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Research Article

Analysis on Backfill Mining of "Under Three" Coal in Zhouyuanshan Mine and Strata Movement Law

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Abstract: In order to solve the problem of "under three" (under railways, buildings and water bodies) coal pillar mining, analysis on backfill mining and strata movement law is carried on in 24 mining district of Zhouyuanshan coal mine. First of all, according to the engineering geology and strata occurrence condition in 24 mining district of Zhouyuanshan coal mine, FLAC2D software be used to establish a two-dimensional numerical model and to analyze and calculate the full caving method, strip method and backfill method and then gaining that backfill mining method is beneficial to improve the protection level of surface buildings and facilities. Then, using the theory of strata control and method of related mechanics to analyze the strata movement law and strata control principle of backfill mining, considering that supporting role of backfill body is mainly on lateral reinforcement of coal pillar and vertical supporting role of overlying strata, forming a cooperative control system of "bearing strata + coal pillar + backfill body" and deducing the equilibrium equations when it is in steady state. At last, using the numerical analysis method, respectively analyzing the surface subsidence of the corresponding important buildings of the three profiles of C-8 exploration line ,C-6 exploration line and A-A (cross section of the profile of C-8 exploration line) after using backfill coal mining in 24 mining district. The results show that: the surface subsidence and horizontal deformation basically control within 30 mm and the surface deformation curvature of buildings generally in 0.1×10^{-3} /km in 24 mining district of Zhouyuanshan coal mine, which accord with the relevant standards and requirements.

Keywords: Backfill mining, coal mining, strata movement, "under three" coal (under buildings, railways and water bodies)

INTRODUCTION

At present, China's coal reserves of "under three" coal is about 13.79 billion tons, including the coal which under buildings is 8.76 billion tons, accounting for 63.5% of the entire amount (Fa-kui and Feng-ming, 2005). Especially for the southern provinces and cities that the coal resources badly lacking in, the coal has been nearly exhausted this easily mined. However, there is still a considerable part of coal resources that was left in "under three" (under water bodies, buildings and railways). According to incomplete statistics, only in different areas of Hunan province the coal reserves of "under three" coal amounts to 650 million tons (Wei-jian *et al*., 2010), most coal mines are faced or will be faced with "under three" mining, the amount of coal reserves not only brings huge loss to national resources, but also brings difficulties to enterprise's production and management. However, for coal mining of "under three", both considering the recovery of mineral resources and focusing on the surface subsidence, deformation and environmental protection etc.

On coal pillar mining of "under three", backfill mining technology is used mainly currently (Xie-Xing and Ming-Gao, 2009). With the large demand of coal resources and enhancement of environmental protection consciousness, it should say that coal backfill mining technology is an important part of the green mining technology, especially that it is a kind of effective method to mine coal resources and important guarantee to coal sustainable development, now which is gradually becoming the key technology of the coal industry. Therefore, this study main research on "under three" coal mining technology in 24 mining district of Zhouyuanshan coal mine, including demonstration of the backfill mining scheme and analysis on strata movement law.

GENERAL SITUATION

The 24 mining district of Zhouyuanshan coal mine is located in the north wing of Zhouyuanshan mine field, Old pingan fault to the north, Baoli fault to the

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Table 1: Each stratum and its description

