

Measurement and Analysis on Failure Height of Overburden Strata of mechanized sublevel caving in Shallow Region of Baodian Coal Mine

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Abstract

Baodian mine is gradually mining shallow area with thin bedrock, and failure height of overburden strata in shallow area has a certain difference from one of thick bedrock area. According to the measurement of “Two zones” in 5304-1 top slice face and 5304 mechanized sublevel caving face, the paper confirms the heights of caving zone and water flowing fractured zone. And then the heights are compared with forecasts of empirical formula. In the end development characteristics of strata damage is concluded.

Key words: Shallow area, Network parallel electrical method, Breakout images, Borehole flushing fluid consumption

1 Preface

For mining under loose aquifer, according to the relevant provisions of the coal mine safety, height of water

flowing fractured zone must be measured after coal is mined in order to obtain reliable height of “Two zones”(caving zone and water flowing fractured zone). Finally, the best mining section is designed to ensure coal mine safety production. Because water abundance above 5304 face is medium and the height of bedrock is only 51~87m, it is suitable for face “crack” high ground monitoring. By monitoring development rule of the proven mining face crack, the development data of “Two zones” is acquired in top slice face and mechanized sublevel caving face, and is compared with one in similar conditions in future, which provides the basis to waterproof pillar of mechanized sublevel caving face under similar strata.

2 General situation of working face

The Jurassic rocks on 5304 working face are denuded. Quaternary and the Permian Shanxi group are directly unconformable contact, quaternary thickness 198.26~215.76m, the group

aquifer thickness 31.76~44.84m, rich water from weak to moderate, belonging to the working face indirect water filling aquifers, quaternary bottom scattered. The thickness of 3rd coal roof sandstone aquifer on average is 32m, rich water medium, belonging to the porosity, fractured confined aquifer, the face direct water filling aquifers. According to the analysis of original data, the thickness between 3rd coal from roof and the bottom of the quaternary system thickness is 51~ 87m, cut at the most thinnest, the roof drilling columnar of 3rd coal as shown in table 1.

Table. 1 Condition of 3rd coal roof strata in 5304 face

Name of the rock	Thickness (m)	Distance from rock to top of 3rd coal (m)
Mudstone	4.15	47.47
Siltstone	5.1	43.32
Mudstone	0.6	38.22
2 coal	0.2	37.62
Siltstone	2.3	37.42
Medium-sandstone	28.42	35.12
Fine-conglomerate	3.9	6.7
Siltstone	1	2.8
Mudstone	1.8	0
3 coal	8.71	

The working face is placed in No.3 coal seam, black, the thickness ranges from 8.10 to 8.76m, with an average thickness of 8.40m, with dominated bright coal upper and dark coal lower, belonging to a semi-dark half-light coal,

stability seam thickness, stripe banded structure, layered structure, $f = 3.5$, seam dip angle $4\sim 15^\circ$, an average of 9° . The strike length of 5304 working face is 2436m, and the face length is 228m, and elevation of working face of coal seam floor is -208~-312m. Among, the mining height of 5304-1 top slice face is 2.8m, working face trend 409~416m long, tilt length 227m. The average coal thickness under the net mining of 5304-2 working face is 5.60m.

3 “Two zones” measured in 5304-1 top slice face

Electrical prospecting lines are arranged in the 5304 working face two belts in the borehole and transport gateway, and dynamically observe potential variation of different location and different elevation through the network parallel electrical instrument. And then Through 3 d electrical inversion method, the resistivity distribution between hole lane is got. Finally objective geological explanation of “Two zones” height growth rule is got, and the dynamic relationship between rock damage of detected coal and the process of mining has been studied further.

3.1 Detection method and construction

According to the research content and the actual situation of roadway, two monitoring drillings are designed In 5304 face transport lane and crosscut. 1# is located in crosscut, mining height 2.85m, which is layout cross-closing for line, and 2# is located in transport lane, mining height 2.90m, which is at the center of face, figure 1 is arrangement plan of two holes. Electrodes were both arranged in drilling and transport lane, and parallel electrical method is adopted to improve the way of data collection.

