

# Study of Large-span Roadway Deformation Feature under the Dongpo Coal Mine Mining

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**Abstract**—Taking the 914 working face of Dongpo Coal Mine as the object of study, through theoretical study and numerical simulation calculation to research large-span trough deformation features of Mining Face under the mining influence and tunnel deformation features under different vertical loads, providing a scientific basis for exploitation design, tunnel support design, etc.

**Keywords**—tunnel deformation feature; numerical simulation; mining influence; working face; rock controlling

## I. INTRODUCTION

Dongpo Coal Mine is located in the northeastern of Liu Jiakou Village, Xia Tuanbao Town, Northwestern Shuo district, Shuozhou City, Shanxi Province. It is dominated to both Xiao Pingyi Town & Xia Tuanbao Town, Shuo District. Its geographic coordinates: longitude:  $112^{\circ} 22' 56'' \sim 112^{\circ} 25' 49''$ , latitude:  $39^{\circ} 24' 52'' \sim 39^{\circ} 26' 29''$ . Its range delineated by 10 coordinate points, Its west-east width of about 3.97km, north-south width of about 2.51km. Its area 8.3236km<sup>2</sup>. After the merger and reorganization of the minefield, it adjoining Shanxi Zhongmei Danshuigou Mining Company in the east, adjoining Maohua Dongyi Mining Company in the west and northwest. No other adjoining mines in the other directions.

Currently, Dongpo Mine tunnel support design, section coal pillar setting relying on experience by analogy and lack of theoretical basis; meanwhile, it is in urgent to sum up experience from the current stope face after mining to provide a reference for subsequent smooth working surface mining. Given this, Shanxi Zhongmei Dongpo Coal Industry Co., Ltd. joint with Beijing University of Science and Technology, proposed a issue of "No.9 coal seam roadway parameter optimization study of Dongpo Coal". By studying the mine pressure features of NO.9 coal seam Dongpo Coal, revealing the movement rules of the roof, bearing pressure evolution characteristics, face mining

sphere of influence, trough deformation mechanism, the research results is very important to accumulate experience of tunnel support, section coal pillar setting for Shanxi Zhongmei Dongpo Coal company.

## II. PROJECT PROFILE

Both of the two cross-heading of 914 working face are set along with the bottom coal, and the tunnel roof is the coal body with the hardness of 2 to 3. The cross-heading of work face is machine transportation tunnel. It is rectangular section with the net width 5.5m and net height 3.3m. The roof is supported by anchor beam and rope. Anchor is the high strength steel anchor with the  $\Phi 20\text{mm}$ , length 2600mm, with arched high strength pallet and distance of 1000X1000mm; the right side uses FRP anchor with  $\Phi 20\text{mm}$ , length 2000mm, along with arched high strength pallet and strength 1500X1000mm; left side uses thread steel anchor with  $\Phi 18\text{mm}$ , length 2000mm, along with arched high strength pallet and strength 1500X1000mm.

It is empty raw material tunnel under the work face cross-heading. The coal pillar of 20m to protect the tunnel, rectangular section with net width of 5.0m and net height of 3.5m. It is same protection way as machine transportation tunnel. Both sides use the anchor net protection. The left sides uses FRP anchor with  $\Phi 20\text{mm}$ , length 2000mm, along with arched high strength pallet and strength 1500X1000mm; right side uses thread steel anchor with  $\Phi 18\text{mm}$ , length 2000mm, along with arched high strength pallet and strength 1500X1000mm.

According to classification of the tunnel, 914 work face cross-heading belongs to large span tunnel. The large span tunnel deformation mainly shown as roof sinking.

