PRELIMINARY STUDY ON INFLUENCE OF DEEP MINING ON THE MOVEMENT OF STRATA AND GROUND

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ABSTRACT

With the increasing of coal mining depth, the surface subsidence caused by deep mining differs from that caused by shallow lay, for the complex change of the mechanics behaviour of rock mass in deep mining. The results based on numerical simulation and actual measurements indicates that at the given mining width, the changing extent of surface movement and deformation in deep mining are less than in shallow mining, The surface subsidence in deep mining is influenced by the increasing of key strata that control the movement of overburden rock mass. The coal pillar far from working face will deform differently under great ground stress, and the holistic compression or deformation of coal and rock pillar is the special constituent of surface subsidence in deep mining, which lead to the influence sphere and movement boundary line in deep mining are larger than in shallow mining. These bring great influence to the value of dynamic angle of draw in deep mining.

Key words: deep mining, strata movement, surface subsidence, key stratum, boundary line.

*Supported by the 111 Project (Project No.B07028)

INTRODUCTION

With the increasing of energy requirement and the adding of mining strength, the shallow resource decreasing gradually, home and abroad mines have come into the state of deep resource mining one after the other. The mining depth of colliery are increasing at the speed of 8-12m per year in our country, many mines have entered into the state of deep resource mining now. With the incessant increasing of the coal mining depth, the deep rock body will take on very complex phenomenon as high ground stress, high-ground temperature and high rock dissolve hydraulic press, the distortion of deep rock will change from brittleness to tractility[1,2], and the rock strata movement and surface subsidence in deep mining differ from that in shallow mining also[3-5]. Therefore, it is necessary to study the movement and deformation rules in deep mining, which has important reference worthiness for deep coal mining under buildings; this question will be discussed in the following.

NUMERICAL SIMULATION STUDY OF DEEP MINING ON THE SURFACE MOVEMENT

The model of numerical simulation

The main coal rock system is composed of surface soil and basement rock. As for most mines, the depth of basement rock is increased along with the addiction of the cut depth, but the depth of surface soil holds the line. Two models with the cut depth of 300m and 800m are built with discrete software UDEC4.0, in order to research the difference of surface subsidence caused by and shallow mining. The model was showed in Fig 1. In the model, the coal bed is level and the thickness is 3.0m. The thickness of surface soil is 100m. The thickness of basement rock is 200m, and there is only 1 key stratum in the shallow mining model, while the thickness of basement rock is added to 700m and there are 3 key strata in the deep mining model. The space between the key stratum 1 and the coal bed is 80m. The key stratum 1 is made up with 40m's thin sandstone in both models. In deep mining model, key stratum 2-a terrane of 50m's thick sandstone is 280m above the coal bed and key stratum 3-a terrane of 60m's mid-thick sandstone is 460m above the coal bed. The other part of the model is mudstone except the key stratum.

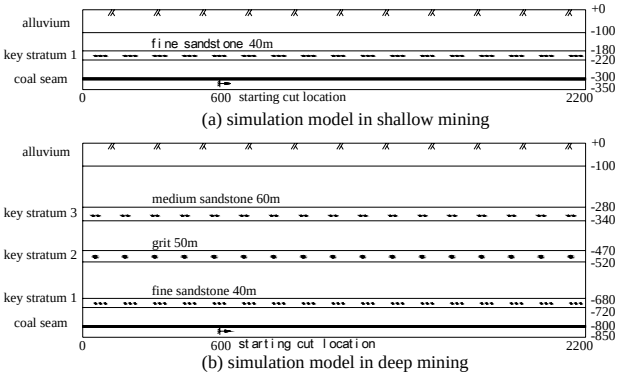


Figure 1.: The simplified numerical models in deep and shallow mining.

Based on the thickness and the property of key stratum, the distance first break is presumed, the distance first break of 1 and key stratum 2 is 160m, and the distance first break of 1 and key stratum 3 is 200m. Considering the influence of fracture angle of terrane, the 3 key stratum break separately when the working face is advanced to 200m, 310m, 450m with the angle of 75°. The bed of mudstone is 5m, and the mechanics parameters of every terrane are showed in Table 1. In the model, there is no block in the key stratum if the cut depth can not cause the break of key stratum, in other word , when the cut depth is advanced to the distance first break, the key stratum are blocked with corresponding distance of break.

