Maintenance characteristics and bolt-mesh-anchor support technology of Large-span roadway in Guotun coal mine

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Abstract: Aiming at the support difficulties of 1100 working face in Guotun coal mine of Shandong energy Linyi Mining Group, this paper analyzes the maintenance characteristics and support principle of large-span roadway, and puts forward the combined support scheme of bolt, mesh and cable combined with the actual geological production conditions. The field measurement shows that the deformation of roadway tends to be stable after 15 days, the accumulated subsidence of roof is 250 mm, the approach displacement of two sides is not more than 130 mm, and the floor heave is 80 mm. Therefore, the support scheme can effectively control the roadway deformation and ensure the safety production of the working face.

1. Introduction
With the development of comprehensive mechanized coal mining technology, and the large-scale popularization of this technology in small and medium-sized coal mines, it has brought many problems, such as the increasing pressure of belt chute transportation, higher and higher requirements of roadway support, in recent years. Therefore, how to maintain the roadway scientifically and reasonably has become an urgent problem. The roadway of 1100 working face in Guotun coal mine of Linyi Mining Group of Shandong energy is a rectangular roadway with width of 5.5m, height of 2.5m and length of 381m. The roof of the roadway is mudstone, and the floor is siltstone with low strength, so the integrity of surrounding rock is poor; the buried depth of coal seam is 600m, the initial geostress is about 15MPa, and the surrounding rock is prone to plastic failure. In order to ensure the safe mining and continuous advancement of the working face, a more safe and reliable support technology must be adopted. Therefore, this paper puts forward a combined support scheme of anchor, mesh and cable, and carries out field industrial test, which provides technical support for the support of other working faces.

2. General situation of guotun coal mine
Guotun coal mine of Shandong energy Linyi Mining Group is located in "ningwen" coalfield, 19km away from Yanzhou City in the East, 5-9km long from east to west, 5.5-9km wide from south to north, with an area of 58km². The geological reserves of the mine are 324 million tons, the industrial reserves are 108 million tons, the design production capacity of the mine is 450000 tons/year, and the equipment production capacity is 900000 tons/year. The main coal seam of the mine is 3 # coal seam. The comprehensive mechanized mining method is adopted, with an average thickness of 2.22m. The coal quality is low ash, low sulfur, low arsenic and high calorific value gas coal, belonging to the mine with low gas and low carbon dioxide content. During the roadway excavation, a roof separation instrument should be installed every 100m (the number of roof separation instruments should be appropriately...
increased in the section with broken roof and high pressure), so as to monitor the mine pressure behavior of roadway.

3. Maintenance and control principle of large-span roadway

3.1 Analysis on maintenance characteristics of large span roadway

According to the mine pressure behavior characteristics of the roadway, the combined support technology of bolt, mesh and cable is proposed to solve the problem of surrounding rock control along the roadway. There are three problems in roadway support: ① The stress redistribution of surrounding rock caused by roadway excavation destroys the original stability; ② the large span of both sides of the roadway will cause greater deformation and even damage in the middle of the roadway roof under the action of tensile stress; ③ the stress concentration at the edge of the roadway leads to a certain range of plastic failure[2]. Therefore, in order to improve the overall stability of surrounding rock of large-span roadway, the middle part and two shoulder angles of roadway are the key points.

3.2 Surrounding rock control principle of large span roadway

The stress redistribution caused by roadway excavation makes the stress of rock strata above the roadway transfer to the surrounding of the roadway, resulting in stress concentration. In this case, the roadway is prone to damage[3]. Based on the above description, RABCWICZ, a famous Austrian tunnel engineer, proposed a construction method as early as the 1950s, which is called NATM [4-6]. According to NATM, it is necessary to make full use of the bearing capacity of the overlying strata to make the surrounding rock become a part of the support system, so as to reduce the difficulty of roadway support.

The combined support of bolt, mesh and cable is different from the traditional single bolt support. It combines long bolt, metal diamond mesh and super long anchor cable, overcomes the shortage of low working resistance of traditional support, and is an active support method with high support resistance [7]. The supporting principle is as follows: 1) the long bolt can connect multiple adjacent rock layers into a thick bearing whole. Compared with single-layer rock mass, the shear strength and tensile strength are greatly improved, and the bearing capacity of surrounding rock is also enhanced[8]. ② Metal diamond net can prevent the broken rock from falling from the roof, so as to improve the overall stability of the roof. ③ The super long anchor cable can fix the weak rock in the lower part of the roof in the hard rock in the upper part of the roof, expand the thickness of the composite beam, and effectively prevent the bolt failure caused by falling. The schematic diagram is shown in Figure 1. To sum up, the anchor mesh cable combined support makes full use of the stability ability of deep stable rock, and achieves the effect of joint bearing of anchor, anchor cable and stable rock, so as to improve the stability of roof and provide an important guarantee for the safety of workers.

![Figure 1 structural diagram of anchor mesh cable support](image-url)
4. Support scheme and field measurement

4.1 Support scheme

According to the support experience of adjacent roadway, the belt chute, refuge chamber and material chamber of 1100 working face are permanently supported by anchor mesh cable, and the whole section is supported by metal anchor and metal mesh. The specific plan is as follows: Msglw-500 left-handed ribbed steel bolts with a diameter of 20 mm and a length of 2100 mm are selected for the roof, and full threaded bolts with a diameter of 18 mm and a length of 2100 mm are selected for the two sides. Each bolt is equipped with a msck2370 resin anchorage agent, and the bolts on both sides of the top are inclined outward by 15°. The top row bolts of the two sides are 300 mm away from the roof, and the inclination angle is 15°. The lowest row of bolts inclines downward for 15°. Other bolts are perpendicular to the roadway wall. The top bolt spacing is 800 or 900 mm, the row spacing is 1000 mm, the two sides bolt spacing and row spacing are 1000 mm, and the trapezoidal steel length is 5300 mm; the metal mesh adopts 8# cold drawn braiding, diamond connection, connection point spacing of 120mm, mesh size of 60×60mm. The detailed support drawing is shown in Figure 2.

When the roadway roof is complete, one anchor cable is arranged every 3m in the middle of the roadway roof; when the roof is incomplete, one anchor cable shall be arranged every 2m. When driving in coal seam, the length of anchor cable is 6m, the diameter is 17.8mm, each anchor cable uses two msck2370 resin anchorage agent, and the anchor cable beam is made of 11# miner's steel, the length is 0.5 – 0.6m; the anchor cable tray is a high-strength round tray with a diameter of 0.22m. The exposed length of anchor cable is 0.15-0.35m, and the pretension force is not less than 200kN.

![Fig. 2 support scheme](image)

4.2 Analysis of support effect

The monitoring station is set up in the middle of the roadway to monitor the displacement of the roadway surface, and the monitoring results are shown in Figure 3.

![Figure 3 deformation curve of surrounding rock](image)
It can be seen from Figure 3 that the deformation of roadway roof increases for a period of time and remains relatively stable, and the accumulated subsidence in 15 days is 250 mm; the distance between the two sides is not more than 130 mm; the deformation of the bottom plate is 80 mm. By analyzing these data, we can know that the method of bolt mesh cable combined support can effectively restrain the deformation of roof, control the development of plastic zone and ensure the stability of roadway.

5. Conclusion

(1) The method of bolt mesh cable combined support can effectively restrain the deformation of roadway and provide a safe working environment for the staff.

(2) The success of bolt mesh cable combined support technology in 1100 working face has important reference significance for other working faces and even other coal mines.

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