Technology of Gob-side Entry Retaining in Steep Soft Outburst Coal Seam

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Abstract: Through the establishment of a mechanical model of stope structure, the scope of internal stress field was forecasted, and the width of the coal pier in gob-side entry retaining was determined based on this. Aim at the seven stages of surrounding rock deformation in gob-side entry retaining, the supporting measures of gob-side entry retaining which is based on the dynamic of stratum was taken to design the control of surrounding rock in different roadways. Especially for the features of the violent deformation of surrounding rock and the extremely soft characteristic of coal pier coal which appeared in the process of gob-side entry retaining in the rear area of upper section working face, in order to prevent the coal pier from being crushed and becoming instability in the process of sinking and bending of the rear rock beam, a technology of roadway protection called 'intensive roadside bolting system' was used. Practice has proved that it meets the safety of transportation, walking and ventilation. Gob-side entry retaining achieved technically feasible, safe reliable, economically rational effect.

Keywords: steep; gob-side entry retaining; mechanical model of stope structure; chemical reinforcement

1. Introduction

Liziya'nan colliery of Guangneng Group mainly mine steep soft outburst coal seam. According to many years' production practice of the colliery, there is a big probability of coal and gas outburst occurrence in mining in such coal seam which not only cause casualties and affect the normal production safety and reduce the economic benefit of mine. As we know, coal and gas outburst is not only the power phenomenon in coal mine mining process, but also one of the important disasters in coal mines. Years of theoretical research and engineering practice proved that it is the rock stress and the gas and the coal cause the coal and gas outburst, and the rock stress is the main power of causing coal and gas outburst. Therefore, in a mine field, in the condition of coal and gas outburst's original geological conditions have been established how to avoid the coal being influenced by the peak abutment pressure is an effective way to avoid the coal and gas outburst. The research achievement of mine pressure theory shows that the internal and external stress fields constitute the abutment pressure distribution around the stope. The external stress field belongs to the high stress area and the internal stress field belongs to low stress area. If retain gob-side entry in the low stress area, the roadway will avoid the influence of the peak abutment pressure so as to reduce the probability of coal and gas outburst occurrence. Therefore, on the basis of studying the existing technology of gob-side entry retaining at home and abroad, according to the actual production of Liziya'nan colliery, a method of gob-side entry retaining and supporting design and process was established, in order to dig less tunnels, reduce the probability of coal and gas outburst and guarantee the safety of production.

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2. Project Situation

The coal seam in 5225 working face of Liziya'nan colliery is coal seam K1 which is steep soft outburst coal seam. The coal seam angle is between 56° and 70° and the coal thickness changes greatly from 0.8m to 1.88m, and average 1.34. Since the coal seam angle is big, so we used the 1.3m tall pseudo inclined quadrilateral flexible shield supporting mining method. In order to prevent coal gangue and coal from dropping into lower gangway, coal piers were reserved. Advanced advancing sneak coal eye and decorate ventilated pedestrian eye in the rear in the process of backstoping with coal piers between them. The coal piers are 3.4m width, 3-4m height. As shown in figure 1.

Normally, along the advancement of working face, ventilated pedestrian eye in the rear constantly scrap, coal gangue in the mined out space drop into lower gangway through the discarded ventilated pedestrian eye. Thus, the lower gangway is filled of coal gangue after the backstoping finished, so it can not be used by the next section. Next section (next working face) have to dig a section gateway again. As shown in the figure 1.

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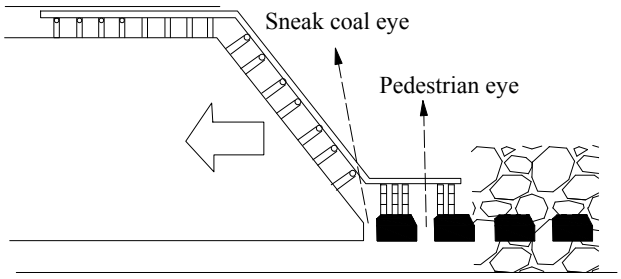

Figure 1. Schematic diagram of working face's mining

In order to achieve gob-side entry retaining, block the scrapped pedestrian eyes to form one with the coal pier so that the coal gangue will not drop into lower gangway. So this roadway can be maintained to use as upper gangway when mining next section. As shown in the figure 2.

