

# FLAC3D Simulation Analysis of the Extended Height of the Water-induced Fracture Zone in Different Coal Seams

Yanhao Chen <sup>a</sup>, Qian Yu, Yukun Cao, Tingyuan Ye, Jianyuan Zhang

College of Mining and Safety Engineering, Shandong University of Science and Technology, Qingdao, China

<sup>a</sup> 529614271@qq.com

**Abstract.** Most and local minable seam in mining field has seven layers, according to the label from top to bottom in turn as follows: 13, 12, 10, 9, 8-3, 8-2, 8-1. coal, total minable seam thickness of 21.92 m, dip angle of coal seam located between 4° and 24°, is nearly horizontal seam. The average thickness is 116.48m. Given the existence of tertiary pore fissure aquifer, in order to predict effectively the impact of the aquifer on site production when seven layers of coal are mined, this paper uses FLAC3D numerical simulation for comparative analysis of the coal mining water fractured zone height, which determine the safe mining boundary thereby provide theoretical guidance for the field working face layout, mining area connection and other safety production.

## 1. Introduction

Often exist in engineering rock mass joints and fissures and cracks on the surface of the weak development degree, distribution density and mechanical properties determine the shape, location and size of structure, and control are the important factors of rock mass stability, rock mass strength. For coal mine, the coal extraction, the overlying strata movement damage, above the goaf formed "three zones", namely the caving zone, fractured zone and bend zone, caving zone above a certain range of rock fracturing, cracks; And the range of rock formations with water conductivity is called [1]. Lead water fracture zones is mining overlying rock destruction form in a crack in the channel, in the mine roof water inrush, mining under water body and protective exploitation of gas control, water and height of fractured zone is an important research content.

The continuous decrease of recoverable coal resources with the eastern part of our country and the constant improvement of the overall level of mining technology, nearly aquifer, in expanding the size of the earth's surface mining under waterbodies, coal mining water fractured zone height research also in unceasingly thoroughly, its increasingly important significance of science and technology. After the coal seam mining, the development height of the guide water fracture zone is an important field in the study of many coal workers in recent years [2-4]. [5] the method of RFP numerical simulation is adopted to solve the development height of the water-induced fracture zone. Zhang wenzhong et al. [6] used similar material simulation method to solve the development height of the guide water fracture zone; The calculation formula [7] is also recommended for the calculation of the height of the water fracture zone in the coal mine control water regulation. RFP numerical simulation and similar material simulation method is not intuitive and is controlled by human factors more, time consuming and



laborious. Therefore, this paper will use FLAC3D to simulate and analyze the expansion height of the water-induced fracture zone of different coal seams.

FLAC3D is an extension of two-dimensional finite difference program FLAC2D, which can conduct simulation and plastic flow analysis of three-dimensional structure of soil, rock and other materials. The actual structure is fitted by adjusting the polyhedron element in the 3d mesh. A linear or nonlinear constitutive model can be used in the unit material. Under the action of external forces, the grid can deform and move (large deformation mode) when the material is subjected to yield flow. FLAC3D adopts explicit Lagrange algorithm and hybrid - discrete partitioning technology, which can simulate the plastic damage and flow of materials very accurately. Since the stiffness matrix is not required, a large range of 3d problems can be solved based on smaller memory space.

#### 1. Determination of simulation scheme.

Combined with the specific geological data, in the premise that the simulation results are not affected, the strata with relatively small thickness and similar lithology (such as fine sandstone and siltstone) are merged into one layer. The name and thickness of specific rock formations are shown in table 1.1.

To monitor the displacement of aquifer effectively, the monitoring line is set up at the bottom of the aquifer, and the location stress and displacement of the bottom plate of aquifer are monitored. Combined with the specific situation of the field of coal seam mining, the excavation of the 600 m within the scope of overburden is enough to achieve full mining influence boundary, analysis of the regularity of overburden rock plastic zone, combined with the overburden rock stress and displacement evolution rule, determine 8-1 after coal mining overlying aquifer influence on the situation.

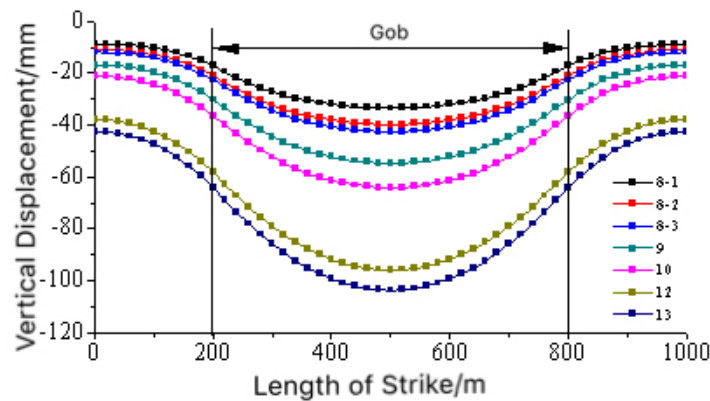
8-1 coal simulation finished, in the same way gradually 8-2 coal, coal 8-3, 9, 10, 12, 13 coal excavation coal, coal and strata stress, displacement and plastic zone evolution analysis, make sure all all the developing regularity of plastic zone after the mining of coal seam, the analysis of the plastic zone connection with overlying aquifer.

