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Influence Mechanism of Lamella Joints on Tunnel Blasting Effect

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Abstract: In this study, we have a research of the influence mechanism of lamella joints on tunnel blasting effect. During the process of the tunnel blasting construction, primary structural planes make an important role for the effect of smooth blasting. Especially, it is difficult to attain the perfect blasting effect when the lamella joints intersect with the designed contour line. Coupled effect of the explosive stress waves and the explosive gas is deemed to the basic theory, analysis the blasting effect in the condition of single closed joint and lamella joints intersect with the designed contour line and test it combined with the tunnel engineering. Research results show that back break will occur at the same time in the condition of single closed joint, on the other hand, hackly back break will occur in the condition of the lamella joints.

Keywords: Blasting effect, hackly back break, lamella joints, mechanism, tunnel

INTRODUCTION

Along with the development of the economic construction, the technology of rock blasting is extensive used in water conservancy and hydropower, mining, transportation, military and other fields and have gained the huge economic efficiency and social efficiency. However, with the development of the modern engineering blasting technology, the request of the blasting quality is higher and higher. At present, the drilling and blasting method is the main method of mountain tunnel construction, during the construction process, influenced by the geological conditions of the surrounding rock, especially the exposed situation of primary joints, the back break phenomenon is very outstanding. Especially for the significant layered rock, such as slate, schist, gneiss, the hackly back break will occur at the position of the intersection of the rock level and tunnel contour line, which will have the detrimental effect on latter construction. How to avoid the back break, is the hot issue of the rock force circles.

Recently, the theory of the back break of tunnel surrounding rock is not perfect. The underground mine back break control was analysed and think that the back break will be decreased by the controlled blasting (Revey, 1998). Light section method to measure the back break was proposed and the test results and actual conditions are consistent with each other Maerz *et al*. (1996). The method of qualitative evaluation of the back break after the tunnel excavation was proposed (Abel, 1982).

Scholars at home are detailed studying the influence of the back break under different excavating methods and analysis the technology of decrease technology combined with the actual projects. A circular tunnel blasting excavation was simulated, discussed the blasting induced particle vibration attenuation characteristics and distribution law of the surrounding rock damage (Shuangying *et al.*, 2011). BAIHE tunnel was took as an example, estimated the fractal dimension, according to the wavelet multi-scale analysis function (Peng *et al*., 2012). How to improve the blasting effect by means of smooth blasting technology was studied (Minghui and Dunli, 2012). The tunnel smooth blasting effect, which is considered by the rock properties and stress wave propagation influenced by the joint has been researched (Nengjuan *et al.*, 2011).

To sum up, there are lots of research results about the blasting parameter reasons which result in the back break, but less results about the geology reasons, especially the back break caused by the lamella joints, which is the pore problem of this study.

FUNDAMENTAL OF ROCK BREAKING UNDER BLASTING LOAD

The fundamental of rock blasting fragmentation mainly explains the failure discipline of rocks under the blasting load. It is a complex process of the rock breaking under blasting load, when the explosive bursts in the rock, the energy will effect on the rock in the way of blasting stress wave and blasting gas, which makes the rock breaking. At present, the rock breaking theory can be concluded into three basic theory: reflection tensile action of blasting stress wave, expansion of explosive gas and the theory of interaction between them. And the finally theory is widely accepted (Huangping, 2009).

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Based on this theory, blasting stress wave and explosive gas are playing important roles at the same time during the rock breaking. The blasting process are as follows: the pressure and speed of propagation of detonation wave are far more than the explosive gas, so the detonation wave effects on the rock firstly and stimulates into the explosive stress wave in the rock, which will produce crushing zone and the radial cracks around the crushing zone. And then, explosive gas wedges into the cracks and make the crack expansion under the effect of quasi static pressure. At the same time, the crack expansion is aggravated by the reflected extension wave.

For different types of rock and explosives, it has different effect degrees about the explosive stress wave and explosion gas. On the condition of hard rock, high brisance explosive and coupling charging or lower coefficient of uncouple charge, the explosive stress wave is playing an important role. In contrast, the quasi static effect of explosive gas plays the leading role under the condition of soft rock, low brisance explosive and higher coefficient of uncouple charge. The essence of the theory is that the initial crack in rock mass by shock wave and stress wave caused by blasting and then explosive gas wedges into the crack, the effect of quasi static pressure expands the cracks which are generated by the stress wave. And the quasi static energy is the main energy that break the rock.

