Surrounding Rock Control Technology for Gob-Side Entry Retaining Under Goaf in Deep and Close Distance Coal Seams

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Abstract. To solve the technical problems in controlling the surrounding rock of gob-side entry retaining of deep and close distance coal seams under goaf, the surrounding rock deformation and failure characteristics of gob-side entry retaining of deep close distance coal seams under goaf were analyzed in this paper. Basic support inside roadway of the high-strength prestressed wire meshes, beam and cable anchor, reinforcement support inside roadway of the single hydraulic support with the hinged roof beam and roadside support of high-water material filling structure were proposed. The engineering practice shows adopting the surrounding rock control technology, the surface displacement of the filling body and the surrounding rock and the amount of the roof separation are all in the controllable range, the stability of the roadway is good.

Keywords. Deep coal mine, close distance coal seams, under goaf, surrounding rock control technology, gob-side entry retaining

1. Introduction

With the increasing depletion of coal resources in shallow parts of our country, it is an inevitable trend that the average mining depth of newly-built coal mines will increase year by year [1]. As the mining depth increases, the problems of rock burst, large deformation of surrounding rock, and coal and gas outburst caused by coal pillars have become more significant. The technology of gob-side entry retaining can effectively solve these problems, and can increase the coal recovery rate and improve the economic benefits of coal mines [2].

GSER (Gob-side entry retaining) is the layout of the mining roadway to retain the mining roadway of the working face along the goaf edge to realize the function of Y-shaped ventilation and mining in the next section [3]. Kang [4] analyzed the relationship between the basic support, strengthened support in the roadway and roadside support, pointed out that the deep and shallow GSER have big difference between the roof fracture position, put forward the design principles of deep GSER. Zhang [3, 5] summarized the key technologies of surrounding rock control such as the “three-in-one” GSER and rapid wall construction, and deduced the calculation formula of required support resistance. Bai [6] proposed a new roadside filling with paste material technology of GSER, established a mechanical model of filling with paste material along...
the goaf, and proposed the method of determining main parameters of the roadside support with paste material. Li [7] determined the support resistance control design principle of the roadside filling body by GSER at each stage, and established the corresponding support resistance and reasonable compression mathematical model. Hua [8, 9] proposed the use of the roadway bolt support and the use of anchor cables to strengthen the support technology along the roadway, and established a mechanical model of GSER with larger mining height that takes into account the self-supporting capacity of the coal body of the roadway and the strengthening effect of the anchor cable beside the roadway, and the mechanism of bolt and cable support is analyzed. Zhang and Ma analyzed the roof activity rule, and studied the support resistance and stability control of the filling body [10-12]. It can be seen that the basic theories and most of the technical problems of GSER have been resolved, but there are still some technical problems of surrounding rock control of GSER under relatively special working conditions that need to be studied in depth.

The 92202 working face of Sanhejian Coal Mine is located below the upper coal seam goaf. Aiming at the technical difficulty of controlling the surrounding rock of its track roadway GSER, this paper proposed the surrounding rock control technology for it under the goaf of the deep close coal seam, and finally carried out the industrial test.

2. Engineering Background

Sanhejian Coal Mine is the main mine in the headquarters of Xuzhou Mining Group Co., Ltd. With the continuous improvement of mine output and production efficiency, the traditional roadway layout can no longer meet the needs of mining replacement and safe mining. The layout of GSER can solve these problems extremely effectively. The 92202 working face has a maximum buried depth of 1017 m, located under the old goaf areas such as 72202 and 72204, and is about 24 m away from the 7th coal’s goaf floor. The plan view of the 72202 and 72204 mining face is shown in Figure 1.

The 92202 is affected by multiple mining operations such as the 7th coal working face and the advanced supporting stress of the 9th coal seam. Therefore, the surrounding rock of each mining roadway is more broken, the deformation and deformation speed are greater, and the support is more difficult. In view of the production geological conditions in the 92202 working face, to conduct technology research of the stability of the GSER surrounding rock under the goaf in the deep and close coal seam is necessary.

3. Surrounding Rock Control Technology

Combining with the deformation and failure characteristics and the theoretical analysis of the GSER in the deep near coal seam, it is proposed rock control technology under the goal in the deep and close coal seam to use high-strength pre-stressed bolt, beam, mesh and cable for basic support in the roadway, single hydraulic props in conjunction with hinged roof beams for strengthen support and high-water filling structure to support the roadside, and to use the system information design method to determine the support parameters. The overall schematic diagram of the surrounding rock control system is shown in Figure 2.
3.1. Supporting Technology in the Roadway

