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STUDY ON STRESS WAVE PROPAGATION IN FRACTURED ROCKS WITH FRACTAL JOINT SURFACES

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ABSTRACT

Blasting pressure release of roof deep hole in the fully-mechanized face interconnection can shorten the first collapse step distance of roof, to avoid rock burst disasters that may cause a large area of roof collapse. Based on the actual geological condition of 6303 working face interconnection in Jining No.3 Coal Mine, from the rock blasting mechanism, this article proposes the two schemes of blasting pressure release of roof interconnection. By using of Ansys-dyna finite dynamic analysis software, this paper simulates blasting effect to the two schemes of deep whole blasting. With the analysis of numerical simulation results, we achieve parameter optimization and obtain the best blasting scheme.

INTRODUCTION

In order to explore the pressure relief and structure stability mechanism of lateral cantilever structure in the stope under the direct coverage of thick hard roof and its impact on the gob-side entry retaining, a lateral cantilever fractured structural mechanical model was established on the basis of clarification for the stress environment of gob-side entry retaining, and the equation of roof given deformation and the balance judgment for fracture block were obtained. The optimal cantilever length was proposed based on the comparison of roof structural characteristics and the stress, deformation law of surrounding rocks under six different cantilever lengths by numerical simulation method. Double stress peaks exist on the sides of gob-side entry retaining and the entry located in the low stress area. The pressure of gob-side entry retaining can be relieved by reducing the cantilever length. However, due to the impact of arch structure of rock beam, unduly short cantilever would result in insufficient pressure relief and unduly long cantilever would bring larger roof stress which results in intense deformation. Therefore, there is optimal cantilever length, which was 7-8 m in this project that enables to achieve the minimum deformation and the most stabilized rock structure of entry retaining. An engineering case of gob-side entry retaining with the direct coverage of 10 m thick hard limestone roof was put forward, and the measured data verified the reasonability of conclusion.

Coal mine methane (CMM) occurs naturally in coal seams as the adsorbed and free state, which is a kind of green energy with high burning value and little emissions after burning. However, CMM is one of the threats for underground coal mine because the accumulated methane in the entry has the potential to trigger methane explosive, and high methane content in coal seams is one of the sufficient conditions for coal and gas outburst disaster. In order to solve gas utilization and prevent gas disaster in coal mine, gas pre-extraction before coal seam mining is one of the important measures, however, the permeability of coal seams is low in most of high gas and outburst mines, and as the coal mining gets deeper and deeper, low-gas mines are gradually replaced by high-gas mines and the geological conditions are becoming increasingly complex. For example, over 70% of state-owned coal mines in China feature very low gas permeability making it immensely difficult to implement direct gas drainage, the essential measure of gas control. So conventional pre-pumping method is not able to solve these problems, which seriously restricts the safe production of coal mine and the development and utilization of coal mine methane.

Therefore, it is necessary to take effective measures to increase the permeability before coal seam mining, so as to improve gas extraction rate. At present, the most extensively study and application of coal seam permeability improvement measures mainly include drilling technology (large aperture drilling, dense drilling, cross drilling), deep-hole blasting technology, hydraulic fracturing, etc, and the application of these measures has achieved the effect of increasing coal seam permeability. Currently deep-hole blasting technology is the most widely used, and many researchers have carried out a series of theoretical and practical studies on this technology in coal mines, especially in regard to the extended range of pre-splitting blasting. Almost all of the reports on the pre-splitting blasting in coal seam are supposed that the coal seam is homogeneous and isotropic, which causes that the shape of fracture range is a circle centered on the blast hole. However, coal body is an anisotropy heterogeneous natural material containing both bedding and cleat structures. This unique feature makes coal showing anisotropy mechanical property, and the differences of the tensile and compression strength in different directions will cause different crack distances as the pre-splitting blasting is carried out in coal seam.

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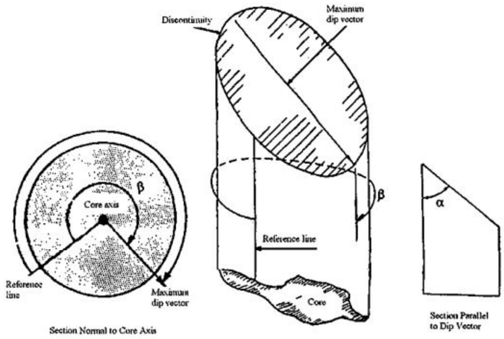
So the layout of blast holes and drainage holes should be optimized with considering the anisotropy mechanical property. In this work, firstly, the radius of pre-splitting blasting is deduced theoretically, and then the tests are carried out on mechanical parameters and effective blasting crack distances of coal seam. Finally, the layout of blast holes in coal seam is designed.

