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Application of advanced deep hole blasting technology for thick and hard roof weakening in Xinji Coalmine

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ABSTRACT. *According to the roof rock mass characteristics of the 210108 working face of the Xinji Coalmine, the initial pressure step distance and periodic pressure step distance of the roof and the corresponding support model and working resistance are calculated. According to calculation results, the blasting step of the roof weakening is determined to be 25m. The field application shows that the hard and hard blasting roof is transformed into a caving roof, which changes the characteristics of the rock pressure in the working face, and has obtained good results in the experiment, and provides a reference for similar projects.*

KEYWORDS: *hard roof, weakening, advanced deep hole blasting, blasting parameter*

1. Project Overview

According to the actual disclosure of 210108 working face of the Xinji Coalmine 1 coal, 1 upper coal roof slate comprehensive drilling and track and coal mining door, from the 1 upper coal to the top: silty sandstone (developed from west to east into sandy mudstone, siltstone, medium-grain quartz sandstone, medium sandstone) 6.0m, medium -fine sandstone 14.8m, fine sandstone 10.5m. On the whole, the top plate of the 1 coal group is mainly siltstone, medium-thick layered, with high strength (R_c=46.7~137.9MPa, R_t=5.98~9.65 MPa), and the stability is good. The specific roof rock properties are shown in Table 1.

Because the top surface of the working face is a thick sandstone roof, the roof has good stability and high strength, and 1 coal belongs to high gas coal seam. If the roof is not taken to take effective measures to control the roof, the roof is difficult to fall during the coal seam mining process, and the ceiling area is huge. Once the large-area roof falls, it will generate a huge impact pressure, crush the bracket, and form a storm, causing the gas to exceed the limit. To this end, the blasting weakening technology of the thick sandstone roof of 210208 fully mechanized mining face is studied to ensure the safe mining of 210108 working face.

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Table 1 Experimental data of sensor measurement accuracy

Group No.	Rock name	Tensile strength (MPa)	Compressive strength (MPa)	Elastic modulus (GPa)	Deformation modulus (GPa)	Poisson's ratio
1	Sandy mudstone	3.03	81.73	19.26	10.94	0.27
2	Piebald mudstone	2.18	63.57	16.12	8.82	0.38
3	Middle sandstone	3.26	135.10	35.05	29.83	0.33
4	Sandy mudstone	3.14	30.59	2.62	2.31	0.13
5	Coarse sandstone	3.87	125.76	27.78	20.01	0.24
6	Sandy mudstone	3.22	27.53	2.90	2.14	0.07
7	Sandy mudstone	3.25	20.89	2.69	2.27	0.12
8	Fine sandstone	3.91	135.94	54.37	37.03	0.30

2. Working face pressure step and bracket load analysis

2.1 Initial pressure step and bracket load

According to the key layer theory, 14.8m sandstone of 1 coal roof is used as the key layer, which plays an absolute role in controlling the mining pressure. The ultimate span of the beam break can be obtained by mechanics of materials. The force analysis diagram of the fixed beam at both ends is established, as shown in Figure 1.

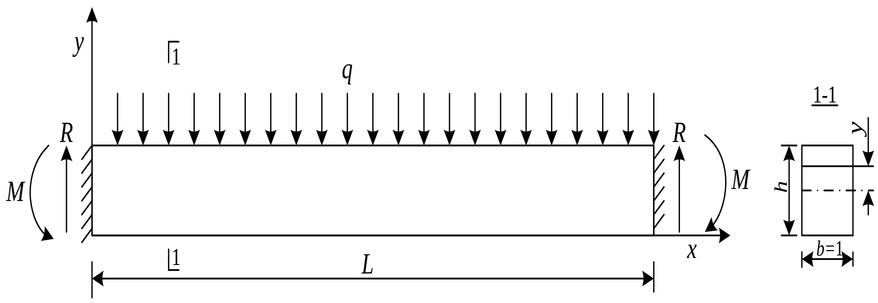

Figure.1 Mechanical model of solid supported beam at both ends

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$$\sigma = \frac{My}{J_z} \tag{1}$$

Where M is the bending moment of the section where the point is located; y is the distance of the point from the neutral axis of the section; J_z is the section moment of the symmetric neutral axis.