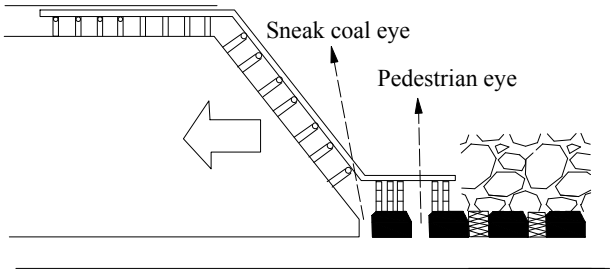

Figure 2. Gob-side entry retaining

3. Width Design of Coal Pier

Correctly analyze the stress distribution characteristics of coal around the stope and arrange the roadways (coal pier) in low stress district were key to ensure the steady of surrounding rock and achieve the success of gob-side entry retaining. Therefore, firstly establish stope structure mechanics model, then used this model to analyze the stress around the stope to determine the range of low stress area, and based on this study and determined the width of coal pier in gob-side entry retaining and its stability. All these had a vital significance to ensure the success of gob-side entry retaining and the safe production in mine.

In regard to steep stope, since the coal seam angle was a little big, we cannot establish a structural mechanics model which was similar to the abutment pressure of an almost horizontal seam. But considering the gravity of the roof partly act vertically on the coal and the rest along the direction of the coal. So we can build the structure mechanics model of internal stress field before the first pressure. As shown in the figure 3.

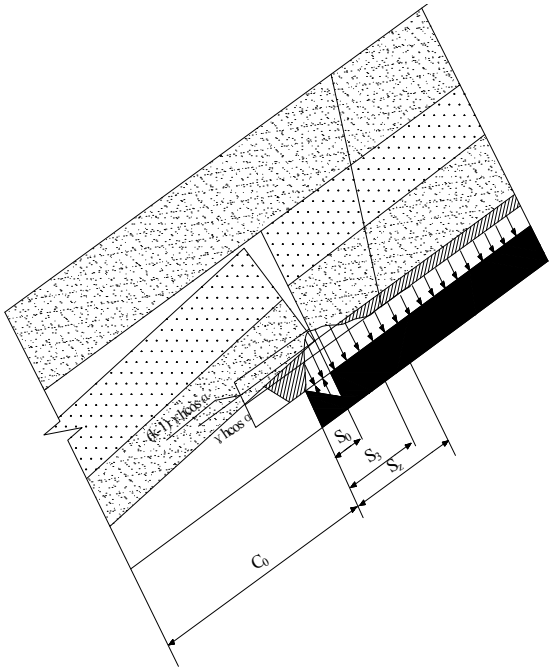

Figure 3. The structure mechanics model of steep stope

The moment of main roof fractures, the distribution of abutment pressure on coal within the scope of stress on coal is equal to the component of main roof rock beam's weight which is vertical to the coal. So:

$$\frac{1}{2}S_0 k\gamma H = \frac{LC_0\sum_1^n M_i\gamma\cos\alpha}{2(L+C_0)}$$

where, S_0—the scope of internal stress field, m ;

L—the length of working face, m ;

M_i—the thickness of main roof rock beam, m ;

C_0—the first pressure step of main roof rock beam, m ;

k—the factor of stress concentration ;

H—mining depth, m ;

n—the number of main roof rock beams ;

γ—the volume weight of rock, t/m^3;

α—the dip angle of rock stratum, °。

So, the calculation formula of the scope of the internal stress field:

$$S_0 = \frac{LC_0 \sum_{i=1}^{n} M_i \cos \alpha}{(L + C_0) kH}$$

5225 working face is 67m long, the first pressure step of main roof is 21m, the thickness of main roof is 10.25m, the average degree of working face's dip angle is 67°, the depth of working face's coal is 450m, take 2.5 for concentrating coefficient of abutment pressure. So, the scope of the internal stress field of abutment pressure around the stope is

S_0=(67 × 21 × 10.25 × cos67)/[(67+21) × 2.3 × 450]=6.2m

According to the need of aeration and walking of coal face, the width of roadway is general 3m. So, the width of coal pier can be 3-4m.

