WEP Warwick Evans Publishing

International Journal of Natural Resources and Environmental Studies

ISSN: 3006-2012 (Print), ISSN: 3006-0834 (Online) | Volume 5, Number 3, Year 2025
DOI: https://doi.org/10.62051/10.62051/ijnres.v2n2.03
Journal homepage: https://wepub.org/index.php/IJNRES/index

Advanced Roof Cutting and Pressure Relief Technology and Application of Mining Roadway

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ABSTRACT

In order to solve the problems of complex advanced support of the mining roadway, high labor intensity, poor control effect of the surrounding rock of the roadway, and the impact of the mining efficiency of the working face during the mining period of the 12203 working face of Xinzheng Coal and Power Co., Ltd., the control technology of the surrounding rock of the mining roadway in the advanced area of the mining roadway was proposed. The numerical simulation data show that the peak value of the advanced support pressure is located 8.24m in front of the working and the peak vertical stress is 21.63MPa in the non-roofing scheme, and the peak value of the advanced support pressure is located 8.64m in front of the working roadway, and the peak stress increases slightly to 21.85MPa, so as to realize the transfer of the peak value of the advanced support pressure to the deep part of the coal and rock mass. The stress concentration area of the shallow surrounding rock in the roof cutting scheme is transferred to the deep part, so that the shallow surrounding rock of the roadway is in a relatively low stress state, which significantly improves the stress environment in the advanced area of the mining roadway and provides favorable conditions for the stability control of the roadway.

KEYWORDS

Mining roadway; Advanced area; Top cutting and pressure relief; Surrounding rock control.

1. INTRODUCTION

Academician He Manchao[1] established a mechanical model of roof cutting along the empty roadway based on the movement law of overburden along the empty roadway, and proposed the surrounding rock control technologies such as shaped energy pre-cracking blasting, constant resistance large deformation anchor cable and dense single pillar beside the roadway. Zhang Guofeng[2] used the deformation of the surrounding rock during the constant resistance anchor cable support to carry out pressure unloading, and then carried out the secondary reinforcement support on the key parts of the roadway through complementary support methods, so as to achieve the purpose of controlling the deformation of the surrounding rock of the roadway in the coal seam mining of the coal seam with high geostress and high stress. Jia Hou et al.[3] obtained the position information of the shallow rock strata above the trough through drilling, and classified the weakly viscous composite roof rock strata, forming a hierarchical pressure relief technology system combining strong support and control roof and differential roof fracturing and pressure relief, which ensured the stability of roadway retention. Gao Yubing, Ma Xingen, Wang Jianwen et al.[4-6] divided the surrounding rock structure of the roadway along the empty roof into the leading area of the working face, the dynamic pressure area of the roadway section and the stable pressure area of the roadway section, and established mechanical models respectively, and concluded that the stability of the dynamic pressure zone of the roadway section was the worst. Guo Pengfei[7] studied the shaped blasting effect under the condition of hard and weak composite roof, and concluded that the shaped blasting effect is better in the hard rock formation, and the blasting energy is easy to wedge along the primary fracture of the hole wall in the weak broken rock formation, and the accumulation effect is poor. Yang Jun[8] established a mechanical model for the basic roof of the roadway with different fault positions, analyzed the deformation characteristics of the surrounding rock in the three cases, and artificially determined the position of the broken roof to achieve the relative stability of the surrounding rock of the roadway.The 12203 working face of Xinzheng Coal and Power Co., Ltd. mainly mines the 21st coal seam at the bottom of the Shanxi Formation, and the 12203 working face corresponds to the flat terrain of the surface position, and there are rural roads passing through the area. The working face is located in the lower part of the east wing of the 12 mining area, adjacent to the Yuezhuang fault protection coal pillar in the east, the Xuzhuang fault protection coal pillar in the south, the uphill protection coal pillar in the 12 mining area in the west, and the goaf of the 12205 working face that has been mined in the north. The average buried depth of the working face is 325m, the inclined length is 220m, the strike length is 500m, and the average thickness is 6.2m. The 12203 working face is mined by fully integrated discharge process, the coal mining height is 3m, and the roof is treated by the collapse method. The 12203 working face transportation roadway is excavated along the bottom plate of the 21 coal seam, and the top coal is supported by a certain thickness. The layout of the 12203 working face and the advance support of the mining roadway site are shown in Figure 1.

