Study on the block-water capability of main roof structures of steep coal seams with fully-mechanized caving

ZhiQuan Yu

School of Transportation Science and Engineering,

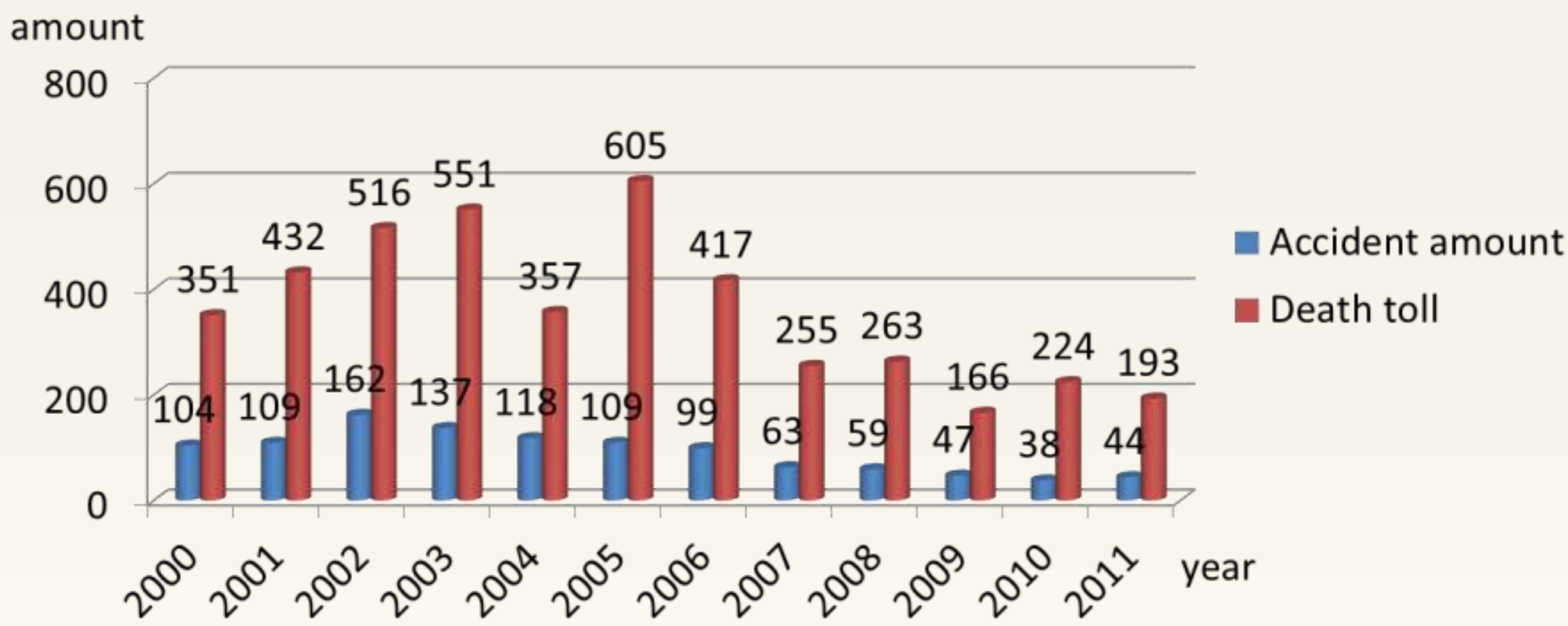
Beihang University

2016.12.15

Contents

Contents

Water disasters of coal mining



Statistical data of casualties due to water disasters of coal mining in China

Water disasters of coal mining




Water disasters of coal mining

According to incomplete statistics, in the past twenty years:

