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NON-REPEATED SUPPORT TECHNOLOGY OF GOB SIDE ENTRY RETAINING WITH ROOF CUTTING TO RELEASE PRESSURE

BASINCI AZALTMAK İÇİN TAVAN KESME İLE DESTEKLENEN GÖÇÜK TARAFI GİRİŞİNİN TEKRARSIZ DESTEK TEKNOLOJİSİ İLE TAHKİMATI

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ABSTRACT

Temporary support of the gob side entry is of great significance to the safety mining. Taking the 1206 transportation tunnel of Shuguang Coal Mine as the engineering background, firstly, the key technical parameters of roof cutting to release pressure were given, the bolt and cable support parameters before entry retaining and the large deformation constant resistance cable reinforcement support parameters of retained entry were determined. Secondly, according to the overlying strata collapse patterns and mechanical model of gob side entry, the calculation formula of temporary support resistance in the dynamic pressure bearing area was derived. Finally, on the basis of determining the temporary support parameters, ZLQ2826/22.5/38 type of non-repeated support and transportation equipment of alternating pressure cycles was developed, the main technical parameters and structural characteristics were analyzed, and a new type of fast and efficient non-repeated temporary support technology in the dynamic pressure bearing area was proposed. Field practice shows that the support parameters are reasonable, the support equipment and bolt support system have a good cooperative support effect, and the roof subsidence and roof separation have been effectively controlled. In the subsequent use process, the structure of support devices should be further optimized to improve the support effect.

Anahtar Sözcükler:
Maden mühendisliği,
Göçük tarafı giriş tahkimatı,
Dinamik basınç taşıma alanı,
Tekrarlanmayan geçici tahkimat,
Giriş tahkimatı.

ÖZ

Güvenli bir madencilik için göçük tarafından açılan galerilerin ilk tahkimatları büyük önem arz etmektedir. Shuguang Kömür Madeni'nin 1206 no'lu nakliye galerisinin mühendislik geçmişi özelinde; öncelikle, galeri üzerindeki gerilmelerin rahatlatılması adına tavan kazısının yapılmasının ardından, yüksek deformasyonlara müsaade etmeden, kablolu ankrajlar ile tavanın tahkim edilmesi önemlidir. İkincil olarak, yürüyen tahkimatların taşıma kapasitesini dikkate alacak şekilde geçici tahkimat dayanımlarının yaklaşımı, askıda kalan tavanın ve göçük tarafındaki yapının mekanik modeline dayanarak elde edilmiştir. Son olarak, geçici tahkimat parametrelerinin belirlenmesine dayanarak, alternatif basınç çevrimlerinin ZLQ2826/22.5/38 tipi tekrarlanmayan tahkimat ve nakliyat ekipmanı geliştirilmiş; temel teknik parametreler ve yapısal özellikler analiz edilmiş ve dinamik basınç taşıma alanında yeni, hızlı ve verimli, tekrarlanmayan geçici tahkimat teknolojisi önerilmiştir. Saha uygulaması, tahkimat parametrelerinin kabul edilebilir olduğunu, tahkimat ekipmanının ve kaya saplama tahkimat sisteminin tahkimat etkisiyle uyumlu olduğunu ve tasman ve tavan ayrışmasının etkili bir şekilde kontrol edildiğini göstermektedir. Müteakip kullanımlarda, tahkimatın etkisini geliştirmek için tahkimat ekipmanlarının yapısı daha da optimize edilmelidir.

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INTRODUCTION

With the continuous increase of mining intensity, the coal resources are decreasing year by year in China, and the problems of great loss of coal resources and mining imbalance caused by the traditional coal pillar mining face are increasingly prominent (Hua, 2006; Xue, 2013), which has not met the requirements of sustainable development and green mining. Based on this, more and more mines begin to adopt the technology of gob side entry retaining by roof cutting to release pressure, the technology has eliminated the traditional coal pillars, improved the recovery rate of coal resources, and extended the service life of coal mines (Tan et al., 2015). In addition, the possible disasters such as serious damage and deformation of roadway, rock burst, coal and gas outburst caused by the stress concentration of coal pillars in the mining process have been avoided, which has good technical and economic benefits.

In recent years, the technology of gob side entry retaining by roof cutting to release pressure has been widely used in China (He et al., 2017a and 2017b), many scholars have done a lot of research on this technology. Sun et al. (2014) studied the key parameters of gob cutting and roadway retaining in thin coal seam through theoretical analysis and numerical simulation and carried out engineering practice. Guo et al. (2016) studied the blasting and related key technologies for the roof of gob side entry. Gao et al. (2017) studied the mechanical mechanism of different support areas in gob side entry by roof cutting and put forward the cooperative support technology of constant pressure displacement for gob side entry. Sun et al. (1992) analyzed the roof movement laws of the gob side entry and gave the roadway support parameters. Zhang et al. (2018) summed up the scheme of combined support of surrounding rock in gob side entry in the process of site time. Lin et al. (2013) analyzed the characteristics and key technologies of pressure relief of double dynamic coordinated roof cutting along the gob roadway.