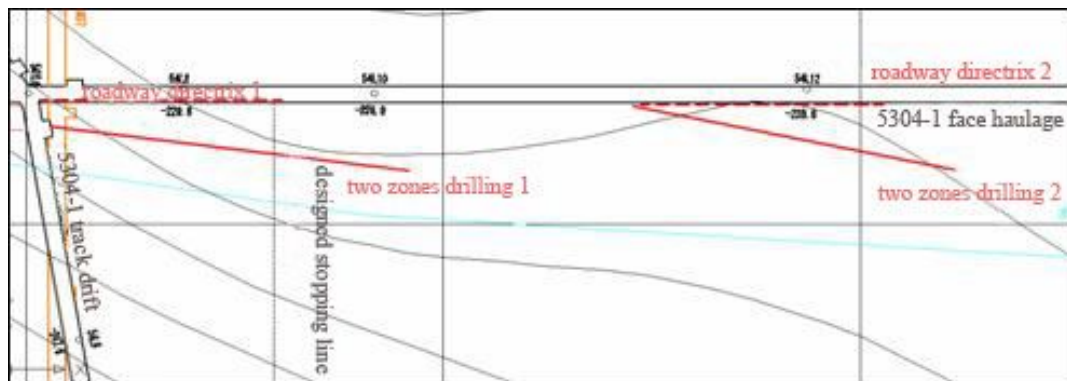


Fig. 1 Electrical method monitoring drilling plan

3.2 Data processing and analysis

With instrument software system decoding the collection of data, hole in the electrode and the electrode in the roadway are unified to the same coordinate system. According to the potential current changes, to perform lane hole resistivity inversion in full space. The inversion results with Surfer software mapping, then with Illustrator software stacking the figure of resistivity geological profile, to further explain. The eventual monitoring diagrams of 1# and 2# are shown in figure 2 and figure 3, where the blue tone is low resistivity value, the red tone is high resistivity value.

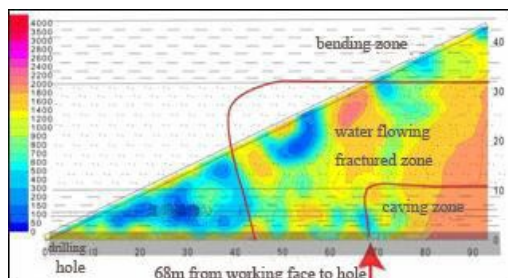


Fig. 2 Eventual monitoring diagram of 1# hole

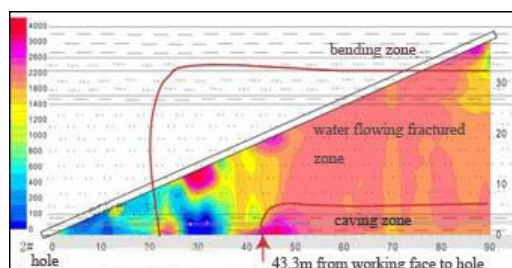


Fig. 3 Eventual monitoring diagram of 2# hole

The height of “two zones” in 1# hole: The caving zone, its height 10m and caving height ratio 3.45, is located in sand shale and thick sandstone layer interface. Fractured zone, its height 32m and crack production ratio is 11.23, is located in thick layers of sandstone and mudstone roof interface position. The height of “two zones” in 2# hole: The caving zone, its height 6.2m and caving height ratio 2.14, is near the thick mudstone and sandstone layer interface; Fractured zone, its height 32.5m and crack production ratio is 11.21, is located in the sandstone layer interface.

To be safe, it is determined that the maximum height of the overburden rock caving zone is 10m, the caving height ratio about 3.45, and the maximum height of the water flowing fractured zone is 32.5m, the crack production ratio is 11.21.

4 “Two zones” measured in 5304 mechanized sublevel caving face

In order to obtain related parameters of overburden deformation and failure after coal seam mining and to ensure the safety of the working face, roof failure characteristics and the development of the “Two zones” are studied in 5304 mechanized sublevel caving face. A drill, L 15, is decorated in the 5304-1 face to stop mining line to 50m from the gallery holes at 54m. Its ground level is 40.81 m, roof elevation 233.59 m and roof buried depth 274.40 m, and mining thickness of coal seam is 8.76 m, where thickness of bedrock is 60.35m. We carried on drilling core, and observed strata damage through the borehole flushing fluid consumption method and borehole imaging test in the drill. The development data of “Two zones” is judged from flushing fluid consumption method combined with borehole imaging test.