The maximum tensile stress produced is:

$$\sigma_{\max} = \frac{6 \times \frac{1}{12} qL^2}{h^2} = \frac{qL^2}{2h^2} \tag{2}$$

When $\sigma_{\max}= R_T$, where the normal stress of the rock layer reaches the tensile strength limit there, the rock layer will crack there. The ultimate span when the beam breaks is:

$$L_T = h\sqrt{\frac{2R_T}{q}} \tag{3}$$

According to the working face lithology column, take q= 0.25MPa, R_T= 2.0MPa, h=14.8m, available, L_T= 59.2m.

In order to ensure that the key layer of the roof is not unstable, it should meet:

$$\begin{cases} T\tan\varphi + p \geq R \\ R = \frac{qL}{2} \\ T = \frac{qL^2}{8h} \end{cases} \tag{4}$$

Where T is the horizontal pressing force of the two blocks after breaking; p is the static supporting reaction force provided by the bracket.

then:

$$p \geq \frac{qL}{2} - \frac{qL^2}{8h}\tan\varphi = 8364(\text{KN}) \tag{5}$$

Where $\tan\varphi$ = 0.3 ~ 0.5, take 0.3.

2.2 Cycle weighting step and bracket load

The formation conditions of the masonry beam structure require that the amount of rotation of the broken block cannot exceed the maximum amount of rotation that maintains its structural stability. Based on this, it is judged that the key layer presents the structure of "masonry beam" and "cantilever beam", which can be started from the length of the broken block and the amount of its rotation. Figure 2 shows a schematic diagram of the pivoting motion of the key layer.

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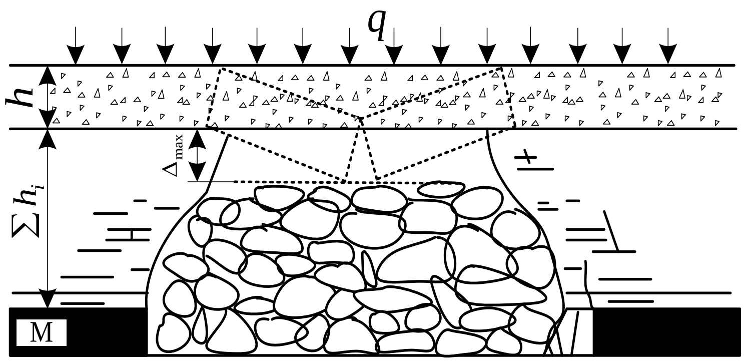

Figure.2 Critical layerrevolving space sketch map

The spatial displacement between the direct collapse and the upper key layer is as follows:

$$\Delta = m + (1 - K_p)\sum h_i \tag{6}$$

Where Δ is the amount of rotation of the critical layer breaking block,*m*is the coal seam mining height, K_p isthe direct top collapse rock mass expansion system, and $\sum h_i$ is the direct top thickness of the lower key layer.

When the critical layer breaking block can be hinged to form a stable "masonry beam" structure, the limit rotation amount is Δ max, then when $\Delta < \Delta$ max, the key layer will be in the fracture zone and present a "masonry beam" structure.According to the mechanical model of the deformation instability of the "masonry beam" structure, it can be obtained

$$\Delta_{max} = h - \sqrt{\frac{2ql^2}{\sigma_c}} \tag{7}$$

Where h is the critical layer thickness, l is the critical layer fracture step, q is the key layer and its overlying load, and σ_c is the critical layer breaking rock block compressive strength. The conditions for the formation of the "masonry beam" structure of the key layer of the fully mechanized mining face is:

From the top plate lithology parameters can be obtained:

$l = h\sqrt{\frac{R_T}{3q}}$ =24.1m; h =14.8m; $\sum h_i$ =0; q =0.25MPa; σ_c =83.07MPa.

Then, the formula (8) <10.6 is established, which indicate that the main key layer can form a "masonry beam" structure as shown in figure 3.