The results and analysis of numerical simulation

The cut of coal bed is set 600m away from the boundary both in the model, and the working face is advanced 1000m. The Table 2 shows the numerical simulation result of ground movement and deformation along with the cut depth. Fig 2 shows the surface subsidence and horizontal displacement corresponding to different mining width widths.

Table 1.: The mechanics parameters of strata in the numerical model.

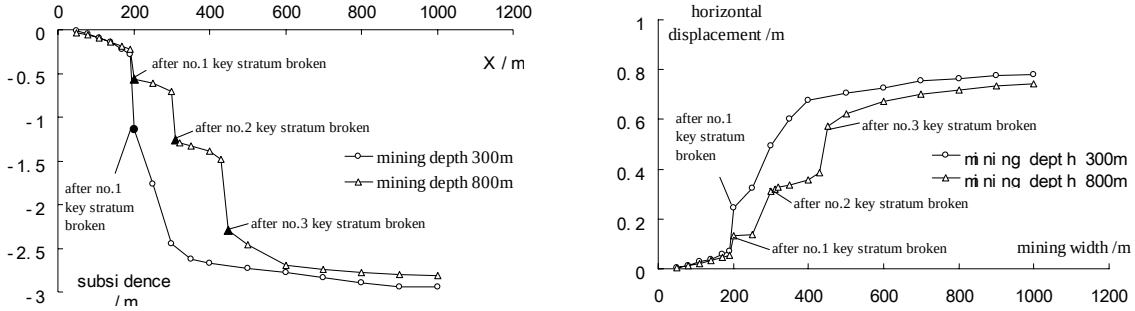
Lithological	Elastic modulus /GPa	Poisson's ratio	Cohesion /MPa	Internal friction angle / °	Tensile strength /MPa
Surface soil	0.3	0.05	0.15	8	0.05
key stratum 3	40	0.38	20	40	6.0
key stratum 2	40	0.38	20	40	6.0
Mudstone	10	0.3	4.9	31	2.5
key stratum 1	40	0.38	20	40	6.0
Coal seam	6	0.24	2.5	23	1.3
Floor	20	0.3	7.3	33	3.4

Table 2.: The numerical simulation results of ground movement and deformation.

Deformation parameter	Mining depth	Mining width									
		80m	140m	190m	200m	250m	300m	350m	400m	500m	600m
Subsidence quantity/m	300m	-0.046	-0.140	-0.281	-1.140	-1.765	-2.444	-2.624	-2.758	-2.898	-2.907
	800m	-0.060	-0.137	-0.224	-0.568	-0.616	-0.704	-1.333	-1.391	-2.460	-2.696
Subsidence factor	300m	0.02	0.05	0.09	0.38	0.59	0.81	0.87	0.92	0.97	0.97
	800m	0.02	0.05	0.07	0.19	0.21	0.23	0.44	0.46	0.82	0.90
incline /(mm·m^{-1})	300m	-0.313	-0.989	-1.863	-8.418	-13.62	-19.30	-19.798	-20.188	-20.412	-20.698
	800m	-0.149	-0.337	-0.612	-1.704	-1.89	-2.323	-5.087	-5.246	-8.530	-8.629
curvature /(mm·m^{-2})	300m	0.009	0.024	0.051	0.527	0.561	0.595	0.623	0.638	0.654	0.677
	800m	0.003	0.008	0.013	0.031	0.035	0.040	0.081	0.168	0.177	0.206
Horizontal displacement /m	300m	0.014	0.039	0.072	0.245	0.324	0.492	0.602	0.675	0.717	0.734
	800m	0.012	0.032	0.055	0.131	0.139	0.355	0.385	0.572	0.621	0.672
Horizontal deformation /(mm·m^{-1})	300m	0.058	0.155	0.323	2.865	3.744	5.060	5.872	6.045	6.266	6.375
	800m	0.057	0.116	0.185	0.418	0.437	0.489	1.313	1.390	2.860	3.122