The above research has important theoretical and practical significance for gob side entry retaining, however, for the temporary support of gob side entry, the main support scheme is dense single hydraulic prop, the support scheme has high labor intensity and requires a large number of people to cooperate. In addition, there are some hidden dangers in the process of returning the column, which has restricted the efficiency of gob side entry retaining to a certain extent. On the basis of previous studies, this study mainly focuses on the problems of temporary support in the dynamic pressure bearing area of gob side entry retaining with roof cutting to release pressure, and the technology of long-distance alternate circulation temporary support without repeated support of gob side entry has been put forward, which has realized the safe and efficient mechanized temporary support for gob side entry.

1. PROJECT OVERVIEW

The coal seam of 1226 fully mechanized mining face in Shuguang Coal Mine is located in Shanxi formation of Lower Permian system, with the average buried depth of 512 m, the average thickness of 2.85 m, and the average inclination angle of 2°. The structure of the coal seam is simple, and the intercalated lithology is mostly carbonaceous mudstone or mudstone, the workable strike length of the working face is 1562.75 m, the dip length is 180.5 m, and the entity length is 176 m.

1226 transport tunnel is a retained entry, and the technology of gob-side entry retaining by cutting roof to release pressure is adopted. The roadway which is designed as a rectangular section is 1562 m in length, 4.7 m in width and 3.5 m in height and is driven along the top. The entry roof and floor are silty mudstone and siltstone, as shown in Figure 1.

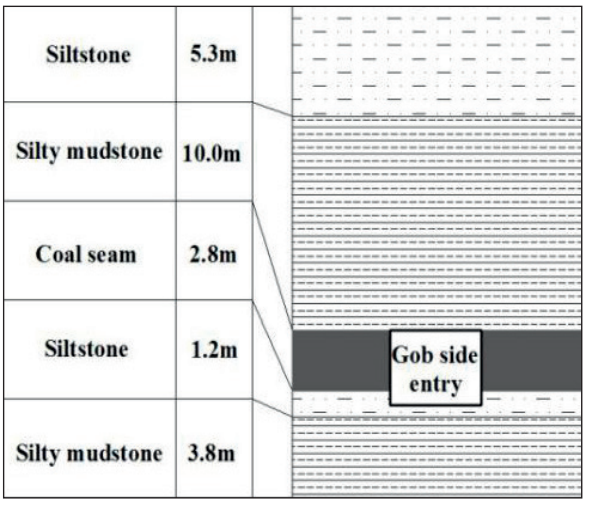

Figure 1. Rock stratum histogram

2. TECHNOLOGY OF CUTTING ROOF TO RELEASE PRESSURE

Pre-splitting blasting is carried out at the edge of the entry roof in front of the working face and under the influence of mining, the roof slate layer of the roadway is cut down along the cracks, on the basis of the original support scheme, the constant resistance and large deformation cables are adopted for the strong reinforcement support to control the subsidence of entry roof and improve the overall stability of roof rock. Meanwhile, temporary reinforcement support measures are adopted to ensure the overall stability of surrounding rock.

2.1. Roof Pre- Splitting Blasting

Bidirectional shaped pre-split blasting technology is adopted, diameter of bidirectional shaped in the roof of 1226 transport tunnel, the outer diameter, inner diameter and length of bidirectional energy collection tube are 42 mm, 36.5 mm and 1500 mm, respectively. The secondary emulsion explosive for coal mine is used with the specification of Φ32×200 mm, and the borehole is sealed with a sealing length of 2 m. The optimal charge parameter is 3 + 2 + 2 + 2 + 2 + 1 with a borehole spacing of 500 mm. According to the occurrence of the roof, the drilling depth is 10m, the deviation is 15° to the outside of the gob, and the drilling pre-splitting blast is performed within 60 m in front of the working face.

