Studying the reasonable roadway layout under the condition of high stress soft rock

Ping Song [1, a *] , Jingli Zhao [1, b] ,Ting Xue[1, c]

1.Faculty of Resources & Safety Engineering, China University of Mining & Technology (Beijing), Beijing 100083, China

[a]spcumtb@163.com , [b]zjl62331941@sina.com, [c]124208291@qq.com,

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Abstract. During mining the high stress soft coal seam, usually adopted traditional method should leave large width coal pillar, which cause severe loss of coal resources, at the same time due to the system stiffness of the high stress soft rock roadway surrounding rock is very low, the plastic deformation is severe, which lead to roadway becomes it difficult to excavation and maintenance. However, when adopted stagger arrangement mining method can solve these problem. This paper combined with actual mining situation of 2 # high stress soft rock coal seam of Shanxi coking coal Fen-xi mine mining group, through theoretical analysis and numerical simulation method to detailed research and analysis. Stagger arrangement roadway layout adopt clever and reasonable layout of roadway, which avoid the influence of high stress soft rock, the excavation and maintenance of roadway becomes very easy. Compared with the traditional layout of roadway mining method, stagger arrangement can improve condition of roadway surrounding rock, reduce the effects of high stress level, improve the production rate and high security, etc. it has certain reference and application value for coal mining with the similar conditions.

Introduction

The mine of Shanxi province Fen-xi group 2# coal seam is near level coal seam, average thickness is 2.2m, the length of working face is 165m, coal 2# mining with high stress soft rock characteristics, in the process of mining roadway excavation, maintenance becomes very difficulty, also due to leaving large section coal pillar, working face coal recovery rate becomes very low. The contradiction between safety, economic investment and the rate of recovery is outstanding. Therefore, research the reasonable arrangement of roadway position in 2# coal seam has become one of the main problems which restricting the development of the mine.

In the traditional layout of roadway, coal pillar is always designed between sections to protect roadway, namely between the adjacent working face left a certain width of coal pillar, so that roadway of the connecting face can avoid the influence of peak value of abutment pressure[1]. As coal far from the working face, which by one-way bearing transit to three-way bearing, due to restrictions on the strength of coal seam, in a certain range of coal pillar which will appear plastic zone and fractured zone, in accordance with the conditions of limit equilibrium analysis, the mechanical model is shown in Figure 1.

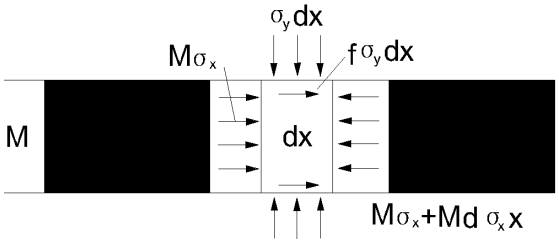


Fig.1 The sketch map of mechanics model of entity coal limit equilibrium conditions

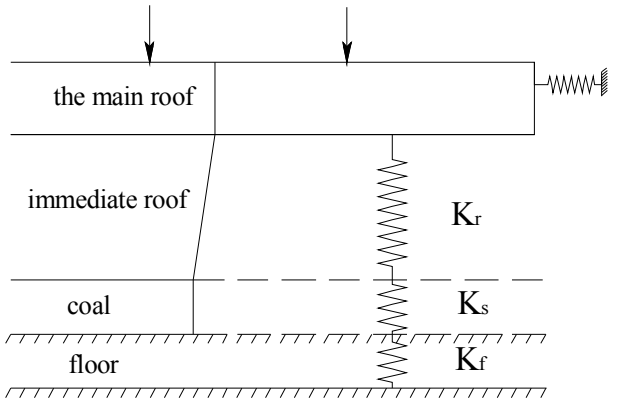


Fig.2 System stiffness model of bracket t and surrounding rock

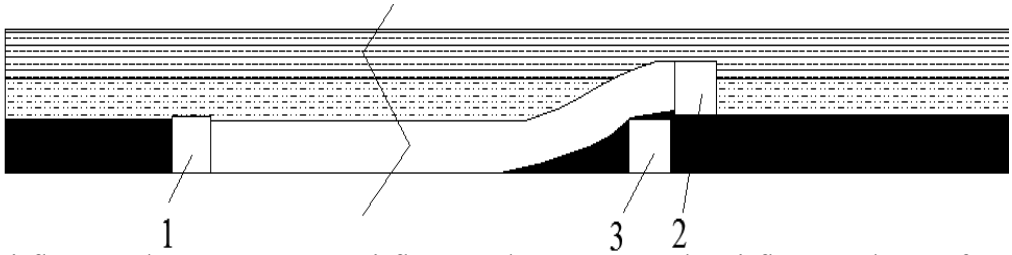
The system of bracket and surrounding rock of stiffness K which is determined by the stiffness of the direct roof and the stiffness of the bracket[2], which as shown in Figure 2.

