Research on the Support Technology of Bolt and Cable in Deep High Stress Roadway

Weijie Song[1,2], Weiguo Qiao[1,2](corresponding author), Pershin Vladimir V.[3], Duohua Wu[1,2], Yanzhi Li[1,2]
1. College of Civil Engineering and Architecture, Shandong University of Science and Technology, Qingdao, 266590, China;
2. Shandong Provincial, Key Laboratory of Civil Engineering Disaster Prevention and Mitigation, Qingdao, 266590, China;
3. T.F. Gorvachyov Kuzbass State Technical University, Mining Institute, 650000, Kemerovo, Russia

Abstract **- Based on supporting failure mechanism and time and space function law of surrounding rock deformation, using the FLAC3D numerical simulation analyzes the bolt mesh cable coupling support of roadway in time support and lagging support. Support in time covers high strength and high strength and pre tightening force of anchor bolt, sagging support covers high strength and high pre tightening force of cables with rigid support. Through the numerical simulation, the timing of the second coupling support is determined, the distance of lag support with the anchor cable is 30m. The engineering practice shows that the whole stability and stability of the roadway can be improved effectively by using the bolt mesh cable coupling support in the deep high stress roadway. The force of surrounding rock is more stable, and the deformation is controlled effectively, which is of great significance to the safe and efficient production of coal mine.**

Keywords **- high stress; pressure support; anchor mesh cable coupling; numerical simulation; stability control**

I.INTRODUCTION

With the gradual depletion of the shallow coal resources and the increasing intensity of the mining intensity, the depth of the coal mining has gradually developed from the shallow depth to the deep part[1-5]. Mine entered the stage of deep mining, roadway surrounding rock geological conditions are more complex, more and more is also high level of stress, resulting large deformation in surrounding rock, difficult protect, repair and other problems in deep soft rock roadway, using combined support technology in order to maintain the basic stability and safety of roadway surrounding rock[6]. A large number of engineering practices show that simply just stressing a supporting structure of the density, strength in supporting the process, but ignoring the dynamic space-time action rule of support and surrounding rock and rock self-bearing capacity, often pose a great threat to the safety in production of coal mine [7-10].

With the Jiulong mine -890m bottom yard as the engineering background, this paper combine with support failure mechanism and space-time action rule of the support structure and the surrounding rock deformation. Using the coupling support with bolt mesh cable with timely support and lagging support, this paper will analysis of surrounding rock deformation evolution characteristics. Support in time covers high strength and high strength and pre tightening force of anchor bolt, sagging support covers high strength and high pre tightening force of cables with rigid support. Through numerical simulation, this paper studies the best supporting opportunity in order to ensure the full play of the bearing capacity of surrounding rock, so as to realize the stability control of surrounding rock deformation of deep roadway[12-13].

II.LAG DISTANCE ANALYSIS

2.1 Model building

The numerical simulation takes Jiulong Coal Mine -890 meters air inlet pedestrian roadway as the background, combining with the engineering geological data, establishing a numerical simulation model with length×width × height =120m×30m×30m, which is divided 379200 unit and 390709 nodes. Upper surface of the model is applied to 22.50MPa

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vertical force to simulate the overburden weight, the horizontal tectonic stress is realized by the side pressure coefficient with λ = 1.3, and limiting the horizontal displacement of the side and fixing on the bottom surface of the three direction displacement. Simulation of rock roadway engineering division and comprehensive geological histogram is consistent, parameters of the physical and mechanical properties of rock material are obtained through the laboratory MTS rock servo testing machine for three axis compression test as shown in Table 1. The stress and deformation characteristics of deep high stress roadway in surrounding rock are analyzed by model with Mohr-Coulomb failure criterion, establishing the FLAC3D model as shown in Figure 1.

TABLE 1 Mechanical properties test results of the surrounding rock

Surrounding rock parameters	Fine grain sandstone I	Coal	Fine grain sandstone II	Sandy mudstone
Tensile strength/MPa	0.48	0.35	0.53	0.73
Bulk modulus/GPa	0.89	0.66	1.05	1.39
Shear modulus /GPa	0.18	0.16	0.22	0.27
Cohesion /MPa	2.39	1.85	2.78	3.37
Internal friction angle /(°)	41	36	42	48