2.2. Gob Side Entry Support

Considering the physical and mechanical properties of rock strata, occurrence conditions, mining technology, roadway use, geological structure, mechanical properties of anchor and other parameters, combined with the previous support practice (Villaescusa et al., 2008; Li et al., 2012), the support scheme before entry retaining is as follows: Φ20 × 2400 mm threaded steel bolts are arranged in the roof, with a spacing of Φ850×1000 mm, the bolts at both ends of the roof are angle bolts, which form an angle of 75° with the horizontal line. Roof anchorage cables are Φ21.6×6500 mm steel strands and support anchorage in “1-2-1” layout: when two cables are arranged in each row, the spacing is 2000 mm at a distance of 1000 mm from the middle of the roadway; when one anchor cable is arranged in each row, the distance is 2000 mm in the middle of the roadway. Four bolts are arranged in each row of the two sides with the spacing of 850×1000 mm; when passing through the special geological structure during the excavation process, a point cable is arranged at the boundary between the 2 # coal seam, and the gangue on the right side of the roadway, the cable forms a 75° angle with the right side of the roadway with a row spacing of 2 m (Figure 2).

Before pre-split blasting, two rows of Φ21.8×12000 mm constant-resistance and large deformation cables are arranged in the roadway roof, the first row of anchor cables is drilled 400 mm from the slit and the row distance is 1000 mm, the second distance from the centerline of the roadway roof is deviated from coal wall 200 mm on the side with the row spacing of 2000 mm. The constant-resistance and large-deformation anchor cable constant-resistance device is 450 mm in length, 85 mm in diameter, 320 kN in constant resistance, and no less than 250 kN in preload.

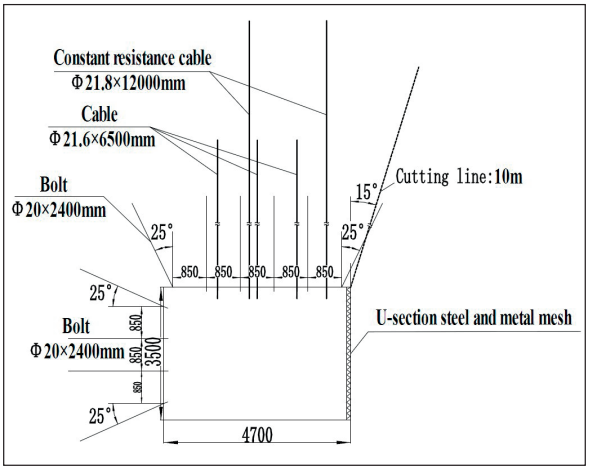

Figure 2. Support scheme of roadway along gob

3. MECHANICAL ANALYSIS OF GOB SIDE ENTRY RETAINING

In the mining process, the immediate roof along the gob will break and fall, and the main roof will break and rotate. Generally speaking, under the action of entry side support, because of the influence of support strength and stiffness, the

hard main roof in the upper part of the gob side entry often breaks on the inside of coal wall, and the other side is suspended on the outside of the gob. After breaking, the main roof rock block will rotate and deform along the gob, which will lead to the increase of surrounding rock deformation, and the stress concentration is easy to occur in both sides of the entry, which is not conducive to the stability of the surrounding rock in the remaining entry. After the movement of the overlying strata tends to be stable, the two sides of the gob side entry are supported by coal wall and entry side support, respectively as shown in Figure 3.

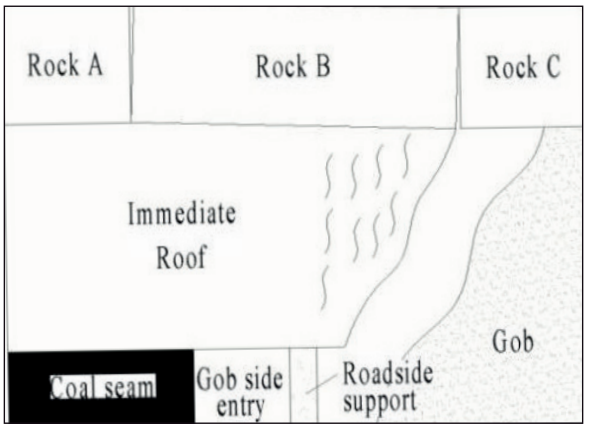

Figure 3. Strata structure of gob side entry with side support

When the pre-splitting blasting is carried out at the edge of entry roof in front of the working face, a directional crack will be formed, and the immediate roof will be cut down along the directional crack under the influence of mining. On the one hand, based on the designed fracture height, the broken rock mass can basically fill the gob, the broken rock mass occupy most of the free space, which will limit the rotary deformation of the overlying hard main roof after breaking, and reducing the deformation of the surrounding rock. On the other hand, the overlying strata of the gob side entry can collapse along the directional crack in time, which reduces the cantilever length of the main roof and the stress concentration of the gob side entry.

