

Numerical Simulation of Basic Support Parameters for the 2304 Working Face Entry in the Main Coking Coal Mine

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ABSTRACT

This study addresses the complex geological conditions of the upper gateway in the 2304 working face of Anyang Main Coking Coal Mine. Using the UDEC numerical simulation method, the displacement and stress distribution laws of surrounding rock under different support conditions were analyzed. The results show that reasonable support measures can effectively control roadway deformation and improve surrounding rock stability, providing a theoretical basis for similar engineering projects.

KEYWORDS

Numerical Simulation; Roadway Support; Displacement Analysis; Stress Analysis.

1. INTRODUCTION

With the gradual extension of coal mining to greater depths in China, the problem of surrounding rock control in roadways has become increasingly prominent[1]. Deep roadway environments, characterized by high in-situ stress, complex geological conditions, and multiple mining disturbances, are prone to large deformations, floor heave, and surrounding rock instability, which seriously threaten mine safety and production. As a key passage connecting the coal mining face to the transportation system, the support design of the working face gateway directly affects mining efficiency and safety[2].

The 2304 working face of Anyang Main Coking Coal Mine employs an upper gateway with a high-low bottom layout along the roof. Due to the large exposed area of the coal pillar in the upper gateway and significant stress concentration, the support difficulty is extremely high[3]. Traditional support schemes often fail due to a lack of pertinence, necessitating the optimization of support parameters through scientific methods[4]. Numerical simulation technology, as an effective means to study the mechanical behavior of roadway surrounding rock, can reveal the evolution laws of displacement and stress under different support conditions, providing a theoretical basis for engineering practice.

2. SIMULATION PROCESS

2.1. Physical model

Based on the geological conditions of the 2304 working face of the Yanchang Zhuziao Coal Mine, a cross-section was made along the advancing direction of the working face to establish a physical model around the upper drift. A 5-meter coal pillar was left[5], and 100-meter overburden voids were

arranged on the left side of the drift, while 50-meter working face coal layers were arranged on the right side of the overburden voids[6]. At the same time, the conditions of the rock layers above and below the drift within 50 meters were monitored[7]. According to the coal seam columnar diagram, the entire physical model finally contains 19 layers of rocks, mainly including the No. 21 coal seam and its roof and floor.

According to the provisions in the UDEC software manual, the normal stiffness K_n of the joint surface in the numerical model is determined by the following formula.

$$K_n = \frac{K + \frac{4}{3}G}{\Delta Z_{min}} \quad (1)$$

K and G represent the rock bulk modulus and shear modulus respectively[8]; ΔZ_{min} is the minimum unit length of the rock block grid division. The tangential stiffness K_s of the joint surface is determined by the following formula:

$$K_s = 0.2K_n \quad (2)$$

2.2. Displacement analysis

In UDEC, the lateral displacement of the roadway sides was extracted. Professional data processing software MATLAB and drawing software Origin were used for data processing[9], and the displacement changes of the roadway sides and the roof and floor in different simulations were obtained, as shown in the following figure.

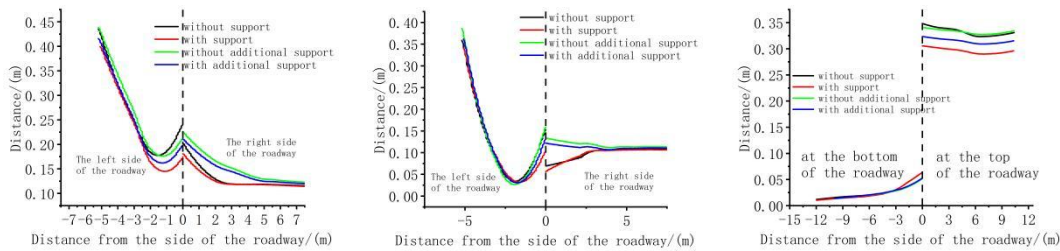


Figure 1 Displacement of the survey line in the roadway

As can be seen from the above figure, with the changes in the excavation and support conditions of the roadway, the displacements on both sides of the roadway and the roof and floor also change. Overall, the floor displacement of the roadway is relatively small, and it remains at around 5 cm in various situations without any floor bulging phenomenon. The floor displacement of the roadway roof is greatly affected by the excavation conditions and support conditions. Without support, the roof subsidence is the largest, reaching 35 cm[10]. With support, the roof subsidence is significantly controlled, and the subsidence is reduced to 30 cm. The roof subsidence increases when the roadway is being mined at the bottom. The simulation results show that additional support for the mined part can control the roof subsidence.

