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Study on Support Optimization of Roadway Surrounding Rock under Mining-induced Influence

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Abstract

Coal resources are still dominant in national resources, and in the process of mining coal, the increasing depth of burial is a situation that must be faced at present, so the problem of roadway rock control is unavoidable. This paper comprehensively adopts the method of combining theoretical analysis and numerical simulation to design the support scheme for the transport roadway of 30101 working face in Yang gui coal industry, and analyzes it using FLAC3D numerical simulation software to verify the feasibility of the support design. It is concluded that after the support is carried out, the transportation tunnel can ensure that the deformation of surrounding rock can be controlled within a reasonable range, and the stability of the roadway is significantly improved, and the safe and rapid advance of the mining operation is ensured at the same time.

Keywords

Numerical Simulation; Anchor Support; Perimeter Rock Control

1. Introducion

As a fundamental energy source, coal dominates China's energy mix. The nation's resource endowment—characterized by abundant coal, lean oil, and scarce gas—sustains an annual coal production and total consumption approaching 4 billion tons[1]. The deformation of mining-affected roadways remains a persistent challenge in surrounding rock control. When subjected to mining-induced stress, the surrounding rock typically exhibits extensive failure depth and asymmetric deformation. This is primarily attributed to an inadequate understanding of the failure mechanisms triggered by such mining activities[2], which hinders the implementation of rational and scientifically sound surrounding rock control technologies.

Through continuous development and exploration, coal mine roadway support technologies have advanced significantly, accompanied by increasingly comprehensive theoretical frameworks. Shan et al.[3] proposed a phased approach to roadway support: initially devising multiple support schemes based on actual geological conditions, subsequently utilizing relevant software for optimal selection, and finally conducting on-site verification of the chosen scheme. Integrating relevant theories, Hou et al.[4] categorized the post-excavation surrounding rock into three distinct zones and determined the propagation direction of rock fractures. Dong et al.[5] investigated the broken rock zone, elucidating the working mechanisms of bolt-shotcrete support in roadways. They posited that the extent of the broken rock zone dictates the difficulty of support, and the primary objective of a support system is to mitigate the expansion of this zone.

Luo et al. [6] suggested that the installation of rock bolts and anchor cables at the roof and floor corners can effectively control stress transfer, fundamentally reducing the impact of the two ribs (sidewalls) on the floor. Furthermore, based on theoretical analysis and field observations, they determined the optimal timing for secondary support. Through field observation and research, Li et al.[7] developed a rational support scheme and introduced the concept of timely "yielding-then-rigid" support, which significantly enhances support efficacy. Based on an in-depth analysis of high-stress conditions in deep mines, Kang[8] proposed support forms tailored to these characteristics, classified existing support methodologies, and investigated the operational mechanisms of rock bolts and anchor cables. Bai et al.[10] utilized graphical methods to intuitively illustrate the evolution of surrounding rock deformation and stress distribution over time.

2. Engineering Geological Background

The Yangchan Coal Mine in Shanxi Province is situated between Gedao Village and Nanshanghe Village in Hanbei Township, in the southeastern region of Wuxiang County. This study primarily investigates the underground No. 3 coal seam.

The haulage roadway of the 30101 working face has a total length of 1466 m. The roadway features a rectangular cross-section with excavation dimensions of 4500 mm × 2800 mm. A combined support system consisting of rock bolts, anchor cables, and steel ladder beams is implemented. The specifications for the rock bolts are Φ20 × 2000 mm. For the roof bolts, the inter-bolt and row spacing is 800 mm × 1100 mm, with six bolts installed per row. At a distance of 250 mm from both ribs, one bolt is installed at an outward inclination angle of 75° toward the respective rib, while the remaining roof bolts are installed perpendicular to the roof. The roof bolts are anchored using two resin cartridges, providing an anchorage length of 1300 mm and a designed anchorage force of 85 kN. The pre-tightening torque applied to the roof bolts is 150 N·m. High-strength domed plates made of Q235 steel, measuring 150 × 150 × 10 mm, are utilized. The anchor cables utilize Φ17.8 × 6200 mm, 1×7 strand high-strength, low-relaxation prestressed steel strands. These are equipped with 300 × 300 × 16 mm high-strength flat steel plates and matching barrel-and-wedge anchors. The cables are anchored using three resin cartridges (one MSCK2335 and two MSZ2360), achieving an anchorage length of 1510 mm. The designed anchorage force is specified to be no less than 300 kN, with a pre-tensioning force of at least 180 kN. The inter-cable and row spacing is 1600 mm × 3300 mm. Two anchor cables are installed per row, each positioned 1450 mm from the coal rib.