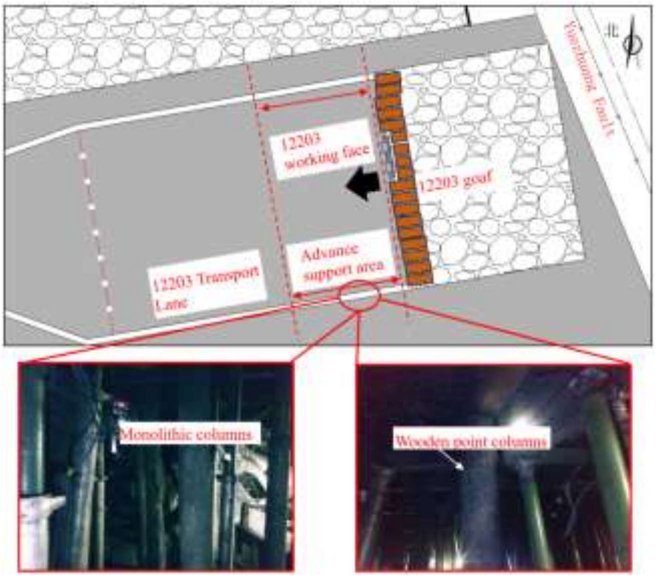

Fig 1. 12203 working face layout and mining roadway site advance support

According to the comprehensive histogram of the lithology of the working face, the roof of the 12203 transportation lane is mainly composed of sandy mudstone, Dazhan sandstone and fragrant charcoal sandstone. The direct top is sandy mudstone, with an average thickness of 0.4m, undulating bedding, argillaceous cementation, grayish-black, and general integrity. The basic top is Dazhan sandstone, with an average thickness of 14m, the whole is light gray, the part is dark gray, and the composition is mainly quartz feldspar, and the integrity is good. The average thickness of the coal seam is 6.2m, which is black, powdery or flaked, and contains pyrite nodules. The direct bottom is sandy mudstone, with an average thickness of 9.85m, gray-black thin bedding, argillaceous cementation, containing pyrite nodules inside, uniform bedding, and a small amount of thin coal seams sandwiched between the rock masses. The lithology comprehensive histogram of the 12203 working face is shown in Figure 2.

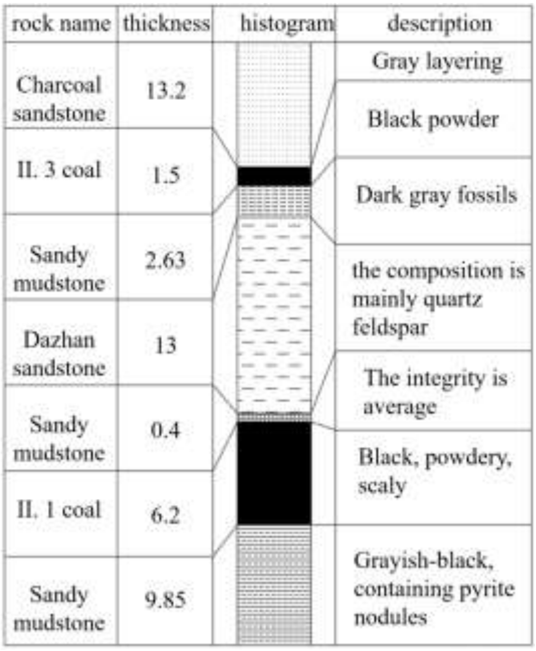

Fig 2. Comprehensive histogram of lithology of 12203 working face

The 12203 working face is a typical three-soft and thick coal seam working face, and the strength of the coal body and the top and bottom plate is low, and it is easy to undergo plastic deformation. In the process of working face mining, the advanced support area of the mining roadway relies on a large number of passive supports such as single columns and wooden point columns to ensure the stability of the surrounding rock of the roadway. Not only the process is complex, the labor intensity of workers is large, but also the control effect of surrounding rock is not ideal, which restricts the mining speed of the working face to a certain extent, and affects the safe and rapid mining of the working face. Therefore, it was decided to use the method of roof cutting to alleviate the stress of the surrounding rock in the advanced support area of the mining roadway, improve the stress environment of the surrounding rock in the advanced area of the mining roadway, and ensure the safety and stability of the advanced area of the mining roadway.