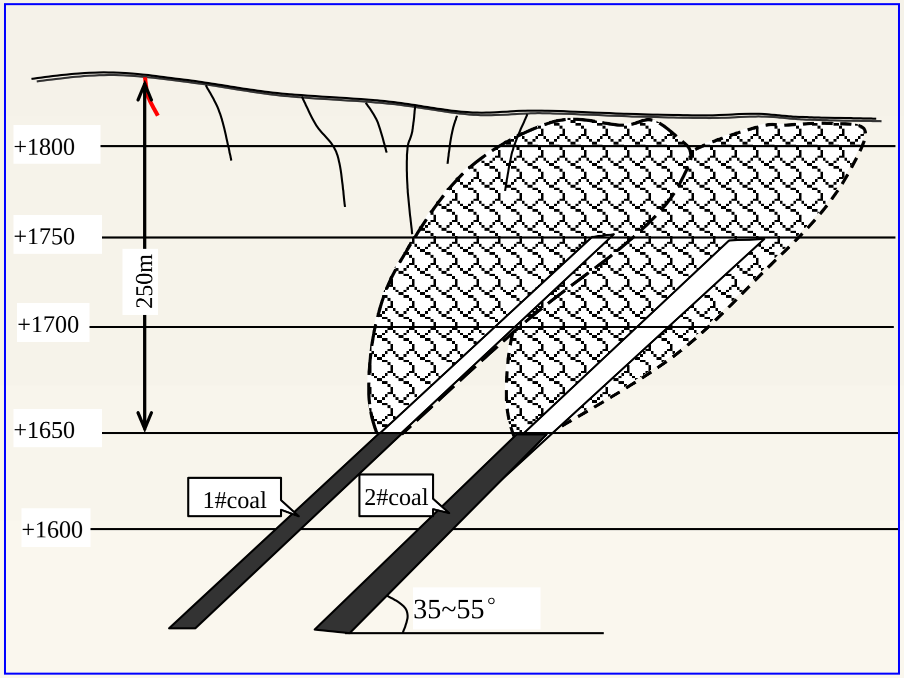
◆more than 220 mines were flooded

◆economic losses was up to ¥300 billion

Atmospheric precipitation and surface water are two of the main factors of water disasters in coal mining.

Steep coal seams

- With an inclination angle between 35° and 55° .
- Account for approximately 20% of the proven reserves of coal mine and 10% of the coal yield in China.
- more than 50% are high quality coking coals and anthracites.



Steep coal seams

Western mining areas:

➢Steep coal seams account for about 30% of the total coal reserves

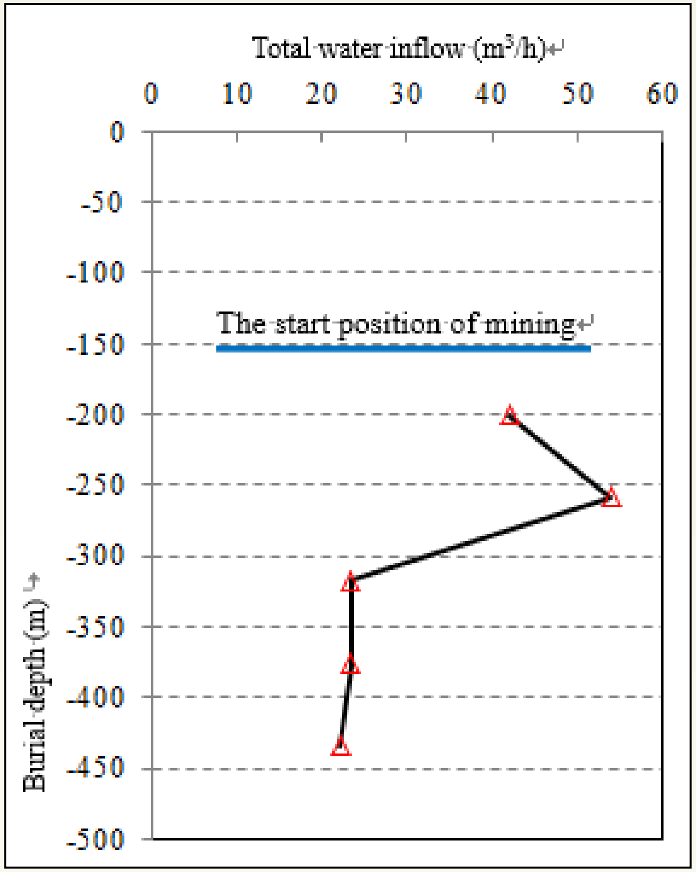
➢There are steep coal seams in over 50% of mines