### III. TUNNEL SURROUNDING ROCKS DESTRUCTION CHARACTERISTIC THEORETICAL CALCULATION

#### A. Basic theory

Let there is a horizontal coal layer with the thickness of  $2h$  and the layer bears the effect of the average vertical pressure  $q$  and horizontal pressure  $\lambda q$  ( $\lambda q$  is Side Pressure Coefficient); As Fig .1 shown, after digging a tunnel of  $2b$  width in the coal body, the stress of the coal body will be distributed again. The stress change area is called disturbed area and marked the length as  $L$ . The areas marked A,B,C are ductile area, flexible movable area and original rock stress area;  $x_p$  is the length of ductile area;  $P_0$  is the protection resistance. Besides,  $\sigma_x$  respects to horizontal stress and  $\sigma_y$  respects to vertical stress. The letters P, C, E mark on the variate respect to the inner of ductile area, flexible movable area and original rock stress area.

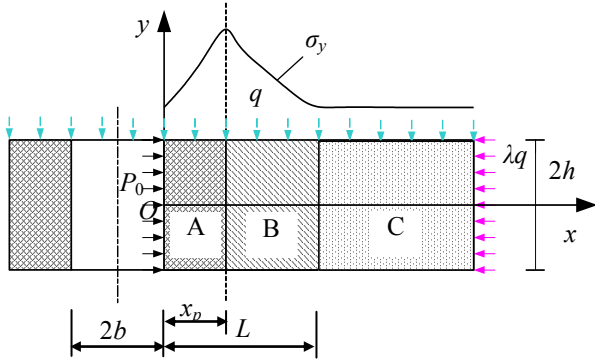


Figure 1. Mechanical Model

#### B. Calculation result

According to the tunnel occurrence condition and the support condition, take  $\mu=0.26, \lambda=0.5, \varphi=35^\circ, c=1.5\text{MPa}, \tan\varphi=0.1, c_0=0.1\text{MPa}, h=1.8\text{m}, b=2.8\text{m}, P_0=0.2\text{MPa}$ . Besides, take  $q=6\sim 20\text{MPa}$ .

Take the parameter above into the equation and make the calculation then get the relationship between the disturbed area length  $L$  and  $q$ . It is shown as Fig .2. The relationship of ductile area width  $x_p$  and  $q$  shown as Fig .3.

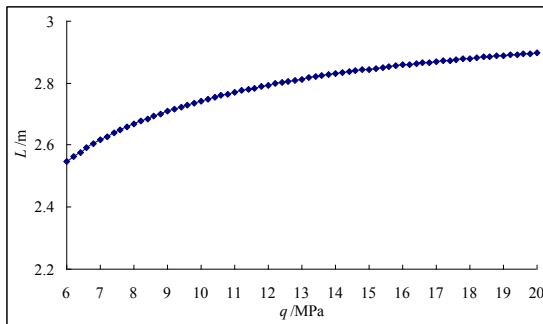


Figure 2. The relationship between disturbed area width  $L$  &  $q$

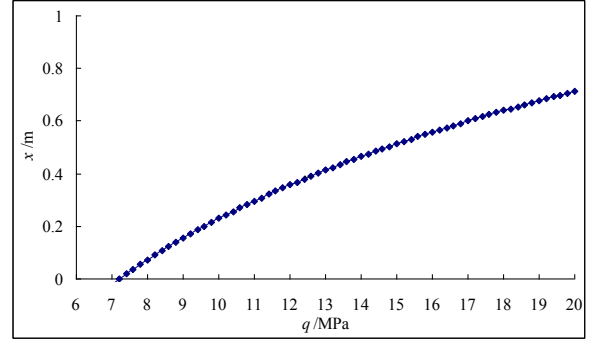


Figure3. The relationship between ductile area width  $x_p$  &  $q$

From the chart, the disturbed area length & ductile width become larger gradually with the tunnel surrounding rock pressure increase. For instance, the tunnel sides disturbed width increased from 2.74m to 2.9m and ductile area width increased from 0.2m to 0.7m when the surrounding rock vertical stress increased from 10MPa to 20MPa.

The calculation result indicates that the surrounding rock inner support stress increased but the amplitude is not big when the work face cross-heading subjects to the mining effect. Meanwhile, the tunnel damaged width is not big when it subject to the mining effect due to the burial difference or coal hardness, etc.

