Numerical Study on Growth of Strata Disturbance Abscission Layer

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Abstract

In the sedimentary strata, rock strata exhibit layered feature and have an obvious level. Overlying rock often produces separation layer along the level after the underground excavation. However, due to the difference of each layer, but the rule of separated layer is extremely complex due to the difference of each layer, the change of the mining process and the height difference in the level and other factors. However, the disturbed overburden separation is an important basis for studying the subsidence of the surface and implementing the damage control. Therefore, in this paper, the phenomenon, feature and regularity of disturbed overburden separation are found by means of numerical simulation. The paper reveals the mechanical mechanism of the development of overburden separation, and it is also explores the way and method of disturbed overburden separation, and verified by experiment. It is of great importance to understand the law of surface subsidence through the overburden separation development process.

Keywords: perturbed; overburden separation; numerical simulation; mechanical mechanism; surface subsidence

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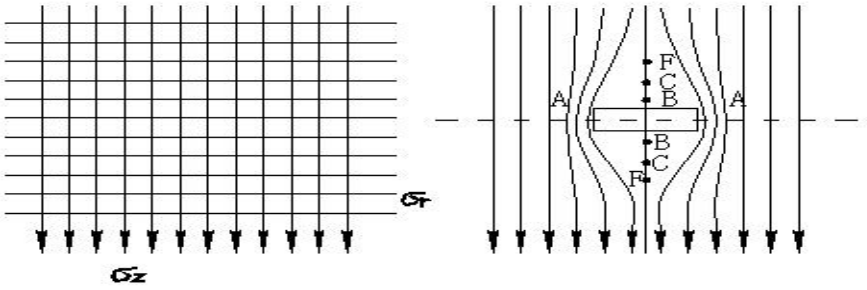
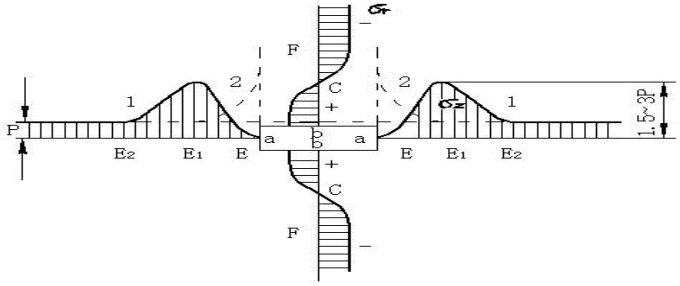
1 The Source of Surface Subsidence

In the sedimentary strata, underground excavation or useful minerals are excavated, the surrounding rock mass is damaged, resulting in stress redistribution (Fig.1), and seeking a new balance, so that the rock stratum and the surface produce movement and deformation (Fig. 2), and even produce non-continuous damage, this is collectively called "strata subsidence", which is defined as the slow or sudden deformation, destruction, prominence and movement in vertical and horizontal direction of the strata because of overheaded or forced, developing up to the surface to produce subsidence which is larger than he underground excavation[1]-[2].



