Numerical Simulation Research on the Influence of Buried Depth on the Stress Field of Overlying Rock in Floor Roadway

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Abstract: In order to explore the influence of burial depth on the stress field of the overlying rock in the floor roadway, FLAC3D software is used to simulate and analyze when the floor roadway is at 600m, 800m, and 1000m. The stress field distribution characteristics of the rock and surrounding rock within 15m on both sides, the stress field distribution characteristics of different areas directly below and on both sides of the floor roadway are obtained, which provides a theoretical basis for the location selection and support of the floor roadway.

1. Numerical simulation program

1.1. Model construction

The simulation test adopts FLAC3D software, and the constitutive relationship of surrounding rock adopts Mohr-Coulomb criterion. The relevant parameters of the model are the actual parameters of the mining area. The cross section of the bottom lane is a straight wall semicircular arch, the roadway is 4m wide, the straight wall is 1m high, and the arch radius is 2m. The section of the coal road is rectangular, with a width of 4m and a height of 3m. The inclination angle of the coal seam is α (°), and the thickness is M=3m. The width of the working face is L=150m, and the horizontal width of the coal body on both sides of the working face is 120m. The strike length (direction) of working face and roadway is 200m. The buried depth of the coal seam along the trench on the working face is H(m). The numerical model is shown in Figure 1.

Figure 1. Numerical model
The bottom of the model restricts the vertical displacement, and the front, back, left, and right sides restrict the horizontal displacement. The upper surface of the model is a free surface, and the effect of the upper layer of the model on the model is approximately uniformly distributed load. The destruction of materials adopts the Mohr-Coulomb criterion. The goaf, coal roadway and floor roadway are simulated by null units. There are roof and floor rock layers of sufficient thickness on the inclined coal seam working surface, and the overlying rock layers except the roof are loaded on the upper surface of the model in the form of uniformly distributed loads.

1.2. Simulation scheme and parameter determination
When the simulated buried depth $H$ is 600m, 800m, and 1000m, respectively, after the floor roadway and the coal roadway directly above are excavated, the surrounding rock directly above the floor roadway and the surrounding rock stress field distribution characteristics within 15m on both sides. The relevant parameters of the model are the actual parameters of the mine (see Table 1).

| Rock Type          | Bulk Modulus /GPa | Shear Modulus /GPa | Tensile Strength /MPa | Cohesion /MPa | Density /kg/m$^3$ | Internal Friction Angle /° |
|--------------------|-------------------|-------------------|-----------------------|---------------|------------------|---------------------------|
| Coal               | 1.35              | 0.85              | 1.0                   | 1.8           | 1400             | 27                        |
| Mudstone           | 5.30              | 2.40              | 3.1                   | 2.8           | 2703             | 29                        |
| Sandy Mudstone     | 8.10              | 7.90              | 2                     | 2.4           | 2619             | 30                        |
| Medium Sandstone   | 10.20             | 17.70             | 4.6                   | 7.8           | 2810             | 40                        |
| Middle-Fine Sandstone | 15.80         | 20.20             | 6.7                   | 9.6           | 2710             | 35                        |
| Fine Sandstone     | 12.23             | 15.60             | 4.4                   | 6.5           | 2606             | 35                        |

2. Distribution characteristics of the stress field of the overlying rock in the floor roadway after the floor roadway is excavated

2.1. Vertical stress cloud diagram of surrounding rock of roadway
When the buried depth $H$ is 600m, 800m, and 1000m, the vertical stress cloud diagram of the overburden rock of the floor roadway is shown in Figure 2.

![Vertical stress cloud diagram of surrounding rock after slab tunnel excavation at different burial depths](image)

Fig. 2 Vertical stress cloud diagram of surrounding rock after slab tunnel excavation at different burial depths

2.2. Analysis of stress field distribution characteristics
By extracting the stress cloud data, drawing the vertical stress reduction curve of the surrounding rock directly above the floor roadway and within 15m on both sides of the floor roadway is shown in Figure 3.
It can be seen from Figure 3(a) that when the buried depth H is 600m, 800m, and 1000m respectively, after only the floor roadway is excavated, the vertical stress drop of the surrounding rock directly above the roof centerline of the floor roadway gradually increases, and the maximum drop rate is 63% respectively., 73%, 85%. The curve is "upwardly convex", and the slope of the curve gradually becomes smaller. It shows that the pressure relief effect of the surrounding rock above the floor roadway increases gradually with the increase of buried depth, but the pressure relief speed gradually slows down. The vertical stress drop of surrounding rock in the range of 0~10.2 m directly above the center line of the roof of the floor roadway is 85%~10%, which is the obvious pressure relief area; the vertical stress drop of the surrounding rock in the range of 10.2~15m is 10%~5%, which is the pressure relief Inconspicuous area; after 15m, the vertical stress drop of the rock is less than 5%, which is basically the original rock stress area.