4.1 Flushing fluid consumption method

Rinses consumption is more volatility between $0\sim 1.50\text{m}^3/\text{h}$ in interval of $0\sim 223.86\text{m}$, which belongs to the normal consumption. Rinses consumption is volatility between $0\sim 0.36\text{m}^3/\text{h}$ in interval of $223.86\sim 237.69\text{m}$, which also belongs to the normal consumption. Consumption increase gradually up to $0.36\sim 5.40\text{m}^3/\text{h}$ in interval of $237.69\sim 243.40\text{m}$, while the consumption of borehole bedrock section is $0\sim 0.36\text{m}^3/\text{h}$ near the hole. When the drill was cored to 243.40m, the rinses

loss appeared for the first time, through which we reduced 243.40m was the beginning of water flowing fractured zone.

Combined the lithology, simple hydrology, digital logging and core crack development situation, we think fissure zone vertex depth of this hole is 243.20m, the elevation 202.39m, and its caving zone vertex depth is 256.23m, the elevation 215.42m.

In conclusion, the primary height of water flowing fractured zone height: $-202.39-(-233.59) = 31.20\text{m}$, and crack production ratio is 3.6. Caving zone height is: $-215.42-(-233.59) = 18.17\text{m}$, and caving height ratio is 2.1.

4.2 Drilling into imaging

A waterproof camera sensor with built-in light source is put into the L15 drilling and slow down uniform from 224m. A series of image of deformation and failure of different depth hole wall was got by making a video every 2m. After the three times borehole imaging of casing under the different depth of surrounding rock of hole wall, video screenshots on different depth were compared with indoors. According to the change of the drill hole wall rock structure crack, we got the deformation and failure of lithologic characteristics on different depth (as shown in Fig. 4, Fig. 5, Fig. 6, Fig. 7 Fig. 8, Fig. 9). In the end, the development levels of caving zone and water flowing fractured zone effected by mining are identified.

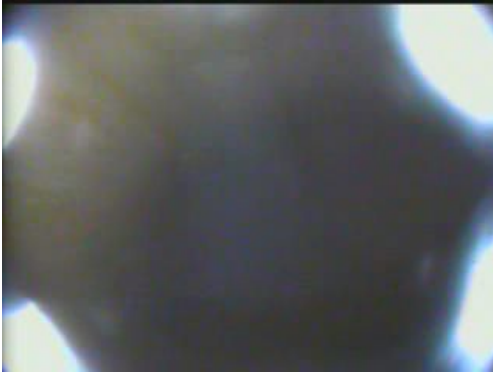


Fig. 4 Hole depth 224.0m (sleeve)



Fig. 5 Hole depth 228.0m(Almost complete)



Fig. 6 Hole depth 229.0m(Top of fractured zone)

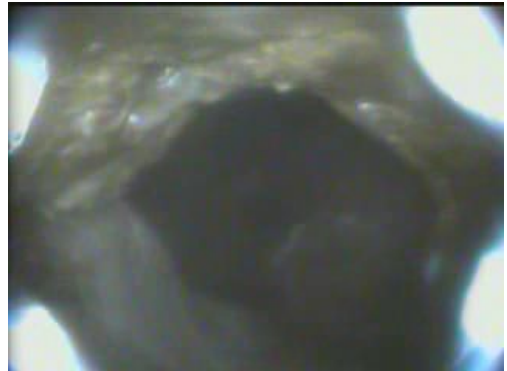


Fig. 7 Hole depth 230.0m(Broken obviously)



Fig. 8 Hole depth 255.8m(Fracture)



Fig. 9 Hole depth 256.0m(Top of caving zone, cavity)

Based on the comprehensive comparison and analysis of figure 4, the top of the water flowing fractured zone is about at 229m, the top of caving zone is about at 256 m, where the thickness of bedrock is about 280.7m. Through calculating, the height of water flowing fractured zone is 51.7m, and crack production ratio is 5.9. The height of

Caving zone is about 24.7m, and caving height ratio is 2.8.

