Research on Stress Distribution and Safe Mining of Lower Layer Working Face Based on Resource Integration

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Research on Stress Distribution and Safe Mining of Lower Layer Working Face Based on Resource Integration

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Abstract. The use of small face mining mode in the upper stratification of Qudi Coal Mine leads to the imbalance of mining succession, in order to improve coal recovery rate and utilization rate, solve the problem of over-limit gas overrun, in the context of resource integration, combine two adjacent working face goafs into one large working face, ensure safe and efficient recovery of the remaining 24m coal pillar, through numerical simulation and on-site measurement, the variation law of stress in lower layer is studied. The results show: ZYP3200/17/28 hydraulic support can fully meet the roof support.Residual gas content and the gas-concentration in air-return laneway indicate that the 31012 mining face has eliminated the outstanding danger, safe, efficient and green mining has been realized.

1. Introduction

China's thick coal seam reserves account for 44% of total coal reserves [1], in an era when the technology was backward, many mines use layered mining technology with small working face mode, especially when using downdraft mining technology, will result in a change in the structure of the coal body in the lower stratified area [2-3], when mining stratified residual coal pillars, prone to stress concentration and difficult roadway maintenance, also increased the roadway digging task,easy to cause mining imbalance[4]. Therefore, in the context of resource integration, how to reduce the impact of residual coal pillars on mine safety production and improve resource utilization is particularly necessary [5].

2. 31012 Mining Face Overview

Qudi coal mine adopts downdraft mining method, the average thickness of coal seam is 5.6m, the lengths of the 31011 and 31031 working faces at the end of the mining are not more than 600m. The tendency length is 100～120m, this small working face mining mode is fast, the amount of roadway excavation is large, and the number of equipment movements is high, which eventually leads to serious imbalance in mine mining succession. To this end, according to the actual needs of mine production, a large 31012 mining face is arranged below the goaf of the 31011 and 31031 working faces, which are internally misplaced with the upper layer (Figure.1). The new 31012 mining face has a dip angle of coal seam 3～5º, the average thickness of the coal seam is 2.6m, the working face length is 540m, cut in length is 220m.

The two upper stratified working faces of 31011 and 31031 adopt "U+L" ventilation, equipped with a dedicated gas tail, in order to ensure that the gas concentration in the upper corner and the return air passage is not exceeded, 31011 gas tail road from 31031 working face (upper layer) return air duct 7m, distance 31011 working surface (upper layer) return air duct slot 17m, special discharge 31031, 31011 working face gas, see the gas tailgate layout Figure 1 shows.

After the upper layer is collected, a 24m wide protective coal pillar and a gas tailway are left in the middle of the 31012 working face. The upper layer mining results in redistribution of the stress in the mining area, and the ground stress generated by the coal-covered rock mass on the 31012 working surface It will mainly act on the coal pillar and generate stress concentration, which makes the mining pressure phenomenon of the lower layer working face complicated. Therefore, it is necessary to study the stress evolution law during the lower layer mining and the gas and roof management problems of the middle coal pillar [6-8].