The importance of obtaining correct and confident geotechnical data for existing mining projects cannot be underestimated. This information is necessary to adequately characterize the geotechnical properties of the ore body and define parameters for stability and hydrogeological analyses that are commonly required as part of the open pit mine design. The characterization of the structure of rock masses is an important consideration at the Sarcheshmeh mine. Often it is the discontinuities and joints and not the intact rock that governs the mechanical and hydrological behavior of the rock mass.

In conventional core drilling method a complete analysis cannot be performed due to the lack of core orientation. Orientation of the core can be easily done with a core orientator. Using triple tube core barrels and Van Ruth downhole device, core can be recovered and oriented. Van Ruth core orientate consists a metal holder, with the same diameter as the core, which contains the movable pins.



Engineering Conditions:

The Bayangaole Coalfield is located in the southern section of the Hugierte exploration area, approximately 30 km west of the town Dabuchake in Wushen County. There are 10 layers of coal deposits currently being mined in the coalfield, of which the 3–1 and 5–1 coal seams are minable within the entire area. The 3–1 coal seam has been determined to be stable. This seam has a thickness ranging from 3.09 to 7.00 m, with an average thickness of 5.74 m. The thickness increases gradually from north to south. The roof of the haulage roadway, and the return airway of the #311103 working face, was determined to be comprised of sandy mudstone measuring approximately 12.2 m; medium-grain sandstone measuring approximately 12.96 m; fine sandstone measuring approximately 3.74 m; and medium-grain sandstone measuring approximately 13.45 m, respectively. The stratigraphic structure of the areas is shown

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Column shape	Rock types	Thickness (m)	Lithological description
	Medium grain sandstone	13.45	Pale grayish white, mainly quartz, with cuttings and mica
	Fine grain sandstone	3.74	Pale, wavy bedding, with cuttings and mica
	Medium grain sandstone	12.96	Pale grayish white, mainly quartz, with cuttings and mica
	Sandy mudstone	12.2	Dark gray, uniform with sand, flat fracture
	3-1 coal	5.74	Black, dark coal containing silk carbon
	Sandy mudstone	6.75	Dark gray, uniform with sand, flat fracture

Development of new surface blast design models

The data collection activities described above were the initial source for empirical data sets needed to develop the proposed new surface-blast design models. As described below, substantial data are available for each blast site. For the pre-blast stage: GPR 3D rock mass data, mine model geological information, blast-hole drill data from the drill monitoring system, and geotechnical properties of the intact rock together with ore content. Blast data: physical characteristics of each drill hole (diameter, location, depth, etc.), amount and type of explosive in each hole, timing patterns, and video tape of the blast itself. For the post-blast stage: rock-mass characteristics (size distribution, particle shapes, etc.) across the blast area, shape of blast pile, and other properties deemed useful. The first step was to use multivariate statistical techniques to help identify important relationships between pre-blast, post-blast and actual blast design parameters. Then, using these initially identified relationships, and knowledge of existing blasting theory, empirical blast-design models are being developed. We propose to investigate several modeling approaches including neural networks (ability to develop mappings between input conditions and output parameters in complex environments) and fuzzy logic. Fuzzy-logic-based systems are well suited for making design decisions with imprecise, incomplete and uncertain information.

Data Acquisition:

The normal sampling rate of the MWD acquisition system used was increased from approximately 5 Hz to 15 Hz during the trial. As there is more than one channel for data acquisition, the actual acquisition rate per channel is about 2 Hz per channel. Data was recorded directly into a laptop computer on the drilling rig because the higher sampling rate generated larger files than normal and the radio system at the mine site was already close to its maximum capacity. Substantially lower overall dimensions and metal capacity absence on additional chains old energy transforming from one kind to another absence to oil station and systems to hydraulic energy iiansmitting are the factoids ensuring impact machines with electromagnetic motor competitiveness in companion with hydraulic impact machines especially in had natural conditions.

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Analysis of the Influence Scope of the Deep-Hole Blasting in Hard Roof

The deep-hole blasting of the roof was required to produce an increased number of cracks around the blast holes. These cracks needed to penetrate between the adjacent blast holes in order to weaken the roof areas. Then, by simultaneously considering the efficiency of the construction and economic factors, the crack zones generated by the adjacent blast holes were required to be in tangent with each other. The expressions of the blastholes intervals obtained from the Mises criterion were as follows

$$d = 2r_{\mathrm{b}}\left(\frac{\sqrt{2}\sigma_{\mathrm{R}}B}{2\sigma_{\mathrm{td}}}\right)^{1/\beta}\left(\frac{\sqrt{2}\rho_0 D^2 n k^{-2\gamma} l_{\mathrm{e}} B}{16\sigma_{\mathrm{cd}}}\right)^{1/\alpha},$$