4.3 Determination of damage height of overburden

The borehole imaging method lacks original rock hole wall video before mining, and drilling is deep and there is water at the bottom, and temperature difference in the camera sensor made

images not very clear in some depth, so there are no clear boundaries between the fractured zone and bend zone and between fracture zone and caving zone. So in order to determine the height of the "Two zones", the borehole imaging test must be compared with borehole flushing fluid consumption and core analysis. The boundaries between bend zone, water flowing fractured zone and caving zone are relatively obvious in Borehole flushing fluid consumption, simple hydrology and field lithology detection, and the strata damage reflected is almost the same. In the other hand, the error of borehole peep imaging test is bigger. So finally detection results of borehole flushing fluid consumption method is the height of "Two zones" of 5304 mechanized sublevel caving face, namely the height of water flowing fractured zone height is 31.20m, and crack

production ratio is 3.6, caving zone height is 18.17 m, and caving height ratio is 2.1.

5 The contrast analysis with the detection results and the empirical formula expectation

Reference the related rock mechanics test and rock sedimentary assemblage structure shows, the uniaxial compressive strength of the sandstone, siltstone and fine sandstone is 21.01~40.4Mpa, the uniaxial compressive strength of sandy mudstone, mudstone, sandstone and mudstone weathering is 10.2~15.7Mpa. So this can be based on the type of medium hard overburden calculation. The slice mining uses "three rules" formula, and mechanized sublevel caving face use Yanzhou mining experience formula, as shown in the table 2.

Table. 2 the "Two zones " height calculation formula^[1]

" Two zones " height	slice mining	mechanized sublevel caving
caving zone	$H_m = \frac{100 \sum M}{4.7 \sum M + 19} \pm 2.2$	$H_m = \frac{100 \sum M}{2.13 \sum M + 15.93} \pm 2.72$
water flowing fractured zone	$H_{Li} = \frac{100 \sum M}{1.6 \sum M + 3.6} \pm 5.6$	$H_{Li} = \frac{100 \sum M}{2.03 \sum M + 1.55} \pm 2.55$

2.8m, the mining height of top slice face, is substituted to Table 2, maximum heights of caving zone and the water flowing fractured zone are 8.70m and 34.65m. 8.76m, the mining height of mechanized sublevel caving face is substituted to Table 2, maximum heights of caving zone and the water flowing fractured zone are 25.33m and 45.31m.

The measured heights of caving zone and water flowing fractured zone in 5304-1 top slice face are 10m and 32.50m, which are relatively closed to experience formula expectation. And the measured heights of caving zone and

water flowing fractured zone in 5304 mechanized sublevel caving face are 18.17m and 31.20m, which are both less than experience formula expectation. This is because firstly the bedrock is thin in the 5304 face, where the development of caving zone and water flowing fractured zone is subject to certain inhibition, especially water flowing fractured zone. Secondly According to exposed situation of ground drill hole L5 and L6 above 5304 face, immediate roof and main roof are both weak rock, and especially weathering zone is mainly mudstone. The thickness of bedrock

weathering zone is 12.85m ~ 14.32m, in which the thickness of the strongly weathered zone is 5 ~ 7m. The oxidation degree of bedrock in 5304 face is higher, so strength of rock mechanics decreased obviously, and goaf overburden sink fast, and immediate roof bent down evenly and fast, and caving zone developed insufficiency. Because of weathered bedrock soft above caving zone, mining crack compacted quickly, so the height of crack in soft rock formation is smaller than ones in middle hard or hard rock strata. So the height of "Two zones" is slightly less than the empirical formula expectation.

6 Conclusion

The height of caving zone is 10m, caving height ratio 3.45, and the height of water flowing fractured zone is 32.50m, crack production ratio 11.21 in 5304-1 top slice face (mining height 2.8m) measured by the network parallel electrical method. Combined with borehole flushing fluid consumption, simple hydrology, field coring and drilling peep imaging, the height of caving zone is 18.17m, caving height ratio 2.1, and the height of water flowing fractured zone is 31.20m, crack production ratio 3.6 in 5304 mechanized sublevel caving face (mining height 8.76m). The study results could provide reference for the design of waterproof pillar of mechanized sublevel caving face

under similar strata.

7 References

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