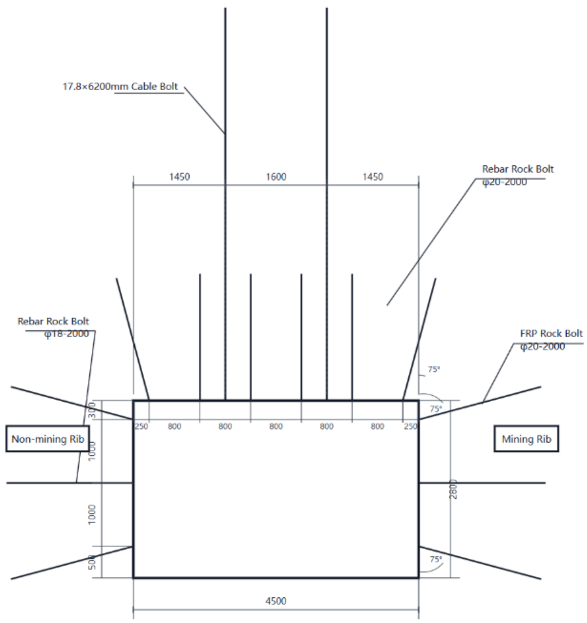


Fig 1. Roadway Cross-section Diagram

4. Numerical Simulation Verification

4.1. Numerical Calculation Model

Based on the stratigraphic conditions and the mechanical properties of the roof and floor of the No. 3 coal seam in the Yangchan Coal Mine, a three-dimensional model was constructed, as illustrated in Figure 2. The model was generated using a rectangular grid (hexahedral mesh), with grid sizes rationally proportioned according to the thicknesses of the respective rock strata. To mitigate boundary effects, the overall dimensions of the model were established as 260 m × 290 m × 45 m. Regarding the boundary conditions, horizontal displacements in the X-direction were fixed at the lateral boundaries (left and right), horizontal displacements in the Y-direction were fixed at the front and rear boundaries, and vertical displacement in the Z-direction was fixed at the bottom boundary. A uniform load was applied to the top boundary to simulate the weight of the overlying strata. Initial vertical stresses were assigned to the internal elements (zones), with the lateral earth pressure coefficient (K) set to 1.0 in both horizontal directions. The Mohr-Coulomb failure criterion was adopted to simulate the constitutive mechanical behavior of the coal and rock materials. While the strata thicknesses were appropriately simplified for the simulation, the mechanical parameters of the coal and rock mass utilized in the calculations were derived from the relevant geological reports of the track haulage roadway for the No. 3 coal seam at the Yangchan Mine, and were subsequently refined through inversion and calibration.

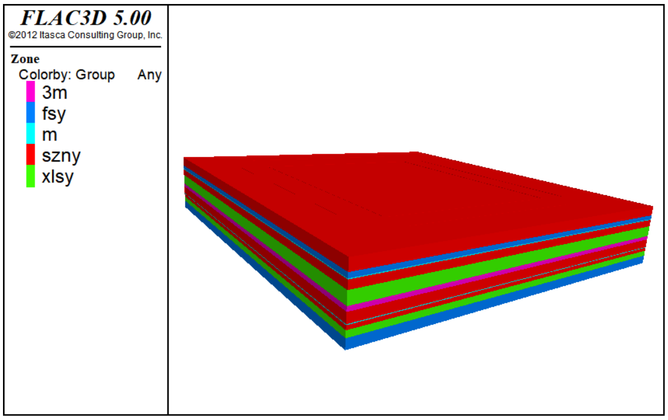
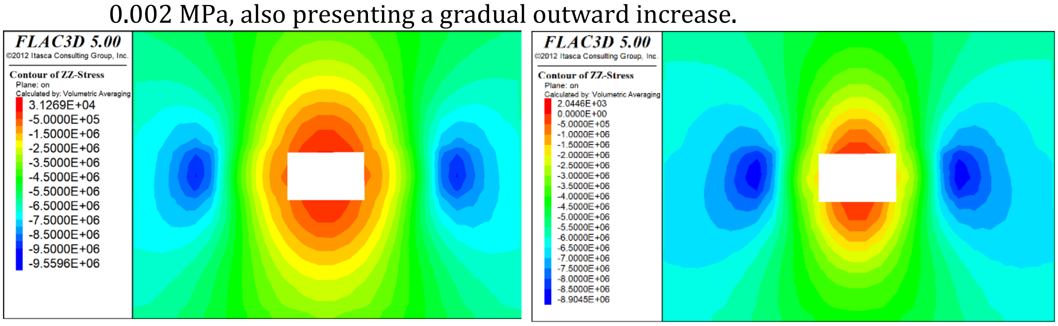