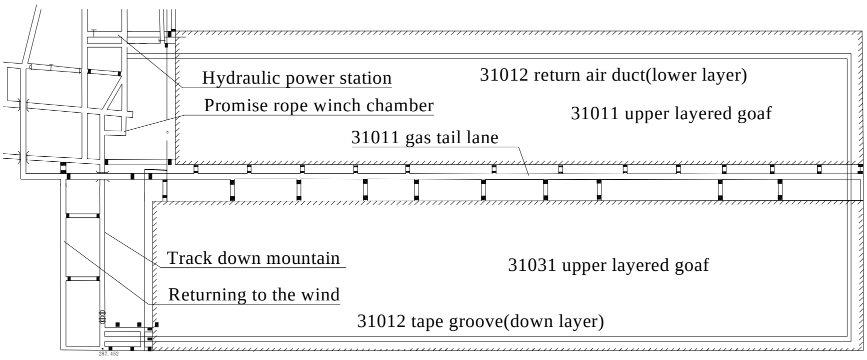


Figure 1. Schematic diagram of the layout of the 31012 mining face

3. Numerical simulation of stress distribution

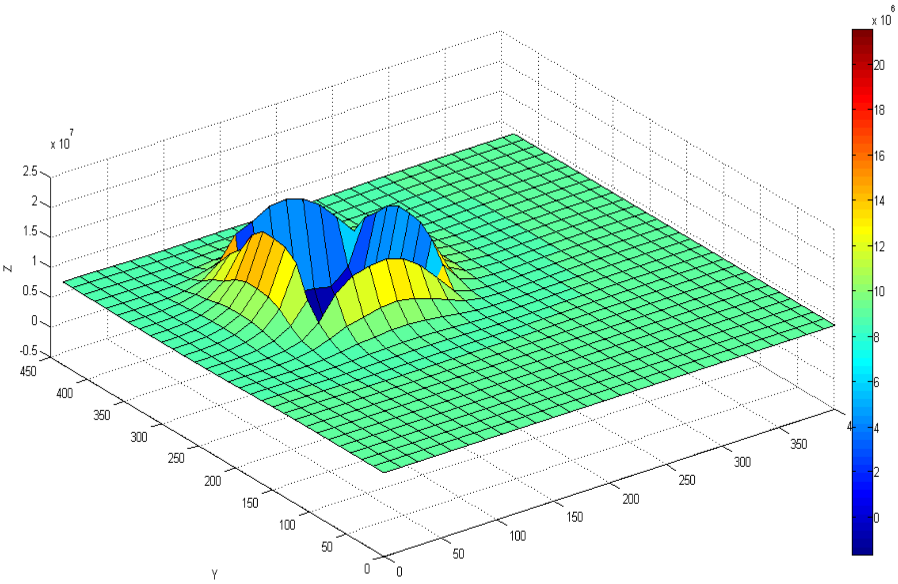
3.1. Establishment of Numerical Model

Using FLAC3D numerical simulation software to establish stress distribution model, apply 8MPa ground stress as the boundary condition in the upper part of the model, lower boundary is a fixed boundary condition,four-round rolling boundary condition, apply 5MPa stress buried depth 350m.