According to the time and space continuous relationship of the technology of roof cutting to release pressure, the surrounding rock of the retained entry can be divided into coal support area, dynamic pressure bearing area and stability area (Zhang et al., 2016). In the dynamic pressure bearing area, the retained entry roof at the side of the gob is in initial cut-off state, and the roof is not completely collapsed, which causes the surrounding rock of the retained entry to deform violently, meanwhile, the bolt and cable support system is easily affected. In order to reduce the surrounding rock deformation and relieve the support pressure of bolt and anchor cable support system, the temporary and dynamic support system should be added in the dynamic pressure bearing area, and after the gob side entry enters into the stability area, the temporary support can be removed (Figure 4).

According to the overlying strata structural characteristics of the gob side entry in the dynamic pressure bearing area, the following mechanical model (Figure 5) can be established (He et al., 2018; Ma et al., 2019).

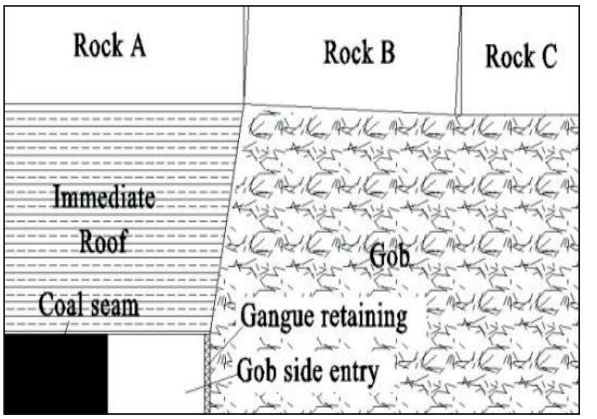

Figure 4. Strata structure of gob side entry with roof cutting to release pressure

After roof cutting and pressure relief, it is assumed that the main roof of the gob side entry breaks at A_0 above the interior of the coal wall, the rock mass have some rotary deformation, and in the shallow zone of the coal wall is in a plastic failure state, while in the deep zone the coal wall is still in elastic state. According to limit equilibrium theory (Wang et al., 2017; Kilerci et al., 2019), it is in the limit equilibrium state at the junction of elastic

zone and plastic zone, the width of the plastic zone in the coal wall of the gob side entry and the stress of the coal wall to the overlying strata in plastic zone are calculated according to the following formula:

$$x_0 = \frac{mk}{x}\ln[\frac{k\gamma H + \frac{c_0}{\tan\varphi_0}}{\frac{c_0}{\tan\varphi_0} + \frac{p_x}{k}}] \quad (1)$$

$$\sigma = [\frac{c_0}{\tan\varphi_0} + \frac{p_x}{k}]e^{\frac{2x\tan\varphi_0}{mk}} - \frac{c_0}{\tan\varphi_0} \quad (2)$$

Where, k is the pressure coefficient; m is the coal seam thickness; H is the buried depth of the coal seam; γ is the unit weight of the overburden; p_x is the lateral binding force of coal wall side; c_0 and φ_0 are the cohesion and the internal friction angle, respectively.

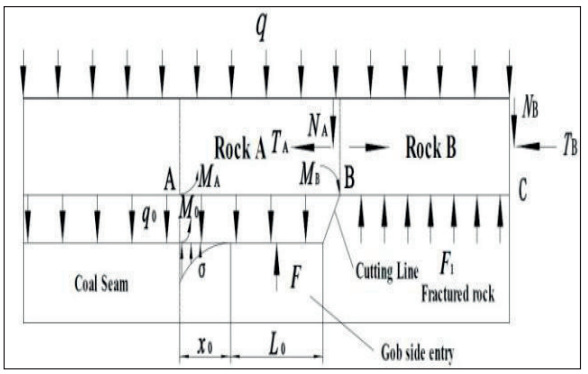

Figure 5. Mechanical model of gob side entry with roof cutting to release pressure

Taking the key block B as the research object,

From $\sum F_x = 0$, it can be obtained:

$$T_A = T_B \quad (3)$$

From $\sum F_Y = 0$ it can be obtained:

$$N_A = N_B + qL \quad (4)$$

From $\sum M_B = 0$, it can be obtained:

$$M_B + T_B(H - \Delta S_C) = N_B L - \frac{qL^2}{2} \quad (5)$$

By derivation, it can be obtained:

$$N_A = \frac{M_B + T_A(H - \Delta S_B) - \frac{qL^2}{2}}{L} \quad (6)$$

$$N_B = \frac{M_B + T_A(H - \Delta S_B) + \frac{qL^2}{2}}{L} \quad (7)$$

$$T_A = T_B = \frac{qL}{2(H - \Delta S_B)} \quad (8)$$

Where, T_A and T_B are the horizontal stress of the key block A and B, respectively; N_A and NB are the shear stress of the key block A and B, respectively; M_B is the bending moment of the block B; ΔS_B is the settlement of the block A at point B; ΔS_C is the settlement of the key block B at point C; L is the length of block B after breaking; q is the overburden load.

