The Stability Study of Overlying Rock Mass of L Working Face Moving from Open-Pit to Underground Mining

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Abstract: Taking a L working face of open-pit to underground mining in *Wuhai* coal mine as an example, based on the numerical simulation software *FLAC3D* which made a detail analysis of deformation and mechanism of rock slope aimed at the two different mining schemes of from inside to outside and outgoing. The results proved that: When the mining sequence is from inside to outside, the slope to the underground mined-out area, which is good for slope stability; On the contrary, it would be accelerate the failure speed, adverse to the slope stability. So underground mining should be adopted by the outward push of design, in order to reduce the landslide damage. The result is useful in surface-underground combined mining operations.

1 Introduction

With the development of the society and the construction of the infrastructure, the demand of mineral resources is increasing rapidly. At present, the proportion of all kinds of mining methods by open-pit mining is bigger. For the influence by stripping ratio when deepening mining from open-pit into underground mining is imperative. Open-pit mining is carried out through conveying soil and rock peeled off from the upside of deposit to dump and then mining from the open pit. Now people for open-pit to underground mining under the condition of mining slope rock mass stability analysis has some certain research, and applied in some projections of metal mine [1]. But, in fact, there are still many problems, especially the study of L working face mining slope stability analysis is rare, so it is necessary to do a more in-depth research and discussion on L mining for slope stability of the underground mining effects.

2 Project profile

1602 L working face of the fourth mining area in Wuhai open-pit to underground mining is the last fully-mechanized caving, which located in the north of main during four mining area. Under the 1602 working face is 1604, and the upper is the primary stripping pit. The 1602 L working face adopt fully mechanized top coal caving method, the design strike length is 1350m and the tendency length is 300m.It mainly mining the 16th coal seam, for which the average thickness is 8.07m, the inclination is 11~15, f=2, the design of mining height is 2.6 m, caving height is 5.47m, and the caving ratio is 1:2. 1. According to the existing study of rock mechanics in Wuhai open-pit mine and reference other data of rock mechanics, it concluded that the dates needed by the numerical simulation of rock physical and mechanical parameters are shown in table 1.

Table 1 physical-mechanical indices of rock masses

Rock Properti-es	Density/ 10^3kg/m^3	Internal Friction Angle/°	Cohesive Force/kPa	Poisson Ratio	Elastic Modulus /MPa	Compre-ssive S trength / MPa
Table Soil	1.58	24	14	0.23	31.5	
Sand Rock	2.537	33	111	0.25	5000	2.43
Mud Rock	2.314	34	69	0.35	1250	1.09
Sandy Mudstone	25.73	34	70	0.35	1250	1.10
Fine-grained Sandstone	25.46	33	111	0.25	5000	2.43
Medium-grain Sandstone	25.61	33	110	0.25	5000	2.45
Coal	1.45	32.7	201	0.30	1200	

3 The FLAC3D numerical simulation

This study is used *FLAC3D* software based on three dimensional *Lagrangian* analysis program. Make the actual measured profile I-I (Fig.1) provided by the Party A as the research object to set up numerical model.

The workspace main formations are sandstone, mudstone and coal seam, etc. When simulates, it need to be considered the influence of additional load, the refuse dump is 15 m high, the slope Angle is 35 °, about 30 m from open-pit slope shoulder and the slope angle is 51 °. Numerical model for grid is shown in Fig. 2.

