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Research on Roof Caving Law of Huoerxinhe Coal Mine Fully Mechanized Mining Face

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Abstract: In order to master the roof collapse characteristics of the working face, through calculating each bed load, the first caving step distance, the periodic caving step distance and the other parameters of 3207 fully mechanized large cutting height face roof, analyzing periodic weighting of working face combining with the observed data, the roof caving process of 3207 fully mechanized large cutting height face is analyzed. The study of this article can provide a basis for mining pressure control and safety mining of 3207 fully mechanized large cutting height face.

Keywords Huoerxinhe coal mine, 3207 large mining height working face, Roof collapse, Periodic pressure.

INTRODUCTION

Shanxi Huoerxinhe coal mine is located in the Zhangzi county Changzhi city, and its area is about 71.3947 km^2. The No.3 coal seam which is the main production of this coal mine is located in the lower stratum of Shanxi formation, its dip angle is about 5°, and average thickness is 5.65m. The No.3 coal seam has the characteristics of thick in eastern part and thin in western part. The 3207 fully mechanized large cutting height face is about 220m in inclined direction and 1389m in trending direction, which belongs to flat seam, average thickness is 5.3m, and coefficient is 0.5~0.6. The immediate roof of this working face is charcoal mudstone, and its geological condition is complicated. According to roof classification standard of gently inclined coal seam working face (MT554-1996), the roof of 3207 working face belongs to soft and broken roof thickness coal seam. So, it is necessary to study characteristics of roof caving of 3207 fully mechanized large cutting height face in No.3 coal seam of Huoerxinhe coal mine in order to provide a basis for mining pressure control and safety mining of 3207 fully mechanized large cutting height face.

THEORETICAL ANALYSIS FOR ROOF ROCK LAYER CAVING LAW

Roof rock can be divided into immediate roof, basic roof and curve subsidence zone three parts according to the theory of roof structure.(1) Immediate roof is the rock formation which a layer or several layers above coal seam and have no self-supporting capability after self-broken. Immediate roof rock will fall along with face advance, and it also can form hanging arch structure sometimes. (2) Basic roof is the rock formation which Located on the top of immediate roof (or on the top of coal seam sometimes), thick and hard, has an immediate impact effect on working face after it broken and forms structure. The structure have some capability and balance rule, which have an effect on movement rule of overlying strata, mine pressure and control parameter of working face. (3) Curve subsidence zone present move as one basically and have no effect on workface support generally.

So, dropping characteristics of the roof rock layer adopted long-wall mining along strike and mechanical effect induced are a basis of surrounding rock control of working face. Along with working face advanced from the open-off cuts, each roof rock layers will bend and sink under the effect of mine pressure, the roof hanging distance of gob roof increase continuously and collapse when they reached ultimate strength. The way of large area caving from roof rock layer whether synchronous or hierarchy each time are determined by horizon, thickness, strength and size of load.

It is need to calculate the load of each rock stratum before calculating breakage length. Because of the difference of thickness and lithology of each roof layer, the load suffered from No.i layer can be calculated according to the following formula.

$$(q_n)_i = \frac{E_i h_i^{\,3}(\gamma_i h_i + \gamma_{i+1} h_{i+1} + \cdots + \gamma_{i+n} h_{i+n})}{E_i h_i^{\,3} + E_i h_i^{\,3} + \cdots + E_{i+n} h_{i+n}^{\,3}} \quad (1)$$

Where $(q_n)_i$ is the load from n layer upside to the i layer; $E_i \cdots E_{i+n}$ is elasticity modulus of each layer; $h_i \cdots h_{i+n}$ is thickness of each layer; $\gamma_i \cdots \gamma_{i+n}$ is unit weight of each layer; i=1,2,3…

When calculating $(q_{i+n-1})_i < (q_{i+n})_i$, $(q_{i+n})_i$ as the load applied to the i layer, the result of formula (1)

can be used to calculate breakage length as the load applied to the i layer this moment.

According to the beam theory, the first and periodic collapsing initially of the each roof layer can be calculated approximately as follows:

$$a_i = h_i\sqrt{\frac{2\sigma_{ti}}{(q_{i+n})_i}} \quad (2)$$

$$a_{ic} = h_i\sqrt{\frac{\sigma_{ti}}{3(q_{i+n})_i}} \quad (3)$$

Where a_i , a_{ic} is the first and periodic collapsing initially of the i layer; σ_{ti} is strength of extension of the i layer.