Stratum	Lithology description	Average thickness /m	Cumulative thickness/m
Surface soil layer	Brown, pale-yellow clay, fine sand with a little gravel.	5.70	5.70
Sandy mudstone	The upper part is gray to grayish green and purple, mottled sandy mudstone, level or gently wavy bedding, gray thin-bedded sandy sandstone; middle part is gray to grayish, greenish to grayish green, thick bedded quartz feldspar fine sandstone in major, intercalated between gray to gray green mudstone; the lower part is gray green to dark grey sandy mudstone, mudstone with fine sandstone.	117.50	123.20
Medium grained sandstone	Light gray to grayish white, consist of quartz in first place, feldspar secondly, enormous thick layered, cross-bedding, several layers of sandy mudstone in the middle-upper section.	235.80	359
Sandy mudstone	Gray to dark lamellar, fine sandstone of thin bed locally, common development.	9.80	368.80
Medium grained sandstone	Gray to light gray, consists of quartz in first place, feldspar secondly, several layers of dark lamellar sandy mudstone.	77.40	446.20
Sandy mudstone	Dark gray to black sandy mudstone, mudstone, with several layers of fine sandstone, containing iron concretion and lamellibranch fossils; the lower 13 m is quartz feldspar fine sandstone.	31.60	477.80
Sandstone	Light gray to gray white, consist of quartz in first place, feldspar secondly, coarse particles upward tapering, sandwiched between the sandy mudstone, mudstone.	38.60	516.40
Medium grained sandstone	Gray to light gray, consist of quartz in first place, feldspar secondly, sandwiched several layers of dark gray lamellar mudstone.	17	533.40
1 coal	In bulk, single structure, dim type.	1.75	535.15
Sandy mudstone	Gray to dark gray, medium thickness layered in major, with Ling irony structure and negative 1 coal.	8.30	543.45
Fine sandstone	Gray to gray white, thin to medium thickness layered, grit stone locally.	1.70	545.15
Sandy mudstone	Gray to dark gray, thin to medium thickness layered, containing plant fossils, occasionally sandwiched irony structure.	7.80	552.95
2 coal	Complex structure, upper layer with bright, good quality in major, lower layer with carbonaceous mudstone, flaky, poor quality, not minable in most part of the district .	0.58	553.53
Sandy mudstone	Gray to dark gray, thin to medium thickness layered, jointing development, jointing surface is smooth and like a "mirror".	8.12	561.65
3 coal	Flaky, complex structure, penumbra, poor quality.	1.60	563.25
Sandy mudstone	Gray to dark gray, thin to medium thickness layered, jointing development.	26.60	589.85
4 coal	In bulk, single structure, semi-bright, high quality.	1.07	590.92
Sandy mudstone	Dark gray, thin to medium thickness layered, the lower sandwiched some layers of fine sand layer.	10	600.92

south, the elevation between -370 and -650 m, which belongs to the second level in deep mining. The area corresponding to south and east of the surface is mountainous region, Baoyuan River, Zhangjialong reservoir, coking coal washing plant, Baoyuan railway, highway of mountain to the north, gangue power plant and other buildings to the west. The 1, 3, 4 coal are minable coal seams in the district and the total amount of "under three" coal is 4.1 million tons, accounting for 85.8% of the entire amount of 24 mining district. At present, the 2411 and 2441 work faces are close to the mining scope of "under three", the 2412 work face which to be arranged belongs to the mining scope of "under three".

The 1, 3, 4 coal are minable coal seams in 24 district and 1 coal seam is a single structure, in bulk, with dull coal in first place, including bright coal and mirror coal strip, average thickness of 1.75 m, average dip angle of 19°; 3 coal seam is a complex structure, scaly, by bright coal strip, dull coal and carbonaceous shale interblended, generally with 1~2 layers of gangue, average thickness of 1.6 m, the average dip angle of 19°, with 26.5 m away from 1 coal, 2 coal which between 1 coal and 3 coal cannot be minable; 4 coal seam is a single structure, in bulk, the type formed by bright and dull coal, average thickness of 1.07 m, the average angle of 19°, with 26.6 m away from 3 coal, deputy 3 coal which between 3 and 4 coal cannot be minable. According to geological data in 24 mining district of Zhouyuanshan coal mines, the each stratum and its description shown in Table 1.

DEMONSTRATION OF BACKFILL MINING SCHEME

Basic calculation parameters and calculation model: Here, using the numerical simulation method to demonstrate the backfill mining scheme and calculating software is FLAC^{2D} program. The Mohr-Coulomb yield criterion is used for the model of rock mass. According to the geological report, the mechanical parameters of

