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Study of Reasonable Hanging Roof Length on Hard Roof

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Abstract

The thesis, from the character of hard roof on longwall working face, moving character and control request, by establishing mechanical model and theoretic deduced method, achieves supporting strength of the breaker props and pressure interval control under the control of hard roof on longwall working face, and therefore realizes managing the hard roof safely and effectively.

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The main difference between the underground pressure of hard roof stope and general stope lies in the degree of periodic roof pressure[1~4]. And so it is an effective method to control hard roof to grasp the basic character and regularity of underground pressure under the condition of hard roof.

1. The moving character and the controlling requirement of the hard roof

The hard roof initial caving is often a whole movement. At first, when the crack is found near the edge of upper rock stratum, flexure torque decreases with it, and the part of decreasing transfers to the middle layer. The study shows[5~6]: with the extension at the end break, the flexural torques in the end and in the middle have a certain transformation. When the extreme abruption extends to a certain degree, corresponding the middle pulling stress gets to maximum and causes broken joint. Due to push which is produced by horizontal press during falling, the middle crack is prevented from expansion quickly. If the middle hanging arch crow is cut and crush, under the horizontal push, the failure rock appears revolution till falling collapses. On the contrary, if the movement stays at deadlock, the middle crack cannot be developed to the whole thickness quickly; if the strength of coal is high and the extreme abruption is just near rib, the accidents of the whole down cutting and slipping are caused because the resistance to shear of extreme residual face is so short that it cannot respond the gravity of hanging layer.

After the stronger hard roof initial caving, with advance of the face, the hard roof will form hanging roof beside the finished stope; with the periodic crack caving, if the load which the upper hanging roof

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bears exceeds the bearing capacity of force piece, the hanging roof must be dealed with timely. Due to the appearance of the hanging roof, two influences will be caused:The contact stress between the immediate roof and the main roof over the area of face roof under control decreases obviously, and the contact layer is destroyed by cutting easily.

b. The hanging roof gives support an additional power, the quantity of falling in the most final row of face roof under control increases, which makes the immediate roof and the main roof separate. Now, the strongest pulling stress in the immediate roof is not in the terminal line of face roof under control, but with the hanging roof distance increasing, it comes into the upper area of face roof under control.

Under this condition, if supported design is unreasonable, while the roof caving, the roof can crack above the area of face roof under control, which causes the support instability or caving.

Known from the upper, in order to prevent the support unsteadily caused by the hard immediate roof from producing caving accident, the key to the supporting design lies in reasonable selecting the distance of face roof under control and supporting strength, and controlling hanging roof length. The distribution of the support resistance should fulfill to make the most strong drawing stress point stands in the edge of emptied stope, which makes the hard roof collapse in the breaking area.

2. Hard roof stress analyze

In order to analyze which supported method is more effective to the hard roof working face, we must first understand the stress situation under the different supported methods, and then precisely judge and analyze. Following, we establish the stress model of the hard roof to analyze stress situation of roof under longwall working face[2,4].

One roof layer or several roof layers in stope may be considerated elastic strain beam retaining between the superior roof and coal and bases on coal, and it is also considered to fulfill Wdrie elastic foundation hypothesis approximately. So we may simplify the hard roof as an overhanging beam. The specific stress state simplifies as the graph 1. The supported force of the based beam in the area of face roof under control is simplified as triangular distribution, the resistance of each support beam in i line is p_1 , and the support resistance of the breaker props is p_n .

