Study on movement law of overlying strata during shallow thinner seam mining

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Abstract

Given the first time for shallow thinner seam mining, this paper resorted to methods of field measurement and numerical simulation to research overlying strata movement law during shallow thinner seam mining. Through research, it was obtained that 20m in front of coal wall was the region influenced by mining. In this region, advanced abutment pressure demonstrated law of single elastic. The pressure reached its peak value at coal wall and the fracture of rock beam occurred only in coal wall. When rock beam ruptured, there was no obviously deformation and other pressure behavior in roadway. As distance to coal wall increasing, pressure value was decreasing in rule of negative exponential.

Keywords: shallow thinner seam; field measurement; numerical simulation; single elastic

1. Introduction

According to literature [1], in coal mine, depth less than 150m is defined as shallow seam. According to Shenhua Group’s specific geological conditions and mining technology, thickness between 1.36m and 2.60m will be defined as thinner seam. As shallow thinner seam mining in Shenhua Group was the first time, there was no successful experience to refer[2-9], so movement law of overlying strata during shallow thinner seam mining was urgently needed to begin, in order that this successful experience could be used as guideline in other mines’ production. Face of NO.71301 in Shi Getai coal mine, which
belongs to Shenhua Group, was the first work face of shallow thinner seam which was fully mechanized. Based on these conditions, using methods of field measurement and numerical simulation, this paper studied the movement law of overlying strata during shallow thinner seam mining.

2. Overview of project

In NO.71301 face, depth was less than 100m, and its thickness of overlying strata was between 45m and 75m, while its thickness of loose layers was between 0 and 20m. NO.1\textsuperscript{2} coal seam, whose average thickness was 2.3m, was mined in this face. Dip angle of this seam was in the range of 1\textdegree{}~3\textdegree{} and its dip length was 300m.

3. Analysis of field measurement results

3.1. Variation law of roadway’s surface displacement

Variation curves of roadway’s surface displacement were shown in figure 1.

![Variation curves of roadway’s surface displacement](image)

Fig. 1. Variation curves of roadway’s surface displacement along face advancing

In figure 1, we can gain that the sinkage of roof was 67mm, and the amount of two sides shifting closely was 61mm. The original size of roadway was that the height was 2200mm and the width was 5600mm. The sinkage of roof was accounted for about 3.0% of roadway’s original height, and the amount of sides shifting was accounted for about 1.1% of roadway’s original width, which indicated that the overall deformation of roadway was small, so that phenomenon of pressure behavior could hardly be observed.

Through analysis of roadway’s variation law, considering whether influenced by mining, roadway could be divided into two regions along face advancing.

(1) Region without influence of mining, which indicated the region beyond area of 20m in front of coal wall. There was almost no deformation in this region and almost independent of mining influence. So surrounding rock’s stability was better.

(2) Region under influence of mining, which indicated the region 20m in the front of coal wall. Affected by mining, roadway deformed obviously and rate of deformation increased gradually. The rate reached its peak value at coal wall.

3.2. Variation law of advanced pillars’ load
Variation curves of advanced pillars’ load were shown in figure 2(a). Fitting formula 1 based on measured data. Curve of formula 1 was shown in figure 2(b).

\[ y = 4.5e^{-x/7.5} + 7.7 \] (1)

From figure 2 we can see that advanced pillars’ load show rule of negative exponential. In the scope of 20m in front of coal wall, pillars’ load increased gradually as distance to coal wall decreasing, and the load arrived at its peak value at coal wall. In monitoring scope, load’s peak value was 10.45MPa. At the same time we can see that pillar’s load proximately remained setting one beyond the region 20m before coal wall. So we can gain that mining influenced area was the scope 20m in front of coal wall.

3.3. Analysis of coal pillar stress

Variation curves of pillar stress were shown in figure 3(a). Fitting formula 2 based on the measured data. Curve of formula 2 was shown in figure 3(b). Due to different influence strength by mining, formula 2 was different from formula 1.

\[ y = 0.7e^{-x/14} + 2.5 \]
\[ y = 0.7e^{\frac{x}{14}} + 2.5 \]  

From figure 3 we can see that stress in pillar show rule of negative exponential. As face advancing, abutment pressure in coal pillar increased gradually, and the stress reached its peak value at coal wall and the maximum stress in monitoring scope was 3.2MPa. In front of coal wall there were two different rates of stress variation: region beyond the area 20m in front of coal wall, in which stress in coal pillar was almost stable; region 20m before coal wall, in which stress was affected by mining obviously, and the stress increased gradually as distance to coal wall decreasing.

Combined roadway deformation law, variation law of pillars’ load and stress evolution law in coal pillar, distribution of advanced abutment pressure can be determined as showing law of single elastic[10]. Feature of this distribution was that advanced abutment pressure decreased in the rule of negative exponential. Its peak value lay in coal wall and the fracture of rock beam occurs only in coal wall. When rock beam ruptured, there was no obviously deformation and other pressure behavior in roadways. Distribution diagram of abutment pressure was shown in figure 4. At the same time, we can deduce that mining influenced area was the scope 20m in front of coal wall. In this region, advanced abutment pressure increased gradually as distance to coal wall decreasing.

4. Analysis of numerical simulation results

FLAC3D model was established based on specific geological and mining conditions in NO.71301 work face. Diagram and variation curves of maximum principal stress along face advancing were shown in figure 5. Simulation results were analyzed as follows.

Fig. 4. Distribution of advanced abutment pressure

Fig. 5. (a) Distribution diagram of maximum principal stress along face advancing; (b) Variation curves of maximum principal stress in overlying strata along face advancing
It is obtained that, as face advancing, peak value of maximum principal stress lay in the coal wall. In front of face, stress decreased gradually as distance to coal wall increasing, which was accord with the measured results. Stress decreased obviously in the region 20m in front of coal wall, which demonstrated that mining influenced area was the region 20m in front of coal wall, which was matched with the results of field measurement.

5. Conclusion

Face of NO.71301 was mined out on March 21, 2009 successfully, which brought large economic benefits for the company and brought a large number of pressure information about shallow thinner seam mining. Through studies on movement law of overlying strata, main conclusions were gained as follows:

(1) Distribution of advanced abutment pressure show law of single elastic. The feature of this distribution was that pressure value decreased in the rule of negative exponential as distance to coal increasing. The pressure reached its peak value at coal wall and the fracture of rock beam occurred only in coal wall. When rock beam ruptured, there was no obviously deformation and other pressure behavior in roadway.

(2) Mining influenced area was the scope 20m in front of coal wall. Region beyond the area 20m in front of coal wall was hardly affected by mining, and advanced abutment pressure almost did not change in this area. Region 20m in front of coal wall was affected by mining obviously and the pressure value was decreasing as distance to coal wall increasing.

References