Table 2: The mechanical parameters of each stratum

Surrounding rock (from above down)		Bulk density γ/g/cm^3	Uniaxial compressive strength R/MPa	Uniaxial tensile strength R_t/MPa	Cohesion C/MPa	Angle of internal friction Φ/°	Elastic modulus E/GPa	Poisson ratio μ
1	Surface soil layer	2.20	2.1	0.03	0.10	25	1.26	0.42
2	Sandy mudstone	2.32	14	1.12	0.52	30	4.38	0.32
3	Medium grained sandstone	2.64	40	1.80	4.25	37	11.65	0.21
4	Sandy mudstone	2.32	14	1.12	0.52	30	4.38	0.32
5	Medium grained sandstone	2.64	40	1.80	4.25	35	11.65	0.21
6	Sandy mudstone	2.32	14	1.12	0.52	30	4.38	0.32
7	Sandstone	2.50	18	1.81	2.70	36	11.05	0.22
8	Medium grained sandstone	2.64	40	1.80	4.25	37	11.65	0.21
9	1 coal	1.60	12	1.43	1.50	18	0.45	0.42
10	Sandy mudstone	2.32	14	1.12	0.52	30	4.38	0.32
11	Fine sandstone	2.50	38	1.81	2.70	34	11.05	0.22
12	Sandy mudstone	2.32	14	1.12	0.52	30	4.38	0.32
13	2 coal	1.60	12	1.43	1.50	18	0.45	0.42
14	Sandy mudstone	2.32	14	1.12	0.52	30	4.38	0.32
15	3 coal	1.60	12	1.43	1.50	18	0.45	0.42
16	Sandy mudstone	2.32	14	1.12	0.52	30	4.38	0.32
17	4 coal	1.60	12	1.43	1.50	18	0.45	0.42
18	Sandy mudstone	2.32	14	1.12	0.52	30	4.38	0.32

Table 3: The mechanical parameters of backfill body

Degree of compaction D_r	Initial void ratio e_0	Bulk density γ/g/cm^3	Compressive strength R/MPa	Tensile strength R_t/MPa	Cohesion C/MPa	Angle of internal friction Φ/°	Elastic modulus E/GPa	Poisson ratio μ
0.95	0.360	1.89	2.00	0.549	0.720	30.60	0.369	0.233

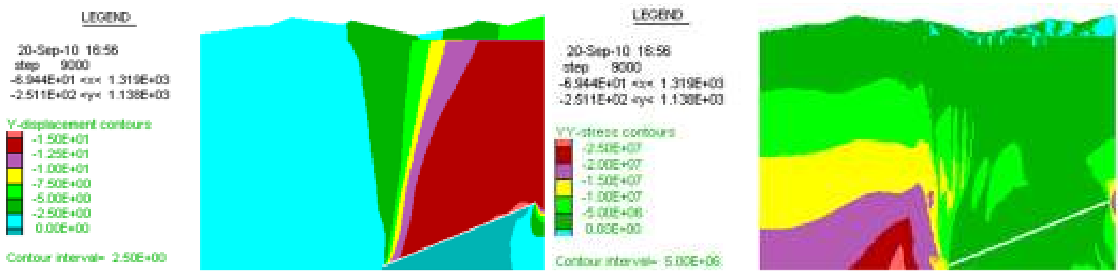
ore body and surrounding rock determined by the mechanical and deformation parameters in Table 2, but in the simulation of initial stress field, the higher rock mass parameters or elastic module can be used for calculation, to avoid parameters of rock mass too low that produce plastic region in the simulation of initial stress field (Wei-jian *et al*., 2009).

The degree of backfill compaction is one of the key quotas to backfill construction quality detection of "under three" coal seam mining, characterizing the condition of density after compaction. Namely: the higher of the degree of compaction, the bigger of the density, the better overall performance of backfill material. From the view of mechanical concept, backfill compactness means compacted degree of backfill body under the action of external force and the specific calculation method is the ratio of actually that reached the dry density and test of the maximum dry density of indoor standard compaction. In order to analyze problems conveniently, the backfill mechanics strength parameters of compaction degree of 0.9 bases on the experimental study are shown in Table 3.

According to occurrence conditions of the 1, 3, 4 coal which are minable in Zhouyuanshan mine coal and considering the influence of mining area and surface construction in 24 district, to identify calculate range of the model as 1250×900 m, therefore, the grid of model is divided into 210×160. The left and bottom of the computational model take displacement boundary and the upper takes stress boundary, the stress that is gravity stress of the overlying strata. In addition, owing to the horizontal tectonic stress caused by tectonic movement is small, so the side pressure coefficient (λ) sets to 1.

