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The Application of Flac3d Numerical Simulation Software to Determine the Reasonable Width of the Section Coal Pillar

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Abstract. Currently, a lot of coal mines select section pillar based on experience, which is unfavorable for reasonable and full utilization of resources and may cause potential safety hazard. For economic benefits and mine safety, we used flac3d numerical simulation method to select a reasonable width of coal pillars at Yujialiang coal mine. At present, pillar width of the retained section is 15m at Yujialiang coal mine. Numerical simulation study was made in the haulageway of working face section (No. 43304) and return airway of working face section (No. 43304). For numerical simulation, three schemes were designed in total. Pillar width of simulation sections was 20m, 15m and 10m respectively and pillar plastic zone scope and abutment pressure change law in the primary and secondary mining situations was simulated respectively. Section pillar width was determined properly by pillar plastic zone scope and abutment pressure change. We have drew a conclusion, the proper section pillar width is 10.5m, which provides theoretical basis for selection of section pillar width at Yujialiang coal mine in the future.

Keywords: Section coal pillar; Flac3d numerical simulation software; Mine safety

1. Introduction

Empirical method has been taken by many domestic coal mines in the selection of section coal pillar width. This selection method is simple, but unscientific. It may not only result in waste of resources, but also with potential safety hazard. If the section coal pillar design is too large, it will result in waste of coal resources. While, if the section coal pillar design is too small, then safe mining will not be guaranteed. Reasonable selection of the width of section coal pillar is very important [1]. Numerical simulation method is to determine a reasonable width of section coal pillar by calculating and analyzing the deformation and stress of surrounding rock of roadway under different coal pillar widths using FEM calculation software. Among others, flac3d numerical simulation software has been used in engineering practice for a long time, and it has made some excellent application results [2].

2. The Stability of Section Coal Pillar

2.1. Selecting a Template

The width of a coal pillar is the major factor that affects the stability of coal pillar and the maintenance of workings. It determines the horizontal distance between the workings and the extraction space, and affects the impact of the bearing pressure caused by extraction on workings and the load of the coal pillar. The ultimate bearing capacity of a coal pillar depends not only on its boundary conditions and mechanical properties, but also on its geometric dimensions and shape [3].

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2.2. Conditions For Maintaining The Stability Of Section Coal Pillars

On one side of a section coal pillar is the extraction space, and on the other side the preparatory workings. The extraction space and the preparatory workings form their own plastically deformed zones at the two sides of chain pillars, and the widths of the plastic zones are X0 and X1 respectively, as shown in Fig.1. Therefore, the basic condition for maintaining the stability of section coal pillars is: the width of the elastic core, which is at the center of the coal pillar whose two sides are plastically deformed, should be not less than twice the height of the coal pillar. Hence, even a very narrow workings excavated in a coal pillar would cause redistribution of the coal pillar and reduction of the effective bearing area, resulting in a sharp decline in bearing capacity of the coal pillar [4]. Pillar width formula is shown in formula 1. Plastic deformation zone of coal pillar and stress distribution is shown in fig.1.

$$B=X_0+2M+X_1 \quad (1)$$

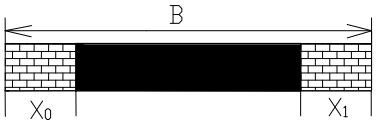


Fig 1. Pillar width diagram

3. The Numerical Simulation and Test of the Coal Pillar Size

3.1. Determination Of Pillar Width For Yujialiang Coal

At present, the stage coal pillar width at working face in Yujialiang Coal Mine is 15m; the numerical simulation research is selected at the transportation channel of 43304 working face stages and tailgate of 43305 working face stages. Length of the model is 270m, width is 250m, height is 50m, there are 41175 unit blocks, 45136nodes, and the numerical simulation model is as Figure2, 3. There are three programs designed for the numerical simulation, see Figure 3, widths of the stage coal pillar respectively are 20m, 15m and 10m, they are used respectively to simulate range of the coal pillar plastic zone and changing regularity of supporting pressure under the conditions of primary mining and secondary mining.

