

The effect of the roadway excavation disturbance by spacing between deep adjacent tunnels

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Abstract. By using the finite element software ABAQUS, the paper carries out numerical simulation analysis on influence of new coal lane tunneling along the groove disturbing the original high pumping Lane in a deep mine 1112 working face in Huainan. This article analyzes two tunnels in different distance with the new roadway excavation cause position change as well as an increase in the maximum stress and displacement of the original high pumping Lane in deep mine. In this essay, we explore the influence of new roadway excavation to original roadway stability, and study the deep adjacent tunnel excavation disturbance effect to the original roadway stress and strain change. The results show that: the reasonable distance between shallow tunnels is not applicable to deep condition. Meanwhile, the roadway excavation disturbance effect between adjacent tunnels is significantly in deep mine. In addition, the original roadway need to add new support measures on the basis of the existing supporting structure to ensure its normal use.

Introduction

With the booming of economy in our country, the energy consumption is growing up year by year, the demand for coal is increasing, the coal resources in shallow part is tapered, the depth of coal mining is also increasing, most of the mines reaches deep mining[1-3]. The crustal stress in mine roadway is on the rise and some new rock pressure problem gradually emerged along with the increase of mining depth, roadway excavation disturbance is one of them.

Roadway driving disturbance means that the second excavation of roadway disturbs the first one in the process of multiple neighboring roadway arrangement. There are some studies of the roadway stability about different arrangement modes and excavation sequences in the shallow underground engineering [4-7]. In the deep case, the enlargement of stress-concentrated areas on both sides of the roadway leading to stress-concentrated zone superimposed on each other between adjacent tunnel, and the disturbance of second excavation to the first one appeared gradually. When it gets more serious, it can cause the whole deformation of first laneway [8-10]. Existing research focuses on the support principle of neighboring roadway, but the influence of the different spacing of roadway on the stability in the research is less. This thesis regards the tunneling transport gateway of roadway and high pumping tunnel in a deep mine 11-2 coal seam in Huainan mining group as research object, and studies the stability of the two roadways at different pitches. By using the finite element software ABAQUS for numerical simulation, this paper carries out the influence of new roadway tunneling disturbing the original roadway at different pitches in deep mine.

1. Calculation model and simulation program

1. 1 Engineering site condition

The high pumping Lane in a -906m deep mine 1112 working face in Huainan Mining Group has excavated for a long time, the coal lane tunneling along the groove below it starts construction. These

two roadways are 45 meters apart with the same direction. The two roadways are suitable for research on the effects of roadway excavation disturbance in deep mine, as shown in figure 1.

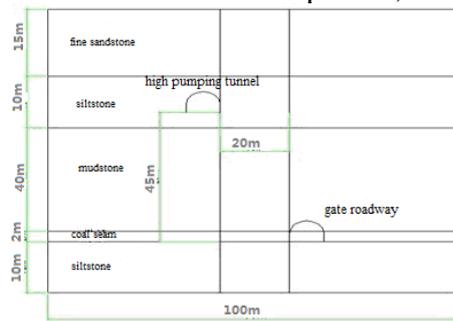


Figure 1 the relative position of two roadways

The mutual distance between adjacent coal roadway in our country design in accordance with “the procedure of rational distribution of protection and supporting in coal roadway” from former Soviet Union. According to this regulations, the reasonable spacing D of two roadways is decided by five factors: span length, the burial depth of the tunnel, the intensity of the surrounding rock, dip angle of rock stratum and intersection angle between the roadway and terrane strike. It calculated according to the following formula:

$$D = (a_1 + a_2)K_1 \quad (1)$$

in the type $a_1 + a_2$ ——the total widths of interactional roadways, m;

K_1 ——the interaction coefficient of roadways,

In general, the reasonable distance between two roadways is 20~40m, and the spacing of raise and dip roadway concentration area is 15~30m. Surrounding rock is stable in small value, and unstable regularly take large value. When the spacing of roadway is greater than reasonable spacing, interaction between two roadways can be neglected. But in the case of deep mining, neighboring roadway influenced by the roadway disturbance, the scope of reasonable spacing as above has been unable to apply. The distance between two tunnels in the text is more than 40m, but the deformation of high pumping tunnel is increased by coal gate roadway excavation in the actual construction. Therefore, the thesis regards these two roadways as the research object to simulate the influence of different spacing of roadway.