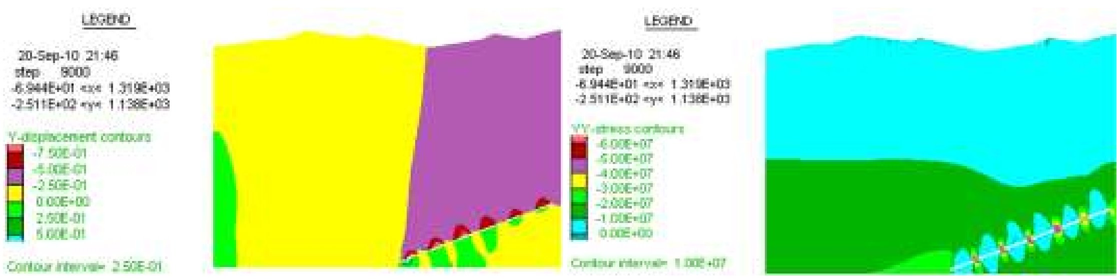
Comparative analysis of the three kinds of mining schemes: In order to prove the rationality of backfill mining in Zhouyuanshan coal mine, now aiming at full caving method, strip method and backfill method for calculation and analysis and carrying on the contrast analysis and the calculated results are shown in Fig. 1 to 4, knowing that:

- From the perspective of overlying strata movement law of the whole mining area, when using full caving method for coal seam, roof strata produce large-scale caving after mining and strata displacement is big, the maximum can reach a few meters, equivalent to the thickness of mining coal seam. And range of strata stress release is large, making a wide range of strata lose bearing capacity.
- When using strip mining method for coal seam, the coal pillar has a definite function to the overlying strata, but due to gob area more and depth of burial is big, the coal pillar occurs some disruption under the high stress and it lost supporting ability, leading to the movement of overlying strata is big and spread to the surface. In addition, from the view of the stress state, the stress release range of roof strata is big, but near the coal pillar appears the stress concentration phenomenon, which is very adverse for the stability of gob, once the instability



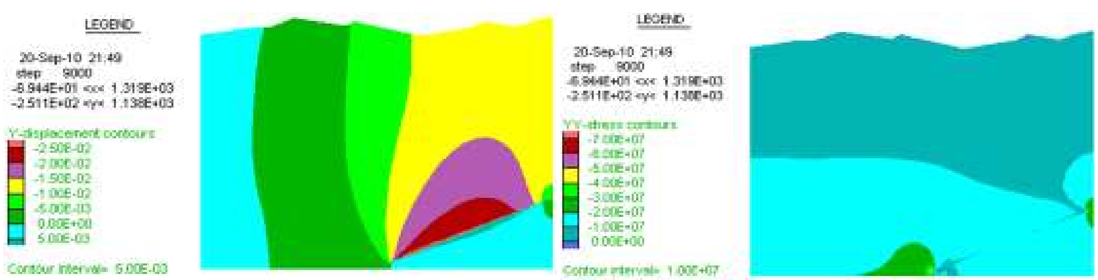
(a) Situation of strata movement (b) Situation of strata stress redistribution

Fig. 1: The situation of strata movement and stress redistribution caused by full caving mining



(a) Situation of strata movement (b) Situation of strata stress redistribution

Fig. 2: The situation of strata movement and stress redistribution caused by strip mining



(a) Situation of strata movement (b) Situation of strata stress redistribution

Fig. 3: The situation of strata movement and stress redistribution caused by backfill mining

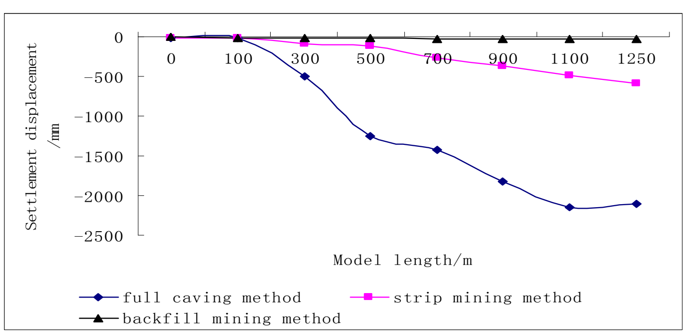


Fig. 4: Contrast in the curves of surface subsidence caused by three kinds mining methods

occurs that it is bound to affect the surface, causing damage of surface buildings.

- When the coal picked out and taking backfill body to fill the mined area, as the backfill body plays a definite supporting role, effectively inhibiting the subsidence of overlying strata which is further, reducing the release degree and scope, so in this mining method the strata movement is in low level, contributing to the control of surface subsidence, providing basis to ensure the surface construction.