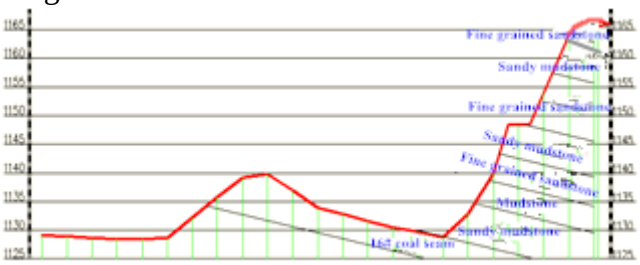

Fig.1 I - I profile stratigraphic distribution measured

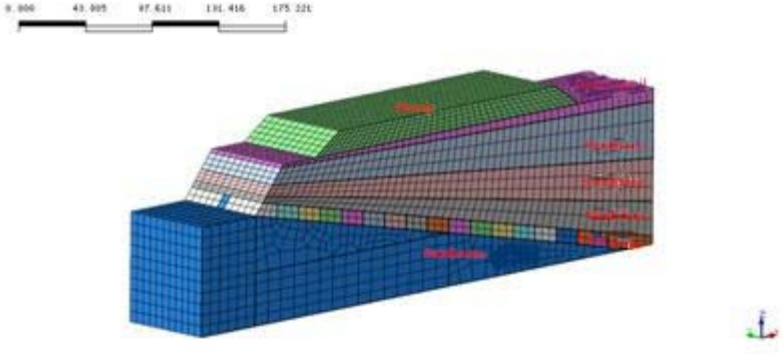

Fig.2 I - I profile 3d numerical model diagram

In order to study the influence produced by different mining sequences of slope rock mass damage, respectively simulated by outward in the mining and outgoing. Program one is by mining along the tendency from inside to outside, every step excavation width is 20m, a total of 15, 300 meters, strike wide is 20m; Program two is by mining along the tendency by the outgoing, the others as same as program one.

3.1The evolution characteristics of stress field under different mining sequences

Based on two different mining sequences scheme of numerical simulation analysis, the change regulations of the stress proved to be:

(1)Different mining sequences had great influences on vertical stress of overlying rock mass, the comparison showed that: from the program one, with the mining depth deepening the stress will gradually increase ,when it arrived at 200m ,the biggest stress will be 9.23MPa, appeared in the coal wall; But it will be 9.40MPa by program two, more conducive to the stability of the overlying rock mass, for lack of protective coal pillar behind the goaf , in the process of excavation, the mined-out area at the top of the rock pressure in the surrounding rock mass stress transferred to mining, in front of the coal wall it was most affected.

(2) The XZ plane shear stress of the overlying rock mass under different mining sequences also have very big difference. Coal mining, according to the plan one shear stress concentration in front of the rear wall, with the working face advancing, working face coal wall behind the formation of the maximum shear stress increased gradually, and when arrived to 200 m the maximum shear stress increases to 3.5Mpa, it will lead to failure once the shear stress exceeds the shear strength of rock mass, and easy to form tensile failure above the mined-out area; According to the second scheme, following an excavation working face in front of the coal wall side and underside appear stress concentration phenomenon, with face increasing the shear stress increases continuously, when arrived 200m maximum shear stress will be 3.0MPa, below working face of coal wall prone to shear failure, above the formation tensile damage is easily. Contrast, plan one mining from the inside to the outside of the overlying rock mass stability is better and safer.

(3) For program one, the numerical simulation analysis shows that the compressive stress will appear in high and stress area reduction during the process of mining, shear stress, high in the corner of the roof and side wall overlap plane as the center to the surrounding extension, international airport as the rock mass increased, stress concentration degree aggravate [2]; With the expansion of the scope of excavation, dangling above the mining area will also increase, pressure of rock mass above the gradually turned to the coal wall on either side of the mined-out area. It was more conducive to the stability of the overlying rock mass, and more favorable to deep mining.