It can be seen from Figure 3(b) that when the buried depth H is 600m, 800m, and 1000m, only after the excavation of the floor roadway, the vertical stress reduction amplitudes of the two banks of surrounding rocks above the roof centerline of the floor roadway gradually increase, and the maximum reduction amplitudes are respectively 29%, 34%, 39%, the curves are in a "descent" shape, and the slope of the curve gradually decreases, indicating that the pressure relief effect of the surrounding rock above the floor roadway gradually increases but the pressure relief speed gradually slows down. The impact range of the pressure relief of the lower side of the roadway is larger than that of the upper side, and the impact range of the pressure relief of the upper and lower sides is 5.5m and 6.1m respectively. The vertical stress drop of the surrounding rock within the 0~4.7m range of the center line of the floor roadway is 39%~10%, which is the obvious pressure relief area; the vertical stress drop of the surrounding rock within the range of 4.7~6.1m is 10%~0%, which is the unloading The pressure is not obvious area; 6.1~15m is the pressurization area, and the maximum increase is about 5%.

3. Distribution characteristics of stress field of overlying rock in floor roadway after coal roadway excavation

3.1. Vertical stress cloud diagram of surrounding rock of roadway
When the buried depth H is 600m, 800m, and 1000m, the vertical stress cloud diagram of the surrounding rock of the roof and floor of the coal roadway is shown in Figure 4 after the coal roadway is driven.
3.2. Analysis of stress field distribution characteristics

By extracting the stress cloud map data, drawing the vertical stress reduction curve of the surrounding rock directly above the floor roadway and within 15 m on both sides after the coal roadway is driven is shown in Figure 5.

It can be seen from Figure 5(a) that when the buried depth $H$ is 600 m, 800 m, and 1000 m respectively, after the excavation of the coal roadway, the vertical stress reduction curve of the surrounding rock between the center line of the coal roadway floor and directly above the roof of the floor roadway appears to be a "convex" type, the vertical stress drop at both ends is large and the rate of decrease slows down, the vertical stress drop in the middle is small and the drop is basically unchanged, the maximum drop at both ends is about 100%, and the maximum drop in the middle is 36% and 39% respectively, 45%. It shows that the surrounding rock at both ends of this area has a more significant pressure relief effect than the surrounding rock in the middle, and the closer to the coal roadway floor or floor roadway roof, the pressure relief effect is more significant. On the whole, the pressure relief effect of surrounding rock gradually increases with the increase of buried depth, and the pressure relief speed gradually slows down. The vertical stress drop of the coal road floor in this area is the smallest 36%, and the pressure relief is significant, which is an obvious pressure relief area.

It can be seen from Figure 5(b) that when the buried depth $H$ is 600 m, 800 m, and 1000 m respectively, after the excavation of the coal roadway, the vertical stress drop amplitude of the surrounding rock on both sides below the center line of the coal roadway floor gradually increases, and the maximum drop amplitude is 60% respectively. %, 64%, and 73%, the curves appear as "descent", and the slope of the curve gradually decreases, indicating that the pressure relief effect of the surrounding rock above the coal roadway gradually increases but the pressure relief speed gradually slows down. The influence range of the pressure relief of the lower side of the roadway is larger than that of the upper side. The vertical stress reduction range of the surrounding rock within the 0~7 m range of the two sides of the
coal roadway roof is 73%~10%, which is an obvious pressure relief area; the vertical stress reduction range of the surrounding rock within the range of 7~10m is 10%~0%, which means that the pressure relief is not obvious area; 10~15m is the pressurized area, and the maximum increase is about 9%.

4. Conclusion
Numerical simulation shows that after the excavation of the floor roadway, the vertical stress of the surrounding rock directly above the centerline of the floor roadway roof and the vertical stresses of the surrounding rocks above the centerline of the floor roadway’s top slab both decrease. The greater the decrease; the maximum vertical stress decrease of the surrounding rock directly above the center line of the roof of the floor roadway and the area affected by pressure relief are about 2 times and 2.5 times that of the two banks of surrounding rocks, respectively.

Numerical simulation shows that after the excavation of the coal roadway, the maximum vertical stress reduction and the pressure relief affected area of the surrounding rock directly above the centerline of the floor roadway are both about 1.5 times that of the surrounding rocks of the two banks.

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