Based on the analysis of the results, the maximum value of surface subsidence caused by full caving mining is nearly 2.5 m; the maximum value of surface subsidence caused by strip mining is nearly 0.6 m; but the maximum value of surface subsidence caused by backfill mining is less than 0.035 m. Moreover from the view of subsidence curve, the in homogeneity of surface subsidence caused by full caving mining and strip mining become more obvious, while the surface subsidence value caused by backfill mining not only small, but also homogeneous. Therefore, backfill mining is a kind of green mining methods, suitable for coal seam mining of "under three" and conducive to the protection of surface buildings and facilities.

THEORY OF THE CONTROL OF BACKFILL MINING AND PREDICTION OF BUILDING SUBSIDENCE

System cooperative control principle of strata movement in backfill mining: In order to pick out the coal resources more, the width of coal pillar much reduced in the mining of "under three" coal, such as there are important buildings or objects to be protected on the surface, backfill mining is needed. Generally speaking, when using backfill mining, overlying strata and backfill body form new bearing community, this "bearing strata + coal pillar + backfill body" that form supporting body whose stability is the basic requirements to guarantee of overlying strata to achieve stable situation and their interactions as shown in Fig. 5. The mechanical mechanism is mainly manifested as follows:

Lateral reinforcement effect of backfill body on coal pillar: Under the pressure of overlying strata, due to both sides of gob, making the pillar stress by three-dimensional to two-dimensional state, pillar near gob side will generate lateral expansion (deformation displacement). When gob is backfilled, backfill body is in contact with coal pillar. Backfill body generates lateral stress on coal pillar and making the two-dimensional stress state variable for the three-dimensional stress state again, inhibition of the coal pillar of lateral displacement to increase further that resulting instability. From another perspective, strengthening coal pillar, improving the stability of coal pillar, making the coal pillar get balance in the three-dimensional pressure, which is beneficial to improve the overlying strata supporting force. The mechanism of action as shown in Fig. 5: Both sides of backfill body generate lateral pressure F_{fc} on the coal pillar, inhibition of the lateral expansion deformation of coal pillar, meanwhile the coal pillar generates support pressure F_{cr} on overlying strata.

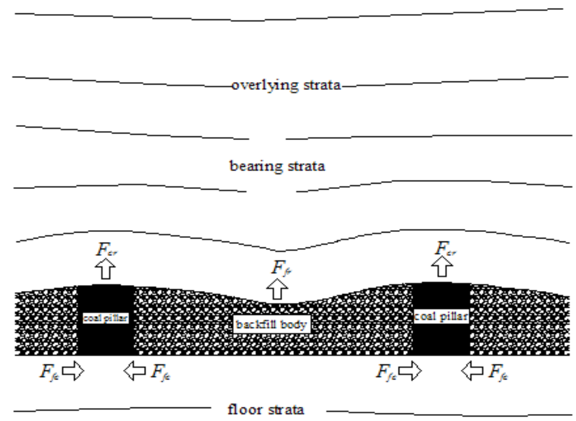


Fig. 6: System cooperative control principle of the supporting body of "bearing strata + coal pillar + backfill body" F_{fc}: Backfill body generates lateral supporting pressure on coal pillar; F_{cr}: Coal pillar generates supporting force on overlying strata; F_{fr}: Backfill body generates supporting force on overlying strata

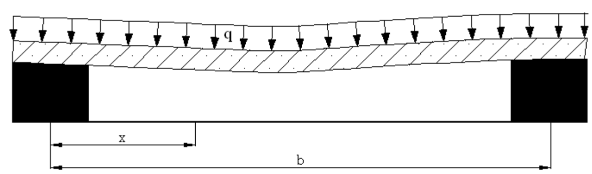


Fig. 5: Mechanical model of roof strata

Backfill body generates vertical supporting role on bearing strata: When backfill body reaches roof strata, in process of overlying strata continuing to sink and compress, the strength of backfill body sustaining to play out, generating supporting force opposite to strata pressure of overlying strata, inhibition of overlying strata to sink further deflection, to avoid the collapse and destruction of strata. Its mechanism of action as shown in Fig. 6: In process of overlying rock sinking, backfill body is gradually compacted and plays a greater upward supporting force F_{cr} to resist the overlying strata continue to sink, which is conducive to maintain the integrity of the strata.

