Short communication

Criteria of support stability in mining of steeply inclined thick coal seam

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1. Introduction

The level slice cutting or pseudo inclined slice cutting method associated with top coal caving mining is usually used in extraction of steeply inclined thick coal seams. A layout of short wall working face is simple and the support stability is easily guaranteed. However, the width of the mining face is limited by the thickness of the coal seam. As a result, the mining efficiency is low, due to a high ratio of the amount of roadway excavation to the amount of coal production. Therefore, how to take advantages of longwall mining to enhance the efficiency and safety of mining in steeply inclined coal seam becomes a key issue.

As well known, the roof caving and movement, gravity traction and other factors directly affect the stability of supports in steeply inclined thick coal seam. The supports are prone to sliding or toppling along a steeply inclined working face. 1-3 In order to solve the problems of support instability, comprehensive technical measures and researches have been performed regarding different aspects, such as curving layout of the longwall working face, 4 support connection, 5-7 and interaction between support and roof and floor strata 8-10 etc. Kong and Jiang 11,12 studied the reasonable supporting resistance and obtained the relationship between the roof structure and support working resistance for a general top caving mining face. They also proposed quantitatively the expression of the “support- surrounding rocks” relationship under three kinds of roof structure model in top caving mining face. Wu et al. 13-15 analyzed the relationship between masonry structures of overlying rock strata and support stability, they put forward the stability criterion of the ‘roof-support-floor’ system (R–S–F model). Xie 8 studied the layout of longwall working face and pointed out that ‘nonlinear bifacial’ face layout is the key technology to ensure the support stability in steeply inclined thick coal seam. In addition, the varying of supporting resistance with time, 9 the mechanical analytic model of support 16,17 and the non-uniqueness of supporting resistance 18,19 have been studied.

Dongxia Coalmine is located in Huating coal field, Gansu province of China, where folds are the major tectonic structure. Mining panel 37220 is seated at the eastern wing of syncline with dip angles ranging from 34° to 62° (an average value of 52°). The thickness of coal seam No. 6–2 is 19.8 m. The working face is at depth between 603–657 m with an inclined length of 93 m and a strike length of 1036 m. The geological characteristics of major overlaying rock strata and the coal seam are summarized in Table 1. According to in situ stress measurement by using core covering method, the orientation of the maximum principal stress is approximately 18°/258° (dip/azimuth angle), that is almost perpendicular to the strike of the coal seam. The maximum principal stress and minimum principal stress increase linearly with the depth as follow:

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As shown in Fig. 2(a), the basic support has a whole along the inclination of coal seam. Also, it improves significantly stability of the supports as a whole along the inclination of coal seam.

The working face is equipped with four column shield supports (ZF5000/17/28). As shown in Fig. 2(a), the basic support has a weight of 17 t with a height of 2.8 m and a width of 1.5 m. The supporting force at installation can reach 3958 kN, and the maximum supporting capacity is 5000 kN. As shown in Fig. 1, three transitional supports are placed in the horizontal section numbered as 1#–3#. 23 basic supports are installed in the curving section, numbered upward, respectively, by 1#–23# (supports from 1# to 15# transitionally incline from level to the angle of 25° with an increment angle of 1.67°, and supports from 16# to 23# incline gradually to 52° with an increment angle of 3°). 36 basic supports are installed on the inclined straight plane with the inclination angle of 52°, and numbered upward by 24#–59#, respectively.

In the initial mining stage, when the working face 37220-1advanced 6.5 m from the open cut, a small scale roof collapse occurred along the face wall ahead of supports 28# and 29#. The caved size is 2.5 m × 1.5 m × 1.2 m. A successive larger scale collapse of the roof stratum occurred after the supports were moved forward. The collapsed roof coal buried the mining face up to support 25#. From the position of support 12# in the mining face, the collapse of roof coal and the working face developed and enlarged up and forward, giving rise to a huge funnel shaped cave space with the maximum width of 4 m and the maximum height of 11.6 m (Fig. 3). The supporting system from the middle to the up region of the working face was completely destroyed. As like a domino effect, toppling and gripping of the supports severely took place.

The essential reasons of the accidental collapse and support instability are majorly as follows:

(1) Failure of surrounding rocks. The structure of coal seam no. 6–2 is complicated, and lamination and joints are densely developed in the brittle coal seam. Under a high tectonic stress...