Eastern and Central mining areas:

➢High-intensity mining causes that complex large dip or steep coal seams become the mining focus

Contents

Research background



Initial conclusion

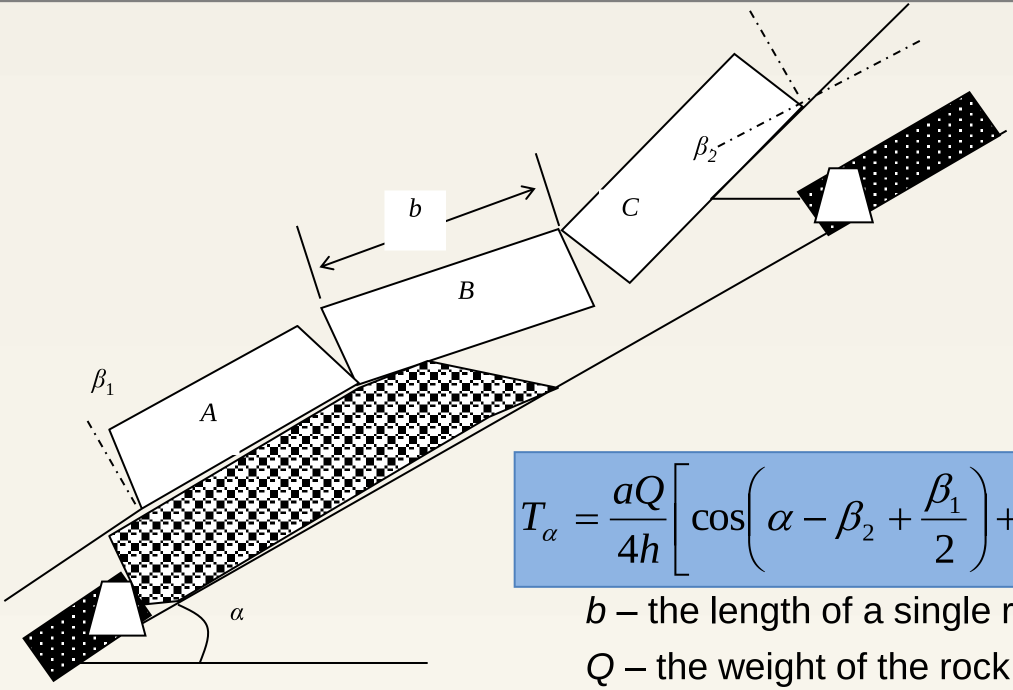
The total water inflow decreases with the increasing of burial depth.

Fractures of the overlying rocks are closing.

The main roof structure in the direction of inclination can prevent water to a certain extent.

Contents

Theoretical equation



(Pingwu Shi)

$$T_\alpha = \frac{aQ}{4h}\left[\cos\left(\alpha-\beta_2+\frac{\beta_1}{2}\right)+\cos(\alpha+\beta_2)\right]-\frac{Q}{4}\left[\sin\left(\alpha-\beta_2+\frac{\beta_1}{2}\right)-\sin(\alpha+\beta_2)\right]$$

b – the length of a single rock in the direction of inclination, m;

Q – the weight of the rock making up the main roof, $Q=bhL\gamma$, kN;

h – the thickness of the main roof that is involved in a single weighting, m;

L – the weighting distance of the main roof, m;

γ – the bulk density of the rock making up the main roof, kN/m^3;

α – the coal seam's inclination angle, °;

β_1 – the angle of rotation of gangue-filled lower rock A during weighting, °;

β_2 – the angle of rotation of upper rock C, °;

β_2 - (β_1/2) – the angle of rotation of the rock in the middle, °.

