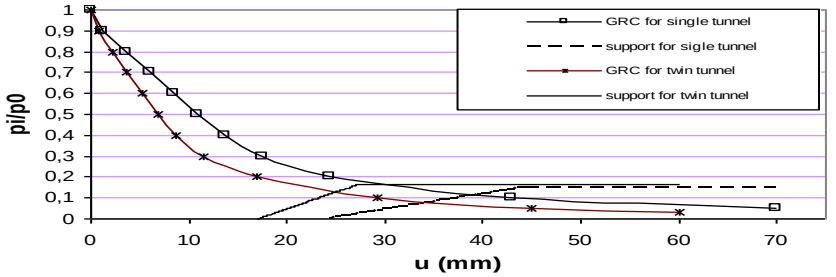


Figure 10: Curve interaction of land and maintenance system (2)

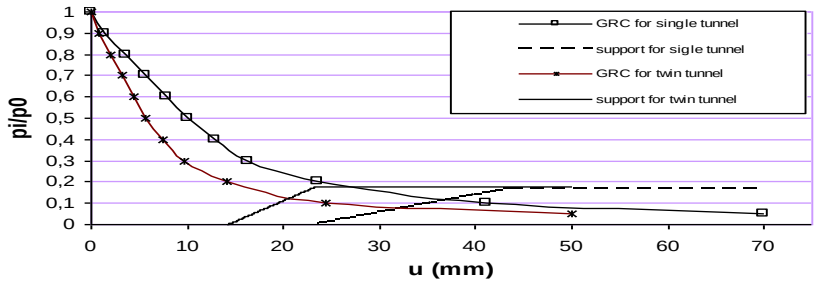


Figure 11: Curve interaction of land and maintenance system (3)

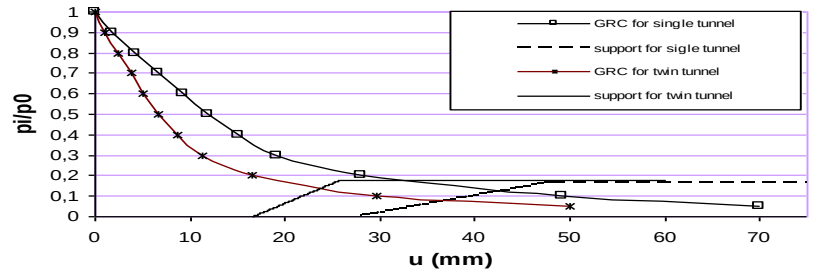


Figure 12: Curve interaction of land and maintenance system (4)

Economic Analysis

To determine the amount of required storage systems, tunnels in the costs are compared with each other. The twin tunnels to determine the amount Saprt, should be given the same two periods, Saprt amount needed to sustain one point, the number is multiplied by two. Crete shot in Figures 13 to 16 compare the size and length of rock bolts needed to stabilize the single and twin tunnels in different situations to show us.

Table 6: The rock bolts and shotcrete for the stabilization of twin tunnels

Condition	Shotcrete(cm) in roof	Shotcrete (cm) in wall	Spacing bolt=3,6 m in roof	Spacing bolt=3,2 m in wall
1	5	5	3	3
2	10	7.5	2	2
3	12.5	7.5	1.5	1.5
4	12.5	7.5	1.5	1.5

Table 7: The rock bolts and shotcrete required to stabilize the single tunnel

Condition	Shotcrete(cm) in roof	Shotcrete(cm) in wall	Spacing bolt=5,2 m in roof	Spacing bolt=3,6 m in wall
1	12,5	7,5	2	2
2	15	7.5	1.5	1.5
3	20	10	1.5	1.5
4	22.5	12.5	1.5	1.5

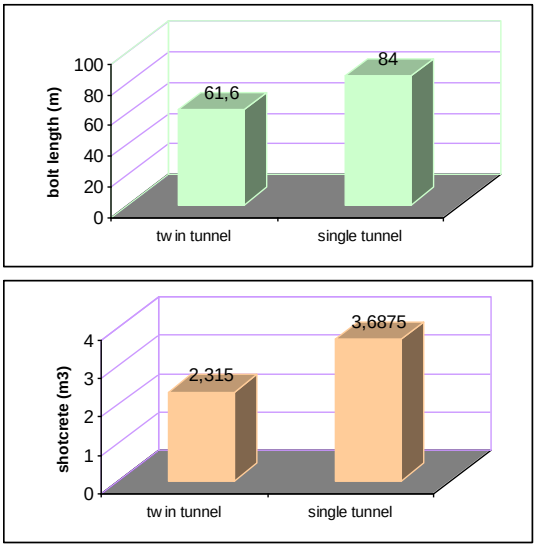


Figure 13: Size of shotcrete and rock bolt length needed to stabilize the single and twin tunnels for the length of the tunnel (1)