Taking the key block A as the research object:

From $\sum M_B = 0$, it can be obtained:

$$M_A + M_0 + F_0(x_0 + \frac{L_0}{2}) + \int_0^{x_0}\sigma(x_0 - x) + T_A(H - \Delta S_B) = M_B + \frac{qL^2}{2} + \frac{q_0(x_0 + L_0)^2}{2} + N_A(x_0 + L_0) \quad (9)$$

Calculate the above formulas, it can be obtained:

$$F = [M_B(L + x_0 + L_0) + \frac{q(x_0 + L_0)^2}{2} + \frac{qL(x_0 + L_0)}{2} + \frac{q_0(x_0 + L_0)^2}{2} + \frac{q(x_0 + L_0)}{2} - M_A - M_0 - \frac{qL}{4} - \int_0^{x_0}\sigma(x_0 - x)]dx/(x_0 + \frac{L_0}{2}) \quad (10)$$

Where, L_0 is the entry width; σ is the support stress of coal wall to overlying strata in the limit equilibrium zone; M_0 is the bending moment of immediate roof; M_A is the bending moment of the block A.

4. TEMPORARY SUPPORT TECHNOLOGY OF GOB SIDE ENTRY

4.1. Support Area

With the continuous advance of working face, the gob side entry is affected by different degrees: the entry is located in the stress concentration area within a certain range in front of the working

face, it is greatly affected by the advanced stress, therefore, temporary strengthening support should be taken. In the early stage of entry formation, the immediate roof caving at the gob side of the entry is not sufficient to effectively bear the hard overburden rock, resulting in a large-scale rotation deformation of the roof strata. During the process of overburden migration, the stability of the entry surrounding rock is seriously impacted, and the area should be strengthened and supported. According to the monitoring results, combined with the mining practice of the adjacent mining area, it is determined that the advanced support range is 30 m in front of the working face. Both sides of roadway roof in this area are supported by solid coal, which is less affected by mining, and roadway surrounding rock can remain relatively stable. Therefore, the single hydraulic supports and π-shaped steel beams are used for advanced support. The dynamic pressure bearing area is 200 m behind the working face and belongs to the key strengthening support area. 200 m away from the back of the working face is a stable area for tunnel formation, no reinforced support is provided.

4.2. Support Parameters

The 1226 transportation tunnel of Shuguang mine is a retained entry, according to the geological and mining conditions and the physical and mechanical properties of the strata, the parameters were monitored in the field and in the laboratory, it is found that the required support resistance in the dynamic pressure bearing area of the gob side entry is 1962 kN in the range of 1 m.

4.3. Non-repeated Temporary Support Technology

In the early stage of entry formation, the overburden rock moved violently, and the surrounding rock deformation of the entry is large. In order to adapt to the large-scale deformation of the surrounding rock in the early stage of the entry formation, according to the actual geological conditions of gob side entry, ZLQ2826/22.5/38 type of non-repeated support and transportation equipment of alternating pressure cycles have been developed, the equipment is composed of 200 single span support devices and a multi-functional carrier, which can dynamically strengthen the support in the dynamic pressure bearing area.

The single span support device is composed of a narrow long-span beam and a column, which are connected by pin shafts, and the beam is made of Q690 high-strength steel with a length of 3.9m and a width of 0.4 m (Figure 6). The column is designed as a solid structure, each column is equipped with a 500L/min nitrogen filling safety valve and a fast inserting device. Besides, a circular support base is designed at the bottom of the column, with a diameter of 600mm. In the actual support, the single span support device is arranged between two rows of bolts on the gob side entry roof, it can fully contact the entry roof without damaging the bolt and cable support system. The supporting device has a low initial support force and a high working resistance, which can avoid damaging the entry roof during the initial load. The vertical columns on both sides of the beam can increase resistance quickly, which provide a high cutting resistance for the entry roof, limit severe deformation during the entry initial formation, and facilitate the rapid collapse of the overlying strata on the side of the gob. The main technical parameters of the support devices are as follows:

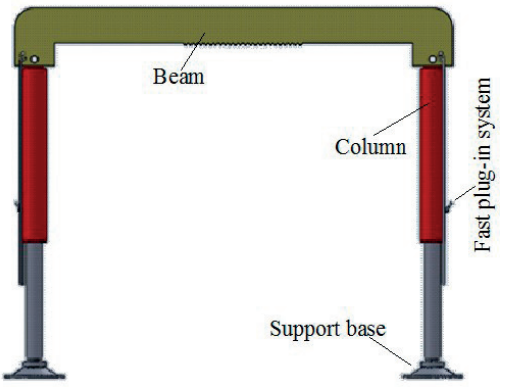

Figure 6. ZLQ2826/22.5/38 type of support device

Type: Single-span
Height: 2250~3800 mm
Initial supporting force: 2×785 kN
(P=25 MPa, adjustable)
Working resistance: 2×1413 kN

