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# Surrounding Rock Failure Mechanism and Control Technology of Gob-Side Entry with Triangle Coal Pillar at Island Longwall Panel in 15 m Extra-Thick Coal Seams

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## Abstract

Taking the return air roadway of Tashan 8204 isolated island working face as the background, the evolution law of the stress field in the surrounding rock of the widened coal pillar area roadway during the mining period of the isolated island working face is obtained through numerical simulation. The hazardous area of strong mine pressure under different coal pillar widths is determined. Through simulation, it is known that when the width of the coal pillar is less than 20 m, there is large bearing capacity on the coal side of the roadway entity. The force on the side of the coal pillar is relatively small. When the width of the coal pillar ranges from 25 m to 45 m, the vertical stress on the roadway and surrounding areas is relatively high. Pressure relief measures need to be taken during mining to reduce surrounding rock stress. When the width of the coal pillar is greater than 45 m, the peak stress of the coal pillar is located in the deep part of the surrounding rock, but it still has a certain impact on the roadway. It is necessary to take pressure relief measures to transfer the stress to a deeper depth to ensure the stability of the triangular coal pillar during the safe mining period of the working face. This provides guidance for ensuring the stability of the triangular coal pillar during the safe mining period of the working face.

## Keywords

Island Coal Face, Evolution Law of Surrounding Rock Stress Field, Strong Mine Pressure Hazardous Area

## 1. Introduction

Rock burst has always been one of the major disasters in coal mines. In recent years, with the increasing depth and intensity of mining in China's mines, many scholars have studied the significant increase in the intensity and frequency of rockburst occurrence.

Jicheng Zhang [1] established a mechanical model and numerical model for the spatial structure of a large mining height working face, and obtained that the mining operation of a large mining height working face experienced dynamic rock pressure and periodic pressure phenomena.

Shuren Wang [2] established a mechanical model of the surrounding rock in the mining area, determined the identification indicators of the pressure arch after mining, and verified the evolution characteristics of the pressure arch under shallow horizontal coal mining conditions.

Sitao Zhu [3] studied the distribution of support pressure in typical thick alluvial coal mines in China that frequently experience strong rock bursts.

Jing Xie [4] analyzed the crushing range of middling coal and rock in the mining process, and proposed that the occurrence of local mining mechanics caused by coal release should not be ignored. Peng Zhou [5] used a combination of on-site monitoring and numerical simulation to analyze the distribution characteristics of mining pressure throughout the entire working face range during the advancing process of the working face.

Shuren Wang [6] established mechanical models of symmetric pressure arches, stepped pressure arches, and rotating compression pressure arches in mining areas, derived instability criteria for each pressure arch structure, and revealed the evolution characteristics of composite material pressure arches in the near and far fields.

Kaijun Miao [7] used a combination of theoretical analysis, numerical simulation, and on-site measurement to study the mechanism of strong rock pressure control in the early stage of multi key layer (MKS) mining and caving, avoiding dynamic pressure accidents caused by the interaction between MKS during the early stage of mining and caving.

Qiang Zhang [8] proposed the "Mobile Setting Room" theory (referred to as MSUR theory) to characterize the reduction of mining pressure caused by backfill, based on the motion model of the overlying layer in longwall mining.

Tao Gong [9] established a pressure parameter model of the overlying layer in the mining area that takes into account the physical and mechanical parameters of the strata and the structural parameters of the mining area, which can be used to calculate the support pressure of each roof on the working face.

Shi Jiulin [10] analyzed the evolution of geological structure and the occurrence of rock pressure in Tashan Coal Mine in Datong Mining Area through on-site experiments, numerical simulations, and theoretical analysis.

Junwen Feng [11] used similar material simulation, theoretical analysis, numerical simulation and other research methods to conduct in-depth research on the instability characteristics of the overlying rock structure on the Huainan coal mine working face, the inducing factors and mechanisms of strong mining pressure during the mining process, and control measures.

Yanhai Zhao [12] analyzed the load distribution characteristics of the roof of the mining area and established a mechanical model of the surrounding rock pressure arch, ensuring the safety of shallow horizontal mining. Through theoretical and numerical analysis, the evolution characteristics of pressure arch and elastic performance during shallow mining were revealed.

Haifeng Zhou [13] used a combination of measurement, theoretical analysis, and numerical simulation to obtain the law of overlying rock pressure in a fully mechanized mining face. He summarized the movement and development characteristics of the coal pillar strata in a fully mechanized mining face, analyzed the reasons and mechanisms of coal pillar breakage, and proposed corresponding preventive measures and management methods. Qiang Zhang [14] analyzed and established the basic principles and methods of mine pressure monitoring based on the characteristics of fully mechanized solid fill mining (FMSBM) technology and the principles of mine pressure control.

Zhijie Zhu [15] analyzed the stress distribution patterns and coal pillar stability under different roof strengths, and explained the impact of hard roof on the stress distribution of the working face.

Pengfei Guo [16] used the three-dimensional finite element global model to obtain the local stress of the surrounding rock of the gob-side entry retaining. The extracted local stress results were applied to the three-dimensional discrete element gob-side entry retaining model as boundary conditions to evaluate the support effect of different support schemes in the support process of gob-side entry retaining.

J. Z. Li [17] analyzed the failure mode of roadside backfill, and then carried out numerical simulation and field test to characterize the stress environment of roadside backfill under the conditions of caving and goaf filling. Finally, the control measures of regional pressure are put forward. The results show that adjusting the three-dimensional stress field of surrounding rock will make most of the principal deviatoric stress concentrate on the filling body, resulting in the destruction of surrounding rock. Based on the stress environment of gob side entry retaining clarified by C. L. Han [18], a mechanical model of transverse cantilever fracture structure is established, and the given deformation equation of roof and the judgment of fault block balance are obtained. The mechanism of pressure relief and structural stability of transverse cantilever structure of stope under direct coverage of thick and hard roof and its influence on gob side entry retaining in goaf are discussed.

In previous studies by scholars, there have been few analyses on the prevention and control of coal pillar rockburst in the return airway section of isolated working faces. This article takes the 8204 isolated working face as the background, analyzes the dominant factors of rockburst, evaluates the risk of coal pillar rockburst in the section based on numerical simulation results, and formulates targeted rockburst prevention and control measures, in order to provide reference for rockburst prevention and control under similar conditions.