According to Fig. 6 shows, the overlying strata rely on backfill body, coal pillar and bearing strata (including key layer) to maintain stability. If the backfill body destroyed, it will certainly influence the stability of coal pillar; eventually leading to the sinking displacement of overlying strata is larger and cause larger surface subsidence. Therefore, it is a system engineering of supporting body of "bearing strata + coal pillar + backfill body", which is a coordinated function process and its stability is also the comprehensive performance results of whole system. Here, in order to the need of analysis, roof strata can be viewed as simply supported beam. The mechanical model is shown in Fig. 5.

Therefore, to get the roof subsidence this moment is the deflection of simply supported beam, i.e.:

$$S_1 = \frac{qx}{24EI}\left(b^3 - 2bx^2 + x^3\right) \quad (1)$$

In the above formula:
E = The modulus of elasticity for roof strata, GPa
I = The section moment for roof strata, m^4
q = The concentrated load that role in the roof strata, its value is $q = \sum_{i=1}^{n} \gamma_i h_i$, MPa
b = The distance of two midpoints of the two coal pillars which left in strip mining, m
x = The arbitrary distance of the midpoint of the left coal pillar and roof of gob, m

Figure 7 shows that: When $x = b/2$, S_1 gets the maximum, i.e.:

$$S_{1\max} = \frac{5qb^4}{384E_f I} \quad (2)$$

In addition, to use the void ratio of backfill body to represent degree of compaction, therefore, the amount of compaction d_1 which generates after backfill compaction can be obtained through the following formula:

$$d_1 = \frac{1+e_0}{H_f(1+e)} \quad (3)$$

In the above formula:
H_f : The height of gangue backfill body, m
e_0 : The initial void ratio of gangue backfill body
e : The void ratio of gangue backfill body after compaction

According to the reality of backfilling, the ratio of the height of gob and backfill body can be as backfill ratio, namely the calculative formula of backfill rate is the following:

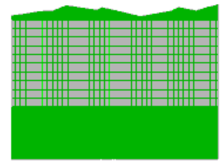
$$F_f = \frac{H_f}{H_c} \times 100\% \quad (4)$$

In the above formula:
F_f = Backfill rate, %
H_c = The height of gob, m
H_f = The height of backfill body, m

Thus, can get the height of gob which is not backfilled:

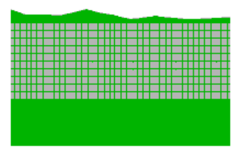
$$H_n = \left(1 - F_f\right) H_c \quad (5)$$

In the above formula, H_n is the height of not backfilled, m



(a) Profile of C-8 prospecting line

(b) Profile of C-6 prospecting line



(c) A-A profile

Fig. 7: The numerical models of corresponding profile of 24 mining district

According to theory of the strata movement and principle of beams, subsidence movement value of overlying strata should not be greater than the maximum deflection, so as to safeguard the stability, therefore, according to the backfill body is compressed and subsidence of overlying strata and alliance with the formula (2), (3), (4) and (5), can get the stability conditions of backfill body which supporting the overlying rock, as below:

$$\left(1 - F_f\right) H_c + \frac{1+e_0}{H_f(1+e)} \le \frac{5qb^4}{384E_f I} \quad (6)$$

The expectation of subsidence of buildings caused by backfill mining: Now to select three profiles that calculated respectively and getting the value of subsidence of the main buildings. Selecting profile of C-8 prospecting line, profile of C-6 prospecting line and profile A-A (cross section of the profile of C-8 prospecting line) of 24 mining district. These profiles establish numerical calculation models shown in Fig. 7.

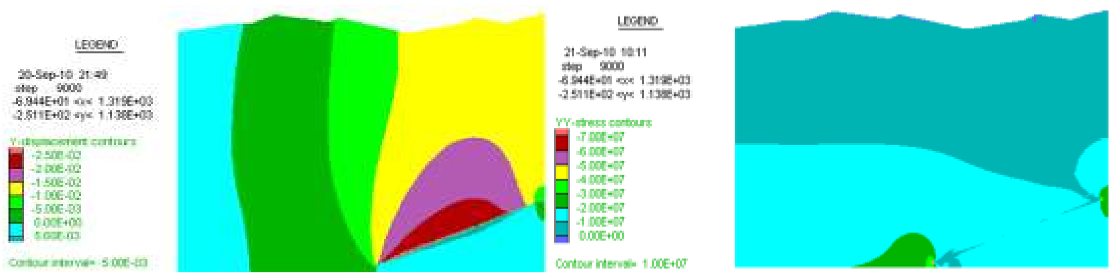
In order to analyze the problem and calculate conveniently, the calculations on profile of C-8 prospecting line and profile of C-6 prospecting line, the seams don't take into account except 24 mining district and the important buildings are located in the left of 24 mining district, therefore, only to choose the scope away from 1250 m of families district to establish the models. For A-A profile, due to the important buildings are located in the middle centre above 24 mining district, therefore, choosing the scope away from 1400 m of families district to establish the model. The strata