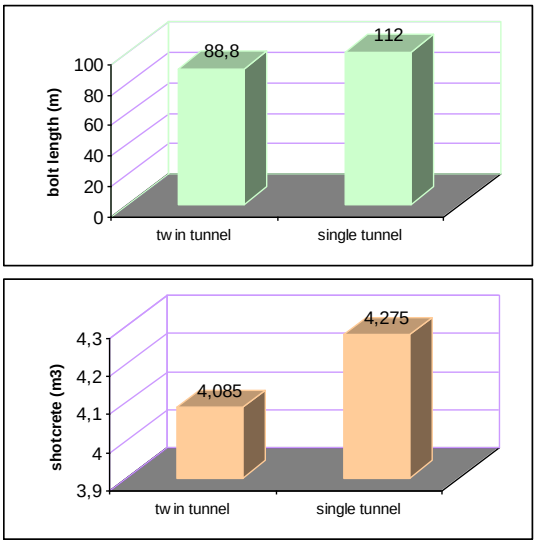


Figure 14: Size of shotcrete and rock bolt length needed to stabilize the single and twin tunnels for the length of the tunnel (2)

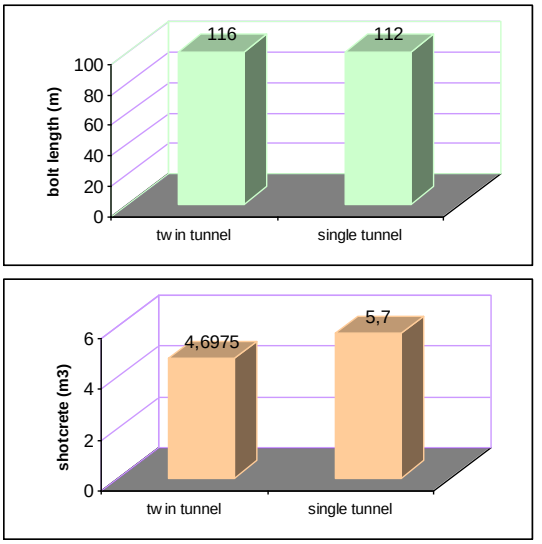


Figure 15: Size of shotcrete and rock bolt length needed to stabilize the single and twin tunnels to the tunnel length unit (3)

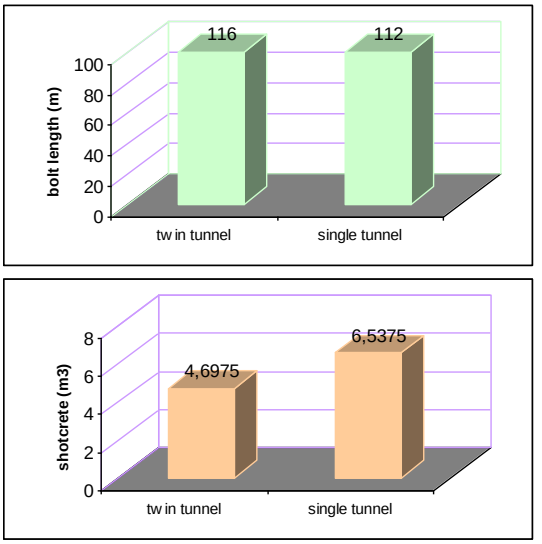


Figure 16: Size of shotcrete and rock bolt length needed to stabilize the single and twin tunnels for the length of the tunnel (4)

Conclusion

In the present study, the number of joint alteration Ja of rock, in the buffer required for the stabilization of single and twin road tunnels, using distinct element method was studied. Accordingly, given the number of joint rock mass displacement in a tunnel to control the hybrid system was used rock bolt and shot Crete. The results show that the preservative system needed to stabilize the single tunnel is more than double tunnels. Finally, based on the amount of buffer required in the tunnel, Economic Survey was

conducted. Studies show that, in the rock mass joint studies with different, more economical twin tunnels implementation of the single tunnel.

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