## 2. Project Overview

8204-2 working face is located in the southeast of Honda, the Northeast of the Second District, Donglin 8202 goaf, southwest is the 8204 goaf, F13810 fault in the northwest, the southeast is the return air lane of the second panel area, cover the mountain with a thickness of 492 - 541 meters, average 517 meters. The overlying area is the Jurassic 14 # coal seam goaf and Guyao goaf of Tongmei Group's Dig Jinwan Coal Industry Company, the 305 panel area of Coal Seam 14 within the scope of Dig Jinwan Coal Industry Company was mined out in the 1970s using the long wall large roof fall method and the knife pillar method, the coal thickness is 4.7 - 5.7 meters, the mining height is 4.7 - 5.7 meters, and the interlayer spacing is 453 meters.

The 8204-2 isolated island working face of Tashan Mine adopts a "knife handle" layout. As shown in Figure 1, along the advancing direction, the length of

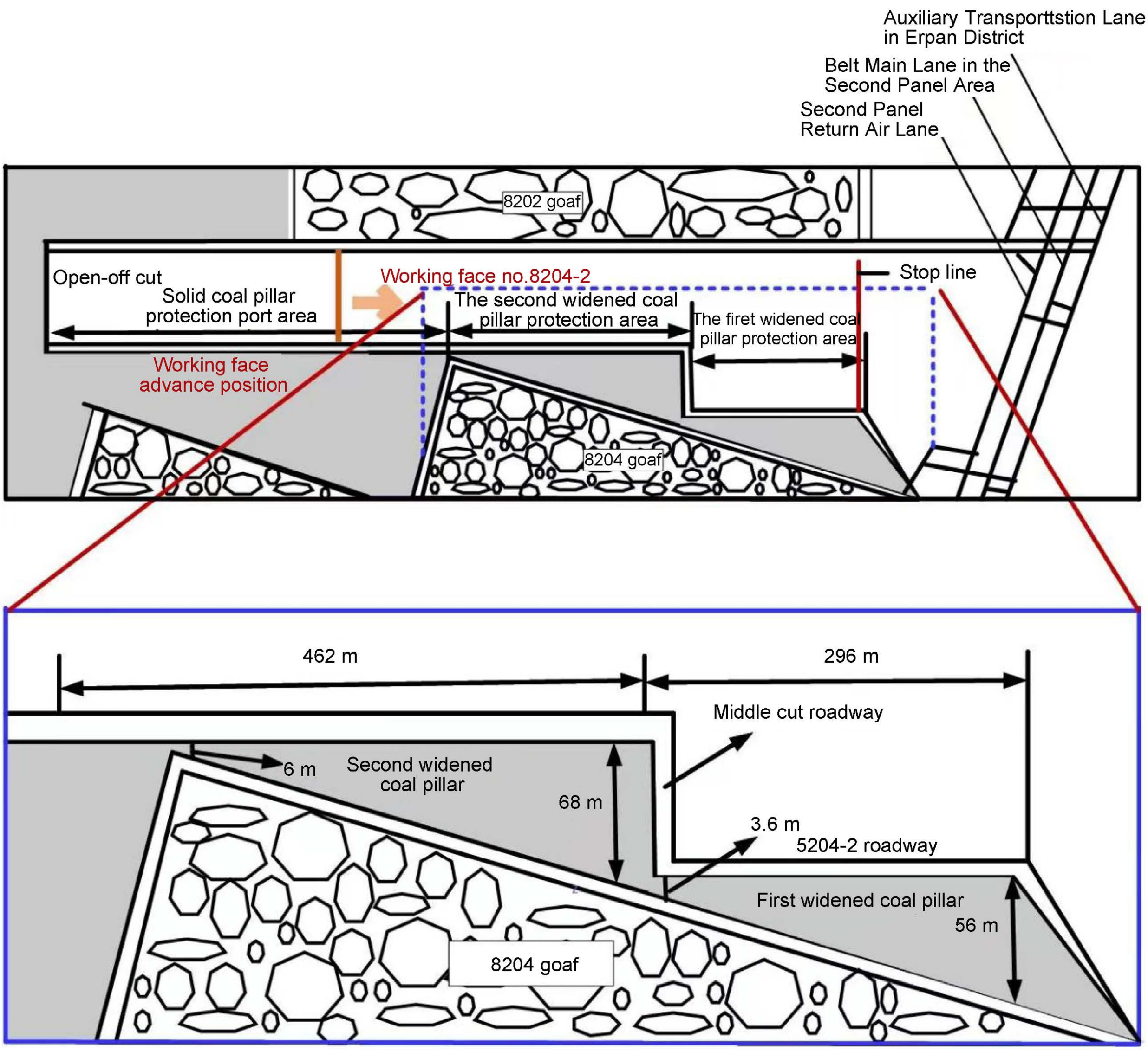


Figure 1. 8204-2 working face layout.

8204-2 working face is 209 m (in the later stage of mining) and 146 m (in the early stage of mining), respectively, working face strike length 1653.8 m. The working face adopts top coal caving mining, with a cutting height of 3.6 m and a coal caving height of 11.4 m. Lane 5204-2 is a return air roadway in the 8204-2 working face, adjacent to the 8204 goaf and excavated along the coal seam floor; According to the conditions of coal pillar protection along the advancing direction, it can be divided into solid coal pillar protection area, the second widened coal pillar protection area, and the first widened coal pillar protection area, he first widened coal pillar protection area is between the stop mining line and the central cutting roadway. The total length of the coal pillar is 296 m, and the width gradually decreases linearly from 56 meters to 3.6 meters. The second widened coal pillar protection roadway area is from the central cutting roadway to the cutting roadway chamber of 8204 working face. The coal pillar has a total length of 426 m, and the width gradually transitions from 68 m to 6 m.

## 3. Risk Analysis and Numerical Simulation of Isolated Working Face

### 3.1. Movement Pattern of Overlying Rock at the End

The mining of the working face resulted in the disruption of the equilibrium state of the original rock stress, stress redistribution. After stabilizing for a period of time, reaching a new equilibrium point, during this process, there is accompanied by rock movement and damage. The structure of the fractured coal and rock mass at the end of the goaf largely determines the stress environment and occurrence state of the surrounding rock in the lower section of the roadway. Therefore, analyzing the fracture structure characteristics of the overlying rock at the end is crucial for studying the stress environment and boundary conditions before excavation in the lower section of the tunnel.