$$\begin{cases} \alpha = \dfrac{2-\mu_{\mathrm{d}}}{1-\mu_{\mathrm{d}}}, \\ \beta = \dfrac{2-3\mu_{\mathrm{d}}}{1-\mu_{\mathrm{d}}}, \\ b = \dfrac{u_{\mathrm{d}}}{1-u_{\mathrm{d}}}, \\ B = \sqrt{(1+b^2)+(1+b)^2-2\mu_{\mathrm{d}}(1-\mu_{\mathrm{d}})(1-b)^2}, \end{cases}$$

where d denotes the blasthole intervals, m; σ_R is the radial stress on the interface between the crushing zone and the crack zone; represent the density of the explosives and rock mass, respectively, kg/m^3; is the explosive velocity, m/s; denotes the longitudinal wave velocity, m/s; is the dynamic tensile strength of rock, MPa; represents the load transmission attenuation index; is the stress wave attenuation index; is the dynamic uniaxial tensile strength of rock, MPa; is the lateral stress coefficient; denotes the rock dynamic Poisson's ratio, ; represents the radius of the blast hole; denotes the property parameters of the explosives; represents the decoupling coefficient; is the adiabatic coefficient of the detonation products, which was generally set to 3; represents the charge axial coefficient; and is the increment coefficient of the expanding detonation product colliding with the hole wall, which was generally set to 10.

According to the data of the Bayangaole Mine's working face, the density of the medium-grain sandstone was 2,130.8 kg/m^3; was set to 3,300 m/s in the rock stratum; was set to 0.178; and was set to 0.126. The dynamic tensile strength of blasting changed slightly with the loading strain rate, and was set to 2.852 MPa. The dynamic compressive strength of the blasting varied with the loading strain rate, where in this research study. Also, adopted a continuous charge with. The parameter values were substituted into formula (5), and the crack zones were tangent with each other when the blasthole interval was 10.055 m.

METHODOLOGY

Driving Speed

After blasting, because the macroscopic fracture of rock mass and micro blasting damage, integrity of rock mass is damaged; it is advantageous to the comprehensive machine cutting. According to field observations, the overall advance has increased greatly than before blasting, it is can realizes cutting 1.0 to 1.2 m per 8 hours, meets the requirements of the first support; increased by 40 % to 50%. The working face can be divided into two areas:

1) Poor blasting effect area: area of blocking section (with no explosive) and away from hole area (main upper part of roadway and surrounding). In such area, cracks

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developed poor; there is no obvious change for cutting. But the poor blasting effect is verified influence of large diameter deep hole blasting to surrounding rock is finite, it is better for surrounding rock of roadway stability.

2) Good blasting effect area: the main area is nearby the hole of charging section 1.0 m or so, slightly bigger than the fracture zone, it is mainly caused by stress wave, the stress wave making a certain degree of damage in rock mass. Within the area, comprehensive machine cutting rock mass fall down as a pack rock, and with suitable speed.

Cutter Consumption

Like the driving speed, cutter consumption is larger in area of blocking section and away from the hole; within the scope of blasting damage, because of the existence of crack and damage, rock mass strength is reduced, cutter consumption is also significantly reduced. During the whole test, cutter average consumption is 6.27and 6.44 per meter, save as much as 27.3%. Where, the average value is 7.9 with 8.86 per meter in poor effect section, and in charged section, cutter consumption average value is 4.92 and 4.42 per meter. Excluding blocking section, the cutter consumption is reduced by 52.4%.

At the same time, the rock mass integrity are destroyed, massive dirt by comprehensive machine, the efficiency of loading improved, and also avoid the powder mixed with water forming mud, brings convenience for construction and transportation of dirt; and also reduce dust production at some extent, improve work environment of working face.

CONCLUSION

Using large diameter deep hole blasting, increases cracks of rock mass and damage its integrity, decreases the difficulty of comprehensive machine cutting. Evaluated blasting effect by three indicators: borehole camera observation before and after blasting, driving speed, and cutter consumption. Obtained main conclusions as following: 1) Using of large diameter deep hole blasting can improve the efficiency of comprehensive machine construction in hard rock section, bring good economic benefits. 2) By blasting field test, comprehensive machine cutting speed increased by 40% to 50%, cutter consumption reduced by 52.4%, and improved the construction environment. 3) Blasting field test results successfully proved that blasting parameter is reasonable: blasting hole diameter is 75 mm, charge diameter is 63 mm and 1400 mm as hole spacing. Strict and careful construction is the key to success of large diameter deep hole blasting. 4) Borehole camera observation results before and after blasting show that effect of blocking section is poor, total length blasting of hard rock section

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is suitable, for reduces blocking length and improves the blasting effect.

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