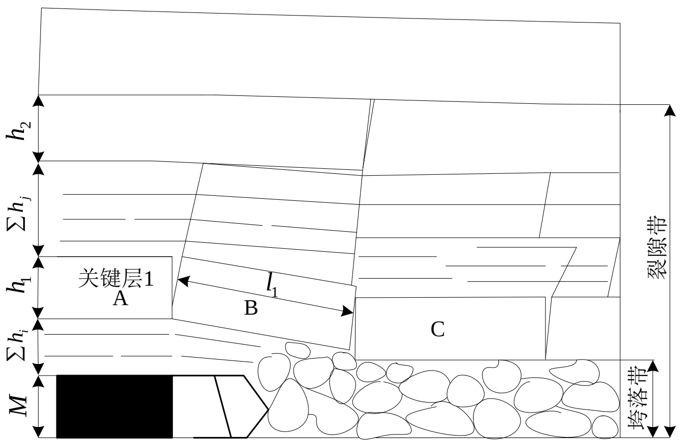

Figure.3 Critical layer "masonry beam "structure

Under the given deformation conditions, when the bracket is in the "masonry beam" structure of Figure 3, it is necessary to provide the maximum additional force for maintaining the critical B balance.The additional force *P* can be expressed as:

$$P = \left[Q - \frac{lQ\tan(\varphi - \theta)}{2(h - \Delta)} \right] B = 6326\text{KN} \tag{9}$$

Where *B* is the width of the bracket, 1.75m; φ is the friction angle between the rocks; θ is the breaking angle of the rock; $\tan(\varphi-\theta)=0.5$; *Q* is the critical A, B breaking rock itself and overlying controlled rock load.

If the dynamic load factor of 1.3 is considered, the bracket should provide a support reaction force of 8224KN.

According to the mining surface technical conditions and equipment equipment conditions, the working face selection bracket type is: ZZ9200/24/50 bracket, working resistance 9200KN. Considering the strong influence of the dynamic pressure of the thick hard roof, the design cuts the front forward blasting every 25m to slow the impact of the dynamic load on the bracket.

3. Blasting plan and parameters

In order to prevent the top plate from breaking and causing the power impact on the working face support, the pre-splitting blasting of the thick hard sandstone roof is carried out by adopting the pre-cracking method. In the upper and lower grooves, a set of blastholes are implemented in each working face every 25m, and each group has 4 blastholes. The specific parameters are shown in Table 2, and the blasthole arrangement is shown in Figure 4.

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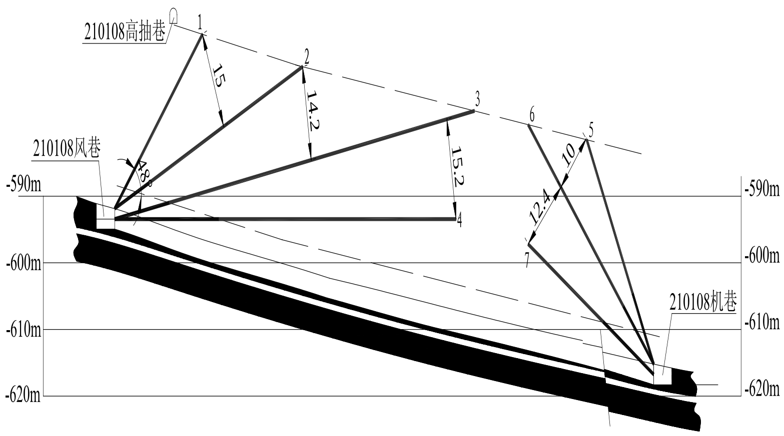

Figure .4 Blasthole layout plane

Table 2 Blasting parameters

Roadway name	Blasthole No.	Blasthole depth /m	Tilt angle /º	Horizontal angle /º	Blasthole diameter /mm	Fillingle ngth /m	Blockage length /m
Machine roadway	1#	71	24	0	94	48	23
	2#	52	28	0	94	35	17
	3#	33	38	0	94	22	11
	4#	20	55	0	94	13	7
Wind roadway	1#	71	-2	0	94	48	23
	2#	52	2	0	94	35	17
	3#	33	12	0	94	22	11
	4#	20	29	0	94	13	7

