

Simulation of strata behaviour laws of a coal mine in Jungar Coalfield

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ABSTRACT

The present study uses a similar material experiment to systematically examine the performance of the law of overlying strata caving, mine ground pressure, and crack development when the first coal mining face in Jungar coalfield was exploited. The overburden movement, roof collapse, severe wall caving, and a range of other issues related to mine ground pressure caused by the exploitation process in Jungar coalfield are considered. The results prove that the pace of the immediate roof caving of the first coalface was about 15.0 m. The pace of the first weighting of the rock stratum of main roof was 45 m, with an average pace of periodic weighting of 17 m. The maximum loading-increasing factor of first weighting was 1.40, and the value of loading-increasing factor for the whole weighting period was 1.32. For the distribution of the three zones of the overlying strata on the first coalface, the height of the caving zone was about 4.5 times the average mining height, the height of the fissure zone was about 14.5 times the mining height. The bending zone is the stratum over 43 m from the coal roof, which takes on the features of overall down movement. Therefore, a reasonable choice of mining method to reduce the thickness of the mining working face should be taken to reduce the disturbance from exploitation to overlying strata of the upper goaf and the earth's surface.

KEYWORDS: Mine pressure; Similar material simulation; Bending zone; Fissure zone; Caving zone; Overlying strata failure

1. INTRODUCTION

Jungar coalfield is located in the southwest of the Inner Mongolia Autonomous Region, and is an important part of the Ordos coal-accumulating basin, which is a Neopaleozoic permo-carboniferous oversize coalfield. Due to the coal properties in the Jungar coalfield featuring natural conditions of especially low-sulfur, low-phosphorous, high ash-melting, high calorific power and high volatile, it is the most appropriate power coal and fossil fuels. Therefore, Jungar coalfield is the largest comprehensive energy base in western China (Cui et al., 2002). In recent years, with the intensity of coal mining increasing, damage to coal mining is increasingly serious and the incurred engineering problems such as goaf overlying strata movement, surface deformation, and the acute weighting and pouring of water and sand of working faces are continuously compounded (Jin et al., 2010).

Chuancao Gedan coal mine is located in the midwest of Jungar coalfield. The recoverable reserve of the whole mine is 1205.57 Mt, with a designed production capacity of 10.00 Mt/a, and a length of service of 86.1 a. However, since there are many minable seams within the mine field, and the hydrogeological conditions are complicated under the mine, coal mining causes a series of negative environmental geology effects, such as overlying strata movement, roof collapse, water resources oversight, and ecological environment deterioration.

At present, there are many major research methods concerning the mine ground pressure and rock stratum

displacement law (Liu, 2015; Tu et al., 2011; Wei et al.). However, it is difficult to accurately predict and analyze its settlement law. Therefore, this paper adopts the method of similar simulation test (Wu, 2013; You, 2000; Zou, 2004) to perform a preliminary study on the law of overlying strata caving, fracture development and mine ground pressure of 4101 first coalface mining of Chuancao Gedan coal mine, which not only has theoretical and practical significance to working face safety mining design and controlling strata movement, but also provides a reference for the safe construction of similar projects in the future.

2. GEOLOGICAL BACKGROUND OF THE MINE PROJECT

Chuancao Gedan coal mine is affiliated with Changtan Township and Xuejiawan Town of Jungar Banner. The mine field is a polygon, with an east-west length of about 8.9 km, north-south width of about 5.5 km, and an area of 42.64 km². The first-mining coal seam is determined as No. 4 coal seam in the first level of the first panel, and the first-mining working face is determined as 4101 working face. The results of a rock mechanical properties test show that the overall intensity of the rock within the mine field is such that fine grained rock has greater crush resistance and shearing resistance than coarse grained rock. The rocks whose crush resistance ≤ 30 MPa account for 68%, and those between 30-60 MPa account for 32%. It indicates that for all kinds of rocks in coal measure strata of this mine field, they are mostly weak

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rock, or secondarily are half-hard rock.

3. SIMULATION EXPERIMENT

According to the data on coal mine drill, one must select representative regional strata as the geological model for the similar simulation test, conduct merging homogenization to the stratum stratification character, and establish an engineering geological model reflecting the roof and floor conditions of the coal seam.

The experiment adopts a self-developed plane stress frame model. The model frame is designed with a length of 3 m, height of 2 m, and width of 20 cm. The geometric similarity ratio is 1:100. Based on the histogram of No.Y14 drill hole of this mine, geometric similarity constant of the model is $\alpha_L=100$, density similarity constant is $\alpha_V=1.56$, and the stress similarity constant is $\alpha=\alpha_L\alpha_V=100\times1.56$.

Material used for the model includes quartz sand as aggregate, gypsum and calcium carbonate as the cementing material. This is then mixed with water in accordance with a certain proportion, laid in the model frame in layers, and mica powder is scattered between levels (Figure 1).