**Table 1.** name and thickness of specific rock formations.

Lithology	Thickness/m	Lithology	Thickness/m
Gritrock	73.8	13Coal	3.2
Sandstone	30	12Coal	2.4
Sandstone	42.6	11Coal	0.6
Sandstone	81.4	10Coal	4.6
Sandstone	22.4	9Coal	2.1
Siltstone	34.9	8-3Coal	1
Siltstone	8	8-2Coal	3.4
Packsand	13.6	8-1Coal	1.4
Packsand	39.6	Siltstone	50
Mudstone	8	Sandstone	117
Mudstone	160		

## 2. Analysis of simulation results.

### 2.1. analysis of displacement evolution law.

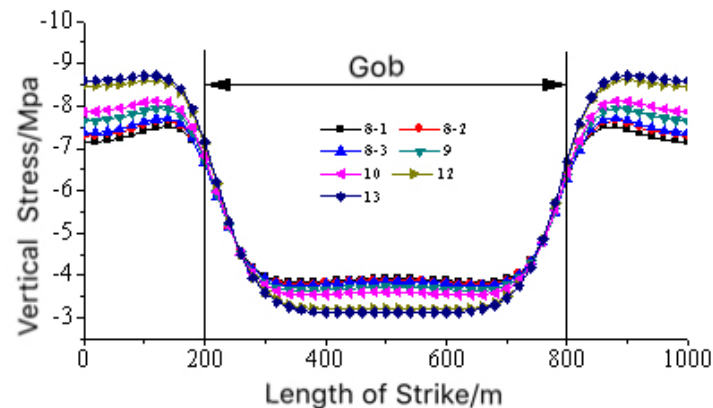


**Figure 1.** vertical displacement evolution of aquifer floor.

The evolution rule of vertical displacement of the bottom layer of aquifer of 8-1 coal seam is shown in Figure. 2.1. After the excavation of coal seam and strata have a certain degree of sinking, the roof strata subsidence of coal seam is high, but in the aquifer bottom position, aquifer close to overall sinking, and the subsidence is smaller. After the 8-1 coal seam was extracted, the maximum subsidence of the aquifer was 33.47mm. The maximum subsidence of the aquifer after the mining of 8-2 coal seam reached 39.77mm; After the mining of 8-3 coal seam, the subsidence amount is 42.55mm; After coal mining, the subsidence rate is 54.64mm; After coal mining, the subsidence amount is 64.19mm; After coal mining, the subsidence rate is 95.81mm; After coal mining, its subsidence amount reached 103.7mm. At the bottom of the aquifer is a 8m thick mudstone layer, which is difficult to extend to the aquifer under the small subsidence.

### 2.2. analysis of stress evolution law.

The vertical stress evolution law of the bottom layer of the aquifer above 8-1 coal seam is shown in Figure. 2.2. After the coal seam is excavated, the unloading belt will be formed within a certain range in the excavation area. Aquifer bottom position embedded depth of 277 m, the registry location of rock 23 kn/m<sup>3</sup>, the average density of position should be the original rock stress is about 6.371 MPa, in coal seam 8-1 after extraction, aquifer bottom position to reduce the vertical stress is 3.932 MPa, it decreased to 61.7% of the original rock stress at this time; The vertical stress of the bottom plate of the aquifer after the mining of 8-2 coal seam decreased to 3.893MPa, and the stress decreased to 61.1% of the original rock stress. After the mining of 8-3 coal seam, its vertical stress decreased to 3.868MPa, and the stress decreased to 60.7% of the original rock stress. After coal mining, its vertical stress decreased to 3.731MPa, and the stress decreased to 58.6% of the original rock stress. After 10 coal mining, its vertical stress was reduced to 3.61MPa, and the stress decreased to 56.7% of the original rock stress. After coal mining, the vertical stress decreased to 3.218MPa, and the stress decreased to 50.5% of the original rock stress. After coal mining, the vertical stress decreased to 3.135MPa, and the stress decreased to 49.2% of the original rock stress.