2. NUMERICAL SIMULATION STUDY ON THE FEASIBILITY OF ADVANCED ROOF CUTTING AND PRESSURE RELIEF IN MINING ROADWAY

The design of the topping and non-topping schemes as a comparison, the numerical simulation method was used to numerically simulate and analyze the advanced roofing and pressure relief project of the 12203 working face mining roadway, and the topping effect was determined.

2.1. The numerical model of advanced roof cutting and pressure relief in the mining roadway was established

Using FLAC3D numerical simulation software, a numerical model was established according to the occurrence of coal and rock mass in the 12203 working face of Xinzheng Coal and Power Co., Ltd., and the model was parameterized according to the experimental parameters of rock physics and mechanics and geological data information, and the physical and mechanical parameters of coal and rock mass are shown in Table 1. The model is × wide× high = 150×60×100m, the upper width of the trapezoidal roadway is 4m, the width of the lower side is 5.4m, and the height of the roadway is 3.4m. The X-axis is parallel to the working face inclination, the Y-axis is parallel to the working face trend, and the Z-axis is vertically upward. The displacement and stress boundaries of the numerical model are constrained at the sides, bottom, and front and back interfaces. The average buried depth of the mining roadway is 340m, the initial vertical load σz=γH=7.2MPa is applied to the top of the model, and the physical and mechanical properties of the simulated coal rock mass are based on the Moore-Coulomb criterion, and the numerical calculation model is shown in Figure 3.

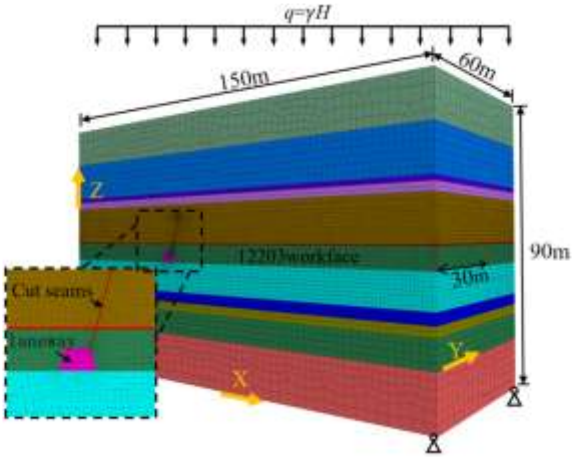

Fig 3. Numerical simulation model of roof cutting and pressure relief

In the model, the length of the 12203 working face (model Y direction) is 60m, and the excavation face is 30m in the Y direction during the simulation, and 30m is retained to simulate the stress change of the surrounding rock in the advanced area of the mining roadway. Taking the topping angle of 15° and the topping depth of 13m as an example, the topping is cut by means of excavation and seam to simulate the roofing pressure relief.

Table 1 Physical and mechanical parameters of coal and rock mass

rock name	thickness /m	bulk/GPa	shear/GPa	cohesion/ MPa	tension/ MPa	Friction(°)
Sandy mudstone	10.6	5.09	4.94	5.8	4.56	44
Charcoal sandstone	10.2	5.01	5.45	5.4	4.17	45
II. 2 coal	1.5	2.05	2.16	2.5	1.35	28
Sandy mudstone	2.6	3.97	3.35	3.3	2.56	37
Dazhan sandstone	16	4.71	5.05	5.0	5.68	41
Sandy mudstone	0.7	2.97	2.35	2.3	1.56	32
II. 1 coal	8.4	1.95	1.96	2.1	0.9	26
Sandy mudstone	9.9	4.57	2.35	3.1	2.56	37
L8 limestone	3.4	2.97	2.35	2.3	1.56	32
Sandy mudstone	2.9	2.05	2.16	2.5	1.35	28
L7 limestone	8.1	3.36	3.06	2.3	1.56	32
Fine sandstone	15.7	2.97	2.35	2.3	1.56	32

