Study on Reasonable Size of Coal Pillars in Large Dip Angle Coal Seam

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Abstract: In order to analyze the reasonable size of coal pillars in the large dip angle coal seam section, the fully mechanized mining face of B8 coal seam in Nanshan coal mine was taken as the basic prototype. And the influence of different inclination angle and coal pillar width on stress distribution of working face was conducted by FLAC numerical simulation software. It concludes that as the inclination angle increases, the point of concentrated stress shifts to the upper part of roof and the inner part of the working face. The larger the inclination angle, the smaller the influence range of the vertical stress. According to the simulation results, it is reasonable to leave a coal pillar with a width of 15 m to 20 m for the coal pillar section of the working face of Nanshan Coal Mine.

1. Introduction

According to statistics, large dip angle coal seam accounts for about 20% of the proven reserves of coal in China. Because of its special coal-forming conditions, more than 50% of the coal resources of large dip angle coal seams are high-quality coking coal and anthracite, which are less abundant in China [1]. However, due to the particularity of coal and rock occurrence in the large dip angle working face, the mechanical failure characteristics and retention methods of the coal pillars in the working face are different from those in the near horizontal and middle inclined coal seams. After the coal pillar breaks and unstable, it will slide down to the lower part of the working face, and completely lose the bearing capacity to the overburden, causing disasters.

Scholars have earlier studied about the strength of coal pillars and the stability of coal pillars. Bieniawski [2] proved that the strength of coal pillars is related to its size through experiments, and the theoretical formula of coal pillar strength was summarized. Poulsen [3] analyzed the support effect of coal pillars on the upper strata by studying the roof pressure arch theory and its overburden load. Sheorey et al. [4] studied and analyzed the stability of coal pillars by studying the coal pillar width, height and strength during coal pillar instability. The common research results of coal pillar retention are effective area theory, pressure arch theory, Wilson theory, limit equilibrium theory, platform load method theory, etc [5~10]. Based on the fully mechanized mining face of B8 coal seam in Nanshan coal mine, this paper uses FLAC numerical simulation software to analyze the stress distribution law of working face under different dip angle and coal pillar width, to determine the reasonably size of coal pillar of large dip angle coal seam section.

2. Working face situation

Taking the fully mechanized mining face of B8 coal seam in Nanshan coal mine as the basic prototype, the working face has a length of 950 m and a tendency length of 114 to 136 m. The average thickness of the coal seam is 4.2 m and the coefficient of variation is 45%. The coal seam is inclined between 38° and 42°, and the structure is relatively stable. Its old roof is 14.6 m fine sandstone, the direct top is 20.2 m siltstone, and the direct bottom is 1.2 m fine sandstone.

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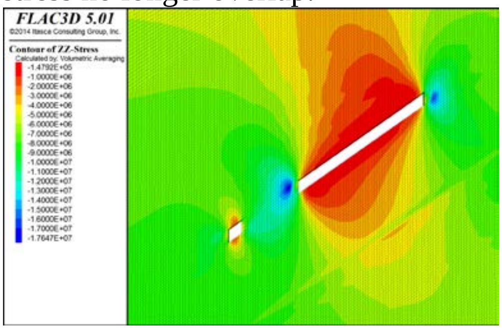
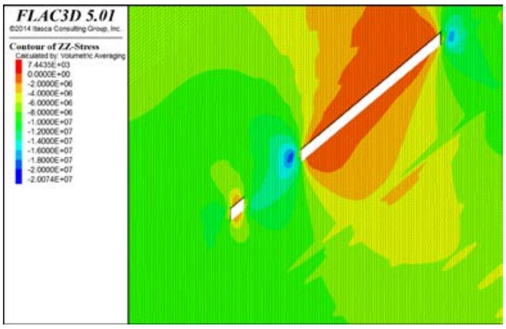
3. Stress distribution law under different dip conditions

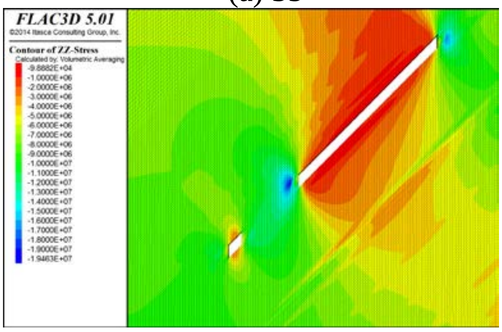
In order to study the deformation characteristics of section coal pillars under different coal seam dip angle conditions, according to the geological histogram of Nanshan coal mine, the numerical simulation model with coal seam dip angles of 35°, 40°, 45° and section coal pillars of 20 m was established. The vertical stress distribution of coal pillars with different dip angles is shown in Fig.1. It can be seen from Fig. 1 that the maximum concentration of concentrated coal pillars in the working face of the large dip angle coal seam is located at the upper of coal pillar near the top of the working face. With the increase of the inclination angle, the concentrated stress action point is transferred to the upper part of roof (the upper end of the coal pillar) and to the interior of the coal wall of the working face. The larger the inclination angle, the smaller the influence range of the vertical stress. Even when the working surface inclination angle is 45°, the "saddle-shaped" stress distribution curve appears in the coal pillar, indicating that the working surface stress and the coal pillar side stress no longer overlap.