**1) Formation of masonry beam structure**

After coal seam extraction, the overlying rock of the mined face has collapsed, forming a goaf, and the continuous mining of the working face causes periodic breakage of the upper basic roof of the goaf. Resulting in periodic fractures of the surrounding rock at the end of the goaf as the direct roof of the goaf falls, rotation and bending sinking. The broken rock blocks are hinged together to form a masonry beam structure. Following the direction of the working face, Rock mass A, rock block B, and rock block C are distributed in sequence. Among them, rock mass A is the basic roof rock mass at the upper part of the coal body at the end of the goaf that has not yet been disturbed by mining. Rock block B is the basic top block that has undergone rotational subsidence. Rock block C is the basic top block that has collapsed above the goaf, as shown in Figure 2.

**2) Stability of masonry beam structure**

After the mining of the working face, the masonry beam structure is not yet stable. It takes a certain amount of time for rock strata to migrate. Fully collapse

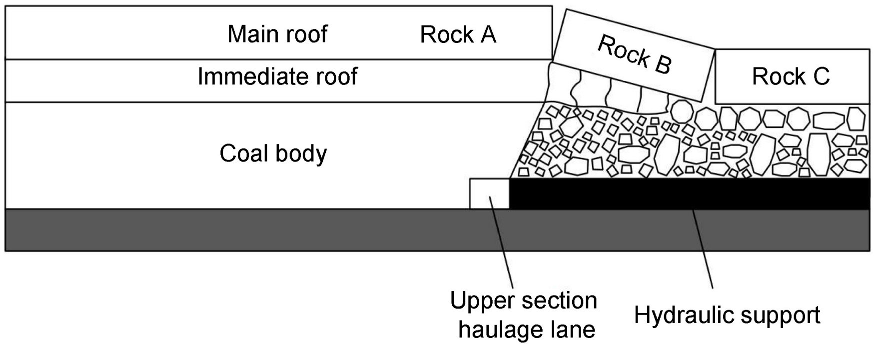


**Figure 2.** Stability of the masonry beam structure.

the direct roof above the goaf, during this process, rock block B continues to rotate, until the lateral constraints generated by rock mass A and rock block C are sufficiently stable, the direct top gangue that has completely collapsed in the goaf is completely compacted by rock block C. The masonry beam structure gradually stabilized. as shown in Figure 3.

**3) Instability failure of masonry beam structure**

The advanced stress caused by the mining of the next section of the working face causes the previously stable masonry beam rock block to move again, a new masonry beam structure will also be formed at the end of the goaf in the lower section; both sides of the coal pillar are mined out and become isolated coal pillars. At this point, if the internal structure of the coal pillar is not stable enough, it is easy to cause damage. The overlying masonry beam structure may also experience instability and failure, causing a sharp increase in stress in the surrounding rock of the coal pillar. The deformation of the surrounding rock of the tunnel is large, ultimately, it leads to the instability and failure of the entire coal pillar. If the internal structure of the coal pillar is sufficiently stable, the coal pillar bears most of the gravity of the upper rock mass. Continuously accumulating energy in the coal pillar poses a threat to the safety of mining in the working face, as shown in Figure 4.

## 3.2. Hazard Analysis of the Working Face

**1) Statistics of dynamic phenomena during tunnel excavation**.

June 6, 2017 to February 4, 2018, 531 cumulative occurrences of coal cannon in the 1st widened coal pillar roadway protection area, mainly concentrated within the coal pillar width range of 33.5 m to 7.9 m. The second widening of the coal pillar in the roadway protection area has resulted in a cumulative occurrence of 2176 coal explosions, mainly concentrated within the range of 64.4 m to 22.4 m in coal pillar width. The phenomenon of coal blasting during tunnel excavation indicates that: Under the combined influence of lateral support pressure in the 8204 goaf and disturbance stress in the excavation roadway, the surrounding rock of the roadway becomes unstable, and the accumulated elastic energy is rapidly released in the form of kinetic energy. If the mining stress of 8204-2 working face is superimposed in the later stage (the dynamic disturbance

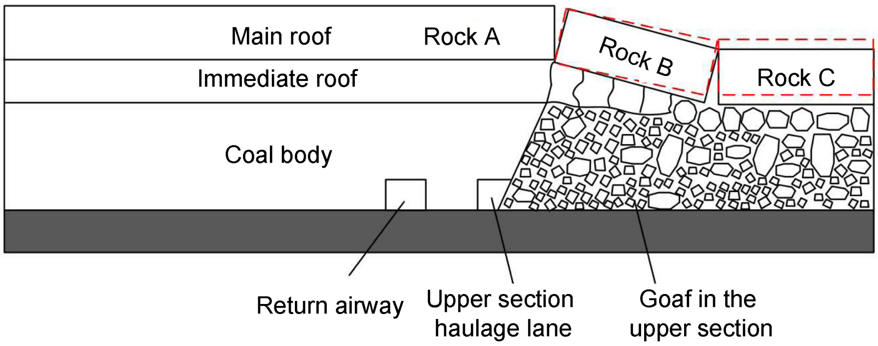


**Figure 3.** Stability of the masonry beam structure.

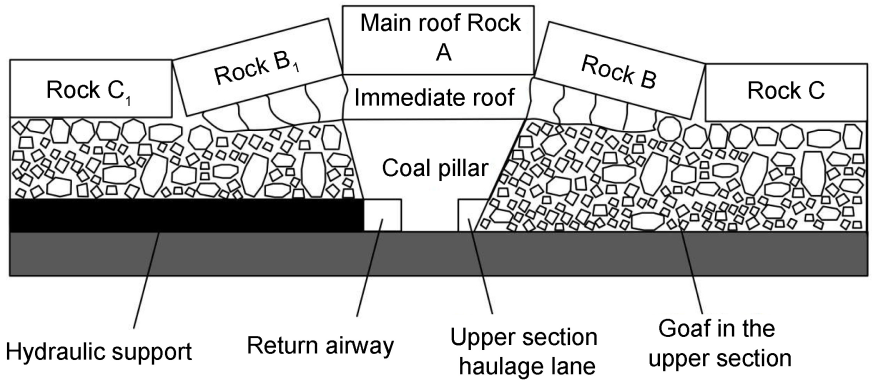


**Figure 4.** Bilateral masonry beam structure.

generated by mining and the superimposed advanced support pressure), the risk of strong rock pressure occurring in the surrounding rock of the return air tunnel is very high.