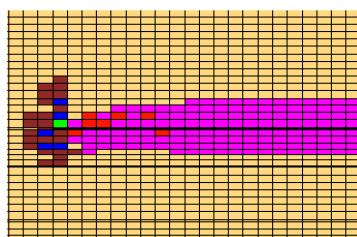
**Figure 2.** vertical stress evolution law of the bottom plate of aquifer.

### 2.3. analysis of the evolution law of plastic zone.

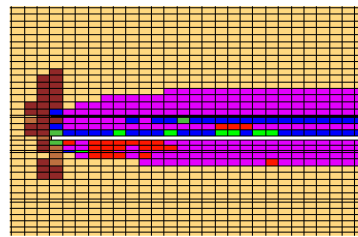
In FLAC3D, after excavation, is the scope of the plastic zone of surrounding rock under the action of stress redistribution produced the plastic damage area, within the region that contains internal crack extension of the plastic damage area, and not to produce crack only the area of plastic flow failure happens, by simulation of the plastic zone as conservative forecast water fractured zone height is reasonable and feasible.

In the whole Figureure, the plastic zone is relatively small, because the evolution rule of the plastic zone is symmetrical distributed along the direction of the direction, and the intercept model is half as large as the length, as shown in Figure. 2.3.

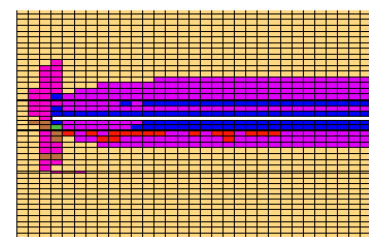
After the coal seam is excavated, the plastic damage zone is formed in the overlying strata. It can be seen that, with the increase of the number of coal seam mining layers, it is not obvious that the plastic failure zone of overlying strata is extended upward. After 8-1 coal seam mining, the overburden plastic zone range extended to seam above 24.1 m, two shoulders angular position in excavation area, the plastic zone height reached 46.6 m above the coal seam, the remaining coal excavation in succession, but above the coal seam 8-1 general scaling up of the plastic zone are not obvious. Layer 7 after coal mining, the plastic zone extended range while retain the original height, namely two shoulders angular position in the mining area, the extended to 8-1 coal above 46.6 m, in the central mining area, the plastic zone only extended to 8-1 coal seam above 24.1 m.



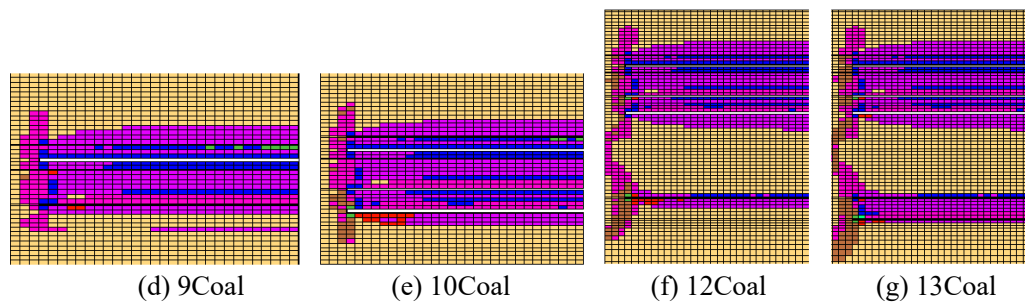
(a) 8-1Coal



(b) 8-2Coal



(c) 8-3Coal



**Figure 3.** enlarged image of plastic zone evolution.

### 3. Determination of waterproof coal (rock) column.

At the end of the seven-layer coal mining, the extension range of the two-shoulder position plastic zone in the mining area is relatively high, and it is extended to 46.6m above 8-1 coal. Based on the calculation formula of the waterproof coal (rock) column, the height of the waterproof coal (rock) column at this time is:

$$H_f = H_L + H_b = 46.6 + 10.36 = 56.96\text{m}$$

### 4. conclusion

(1) after the coal seam excavation, the overburden caused a certain degree of subsidence. In aquifer bottom position, aquifer near a whole sink, but the quantity is small, the at the same time in the aquifer beneath a 8 m thick mudstone water-resisting layer, subsidence, is in the lower coal seam mining lead water fracture zones is difficult to extend to the aquifer.

(2) after the coal seam is excavated, the unloading pressure zone shall be formed within a certain range in the excavation area. After the coal seam is excavated, it is affected by the unloading pressure, and its vertical stress is not much different in the bottom of aquifer.

(3) after the coal seam is excavated, the plastic failure zone is formed in the overlying strata. With the increase of the number of coal seam mining, it is not obvious that the plastic failure zone of overlying strata is extended upward. At the end of the seven-layer coal mining, the extension range of the two-shoulder position plastic zone in the mining area is relatively high, and it is extended to 46.6m above 8-1 coal, and the height of the reasonable waterproof coal (rock) column is 56.96m.

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