According to these formulas above, each rock formation caving synchronously or hierarchically can be confirmed as the following methods, the caving characteristics of face roof are like these: (1) when $a_i \geq a_{i+1}$, $a_i \geq a_{i+2}$,…, $a_i \geq a_{i+j}$, from the i+1 layer to the i+j layer are caving following the i layer(j=1,2,3…). (2) when $a_i < a_{i+j+1}$,the i+j+1 layer moves forward and collapses until reaches its ultimate strength. By that analogy, breakage length and thickness of stratum caving at the same time can be confirmed.

THE LOAD OF EACH ROCK FORMATION OF FACE ROOF

According to the distributing characteristics of 3207 working face, the structure of roof rock layer is complex, which is mainly made up of charcoal mudstone, sandy mudstone and sandstone, coal streak partly. The roof is made up of charcoal mudstone, sandy mudstone, coal seam, charcoal mudstone, siltstone and charcoal mudstone from bottom to up. Strata distribution and physical and mechanical feature of No.3 coal seam roof as Table 1 show.

Table 1 Strata distribution and physical and mechanical features of No.3 coal seam roof

No.	Roof rock layer	Thickness(m)	Poisson's ratio	Tensile strengt h(MPa)	Elasticity modulus(GPa)	Apparent density (kg/m^3)
1	charcoal mudstone	3.8	0.34	2.97	8.67	2236
2	sandy mudstone	3.6	0.31	2.88	13.8	2708
3	coal seam	1.0	0.32	0.1	2.97	1390
4	charcoal mudstone	1.0	0.34	2.97	8.67	2236
5	siltstone	3.4	0.34	3.14	27.6	2656
6	charcoal mudstone	0.5	0.34	2.97	8.67	2236
7	sandy mudstone	3.7	0.31	2.88	13.8	2708
8	coal streak	0.6	0.32	0.1	2.97	1390
9	sandy mudstone	4.4	0.31	2.88	13.8	2708
10	coal streak	0.4	0.32	0.1	2.97	1390
11	sandy mudstone	1.9	0.31	2.88	13.8	2708
12	siltstone	5.0	0.34	3.14	27.6	2656

According to the formula (1) and physical and mechanical features of each roof layer of Table 1, the load of each roof can be calculated, as shown in the Table 2.

Table 2 Load of each roof layer

No.	1	2	3	4	5	6
Load (kN/m^2)	84.97	131.37	13.90	22.36	127.60	11.18
No.	7	8	9	10	11	12
Load (kN/m^2)	108.47	8.34	163.01	5.56	51.45	132.8

THE CAVING CHARACTERISTICS OF EACH ROCK FORMATION OF FACE ROOF

The pace of collapsing initially is the main characteristic appraising roof stability, which can be calculated by "plate" and "beam". The calculating method "plate" is the "thin plate" which located in the rectangular region above golf after mining of long-wall face. According to different boundary conditions, when calculating dimension of the plate, breakage length is the distance working face advancing when the plate breaking.

According to assumption of "thin plate" theory, under the condition of $(\frac{1}{80}\sim\frac{1}{100})\leq\frac{h}{a(b)}\leq(\frac{1}{5}\sim\frac{1}{8})$, the maximum tensile stress can be confirmed when analyzing the stress states of different boundary conditions. When the maximum tensile stress exceeding tensile strength of rock, the plate will be broken, and this is used to calculate the pace of collapsing initially. Generally, when the expected pace of collapsing initially a far less than the length of working face b, error of calculation less.

Using the recommended calculating method by "Strata control around long-wall face of China's coal mine", the pace of collapsing initially a1 is calculated by the following formula.

$$a_1 = \begin{cases} b\cdot\sqrt[4]{\dfrac{l_m^2}{b^2-l_m^2}} & (l_m < b < \sqrt{2}l_m) \\ \dfrac{b}{\sqrt{2}l_m}\sqrt{b^2-\sqrt{b^4-4l_m^4}} & b \geq \sqrt{2}l_m \end{cases} \quad (4)$$

Where $l_m = \frac{h}{1-\mu^2}\cdot\sqrt{\frac{2\sigma_t}{q}}$, l_m is limiting rupture length of slat when four edges rigid supports infinite.

According to the beam theory, the first and periodic collapsing initially of the each roof layer can be calculated approximately as the formula (2) and (3). The length of 3207 fully mechanized large cutting height face in No.3 coal seam of Huoerxinhe coal mine is 220m, its distributing characteristics, physical and mechanics parameters of roof rocks as shown in Table 1. Because the structure of roof rock layer is complex, and considering the influence of geological structure, joint fissure influence coefficient of the overlying strata is chosen 0.55, and stratified rock roof influence coefficient is chosen 0.38. The first and periodic collapsing initially of 3207 fully mechanized large cutting height face in No.3 coal seam can be calculated by formula (2) and (3), as shown in Table 3.