(P=45 MPa, adjustable)

Support strength: 0.315 MPa

Inner diameter of column: Φ 200

Operation mode: Rapid liquid supply

Row spacing: 1 m

The support and transportation equipment is equipped with a narrow multi-functional carrier, which is composed of a WC3 type of trackless rubber tyred vehicle, a lift platform, a rotary clamping device, and a emulsion pump station (Figure 7). It comes with a narrow rigid frame, and the frame of the rubber wheel car is designed as a whole rigid welded type with 6×6 full wheel hydraulic press mechanical drive and bidirectional driving function, which can carry the support device safely, automatically and quickly. The main technical parameters are as follows:

Rated load capacity: 5000 kg

Full weight: 9000 kg

Size (length × width × height): 4600 mm × 1600 mm × 2680 mm

Driving form: bidirectional independent driving

Maximum speed: 5 km/h for no load and 2 km/h for fully load

Maximum gradient: 18° for fully load

Minimum ground clearance: 210 mm

Minimum turning radius: 3500 mm

Emergency braking distance: ≤ 8 m

Rated power: 75KW

Rated speed: 2200 rpm

Maximum torque: 340 Nm.

Specific pressure to ground: 0.1 MPa at full load and 0.05 Mpa at no load.

The beams of ZLQ2826/22.5/38 type of support devices are connected by flexible chains, and the overall structure is stable. The support devices and the roadway floor within the support range form a stable “support-floor” bearing structure, which has the characteristics of allowing pressure, high strength, high bearing capacity, no repeated support and can be reused. The bearing structure is in close contact with the entry roof in the support range, and the “bearing structure-roof” has a good coupling effect. Under the active support, it can enhance the overall strength and deformation resistance of the entry surrounding rock, undertake collaborative support with bolt and rope support system, restrict the development of roof separation layer and maintain the integrity and stability of the entry surrounding rock in the dynamic pressure bearing area.

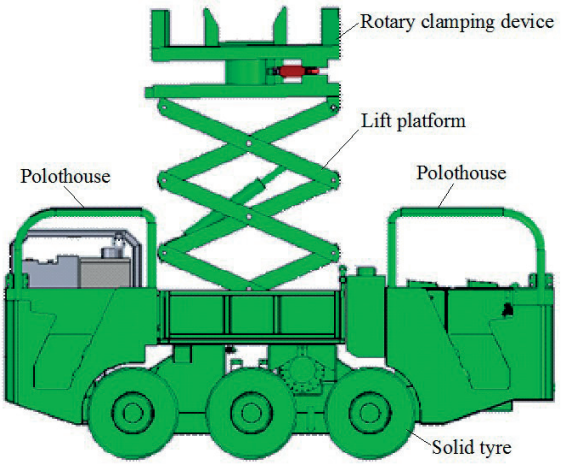

Figure 7. WC3 type of the multi-functional carrier

Support scheme: during the entry retaining, support devices shall be arranged in the range of 0~200 m behind the working face, with a row spacing of 1.0 m, and the support shall be moved alternately and circularly with the advance of working face (Figure 8). When a support device

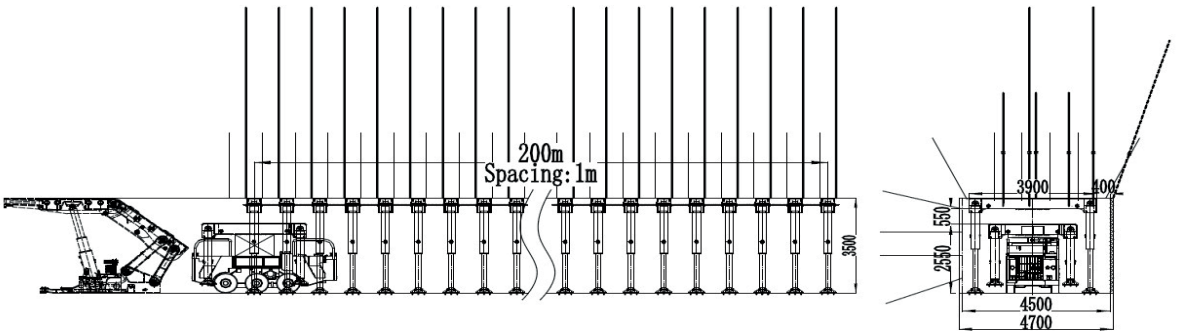

Figure 8. Temporary support scheme of gob side entry

is moved, the multi-functional carrier moves to the bottom of the last support device, operate the lifting platform and clamping device of the carrier to fix the support device on the carrier, lower the column and operate the rotating platform, after rotating a certain angle, the carrier moves from the bottom of the support devices to the front of the entry, operate the carrier to restore the support device to the support position, and then lift the column. When carrying, the initial support force can be adjusted according to the complete condition of the entry roof, and the circulation support will be completed with the advance of working face (Photo 1).

