



Study on Support Technology of Deep Mine Roadway in Xingdong Coal Mine

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Abstract Because of the large depth of the mine, the original use of bolt, mesh and spray composite support, the roadway shrinkage deformation is more serious, which not only affects the use but also endangers the safety of production. According to the deformation of surrounding rock and the characteristics of engineering technology, the following three different supporting technologies are adopted: the combined reinforcement technology of bolting and shotcreting grouting, the support technology of anchor cable on the floor, and the support technology of fully enclosed U-shaped steel ring support. The research results are applied to the field engineering practice. The monitoring results show that the fully closed U-shaped steel ring support technology has the best supporting effect, the roadway deformation meets the production requirements, the roadway renovation time is longer, and it can meet the requirements of the surrounding rock of the roadway with a depth of one kilometer.

Keywords Deep roadway · Support scheme · Anchor cable of the floor · Closing bracket · Floor heaving

1 Maintenance Status of Main Roadway

The main coal seam of Xingdong Coal Mine is 2# coal, the mining depth is from 600 m to nearly 1300 m. With the extension of the mine into – 980 m level mining, the roadway maintenance problem is increasingly prominent, the support body is seriously damaged, and the phenomenon of partial or even broken bolt is serious. The surrounding rock of the roadway expands, loosens, breaks, and has a large amount of deformation, as shown in Fig. 1. It has a very adverse impact on mine production and safety (He et al. 2011; Yuan et al. 2011; Wang et al. 2015; Kang et al. 2015).

Three observation stations are set in – 980 m roadway, and Table 1 is the statistical table of three observation points. It can be seen from the table that the deformation rate of the roof and floor of – 980 m roadway is higher than that of the two ribs, and the maximum deformation rate is 2.48 mm/d.

According to the characteristics of surrounding rock deformation and engineering technology in Xingdong Mine, the following three different support technologies are adopted: the combined reinforcement technology of roadway bolting and shotcreting, the support technology of floor anchor cable and the support technology of fully enclosed U-shaped steel ring support, which are described as follows.

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Fig. 1 Roadway damage map

Table 1 Statistical table of surface displacement of each measuring station

Name of station	Maximum movement of two ribs/mm	Approach speed of two ribs/mm	Maximum approach of roof and floor/mm	Roof and floor approach speed/mm
1	119	0.712575	299	1.790419
2	149	0.892216	414	2.479042

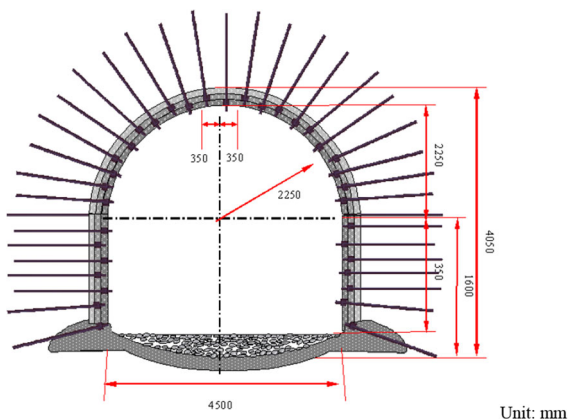


Fig. 2 Bolt layout section

2 Combined Reinforcement Technology of Bolting, Shotcreting and Grouting

In order to improve the strength of surrounding rock, we should adopt the active, dynamic and active control support concept, and implement the new technology of bolt and grouting support system to repair. And the three support schemes implemented at the same time and in the same roadway (He et al. 2005; Ma et al.