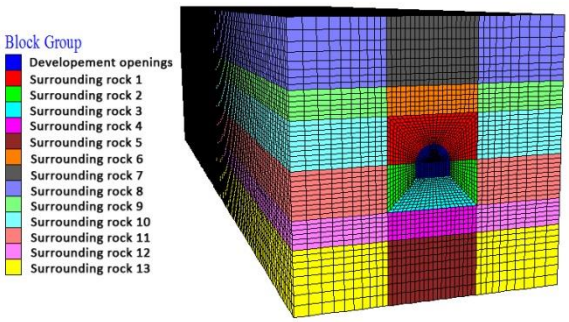


Fig.1 FLAC^{3D} three-dimensional numerical simulation model

2.1 Numerical simulation of hysteresis support distance

Simulation program focuses on three schemes with the excavation without support, bolting with wire mesh, bolt mesh anchor combined support, analyzing of the distribution of the displacement of the roadway surrounding, revealing the influence of support strength, support time and other parameters on stability of surrounding rock. The simulation program used in this study is as follows:

1) Excavating step by step without support, the simulation program analyses the displacement evolution law of roadway surrounding rock;

2) The roadway is divided into a long distance, and the anchor net is used in time to support, so as to determine the lag distance.

3) According to the lag supporting distance of the cable simulation, through anchor coupling support and the surrounding rock node displacement monitoring, this paper analyses of roadway surrounding rock stability.

In the parameters, bolts use high-strength threaded steel bolts, the length of a bolt is 2400mm and its diameter is 28mm, spacing and row spacing is 800mm × 800mm; the cable consists of pre-stressed steel strand with ∅18.9 × 8300mm. The metal net is simulated by adding solid equivalent layer.

2.2 Simulation results analysis

2.2.1 Excavation without support

After the excavation of the roadway is not supported, the deformation curve of the surface of the surrounding rock is obtained as shown in figure 2.

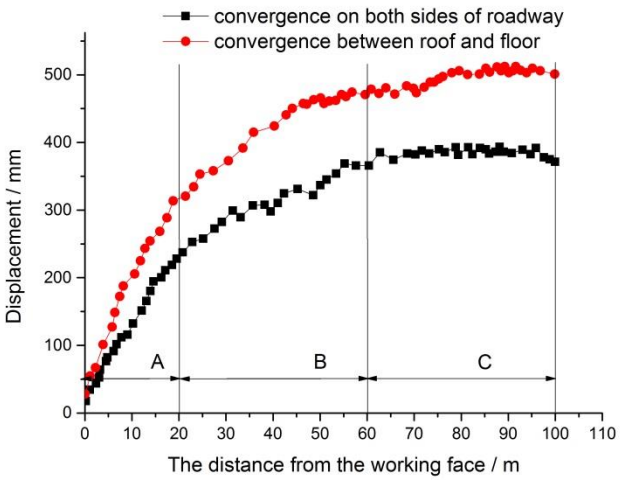


Fig.2 Distribution of surrounding rock deformation at different distances from working face without support

Figure 2 shows that the maximum displacement of the top floor is about 50.2cm, the maximum horizontal displacement of both sides of roadway is about 38.0cm, and the convergence deformation law of surrounding rock is that the top floor displacement of the top floor displacement is greater than both sides of roadway. Surrounding rock deformation can be divided into three stages: 0~20m is the deformation of the severe stage, 20m~60m is the deformation of the flat stage, over 60m is the deformation and stability stage.

2.2.2 Anchor net support timely

After the tunnel excavation by anchor net supporting in time, the rock surface deformation curve is obtained as shown in Figure 3

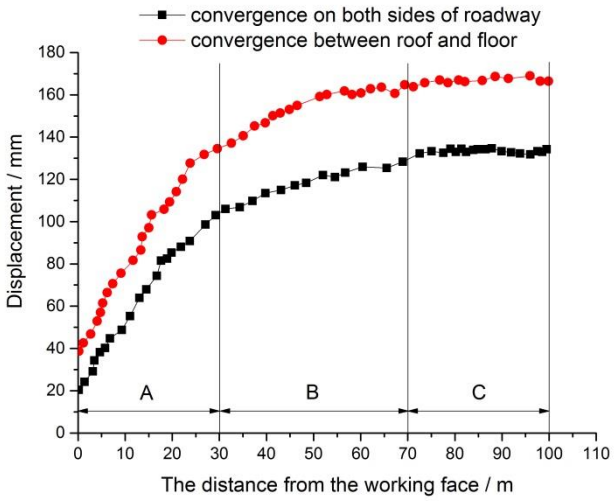


Fig.3 Distribution of surrounding rock deformation at different distances from working face under bolt-net support