2.2. Comparative analysis of numerical simulation results of advanced roof cutting and pressure relief in mining roadway

(1) Comparative analysis of the advance support pressure of the working face of different schemes

When the working face is mined, the vertical slice is carried out at X=100m in the middle of the working face in the model, and the vertical stress curve is extracted at the same position, and the vertical stress within the range of 30m ahead of the working face is shown in Fig. 4 and 5.

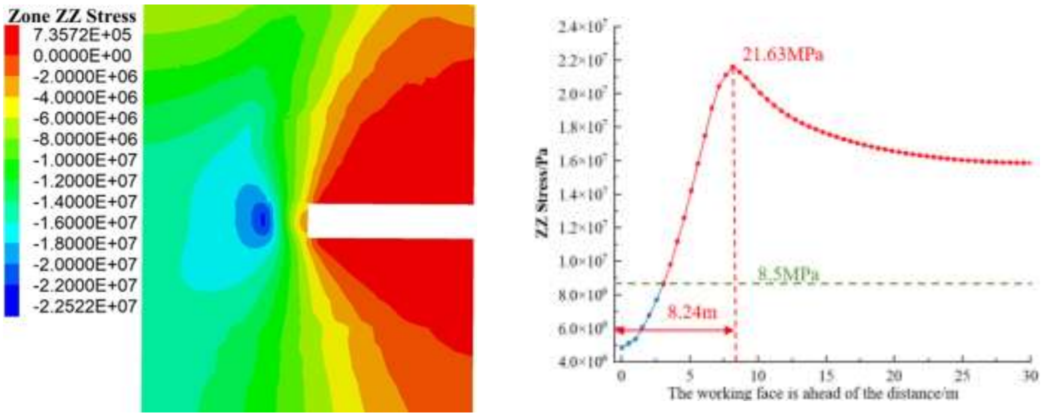

Fig 4. Distribution of advance support pressure in the non-topping scheme

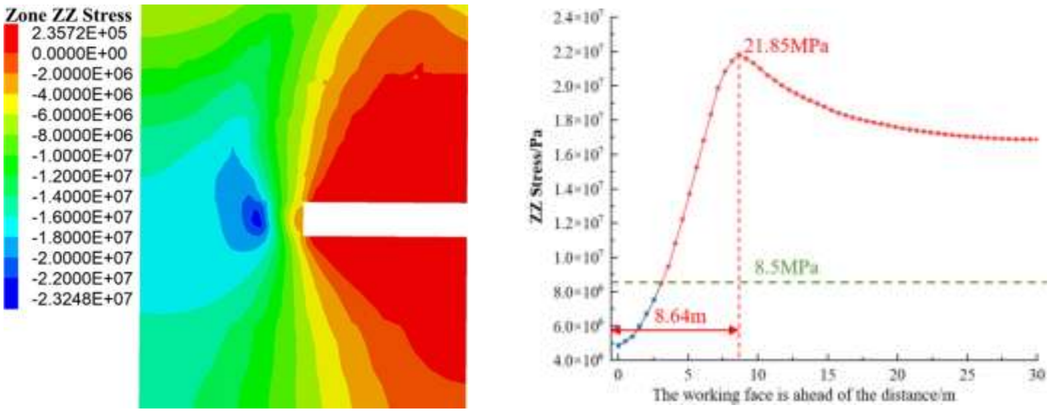

Fig 5. Distribution of the advance support pressure of the roofing scheme

As can be seen from Figure 3-8, in the non-topping scheme, the decompression area is within 0 to 3 m ahead of the working face. The peak stress of the advanced working face reached 8.2m, the peak stress was 21.63MPa, and the stress concentration coefficient was 2.57.

