Yield Evolution Mechanism and Control Technology of Roadway Surrounding Rock in Deep Mine

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Abstract. To solve the support problem of surrounding rock roadway in deep mine with high stress, based on the geological conditions of the third level roadway in Haizi colliery,it discussed the factors affecting the surrounding rock deformation first, and established the numerical simulation model of roadway and studied the failure characteristics and deformation mechanism of the surrounding rock in this paper. The results show that when roadway being dug, the high stress environment led to serious deformation and failure to the surrounding rock, so the surrounding rock need to play a supporting force by itself. According to the deformation characteristics, the supporting scheme and parameters were determined and applied in field test. The monitoring results show that the full section bolt-grouting could effectively limit the harmful deformation of the roadway , and it successfully maintains the stability of roadway .

Introduction

Serious deformation and maintenance of roadway had become major and common problems of deep mining [1,2]. Domestic and foreign scholars done a lot of research on deep mine, but because of the complexity and uncertainty of roadway occurrence conditions, deformation mechanisms were different from each other.

Not considering the impact of temperature and karst water, one of the factors that affecting deep roadway stability is the high field stress, strata behaviors of deep roadway excavation compared to Strata behavior in shallow becomes more significantly, causing the surrounding rock in a wide range of yield failure[3,4]; Therefore, deep surrounding rock deformation and failure analysis, forecasting and governance has become a key project to be solved. Based on the characteristics such as large embedded depth, easy deformation of third level roadway on Haizi Colliery, Huaibei Mining Group, on the basis of experimental rock mechanics and numerical simulation, the reasonable supporting scheme and parameters were determined, and the roadway deformation was successfully controlled.

Engineering simulation and deformation factor analysis

Engineering simulation. The third level roadway supporting engineering on Haizi colliery, roadway vertical wall of the semicircle, clear width 4.4m, height 4.2m. the roadway floor elevation was 1000 m, and it is located at 10 coal seam floor , the distance between the roof and 10 coal seam floor was 16 m~30 m, lithology is siltstone, fine sandstone, and part mudstone. Roadway roof and floor lithology, see Table 1.

Table1 lithology status

NO.	rock	thickness/m
1	Fine ssandstone	5.7
2	mudstone	1
3	10th coal seam	3.2

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4	mudstone	2.9
5	Fine sandstone	37.7
6	mudstone	6.55
7	1st limestone	1

Influencing Factors of roadway deformation. When constructing of the third-level roadway, an anchor beam supporting method was used initial, but the roadway roof had cracked and floor heave after completion of construction, the reasons that lead to the roadway deformation factors are the following;

(1) Overburden pressure

The depth of Roadway is 1000 m, thus the overburden pressure is larger role in the load on the supporting structure. When the supporting structure can not afford the loads, it would inevitably produce a distortion, gradually causes in the destruction of roadway supporting structure.

(2) Tectonic stress

Tectonic stress is generated by the long-term tectonic movements, the more complex geological structure of the mine, the more active and greater was the tectonic stress. Tectonic stresses have great influence on roadway stability, the direction of tectonic stress is usually affected by the impact of structural direction, in most cases, the tectonic stress is 1-1.5 times greater than gravity. Compared with gravitational filed, tectonic stress is very unstable, and its parameters are very different in time and space, and its existence directly determines the stability of the roadway.

(3) Surrounding rock fissures

The lithology of the roadway surrounding rock is mainly fine sandstone, siltstone and mudstone. Rock block has a certain strength, but the surrounding rock strength is very low because of great depth, surrounding rock fissures. In addition, the surrounding rock is crushing caused by structure, so it is easily distorted by the hulking pressure

(4) Construction Quality

Failure and instability of the reason of roadway is related to that the quality of construction fails to meet requirements, especially to the bolt-spraying roadway, if it fails to realize smooth blasting, a strong disturbance would act on the surrounding rock when blasting, and it could destroy the integrity of the surrounding rock.

Numerical simulation

A Mohr-coulomb model with the dimensions 58m×100m×100m was selected. The lithology and mechanical parameters of the model are shown in table 2. as calculated, a vertical pressure of 24.5MPa is applied on the upper boundary of the model; the side pressure coefficient is 1.0, the left and right sides of the model are horizontal displacement constraints, while the bottom is subject to horizontal and vertical displacement constraints.

Table 2 Lithology and mechanical parameters of simulated model

Lithology	Density, γ (105N/mm3)	Elasticity module E(GPa)	Poisson ratio ,μ	Cohesion C(MPa)	Friction Angle φ(°)
Fine sandstone	25.67	36	0.22	4.17	35.05
Mudstone	26.00	12	0.18	4.36	26.67
10th coal seam	14.12	1.5	0.23	0.88	30.91
Siltstone	25.67	42	0.23	3.17	30.05
1st limestone	25.67	50	0.25	5.17	34.05

Roadway stress. When the roadway being dug, the stress of surrounding rock redistributed. Vertical stress contours is shown in fig.1

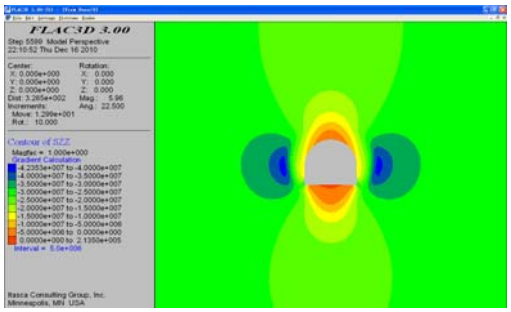

Fig.1 Vertical stress contours

As we can see form fig.1, when roadway being dug, vertical stress concentrates in the roadway roof and floor , the largest stress concentration is 38.7MPa, and the stress concentration ratio is 1.52, while vertical stress relief zone at two walls.