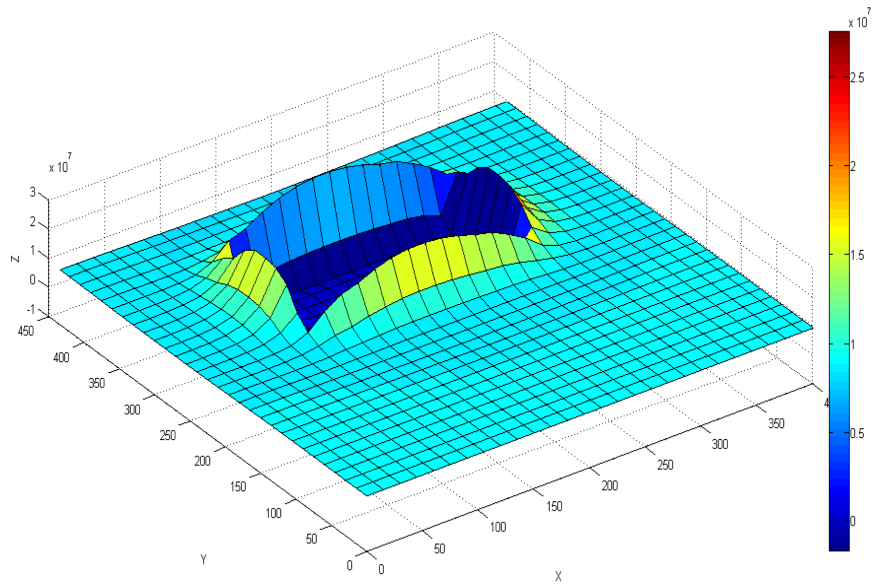
3.2. *Simulation Result Analysis*

The Hist command of FLAC3D is used to monitor the vertical stress (S_{zz}) and horizontal stress (S_{xx}, S_{yy}) of the 31011 and 31031 working faces, and a monitoring point is arranged every 15m along the X and Y directions. Drawing the monitoring data using Matlab's Surf function, the change of the lower layer S_{zz}, S_{xx}, S_{yy} is obtained. Since the variation law is the same, only the stress change in the S_{zz} direction is taken as an example for analysis.

It can be seen from Figure. 2~3that after the mining of 31011 and 31031 working faces, the pressure relief zone, the stress concentration zone and the original stress zone appear in the lower layer. When the 31011 working face is recovered, the stress concentration phenomenon appears in the coal pillar area, and the stress concentration area increases with the increase of the mining distance.After the mining of 31011 working face, the concentrated stress in the coal pillar area reaches 20MPa.When mining 31031 working face, due to the superposition of stress concentration, the stress concentration factor of coal pillar area is obviously increased, which is several times of the stress concentration factor when only one working face is mined, indicating that the mining of the second upper stratified working face is intensified. Stress concentration in the layered coal column area, the pressure in the stress concentration area reaches 35MPa.



(a)Excavation 100m



(b)Excavation 200m

Figure 2. Vertical stress distribution of the lower layer when the working face of 31011 is excavated at 100m and 200m

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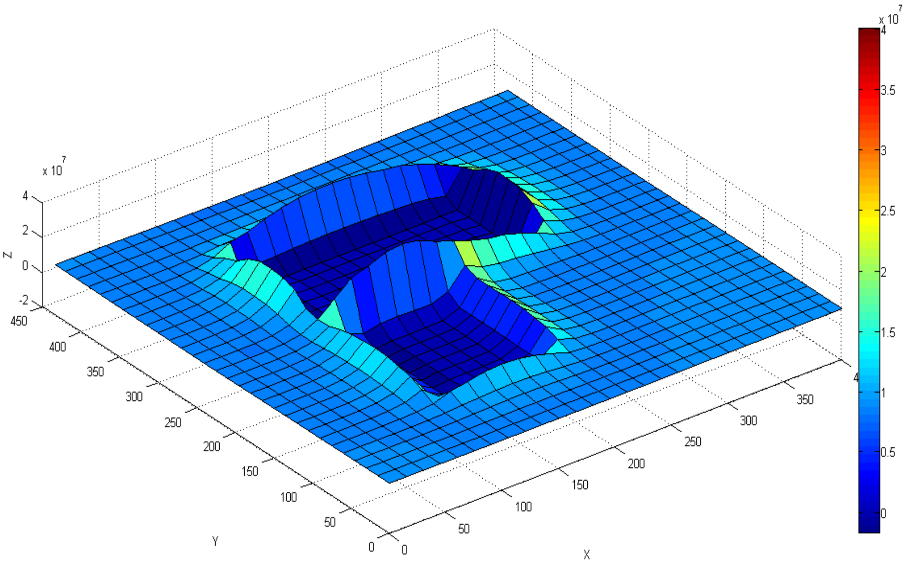
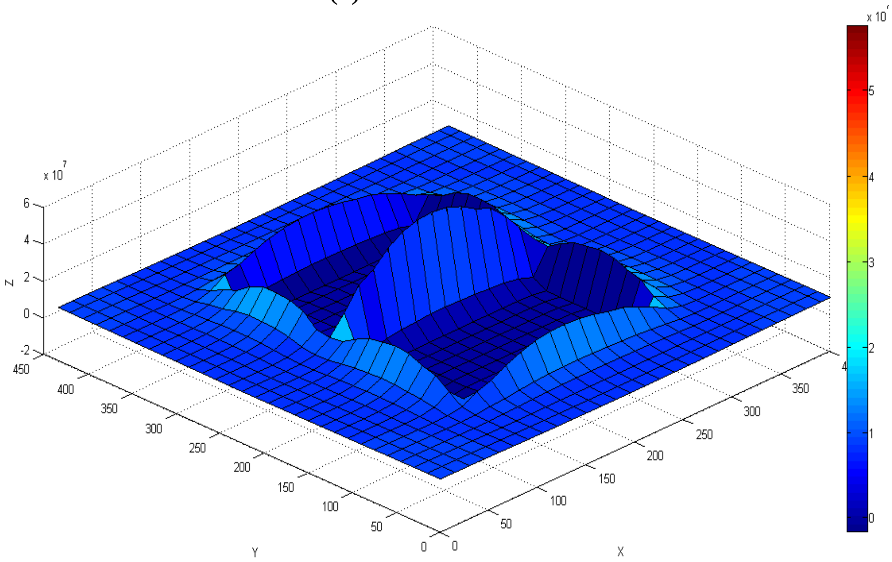


