Control Technology of Overlying Roadway in 7m Goaf

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Abstract. This paper takes Zhuxianzhuang Mine as the research background. In this research, the reasonable height of "three zones" of overlying strata at 7m mining height is determined by key strata theory, and the movement law of overlying strata is studied by FLAC3D numerical simulation. The stress, displacement and plastic zone of surrounding rock under the three schemes of no support, bolt support and roof support are compared and analyzed according to the site construction situation. On this basis, the regional treatment scheme is put forward. The test results prove that the adoption of staged process control technology and enhanced support technology can effectively control the surrounding rock deformation of overlying strata roadway, which is scientific and reasonable in technology and effective and feasible in construction.

1. Introduction
The roadway in Zhuxianzhuang Mine is seriously damaged due to the combined action of ground pressure, tectonic stress and mining stress, which directly threatens the safety of mine production. 7 coal belongs to thin seam, while 8 coal belongs to thick seam. With conventional downward mining sequence, the initial output is low and the economic benefit will be poor. In order to stabilize coal production, and improve production efficiency and economic benefits, it is necessary to carry out upward mining in Zhuxianzhuang Coal Mine [1-5]. North wing belt conveyance roadway is an important part of Zhuxianzhuang upstream mining technology system. It is significant to arrange the roadway in a specific area affected by upstream mining, generally located in fracture zone or bent subsidence zone. With the increase of mining depth, the degree of mining stress concentration is higher, the scope of mining influence is wider, the mining influence time is longer, the spatial stability of mine roadway engineering is worse, and the difficulty of roadway maintenance is aggravated. The research on soft rock roadway treatment technology under such conditions will help enrich the technical route and theoretical system of roadway surrounding rock control in mining area, and further guide the engineering practice of surrounding rock treatment in mining area.
2. Determining the Reasonable Height of "Three Belts" of Overburden Strata and the Migration Law of Overburden Strata by Key Strata Theory

The plastic zone of the working face is saddle-shaped with high end and low middle. The working face is symmetrical along the direction of strike and inclination. The plastic zone in the middle of the goaf is smaller than that in the upper part of the working face, which is caused by the tension stress above the mining boundary caused by the subsidence of overlying strata on the side of the goaf due to the support of coal pillars, which makes the damage scope larger than that in the middle part of the goaf. From the bottom to the top of the roof, the order is tensile failure area, shear failure area, shear failure area and undamaged area. The tension failure zone is mainly distributed in the strata of the tension stress zone above the goaf, and is divided into caving zone with a height of 40.4m. There are tension fissure zones on the upper part, which produce unidirectional or bi-directional fissures and are divided into fissure zones with a height of 90 m. The elastic and plastic deformation zones of the model can be divided into bending subsidence zones because of the overall movement, small subsidence, plastic deformation caused by certain cracks and local shear failure of the rock strata in the bending subsidence zone.

Figure 1. Plastic Zone Distribution along Strike Direction and Dip Direction while Advance is 100 m with Various Mining Heights

3. Roadway Surrounding Rock Control Technology

3.1. Numerical simulation analysis of roadway

3.1.1. Simulation Schemes of Supporting. According to the construction situation in Zhuxianzhuang, two kinds of support schemes are designed, and the bare roadway without support is compared. Meanwhile the distribution law of displacement field, stress field and plastic zone is analyzed, and the reasonable support measures are discussed.

(1) The first scheme is to simulate and analyze the distribution of displacement field, stress field and plastic zone of bare roadway without support. (2) Scheme 2: 7 bolts are constructed at the top of the roadway. The specifications of the bolts are M22-20×L2500mm, the distance between rows is 800mm×800mm, and the preload is 80kN. Three anchor cables are constructed at the top, with the specifications of 17.8×6300mm. The middle row is in the center of the roof, the distance between rows is 1400mm×1600mm, and the pretension force is 120kN. Six bolts are arranged in the upper part, with a row spacing of 700mm×800mm and other bolts on the same top. (3) Scheme 3: 29U shelf with row spacing of 500mm, 4 sections of shed beam, overlap length of 400mm, 700mm×300mm steel bar barbed net roof protection.