4. Support Design of Gob-Side Entry Retaining Based On Trends of Rock

Theoretical studies show: the rock deformation process of gob-side entry retaining can be divided into seven stages, as shown in the figure 4. Because of the movement features' differences of each section's rock, the rock stress on each section's roadway is quiet different which cause a big deformation of the surrounding rock. So 'the support design of gob-side entry retaining based on trends of rock' is proposed.

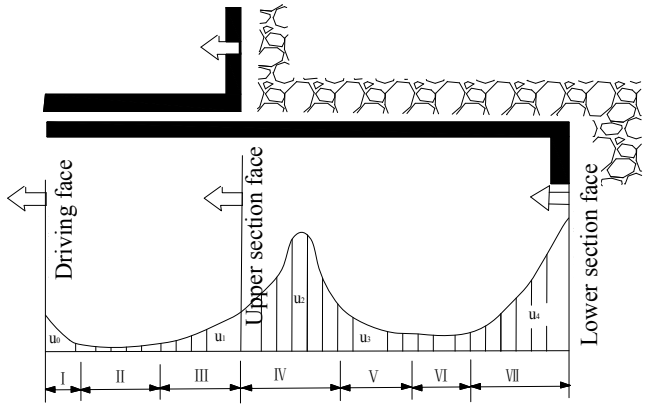

Figure 4. The rock deformation process of gob-side entry retaining

The method's core idea is with the overburden's movement as core, aim at the different movement stages and characters of overburden, different support form and parameters are adopted, so as to achieve the goal of 'technical feasibility, ease of application, economy reasonable, safety and reliability.

According to the above guiding ideology, the support design of 5225 roadway different stages which used the gob-side entry retaining as follows.

I~ II: stage of roadway drifting and steady

Based on research, we designed to use trapezoidal metal stent which is well established as permanent support and chose 9# I-beam. Trapezoidal roadway is 2600mm wide at the top and 3300mm at the bottom, under this condition, trapezoidal metal stent's support capacity to roof is R=90kN/stent. Calculation shows that the distance of each trapezoidal metal stent is 0.8m. And it will be 0.6m when encountered geological structures.

III: stage of upper section working face influenced by advancing abutment pressure

Base on the support in Ⅰ~Ⅱ, enhance supper support. The scope of supper support is the scope obviously infected by abutment pressure, and its value is 20m according to the mine pressure observation. At the front 10m use double row monomer hydraulic props as supper support, at the back 10m use single row monomer hydraulic prop as supper support.

IV~V~VI: stage of gob-side entry retaining at upper section working face's rear area

Aim at the character that coal pier coal belongs to extreme soft lithology, to prevent coal pier from being crushed and becoming unstable in the process of bend and subsidence of upper section working face's rear rock beam. The technology of roadway protection called "intensive roadside support system" was used, explained as a comprehensive technical measure of combining "coal pier chemical reinforcement" with "coal eye injection".

(1) Coal pier chemical reinforcement

Because the coal is extremely soft, in order to ensure the stability of protect lane coal pier, take the method of chemical reinforcement to reinforce the coal pier. Through chemical grouting reinforcement can change the weak mechanics properties of coal and rock which improve the adhesion and internal friction Angle of coal and cluster, increase the relative displacement resistance between internal rocks of rock, thus to improve the overall stability of surrounding rock. Through the grouting reinforcement, can make the broken rock, fracture and loose coal cement into a whole, form the bearing structure, give full play to its stability and the bearing capacity.

Vertically decorate three grouting drill holes in the roadway roof, three presbyopia's form, spacing is about 2m, diameter is 42mm, depth is 4-5m, hole 2 is vertical to the roof, hole 1 and 3 are outward 20-30° , length of hole sealing is around 1.5m. Chemical grouting material is the resin emulsion polymer materials consists of resin and catalyst by 1:1 ratio, it's used special pneumatic grouting pump to inject and creat.

(2) Intensive bolting of sneak coal eye

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Cement the loose waste rock in sneak coal eye with cement mortar to form the 'intensive bolting system'. It not only can plug the sneak coal eye and prevent the waste rock from whisk into the reserved roadway, but also make the loose waste rock a whole, to reinforce and support the coal pier, and to protect the reserved roadway.

According to the space and coal pier's size of the reserved roadway, the space designed between injection holes is 5m. The depth of injection hole is 4-5m and the aperture is 42mm, decorate them follow the sneak coal eye in the real dip direction of the coal seam. The cement mortar is made of cement and sand mixed by 1:1 ratio, and then allocates its consistency several times in the waterproof condition.