A self-developed multiple pressure computer data acquisition system conducts real-time monitoring on the coal column variation of stresses. 57 pressure sensors are arranged at the bottom of No.4 coal seam of the first mining simulation 4101 working face, and the simulation stands to confirm the rational supporting intensity of the force piece. Displacement monitoring is conducted for roof strata. Five measuring lines are arranged at 10 m, 30 m, 50 m, 70 m, and 90 m away from the coal seam roof. The displacement changes of roof strata and the advance of the working face are monitored.

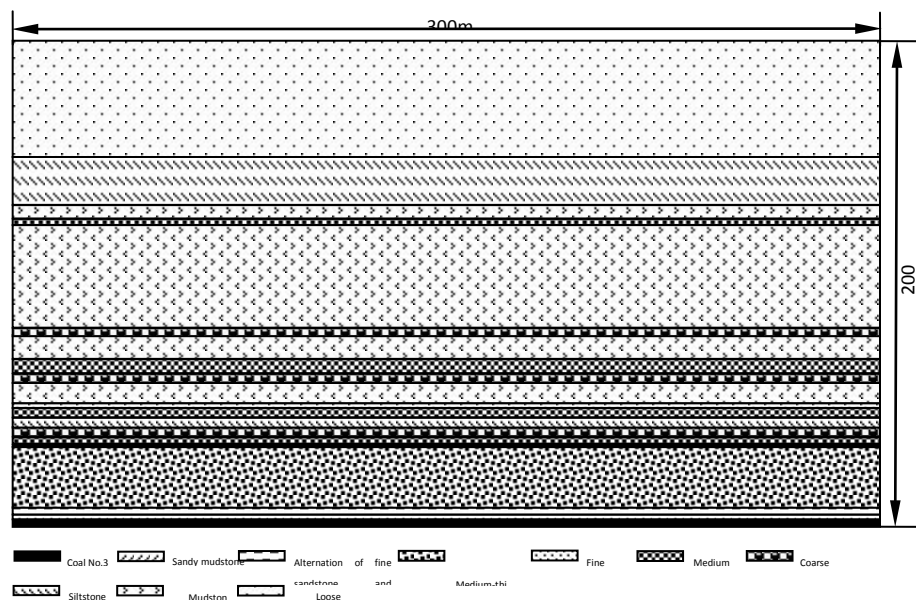


Figure 1: Profile map of simulation working face.

4. ANALYSIS OF EXPERIMENTAL RESULTS

4.1 First mining stage

4101 working face ranges from 2.55 - 3.95 m in thickness, with an average of 3.09 m. The coal property is hard, and the immediate roof is sandy mudstone of 1.5 - 2.1 m. In order to reduce the influence of refuse content during recovery and study the effect of the setting of roof-coal in working face advanced stages on the stability of roadway maintenance, coal seam thickness when filling the model ranges from 3.09 - 3.95 m, the full-seam mining of the working face in the first mining stage is 3.2 m with reserve, and roof supporting coal is set to 0.5 - 0.75 m, and support resistance is set according to 5 times the mining height.

Leave 30 m a boundary pillar when exploiting simulating mining the working surface, with an open-off

cut width of 6 m. When advancing the working face to 12 m, microcracks appear in the coal roof of the roof supporting coal; when advancing the working face to 14 m, the microcracks extend further. When advancing the working face to 16 m, microcracks appear in immediate roof stratum 1.5 m away from the coal roof along with the stratum direction. When advancing the working face to 22 m, microcracks in immediate roof stratum 1.5 m away from coal roof extend continuously. When advancing the working face to 26 m, the coal roof of the roof supporting coal generates an obvious separation layer, as shown in Figure 2 (a). When advancing the working face to 32 m, the roof supporting coal with has a suspended length of 7 m after support collapses (Figure 2 (b)). Advancing the working face to 40 m leaves no roof supporting coal in the working face advance, full-seam mining is 3.85 m, the lower stratum of the immediate roof and main roof in the

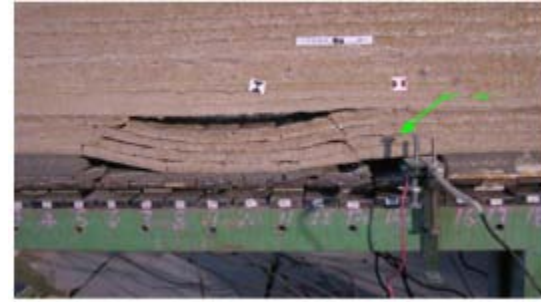
back of the stand fractures, and the upper end of the fracture line is 6 m away from coal roof. The lower end of the fracture line extends to the upward side in front of the stand, and the collapsed rock of fracture rock and goaf takes on a splicing structure with the advancing front of the working surface, and the support load shows no obvious lifting (Figure 2(c)).



(a) Separation layer of coal roof (the working face is to 26 m)



(b) Separation layer of coal roof (the working face is to 32 m)



(c) Separation layer of coal roof (the working face is to 40 m)

Figure 2: Deformation and failure process of roof strata in first mining stage.