Theoretical equation

$$\gamma_w H_\alpha + \bar{\gamma} H_\alpha \le T_\alpha \sin\alpha$$

γ_w – the bulk density of water, which is normally 10 kN/m^3;

γ- the average bulk density of the rock above the mining surface, kN/m^3;

H_α – the burial depth of the main roof, m.

$$H = H_\alpha + H_{dr} + H_{fr} + h$$

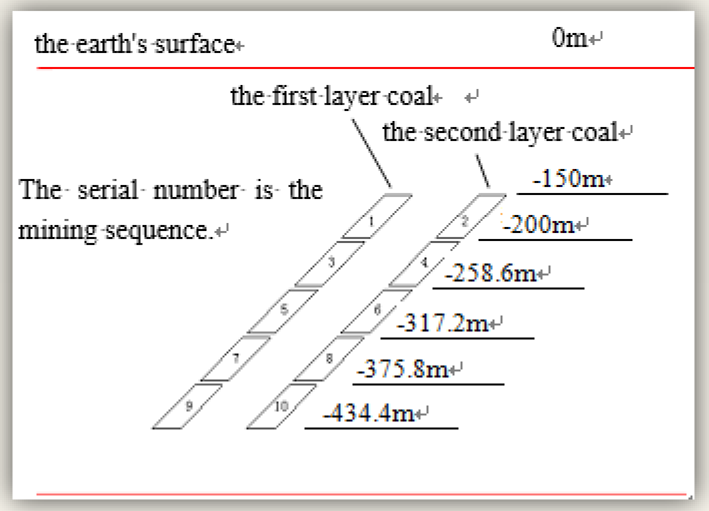
H_{dr}—the height of the direct roof, m;

H_{fr}—the height of the false roof, m;

the meanings of H_α and h in these equations are the ones given previously

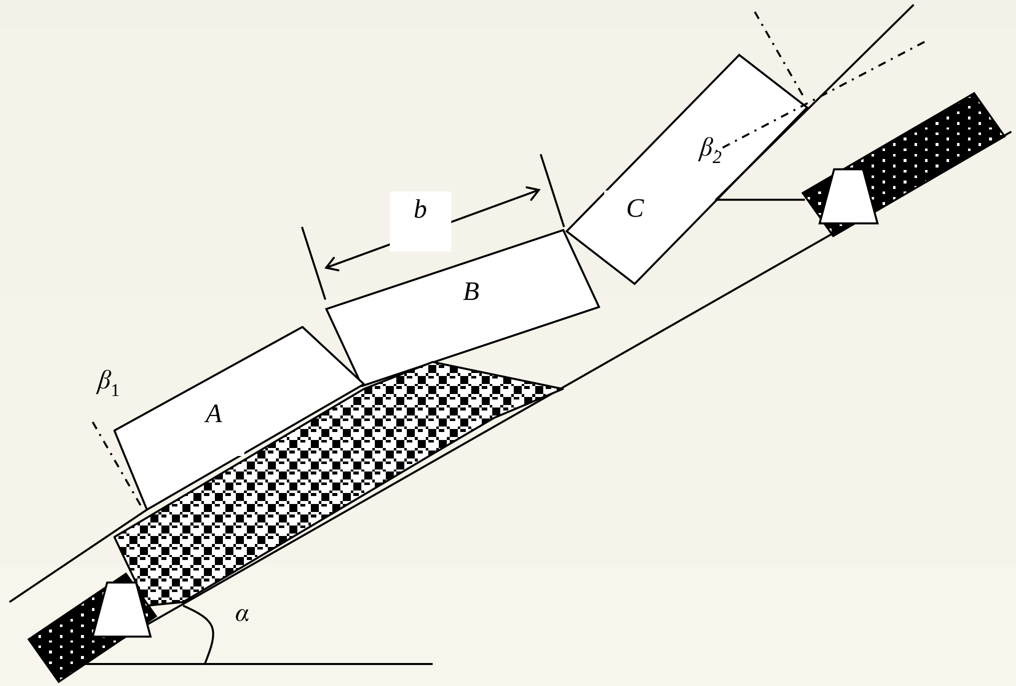
Contents

Similar material simulation experiment



Similar material simulation experiment(300:1)		
Strike length(m)	Single vertical mining height(m)	Coal pillar vertical height(m)
400	50	8.6

