Research on gob-side entry retaining using high-strength lightweight block

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Abstract. In order to effectively reduce the tension between the mining face and the tunnelling connection and increase the underground work efficiency. The engineering background of this paper is - 4111 face of Jingang Coal Mine, located in Dazhou, West China’s Sichuan Province. The theoretical analysis, FLAC 3D simulation and pressure engineering practice of high-strength lightweight block are studied. Combining with the underground scene and using FLAC 3D, the model of different width of support body was established, and the deformation characteristics of surrounding rock were analysed to determine the reasonable width of the support body. According to the field situation of the underground working face, the size of high-strength lightweight block and the way of wall building were designed. The stability effect of transportation lane in working face was observed and analysed with instruments in the field, which ensured the stability of high-strength light block along the roadway and surrounding rock of roof, and the rationality and scientificity of supporting design.

1. Introduction

In China’s mines, gob-side entry retaining has been being widely used. Many domestic research institutes and universities have also made remarkable achievements in the study of the theory of it, as well as the law and support of overlying strata movement along the roadway. A lot of research has been done on the stability of the support body. [1,2] The technology of gob-side entry retaining cancels the maintenance of the coal pillars of the roadway, improves the coal resource recovery rate, cancels the island working face and shortens the moving duration, helps to prevent fire and achieve safe production of the mine, and improves the technical and economic benefits of the mine. The social benefits are very significant. Over recent years, China has done a lot of research on the theory and technology of it. [3-6] Hua Xinzhu [7] proposed a kind of active roadside reinforcement support method and analyzed its action mechanism. Wang Jun [8] proposed and verified the new technology of steel-filled concrete piers and lining walls along the mined-out roadway. Lin Dongcai [9] used concrete block walls for the gob-side entry retaining and effectively ensure the safety and stability of the roof.

Taking Jingang Coal Mine as an engineering example, this paper researched on the technology of gob-side entry retaining along the high-strength and lightweight block of inclined coal seam was carried out, and designed the scheme of high-strength lightweight concrete block, roadway support and filling body. Meanwhile, through measured data this paper also analyzed the deformation law of surrounding
rock in the roadway along the goaf and improved the surrounding rock control method of the roadway and the structural parameters of the surrounding wall.

2. Working face overview
The coal seam of the -4111 working face of Jingang Coal Mine is 315° for the monoclinic structure; The coal seam inclination angle is 27°~34°, with an average of 31°; The thickness of the coal seam is 1.63m~2.3m, and the average thickness is 1.9m; The buried depth is about 450m; The mining height is 2.8m, the stability is moderate, and the structural mode is connected with the inner coal and the dark gray mudstone coal seam and soft coal. The -4111 working face is simple in structure and belongs to the west wing of the Zhongshan anticline. The coal seam is generally inclined to the northwest. Two reverse faults have been exposed during the tunneling of the machine and wind tunnel.

3. Technology of gob-side entry retaining using high-strength lightweight concrete masonry

3.1. High-strength lightweight concrete design and performance test
In view of the high cost of roadway along the -4111-working face of Jingang Coal Mine, the low support strength of the roadway, the large deformation of the roadway and the poor effect, the high-strength lightweight concrete is analyzed and researched, and the support of the roadside support is improved by the high-strength lightweight concrete block. The utility model has the advantages of high capacity, good support effect, low cost reduction, and the stability of the surrounding rock and the stability of the support body.

The research on the cooperation of high-strength lightweight concrete is to determine the optimal proportioning scheme of LC50 high-strength lightweight concrete, and to prepare high-strength, low-density, high-strength, high-cost-effective high-strength light with the ability to meet the requirements of roadway support along the roadway. Quality concrete. When the proportion of concrete is studied, the water-to-binder ratio, volumetric sand ratio, fly ash content and silica fume content are the most important parameters affecting the concrete proportioning design. The test was divided into two steps. Firstly, the orthogonal test design method was adopted. The water-binder ratio, the volumetric sand ratio, the fly ash content and the silica fume content are the four factors of the orthogonal test, and the LC50 is high-strength and light. The concrete slump, density and compressive strength were analyzed to determine the best technical solution for the preparation of high-strength lightweight concrete with 800 grade ceramsite. In the second step, after determining the best ratio of concrete, the ceramsite experiments of 800 and 900 grades are respectively used to verify the rationality of the ratio of 800 grade ceramsite concrete according to the experimental index, and the high strength and lightness of the 800 grade and 900 grade ceramsite are prepared. The cost performance of the quality concrete is analyzed to determine the optimal ratio of LC50 high strength concrete.