(1) Roadway Basic support

The track roadway of 92202 working face is designed as an inverted trapezoid section. The width of the roadway is 4.8 m, the height of the upper side is 3.5-5 m, and the height of the lower side is 2.0 m-3.5 m. After research, it is determined that the combined support method of bolt, beam, mesh and cable is adopted. Roadway roof support: adopts Φ22 mm × 2500 mm left-handed non-longitudinal rebar steel and other strong bolts. The steel belt is processed by Φ16 mm round steel. The specification of the steel belt: 4500 mm × 800 mm × 70 mm, paved with diamond-shaped metal mesh for joint support, and the bolts’ row spacing is 800 mm × 800 mm. At the same time, Φ18.9 mm × 6300 mm anchor cables are used to strengthen the support, the row spacing is 2000 mm × 2400 mm. Roadway lining support: adopt Φ20 mm × 2000 mm left-handed non-longitudinal rebar steel and other strong bolts, the row spacing is 750 mm × 800 mm, the steel belt is processed by Φ12 mm round steel, and the specifications of the steel belt: 2600 mm × 750 mm × 70 mm, with double-resistance plastic net for joint support.

(2) Roadway Strengthen support

The support distance of the advanced section in the roadway is not less than 30 m, single hydraulic prop is selected to cooperate with the hinged top beam to strengthen the support, and the initial support force of the single hydraulic prop is as large as possible. The parameters of reinforced support in the back roadway are: three single hydraulic
props wearing iron shoes are arranged in each row in 100 m behind the 92202 working face, and the distances to solid coal body are 0.8 m, 2.8 m and 3.8 m. With the working face’s advancement, the hydraulic props 100 m behind are removed in turn.

3.2. Roadside Support Technology

The filling area’s roof is supported in advance by the side of the roadway, and the high-water filling structure is adopted for roadside support after the mining.

(1) Maintenance of the roof of the filling area

The working face is pushed, the roof above the filling body will be exposed for a period of time until the filling body is condensed and has sufficient strength to support the roof. It’s necessary to support the roof of filling body area in advance by the side of the roadway before the filling body’s strength reaches the expected value.

What the specific plan is that a safety gap is made by blasting at the filling position in front of the working face. The safety gap is about 4400 mm × 3300 mm. The bolts’ row spacing is 1100 mm × 1100 mm; each row has two anchor cables with a row spacing of 2200 mm, which are respectively 5.4 m and 7.6 m away from the solid coal body.

(2) High water filling structure

Considering safety and construction factors, the actual filling body width is 1.5 m. The high-water material is filled once a day, 3.2 m each time. Before grouting is carried out, cross anchors are placed on the filling bag. The cross anchors are made of 22 mm rebar material, and are arranged in 800 mm × 900 mm. The reinforced ladder beam is made of Φ14 mm round steel welding. The metal mesh is made of Φ4.5 mm round steel, and the mesh hole is not more than 100 mm × 100 mm.

4. Surrounding Rock Control Effect

The mine pressure monitoring was carried out on the site at all stages, including monitoring of roadway surface displacement and roof separation. The surface deformation of the surrounding rock are shown in Figure 3.

![Figure 3. Surface deformation curve](image)

The monitoring results of surface deformation of the roadway show: (1) There is almost no roof subsidence and the surrounding rock deformation is a little in the range...
of 0-20 m behind the working face. (2) The surrounding rock has obvious deformation in the range of 20-110 m behind the working face. The approaching amount of the roof and floor of the solid coal side is the largest, with the maximum value reaching 800 mm, of which the bottom drum is 660 mm, and the top sinking is 140 mm. The deformation is mainly manifested as the bottom drum. The maximum roof sinking amount is 250 mm, the maximum two sides moving distance is 550 mm, and the deformation rate first increases, then gradually decreases, and finally reaches zero. Among them, the moving rate between 20 m and 80 m in the rear is relatively large, with the maximum reaching 90 mm/d, while the rate between 80 and 110 m in the rear is relatively small. (3) The deformation rate of surrounding rock is very small, and the amount of deformation gradually tends to zero beyond 110 m behind the working face. (4) The approaching amount of the solid coal side’s top and bottom does not exceed 800 mm, the approaching amount of the filling body side’s top and bottom does not exceed 610 mm, the two sides approaching amount is about 550 mm. The overall deformation is controllable, and the surrounding rock control effect better.

It can be seen the set of supporting technology is effective in the track roadway in 92202 working face, the filling body and surrounding rock are both stable. This set of technology can well meet the requirements of actual use in deep and close distance coal seams under goaf.

5. Conclusion

Based on the engineering background of the 92202 working face GSER in Sanhejian Coal Mine, the set of surrounding rock control technology was proposed, and industrial test was conducted. The main conclusions are:

(1) The set of surrounding rock control technology is proposed to use high-strength pre-stressed anchor beams and mesh cables, single hydraulic props with hinged roof beams and high-water filling body structure for roadside support.

(2) The monitoring results of industrial tests show that the proposed surrounding rock control technology can effectively control the filling bodies and surrounding rocks, and the surrounding rock and filling bodies can maintain stable during the two stopping periods. This set of technology has certain application value.

References