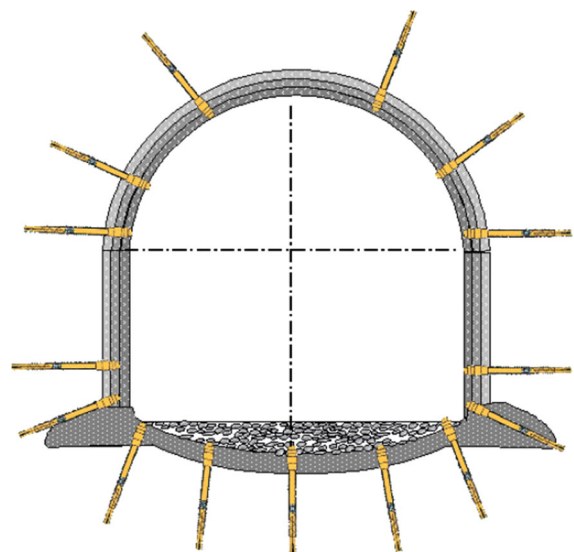


Fig. 3 Layout section of grouting anchor

2015; Zhou et al. 2011, 2013; Li et al. 2010; Zhang et al. 2013).

2.1 Reinforcement Technology

Construction process: expanding section → initial spraying 80 mm → drilling the first level anchor bolt and hanging net → re spraying 60 mm → drilling the second level anchor bolt and hanging net → re spraying 60 mm.

Installation of anchor bolt: the anchor bolt is divided into two levels, the first level after the initial spraying and the second level after the re spraying. The specifications of two layers of anchor bolts are GM22/2400 mm high-strength anchor bolts with row spacing of 700 × 700 mm (see Fig. 2).

Grouting bolt: the grouting bolt is designed to be a $\Phi 22 \times 2000$ mm grouting bolt made of 6 “black steel pipe, and the row spacing between the bolts is 1500 × 1500 mm. The anchor heads of bottom angle

grouting anchor and float grouting anchor are all 100 mm lower than the bottom plate (see Fig. 3).

2.2 Effect Analysis

The technology is applied to – 980 m main roadway, and the surrounding rock deformation before and after support is shown in Fig. 4.

According to the above observation results, the roadway deformation can be effectively controlled by the combined reinforcement technology of bolting, shotcreting and grouting, and the deformation speed of surrounding rock changes from 2.6 mm/day before support to 0.7 mm/day after support. During the observation period, the deformation of the roadway did not reach a stable trend (Fig. 5).

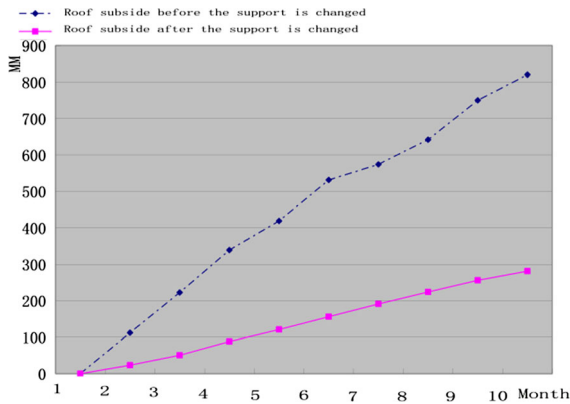


Fig. 4 Comparison of roof deformation before and after – 980 m roadway support

3 Anchor Cable Support of Floor

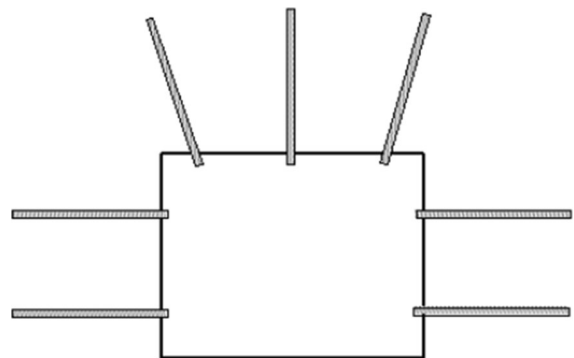


Fig. 6 Anchor cable layout



Fig. 5 Comparison of roof deformation before and after – 980 m roadway support

By using anchor cable support to change the stress state of the rock near the floor and improve the compressive strength of the surrounding rock, it can effectively prevent the displacement of the floor rock to the roadway, and play a role in supporting and preventing the floor heave.