3.2. Model establishment

3.2.1. Calculation of support resistance under different support body widths
According to the geological data of the -4111-working face of Jingang Coal Mine, the parameters required for the calculation of the support resistance of the roadway are obtained. According to the support resistance formula, the support resistance under different support body widths is calculated. The result is shown in Figure 1.
Figure 1. Sideline support resistance line diagram for different support body widths

It can be seen from the line graph that the support resistance is approximately proportional to the width of the support body. As the width of the support body increases, the front and rear support resistance of the side lane support body also increases. If the width of the support is too small, the support resistance cannot meet the cutting resistance; If the width of the support body is too large, it will cause waste of resources and affect the economic benefits of the mine; Therefore, there is a reasonable value for the width of the support.

3.2.2. Stress analysis of surrounding rock of different support body width roadway

In order to study the influence of the width of different support bodies on the vertical stress of the surrounding rock of the roadway, the vertical stress contour maps of the four simulation schemes are listed, as shown in Figure 2.

Figure 2. Vertical stress contour plots at different support widths
The relationship between the vertical stress and the width of the support body is analyzed by Fig. 2. The vertical stress distribution under the width of different support bodies is basically the same. The stress concentration mainly appears in the inner part of the support body and the depth of the coal gang is about 7~9m. When the width of the support body increases from 0.5m to 0.75m, the maximum vertical stress at the depth of the coal gang is reduced to 29MPa, which is reduced to MPa, and the stress of the support body is increased from 5MPa to 6 MPa, which is increased by 20%. When increasing from 0.75m to 1m, the stress in the deep part of the coal gang is reduced by 3%, and the stress of the support body is increased by 8%; When the width of the support body continues to increase to 1.5m, the vertical stress of the coal gang and the support body still increases, but the increase has stabilized. The results show that with the larger width of the supporting body, the vertical stress of the supporting body increases, the bearing capacity is enhanced, the pressure in the deep part of the coal gang is shared, and the vertical stress in the deep part of the coal gang is reduced, which is consistent with the “hard branch and multi-load”. law; When the width of the support body reaches a certain value, the width of the support body is continuously increased. The change of the vertical stress of the coal lining and the support body is not obvious, indicating that the width of the support body has a reasonable value; It is proved that the support body mainly plays a role in maintaining the stability of the surrounding rock of the roadway. The main factor affecting the stress distribution and peak value of the surrounding rock is the large structure of the overburden.

3.3. Concrete block size design

The high-strength lightweight concrete block specification is the basis for the design of the side wall. Although the weight of lightweight high-strength concrete has been greatly reduced compared with ordinary concrete blocks, in order to further improve the construction efficiency, the block specifications are designed. According to the mining height of the 4111 working face of Jingang Coal Mine, the surrounding rock conditions of the top and bottom plates and other similar conditions of the coal seams, the specifications of the block wall are determined as follows: Length \( \times \) width \( \times \) height = 500m \( \times \) 250mm \( \times \) 200mm, in order to save materials, reduce costs, while reducing the weight of the block, reduce the labor intensity of workers, the use of high-strength lightweight concrete two-hole prefabricated blocks. Block porosity is: 29.2%, the weight of the block is 34kg, as shown in Figure 3.

![Figure 3. Block Structure Design](image)

4. Deformation observation data analysis

Through the deformation observation and actual data collection of 4 stations in the -4111-working face, the roof and bottom floor change line diagrams are drawn, as shown in Figure 4.
By observing the cumulative displacement amount of the top and bottom plates of 12 measuring points of 4 stations, it can be seen that the roof and bottom plates of the support side of the roadway have the largest amount of movement, and the coal side has the smallest amount of movement, which means that the supporting body has no The support of the coal pillars has a large space for the roof to sink, and the space for the lower sag is limited, and there is no release pressure. In order to avoid the large area of the coal gang, it is necessary to carry out reasonable support design for the coal gang.