### IV. NUMERICAL SIMULATION CALCULATION

#### A. Numerical Model

According to the 914 work face cross-heading roof & floor condition, establish the numerical calculation model as Fig .4, Length X Width is 60m × 60m. Total 9840 grids. The tunneling across along the floor with the Length x Width 5.5m×3.5m. The model calculation uses Mohr-Coulomb rule, the yield rule can be expressed as,

$$f_s = \sigma_3 - \sigma_1 N_\varphi + 2c(N_\varphi)^{1/2} \quad (1)$$

$$f_t = \sigma_t - \sigma_1 \quad (2)$$

In the equation,  $\sigma_1$  is the Max main stress、 $\sigma_3$  is the Min main stress;  $\varphi$  is the inner friction angle;  $c$  is the cohesion;  $\sigma_t$  为 is the tension strength;  $N_\varphi$  为 is the parameter that related to the inner friction angle, and  $N_\varphi = (1 - \sin\varphi) / (1 + \sin\varphi)$ .

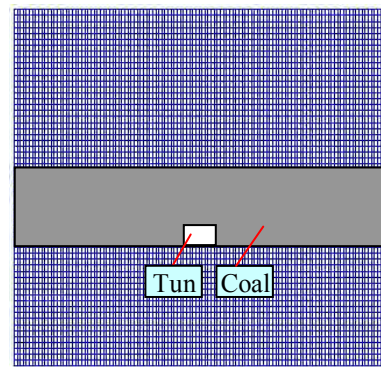


Figure 4. Calculation model

## B. Boundary Condition

Two sides of the model and the bottom imposed to displacement boundary and the top imposed to stress boundary. For simulating the effect of mining to the tunnel bottom heave, the top will be imposed to the vertical loading of 6MPa、9MPa、12MPa、15MPa、18MPa、21MPa separately. The tunnel surrounding rock will have no support.

## C. Result Analysis

As shown in Fig .5, it indicate that the tunnel surrounding rock vertical displacement nephogram of model top is imposed the different vertical stress as 6MPa、9MPa、12MPa、15MPa、18MPa、21MPa. From the Chart, the sinkage of corresponding tunnel roof will be 125mm, 200mm, 300mm, 450mm, 600mm, 1000mm, when the model top is imposed the vertical stress of 6MPa、9MPa、12MPa、15MPa、18MPa、21MPa. In this case, the tunnel roof sinkage increases gradually when the mining effect increases. When the model top loading increases from 6Mpa to 21Mpa, the tunnel top sinkage increases from 125mm to 1000mm and it is 8 times as original. Therefore, the mining effect influences significantly to the roof sinkage.

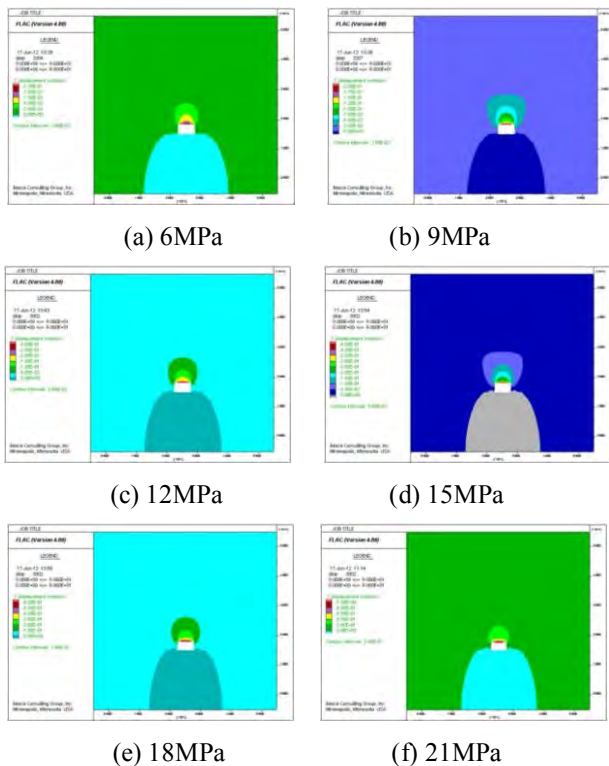


Figure 5. Tunnel surrounding rock vertical displacement distribution nephogram when the roof is imposed different vertical loading