Table 4: The maximum deformation value of the corresponding important buildings of the profile of C-8 prospecting line of 24 mining district

The name of the buildings	Total deformation of surface: Horizontal displacement *d*/mm	Total deformation of surface: Subsidence displacement *s*/mm	Unit length deformation of surface: Horizontal distortion ε (mm/m)	Unit length deformation of surface: Tilt deformation *i* (mm/m)	Unit length deformation of surface: Curvature K (10^{-3}/km)
Mine family village	8.5	17.8	0.036	0.057	0.026
Gangue power plant	16.6	28.3	0.078	0.098	0.087
Reservoir	19.4	35.4	0.124	0.136	0.099

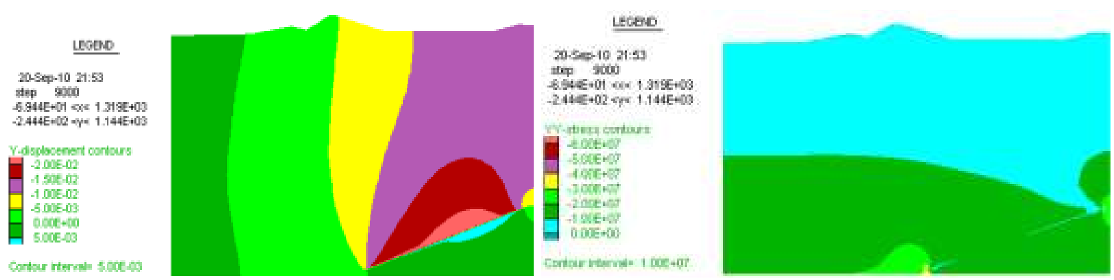
Table 5: The maximum deformation value of the corresponding important buildings of the profile of C-6 prospecting line of 24 mining district

The name of the buildings	Total deformation of surface: Horizontal displacement *d*/mm	Total deformation of surface: Subsidence displacement *s*/mm	Unit length deformation of surface: Horizontal distortion ε (mm/m)	Unit length deformation of surface: Tilt deformation *i* (mm/m)	Unit length deformation of surface: Curvature *K* (10^{-3}/km)
Gold trade city	6.3	11.8	0.011	0.030	0.017
Endowment bureau II	8.1	13.4	0.016	0.041	0.023
Coal washing plant house	15.5	24.7	0.072	0.090	0.087
Office building of coking plant	16.9	27.1	0.081	0.095	0.091
Site area of coking plant	18.5	34.8	0.129	0.132	0.099
Gangue brick residence	21.1	36.9	0.131	0.167	0.114



(a) Situation of strata movement (b) Situation of strata stress redistribution

Fig. 8: The calculation results of the profile of C-8 prospecting line of 24 mining district



(a) Situation of strata movement (b) Situation of strata stress redistribution

Fig. 9: The calculation results of the profile of C-6 prospecting line of 24 mining district

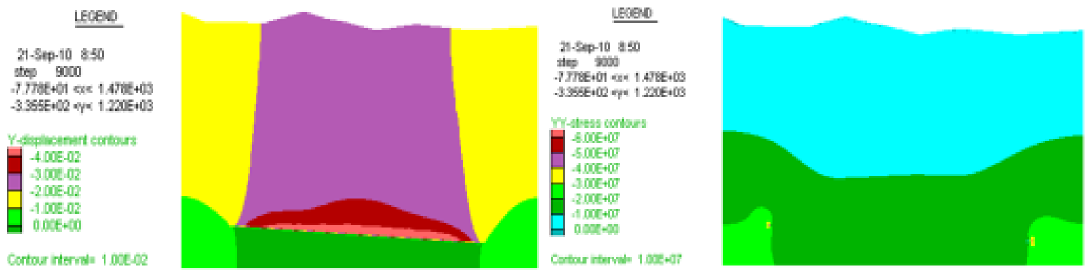
displacement and stress distribution can be obtained after calculating the model established by profile of C-8 prospecting line which is shown in Fig. 8, the maximum subsidence value to the corresponding structure shown in Table 4; The strata displacement and stress distribution can be obtained after calculating the model established by profile of C-6 prospecting line which is shown in Fig. 9, the maximum subsidence value to the corresponding structure shown in Table 5; The strata displacement and stress distribution can be obtained after calculating the model established by A-A profile which is shown in Fig. 10, the maximum subsidence value to the corresponding structure shown in Table 6.