Similar material simulation experiment



Similar material simulation experiment(300:1)			
h(m)	L(m)	β_1(°)	β_2(°)
7	18.5	5	10

Similar material simulation experiment

Similar material simulation experiment(300:1)			
h(m)	L(m)	β_1(°)	β_2(°)
7	18.5	5	10

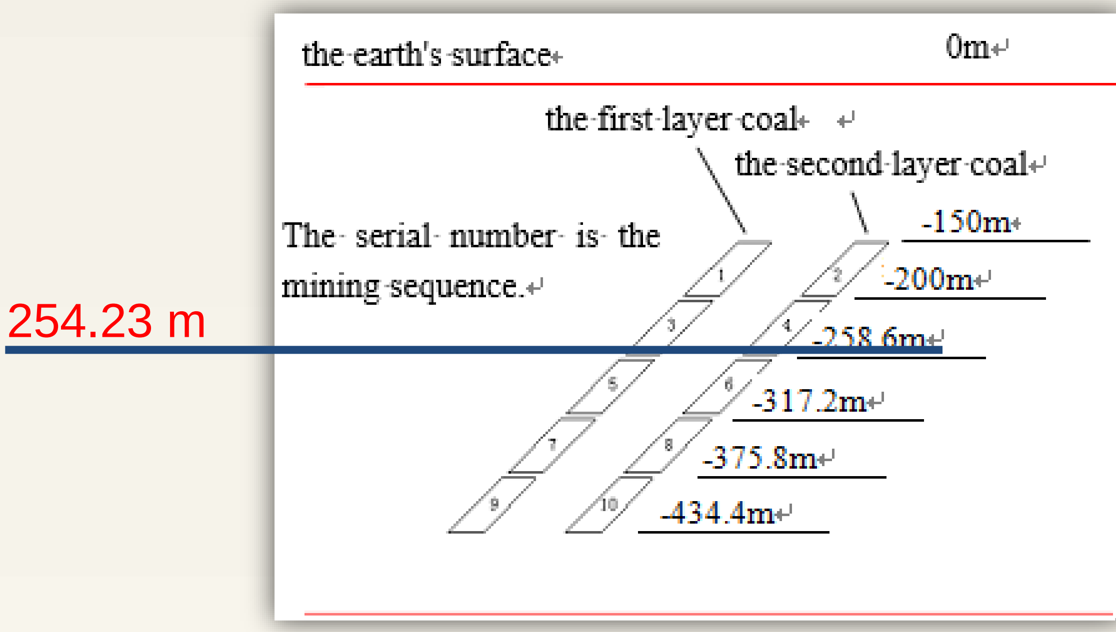
$$T_\alpha = \frac{aQ}{4h}\left[\cos\left(\alpha-\beta_2+\frac{\beta_1}{2}\right)+\cos(\alpha+\beta_2)\right]-\frac{Q}{4}\left[\sin\left(\alpha-\beta_2+\frac{\beta_1}{2}\right)-\sin(\alpha+\beta_2)\right]$$