As can be seen from Figure 3-9, the decompression area is within the range of 0 to 3 m ahead of the working face in the non-topping scheme. The peak stress of the advanced working face reached 8.6m, the peak stress was 21.85MPa, and the stress concentration coefficient was 2.54.

By comparing the vertical stress distribution characteristics of the topping scheme and the non-topping scheme, it can be seen that the extreme value of the stress concentration area in the vertical stress contour diagram of the non-topping scheme is 22.5MPa, while the topping scheme reaches 23.2MPa, which is 3.1% higher than that of the non-topping scheme. Comparing the characteristics of the vertical stress curves of the two schemes, it can be seen that the peak value of the vertical stress curve of the non-topping scheme is located 8.2m ahead of the working face, the peak position of the topping scheme is moved outward to 8.6m of the advanced working face, and the peak position of the advanced supporting pressure of the topping scheme is transferred to the deep part of the coal body by 0.4m, accompanied by a slight increase of the peak stress.

(2) Comparative analysis of the surrounding rock stress of coal and rock mass in the advanced area of the mining roadway.

It is known that the peak positions of the advance support pressure of the non-topping scheme and the roofing scheme are 8.2m and 8.6m respectively at the positions of the advanced working face, and the horizontal measurement line is arranged in the middle of the coal seam along the inclined direction of the working face at the peak position of the advanced supporting pressure of the two schemes, and the vertical stress curves of each scheme are extracted, as shown in Figure 6.

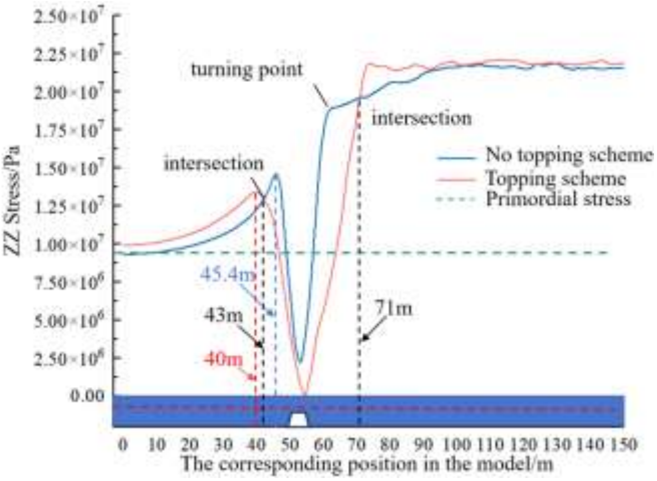

Fig 6. Vertical stress curves with and without topping

It can be seen from Fig. 6 that the trend of the vertical stress curve is about the same as that of non-top cutting, and the vertical stress curve on the left side of the mining roadway shows a trend of first increasing and then decreasing, and finally tends to the original rock stress. The vertical stress curve on the right side of the mining roadway increases rapidly at the beginning, and gradually flattens out after the turning point. From the comparison of the vertical stress curves of the two schemes, it can be clearly seen that the peak point and turning point of the vertical stress curve of the roofing scheme move significantly to the outside away from the roadway, and the vertical stress in the coal rock mass in the area above the roadway is significantly reduced.

The vertical stress curves of roof cutting and non-roof cutting intersect at 43m and 71m, and the vertical stress of the roof cutting scheme is significantly smaller than that of the non-roof cutting scheme in this interval, indicating that the range of stress reduction area near the roadway after roof cutting increases, indicating that roof cutting pressure relief can effectively improve the stress environment of the surrounding rock in the advanced area of the mining roadway.

3. INDUSTRIAL TESTING

In order to determine the effect of the "unloading-supporting" synergistic scheme of 12203 transportation roadway, four anchor cable support force measurement points are arranged in the mining roadway, and the control effect of the roadway surrounding rock is determined by comparing the changes of the anchor cable support force of the blasting section and the normal section of the measurement point in the process of advancing the working face, and the layout of the anchor cable support force measurement points is shown in Figure 6-10, and each measuring point is symmetrically arranged about the initial cutting position. When the working face is pushed closer to 30m away from the 1# anchor cable support force measurement point, start to record the anchor cable support force data of all measurement points, record once every two days, and draw a curve, and the change of the anchor cable support force at each measuring point during the mining of the working face is shown in Figure 7.