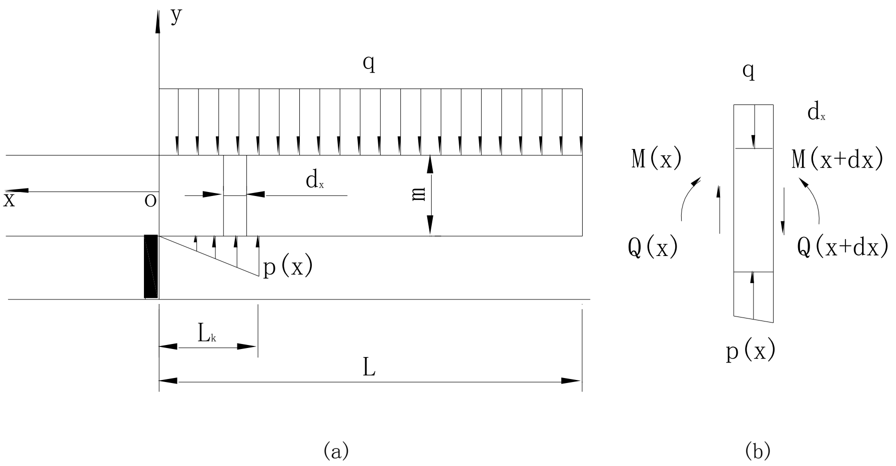

Fig. 1 Model of hard roof stress

In the graph:

q — uniformly distributed load acted on the hard roof, KN/m ;

$p(x)$—counterforce intensity of column in working face, KN ;

$M(x)$—flexure torque in rock beam, $KN \cdot m$;

$Q(x)$—shear force in rock beam, KN ;

L_x—the distance of face roof under control, m ;

L—the length of cantilever beam of hard roof, m .

Through mechanics analysis to elastic foundation beam, we can demonstrate fully in theory that the extreme abruption during the first movement and the periodical movement all happen in the front of rib. Even though the rib is in elastic state, because of the deformation of roof basement, the extreme abruption still penetrates into the rib. In calculation of the model of the graph 1, we think cantilever beam has already cracked in the rib. For the sake of simplicity, the crack in the front of cantilever beam is selected in the rib. If the mass simple moves around the point O in the graph 1,well then, so is the equation：

$$M_P - M = J\varepsilon \tag{1}$$

In the equation:

M_p —countermoment of column of working face, $KN \cdot m$, $M_p = \int_{L_k}^{0} p(x)xdx$;

M —load moment of roof, $KN \cdot m$, $M = \frac{1}{2}qL^2$;

J —moment of inertia that roof rock circles the point O , $kg \cdot m^2$, $J = \frac{1}{3}qL^3/g$;

ε —rotate acceleration that roof rock circles the point O , $KN \cdot Kg$

We select a small unit dx at intervals x to the point O , as the graph 1（b）, so is the balance equation in the roof moving:

$$-qd_x + p(x) + dQ(x) = -x\varepsilon qd(x)/g \tag{2}$$

$$dM(x) + Q(x)d_x = J_{dx}\varepsilon \tag{3}$$

In the formula:

J_{dx} —rotary inertial moment that the unit dx moves around the center of mass,

$KN \cdot m^2$, $J_{dx} = qdx^3/12g$.

By the equation (1-3) we can get bending moment and shearing force of the hand roof model separately:

$$M(x) = \frac{q(M_p - M)}{4Jg}x^3 - \frac{1}{2}qx^2 + \frac{1}{2}p(x)x^2 \tag{4}$$

$$Q(x) = qx - \int_{L_k}^{0} p(x)dx - \frac{q(M_p - M)}{2Jg}x^2 \tag{5}$$

When $x = -L_k$, $p(x) = p(-L_k) = p_n$, p_n is support counterforce of the breaker props. We take it into (4) and obtain the bending moment of the breaker props:

$$M(x)=\frac{1}{2}p_nL_k^{\ 2}-\frac{1}{2}qL_k^{\ 2}-\frac{q(M_p-M)}{4Jg}L_k^{\ 2} \tag{6}$$

The actually drawing stress that roof is given may be expressed by the following formula:

$$\sigma=\frac{M(x)}{W} \tag{7}$$

In the equation:

W —roof sectional module , $W=\frac{m^2}{6}$, m is the thickness of the roof , m ;

σ —actually drawing stress that roof is given, KN/m^2.