$$K = \frac{K_r K_s}{K_r + K_s} \tag{1}$$

considering the 2# practical coal seam geological conditions and other factors, in order to ensure the integrity and stability of surrounding rock of roadway, the field should adopt method which leaving 50m coal pillar, resulting resources serious loss in mining area. Meanwhile, due to the coal 2# is soft rock, the system stiffness is low, in order to meet the production requirements and control the deformation of surrounding rock of roadway, which should provide greater resistance, only by increasing the density of support to ensure the production requirements, roadway support cost will be higher.

Theoretical analysis

The system of Stagger arrangement roadway layout was invented by professor Jingli Zhao of China University of Mining and Technology (Beijing) and authorized the national invention patent[3], this new method has been promoted and used in many mining areas. With consideration of 2 # coal seam of soft rock mining, we decided to adopt this new method, which as shown in Figure 3.



1- intake airflow roadway 2- return airflow roadway 3- Intake airflow roadway of continue working face

Fig.3 the system diagram of 2# coal seam stagger roadway layout

Intake airflow roadway of first mining working face is still soft rock roadway with high stress, so the support scheme still use the original support way, which as shown in Figure 4.

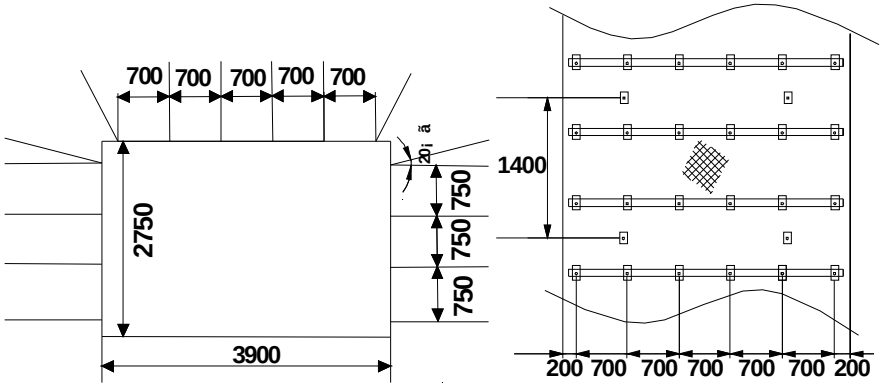


Fig. 4 Support schematic diagram of intake airflow roadway of the first mining face

Return airflow roadway 2 lay in the roof strata of coal seam, the position of the tunnel top about 0.9m has been in the main roof fine sandstone, the stability of which is better, so it can be think that the surrounding rock of return airflow roadway is no longer belongs to soft rock, during the excavation and maintenance do not need too much support investment. Therefore, through the engineering analogy and carries on the optimization to design the supporting scheme, in terms of average anchoring force 150kn, the roof bolt spacing according to 0.95m * 0.95m layout.

Intake airflow roadway of stagger arrangement connection section working face which layout along goaf stress reducing area of the first working face, during the first working face mining needs laying of artificial roof, or the formation of regenerated roof, therefore, roadway no long belongs to soft rock. The load above the roadway due to the weight of the rock mass of goaf areas collapse, average load of roadway at the top of the unit area[4-5]:

$$\sigma = \frac{p}{b} = \frac{1}{2}\frac{\{[a \times tgd] + [(b+a) \times tgd]\}}{b} g \tag{2}$$

b—the width of roadway , m ; a—the distance of the stagger between up and down section roadway , m ; δ—overlying strata caving angle of mined out area ; γ—average volume force of falling gangue of mined out area,kN/m^3.

After calculation, the maximum load of section intake airflow roadway of continuous working face under the goaf is only 117 kN, which can use the U-shaped shed with the metal net, the main work is to maintain gangue don't appear leakage.