By observing the cumulative approaching amount of the top and bottom plates of 12 measuring points of 4 stations, it can be seen that the moving speed of the top and bottom plates occurs at a distance of 5m to 40m from the coal wall. This shows that with the advancement of the working face, the movement of the top and bottom of the roadway is relatively strong within the range of 5m to 40m from the coal wall. In order to avoid large-scale deformation of the roadway caused by the vigorous movement of the top and bottom plates, it is necessary to take corresponding branches at this distance.

5. Conclusion
According to the in-situ situations of the working face, the high-strength lightweight concrete block size and wall masonry design were designed, and the high-strength lightweight concrete two-hole prefabricated block was designed, adopting the two vertical and one horizontal, criss-crossing, staggered cross wall. Body masonry. According to the stress distribution of surrounding rock in the roadway along the goaf, the three types of strengthened support methods were adopted: the advanced reinforcement support, the delayed reinforcement support and the lower exit support. Through on-the-spot observation, the overall deformation of the high surrounding rock of the -4111 working face is not large, and no large deformation and deformation occurred. The design of the support of the high-strength and lightweight block along the empty roadway is reasonable.

6. Major innovations and prospects
Through the establishment of the overall stress model of the auxiliary roadway in the early and late inclined coal seams, the paper determines the dip angle range of the coal seam without the downward turning of the side road support; The mechanical model of the supporting resistance of the roadway along the roadway along the inclined coal seam is established, and the calculation formula of the support resistance of the roadside support is given. Determine the optimal proportioning scheme of LC50 high-strength lightweight concrete, and design high-strength lightweight concrete blocks and wall masonry. Due to the limitations of time and research level, there are many problems and deficiencies in the paper, which entail further exploration and research.

(1) The theoretical calculations of the stability and support resistance of the support body along the retained gob-side entries are all based on statics. How to derive the general formula applicable to the whole mining process invites further study.
(2) The stability of surrounding rock in the roadway along the goaf is affected by many factors. In addition to the width and material of the support, the form of roadway support and its parameters, the basic top fracture location, the shape of the roadway section, and the mining technical conditions. Related, the paper needs further research.

References

[1] Song Zhenduo, Cui Zengqi, Xia Hongchun, et al. The fundamental theoretical and engineering research on the green safe no coal pillar mining model by mainly using coal gangue backfill [J]. Journal of China Coal Society, 2010(5): 705-710.

[2] Gao Desheng. Prospect of roadway retaining technology [J]. Hebei Coal, 1995 (3): 1-5.

[3] Zhang Dongsheng, Yan Xiexing, Feng Guangming, et al. Stability Control of Packing Body for Gob-Side Entry Retaining in Fully-Mechanized Coalfaces with Top-Coal Caving [J]. Journal of China University of Mining and Technology, 2003, 32(3): 232-235.

[4] Hua Xinzhu. Development status and improved proposals on gob-side entry retaining support technology in China [J]. Coal Science and Technology, 2006, 12 (12): 78-81.

[5] Bai Jianwei, Zhou Huaqiang, Hou Chaoyu. Development of Support Technology Beside Roadway in Goaf-Side Entry Retaining for Next Sublevel [J]. Journal of China University of Mining and Technology, 2004, 33(2): 183-186.

[6] Fu Baojie. Stability analysis and application of entry-side backfill [D]. Xuzhou: China University of Mining and Technology, 2007.

[7] Hua Xinzhu, Ma Junfeng, Xu Tingjiao. Study on Controlling Mechanism of Surrounding Rocks of Gob-side Entry with Combination of Roadside Reinforced Cable Supporting and Roadway Bolt Supporting and its Application[J]. Chinese Journal of Rock Mechanics and Engineering, 2005, 24(12): 2107-2112.

[8] Wang Jun, Gao Yanfa, He Xiaosheng, et al. The analysis of roadside supporting parameters and the support technology in the concrete filled steel tubular column in goaf-side entry retaining [J]. Journal of Mining and Safety Engineering, 2015, 32(6): 943-949.

[9] Lin Dongcai, Sun Ruike, Jia Chuanyang. Gob-side Entry Retaining Technology of Concrete Block Walls [J]. Safety in Coal Mines, 2014, 45(5): 82-84.