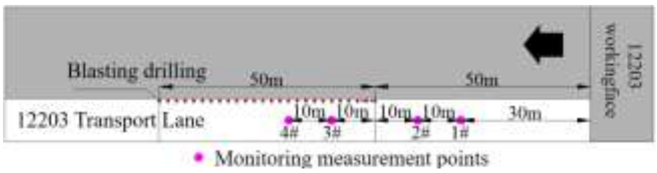

Fig 7. Layout diagram of anchor cable support force monitoring point

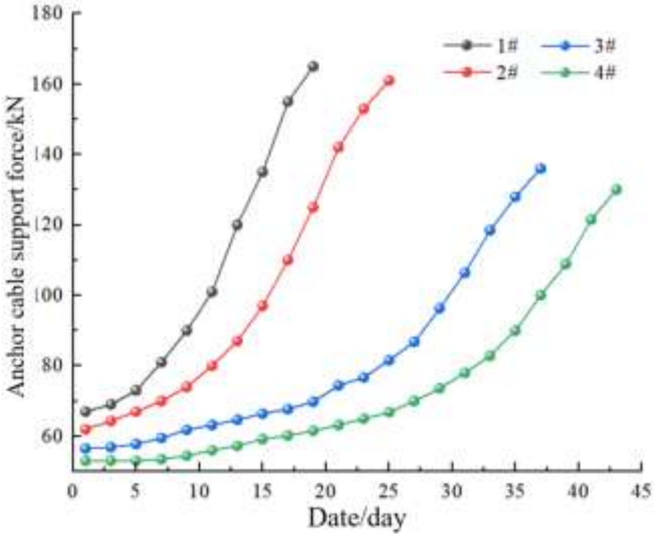

Fig 8. Monitoring results of anchor cable support force at each measuring point in the test section

It can be seen from Fig. 8 that the variation trend of the anchor cable support force of the four measuring points is about the same. When the distance between the working face and the anchor cable support force measurement point is far, the influence of the advance support pressure is small, and the change of the anchor cable support force is not obvious, as the measuring point gradually approaches the working face, when entering the advanced support pressure disturbance range, the anchor cable support force begins to increase gradually. The initial observation data of the anchor cable support force at the 1# measuring point is 67kN, and the final data is 165kN, which increases by 98kN in the process of advancing the working face. The initial observation data of the initial support force of the anchor cable at the 2# measuring point is 62kN, and the final data is 161kN, which increases by 99kN in the process of advancing the working face. The initial support force of the anchor cable at the 3# measuring point is 56.5kN for the initial observation data, and the final is 136kN, which increases by 79.5kN in the process of working face advancement. The initial support force of the anchor cable at the 4# measuring point is 53kN for the initial observation data, and the final is 130kN, which increases by 77kN in the process of advancing the working face. In the whole test process, the increase of anchor cable support force at 3# and 4# measuring points is significantly less than that at 1# and 2# measuring points, that is, the change of anchor cable support force in the test section of the roadway is smaller than that of the normal section during the mining process of the working face, and the anchor cable support force decreases by 16%, indicating that the roof cutting and pressure relief effectively improves the stress environment of the surrounding rock in the advanced area of the mining roadway.

4. CONCLUSION

(1) From the comparative analysis of the numerical simulation results of the roofing and non-roofing schemes, it can be seen that the shallow surrounding rock stress concentration area in the advanced area of the mining roadway of the roofing scheme is obviously transferred to the deep part, which indicates that the roof cutting pressure relief can effectively improve the stress environment of the surrounding rock in the advanced area of the mining roadway.

(2) The industrial test is carried out in the transportation roadway of the 12203 working face, and the roof of the mining roadway in the test section is cut and blasted according to the design parameters, and the advance pressure of the roadway is significantly reduced during the subsequent working face advancement, indicating that the blasting top cutting pressure relief effect is better, which can effectively reduce the stress concentration of the surrounding rock of the roadway and ensure the safety and stability of the roadway.

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