Photo 1. ZLQ2826/22.5/38 type of non repeated support and transportation equipment

5. APPLICATION

During the mining of 1226 working face, a monitoring station was arranged every 60 m in the gob side entry, the column stress, roof separation and roof deformation were monitored to analyze the actual support effect of the support devices.

5.1. Column Stress

Figure 9 shows the stress curves of the support devices monitored by station 2 during the entry retention. It can be seen from the figure that the roof pressure of the entry was mainly manifested as that the pressure on the roof near the cutting line was greater than the side near the coal wall. The support device columns generally increase significantly within 60 m behind the working face, in the range of 60 m to 200 m behind the working face, with the working face away, the column stress near the cutting line fluctuated between 40 MPa and 42 MPa and the column stress near the coal wall side remained between 29 MPa and 32 MPa, the column stress remained basically stable. It shows that the entry roof and support device can maintain a relatively stable state for a long time after the entry entered the working face for 60 m, the “support device-roof” has a good interaction effect. In combination with the monitoring data from the other stations, the column stress of the support devices during the monitoring period was less than the opening pressure of safety valve, indicating that the support parameters are reasonable in design and can meet the requirements for temporary strengthening of support in the dynamic pressure bearing area.

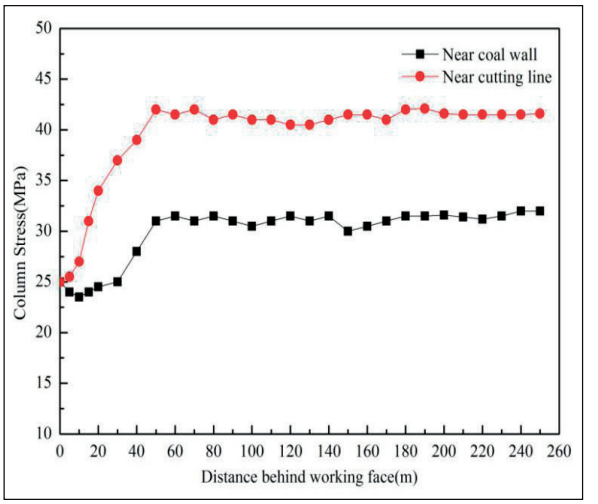

Figure 9. Stress curves of support columns

5.2. Roof Deformation

Figure 10 shows the roof subsidence curves behind the working face during the entry retaining. It can be seen that the roof subsidence of the entry gradually increased and then stabilized with the working face away. In the dynamic pressure bearing area, the roof of the roadway was generally increased, the roof subsidence of the entry near the cutting line was greater than the side of coal wall, in the area of 0~90 m behind the working face the roof subsidence increased significantly, and in the range of 90~200 m behind the working face, the roof subsidence increased slightly. After

removing the temporary support device at 200 m behind the working face, the entry entered the stability area, the roof subsidence near the coal wall side and the cutting line was 282 mm and 391 mm respectively, with the working face far away from the retained entry, the subsidence remained basically stable, and the surrounding rock of the retained entry entered a stable state. According to the monitoring results of the roof subsidence of the gob side entry, the temporary support area in the dynamic pressure bearing zone can be further divided into the severe deformation area (0~90 m behind the working face) and the slow deformation area (90~200 m behind the working face).

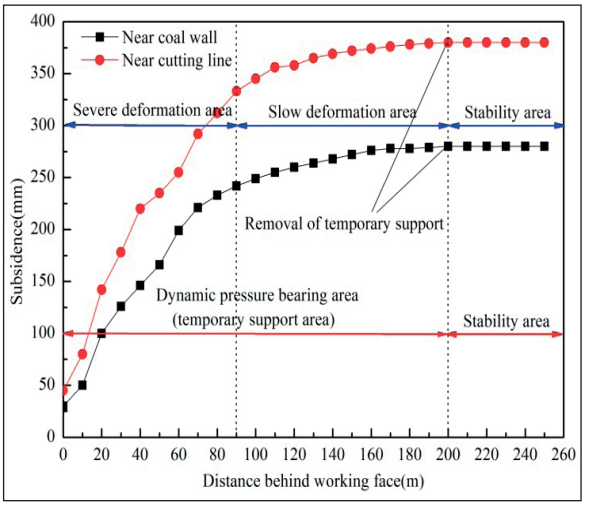

Figure 10. Roof subsidence curves of gob side entry

Field monitoring shows that after using ZLQ2826/22.5/38 type of support and transportation equipment of alternating pressure cycles without repeated support to temporary support in the entry in dynamic pressure bearing area, the support devices, bolt and cable support system have a good cooperative support effect, and the roof subsidence can be effectively controlled under the combined support, which is conducive to the overall stability of surrounding rocks in the later stage of roadway formation.