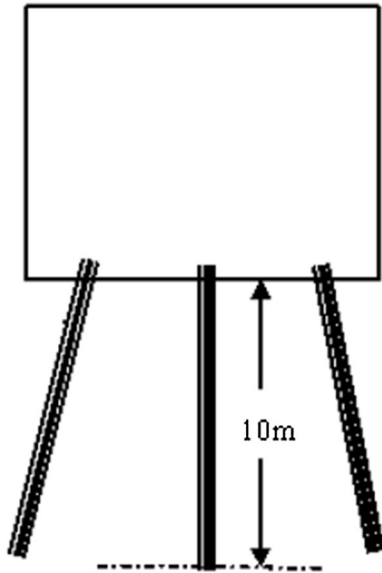


Fig. 7 Anchor cable layout

3.1 Prestressed Anchor Cable Parameters

Specification of anchor cable: $\phi 21.8 \times 8500$ mm. Arrangement of anchor cables: row arrangement is adopted. Each row of anchor cables is arranged between two rows of grouting holes with a row spacing of 3.2 m. Seven anchor cables are arranged in each row, including three on the roof, the two corners are placed outside 15° , two on each rib, and the arrangement of anchor cables is shown in Fig. 6.

Floor combined anchor cable: the combined anchor cable is composed of three $\phi 17.8 \times 10,500$ mm roof anchor cables, which are arranged in rows with a row spacing of 2.0 m, three cables in each row, and the distance between the two sides of the anchor cables is 0.5 m from the ribs, 15° from the outside, and the central anchor cable is vertical to the floor. Use a $\phi 80$ mm drill bit to drill holes with a depth of 10 m. See Fig. 7 for the arrangement of anchor cables on the floor.

3.2 Effect Analysis

According to the observation data in Fig. 8, the average floor heave of the roadway changes from 3 to 0.8 mm/day after support. The two ribs are

