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Study on the Structural System of Roof in Fully Mechanized Top Coal Caving

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Abstract. Based on the structural characters of roof in fully mechanized top coal caving, mechanical analysis, mechanical calculation and simulation experiment were used to explore the particularity of roof structure in fully mechanized top coal caving. The simplified model of roof structure was built in final. The results shown that, during the mining by fully mechanized top coal caving, dynamic balance arch structure was formed by the roof and surrounding rock in working face. In the same time, multi span beam structure was formed in the tendency direction. The results of this paper would provide the theory basis for exploring the strata behavior regularity in further, and promote the safety in production of coal mining enterprises.

Introduction

Analysis the relationship between the supporting frame and surrounding rock in working face is a fundamental problem for studying mining method of fully mechanized top coal caving. It plays a decisive role on strengthening the control of roof in fully mechanized top coal caving mining face, determining the roof pressing step pitch and intensity, the performance of hydraulic support, the same as adaptation and control effects of support for roof and floor, and the application of fully mechanized top coal caving mining technology [1-3].

Comparing with the general fully mechanized mining, the top coal caving has two different basic factors, mining height and the properties of roof. The change of mining height directly affects the height of caving zone, and the change of roof's properties affect the transfer mode form overlying strata structure to support's force.

In this paper, the change and change form of overlying strata structure, determining working characteristics and reasonable support resistance of hydraulic supporting frame, and the relationship between these factors, parameters and properties of mining height and roof were systematically analyzed in the condition of fully mechanized top coal caving.

Support system of surrounding rocks in fully mechanized top coal caving

The force of support in face was mainly coming form immediate roof and main roof. In the traditional theory of ground pressure, immediate roof was regarded as rigid body. In another word, the main roof subsidence was conveyed by immediate roof to face and support, which could be used to determine nominal yield of support and roof subsidence. Obviously, when the immediate roof strength was low, especially during the top coal was caving, it could not be accurate compared with the actual situation. This is one mainly reason which lead to complex ground pressure behavior in top coal caving mining face. Along with deeply research for immediate roof stability and the top coal caving ground pressure, people gradually realized the role of immediate roof, especially in ground pressure behavior in top coal caving mining face, and a further understanding for the nature of stope support force and "support - rock" relations and other issues. That laid the foundation for development of the ground pressure theory.

The mechanics model of steady arch structure in fully mechanized top coal caving. During the process of fully mechanized top coal caving, overlying strata formed a stable arch in the upper rock layers, and an multi-span beams structure under the stable arch. The horizon of the stable arch is proportional to the thickness of mining coal layer. When the mining coal layer is thicker, the horizon of the stable arch is higher. The stable arch is a dynamic balance structure. With the face mining forward, front arch foot and rear arch foot will move ahead and re-formed a new stable arch structure after the stable arch strength reaching ultimate and destroying. Similarly, the multi-span beam is a dynamic equilibrium structure. For revealing ground pressure behavior in fully mechanized top coal caving and determining initial caving step and periodical pressure step of main roof.

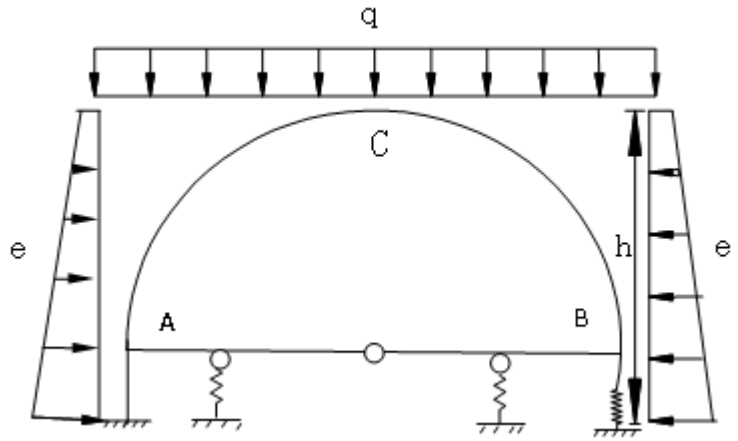

Fig. 1 Mechanical model of dynamic stabilization arch in fully mechanized top coal caving

As shown in Figure 1, the distance from caving zone to support roof was calculated and simplified to stable arch. Caving zone was compressible and could be simplified to elastic support. Hydraulic support could be simplified to rigid support, and elasticity coefficient got k=0.03 by expansion coefficient after rock mass caving.

Upper load calculated by loads of range of forming arch using calculation method of natural arch upper part of the tunnel. Stable arch's span and lateral loads calculated by lateral surrounding rock pressure. The stable arch is cubic indeterminate arch system. According to internal force calculation of above model of dynamic stability arch, typical equation of the most reasonable stable arch axis was obtained as follows [4]:

$$y = \frac{\frac{1}{2}qx(l-x)}{\frac{ql^2}{8f}} = \frac{4f}{l^2}(l-x)x \tag{1}$$

Where, y is vertical distance from calculate point, m; q is upper load, N; x is horizontal distance from calculate point, m; l is the distance from caving zone to support roof, m; f is supporting force, N.