The mechanical parameter of coal and rock strata is shown in the table1.

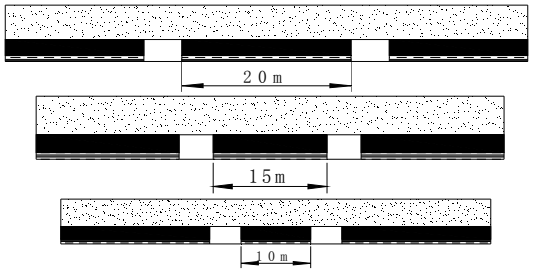


Fig 2. Numerical simulation of three scenarios

TABLE 1 Mechanical parameters of coal and rock strata

Name of coal and rock	Bulk density (Kg/m3)	Bulk modulus (Mpa)	Shear modulus (Mpa)	Tensile strength (Mpa)	internal friction angle (。)	Adhesion (Mpa)
main roof	2500	8000	4000	2.87	50	8
direct roof	2400	5000	2440	1.5	40	4
Coal	1300	2000	1000	0.7	30	1.1
direct floor	2400	5000	2440	1.5	40	4
main floor	2500	8600	5700	4	56	10

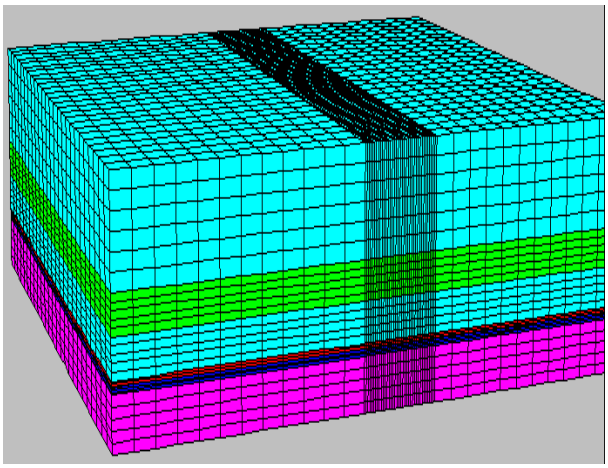


Fig 3. Numerical simulation model

3.2. The Changes Law Of The Plastic Damage

Fig.4 shows the damage to the plastic conditions of the rock around the roadways in different positions when the coal-mining is underway on the condition that width of the coal pillar is 20m. At working face 43304, when coal extraction goes along, that is when the roadway is affected by a round of coal-extracting, the negative supporting side of the transport trough 43304 reaches plastic condition within the limit of 0.6m, and the roof reaches plastic condition within the limit of 0.5m. The positive and negative supporting sides of the return air trough 43305 reach plastic condition within the limit of 0.5m, and the roof reaches plastic condition within the limit of 0.5m. This indicates that the damage here is smaller than that is done to the roof of transport trough 43304. In the position 10m ahead of the working face, the positive and negative supporting sides of the transport trough 43304 reach plastic condition within the limit of 0.7m, and the roof reaches plastic condition within the limit of 0.6m. The positive and negative supporting sides of the return air trough 43305 reach plastic condition within the limit of 0.6m, and the roof reaches plastic condition within the limit of 0.5m. This means that the damage here is smaller than that is done to the roof of transport trough 43304.

During extracting at 43305 working face, that is, when the channel is affected by the secondary mining, because 43304 transportation of down trough has been in the gob, we should analyze the destroyed situation of surrounding rock at 43305 return grooves. At the position of working face, the negative wall of 43305 return air trough can reach the plastic conditions within the range of 0.7m, and the positive wall can reach the plastic conditions within the range of 0.6m, the roof can reach the plastic conditions within the range of 0.7m; at 10m front of the working face, the negative wall of 43305 return groove can reach the plastic conditions within the range of 0.8m, and the positive wall can reach the plastic conditions within the range of 0.7m, the roof can reach the plastic conditions within the range of 0.8m, destroyed range of the surrounding rock is severer than that at the working face.