INFLUENCE OF LAMELLA JOINTS ON TUNNEL BLASTING EFFECT

When the single closed joint is intersected with the designed contour line, back break alternate phenomenon will appear ,which is shown in Fig. 1. The analyze with the smooth blasting theory are as follows:

The stress wave propagation law will be controlled by single closed joint: When the compression stress wave produced by the blast hole A and B diffusion around with cylindrical wave form, due to the joint surface exists between the holes, the wave propagation will be hinder, so as to reflection and transmission on the boundary, which causes large number of energy consumption. Because of the lower strengthen and energy, the tangential stretching effect will reduce. At the same time, the reflection wave will be formed to tensile wave and the earliest point occurred is the nearest from the blast hole which is on the joint plane, named by C and D point. Because of the interaction of the reflective stretching wave and the incident compression wave in AC and BD direction, will produce synthetic stress superposition, which will make increase the tensile stress on AC and BD direction. When the tensile stress is larger than the tensile strength of the rock, the incipient cracks will occur on the direction of AC and BD.

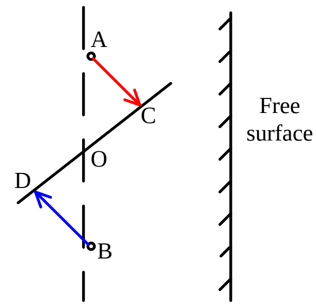

Fig. 1: Influence on single closed joint on tunnel blasting effect

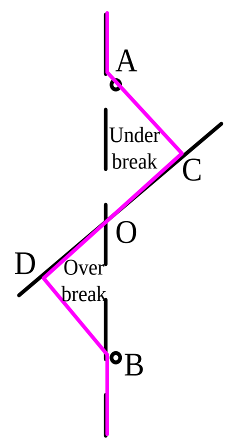

Fig. 2: Back break situation on the condition of single closed joint

The direction of explosive gas quasi static pressure will be changed by single closed joint: Because of the joint, the original free surface and the line of least resistance are both changed and as for the largest tangential tensile stress existed in the AC and BD direction, the blast A and B will respectively produce the stress concentration from AC and BD direction, under the quasi static pressure of the explosive gas, the initial radial crack will extend from these two direction, but not along the direction of blast hole attachment.

The comprehensive control function of blasting effect on single closed joint: After the detonation of the blast hole A and B, under the effect of the stress wave superposition, the initial radial cracks will be produced on the direction of AC and BD, which are the attachment of blast hole and the nearest joint surface points. Under the effect of the explosive gas quasi static pressure function, the advantage crack will further expand, at the same time, will limit the crack expansion on the other direction. In this condition, the priority radial crck AC and BD, along with the original joint CD, will form the back break alternate phenomenon under the control of the main stress field of the blasting formation, which is shown as Fig. 2.

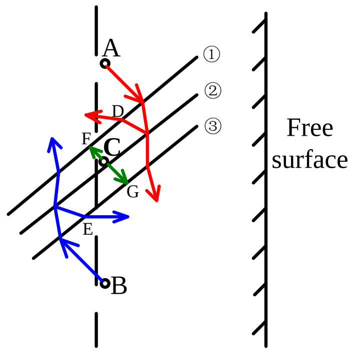

Fig. 3: Influence on lamella joints on tunnel blasting effect

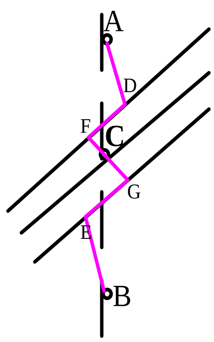

Fig. 4: Back break situation on the condition of lamella joints

The back break analysis under the condition of lamella joints: From the above analysis, it is known that when a single closed joint is intersected with the blast hole attachment, the back break alternate phenomenon will occur. And when there are lamella joints intersected with the blast hole attachment (Fig. 3), when blast hole A, B and C explosion, the direction of the explosive stress wave propagation is the same as the single closed joint condition. At this time, blast hole A and B explosive stress wave is reflected and refracted by joints (1), (2), (3), the finally reflection wave will, respectively propagate into rock from D and E points. And the stress wave from blast hole C, will respectively vertical propagation to joints (1) and (3) and propagate into rock from F and G points directly.