Thus, reasonable arch of the first formed steady arch is quadratic parabola. Vault displacement adopted principle of virtual work to calculate, which was calculated by integration method. The structure only considers displacement which was generated by bending and elastic support.

$$\Delta c = \int \frac{\overline{M}_K Mp}{EI} dx + \Delta K \tag{2}$$

Where, Δc is the vertical displacement of stability arch, m; $\bar{M}_K$ is the absolute value of moment, N*m; Mp is the moment of upper load, N*m; ΔK is the correction factor, m.

When Δc is equal to allowable displacement, which is more than the ultimate strength of rock beams, the dynamic steady arch will start to be destroyed from the vault.

The mechanics model of multi-span beams structure in fully mechanized top coal caving. Gob area and caving zone can be simplified to elastic support, and coal wall of face can be simplified to rigid support. Through calculating the internal forces of dynamic steady arch, and determining the most reasonable equation of arch axis, load range of multi-span beam structure could be formed in the upper strata of overlying strata in fully mechanized top coal caving mining face. Thus calculating the internal forces of multi-span beam could be obtained in the working resistance of hydraulic support in face. The results showed that the influence of the number of multi-span beam on working resistance within the range of three-span. So this model was used the three-span multi-span beam to calculate.

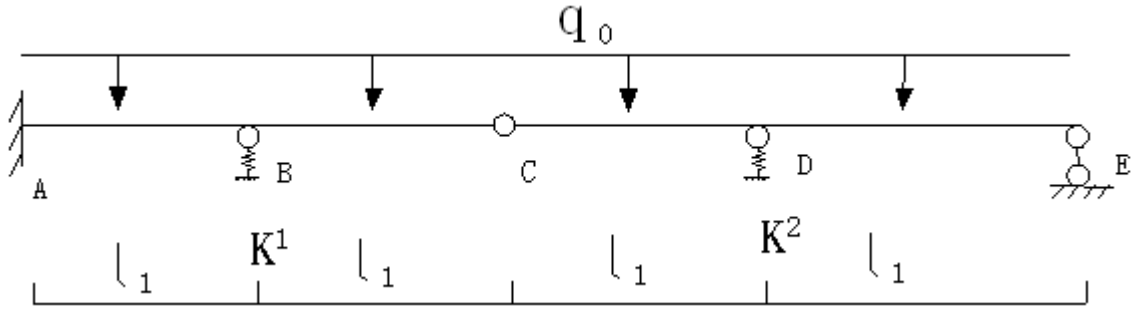

Fig. 2 The model of multi-span in the fully mechanized top coal caving [4]

As shown in Figure 2, the part of CD would be regarded as attachment structure, and the part of ABC would be regarded as infrastructure. Hydraulic support was the B bearing, and the A bearing was steady coal wall in mining face. Support resistance could be calculated by internal force of multi-span beam.

Analysis of similar simulation

In the fully mechanized top coal caving mining face, similar simulation with physical materials was necessary to reveal the changes of the upper structure and the roles of roof coal and immediate roof in ground pressure. In the exploitation process, the activities of the overlying strata was observed and analyzed theoretically.

Through the similar simulation experiment, the abscission layer between the immediate roof layers would be aggravated, and the uneven settlement was appeared. After initial caving of main roof, the lower position strata would filled mined area, and provided a finite deformation space for a certain height of upper strata. Upper strata in face could be seen as the end of the strata fixed to the rock mass of face. The other hinged to steady arch structure of elastic support was composed by caving rock in mined area.

Under the steady arch structure, fracture rock beam formed sizes of regular arrangement of rock mass, and it rotated each other to form extrusion. Because of the role of horizontal force and friction, it formed structure which was similar voussoir beam in appearance. In fully mechanized top coal caving mining face, the deformation and instability of the structure of steady arch formed in upper strata and multi-span beam formed in lower position strata would determine abutment pressure distribution and strata behaviors.

Conclusion

There are many similarities between support pressure change law in fully mechanized top coal caving mining face and ordinary fully mechanized coal face. However, because of the change of mining height and roof properties, it is obvious that the support pressures were difference between the fully mechanized top coal caving and general fully mechanized mining. There is a certain proportion relationship between the location of the three zones and thickness of coal mining. Steady arch can be formed in upper strata of face, and fracture rock beam can be formed structure which is similar voussoir beam in appearance. The deformation and instability of the structure of overlying strata in fully mechanized top coal caving mining face will determine abutment pressure distribution and strata behaviors.

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