According to Figure 3, it can be known that the stress state of surrounding rock can be improved effectively under the condition of anchor net support, but it is not effective to control the deformation of surrounding rock, especially the bearing capacity of the deep surrounding rock cannot be played. The displacement of convergence between roof and floor is about

16.8cm, the maximum horizontal displacement on both sides of roadway is approximately 13.2cm. Surrounding rock deformation can be divided into three stages: deformation range from 0 to 30m is severe deformation stage, deformation range from 30 to 70m is gentle deformation stage, and deformation over 70mis stabilization stage. Compared with excavation without support, deformation of surrounding rock is gentle under the condition of anchor net support, the conclusion is drawn that the distance of cable lag support distance is 30m.

2.2.3 Bolt mesh cable combined support

After the excavation of the tunnel, the support is combined with the bolt mesh cable, the cable lag 30m is supported, and the convergence and deformation curves of the surrounding rock are obtained as shown in Figure 4.

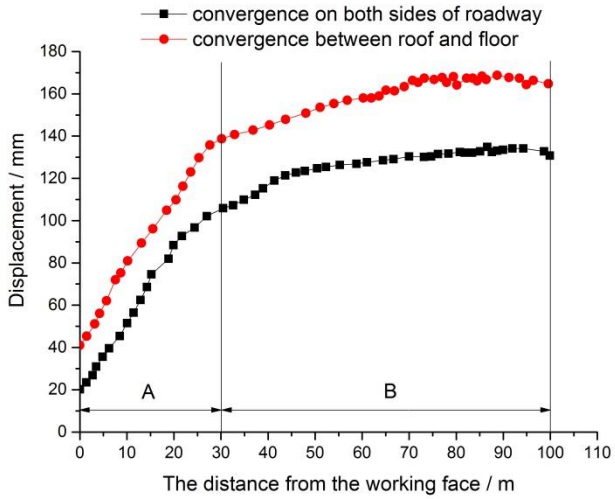


Fig.4 Distribution of surrounding rock deformation at different distances from working face under bolt-mesh-anchor support

According to Figure 4, by mobilizing the strength of deep surrounding rock, the support of anchor cable plays a controlling role in the shallow surrounding rock. Deformation of surrounding rock can be divided into two stages: 0~30m is the deformation of the severe stage,over 30m is the deformation and stability stage. The results show that the lag support of anchor cable is a kind of effective support measure, which can control the deformation of surrounding rock and improve the stability of the roadway.

III.ENGINEERING APPLICATIONS

-890m shaft bottom of Jiulong Coal Mine is located in No. 2 coal roof horizon, surrounding rock contains fine sandstone, sandstone, grit and sand conglomerate. Fracture is not developed, and the water is weak. With an aquifer in the surrounding rock, if there is a large gap in the fault, the roof, floor, or two sides of roadway, the water inrush may occur. So we must take preventive measures, the specific support chart is shown in figure 5.

In view of supporting problems of deep high stress roadway surrounding rock in Jiulong mine of the Fengfeng Group, combining with the results of numerical simulation, this paper put forward to combined support system of bolt mesh cable injection which is the core of anchor bolt and anchor cable. According to the actual characteristics of the pedestrian wind tunnel and surrounding rock mechanics characteristics, reasonable support scheme is adopted in the tunnel, and the dynamic adjustment is carried out on the spot.

Parameters of bolt mesh cable spray combined support in air inlet pedestrian roadway are as follows:

Anchor bolt: with the high strength thread steel bolt, its length is 2400mm and spacing and row spacing is 800mm × 800mm; the design of anchoring force value is 100kN, the torque is not less than 300 N • m.

Anchor cable: t with the Φ18.9 × 8300mm pre-stressed steel strand, it is made up of 7 steel wire, whose the strength is