(a)Excavation 100m



(b)Excavation 200m

Figure 3. Vertical stress distribution of downward slicing with the 31031 workface being excavated 100m and 200m

3.3. *Roof Management*

(1)After the upper layer is harvested, the stress is redistributed, and the lateral bearing pressure is formed in the coal bodies on both sides of the goaf, resulting in poor integrity of the coal on both sides. Therefore, the method of moving the front drum is adopted at the scene. Ensure that the bracket has a high support.

(2)Roof management under the gas tail lane. The top plate below the gas tail lane is filled with high water material, and the roof is highly stable. According to the theory of mine pressure [9], roof rock mass with a pressure of 4 to 8 times the working face support, which is:

$$P = 8\rho ghlb = 2904 \tag{1}$$

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Where is the support strength required to cover 8 times of high rock on the working surface,KN; ρ is rock density,t/m^3,take2.5; g is the acceleration of gravity,take 9.8m/s^2; l is the maximum control top distance of the working surface, take 3.8m;b is the support width, 1.5m.

According to the above calculation results, the ZYP3200/17/28 hydraulic support is selected, which can fully support the top plate of the 31012 mining face.

4. Engineering Practice

In the 31012 mining face, the track is arranged along the slot and the transport slot. Tape along the groove is arranged at 40m and 80m away from the open-off cut No.1 and No. 2 measuring point. The orbital gateway is arranged at 40m and 80m away from the open-off cut No.3 and No. 4 measuring point. The stress monitoring device is installed at each measuring point, and the observation values of measuring points 1 to 4 are shown in Figure. 4.

From the analysis of Figure 4, the stress distribution characteristics of coal seam in 31012 mining face: The stress of the coal body on the side of the track is generally higher than the stress of the coal body on the side of the transport groove, The variation of the stress distribution measured by the four measuring points is basically the same. The stress of the track along the working face can reach up to 21Mpa, and the maximum of the transport groove can reach about 16Mpa, that is, the peak value of the track groove is greater than the transport pass.