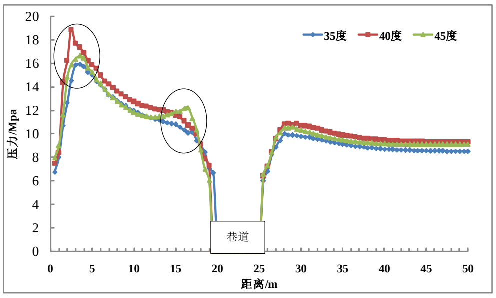
(a) 35°



(b) 40°



(c) 45°

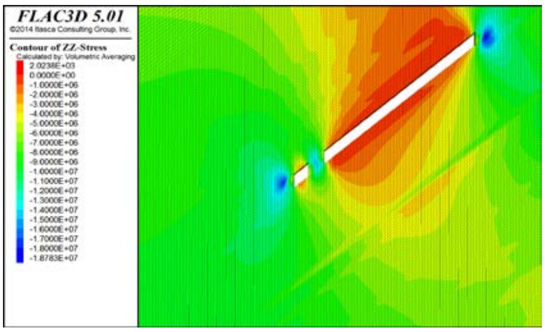


(d) Different inclination angle comparison

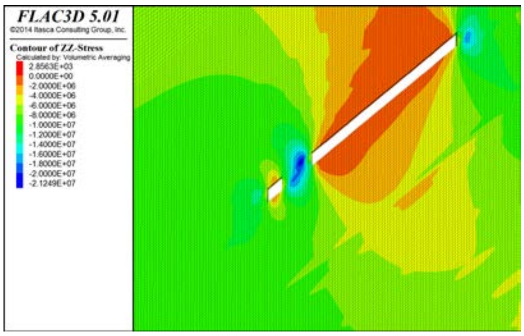
Fig.1 Stress distribution law of coal seams at different inclination angles

4. Stress distribution law under different width section coal pillar

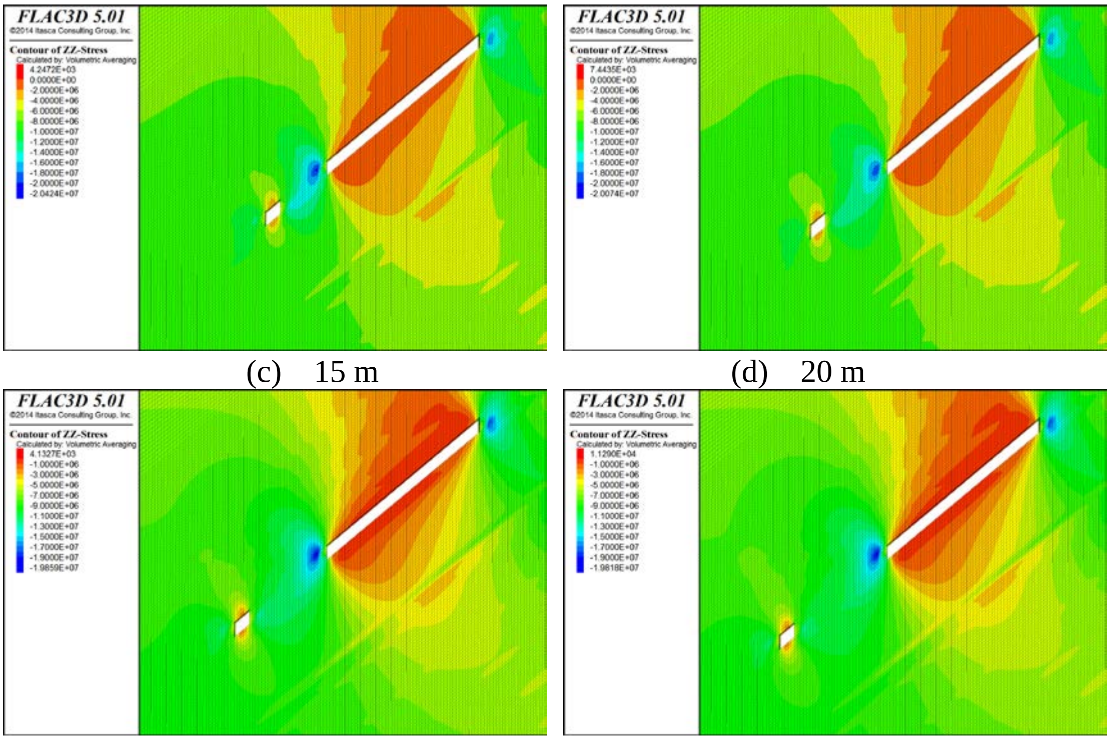
In order to study the law of deformation and failure of coal pillars with different widths under large dip angle conditions, numerical models with coal seam dip angle of 40°, and the coal pillars width of 5 m, 10 m, 15m, 20 m, 25 m, and 30 m respectively was established. The results are shown in Fig.2 and 3.