As Table 2. shows, every movement and distortion parameter value of surface caused by deep mining is less than that caused by shallow mining. The movement and distortion value of 2 models are little and close, when the mining width is little. For example, when the working face is advanced to 80m, the subsidence of surface is 0.02 in both models, and the level distortion value is 0.058mm/m in the shallow mining model while the level distortion value is 0.057mm/m in the deep mining model. As the working face is advanced, the movement and distortion parameter of surface caused by deep mining is less than that of shallow mining in evidence. For example, when the working face is advanced to 250m, the subsidence of surface is-0.616m and the level distortion value is 0.437 mm/m in deep

mining models, while the subsidence of surface is -1.765m and the level distortion value is 3.744 mm/m in the shallow mining model. When the surface reaches super-critical mining condition, there is no big difference for the 2 parameter value in the model, and both of them also change steadily. However, the value of dip, curvature and the level distortion caused by deep mining are much less than that of shallow mining. The subsidence of surface is -2.696m, the level distortion value is 3.122mm/m and the dip value is -8.629mm/m in deep mining models, while the corresponding value is -2.907m, -20.698mm/m and 6.375mm/m in the shallow mining model.



(a) surface subsidence corresponding to different cut widths.

(b) horizontal displacement corresponding to different cut widths.

Figure 2.: Surface subsidence and horizontal displacement corresponding to different cut widths.

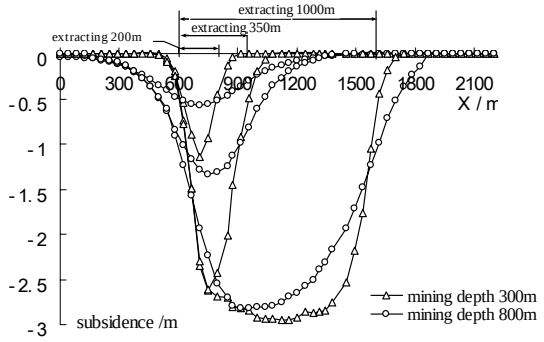


Figure 3.: surface subsidence basin corresponding to different cut widths.

The rock stratum that can control part or all of the overburden rock strata above working face is named as key stratum, theory and practice indicated that the ground movement and deformation is controlled by the key strata[6]. The quantity of key strata will augment with the basement rock height increasing in deep mining; we can see that the three key strata of deep mining influence the ground movement directly from fig.2. When the mining width is 200m, ground subside from -0.281m to -1.140m after the no.1 key stratum in the shallow mining model broken, the ground subside from -0.224m to -0.568m after the no.1 key stratum in the depth mining model broken, because of no.2 and no.3 key strata have not broken, which can make they support the overburden strata effectively still, restrict the trend of rock strata movement toward ground, so the ground subsidence value after no.1

key stratum broken in the deep mining is less than that in shallow mining. As the same, when the no.2 key stratum broken in deep mining, the ground subsidence value in deep mining is also less than in shallow mining owing to the support of the no.3 key stratum. Only when no.3 key stratum broken in deep mining, can ground subsidence value approach shallow mining model gradually.

THE CHARACTERISTIC OF GROUND MOVEMENT BOUNDARY LINE IN DEEP MINING

Large numbers of actual measurement analysis indicate: the surface influence area in deep mining is larger than that in shallow mining. From figure 3. results are also confirmed from numerical simulation.

In order to find out the external reason that cause ground influence area in deep mining larger, first of all, the boundary line of rock strata movement inside overburden strata must be studied after mining. Such as the mining width is 500m in the model, figure 4. is the movement boundary line based on 10mm as the subsidence boundary, curve a is the movement boundary line according to 300m mining depth and curve b is the movement boundary line according to 800m mining depth. Fig.4 tells us that: the distance between the ground influence boundary line and stopping mining line is about 140m in shallow mining, and that in deep mining is about 505m, the influence range is 365m larger than in shallow mining, which indicate ground influence range in deep mining is larger than that in shallow mining. Key stratum has affected internal rock stratum movement and deformation, the separation angle of movement boundary line and horizontal level inside rock strata augment gradually in the condition of each key stratum up and down, the angle above the three key strata in deep mining is 69°, 77°, 87°respective. The angle of draw in the surface soil stratum is basically close in despite of deep mining and shallow mining,