Roadway Deformation Characteristics. After excavation of the roadway in the model, the model will be recalculated until convergence. Fig.2 shows the plastic zone on the roadway surrounding rock.

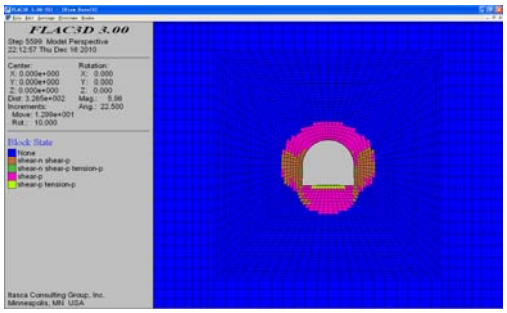

Fig.2 plastic zone

Figure 2 shows that the failure depth of roof and floor is 2.0m, 3.33m respectively. The maximum failure depth on the two walls is 2.33m. It could be seen that if we use traditional method on deep roadway, it couldn't achieve the desired results. The surrounding rock damage depth exceeds the maximum depth of the traditional supporting material can support, so it need another way to activate the surrounding rock supporting ability.

Roadway control

Supporting scheme. Researches of interaction between Roadway support and surrounding rock prove that the supporting strength is a key factor to control the surrounding rock deformation. Only supporting strength is greater than 0.3MPa, it could effectively control the serious deformation of the roadway. Practice has proved that the maximum supporting intensity range before and after the destruction or collapse that could achieve is rather narrow, regardless of what kinds of supporting form, the maximum supporting strength are belong to the same magnitude. Mainly in the form of active reinforcement bolt-grouting could fundamentally change the structure and mechanical properties. According to this article 1.2 and 2.3, it is drawn that in order to better control the surrounding rock, and put forward a supporting scheme of the third level roadway, it should begin with fundamentally changing the internal structure of rock mass and its mechanical properties[5,6]. First blot-beam-net was used on the third level roadway, then the surrounding rock fissures get to a certain level, the blot-grouting which is the core of Combined Support System are used.

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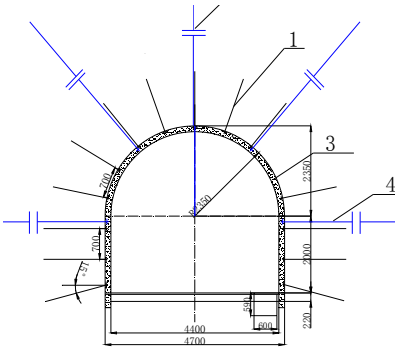

Fig.3 Roadway supporting section plan

Main supporting parameters.

(1)Bolt

Blot specification is Φ22 × 2400mm, high strength, by anchoring with 2 volumes No. Z2937 anchor agent, the anchoring force is not less than 80kN, section layout, and inter-row distance is 700 × 700 mm.

(2) Steel mesh

The mesh is welded together by Φ6 round steel, the network block size is 150 × 150mm.

(3) M strip

Strip width is 140mm, a thickness is 4.2mm.

(4) Concrete

Sprayed concrete strength class is C15, first the spray thickness is 50mm, and spray thickness is 100 mm second time, the mix ratio is 1:2:2.

(5) Grouting anchor cable

Grouting anchor cable: grouting anchor cable specification is Φ22 × 5500mm composed of Steel Cable, by anchoring with 3 volumes NO.Z2937 anchoring agent, three optical per row, inter-row distance is 1400 × 1400mm.

Industrial test

According to the proposal supporting scheme in this article 3.1, it did test on the third level roadway of Haizi Colliery. In order to monitor the results of supporting scheme at the roadway layout No.1 and No.2 two observation section, in the observation section set of displacement meter and surface displacement observation points. Select the results of the observation section No.1 for analysis, respectively into the Figure 4

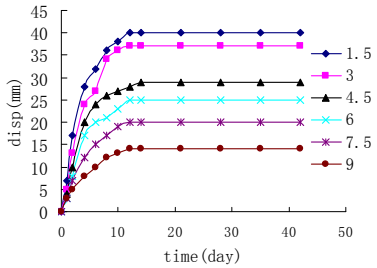

Fig.4 observational data graph

From fig.4, we can see that 3m within the roof began to deform slowly, and after 8 days it is stable. deformation value of roof that 1.5m range is 13 mm; 3 m outside of the roof began to transform in proper order to delay, and the values gradually decreased the deformation value of roof that between 3 to 4.5m is 6mm, the deformation value of 4.5~6m, 7~9m is 4 mm, 2 mm respectively.

Conclusions

1)The roadway surrounding rock in high stress of deep mine, was affected by lithology, and ways of supporting etc, the combined effect lead surrounding rock to crushing increases, the

roadway is severely damaged.

2) According to the results of numerical simulation analysis, after excavation, the vertical stress and horizontal stress has a greater degree of focus on the roadway, plastic zone is very large, especially the roadway floor need strengthen control.

3) The roadway surrounding rock in deep mine is supported by full-section bolt-grouting method, surrounding rock is under control, and it maintains the stability of surrounding rock.

Acknowledgements

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