Class of rocks	Bulk density (kN/m³)	Internal friction angle (°)	Cohesion (MPa)	Tensile strength (MPa)	Compressive strength (MPa)	Elasticity modulus (GPa)	Poisson ratio
IV	22~24	27~38	0.5~1.0	0.2~0.5	1.6~4.1	2~6	0.325
V	19~22	<27	<0.5	<0.2	<1.6	<2	>0.35

$$\gamma_w H_\alpha + \overline{\gamma} H_\alpha \le T_\alpha \sin\alpha$$

$$H = H_\alpha + H_{dr} + H_{fr} + h$$

Similar material simulation experiment

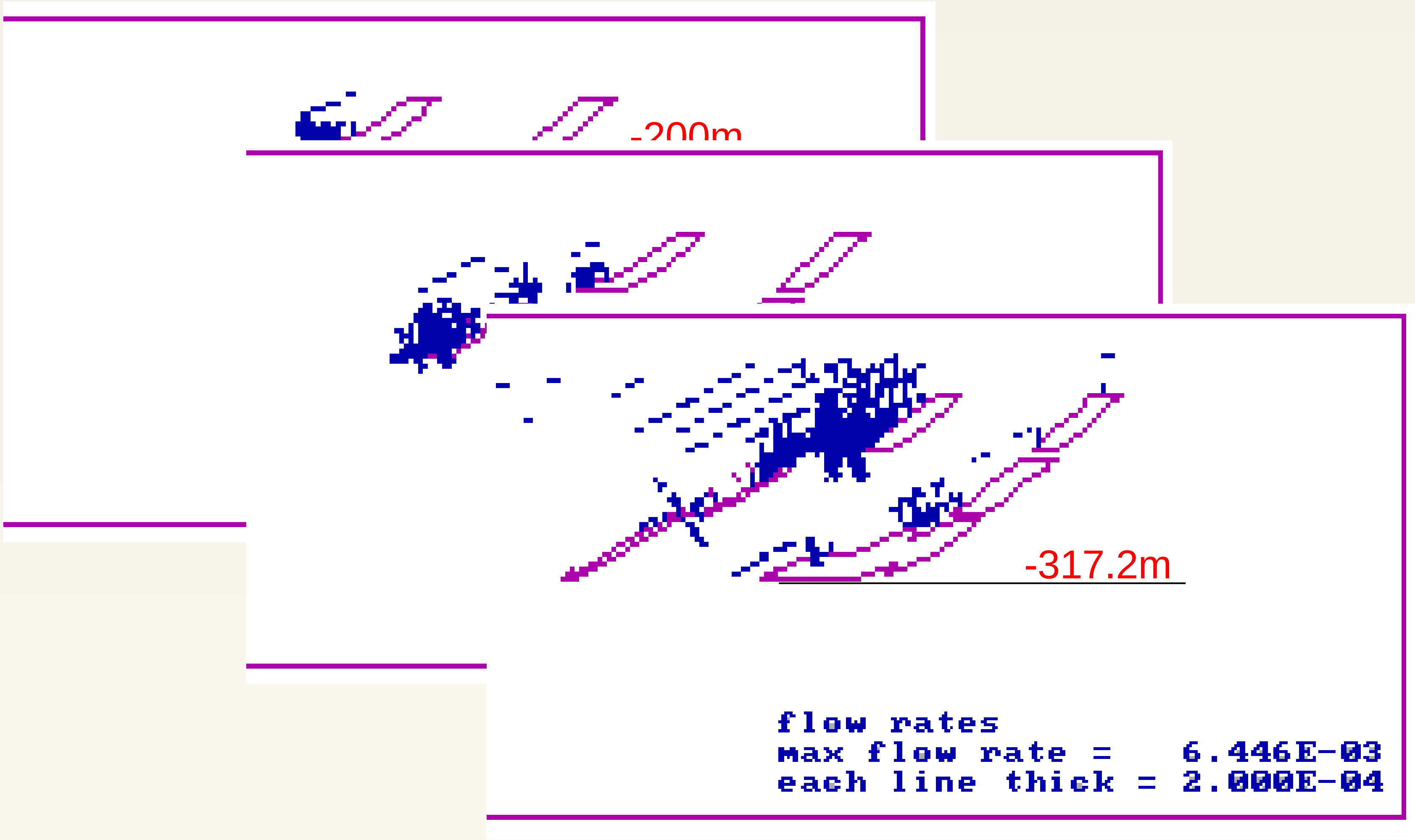


The result of this calculation is 254.23 m, aligns with the situation monitored onsite.