(a) Balanceable state of initial stress (b) Redistribution of stress



(c) stress distribution of arounding rock in mining region

Figure 1. Redistribution of initial stress caused by mining

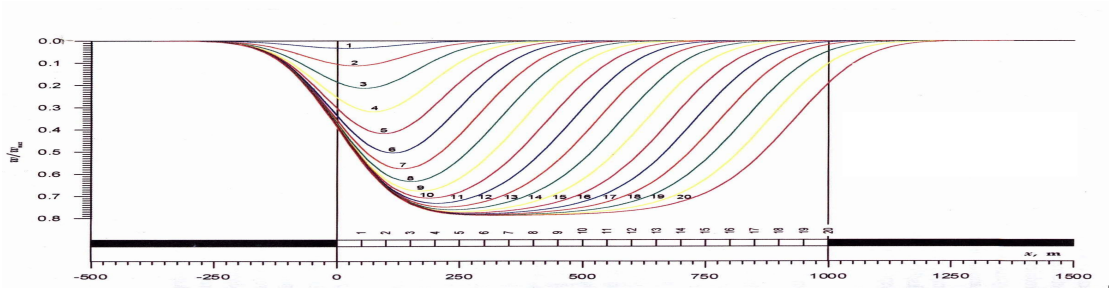


Figure 2. Subsidence of the earth's surface

2 Basic Characteristics of Perturbed Overburden Damage

Under the geological conditions of normal sedimentary strata, when the subterranean excavation is carried out, from its direct roof, and from bottom to up in order to occur creep, break, bend, separation, that is, in the overlying fracture, separation and synchronous bend field of the excavation area. In the creeping field, the rock mass is broken from the bottom, and produce a rearranged structure; In the fracture field, the rock mass is fractured or broken perpendicular to the plane, and its fracture depth and fracture frequency decrease with the vertical distance from the working face increase; In the separation field, the rock mass splits along the plane and develops into separation; In the synchronous bend field, the rock mass including the topsoil developed to synchronous bend under the action of geostatic stress(Figure3).

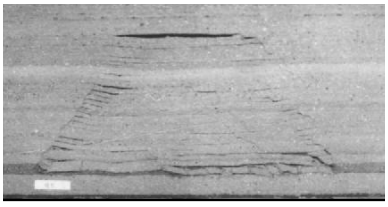


Figure 3. The picture of failured disturbed overburden separation

3 Mechanics Mechanism and Dynamic Process of The Development of Strata Disturbance Abscission Layer

3.1 Mechanics of The Formation and Development of Separation

After the underground excavation, in the overlying rock mass which is effected by disturbance, the direction of the maximum principal stress σ1 changed from the vertical direction before excavation to the skew on both sides of the excavation area Due to the fact that some of the vertical stress protoliths on the top of the roof are transferred to both sides of the excavation area, the load on both sides of the rock mass is higher than that before exploitation, and form the bearing pressure belt on both sides of the excavation area. A large number of studies have shown that the bearing pressure belt takes the shape of "arch" in the overlying rock mass, called the bearing pressure arch. The two arch feet are located in the rear of the face and in front of the working area, and move forward with the advance of the working face; Because of the pressure of the upper strata is guided by the bearing pressure belt to the rock mass on both sides of the mined-out area, the vertical stress is lower than that before the mining, and it is called unloaded arch[3]-[4]. The rock itself in the unloaded arch moves to the surface of the mining area due to the elastic recovery and the self-weight action, resulting in bending deformation. Because the difference of lithology, thickness and height of the strata, the sinking of the upper and lower strata is not synchronized. When the deflection of the upper strata is smaller than that of the lower strata, the upper and lower strata undergo a abrupt instability of spallation and then produce separation.

In the first stage of force and destruction of the overburden in the excavation area, the overlying rock mass in the excavation area first forms a small bearing pressure arch and unloaded arch. In the continuous excavation stage, as the working face forward and pull back the top, the front arch of the bearing pressure arch and unloaded arch to move forward, and continue to expand. As the working face constantly advancing, the creeped rock at the back of the working face is compacted, and the stress state in the upper rock mass gradually returns to the original stress state. At this time, the bearing pressure arch and unloaded arch will continue to advance with the working face forward, as the road continuously to move forward. When entering the stop phase, the bearing pressure arch and unloaded arch will enter the static stage(Fig.4).

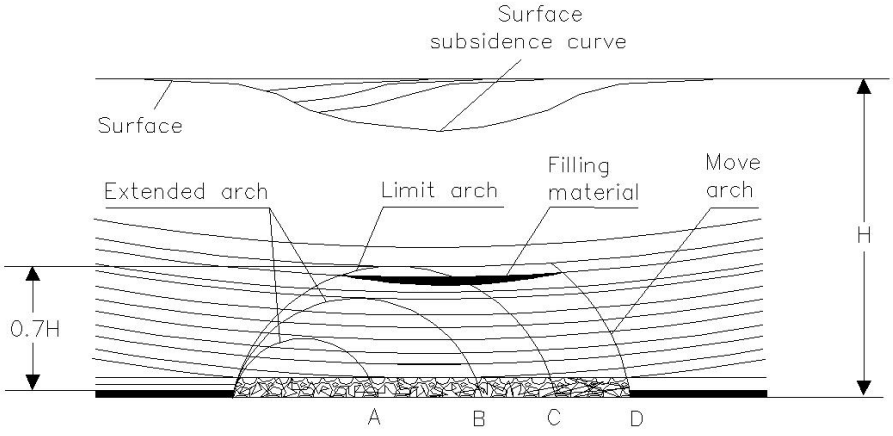


Figure 4. The distribution of the movement and separation of bearing pressure arch and unloaded arch

3.2 The Dynamic Process of The Formation and Development of Separation

With the three stages of the dynamic stress process of the overburden in the excavation area, the formation and development of the separation in the overlying strata have experienced three periods, and a series of dynamic changes.