1.2 Model establishment and parameters

According to the engineering geological conditions of this mine, the paper builds up analysis model about the stability of high pumping tunnel after coal gate roadway excavation. The rocks of this calculation model choose coal seam, mudstone, siltstone and sandstone. Coal floor can be simplified as siltstone, and the roof shall comprise of mudstone, siltstone and sandstone. The parameters of rock mechanics performance are shown in table 1.

Table 1 the parameters of rock mass mechanics

lithology	bulk modulus /Mpa	shear modulus /Mpa	cohesive force /Mpa	angle of internal friction/°	tensile strength /Mpa	density /g/cm ³	elasticity modulus /Mpa	poisson ratio / ρ
mudstone	260	2465	1.33	13.8	5.41	2.82	3547	0.39
siltstone	1110	3627	3.20	22.83	7.61	2.92	5846	0.22
fine sandstone	2787	8023	5.16	25.22	10.96	3.10	13484	0.19
coal seam	43.9	584	0.18	12.5	0.8	2.4	822.3	0.42

Simulation using the Mohr-Coulomb model, the form of M-C rule is:

$$\tau = c + \sigma_n \tan \varphi \quad (2)$$

Promote to the general case, also can be written as:

$$\frac{\sigma_1 - \sigma_3}{2} = -\frac{\sigma_1 + \sigma_3}{2} \sin \varphi + c \cos \varphi \quad (3)$$

In this type: c is cohesive force, φ is angle of internal friction, σ_n for the Normal stress in shear plane, n for outward normal direction in shear plane. We perform the spacing of two roadways in model once every 10m for a simulation from 10m to 50m. Comparing the simulation results of the 5 cases, the influence of roadway excavation disturbance to the original roadway stability in different spacing was observed. Model is shown in figure 2 [11, 12].

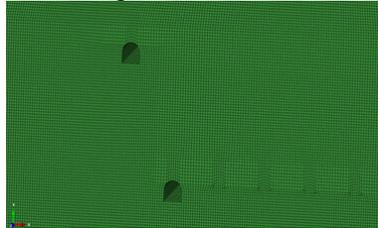
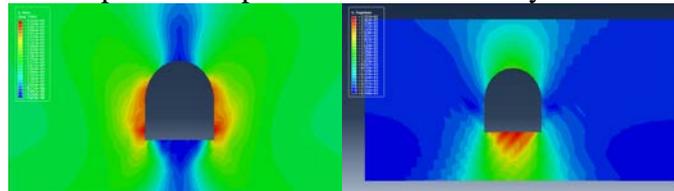


Figure 2 the numerical model

2 The simulation results analysis

The stress and displacement of high pumping tunnel in original state are shown in figure 3. It can be seen in the case of - 906m, the pressure on high pumping tunnel is still larger due to the high ground stress. Although the initial support have been proceeded. The position of the maximum vertical stress of surrounding rock in roadway at the bottom of roadside and the maximum value close to 43Mpa, and the maximal displacement position in the roadway floor reaches 25mm.



(a)The stress nephogram (b) The displacement nephogram

Figure 3 the stress and displacement nephogram of high pumping tunnel in original state

According to the simulation scheme, the stress and displacement nephogram of high pumping tunnel are shown in figure 4 and 5 respectively when the spacing between coal gate roadway and high pumping tunnel is 10m, 20m, 30m, 40m or 50m. In the figure 4, the stress distribution of high pumping tunnel have taken place in a certain excursion after the coal roadway excavation because the coal gate roadway locate in the low right of high pumping tunnel. The location of maximum stress happened changes especially in small spacing, and it also led to the position of maximum displacement changes.

Roof convergence becomes the biggest problem of roadway deformation. When the spacing of roadway is 10m, coal roadway has pressure relief effect on high pumping tunnel. The maximum stress of high pumping tunnel is only 39Mpa less than the maximum stress that coal roadway is not excavated, but it did not affect the increase of maximum displacement. At this time, the maximum displacement of high pumping tunnel turns into 46.8mm. When the spacing is larger than 20m, changes of maximum stress and displacement start regularly. The maximum stress and displacement gradually reduced with the increase of spacing. The maximum stress changes from 51Mpa in 20m of spacing to 44.8Mpa in 50m, all of them are larger than the original state stress of high pumping tunnel. At the same time the maximum displacement changes from 46.8mm to 25.8mm, and it is still larger than the original. Through the simulation, we can see the position of stress in high pumping tunnel has changed and the location of the maximal displacement also changed after coal roadway excavation. The figure 5 reveals that the position of the maximum displacement is located in the roof of high pumping tunnel. When the distance between two tunnels is 50m, the high pumping tunnel is still affected by the roadway excavation disturbance. The position of the maximal displacement has