At this time, in the lamella joints area, produce three critical raw crack named AD, BE and FG, under the function of the explosive gas quasi static pressure, the gas will firstly wedge from the cracks AD, BE and FG and make the cracks propagation and intersected with the joint surface. With the high-speed wedge of the explosive gas, the joint surface will further failure and expand because of the shear break. In this condition, the priority radial crack AC and BD, along with the original joint CD, will form the hackly back break phenomenon under the control of the main stress field of the blasting formation, which is shown as Fig. 4.

Fig. 5: Entrance of GAOLING Tunnel

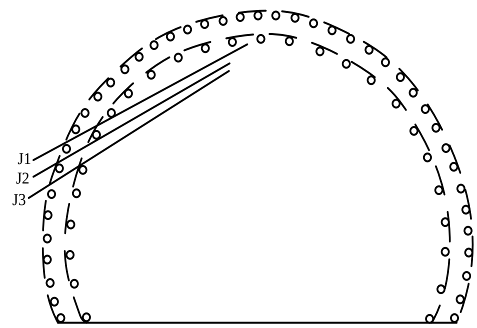

Fig. 6: Joints distribution on RK343+689 section

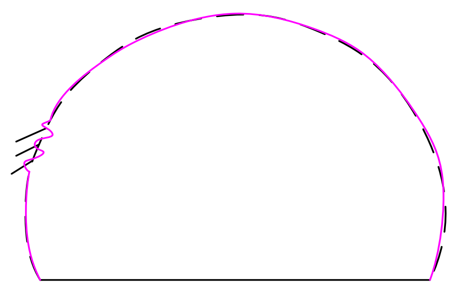

Fig. 7: Blasting effect on RK343+689 section

ENGINEERING PROJECT

GAOLING tunnel, on the highway from YANJI to TUMEN, is located 7km north from TUMEN city in JILIN province, which is shown in Fig. 5. The tunnel is located on the northeast ridge, which forms complex, but have no obvious in valleys and negative terrain cutting the tunnel area and the geological structure is simple. Generally, it has a gentle terrain and e thick quaternary system covering layer on the foot of the slope, which is about 15-25 m thick. It is an easy water catchment area and underground water seepage partly. The tunnel is in the northeast part of the eastern mountain wet season frozen zone, the rock type is mainly Mesozoic Triassic tuffaceous andesite and granodiorite.

The surrounding rock compressive strength on RK343+689 section is 59.41 MPa and the tensile strength for 7.72 MPa. According to the stress wave and blasting gas action principle calculation, the spacing of the peripheral hole is 0.47 m, in order to convenient construction, the actual spacing of the peripheral holes is 0.5 m, which is loading 3 roll explosive. Take the line of least resistance 0.6m and the second barrel blast holes are, respectively loaded 8 roll explosive.

At the left side of the tunnel face of RK343+689 section, there are lamella joints named J1, J2, J3, which are located at 3.5-4.5 m height (Fig. 6).

According to the theoretical analysis in the former section and the field blasting test, we get the results that because of the lamella joints, it produced the hackly fracture surface at the joint existence area and the convex degree is about 35 to 45 cm, which is shown in Fig. 7.

In view of appear hackly fracture surface, it is suggested that the blasting parameters adjustment are as follows:

- Adjustment the charge structure of the peripheral holes from the bottom of hole continuous instead of detonating cord interval charging, at the same time, increase the distance of cartridges and explosive load
- Increase the extrapolation quality of the perimeter holes at the under break area
- Decrease the distance of perimeter holes at the joint band area and adjust the charging structure

CONCLUTIONS

- The rock breaking reason under the blasting load is the combined action of the explosion stress wave and the explosive gas
- When a single closed joint intersected with the hole attachment, the crack surface will appeared firstly at the hole and joint vertical direction and will appear the back break alternate phenomenon finally
- When there are lamella joints which intersection with the hole attachment, the explosion stress wave, which is from the outside of joint will be reflection and refraction and will compositions with the stress wave propagated by the inside hole, form the initial crack finally. When the high pressure explosive gas wedge, the tensile cracks will appear between the stress wave reflection point of outside blast hole and the stress wave tensile splitting point of inside hole and hackly fracture surface will present finally
- After the field blasting test, it is suggested to adjust the charging structure of peripheral holes, especially the lamella joint area, at the same time, the distance between peripheral holes should be decreased.

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