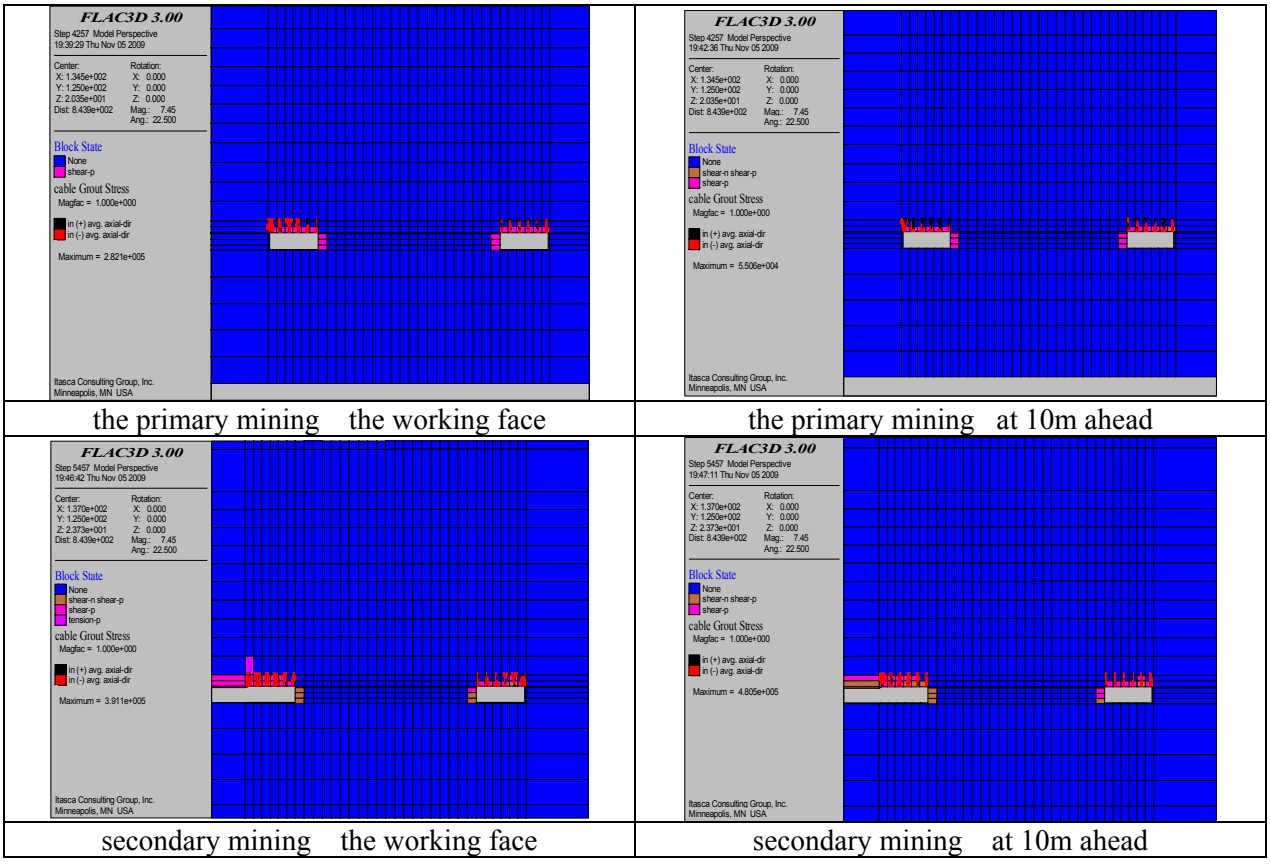


Figure 4 Different locations in roadway plastic failue figure when the width of the pillar is 20m under the influence of the mining

This method also in accordance with 15m, 10m pillar simulated results are as the table 2.