Fig 2. 3D Numerical Calculation Model

4.2. Analysis of Simulation Results

(1) Stress Analysis of Roadway Surrounding Rock

It can be observed from Figure 3 that under the unsupported condition, the maximum stress of the surrounding rock around the gateway is approximately 9.96 MPa, while the minimum stress of the surrounding rock near the roadway is about 0.031 MPa, which gradually increases outwards. Under the supported condition, the maximum stress of the surrounding rock around the gateway is roughly 8.5 MPa, and the minimum stress of the surrounding rock near the roadway is approximately 0.002 MPa, also presenting a gradual outward increase.

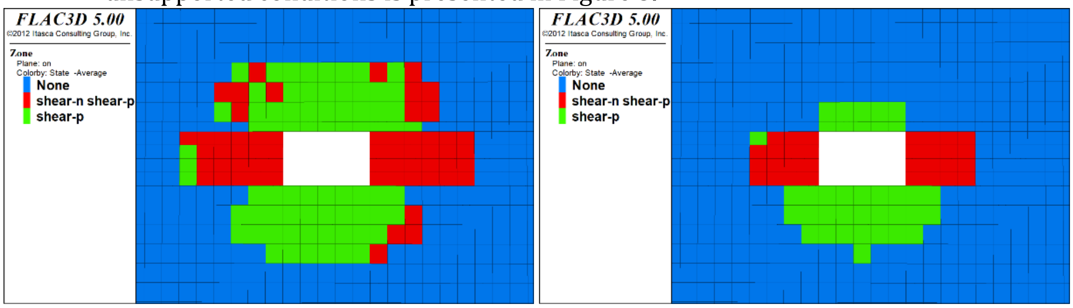


(a)Unsupported condition (b) Supported condition

Fig 3. Stress state of surrounding rock in the gateway

(2) Plastic Zone Analysis of Roadway Surrounding Rock

It can be observed from Figure 4 that the surrounding rock around the gateway is dominated by shear failure. Nevertheless, the application of support design can effectively reduce the failure scope of the surrounding rock near the roadway, particularly at the upper-left and upper-right corners. During the mining stage, several sections are cut along the roadway in the Z-axis direction. The plastic zone distribution of the surrounding rock in the haulage gateway under supported and unsupported conditions is presented in Figure 5.