**2) Coal pillar stress.**

The average mining thickness of 8204-2 working face is about 15 m, and the mining depth is about 500 m. The mining disturbance range is large, the roof rock layer activity is intense, and the mining stress is high. When the 8204-2 working face is mined to the second widened coal pillar, the vertical stress inside the coal pillar reaches 43.8 MPa (stress concentration coefficient is about 3.504) due to the combined influence of lateral support stress on both sides of the goaf and advanced mining stress. When the first widened coal pillar is mined, the vertical stress of the second widened coal pillar located behind the working face reaches 66.7 MPa (stress concentration coefficient is about 5.336).

**3) Coal pillar energy.**

When mining to the 2nd widened coal pillar at 8204-2 working face, the peak strain energy density of the coal pillar is about 1.23 × 106 J/m$^3$. When mining to the first widened coal pillar, the peak strain energy density of the second widened coal pillar increases to 1.78 × 106 J/m$^3$. If a strain energy density of the 6th order is released, it is sufficient to collapse the entire tunnel, the preliminary numerical calculations and statistical results of coal gun events indicate that, the width of the lateral plastic zone of the goaf under the geological conditions of mining in Tashan Mine is about 21 m. When the width of the section coal pillar exceeds 21 m, it is converted into a bearing coal pillar, and there is an elastic core inside the coal pillar, this bearing coal pillar serves as the support point for the arch foot of the overlying rock large structure arch, and this arch foot can only passively bear the high static load of the overlying rock and cannot be transferred. When 8204-2 working face the near widening coal pillar area, the advanced mining stress is applied to the coal pillar in the second widening area in front of the working face at a certain loading rate, and the superposition of dynamic and static loads easily induces the rapid release of elastic energy in the elastic core of the bearing coal pillar, formation of strong mineral pressure phenomenon. When the 8204-2 working face advances to the first widened coal pillar area, the second widened coal pillar behind the working face becomes an isolated coal pillar due to its wider width, and its elastic core still bears the high static load of the overlying rock; and at this time, the 8204-2 goaf has not yet been completely stable, and the hinged structure rock plate activity is intense, which is also prone to triggering the impact dynamic phenomenon of the second widened coal pillar. This dynamic load further triggers the occurrence of strong rock pressure in the local area of the first widened coal pillar.

Based on the dynamic phenomena, coal pillar stress, coal pillar energy, distribution of coal pillar elastic zone, and analysis of overlying rock structure that occur during excavation and mining, it can be concluded that, the risk of strong rock pressure or even strong impact occurring in the surrounding rock of the return air roadway during the mining period of 8204-2 working face is very high. It is necessary to attach great importance to it, and develop targeted prevention and control measures, to ensure the safe mining of 8204-2 working face.

### 3.3. Simulation of the Evolution Process of Stress Field in the Surrounding Rock of the Roadway in the Widened Coal Pillar Area during Mining

Through FLAC3D simulation software, a model is established as shown in Figure 5. The model is divided into a total of 202,514 units, 223,216 nodes. The model size is 1000 m × 730 m × 200 m, assign physical and mechanical parameters to the rock layers based on the specific geological conditions of the Tashan mine.

In terms of boundary conditions, fix the vertical displacement at the bottom of the model, and fix lateral displacement at the front, rear, and left and right boundaries. Add interfaces to the model to simulate the contact between the collapsed roof and floor of the goaf. Apply a vertical stress of 9.12 MPa at the top to simulate the self weight of the overlying rock layer.

**1) Variation law of vertical stress field in widened coal pillar area**

The stress field distribution in the first widened coal pillar area and the second widened coal pillar area has the same pattern. The highest degree of stress concentration is observed in the surrounding rock within a range of 30 m to 36 m from the edge of the 8204 goaf. The maximum stress reaches 30.21 MPa. The

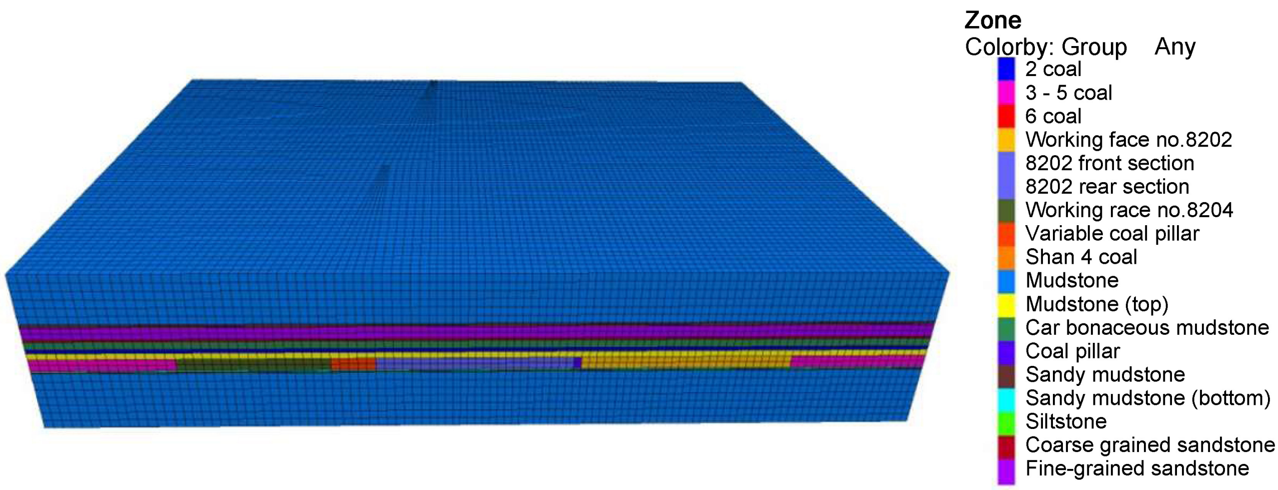


**Figure 5.** Model schematic diagram.

stress concentration coefficient reaches 2.44. The height of the stress concentration area from the coal seam floor is about 18 m to 27 m. When the width of the coal pillar between the roadway and goaf is about 30 m, the roadway is roughly located below the stress concentration area. Arrange tunnels in this area, It is extremely unfavorable for the stability of the surrounding rock of the tunnel. When the width of the coal pillar is reduced to within 20 m, the stress concentration area is located on the upper right side of the tunnel, the roadway gradually approaches the edge of the goaf, and the peak stress of the surrounding rock gradually decreases.