As shown in Fig .6, it indicate that the tunnel surrounding rock horizontal displacement distribution nephogram of model top is imposed the different vertical stress as 6MPa、9MPa、12MPa、15MPa、18MPa、21MPa. From the Chart, the upheaval of corresponding tunnel will be 15mm, 40mm, 75mm, 100mm, 150mm, 200mm, when

the model top is imposed the vertical stress of 6MPa、9MPa、12MPa、15MPa、18MPa、21MPa. In this case, the tunnel roof upheaval increases gradually when the mining effect increases. When the model top loading increases from 6Mpa to 21Mpa, the tunnel top upheaval increases from 15mm to 200mm and it is almost 12 times as original. However, in view of total amount, the tunnel upheaval is not big with the mining effect.

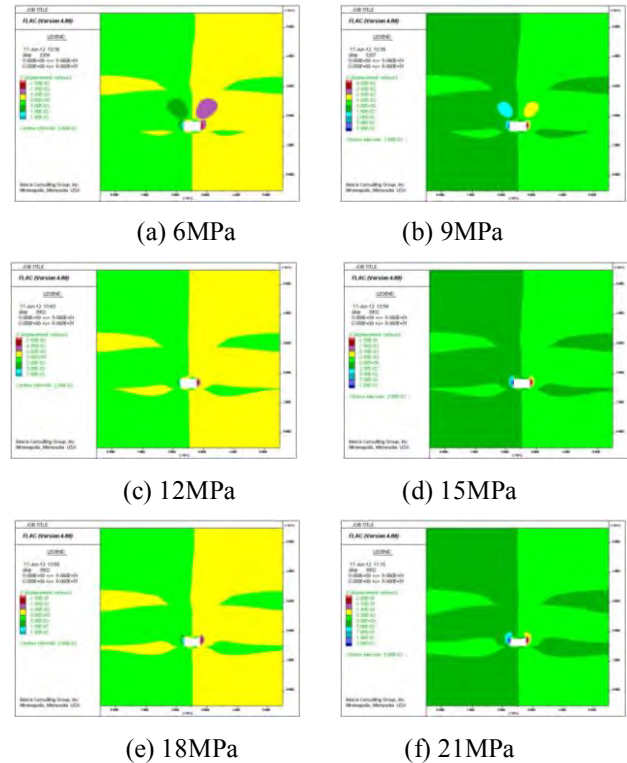
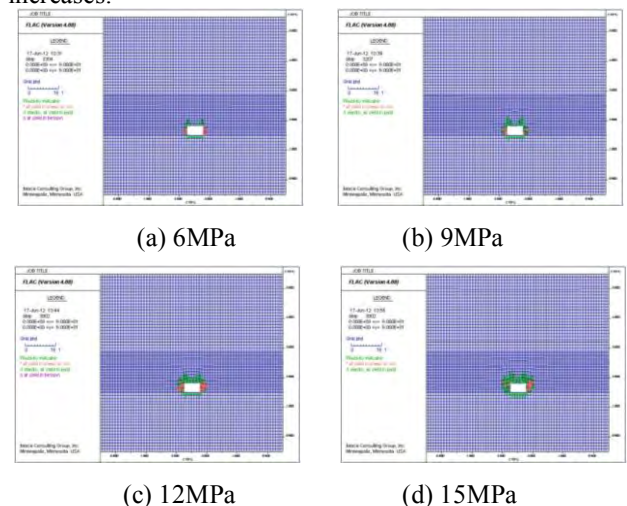


Figure 6. Tunnel surrounding rock horizontal displacement distribution nephogram when the roof is imposed different vertical loading

Fig .7 shows the corresponding tunnel surrounding rock ductile area distribution when model roof is imposed vertical stress as 6Mpa、9Mpa、12Mpa、18Mpa、21Mpa. From the chart, the tunnel surrounding rock deformation area increases gradually, and there is obvious increases for the tunnel roof deformation area when the mining effect increases.