From the displacement on both sides, the displacement within the coal pillar shows a trend of increasing after decreasing. This is because the stress on the left side of the coal pillar is affected by the stress range of the mined area, so the displacement is larger. The stress decreases away from the mined area, and the displacement decreases. Then it reaches the stress range of the roadway, and the stress increases, and the displacement increases accordingly. The displacement within the coal pillar is larger than that of the working face of the coal layer on the right side of the roadway. Overall, the displacement of the waistline part of the roadway is greater than that of the bottom part. With support, the displacement is smaller than without support. The displacement at the bottom of mining is greater than that at the time of roadway excavation[11].

The simulation results show that the support state can significantly affect the displacement of the surrounding rock around the roadway. Good support can well control the displacement of the roadway.

2.3. Principal stress analysis

In UDEC, the lateral displacement of the roadway sides was extracted. Professional data processing software MATLAB and drawing software Origin were used for data processing, and the stress conditions of the roadway sides and the roof and floor in different simulations were obtained, as shown in the following figure.

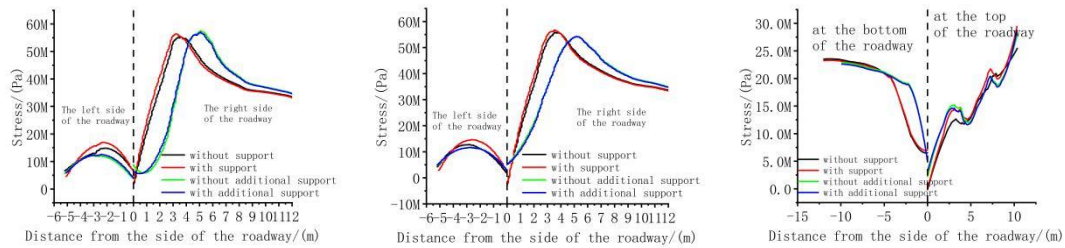


Figure 2 Stress of the survey line in the roadway

From the above figure, it can be seen that with the changes in the excavation and support conditions of the roadway, the stress on both sides of the roadway and the roof and floor also change, but their overall change patterns tend to be similar. Generally speaking, after the excavation of the goaf area, the position where the roadway is located is in the stress increase area, but the surrounding rock has not been damaged and still has the bearing capacity.

After the roadway excavation, asymmetrical stress increase areas were formed on both sides. This is because the coal pillar was damaged under the additional stress generated by the mining of the goaf area and then relieved the pressure, causing the displacement to increase and the stress to decrease. The coal seam in the working face on the right side of the roadway did not experience pressure relief, so the stress was higher than the stress inside the coal pillar. After supporting the roadway, the stress inside the coal pillar was greater than that in the unsupported state, which indicates that the support function played a role in restricting the deformation of the surrounding rock and causing the stress to rise.

The support has little effect on the coal seam in the working face on the right side of the roadway. The reason is that this part did not damage the coal body after the excavation of the goaf area and has a strong bearing capacity. While the coal pillar has a weak bearing capacity and a strong deformation capacity, the additional stress brought by the support was transferred to the coal pillar. After the initial excavation of the roadway, the stress peak value area of the stress increase occurred at 3-4m on the right side, and the stress decreased to the average level at about 10m. After the roadway bottom was mined, the stress increase area of the roadway bottom extended about 2m towards the deep part.

Under different support conditions, the stress at the roof and floor is basically the same. The floor stress is greater than the roof stress because the roof is generally under the pressure relief range of the goaf area. After the initial excavation of the roadway, the roof and floor began to relieve pressure at 5m below the floor and 3m above the roof. After the roadway bottom was mined, the pressure relief occurred at 2m below the floor, because the stress of the goaf area and the roadway excavation after this part has reached a balanced state, and the floor mining did not break the original balance, thus reducing the range of the pressure relief area.

3. CONCLUSION

This study, through UDEC numerical simulation, revealed the deformation and stress response patterns of the surrounding rock in the bottom roadway of the 2304 working face:

(1) The displacement of the floor remained stable within 5 cm without obvious floor bulging. The displacement of the roof was sensitive to support, with a maximum subsidence of 35 cm without support and 30 cm with support. Additional support during the mining stage can effectively control the deformation. The displacement of the coal pillar showed a "decrease then increase" trend. The left side was significantly affected by the stress of the goaf area, while the right coal seam had a smaller displacement. Support can significantly reduce the displacement of the surrounding rock.

(2) After the excavation of the goaf area, the roadway was in the stress increase zone but the surrounding rock was not damaged. The support limited the deformation and caused the stress of the coal pillar to increase. The stress of the right coal seam was higher than that of the coal pillar due to the unloading effect, and the additional stress of the support was mainly transferred to the coal pillar. The stress peak appeared at 3-4 m on the right side after the initial excavation, and the peak area extended 2 m towards the deeper part after mining.

(3) The U-shaped steel + anchor cable + hydraulic support combined support significantly improved the stability of the surrounding rock and verified the rationality of the support scheme. It is recommended that additional support be implemented on the floor during the mining stage to enhance the overall stability.

4. REFERENCES

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