Experimental Investigation for Water Flowing Fractured Zone Due to Coal Mining Under Sea Area

W. X. Wang, W. Hu, and Y. K. Liang

Abstract

This paper presents an experimental investigation of development of water flowing fractured zone due to coal mining under sea area by scaled model test. Two models are designed to simulate coal mining along the strike and the dip. In model 1, the thickness of the overburden varies from 74 to 124 m and coal seam dips at an angle of 8°, and model 2 with a overburden thickness of 90 m and a dip angle of 0°. The results indicate that the height of overburden caving and water flowing fractured zones both increase at first then decrease to a comparatively stable values with the mining distance increasing; the height of overburden water flowing fractured zone increases significantly with the thickness of the overburden increasing and the height of overburden caving zone does not. When the coal mining thickness is 6 m, the maximum height of overburden water flowing fractured zones is 64.16 m (in model 1) and 48.20 m (in model 2), the maximum height of overburden caving zones is 12.76 m (model 1) and 12.00 m (model 2), respectively. The research results provide a helpful basis for upper mining limit decision-making and risk assessment.

Keywords

Water flowing fractured zone • Experimental investigation • Mining under sea • Upper mining limit

1 Introduction

The observation methods of ultrasonic imaging, parallel network electricity method CT, physical simulation, numerical simulation, drilling hole for injecting water experiment and so on are used to observe the overburden fracture due to coal mining (Sun et al. 2009; Liu et al. 2011). The mechanism and prevention on quicksand hazards in underground coal mines has been studied by many researchers (Sui et al. 2007, 2008; Xia et al. 2008).

Until now, only few countries have had the experience in mining under sea, which are England, Australia, Chile, Japan, Canada and so on(Sun 1998; Peng et al. 2011). The minimum thickness of overburden for mining under sea is 46 m in Australia, 60 m in America and 60–100 m in Japan by longwall collapse mining, respectively.

The Beizao Coalmine is located in Shandong Province, China. It has about more than 10 millions tons coal resources under sea area with an overburden thickness of less than 105 m. With the coal mining thickness of 6 m the water flowing fractured zones may conduct the upper aquifer and most panels are facing water inrush hazards. A safety mining verification must be carried out when the thickness of overburden is between 80 and 105 m.

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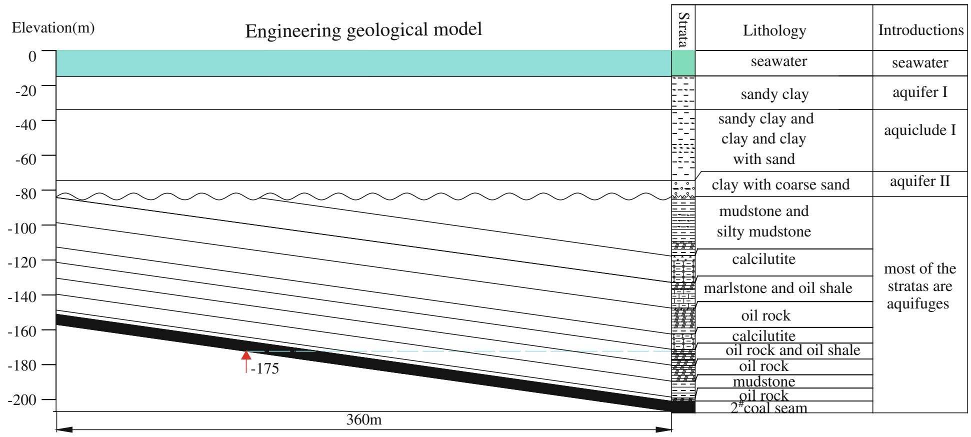
Fig. 1 Engineering geological model



2 Hydrogeoloical and Engineering Geological Conditions

The coalmine faces south coast of the Bohai sea and the No. 2 coal hides in the Tertiary strata with a dip angle of 8°and thickness of 6 m. The overburden strata are mainly mudstone, calcicutite, and oil shale, the uniaxial compressive strengths of which are mostly lower than 30 MPa. Most of the strata are aquifuges which can disconnect the hydraulic relationship between the aquifer I and No. 2 coal seam.

The Quaternary strata in this area encompass two aquifers inter-bedded by one aquifuge as shown in Fig. 1. The aquifer I with a maximum thickness of 17.83 m consists of sandy clay and has a specific capacity of 0.1186–3.713 L/s m. The aquifuge I with a minimum thickness of 31.79 m is composed by sandy clay and clay. It constitutes a regional aquifuge and disconnects the hydraulic relationship between the aquifer I and II. The aquifer II with a thickness of 10.07 m in maximum consists of clay with coarse sand and has a specific capacity of 0.249–1.094 L/s m.

3 The Experimental Model

In this paper, two models are designed to simulate coal mining along the strike and the dip of Panel H2303. The main purpose of the experiment is to investigate the overburden failure due to mining in an elevation of −175 m and deeper. In model 1, the thickness of the overburden varies from 74 to 124 m and coal seam dips at an angle of 8°, and model 2 with the overburden thickness of 90 m (where the elevation is −175 m) and a dip angle of 0°.