According to the deformation calculation results of important buildings in above, two conclusions can be obtained:

- From the situation of strata movement, each profile carries on backfilling after mining, improving the stability of stope for supporting system which formed by overlying strata, coal pillar and backfill body and getting better control of strata moving in large range, greatly reducing the degree of subsidence. The results show that: the subsidence of surface and horizontal deformation basically control within 30 mm, subsidence displacement of a few buildings beyond 30 mm; the deformation

Table 6: The maximum deformation value of the corresponding important buildings of A-A profile (cross section of the profile of C-8 prospecting line) of 24 mining district

The name of the buildings	Total deformation of surface: Horizontal displacement d/mm	Total deformation of surface: Subsidence displacement s/mm	Unit length deformation of surface: Horizontal distortion ε (mm/m)	Unit length deformation of surface: Tilt deformation i (mm/m)	Unit length deformation of surface: Curvature K (10^{-3}/km)
Treasure source highway	14.3	21.2	0.070	0.094	0.085
Treasure source Railway	14.9	25.7	0.079	0.101	0.097
Office building of coking plant	15.9	26.5	0.089	0.121	0.131
Dormitory of bureau	15.4	28.1	0.091	0.164	0.167
Office building of power plant	15.6	28.7	0.097	0.171	0.179
Reservoir of zhang ridge	13.4	20.5	0.071	0.092	0.090



(a) Situation of strata movement (b) Situation of strata stress redistribution

Fig. 10: The calculation results of A-A profile of 24 mining district

curvature of surface buildings in 0.1×10^{-3}/km, the maximum no more than 0.18×10^{-3}/km, therefore, the backfill mining in accordance with the relevant standards and requirements.

- From the characteristics of strata stress distribution caused by backfill mining, due to the dip angle of coal seam is 19°, the range of stress release in the head entry of working face is most obvious and the range of stress release is relatively moderate, indicating the backfill body, coal pillar and overlying strata has formed a more coordinated mechanics system. The phenomenon of stress concentration exists mainly in the troughs of working face; therefore, it should strengthen the mine pressure monitoring and roadway supporting.

CONCLUSION

- For the calculation and analysis on full caving method, strip method and backfill method, the results show that the maximum value of surface subsidence caused by full caving mining nearly 2.5 m; the maximum value of surface subsidence caused by strip mining nearly 0.6 m and the maximum value of surface subsidence caused by backfill mining is less than 0.035 m. Furthermore the surface subsidence caused by backfill mining is relatively uniform, this kind of mining method is suit for coal mining of "under three", beneficial to protect the important buildings and facilities of surface.
- The supporting role of backfill body mainly in these two aspects for reinforcement of coal pillar and vertical supporting role on load-bearing strata. The lateral stress role of backfill body on coal pillar, can effectively inhibit the swelling deformation of coal pillar, playing the role of reinforcing coal pillar, enhancing the stability of coal pillar, further improving supporting capacity on the overlying rock; in addition, backfill body generating supporting force on overlying strata, inhibition of displacement to increase for overlying strata subsidence, avoiding the strata caving and instability, maintaining the integrity of the strata.
- To make the cooperative control system of "bearing strata + coal pillar + backfill body" be stable, lateral stress of backfill body on coal pillar should reach a certain value, the value of stress not only relevant with the own strength of coal pillar, but also relevant with the pressure of overlying strata; In addition, also considering the relationship among subsidence of roof bearing strata, backfill rate of gob and the compression between backfill body and coal pillar.
- Prediction is carrying on the backfill mining, from the view of calculated results of three profiles of C-8 exploration line, C-6 exploration line and A-A (cross section of the profile of C-8 prospecting line), owing to each section were filling after mining, surface subsidence and horizontal deformation basically control within the 30 mm; the deformation curvature of surface building generally in 0.1×10^{-3}/km, in line with the relevant standards and requirements.

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