3.1.2. Simulation results. In the absence of support conditions, horizontal stress concentrates on the roof and floor of roadway, the maximum value of roof stress concentration is 13.942 MPa, and the maximum value of floor stress concentration is 12.98 MPa. There are some pressure relief zones on both sides, ranging from 1.5 m to 1 m, and the bottom angle has a certain stress concentration of 13.8 MPa. The
vertical stress decreases from shallow to deep, and there are corresponding tension stress areas in the
two sides, the top and the bottom of the roadway. There is no stress concentration area on the roof and
floor. The variation range of stress value on the surface of roadway is 0.53-6 MPa. Among them, the
value at the two sides and the roof is 0.35-4 MPa, and the floor decreases gradually from the middle to
the two sides. The vertical stress concentration mainly distributes in the two sides of the roadway, and the
range is about 1.6m. The displacement of surrounding rock is very large. The maximum
displacement is that the roof reaches 220.2 mm, which is mainly composed of vertical displacement.
The displacement distribution of the two sides is similar, which is mainly composed of the axial
displacement of the vertical roadway. The floor heave is 159.5mm, and the maximum is at the center of
the floor. The circular footage of roadway excavation makes the displacement change regularly along
the axis direction.

Through bolt support, the stress concentration of bottom angle has not been eliminated, and the stress
concentration range of roof is slightly reduced, while the stress concentration range of bottom plate and
the pressure relief range of both sides are much reduced. The displacement of surrounding rock of
roadway decreases to about 35%, and its distribution law is similar to that without supporting conditions.
The roof and floor approach is the largest, and the two sides are the second. In bolt support, the roof
pressure relief range is 2.3m and the floor pressure relief range is 6m, which shows that bolt support has
formed good integrity of surrounding rock mass and good control effect.

Under the condition of roof support, the stress concentration at the bottom angle increases to about
23 MPa, and there is no significant difference in the stress concentration range between the two sides.
Other laws are similar to those of bolt support. Due to the horizontal stress transferring to the roof and
floor after excavation, the roof and floor are destroyed. Timely roof support restricts the roof and floor
displacement of surrounding rock to the greatest extent, and reduces the displacement of both sides of
the roadway by 65.5%, 48.1% and 74.5%. The roof pressure relief range of roof support is only 1.2m,
and the floor pressure relief range is 3.4m. The stress concentration area of the roof support moves closer
to the inside of the roadway, which shows that the roof support can better maintain the integrity of the
surrounding rock.

From Fig. 2, it can be seen that the roof displacement of the roadway without support is the largest,
and the deep displacement curves of the roof under the two supporting conditions are close to
coincidence, with little difference; the displacement of the roof decreases with the increase of the
distance to the roof surface of the roadway. The surface and deep displacement of roadway mainly
concentrates on the range of 4m of roadway roof, 3M of roadway floor and 6m of roadway wall. The
roof support control wall only produces small displacement in the shallow part, and the surrounding
rock still has large deformation in the area of 12m. Therefore, in engineering practice, the single roof
support can not effectively control the deformation of roadway, so bolts should be added to the side,
fully considering the length of bolts, to achieve a reasonable reinforcement range.

![Figure 2. The Deep Displacement of Roadway under Different Support Conditions](image)

As shown in Fig. 3, the plastic zone of the roadway is enlarged at the bottom of the roadway in the
left and right circles. Through comparison, it can be clearly found that the roof support has a great effect
on the control of the bottom.
The plastic zone of floor is very wide, most of the failure types of surrounding rock are shear failure, the shallow part of floor appears tension-shear failure along the roadway axis, and the deep part of surrounding rock below floor gradually becomes shear failure; the roof is also mainly shear failure; the surface layer of both sides at the bottom corner is tension and shear failure, and with the progress to the deep part, the failure types are classified as follows. In the process of shear failure, the surrounding rock with low strength may have destabilized, resulting in the decline of surrounding rock resistance, thus continuing to destroy. Under the action of bolt support, the plastic zone of roof and two sides decreases slightly, but the tensile shear failure of the bottom angle of two sides has basically disappeared. This shows that the scheme makes bolt and surrounding rock become a complete support system, and the tensile strength increases obviously.