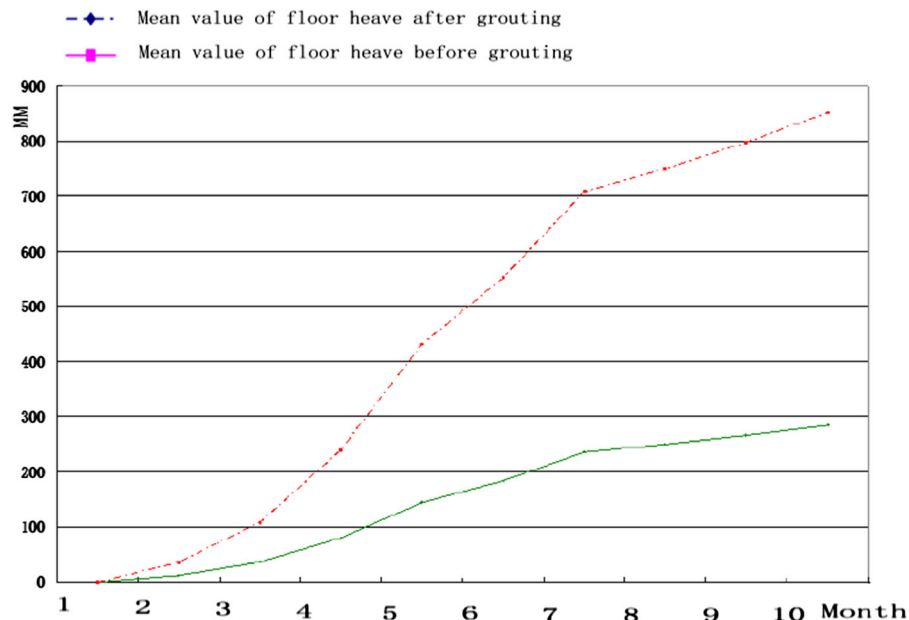


Fig. 8 Comparison of floor heave before and after grouting

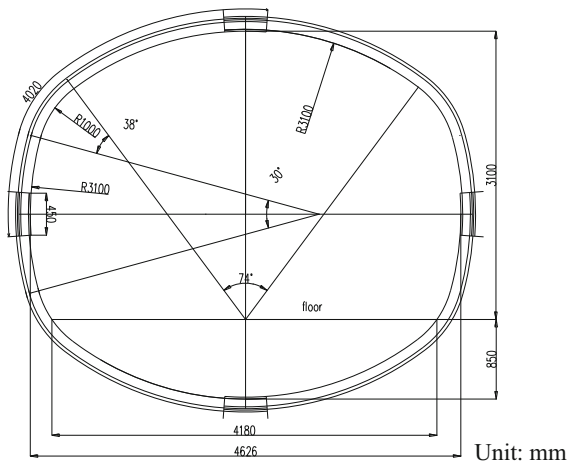


Fig. 9 Ring bracket

consolidated by high prestressed anchor cable grouting, but the effect is not obvious.

4 Ring Support Technology

4.1 Support Technology

In order to solve the problem that the effect of roadway support is not ideal after the initial support of bolt support in high stress roadway, 36 U-shaped steel ring

retractable fully closed metal support is used as the secondary support. The support is shown in Fig. 9.

4.2 Effect Analysis

According to the observation results in Fig. 10, the fully enclosed U-shaped steel ring support can effectively control the deformation of the roadway, especially the floor heave of the roadway, and the average deformation speed of the surrounding rock is greatly reduced. The supporting effect is shown in Fig. 11.

5 Conclusions

In Xingdong Mine, due to the deep and high stress of the roadway, the roof subsidence, the convergence of the two ribs, the floor heave, the instability of the support and so on are very serious. According to the characteristics of surrounding rock deformation and engineering technology in Xingdong Mine, three different supporting technologies are adopted. It is proved by practice that the fully closed U-shaped steel ring support technology can better maintain the roadway, and the effect is better. Although the supporting effect of Ring support is good, but the cost is high. It should be used in high pressure areas.

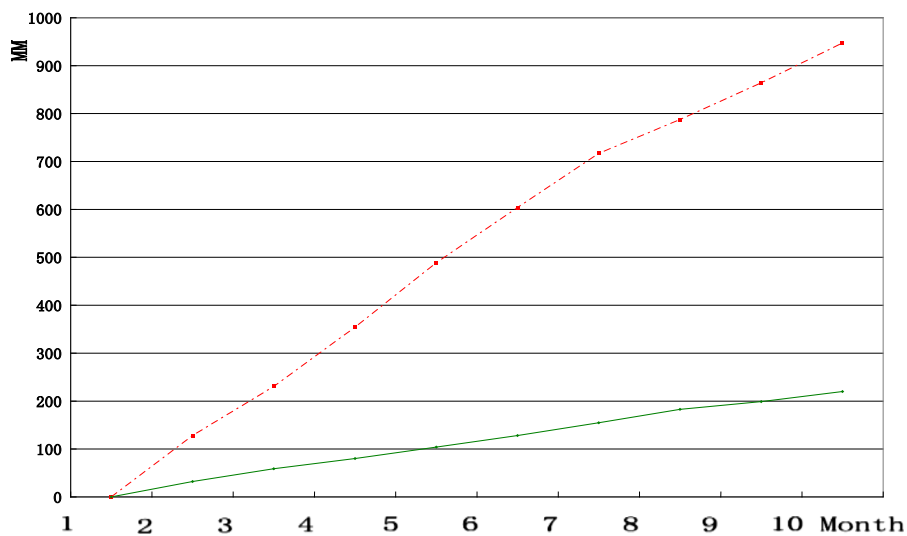


Fig. 10 Comparison of front and rear roof of ring support in – 980 m main roadway



Fig. 11 Support effect

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