VII: the stage influenced by advanced abutment pressure of lower section working face

Based on the chemical reinforcement to piers and the intensive bolting to sneak coal eye with grouting, this stage roadway will be affected by the advanced abutment pressure of lower section working face. This stage's reinforcement bolting method is the same as that in stage Ⅲ.

5. Analysis of Surrounding Rock Control Effect

In order to test the supporting effect of gob-side entry retaining, we monitored the surrounding rock deformation of 5225 roadway, as shown in the figure 5 and 6.

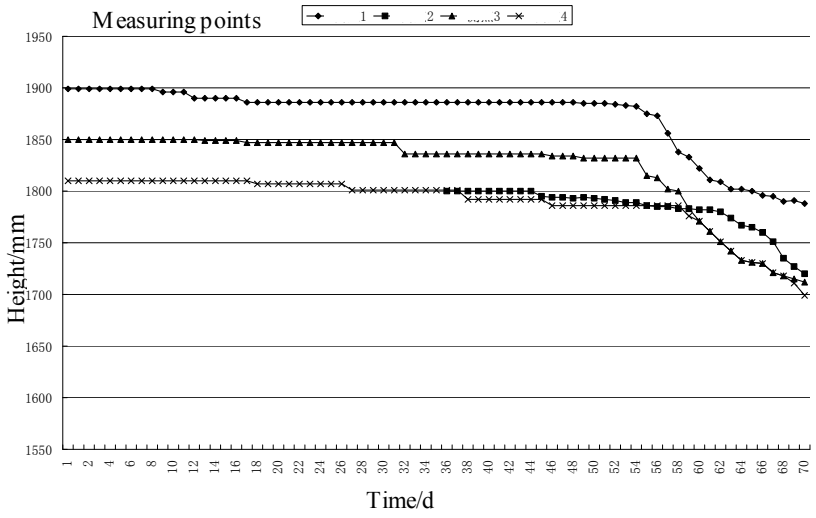

Figure 5. Vertical deformation of roadway

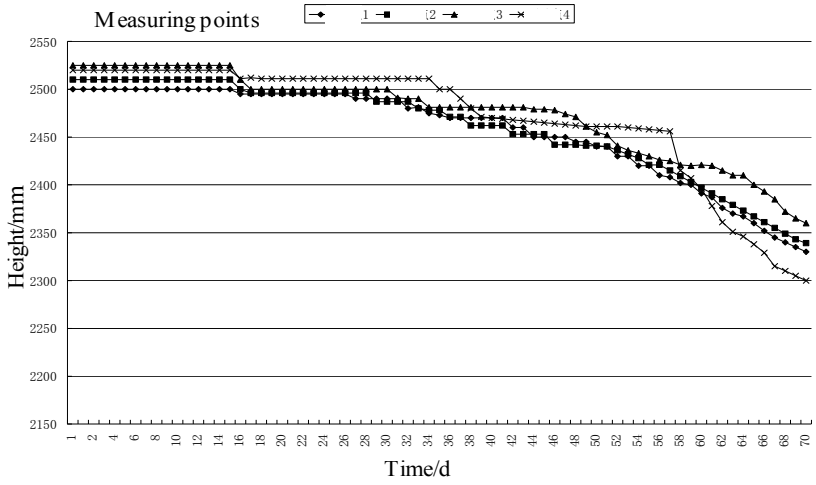

Figure 6. Horizontal deformation of roadway

Figure5 and 6 shows us the deformation condition of surrounding rock of 5225 roadway's 5227 working face under the advanced abutment pressure. Under the advanced abutment pressure, the vertical deformation of roadway of 5227 working face is 111mm, 80mm, 138mm, 111mm, and average 110mm. horizontal deformation of roadway is 170mm, 171mm, 165mm, 220mm, and average 181mm. The minimum height of roadway is 1700mm and the minimum width is 2300mm which can fulfill the safety of transportation, walking and ventilating of working face.

This shows that adopted the supporting measures of gob-side entry retaining which is based on the dynamic of stratum, with the overburden's movement as core, aim at the different movement stages and characters of overburden, adopted different support form and parameters and finally achieved technically feasible, safe reliable, economically rational effect.

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