Numerical simulation

Adopted stagger arrangement roadway layout in coal seam of high stress soft rock which formed three types of roadway, only intake airflow roadway of the first working face is soft, the maximum stress is 33Mpa and stress concentration factor K= 4.1. Return airflow roadway of the first working face and intake airflow roadway of continue working face get rid of the influence of the soft rock, and the intake airflow roadway of continue working face below goaf which is stress reducing area, perimeter maximum stress is 4.5Mpa, the stress concentration factor K = 0.6.

Seen from the Figure 5 and Figure 6, during the mining of the three types of roadway, maximal roadway deformation is high stress soft rock roadway, the least roadway deformation is low load of roadway, the cumulative amount of the two sides of roadway and roof and floor is 56mm and 82 mm, deformation of roadway is minimum, which can be thought of basic no deformation.

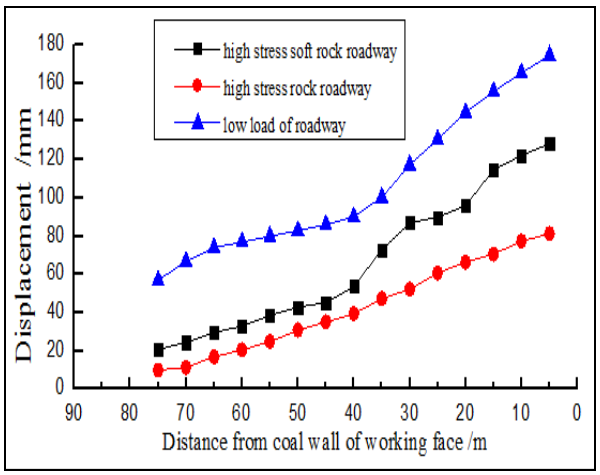


Fig.5 The displacement of two sides roadway

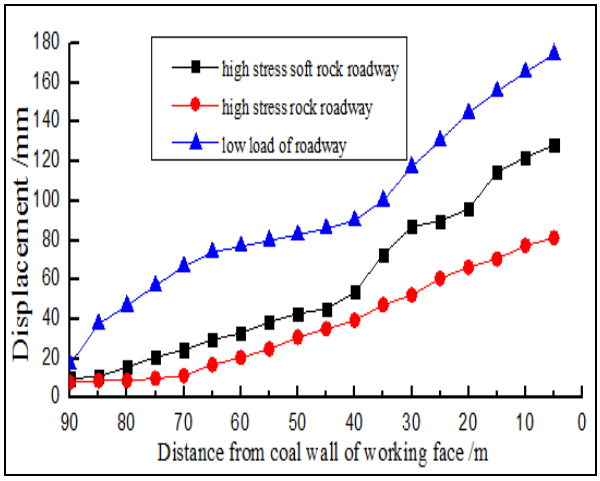


Fig.6 The displacement of roof and floor

Conclusion

a) When mining high stress soft coal seam, used the traditional mining method should leave a certain width of coal pillar, which cause severe loss of coal resources, and the stiffness of the system is very low, the roadway becomes very difficult to excavation and maintenance, however, stagger arrangement roadway layout can success solve these problem.

b) Compared with the traditional arrangement, the stagger arrangement roadway layout produces the new mechanism of roadway layout, through the reasonable arrangement of roadway layout, return airflow roadway and intake airflow roadway of continue working face can avoid the influence of high stress soft rock.

c) Stagger arrangement roadway layout which have good coordination of roadway excavation, maintenance and recovery rate without significantly increased economic investment, improved the safety, economy and reliability, and achieved successful mining under high stress soft coal seam, which has a certain reference significance and promotion value to the coal seam under high stress soft rock.

References

[1] JIANG Yao-dong, LIU Wen-gang, ZHAO Yi-xin, etal. Study on surrounding rock stability of deep mining in kailuan mining group [J]. Chinese Journal of Rock Mechanics and Engineering, 2005,24(6):1857-1862.

[2] LI Gang, LIANG Bing, ZHANG Guo-hua .Deformation features of roadway in highly stressed soft rock and design of supporting parameters [J].Journal of Mining & Safety Engineering 2009,26(2):183-186.

[3] ZHAO Jing-li. The three-step extraction process of thick coal seam mining[P]. Chinese patent: 2004100395750.2009

[4] WANG Zhi-qiang. Research on strata pressure laws working face lapped each other of the stagger arrangement roadway layouts in thick coal seams [D], China University of Mining & Technology (Beijing),2009.

[5] WANG Qi-sheng Study on support technology and ground pressure behavior of deep soft rock tunnel[D],Changsha, Central South University, 2008.