**2) Evolution process of stress field on the roof of roadway in widened coal pillar area**

Figure 6 shows the stress distribution of the roof of the roadway in the first variable width coal pillar area. From the figure, it can be seen that, as the distance from the edge of the goaf increases, the stress on the roof of the tunnel increases first and then decreases.

When the width of the coal pillar in the roadway is less than 20 m, the stress on the top plate is distributed in a "single peak" shape. At this point, the stress on the side of the solid coal is much greater than that on the side of the coal pillar, and the stress on the roof and coal pillar at the location of the tunnel is relatively small. When the width of the coal pillar is 30 m, the stress on the roof exhibits an asymmetric "bimodal" distribution, the stress on the side of the solid coal is still greater than that on the side of the coal pillar, but the stress on the side of the coal pillar also increases. When the width of the coal pillar is 40 m, the stress on the top plate is distributed in a saddle shape. Both sides of the roadway roof are subjected to the same amount of force, and the stress on both sides of the roadway is at a relatively high level. When the width of the coal pillar is 50 m, the stress on the roof of the roadway presents an asymmetric "bimodal" shape, where the stress on the side of the coal pillar is greater than that on the side of the solid coal, but the stress around the roadway decreases relative to 40 m.

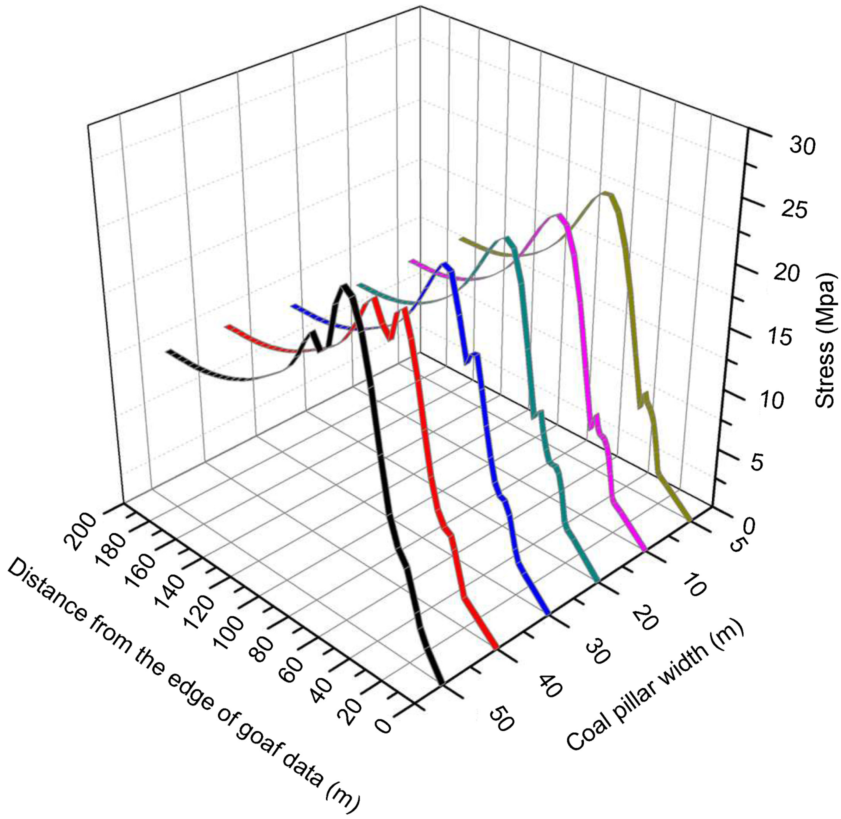


**Figure 6.** Stress distribution of the roof of the roadway in the first widened coal pillar area.

**Figure 7** shows the stress distribution of the roof of the roadway in the second variable width coal pillar area. It can be seen that the stress distribution pattern is similar to the first variable width coal pillar area. When the width of the coal pillar is less than 20 m, the stress on the side of the solid coal is much greater than that on the side of the coal pillar, showing a "single peak" distribution. At this time, the stress on the roof of the tunnel decreases, and the impact on the stability of the surrounding rock is relatively small. When the width of the coal pillar is 30 m, the stress on the side of the solid coal is greater than that on the side of the coal pillar, exhibiting an asymmetric "bimodal" distribution. When the width of the coal pillar is 40 m, the forces on both sides of the roadway roof are the same, distributed in a "saddle shape"; When the width of the coal pillar is 50 m - 60 m, the stress on the side of the coal pillar is greater than that on the side of the solid coal, exhibiting an asymmetric "bimodal" distribution.

Simulation conclusion:

1) When the width of the coal pillar is less than 20 m, the stress on the coal side of the roadway is greater, while the stress on the coal pillar side is smaller.

2) When the width of the coal pillar ranges from 25 m to 45 m, the vertical stress on the roadway and surrounding areas is relatively large, and pressure relief measures need to be taken during mining to reduce the stress of the surrounding rock.