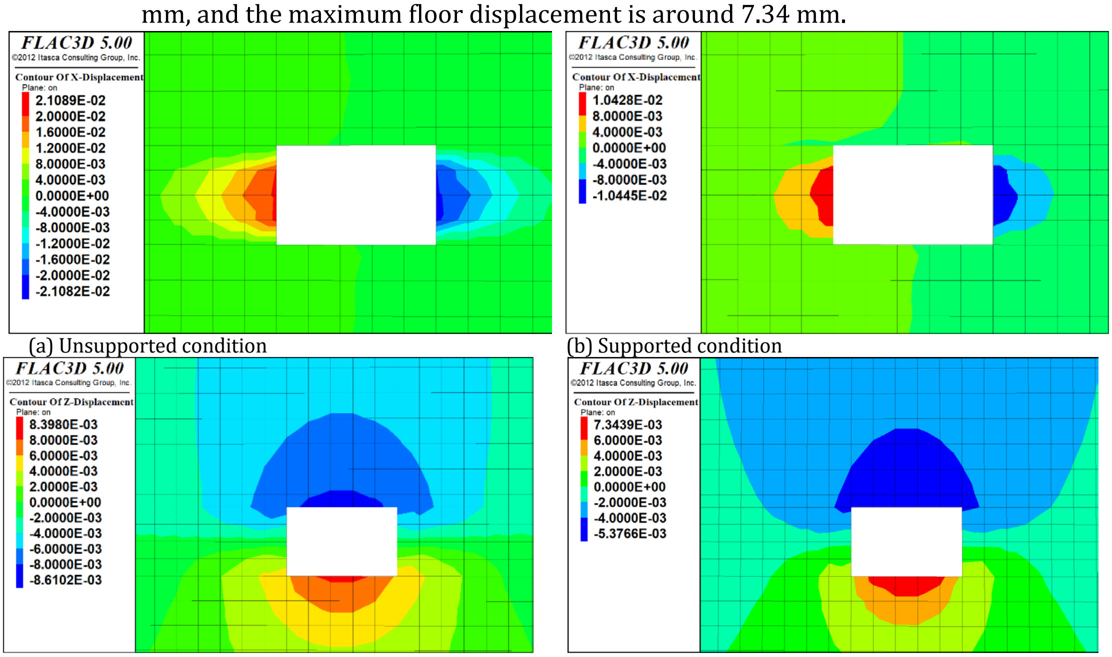


(a) Unsupported condition (b) Supported condition

Fig 4. Plastic zone distribution of surrounding rock in the gateway

(3) Surface Displacement Analysis of Roadway Surrounding Rock

It can be observed from Figure 6 that during roadway excavation, under the unsupported condition, the maximum displacement of the solid coal rib of the gateway is approximately 21.09 mm, the maximum displacement of the working face rib is about 21.08 mm, the maximum roof displacement is roughly 8.61 mm, and the maximum floor displacement is around 8.39 mm. Under the supported condition during roadway excavation, the maximum displacement of the solid coal rib of the gateway is about 10.43 mm, the maximum displacement of the working face rib is approximately 10.46 mm, the maximum roof displacement is roughly 5.38 mm, and the maximum floor displacement is around 7.34 mm.



(a) Unsupported condition (b) Supported condition

(a) Unsupported condition (b) Supported condition

Fig 6. Surface displacement of surrounding rock in the gateway

5. Conclusions

The application of bolt-cable combined support has reduced the roof-to-floor convergence of the roadway by 20% and the rib-to-rib convergence by 15%, achieving the expected effect set at the initial stage of the scheme design. After optimizing the support parameters, the 30101 haulage gateway can keep the surrounding rock deformation within a reasonable range, with significantly improved roadway stability, while ensuring the safe and efficient advancement of mining operations.

References

[1] Editorial Department of Energy. Retrospect and Prospect of China's Energy Industry over the Past Decade[J]. Energy, 2018(11): 40-46.

[2] Hou Chaojiong. Control of Roadway Surrounding Rock[M]. Xuzhou: China University of Mining and Technology Press, 2013.

[3] Shan R L, Kong X S, Zhou J J, et al. Study and Application of Three Step Supporting Design Method in Coal Roadway[J]. Applied Mechanics and Materials, 2013, 353: 252-257.

[4] Hou Huaqiang, Wang Lianguo, Lu Yinlong, Zhang Bei. Study on Stress Distribution and Failure Mechanism of Surrounding Rock in Rectangular Roadway[J]. Chinese Journal of Underground Space and Engineering, 2011, 7(S2): 1625-1629.

[5] Dong Fangting, Song Hongwei, Guo Zhihong, Lu Shoumin, Liang Shijie. Support Theory for the Loose Zone of Roadway Surrounding Rock[J]. Journal of China Coal Society, 1994(01): 21-32.

[6] Luo Liqiang, Wang Weijun, Yu Weijian, Wu Hai, Zhang Yongqing, Qu Yansi. Prestressed Truss Cable Support Technology for High-Stress Soft Rock Roadways[J]. Journal of Hunan University of Science & Technology (Natural Science Edition), 2012, 27(01): 17-22.

[7] Li Yanqing. Optimization of Support Technology for Deep High-Stress Soft Rock Roadways and Engineering Practice[A]. China National Coal Association. National Technical Symposium on Coal Mining in Kilometer-Deep Shafts[C]. China National Coal Association, 2013: 5.

[8] Kang Hongpu. New Advances in Bolt Support Theory and Technology for Deep Coal Roadways[J]. Coal Mine Support, 2007(2): 1-8.

[9] Kang Hongpu, Wang Jinhua, Lin Jian. Research and Application of Roadway Support Technology in Coal Mines[J]. Journal of China Coal Society, 2010, 35(11): 1809-1814.

[10] Bai Jianbiao, Wang Xiangyu, Yao Zhe. Study on Coupled Support for High-Stress Soft Rock Roadways[J]. Journal of China University of Mining & Technology, 2007(04): 421-425.