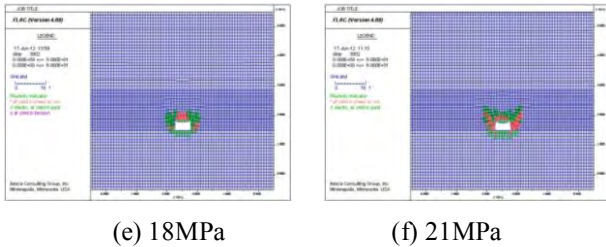


Figure 7. Tunnel surrounding rock ductile area distribution nephogram when roof is imposed different vertical loading

Fig .8 shows the corresponding tunnel surrounding rock displacement vector nephogram when the model roof is imposed vertical stress as 6Mpa, 9Mpa, 12Mpa, 18Mpa, 21Mpa. From the chart, the tunnel displacement amount increases gradually but the displacement is mainly shown as the tunnel roof sinks when the mining increase. Besides, from the chart, the tunnel roof upheaval rock mainly come from the tunnel roof but not from the two sides.

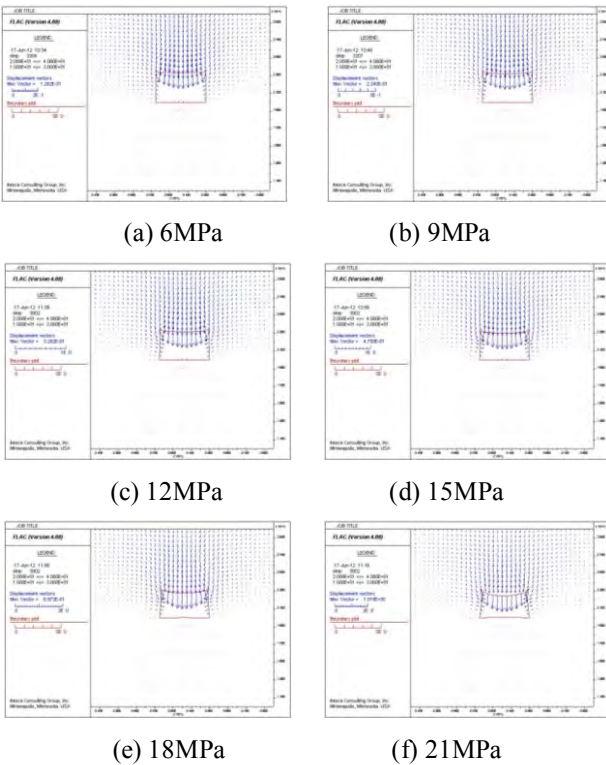


Figure 8. Tunnel surrounding rock displacement vector nephogram when the top is imposed different vertical loading

From the analysis of the numerical simulation result, the conclusion is, (1) With the increase of mining effect, the tunnel roof sinkage and upheaval amount increases gradually, and the floor upheaval amount is small. The tunnel deformation mainly comes from the roof sink. (2) Tunnel roof is the main control point of large span tunnel.

From the study above, the 914 work face cross-heading surrounding rock deformation mechanism as shown as below. Tunnel roof changes to bent and damaged with the horizontal stress and dead weight.

The key to cross-heading deformation control, firstly, use the anchor net support to reinforce the rock body in the roof damage range and make it to a whole structure that is called Small Structure; Secondly, use the high prestress anchor cable support to fix the Small Structure to the steady rock body then become to the steady Big Structure.

## V. CONCLUSIONS

- (1) The theoretical result shows, the tunnel surrounding rock peak stress, ductile area width, breakage width with the mining effect gradually increase to the tunnel.
- (2) The theoretical result shows, with the mining effect gradually increase to the tunnel, tunnel roof sinkage increases gradually and the surrounding rock ductile area distribution area increases gradually; tunnel roof sink is the main deformation of big span tunnel surrounding rock.
- (3) Roof is the main control point for 914 work face cross-heading surrounding rock.

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