After the first caving, the rock in the unloaded arch generates curve subsidence and split for the action of gravity, and then produce the separation, forming the initial four-domain distribution and the "arch-balanced structure" of overburden. With the continuous advance of the working face, the arch-beam equilibrium structure is expanding, the internal separation occur a series of changes, the original separation continuously expand, and then closed, the new separation produce and expand in the higher separation, but the vertical largest discontinuous deformation generally occurs at the top of the unloaded arch. However, this kind of arch-beam equilibrium structure is only a very quasi-static balance, but in reality with the advance of the working face it transits from a quasi-equilibrium state to another quasi-equilibrium state. It is a dynamic development process from small to large, low to high and back to forward. When the bearing pressure arch and unloaded arch reache the limit stage, the arch-beam equilibrium structure reaches the maximum period, called the ultimate equilibrium arch; the separation on the top of the arch is also developed to the highest position, called the separation limit height. And then with the advance of the working face, the space range of limited arch-beam equilibrium structure translates forward instead of expanding. The separation is no longer to develop upward, but forward expansion, and to a certain period of time, the rear part of the separation closed. Until the late mining, due to the continuous subsidence of the upper rock, the separation is closed continuously [5]-[9].

From the above analysis we can see that the separation start from the tension of the layers, first occurred separation from the gradient to the mutation, resulting in separation. And then with the advance of the working face, the separation expand and closed, and the distribution and development of separation is from small to large, from bottom to up, from back to forword, with the development of the internal space occupied by the separation is increased by less, then by the reduction of the number of changes.

4 Mining The Spallation of The Overburden Strata — Mechanics Mechanism of The Abscission Layer

The spallation of rock mass is refers to the cracking of the sedimentary rock mass along the rock interface under the action of mining stress, including shear (interlayer dislocation) and cracking (separation).Spallation is a common problem in mining subsidence. The sedimentary layered rock mass is relatively common. During the process of sedimentary rock, due to the change of external conditions, the sedimentary process is interrupted or temporarily interrupted. In the rock mass, the unconformity surface, the pseudo integration surface and the the lithology of different surfaces are formed. Due to the difference between the upper and lower layers of the rock and the existence of the structural plane, making it becomes the stress and displacement discontinuity. The amount of stress displacement transfer, depends on sedimentary surface properties and load conditions. With the action of additional stress in rock strata, the overlying strata of the mining area will be split, and the interlayer is also connected

in the vertical direction near the stope area, and the abscission layer is formed away from the stope.

The delamination (referred to as cracking) caused by transverse stretching occurs and develops under the self-weight of the pull-down strata. As shown in Fig. 5, the mechanical conditions can be simply expressed as:

$$\sigma_A \geq [\sigma_T] = C \tag{1}$$

In the formula: σ_A is the tensile stress of A point on the level； $[\sigma_T]$ is the level of unidirectional tensile strength， in fact, is the level of adhesion C.

The final result of the tensile fracture is the separation between the layer and the layer, and it is clear that the spallation will rapidly expand after the crack of the a point, and its extension will depend on the suspended span and the cohesive force between the layers.

Caused by the longitudinal shear layer crack (referred to as shear crack) is implemented in the process of strata subsidence curve, as shown in figure 6, the mechanical conditions as follows:

$$\tau = C + \sigma_n tg\varphi \tag{2}$$

In the formula: τ is the interlayer shear force; τ_n is the normal stress on the level ； φ is the friction angle between layers.