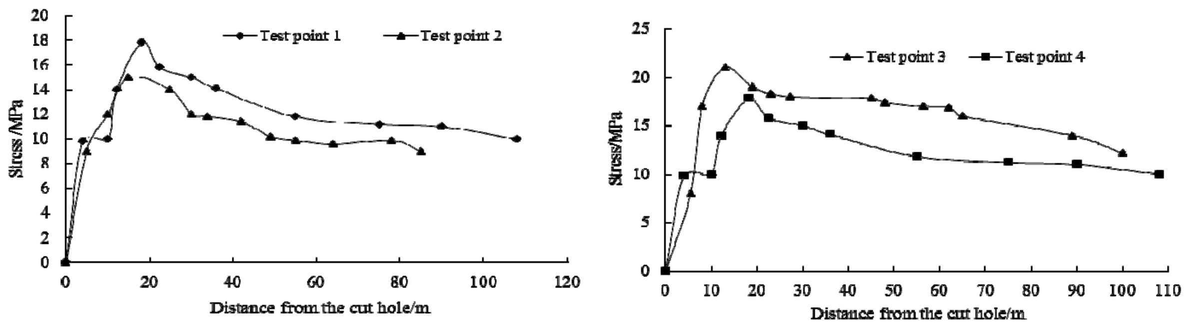

Figure 4. Stress distribution curve along the working surface

5. Lower Layer Security Recovery

5.1. Residual Gas Content Determination

The gas content in the remaining coal pillars in the central part of the 31012 mining face may be higher, Therefore, the residual gas content test point is arranged on the working surface, and one test point is arranged every 25m along the working surface. The residual gas volume test results are shown in Table 1.The measured maximum residual gas content is 5.77m^3/t, far below the threshold is 8m^3/t.

Table 1. Residual gas content test results

Distance from cut to eye/m	Residual gas content/m^3/t	Distance from cut to eye /m	Residual gas content /m^3/t	Distance from cut to eye /m	Residual gas content /m^3/t
30m	3.2	200m	5.04	380m	4.5
50m	4.63	230m	4.35	400m	5.13
80m	3.4	250m	5.58	430m	4.58
100m	4.52	280m	4.76	450m	5.1
130m	4.43	300m	5.77	480m	4.87
150m	4.46	330m	4.21	500m	4.89
180m	4.1	350m	5.2	530m	4.48

5.2. Investigation on Gas Control Effect in Working Face Mining Process

During the mining of the 31012 working face from May 1 to July 31, 2014, the gas concentration of the return air flow was counted. The results are shown in Figure 5.

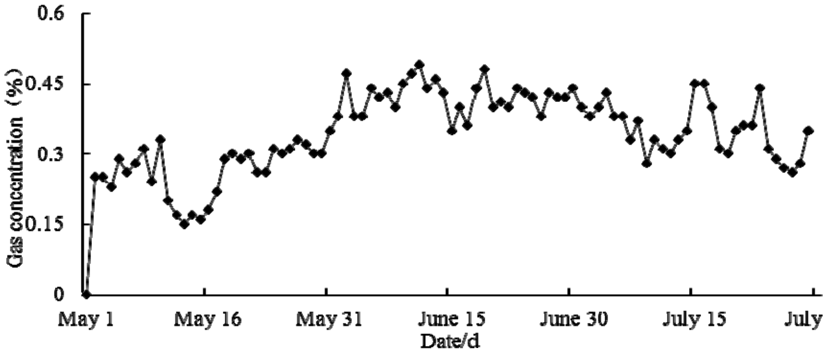

Figure 5. Gas concentration variation curve of returning face

The statistical results show that the return airflow gas concentration is 0.15～0.49%, less than 1%, visible, the gas control effect in the coal pillar area of the 31012 mining face is better.

6. Conclusion

In this paper, the combination of field test, theoretical analysis and numerical simulation is used to study the high-efficiency and safe mining technology under the thick coal seam of Qudi coal mine. The conclusions are as follows:

(1) According to the special formation of 31012 working face, it is analyzed that the gas and roof management in the coal pillar area during the mining process is the biggest safety hazard.

(2) Using FLAC3D numerical simulation software, the stress distribution law of the lower layer is analyzed. After the mining of 31011 working face, the concentrated stress of the coal pillar area reaches 20MPa.The stress concentration factor of the coal pillar in the 31012 working face is several times the stress concentration factor when only one working face is mined, indicating that the mining of the second upper stratified working face exacerbates the stress concentration in the lower stratified coal column.

(3) The residual gas content, the amount of cuttings, the gas desorption index of the drill cuttings and the gas concentration of the return air flow were measured at the site. All the indexes were less than the specified critical value, indicating that the gas control effect in the coal pillar area was better.

Acknowledgments

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