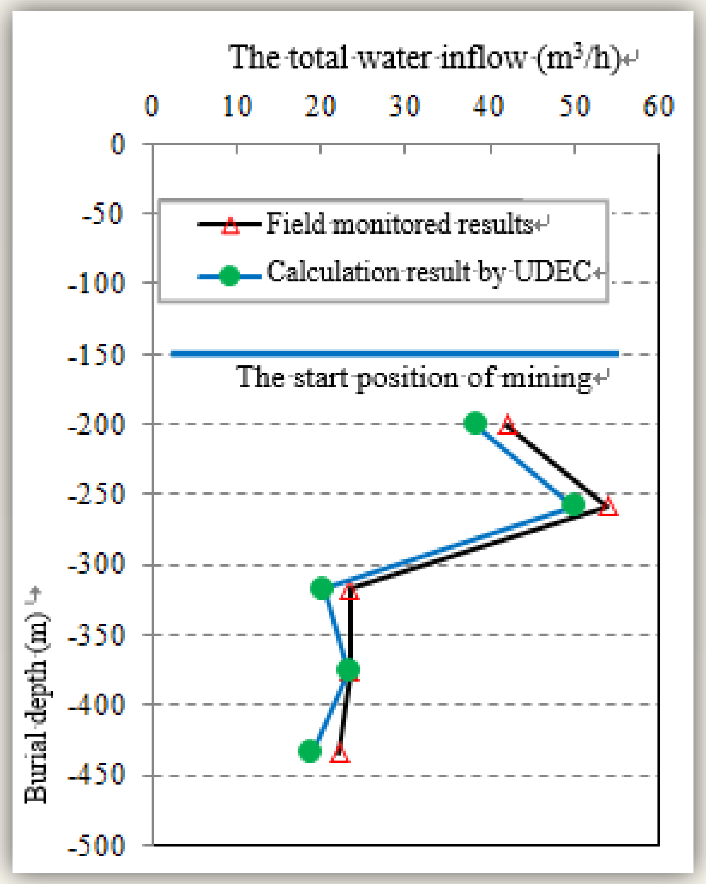
Is it reasonable?

Contents

Numerical calculation--UDEC2d



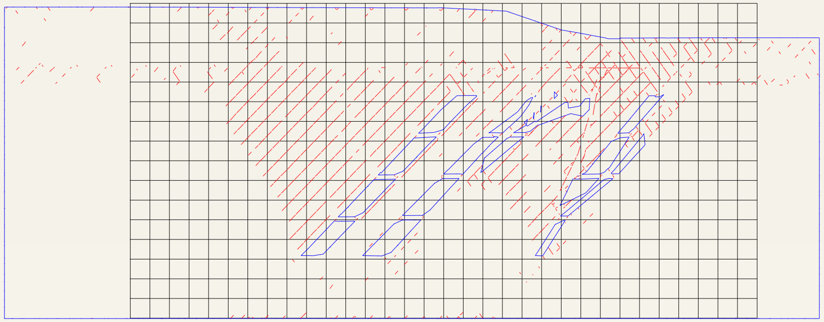
Numerical calculation--UDEC^{2d}



- The calculated and field monitored results exhibit identical trends in their variations.
- The main roof structure formed in the direction of inclination becomes waterproof.

Why?

Fracture analysis– fractal method



- The fractal method was applied, and the fractal dimension was obtained by changing the degree of macroscopical visualization.
- For the fractal meshing of the overlying strata, the vale of r are 250m，125m，62.5m，31.25m and 15.625m respectively.