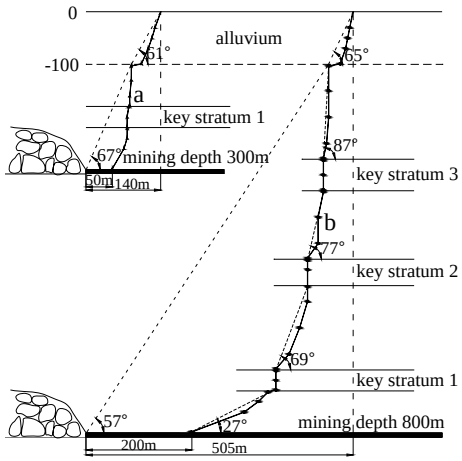


Figure 4.: The movement boundary line inside strata of model.

Being worth paying attention to that: the point away from stopping mining line 50m subside 10mm in shallow mining, while the point that subside 10mm in deep mining is 200m away from stopping mining line, thus increase the analysis difficulty to confirm the strata movement angle and boundary angle in deep mining, in the course of modifying the parameter, it is necessary to consider the distortion influence changing from brittleness to tractility on coal pillar and wall rock under high ground stress.

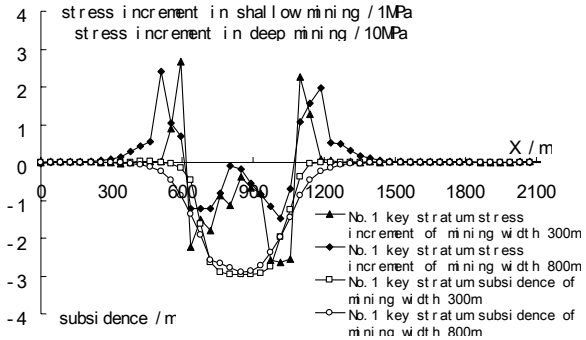
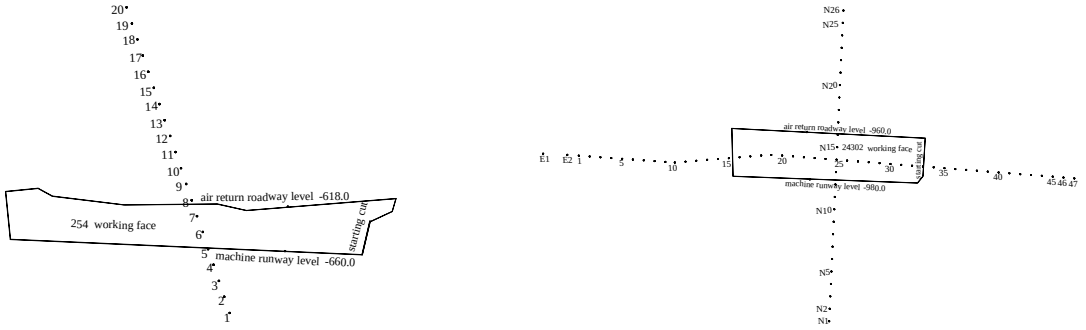


Figure 5. The horizontal stress and subsidence curve of key strata in deep and shallow mining.

Figure 5. shows the horizontal stress and subsidence curve of key strata in deep and shallow mining, the stress increment in the fig has decreased the rock stress in-situ (the rock stress of key stratum1 in shallow model is 3.8MPa and that of deep mining model is 16.2MPa). As the figure shows, the stress increment is 1MPa in shallow mining model and that of deep mining model is 16.2MPa. For the stress curve of deep mining model, the maximum is larger and the shape is wider. When the working face is advanced to 500m, the stress increment of key stratum1 is 2.67MPa, and the width of peak abutment is 106m in the swallow mining model. However, in the deep mining model the stress increment is 24.16MPa, the width of peak abutment is 304m. It shows that there is a wider the stress increment area in deep mining. That is why the surface subsidence is 10mm in deep mining model, much less that in the shallow mining model.



(a)observation station of working face 254 (b) observation station of working face 24302

Figure 6.: Ground layout of station of two working face.