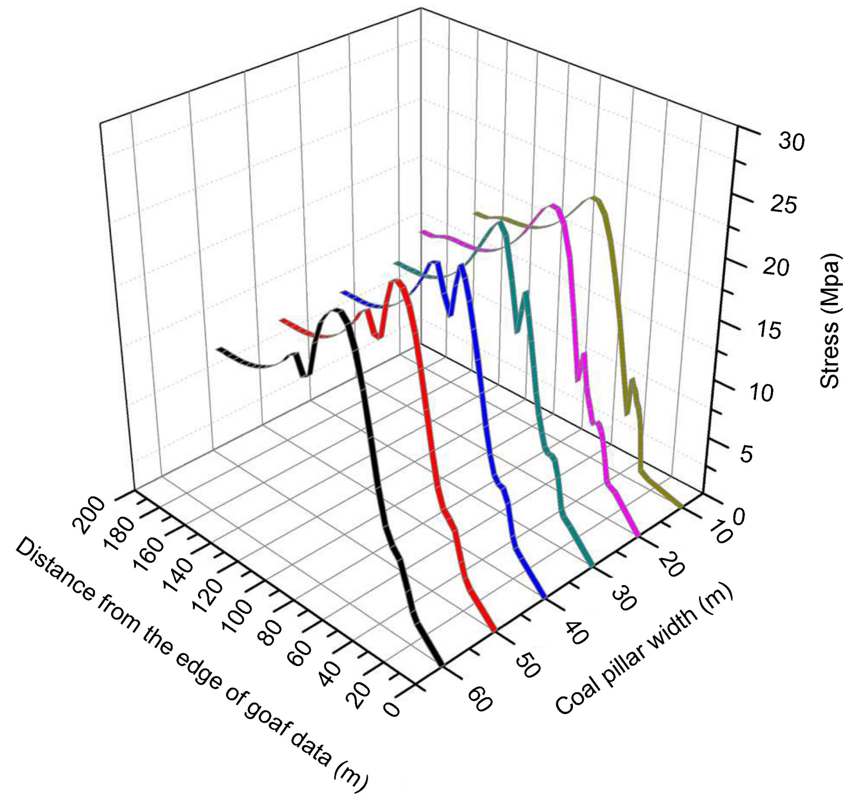


**Figure 7.** Stress distribution of the roof of the roadway in the second widened coal pillar area.

3) When the width of the coal pillar is greater than 45 m, the peak stress of the coal pillar is located in the deep part of the surrounding rock, but it still has a certain impact on the roadway. It is necessary to take pressure relief measures to transfer the stress to a deeper depth to ensure the stability of the triangular coal pillar during safe mining of the working face.

## 4. Prevention and Control Measures

Based on the analysis of numerical simulation results, in order to prevent the occurrence of disasters, strong pressure relief measures were implemented for the return airway of the 8204 isolated working face, and improvements and suggestions were proposed for the original working face advancement speed and roadway support. The specific details are as follows:

**1) Measures for strong pressure relief in tunnels**

a) Tunnel side

The coal pillar side of the 5204-2 return air tunnel is depressurized by drilling large diameter holes, and a tracked drilling rig is used to drill holes in the side construction, 130 mm diameter. The total construction length is 246 m (with mining positions ranging from 800 m to 1046 m). A total of 1088 pressure relief boreholes were drilled. The pressure relief drilling is arranged at the lower part of the second row of support and the middle part of the third row of support.

The horizontal distance between boreholes is 900 mm, vertical distance 500 mm. The length of coal pillar side drilling is 10,000 mm/15,000mm, the drilling length of the coal mining side is 15,000 mm, seal the hole with yellow mud for 300 mm. The drilling arrangement is shown in Figure 8.

b) Bottom plate pressure relief

The method of cutting grooves on the bottom plate is used to relieve pressure on the tunnel floor. The excavation parameter of the bottom plate pressure relief groove is 500 mm in width, and 1000 mm in depth. The excavated pressure relief groove is tightly covered with 20 mm thick wooden boards. To prevent personnel or objects from getting trapped, the specific arrangement is shown in Figure 9.

c) Top plate pressure relief

Hydraulic fracturing method is used to relieve pressure on the overlying basic roof of the working face. The hydraulic fracturing of the hard top plate reduces the thickness of the rock beam, the bending section modulus of the rock beam decreases, and the integrity of the roof is destroyed, thereby reducing the ultimate collapse step of the top beam and slowing down the mining pressure of the working face.

**2) Reduce propulsion speed**

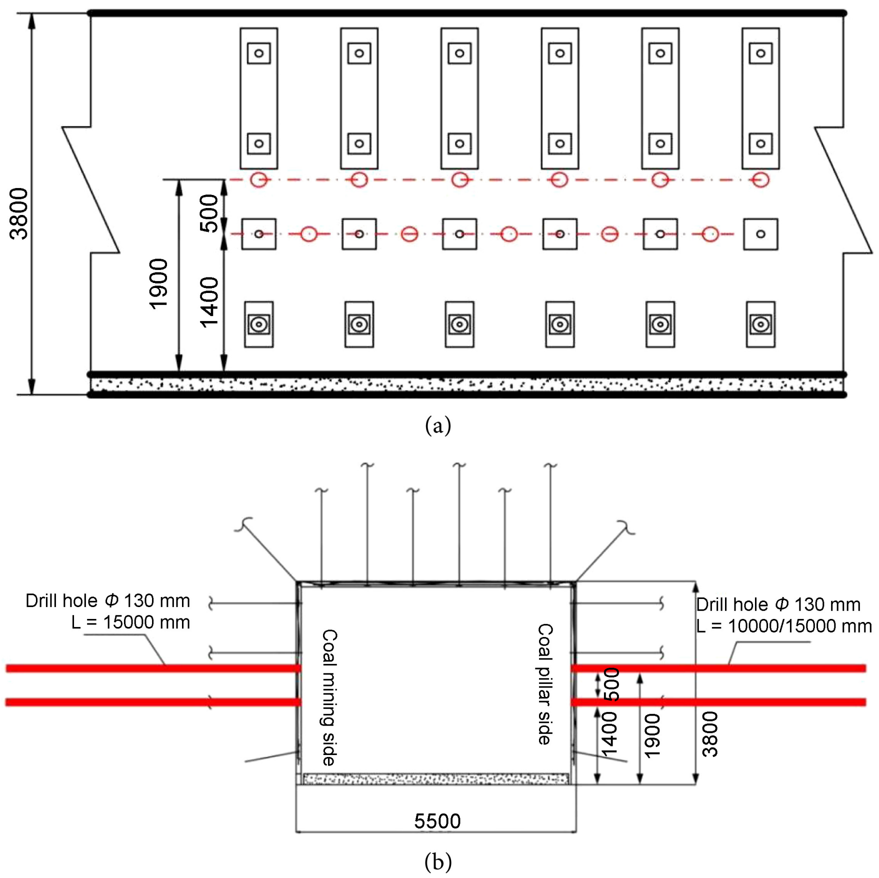


Figure 8. Layout of pressure relief drilling. (a) Lane support plan; (b) Tunnel cross-section.