Table 3 Calculation of the first and periodic collapsing initially of roof strata

Horizon	Thickness(m)	First collapsing initially(m)		Periodic collapsing initially(m)
		by beam	by plate	by beam
12	5.0	34.4	38.9	14.0
11	1.9	20.1	22.2	8.2
10	0.4	2.4	2.7	1.0
9	4.4	26.2	28.9	10.7
8	0.6	2.9	3.3	1.2
7	3.7	27.0	29.8	11.0
6	0.5	11.5	13.0	4.7
5	3.4	23.9	27.0	9.7
4	1.0	16.3	18.4	6.7
3	1.0	3.8	4.2	1.5
2	3.6	10.6	11.7	4.3
1	3.8	14.1	16.0	5.8

As shown in Table 3: (1) the pace of direct top collapsing initially is 14.1~16.0m, the pace of basic top collapsing initially is 27.0~29.8m, the cycle collapsing initially is about 11.0m.(2) the way of roof caving at mined-out areas of 3207 working face is layer caving each time. The first layer charcoal mudstone caving first when working face advanced 14.1~16.0m; the second layer sandy mudstone and the third layer coal seam caving synchronous, and the caving height of roof is 8.4m;with the working face advanced, the fourth layer carbon mudstone caving at the same time, and the caving height of roof is 9.4m;when the working face advanced to 23.9~27.0m, the fifth layer siltstone and the sixth layer carbon mudstone caving at the same time, and the caving height of roof is 13.3m; when the working face advanced to 27.0~29.8m, the caving height of roof reached 24.3m.

ANALYSIS OF PERIODIC WEIGHTING OF WORKING FACE

The main roof of 3207 working face occurred five times periodic weighting during the site observation. The periodic weighting changing curve of 100# hydraulic support is shown in Figure 1, periodic weighting of three parts of working face are as shown in Table 4 and Table 5. From the day 5.13 to 5.25, the average daily advance degree of 3207 working face is 4.4m; and from day 5.26 to 6.14 the average daily advance degree of 3207 working face is 2.4m.

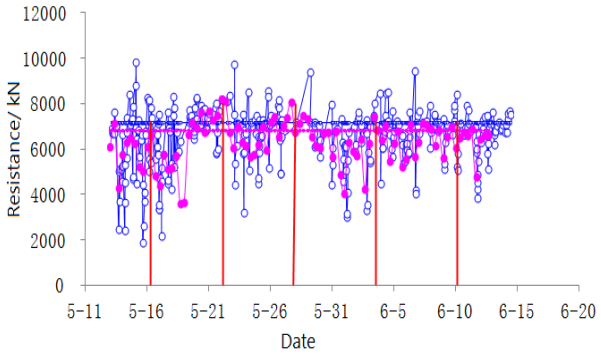

Figure.1 The periodic weighting changing curve of hydraulic support

Table 4 Periodic roof weighting pace of working face

Roof weighting pace	Location	Bottom		Middle part		Upside		Advance degree average value
	Hydraulic support	8#	30#	53#	77#	100#	122#	
4.4m	1	17.6	17.2	20.2	21.6	19.2	20.2	19.8
	2	21	22.4	19.4	21	19.4	19	
	3	20	18.4	13.2	12	12	15.6	
2.4m	4	16	20	14	11.6	13.6	13.2	14.7
	5	/	/	14	12.4	16.4	/	

As shown in Table 4: The periodic weighting of main roof decreased along with daily advance degree increased. When daily advance degree is 4.4m, the periodic weighting of main roof is 19.8m; and when daily advance degree is 2.4m, the periodic weighting of main roof is 14.7m.

CONCLUSION

(1) The way of roof caving at mined-out areas of 3207 working face is layer caving each time.

(2) The pace of direct top collapsing initially is 14.1~16.0m, the pace of basic top collapsing initially

is 27.0~29.8m, the cycle collapsing initially is about 11.0m.

(3) The Periodic weighting pace of main roof increasing by daily advance degree increased. When daily advance degree is 4.4m, the periodic weighting pace from 11.6m to 20m, average is 14.7m; when daily advance degree is 2.4m, the periodic weighting pace from 17.2m to 22.4m, average is 19.8m.

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