changed significantly, although the maximal displacement and stress did not increase obviously. The original supporting measure in high pumping tunnel can not be applied after coal roadway tunneling. The distance between two tunnels is about 45m between 40m and 50m in practical engineering, the maximum stress and displacement of high pumping tunnel are increased and the position are changed after coal roadway excavation. The original supporting structure needed to add new support pattern in order to guarantee the high pumping tunnel exploit successfully.

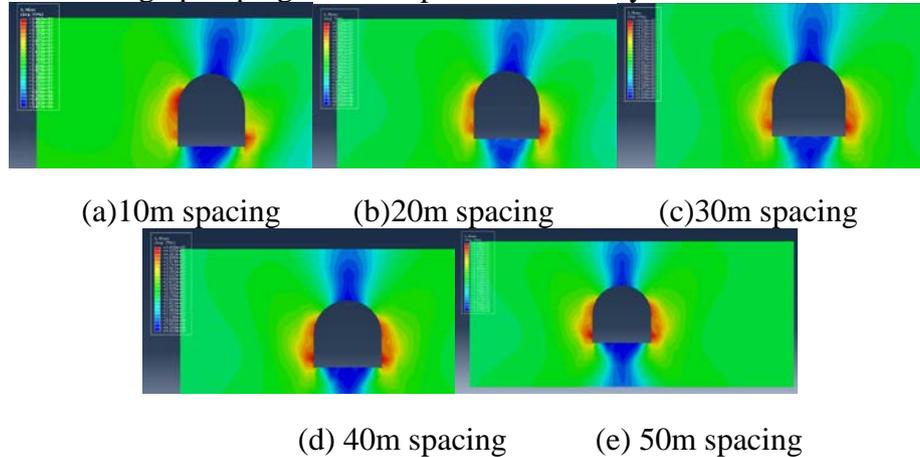


Figure 4 the nephogram of high pumping tunnel stress after coal roadway excavation

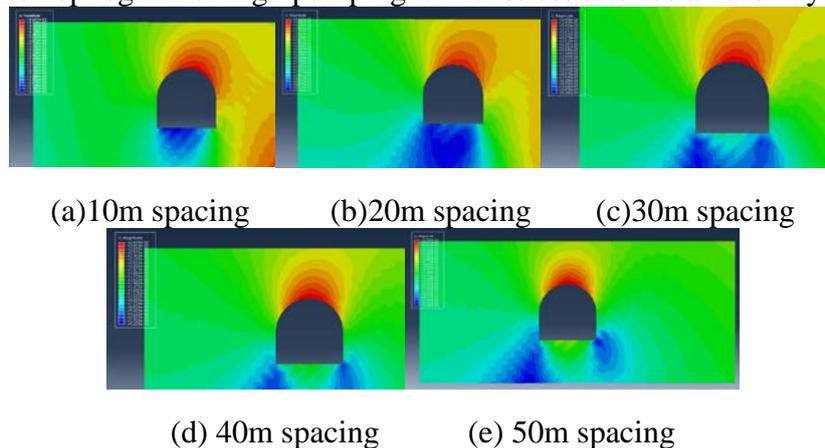


Figure 5 the nephogram of high pumping tunnel displacement after coal roadway excavation

Summary

1) The roadway excavation disturbance effect between adjacent tunnels is obvious in the deep mine. For this reason, the original reasonable spacing of roadway no longer applies in deep mine. The original roadway supporting measures should be adjusted to ensure that the tunnel can be used under the action of new roadway excavation disturbance.

2) Based on the results of numerical simulation, the different location of the new tunnel will lead to value increased and the position changed in maximum stress and maximum deformation of original roadway. When the distance between two tunnels reaches 50m, the effect of roadway excavation disturbance begins to abate and maximum deformation does not increase obviously. However, the changes in the location of maximum displacement will still lead to instability of the original supporting structure of roadway.

3) Numerical simulation methods effectively consider the complex geological conditions and construction factors and the results from that are more close to the engineering practice. Make full use of the results from numerical simulation can predict the possibility of stress and deformation of roadway, therefore, corresponding supporting measures can be formulated in advance to avoid the destruction of the roadway and delay of the project.

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