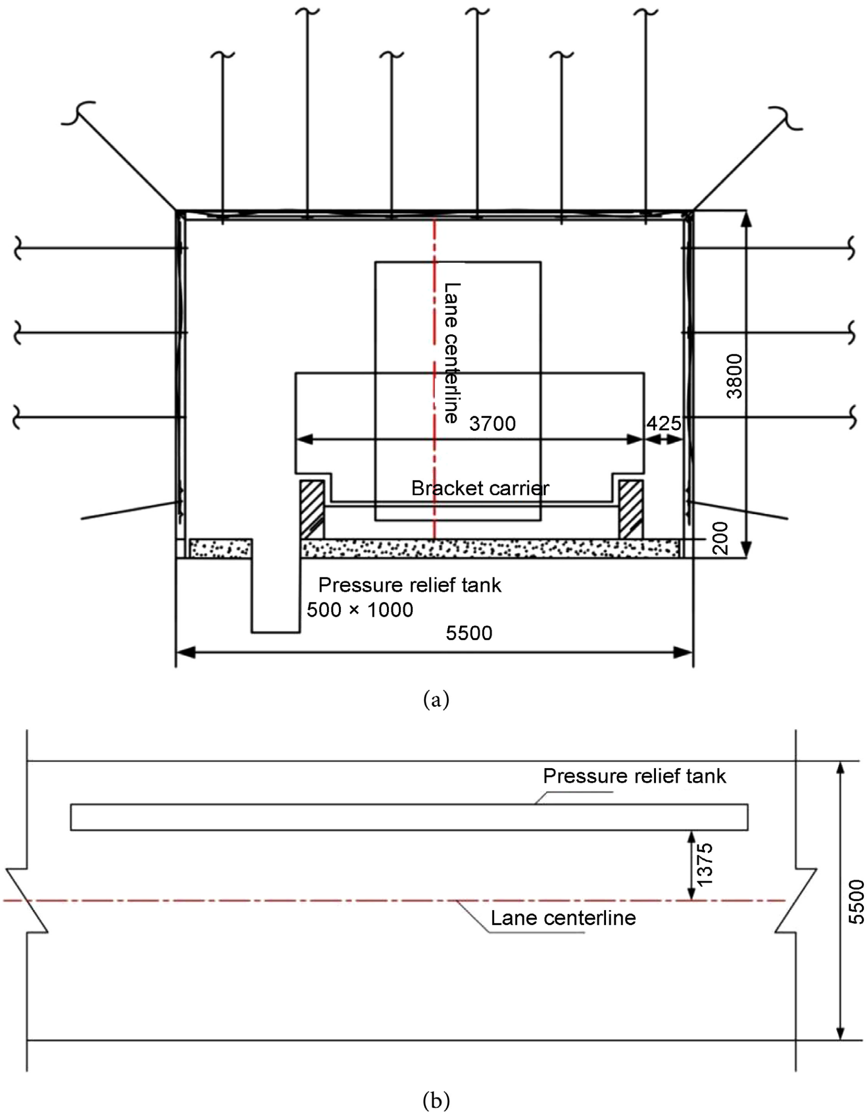


**Figure 9.** 5204-2 layout of return air shunt pressure relief tank. (a) 5204-2 Cross section diagram of pressure relief groove layout for return air channel; (b) 5204-2 layout plan of return air shunt pressure relief tank.

To reduce the loading rate of mining stress and the impact of roof collapse on coal pillars, need to reduce the advancing speed of the mining face. The rapid propulsion speed results in a shorter deformation time of the top plate under load. The pressure step distance is long, and the potential energy stored in the roof is large; when the roof is damaged, it has a significant impact on the coal pillars and tunnels. Reducing the propulsion speed can fully release the deformation of the roof.

The basic roof collapses in a timely manner, shorten the weighting step, reduce the compressive strength.

**3) Strengthen microseismic monitoring and early warning**

Due to the possibility of dynamic disasters in the coal pillars of the variable coal pillar section, therefore, during the mining process of the working face, starting from 50 m before entering the coal pillar section of the 8204-2 return air roadway. Drill holes every 30 - 50 m, a total of 20 three component detectors are arranged, until the stop line position. Install a microseismic monitoring system, by shooting calibration. After the installation of the detector and the overall monitoring system are in good working condition, monitor the location of microseismic events as the working face progresses.

During the mining stage of the working face, especially when entering the coal pillar section for mining, pay close attention to microseismic events during the advancement of the working face, and make judgments on the trend of microseismic events, provide timely warning for areas with potential power hazards.

**4) No or few people in the return air lane**

To ensure personnel safety, personnel are strictly prohibited from entering the return air lane during production, except for necessary maintenance and repair work.

**5) Reinforcement support**

From the above research, it can be concluded that. There are elastic cores in the widened coal pillar, during the mining process, under the influence of advanced stress; impact phenomena such as "coal cannon" are prone to occur, leading to the destruction of the surrounding rock of the tunnel. Strengthen and support the relevant areas to increase the stability of the roadway.

## 5. Conclusions

By analyzing the evolution law of the stress field of the surrounding rock in the widened coal pillar area of the isolated working face during mining, the high-risk area of strong mining pressure under different coal pillar widths is determined. The following conclusions are drawn: 1) When the width of the coal pillar is less than 20 m, the solid coal side of the roadway bears more force, while the coal pillar side bears less force. 2) When the width of the coal pillar is within the range of 25 m - 45 m, the vertical stress on the roadway and surrounding areas is relatively high. Therefore, pressure relief measures need to be taken during mining to reduce the stress on the surrounding rock. 3) When the width of the coal pillar is greater than 45 m, the peak stress of the coal pillar is located in the deep part of the surrounding rock, but it still has a certain impact on the roadway. It is necessary to take pressure relief measures to transfer the stress deeper to ensure the stability of the triangular coal pillar during safe mining of the working face.