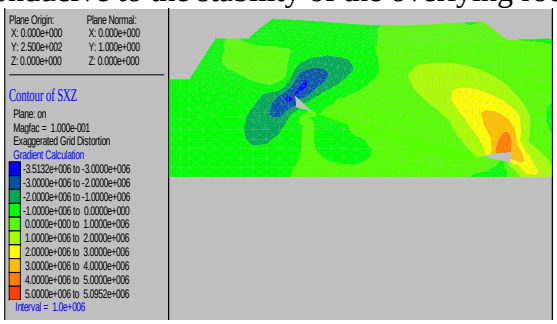

Fig. a XZ plane shear stress variation

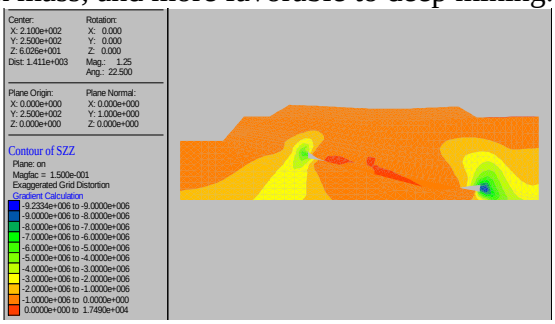

Fig. b Z direction stress variation

Fig.3 Stress variation of program 1 excavate to 200m

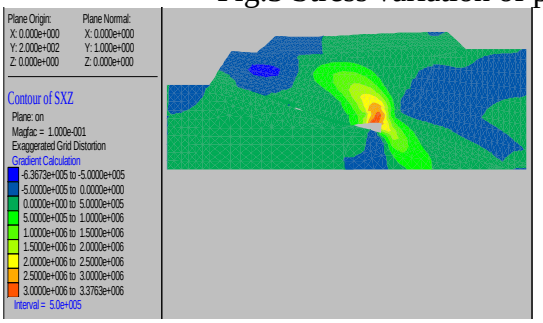

Fig. a XZ plane shear stress variation

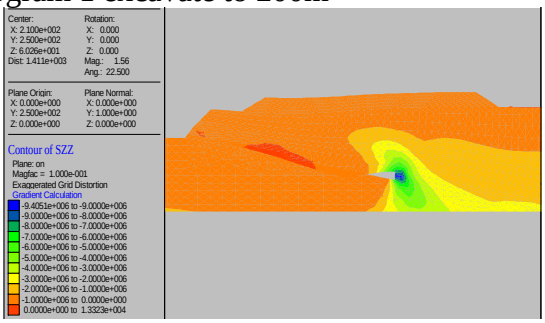

Fig. b Z direction stress variation

Fig.4 Stress variation of program 2 excavate to 200m

3.2 Characteristics of slope rock mass destruction by different underground mining advancing sequences

According to the numerical simulation results of two kinds of excavation scheme, there was a big difference of overlying rock destruction characteristics between different mining sequences. Selecting one checkpoint A in the top, make a contrast between the two different mining sequences under the condition of the change of the surface displacement, it is concluded that the main characteristics are as follows:

(1) The Fig. 5 shows that one way, point A's horizon displacement increases gradually, when the excavate to 240m achieving the maximum, then decreased gradually, and point A's horizontal displacement always point to the direction of mining area in the whole process; for the program 2, point A's horizontal displacement always point to opening direction, when excavate to 120m it reached the maximum, but gradually reduced after that.

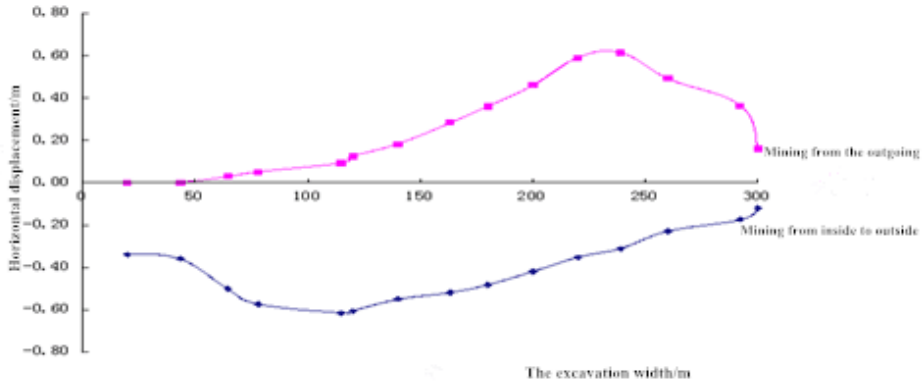

Fig.5 Contraction of the surface horizontal displacement value by two mining sequences on I - I profile

(2) The Fig.6 shows that: the program 1, point A's sinking value changed little within 100m mining on width, but gradually increase after excavate to 120m, and ultimately achieve the maximum; program 2, point A's sinking value continues to increase to the maximum, sinking value basically constant until the mining width arrived to180m.