CONTRASTIVE STUDY ON GROUND ACTUAL MEASUREMENTS OF DEEP MINING AND SHALLOW MINING

254 and 24302 working face both belong to zhangxiaolou coal mine, and they extract the same number 2 coal seam. The strike length of 254 working face is 750m, the incline width is 120m, the mining width in average is 1.8m, the coal seam pitch is 20°, the air return roadway elevation of 254 working face is -618.0 m, the machine runway elevation is -660.0m, the ground level is +36m, the thickness of alluvium is 106m, the average depth of mining is 680m. 24302 is the first working face in xinda well of zhangxiaolou coal mine, and its strike length is 400m, the incline width is 150m, the mining width in average is 1.8m, the coal seam pitch is 8°, the air return roadway elevation of 24302 working face is -960.0 m, the machine runway elevation is -980.0m, the average depth of mining is 1000m. The ground layout of station of these two working face can see from Figure 6., Table 3. list the maximal actual measurement results of ground movement and deformation.

Table 3.: Actual measurement results of ground movement.

Working face	Length (m)	Mining depth /m	Mining degree L/H	Subsidence quantity (mm)	Incline ($mm \cdot m^{-1}$)	Curvature ($mm \cdot m^{-2}$)	Horizontal displacement (mm)	Horizontal deformation ($mm \cdot m^{-1}$)
254	120	680	0.176	360	1.47	0.072	97	-0.95
24302	150	1000	0.150	137	0.53	0.021	34	-0.33

Figure 3. indicate that mining degree of the two working face are similar, however, every aspect of ground movement and deformation caused by deep mining of 24302 working face are less than that by shallow mining of 254 working face, using the key strata distinguish software to differentiate the borehole columnar section near the two working face, concluded that the quantity of key strata above working face 24302 are more than the working face 254, the actual measurement results is sameness with numerical simulation. And the actual measurements also indicate that the mining influence region along the down dip direction of 24302 working face is 650m, which is 200m larger than general calculation.

CONCLUSIONS

(1) Numerical simulation and actual measurements results show that the changing extent of surface movement and deformation in deep mining are less than in shallow mining in condition of the same mining width; the difference are more obviously when ground have not reach supercritical mining; and the value of surface subsidence and horizontal displacement caused by deep mining or shallow mining approach gradually when ground movement reach supercritical mining, however, the three variable of incline, curvature and horizontal strains in deep mining are still far less than in shallow mining.

(2) The key strata control the movement and deformation of rock strata and ground, the region controlled by key strata enlarge along with the amount of key strata increasing in deep mining, there are appearing large-scale mining subsidence only when the mining width have the ability to make all of the key strata broken.

(3) Due to the influence of high additional stress after mining, the coal pillar in deep mining would exist biggish distortion under high ground stress, which change the direction of movement boundary line within overburden rock strata, and result in that the ground incidence in deep mining is larger than in shallow mining.

REFERENCES

[1] HE Man-chao,XIE He-ping,PENG Su-ping,et al. Study on rock mechanics in deep mining engineering[J]. Chinese Journal of Rock Mechanics and Engineering,2005,24(16): 2804-2813.

[2] ZHOU Hong-wei,XIE He-ping,ZUO Jian-ping. Developments in researches on mechanical behaviors of rocks under the condition of high ground pressure in the depths[J]. Advances in Mechanics,2005,35(1):91-98.

[3] YANG Lun,WEN Ji-yang,YU Shi-quan. The law of subsidence and calculation method in the case of utmost non-full extraction[J]. The Chinese Journal of Geological Hazard and Control, 2005,16(1):81-83.

[4] DENG Ka-zhong,ZHANG Dong-zhi,ZHANG Zhou-quan. Study on prediction and control of surface subsidence in deep mining[J],Journal of China University of Mining & Technology, 2000,29(1):52-55.

[5] ZHU Wei-bing,XIE Xiang-zheng,GUO Gao-sheng,et al. Study on the influence of mining depth on mining subsidence[J]. Ground Pressure and Strata Control,2003(1):104-106.

[6] XU Jia-lin,QIAN Ming-gao,ZHU Wei-bing.Study on influences of primary key stratum on surface dynamic subsidence[J].Chinese Journal of Rock Mechanics and Engineering, 2005,24(5):787-791.