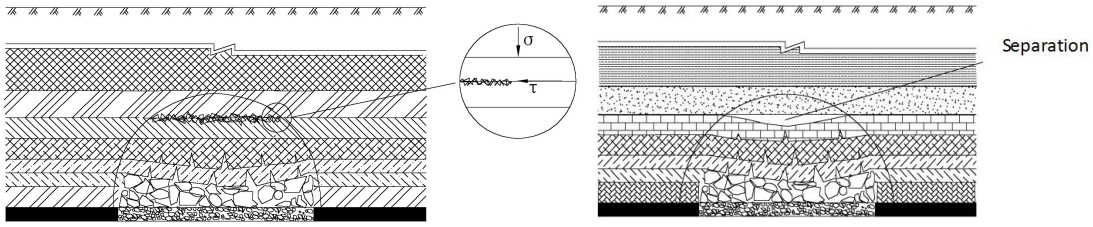


Figure 5. Bearing force state of strata lay **Figure 6. Leaving lay of covering rock**

5 Numerical Calculation and Analysis of Disturbed Overburden Separation

According to the rupture process of disturbed rock mass, the actual state of engineering rock mass and the mechanism and regularity of overburden separation which reveals from above research, we use the RFPA simulation software[10] to analyze the failure process of rock mass, realize the visualization simulation of overlying strata, as shown in Figure 7 is the rupture process simulation of no jointed rock mining, Figure 18 is the numerical simulation of the stress in the overlying strata during the different excavation distance of underground excavation.

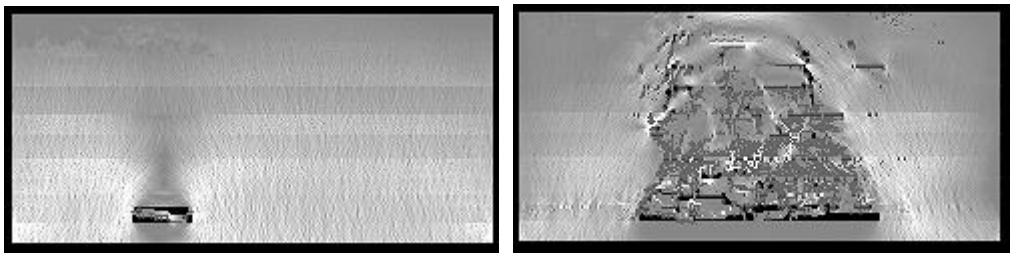


Figure 7. Mining damage process of rocks that have no crannies

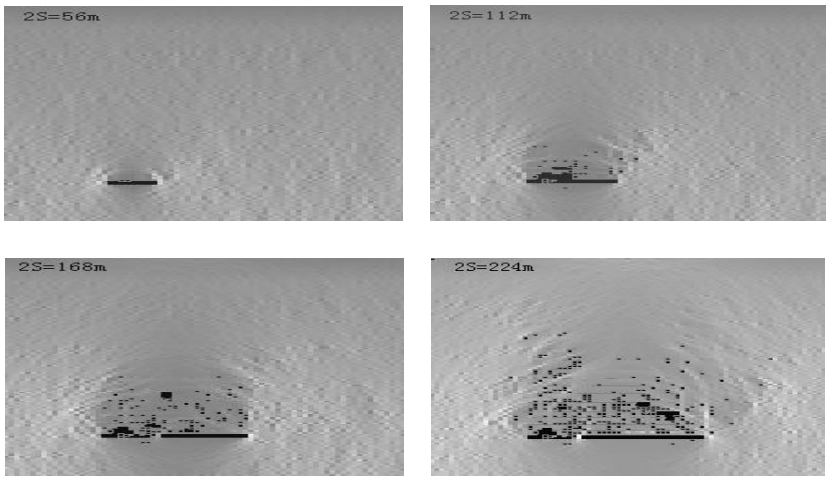


Figure 9. Stress and deformation simulation of covering rocks caused by mining

6 Concluding Remarks

Disturbed strata separation is one of the most important characteristics in the process of strata subsidence, and its evolution rules control the development law of strata subsidence to some extent. Therefore, it is a great theoretical significance and engineering guidance value to study the allometric evolution law of disturbed overburden strata. This paper revolves around the mechanism of disturbed strata separation, meanwhile, analyzing the forming conditions, mechanism and development characteristics of mining overburden rock, etc. The RFPA numerical simulation is used to study the growth evolution law of disturbed strata separation The knowledge of the stress state and the dynamic process of the separated strata are obtained. It makes sense to further study the formation of disturbed strata and its influence on the mechanical properties of overlying strata and surface subsidence.

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