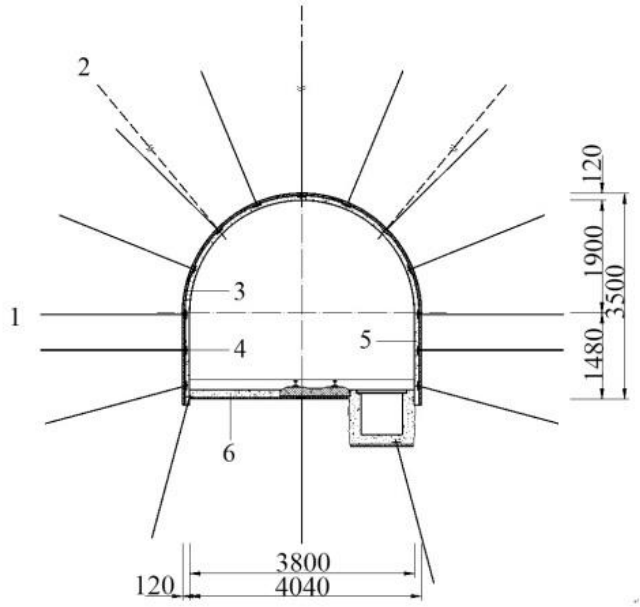
18MPa. The anchor cable is arranged along the center line of the roadway and its spacing and row spacing is 1600mm × 1600mm.

Metal mesh: it is composed with 6.5mm steel by welding, and its size is 1500mm × 900mm.Grid size is 100mm × 100mm and lap length is 100mm.

Bar ladder beam: it is composed with Φ14mm steel by welding, and its size is 2.48m × 0.08m. Grid size is 80mm × 80mm and array pitch is 800mm.

Shotcrete: the strength grade is C25, the total thickness is 150mm.

Ditch, bedding and foundation concrete: strength grade is C25, and bedding thickness is 150 mm. Pouring thicknesses of both sides and bottom of ditches is 100mm; cover thickness is 50mm; the depth of foundation is 100mm.



1- Anchor bolt; 2- Anchor cable; 3- Metal mesh;
4- Bar ladder beam; 5-Shotcrete; 6- Ditch, bedding and foundation concrete
Fig. 5 Bolting and shotcreting with anchor bolts and cables combined support of the roadway

IV.MINE PRESSURE MONITORING

In order to reflect the effectiveness and stability of the support scheme of roadway excavation and master the deformation of surrounding rock and the supporting effect of bolt and cable, the mine pressure monitoring was carried out on the pedestrian street in the wind tunnel[14-16]. Set the corresponding stations in the tunneling process, and with the use of guns by measuring rod, the relationship between the relative displacement of surrounding rock and the time of the roadway surface is shown in Figure 5

From Figure 6 mine pressure observation data analysis shows that the roadway surface deformation in 30 days or so to steady state, roof and floor relative movement amount is 40mm, both sides relative movement amount is 35mm, which showed that the pedestrian wind tunnel excavation through bolt mesh anchor shotcrete support, supporting structure and surrounding rock is synergistic effect, and the overall stability and carrying capacity of the roadway have been effectively improved. Deep and high stress roadway floor heave, stress concentration, large deformation characteristics can be improved significantly, which to ensure the safety and stability of roadway in service life.

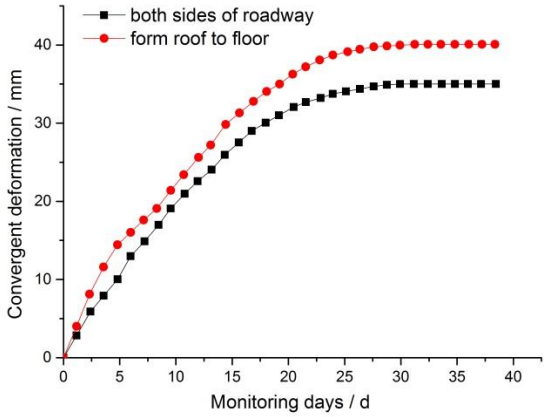


Fig.6 Relatively closer to the surface of the surrounding rock of roadway curves and the amount of time

V. CONCLUSIONS

1) Combined with the engineering geological condition of the JiuLong mine, the mechanical characteristics of the deep roadway with high stress were analyzed quantitatively by using FLAC3D numerical simulation software. Under the condition of excavation without support, the roadway deformation is intense, and the distance from the working face 60m realizes the smooth deformation.

2) The secondary time of the cable coupling support is determined, and the lag distance is 30m. To grasp the time and space function of the secondary coupling support of the anchor cable, and to realize the control of the deformation of the shallow surrounding rock by mobilizing the strength of surrounding rock.

3) The monitoring data show that the roadway integrity is significantly improved and the stress is uniform by anchor cable combined support. Surrounding rock of carrying capacity strengthened, bolt and anchor performance get full play, large deformation of roadway, the stress concentration and the floor heave phenomenon has been effectively curbed. There has a driving effect for safe and efficient production of coal mine.

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