(a) 5m



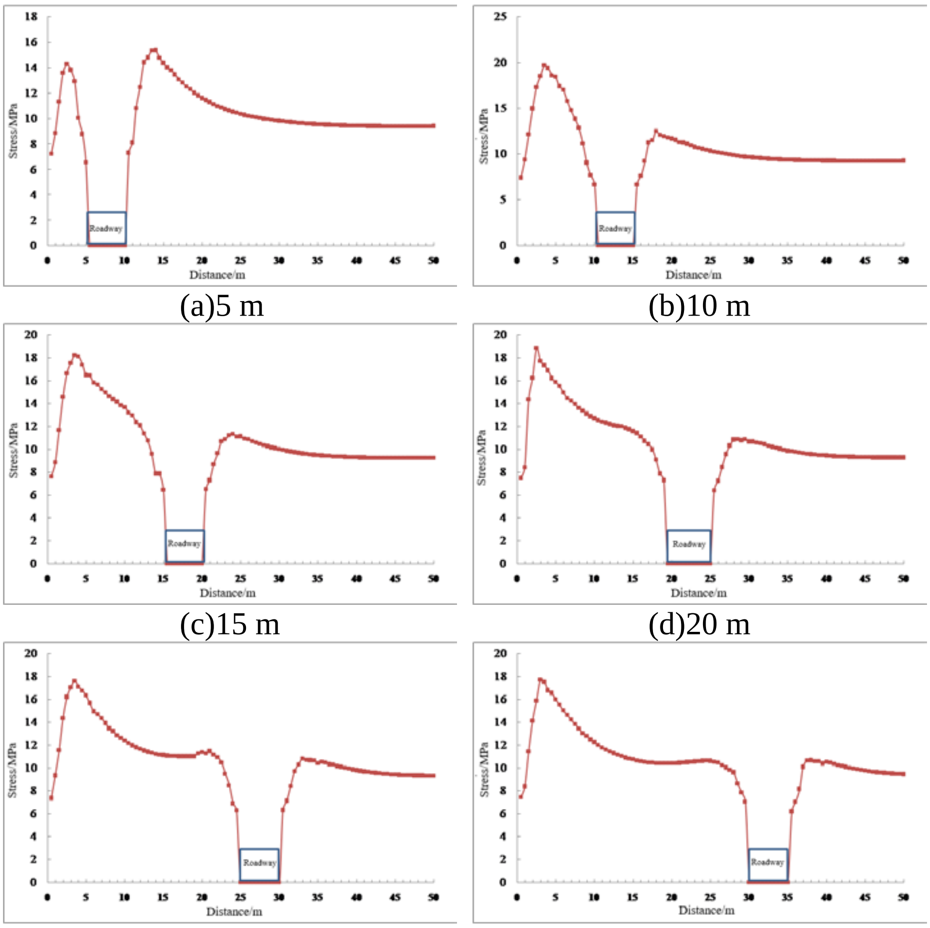
(b) 10 m



(c) 15 m (d) 20 m

(e) 25 m (f) 30 m

Fig.2 Vertical stress distribution diagram of coal pillars with different widths



(a)5 m (b)10 m

(c)15 m (d)20 m

(e)25 m (f)30 m

Fig.3 Vertical stress curves of coal pillars with different widths

According to the vertical stress distribution map and graph of different coal pillar widths, it can be seen that the upper end of the coal pillar, that is, the side close to the goaf, is affected by the upper goaf, and stress concentration occurs. When the width of the coal pillar is about 0~10 m, the overall bearing pressure of the coal pillar is large, and the stress value on the side of the roadway is significantly higher than that of other width coal pillars. This problem is mainly caused by the hard roof of the goaf. When the width of the coal pillar is in the range of 15-20 m, the stress peak is far away from the roadway, and the influence of the roof of the goaf on the roadway begins to become smaller. When the coal pillar width of the roadway is greater than 20 m, the saddle-shaped stress appears on the side of the coal pillar. It is no longer superimposed on each other. From the analysis of numerical simulation results, combined with the recovery rate, it is more appropriate to set the width of the roadway to 15 m to 20 m.

5. Conclusion

In this paper, the stress distribution law of coal pillars under different dip angles and different coal pillar widths is analyzed by numerical simulation. With the increase of the dip angle, the influence range of vertical stress becomes smaller. When the coal pillar width is about 0~10 m, the overall bearing pressure of the coal pillar is larger; when the coal pillar width is in the range of 15-20 m, the stress peak distance the roadway is far away, and the influence of the roof of the goaf on the roadway begins to become smaller. When the width of the coal pillar of the roadway is greater than 20 m, the “saddle-shaped” stress on the side stress of the coal pillar no longer overlaps each other. From the analysis of the numerical simulation results, it is appropriate to leave the roadway width 15 m to 20 m.

Acknowledgments

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