5.3. Roof Separation

Figure 11 shows the roof separation curves monitored by station 2 after the entry retaining. It can be seen that the roof separations occurred near the working face because of the influence of advanced mining, in the range of 0~90 m behind the working face the roof separations increased greatly; in the range of 90~200 m behind the working face, the roof separations increased slowly; in the range of 200 m away from the back of working face, the roof separations were stable and basically unchanged.

After entering the stability area, the maximum delamination of shallow bedrock and deep bedrock were 28 mm and 53 mm respectively. In addition, during the monitoring period, there was no failure phenomenon in the constant resistance anchor cables, which indicated that the constant resistance cables have a good support effect and can maintain the stability of the deep roof bedrock under the enhanced support of ZLQ2826/22.5/38 type of support and transportation equipment of alternating pressure cycles without repeated support.

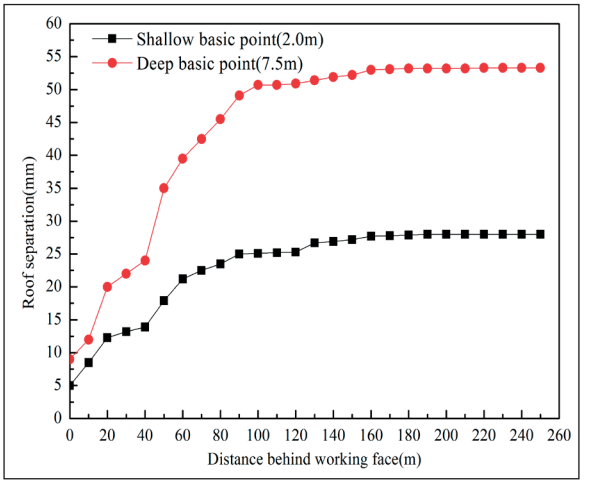

Figure 11. Roof separation curves of gob side entry

6. PROBLEMS AND SUGGESTIONS

After using the devices to strengthen support in time in the dynamic pressure bearing area of 1226 gob side entry, the support devices and the bolt and cable support system have a good synergy, the roof separations of the entry have been further controlled, and the effect of roadway is good, which can basically meet the mining requirements of the next working face. However, there are some problems in the actual support process, which are mainly manifested in the

difference of subsidence in two sides of the entry roof and the eccentric load of columns. In order to further improve the synergy between the support devices and the anchor support system, the support devices should be designed as a variable asymmetric load-bearing structure according to the breaking and moving characteristics of the entry roof, and the column size near the cutting line should be larger than that near the coal wall, so as to ensure the roof strata near the cutting line can be strongly and timely supported. In addition, a limiting mechanism should be designed between the support device beams and the columns, so that there is a certain free space between the weighing beams and the columns, which better adapts to the asymmetric deformation of the entry roof.

CONCLUSIONS

Based on the analysis of the key technologies of gob side entry retaining by cutting roof to release pressure, the non-repeated temporary support technology was systematically studied, the main conclusions are as follows:

• According to actual mining geological conditions, the key technical parameters, such as roof drilling, presplitting blasting and constant resistance cable were introduced, and the parameters of bolt and cable before and after entry retaining were determined.

• The failure patterns of overlying strata in the gob side entry with isolation wall and the gob side entry with roof cutting to release pressure were analyzed respectively, according to the mechanical model of overburden, the calculation formula of temporary support pressure of gob side entry in dynamic pressure bearing area was deduced.

• Combined with the physical and mechanical parameters of overlying strata and the key parameters of gob side entry with roof cutting to release pressure, the temporary support pressure in the dynamic pressure bearing area was obtained, on this basis, ZLQ2826/22.5/38 type of support and transportation equipment of alternating pressure cycles without repeated support was developed, and the technical parameters, structural characteristics and support principle were analyzed respectively, a non-repeated temporary support scheme was put forward.

• Field practice shows that the temporary support parameters are reasonable, the roof deformation and roof separation are controllable, and the temporary support, bolt and cable support system have a good cooperative effect, which can meet the temporary support requirements of gob side entry in dynamic pressure bearing area. In addition, the structure of support devices should be further optimized according to the actual problems to improve the support effect in the follow-up application process.

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