The condition of the hard roof breaking in the breaker props is the given drawing stress is greater than its ultimate tensile strength, that is:

$$\frac{M(x)}{W}\geq[\sigma] \tag{8}$$

In the formula:

$[\sigma]$ —ultimate tensile strength of the roof, KN/m^2.

By the formula (6-8), the resistance of topping support P_n which is wanted in the breaker props breaking can be calculated:

$$P_n\geq\frac{2W[\sigma]}{L_k^{\ 2}}+\frac{q(M_P-M)}{2Jg}L_k+q \tag{9}$$

A declaration must be refered that the resistance of breaking support can't increase infinitely, when single intensive support or pier column arrives at the wanted load but can't meet the formula (9), we must considerate compulsory cover caving, cut off roof timely and effectively, shorten the length handing roof and ensure stope safe.

3. Interval flap top slot

Interval flap top slot controls the distance of hanging roof in a certain range, ensures the supporting strength of force piece appropriately and so reaches the goal of safe control. The spacing distance of slot changes with supporting strength and supporting nature. The model is the graph 2. The thickness of coal layer is h, the thickness of roof is m, the distance of face roof under control of working face is L_k, the length of hanging roof working face is L_S.

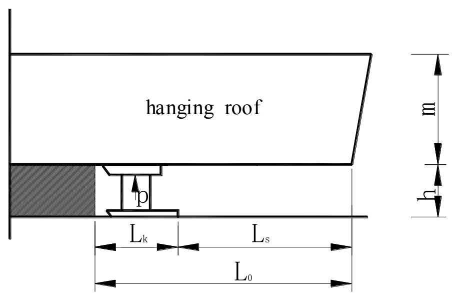

Fig.2 Mechanical model of interval flap top slot

When the hanging roof slot isn 't going , the interval of periodic roof pressure is :

$$L_0 = \sqrt{\frac{m[\sigma]}{3\gamma}} \tag{10}$$

$[\sigma]$ —the allowed drawing stress of rock beam, KN/m^2 ;

γ —the unit weight of rock, KN/m^3 ;

m —the thickness of the roof, m ;

L_0 —the interval of periodic pressure , m .

Now, to ensure safe production of working face, the support must have enough supporting strength. We think in the most dangerous condition, even though the hard roof is cut in the rib, we may deduce in theoretical mechanics the supporting strength p_o of working face:

$$p_0 L_K \frac{1}{2} L_K = L_0 m\gamma \frac{1}{2} L_0$$

$$P_0 = \frac{m\gamma L_0^{\ 2}}{L_K^{\ 2}} \tag{11}$$

L_K —the distance of face roof under control, m .

The purpose of interval hanging roof slot is realizing $L_K + L_S \le L_0$. Now the needed supporting strength is

$$p_0^1 = \frac{(L_K + L_S)^2 m\gamma}{L_K^{\ 2}}$$

The value of P_0 deduced from the upper formula is often bigger in the hard roof with thick rock. Because the supporting strength of working face can't be big infinitely, it has a maximum when the supported strength P_0^1 is a definite value:

$$p_0^1 \ge \frac{(L_K + L_S)^2 m\gamma}{L_K^{\ 2}}$$

SO:

$$L_S \le L_K \left(\sqrt{\frac{P_0^1}{m\gamma}} - 1\right) \tag{12}$$

Form the formula (12) we know that the distance of hanging roof must be less than a certain value during the periodic roof pressure when the supporting strength of working face is sure.

4. Conclusion

When the support resistance of the breaker props fulfills the formula (9), the hard roof may crack here, which releases the energy of roof and the pressure of working face. When the working resistance of the breaker props can't cut roof off timely, the compulsory cover caving must be adopted, the caving interval is calculated by the formula (12). The upper conclusion applies successfully to JinChen $15^{\#}$coal hard roof, arrives at the controlling effect of hard roof and achieves better economic and social efficiency.

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