TABLE 2 UNDER DIFFERENT PILLAR WIDTH CONDITIONS, THE SCOPE CHANGES OF PLASTIC DAMAGE IN THE SECOND MINING

Pillar width /m	**Plastic deformation range m**			
	Mining side	**Pillar side**	**at the front 10m of Mining side**	**at the front 10m of Pillar side**
20	0.6	0.7	0.7	0.8
15	0.75	0.8	0.8	0.9
10	0.9	1	1	1.1

3.3. Rock Stress Changes In Coal Pillar

Stress changes in 20m coal pillar. Fig. 5 shows the vertical stress change under the influence of primary mining and secondary mining at working face and 10m ahead when the coal pillar width is 20m. After the primary mining, the bearing stress at the working face is maximal when 43304 transportation roadway side is 2m away from the wall, i.e. 7.7 MPa, and maximal when 43305 ventilation roadway side is 1.8m away from the wall, i.e. 7.3 Mpa; the bearing stress at 10m ahead is maximal when 43304 transportation roadway side is 1.7m away from the wall, i.e. 7.6 Mpa, and maximal when 43305 ventilation roadway side is 1.6m away from the wall, i.e. 7.2 Mpa. After the secondary mining, the bearing stress at the working face is maximal when 43304 transportation roadway side is 2.1m away from the wall, i.e. 11Mpa, and maximal when 43305 ventilation roadway side is 1.4m away from the wall, i.e. 9 Mpa; the bearing stress at 10m ahead is maximal when 43304 transportation roadway side is2.2m away from the wall, i.e. 11.1 Mpa, and maximal when 43305 ventilation roadway side is1m away from the wall, i.e. 9.2 Mpa.

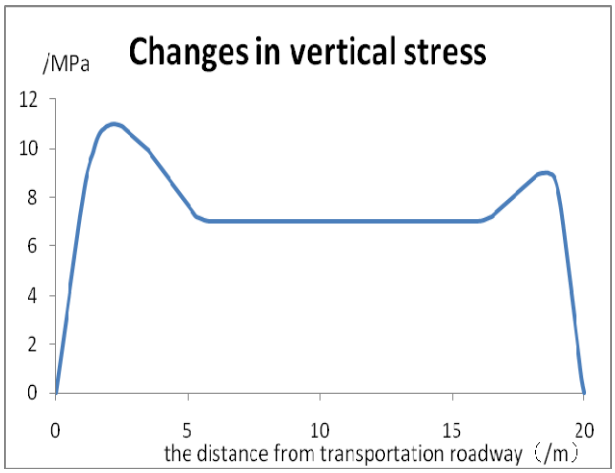
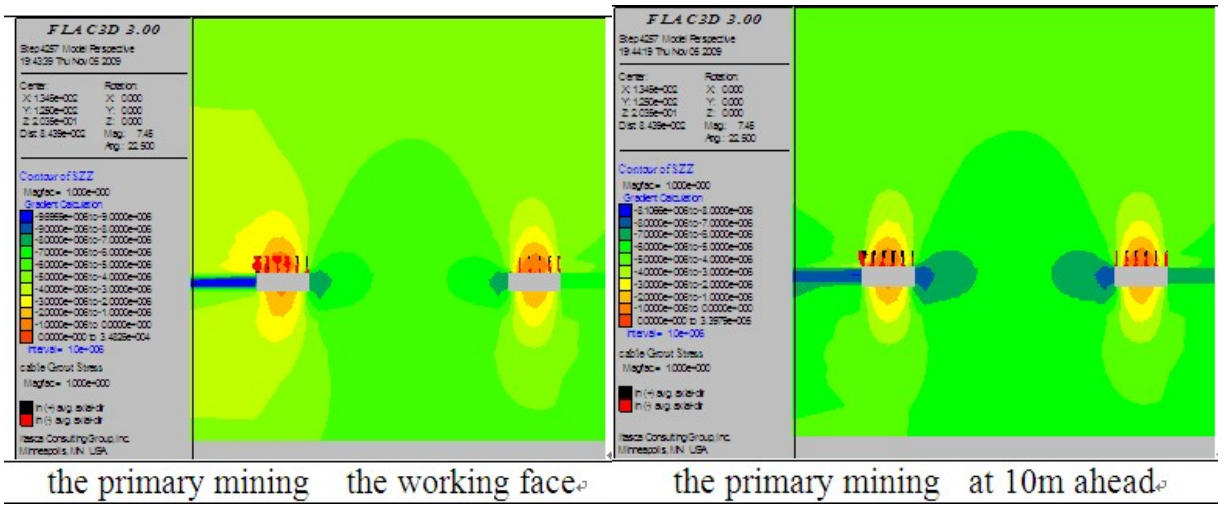