(3) The Fig. 7 shows that the program from inside to outside mining point A's displacement is significantly smaller than program 2, this is because mining from inside to outside, point A's horizontal displacement of sliding direction pointing to underground mining area, and will offset parts of it after stacking by the weight [3], make the overall displacement smaller, which is good for the stability, so improved the degree of slope stability. If mining from the outgoing, point A's gravity as same as the horizontal direction, increases the slope slip, adverse to the slope stability so reduced the degree of slope stability, coupled with lower L working face has no protective coal pillar, all these caused the collapse and fall overlying rock mass directly, which poses a serious threat to mine safety [4]. Although a mining sequence according to the plan has also had a lot of displacement, but relative to program 2, displacement is relatively small, and the slope is more stability. Therefore, use program 1 can improve the stability of the slope, is advantageous to the mine safety production.

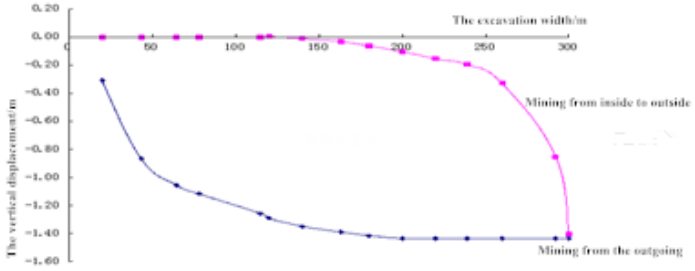

Fig.6 Contraction of the sinking value by two mining sequences on I - I profile

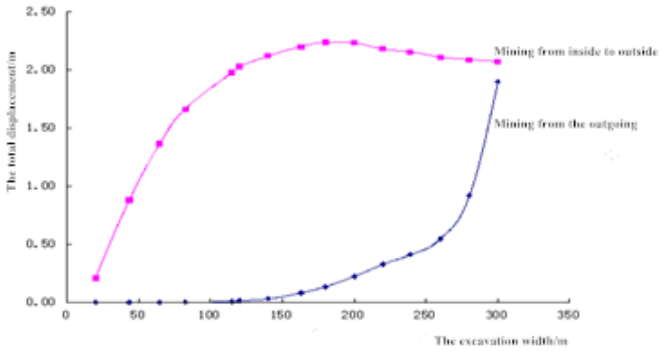

Fig.7 Contraction of A's displacement value by two mining sequences on I - I profile

(4)The surface deformation was large affected by the different mining sequences, for the exploitation of the overlying rock mass slope stability is extremely adverse; The results of numerical simulation show that the deformation caused by mining is large and width due to the steep orebody slope Angle is larger. According to the results of numerical simulation, the mining impact lead Angle is 44 °, which affect the distance in advance to 32m, so the slope is unable to ensure its stability. Above all, the selection of reasonable mining scheme is very crucial, it should choose program 1 from the inside to the outside of the mining sequence.

4 Summary

Open-pit to underground mining is a new subjection, different mining schemes have variable influence mechanism. Through numerical simulation study, from the point of view of safety production, mining sequence from inside to outside is obviously better than that from outside to inside. The influence of two kinds of mining schemes on the stability of the overlying rock mass is that:

(1) Along the surface of the work, it is advanced from inside to outside, With the increasing of mining width, sinking value of overlying rock and horizontal displacement increased gradually, and it can form a subsidence basin gradually at the same time. In terms of the influence on stability of the slope, the open-pit slope trends to slip inside because of the rock mass have the trend to move to the underground mined out area, and the result of slope rock mass movement is good for slope stability.

(2) Working along the mining working face tendency from the outgoing, slope due to the underground mining working face is located in the following of the slope , no protection coal pillars, and mining close to the lower slope lead to the slope lose support, which directly caused the collapse of the upper slope, pulled the whole slope rock mass. With the advance of underground mining, the sliding range increased, which poses a serious threat to the underground safety production.

(3) Deformation characteristics of open pit slope only reflect within a certain depth of the surface of the slope, when it exceeds a certain depth there will be no influence. The impact of mining, therefore, determined the deformation characteristics of the space, and synthetic vector appear to be more influential to the deformation properties. So it must be carry on a corresponding optimization of mining method in the practical engineering application, at the same time in the process of production to strengthen the slope deformation prediction, reduce risk, avoid the occurrence of disasters.

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