Fracture analysis- fractal method

For open fractures:

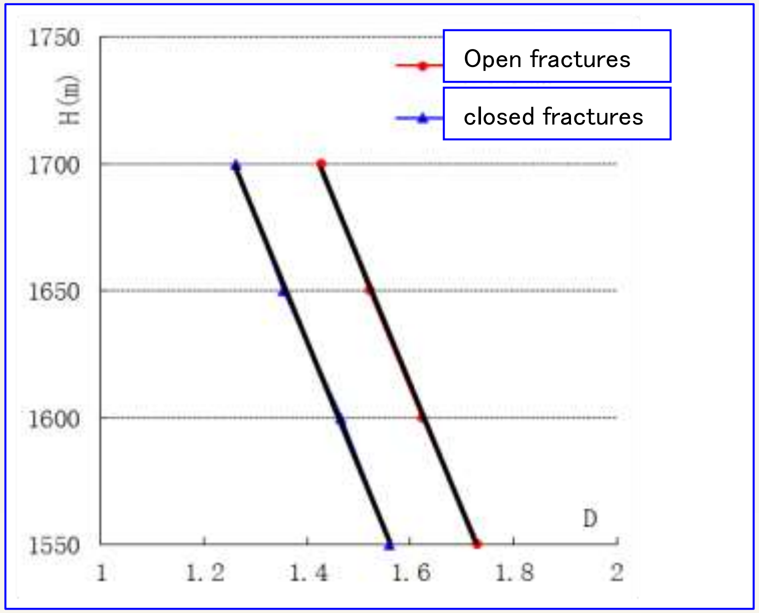
$$H = -492.78D + 2401.4 \qquad R^2 = 0.9991$$

For closed fractures :

$$H = -495.94D + 2324.4 \qquad R^2 = 0.9987$$

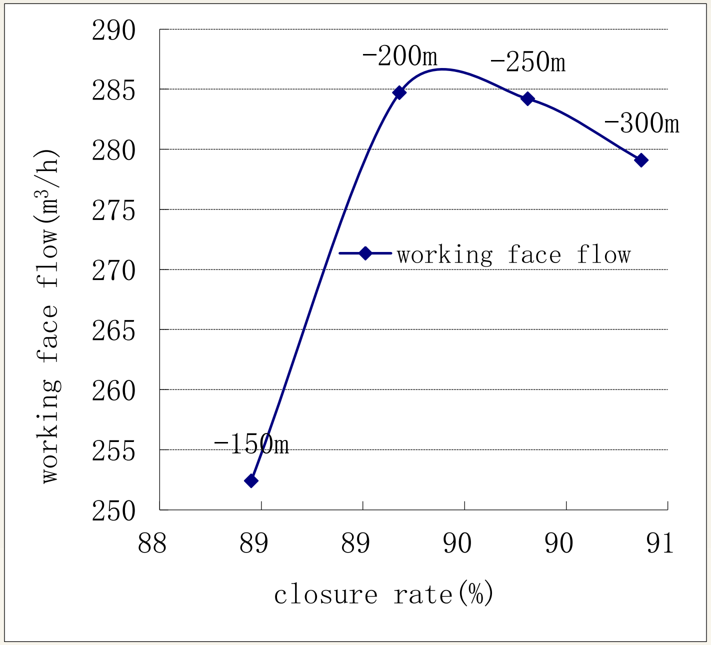
Fracture closure rate:

$$R = \frac{D_{open}}{D_{closed}} \times 100\% = \frac{495.78}{2401.4 - H} \times \frac{2324.4 - H}{495.94} = 0.9936 - \frac{76.5}{2401.4 - H}$$



The relation curve between the flaws in hanging strata and fractal dimensions

Fracture analysis- fractal method



As the depth of mining increasing, the fractures of the main roof structure are closed and become waterproof.

Contents

Conclusions and suggestions

(1) As the mining depth increases, the stable structure of main roof formed in the inclination direction becomes waterproof, because fractures of the upper strata are partially closed.

(2) An equation for the coal seam burial depth necessary for the balanced main roof structure to be waterproof is established.

(3) The balanced main roof structure can prevent water to some extent. Therefore, measures for controlling water disasters in surface caving areas near the mine can be implemented according to time and stage.

THANK YOU

ZhiQuan Yu

School of Transportation Science and Engineering,

Beihang University

2016.12.15