Figure 5 The vertical stress distribution of 20m pillar coal wall



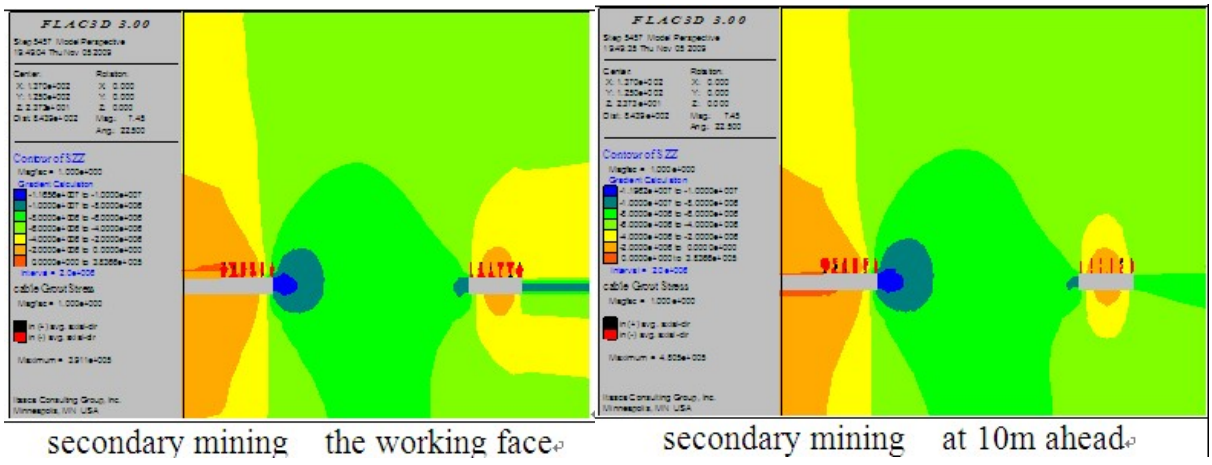


Figure 6 Vertical stress distribution at different position in the pillar under the influence by the mining when the pillar width is 20m

By the above method we have simulated 15m, 10m pillar.We get the plastic zone size under different Pillar and reasonable pillar width.

TABLE I. PLASTIC ZONE SIZE UNDER DIFFERENT PILLAR WIDTH AND REASONABLE PILLAR WIDTH

Pillar width /m	x_0 **/m**	H **/m**	**Reasonable pillar width /m**
20	2.1	1.85	10.5
15	2.6		
10	3.4		
Pillar width /m	x_0 **/m**	H **/m**	**Reasonable pillar width /m**
20	2.1	1.85	10.5
15	2.6		
10	3.4		

4.Conclusion

It is first time to determine a reasonable pillar width by simulating plastic zone and bearing stress through flac3d numerical simulation software.

The method of determination of width of coal pillars is improved in yujialiang coal by the Simulation.

The Simulation shows that rational coal pillar width is much smaller than the width of the current use of coal pillar.

Since the decrease of coal pillars,the imulation will make huge economic benefits for the yujialiang Coal mining.

The application of flac3d numerical simulation software will conducive to rational use of coal resources.

We can see from the table 3, the largest plastic failure is 3.4m. The coal seam thickness is 1.85m. Therefore, the reasonable width of coal pillar is 10.5m by the formula1. And, the width of the existing pillar is 15m. The 15m is unscientific and a waste of resources.

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6. References

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