The 210108 working face adopts a single-long-wall long-return type fully mechanized coal mining method, and all the slumping methods manage the roof, and the whole mining height is 4m. During the mining process, the monitoring and analysis of the mining pressure characteristics of the working face shows that due to the weakening effect of the blasting, the pressure step is reduced, there is no large-scale suspended roof phenomenon, and the pressure of the large coal seam of the working face is avoided. It ensures the safe production during the mining period, and the deep hole blasting has achieved good results.

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4. Conclusion

1) By analyzing the characteristics of the roof rock formation of the working face, the initial pressure step, the cycle pressure step and the corresponding bracket model and working resistance are calculated.

2) The blasting step distance of 25m and the corresponding blasting parameters are designed. After the application, the hard and difficult roof is transformed into a roof that can fall off, and the mining pressure characteristics of the working face are changed. The test has achieved good results.

References

[1] A.Y. Gao and L.M. Dou (2008). Analysis of focal mechanism caused by rupture of stope roof. Chinese Journal of Rock Mechanics and Engineering, vol.27, no.S2, p.3833-3839.

[2] Q. Wang, S.C. Li and Z. Li (2012). Analysis of roof collapse mechanism and supporting measures in fault zone of coal roadway. Rock and Soil Mechanics, vol.33, no.10, p.3093-3102.

[3] Z.Z. Huang(2013). Study on laws of roof strata fracture of fully mechanized caving mining under goaf in ultra thick seam. Coal Science and Technology, vol.41, no.7, p.60-62.

[4] J.W. Guo and J.W. Zhao (2012). Study on breaking law and control mechanism of lower roof in gob-side entry retaining. Journal of Mining & Safety Engineering, vol.29, no.11, p.802-807.

[5] G.L. Xu and Z. Zhang (2012). Study of roof breaking regularity and supports suitability at fully- mechanized caving face in thick coal seam with deep inclined and three soft. Coal Technology, vol.31, no.7, p.71-73.

[6] S.G. Zhang, L. Yang and M.T. Gao (2013). Analysis on roof broken law based on two kinds of sublevel caving hydraulic support. Coal Science and Technology, vol.41, no.S1, p.17-18.

[7] S.G. Cao, H.J. Jiang and F.H. Wang (2013). Numerical simulation of overlying hard strata rupture in a coal face. Journal of Mining & Safety Engineering, vol.30, no.2, p.205-210.

[8] W.Y. Huang, S.L. Yan and Z.G. Liu (2012). Research and application of water gel explosive grain on coal mine gas extraction in coal seam deep hole blasting. Journal of China Coal Society, vol.37, no.3, p.472-476.

[9] N. Zhao, G.L. Dai and W.Y. Huang (2014). Research and application of deep hole pre-splitting blasting forced caving technology. Journal of Safety Science and Technology, vol.10, no.4, p.38-42.

[10] D.Y. Guo, D.Y. Shang and P.F. Lu (2013). Experimental research of deep-hole cumulative blasting in hard roof weakening. Journal of China Coal Society, vol.38, no.7, p.1149-1153.

[11] C.R. Li, L.J. Kang and Q.X. Qi (2009). Numerical simulation of deep-hole blasting and its application in mine roof weaken. Journal of China Coal Society, vol.34, no.12, p.1632-1636.

ISSN 2616-5767 Vol. 2, Issue 2: 110-117, DOI: 10.25236/AJETS.020047

[12] X. Xu, Y. Xu and J.G. Fu (2017). Parameter optimization design of roof-weakening blasting based on PPV safety criteria. Coal Engineering, vol.49, no.4, p.43-45.
[13] M.F. Sheng and Z.Y. Yuan (2014). Analysis on strata behavior characteristics under hard and thick roof weakened with blasting. Coal Engineering, vol.46, no.10, p.173-176.