Under the support of roof, the plastic zone of roadway surrounding rock decreases a lot, and the plastic zone of roof decreases a lot. This shows that the interaction between roof support and roof makes full use of the self-supporting force and bearing capacity of surrounding rock, so that the roof bears the load of overlying strata and transfers smaller concentrated stress on both sides, thus producing smaller plastic zone, the same as the plastic zone of the bottom plate, the range of whose has also been reduced a lot.

3.2. Field test of roadway
The northern belt conveyance roadway is located from the upper coal hole of the second belt conveyor roadway to the lower part of the tenth belt conveyor roadway. It is the southern part of the main conveyance roadway in the tenth mining area. The design length of this section is 1741.098m and the elevation is -414.38~380m. The roadway main body project is located above the goaf of 8415 working face, and the mining height of No. 8 coal is relatively high. Although the lithology of the overlying strata is good and the surrounding rock activity above the goaf is stable, the mining of No. 8415 working face has certain destructive effects on the overlying strata. North wing belt conveyance roadway is the main mine roadway, which has a relatively long service life and requires high deformation control level.

High-performance bolts of IV grade bolt special screw steel are used for supporting stable surrounding rock. 7 bolts are constructed at the top of roadway. The specifications of bolts are M22-20×L2500mm, the spacing between rows is 800mm×800mm, the pre-tightening force is not less than 80 kN, and the anchoring force is not less than 150 kN. Six bolts are arranged in the upper part, with a row spacing of 700 mm ×800 mm and other bolts on the same top. Each bolt is anchored by two Z2360 resin cartridges. The specifications of cold-drawn arc welded steel mesh are 6-100mm×100mm. Three anchor cables are constructed at the top, with the specifications of 17.8×6300mm. The middle row is in the center of the roof, the distance between rows is 1400mm×1600mm, and the pretension force is 120kN. A roll of K2350 and three rolls of Z2360 resin cartridges are used in each hole when installing the anchor cable. Shotcrete to seal surrounding rock in time to prevent cracks from developing, the thickness of shotcrete layer is 50mm; concrete ratio, cement: yellow sand: stone = 1:2:2.

The surrounding rocks in areas with poor stability have low degree of cementation. The surrounding rocks are sandy mudstone and medium-grained sandstone. After excavation, the self-stabilization ability
of surrounding rocks is poor, and the fracture development area is poor. The support of "retractable support + grouting + grouting" is adopted. The support of "retractable bracket + grouting + grouting" is adopted. The support adopts 29# U-shaped steel shed with direct shed spacing of 500 mm, shed beam joints of 4, lap length of 400 mm, cable spacing of 200 mm, depth of pillar socket of 350 mm, roof (side) close connection of 700 mm×300 mm steel bar bars.

By the end of observation, the maximum absolute convergence of two sides of roadway is 446 mm and the maximum absolute convergence of roof and floor is 314 mm. The convergence rate in the first 7 days is the period of intense deformation after roadway excavation. The deformation rate is very high, and the rate decreases gradually with the increase of time. When the convergence rate is about 2 weeks, it begins to enter the stage of stable deformation, and the convergence rate is basically stable within 1 mm/d.

![Deformation Curve of Surrounding Rock](image)

**Figure 4. Deformation Curve of Surrounding Rock**

4. Conclusion

Based on the engineering background of Zhuxianzhuang Mine, this paper uses FLAC3D numerical analysis software to study the law of overlying strata migration. On this basis, the control technology of overlying roadway in 7m mined-out area is discussed. In view of the occurrence and use of surrounding rock of belt conveyance roadway on the north wing of Zhuxianzhuang Mine, the surrounding rock of the roadway is divided into two areas and different support schemes are adopted, i.e. bolt-mesh-cable support and shelf support. The industrial test shows that the supporting effect and the supporting condition is greatly improved. It is of referential values for the support of coal mine roadway under the same geological conditions.

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