The scaled models designed should follow the laws of similarity, which is described as the follow formulas: $l_p : l_m = c_l,\ \gamma_p : \gamma_m = c_\gamma,\ t_p : t_m = c_t$, here l = geometric parameters, γ = bulk density, t = mining time, and subscript p represents real parameters, subscript m represents model parameters. c_l , c_γ , c_σ , c_t are similarity ratios and $c_l = 200$, $c_\gamma = 1$, $c_\sigma = 200$, $c_t = \sqrt{200}$.

In the models, the compensation of horizontal stress and vertical stress are 60 and 70 kPa separately according to earth stress measurements.

The two models' sizes both are 1.8 m × 0.3 m × 0.8 m. The materials used in the models are blancfixe, gypsum, calcium carbonate stone powder, quartz sand, glycerol, and we mixed them in different proportion to gain the suitable strength to every layer. Figure 2 shows the design of model 1.

In model 1, the open-off cut was set at the point that was correspond to the elevation of −175 m in actual as shown in Fig. 3. The coal seam with length of 1.6 cm and thickness of 3 cm would be mined in every 1.69 h from the open-off cut to the right side of model 1, the development of the water flowing fracture was observed by digital camera.

In model 2, the mining method is similar to model 1, the whole mining distance is 100 cm and 40 cm coal seam was left in two sides of model 2 to avoid the boundary effects.

4 Results and Discussions

The model 1 results indicate that when the mining distance is less than 60 m, the height of overburden caving and water flowing fractured zones are the same and increase with mining distance increasing. The height of overburden caving reaches the peak (12.76 m) at the mining distance 60 m and decreases to 8–12 m with the mining distance increasing. However, the height of water flowing fractured zones increase until the mining distance being 210 m when it reaches the peak (64.14 m), then it decreases to 54–64 m with the mining distance increasing which shows a "saddle shape", as shown in Fig. 3. In Model 2 the maximum height of overburden caving and water flowing fractured zones are 12.0 m at the mining distance 80 and 48.20 m at the mining distance 150 m, respectively.

Fig. 2 The experimental model 1

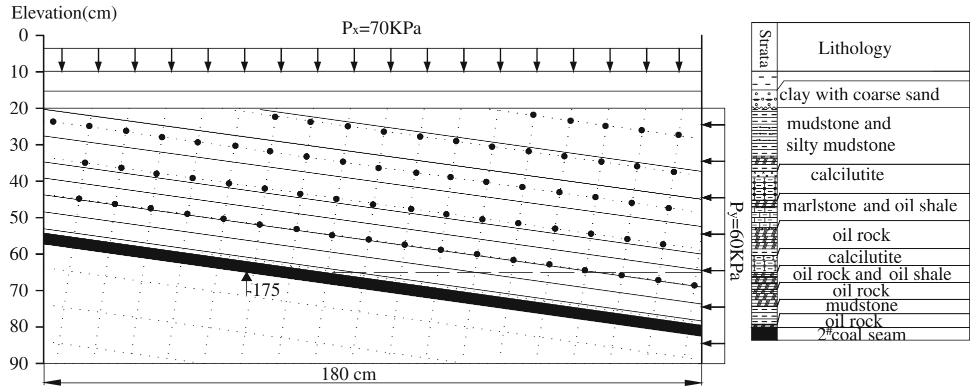
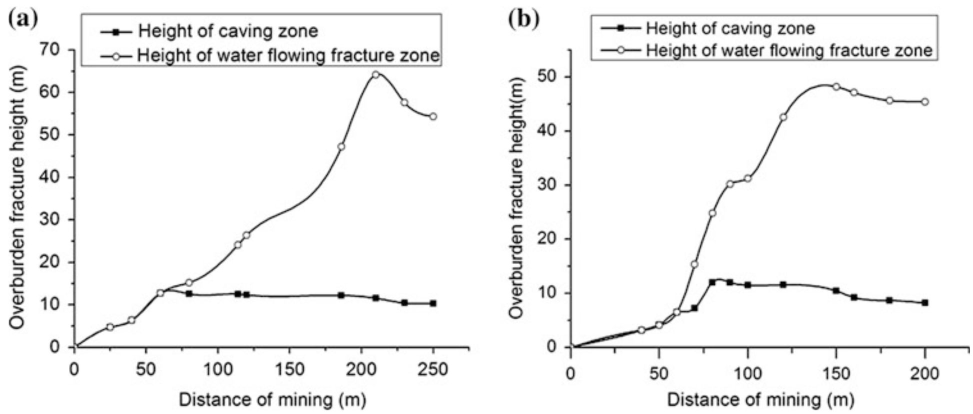


Fig. 3 Overburden failure height with distance of mining



The maximum height of overburden water flowing fracture is 64.16, according to Chinese coal mine of preventing water regulation, 3 times of coal mining thickness should be added for security considerations. It will be dangerous for mining when the overburden thickness is thinner than 82.16 m, and the upper mining limit determined at elevation of −175 m (overburden height is 90 m) should be safe.

5 Conclusions

a) The height of overburden caving and water flowing fractured zones both increase at first then decrease to a comparatively stable values with the mining distance increasing; the height of overburden water flowing fractured zone increases significantly with the thickness of the overburden increasing while the height of overburden caving zone does not.
b) The maximum height of overburden water flowing fracture is 64.16 m. with 3 times of coal mining thickness added, for much safer mining the overburden thickness must be thicker than 82.16 m, and the upper mining limit determined at elevation of −175 m (overburden height is 90 m) should be safe.

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