Simulation test results show that when advancing the working face to 12.0 m, the reserved roof supporting coal starts to generate damage, until the advance reaches 36.0 m, when immediate roof stratum completely collapses. On this basis, it is deduced that under the circumstance of leaving the roof supporting coal, the first caving pace of the immediate roof is about 20.0 - 25.0 m. Since this experiment belongs to the “plane stress model” and there is no constraint in the front and back of the model, when fitting the model, the immediate roof is inclined to be hard.

It is held that the first caving pace of the immediate roof for first coalface is about 15.0 m. The experiment also shows that when the immediate roof first collapses, the support load has no obvious rise; under the condition of using the comprehensive mechanized coal mining, as long as the stand is in normal operating condition, there is no danger for first caving of the immediate roof, and it is unnecessary to take special protective measures.

4.2 Main roof (upper roof) first weighting

Synthesis analysis shows that the range of first weighting of the basic rock strata is between 44 - 48 m, confirming that the pace of the first weighting is 45 m - 50 m. During first weighting the dynamic load factor is 1.40, showing acute weighting. The caving zone height of the stratum is 14 m, which is about 4.5 times the average mining height. The fracture line of coal wall side is located at the upside of the support front, showing that the setting load of the simulation support designed according to 5 times of mining height is insufficient.

4.3 Periodic weighting of main roof

4.3.1 Weighting pace

The simulated working face is totally advanced at 192 m, showing 1 first weighting and 8 periodic weighting. When excluding the 6 m starting cut width, from the position of starting advancing for the working surface, the pace of the first weighting of basic rock strata is 45 m - 50 m. During 8 periodic weightings, the maximum weighting pace is 20 m, the minimum weighting pace is 14 m, and the average weighting pace is 17 m.

4.3.2 Loading-increasing factor

Based on the working resistance of the whole support, the loading-increasing factor during the weighting of working face is as shown in Table 1. Before periodic weighting, setting load of the support is calculated according to 5 times the mining height, and rises to 8 times the mining height after the first weighting. The maximum loading-increasing factor of the first weighting is 1.40, and the mean value of loading-increasing factor during the whole weighting is 1.32, according to mining pressure theory, the weighting approaching is “relatively strong”.

4.3.3 Roof cutting phenomenon

During the advance of the working face, though there is no roof strata cut falling along with the coal wall in front of the support, during the first, sixth and eighth weightings, the fracture line of roof strata of the coal wall side extends to the upside of the support, causing support load to rapidly increase; it is suggested to further raise the setting load on the basis of the calculation for 8 times the mining height, and adopt hydraulic supports with high resistance.

Table 1: Weighting loading-increasing factor of the first mining face

Indicator weighting	Loading -increasing factor	Mean value
First weighting	1.40	1.32
1 st periodic weighting	1.32	
2 nd periodic weighting	1.32	
3 rd periodic weighting	1.33	
4 th periodic weighting	1.22	
5 th periodic weighting	1.28	
6 th periodic weighting	1.37	
7 th periodic weighting	1.30	
8 th periodic weighting	1.35	

4.3.4 Distribution of three zones

The height of the stratum caving zone is 14 m, which is about 4.5 times the average mining height. The range of the fissure zone is 14 - 43 m, the height of the whole fractured zone is 43 m, which is about 14.5 times the average mining height; the area that is over 43 m from the coal roof is the bending zone, and the stratum takes on the characteristic of overall downward movement (Figure 3).

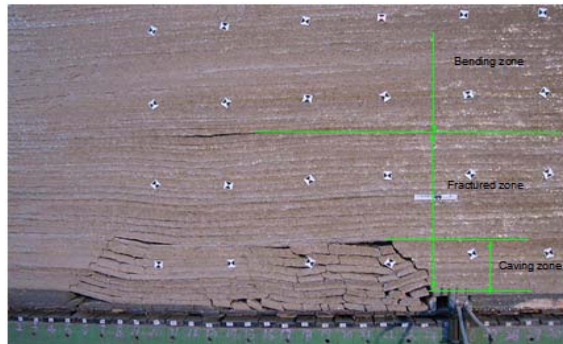


Figure 3: Distribution of vertical three zones of the overlying strata.

5. CONCLUSION

Simulation results show that the first caving pace of the immediate roof of first coalface is about 15.0 m. When the immediate roof first collapses, support load has no obvious rise. As long as the stand is in normal operating condition, there is no danger for caving of the immediate roof, and it is unnecessary to take special protective

measures. Meanwhile, it is important to ensure the setting load of the support to effectively maintain the roof of the head face.

For the main roof (upper roof) stratum, the first weighting pace is 45 m - 50 m, and average pace of periodic weighting is 17 m. The maximum loading-increasing factor of first weighting is 1.40, and the mean value of loading-increasing factor of the whole weighting period is 1.32. According to mining pressure theory, the weighting approaching is "obvious".

In the distribution of the three zones of the overlying strata on the first coalface, the height of the caving zone is 14 m, which is about 4.5 times the average mining height. The range of the fissure zone is 14 - 43 m, the height of the whole fractured zone is 43 m, which is about 14.5 times the mining height. The bending zone is the stratum over 43 m away from the coal roof, which takes on the feature of overall downward movement.

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