Through numerical simulation conclusions, the implementation of strong pressure relief measures in the return airway of the 8204 isolated working face is proposed, and improvements and suggestions are proposed for the original plan's working face advancement speed, roadway support, etc., providing reference for the prevention and control of rockburst under similar conditions.

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

## References

[1] Zhang, J.C., Li, X.L., Qin, Q.Z., Wang, Y.B. and Gao, X. (2023) Study on Overlying Strata Movement Patterns and Mechanisms in Super-Large Mining Height Stopes. *Bulletin of Engineering Geology and the Environment*, **82**, Article No. 142. https://doi.org/10.1007/s10064-023-03185-5

[2] Wang, S.R., Wu, X.G., Zhao, Y.H. and Hagan, P. (2018) Mechanical Performances of Pressure Arch in Thick Bedrock during Shallow Coal Mining. *Geofluids*, **2018**, Article ID: 2419659. https://doi.org/10.1155/2018/2419659

[3] Zhu, S.T., Feng, Y. and Jiang, F.X. (2016) Determination of Abutment Pressure in Coal Mines with Extremely Thick Alluvium Stratum: A Typical Kind of Rockburst Mines in China. *Rock Mechanics and Rock Engineering*, **49**, 1943-1952. https://doi.org/10.1007/s00603-015-0868-x

[4] Xie, J., Gao, M.Z., Zhang, R., Li, S.W., Tan, Q. and Qiu, Z.Q. (2016) Lessons Learnt from Measurements of Vertical Pressure at a Top Coal Mining Face at Datong Tashan Mines, China. *Rock Mechanics and Rock Engineering*, **49**, 2977-2983. https://doi.org/10.1007/s00603-015-0856-1

[5] Zhou, P., Wang, Y.J., Zhu, G.L. and Gao, Y.B. (2019) Comparative Analysis of the Mine Pressure at Non-Pillar Longwall Mining by Roof Cutting and Traditional Longwall Mining. *Journal of Geophysics and Engineering*, **16**, 423-438. https://doi.org/10.1093/jge/gxz026

[6] Wang, S.R., Wu, X.G., Zhao, Y.H., Hagan, P. and Cao, C. (2019) Evolution Characteristics of Composite Pressure-Arch in Thin Bedrock of Overlying Strata During Shallow Coal Mining. *International Journal of Applied Mechanics*, **11**, 1950030. https://doi.org/10.1142/S1758825119500303

[7] Miao, K.J., Wang, D.P., Tu, S.H., *et al.* (2022) The Principle and Practice of Strong Mine Pressure Control in the Initial Mining and Caving Stages under Multiple Key Strata. *Sustainability*, **14**, Article 5772. https://doi.org/10.3390/su14105772

[8] Zhang, Q., Zhang, J.X., Chen, Y., Ntigurirwa, J.D. and Xia, K.Q. (2020) Moving Set-up Room Theory of Weakening the Mining Pressure Caused by the Backfilling Body in Solid Backfilling Mining. *Energy Science & Engineering*, **8**, 898-909. https://doi.org/10.1002/ese3.559

[9] Gong, T., Xia, B.W., Lu, Y.Y., Luo, Y.F. and Hu, H.R. (2020) Study on the Maximum Pressure-Causing Stratum in Longwall Mining Stope and Its Mechanics Analysis. *Arabian Journal of Geosciences*, **13**, Article No. 566. https://doi.org/10.1007/s12517-020-05625-y

[10] Shi, J.L., Yan, S.H., Xu, Z.H., Xue, J.S., Zhao, K.K. and Zheng, J.W. (2021) Analysis of the Progressively Enhanced Mine Pressure in the Fully Mechanized Top Coal Caving Work Face of a 20 m Ultra-Thick Coal Seam. *Shock and Vibration*, **2021**, Article ID: 6678207.

[11] Feng, J.W., Wang, W.M., Wang, Z., *et al.* (2023) Study on the Mechanism and Control of Strong Rock Pressure in Thick Coal Seam Mining under the Goaf of Very Close Multiple Coal Seams. *Processes*, **11**, Article 1320. https://doi.org/10.3390/pr11051320

[12] Zhao, Y.H., Wang, S.R., Hagan, P. and Guo, W.B. (2018) Evolution Characteristics of Pressure-Arch and Elastic Energy during Shallow Horizontal Coal Mining. *Tehnički Vjesnik*, **25**, 867-875. https://doi.org/10.17559/TV-20180305084447

[13] Zhou, H.F., Huang, Q.X., Liu, Y.J. and He, Y.P. (2021) Study on the Mine Pressure Law and the Pressure Frame Mechanism of an Overlying Goaf in a Shallow Coal

Seam. *Shock and Vibration*, **2021**, Article ID: 9675137. https://doi.org/10.1155/2021/9675137

[14] Zhang, Q., Zhang, J.X., Kang, T., Sun, Q. and Li, W.K. (2015) Mining Pressure Monitoring and Analysis in Fully Mechanized Backfilling Coal Mining Face—A Case Study in Zhai Zhen Coal Mine. *Journal of Central South University*, **22**, 1965-1972. https://doi.org/10.1007/s11771-015-2716-2

[15] Zhu, Z.J., Wu, Y.L. and Liang, Z. (2022) Mining-Induced Stress and Ground Pressure Behavior Characteristics in Mining a Thick Coal Seam with Hard Roofs. *Frontiers in Earth Science*, **10**. https://doi.org/10.3389/feart.2022.843191

[16] Guo, P., Zhao, Y., Yuan, Y., *et al.* (2021) Gob-Side Entry Stability Analysis by Global-Finite and Local-Discrete Modeling Approach. *Geomechanics and Engineering*, **27**, 391-404.

[17] Li, J.Z., Zhang, M., Li, Y. and Hu, H. (2018) Surrounding Rock Control Mechanism in the Gob-Side Retaining Entry in Thin Coal Seams, and Its Application. *Journal of the South African Institute of Mining & Metallurgy*, **118**, 471-480.

[18] Han, Cl., Zhang, N., Li, By., *et al.* (2015) Pressure Relief and Structure Stability Mechanism of Hard Roof for Gob-Side Entry Retaining. *Journal of Central South University*, **22**, 4445-4455. https://doi.org/10.1007/s11771-015-2992-x