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Optimization Analysis of Advanced Support for Thick and Hard Roof

Yongkun Zhang*, Kaiwei Wang

School of Mining Engineering, Anhui University of Science and Technology, Huainan, China;
*Corresponding Author: ykunzh@126.com

ABSTRACT

Based on the geological conditions of 1033 working face in Yuandian No.1 Coal Mine, this paper studies the support distance and support strength of hydraulic support in the advanced section of roadway roof. Through numerical simulation analysis, the advance support range of the advance roadway is 5m, 10m, 15m, 20m and 25m four kinds of distance plastic zone and stress cloud diagram; at the same time, in-depth analysis of 0.4 MPa, 0.8 MPa, 1.2 MPa and 1.6 MPa of these five different advanced hydraulic support support strength. Through the above research, it is concluded that the advance support distance of the working face is more suitable at 20 m, and the advance support strength is in the range of 0.8 MPa ~ 1.2 MPa.

KEYWORDS

Thick and Hard Roof, Hydraulic Support, Advanced Support, Support Strength.

1. INTRODUCTION

Under the condition of thick and hard roof, the mining advance section of working face is greatly affected by concentrated stress. When the working face is mined, the roof of the roadway is affected by both the mining disturbance and the release stress of the overlying strata structure balance process. Easy to produce stress concentration. Therefore, it is urgent to study the advance section support of thick and hard roof. Bin Yu[1]et al.established the periodic fracture model of THR using Timoshenko beam theory based on Winkler foundation. Zechao Chang[2]et al.analyzed that due to the large mining area, the lateral roof of the working face is easy to form a cantilever structure in the fully mechanized caving mining with thick and hard roof. Aiming at the problem of high labor intensity of passive advance support, Meng Wang[3]et al.proposed the idea of advance active support in filling stope. Hui Liu[4]et al.explored the support problem of advancing long-wall mining roadway. The research results can provide experimental support for the advanced support parameters of long-wall mining roadway. Many experts and scholars have carried out a lot of research[5-7].

Based on the above research results, this paper studies the support range and support stress of the advanced support for the thick roof of the 1033 working face. Explore the support range and stress suitable for on-site production, and provide support reference for surrounding similar roof working faces.

2. ENGINEERING GEOLOGY

The main characteristics of the roof of the 1033 working face in Yuandian No.1 Coal Mine are light gray white, medium-fine grained sand-like structure, thick layered, mainly composed of quartz and

feldspar, with a small amount of dark stripes and irregular muddy inclusions in the local area. The sorting is general, sub-circular, calcareous cementation, a small amount of cracks, unfilled; the main characteristics of the floor are dark gray, silty structure, thick layer, containing a little mud, uneven distribution, containing plant debris fossils, local fine sand thin layer, a small amount of sliding surface, flat fracture ; the rock strata classification of the working face is shown in table 1.

Table 1. Classification of working face rock strata

Lithologic Characters	Average Thickness/ m	Lithological Characteristics
Mudstone	14.60	Gray, massive, less silty, dense.
Fine Sandstone	19.32	Light gray white, medium-fine sand-like structure, thick layer, mainly composed of quartz and feldspar.
10 Coal	2.18	Black, weak glass luster, mainly pulverized coal, is a semi-bright briquette. A layer of coal-made mudstone parting is locally developed, with a thickness of 0 ~ 1.1 m and an average of 0.3 m.
Siltstone	2.88	Dark gray, silty structure, thick layer, containing a little mud.
Fine Sandstone	11.20	Gray, fine-grained, followed by medium-grained, containing a small amount of silty, siliceous cementation, hard.
Siltstone	4.63	Gray, silty structure, local particles slightly coarse, thick layer, containing a little mud.
Fine Sandstone	2.67	Light gray, fine-grained sandy structure, medium-thick layer, mainly composed of quartz and feldspar.

The roof advance stress of 1033 working face in Yuandian No.1 Coal Mine is seriously affected. In order to achieve the purpose of preventing and controlling the mine pressure disaster of thick and hard roof, it is necessary to take effective measures to control it, so as to ensure the stability of roadway and the safe and efficient mining of working face. To control the advance stress of the thick and hard roof working face, one is to make a reasonable choice of the advance hydraulic support, and the other is the support stress of the roof when the hydraulic support is working, both of which are the key to control the thick and hard roof. The optimization technology of advance support in thick and hard roof working face is demonstrated by numerical simulation, and the effectiveness and feasibility of the technology are demonstrated.

3. RESEARCH ON ADVANCED SUPPORT OPTIMIZATION OF THICK AND HARD ROOF WORKING FACE

According to the previous analysis, under the condition of thick and hard roof, with the advancement of mining face, the hanging roof area of goaf gradually increases, which leads to the ' deterioration ' of the stress environment of coal and rock mass in front of the working face, aggravates the advance damage of coal body in front of the working face, destroys the integrity of the advance roadway, and easily forms high bearing pressure around the advance roadway, resulting in severe deformation of surrounding rock of the advance roadway. Therefore, at this stage, taking the 1033 working face of Yuandian No.1 well coal mine as an example, aiming at the problem of advance roadway in thick and hard roof working face, the optimization technology of advance support in thick and hard roof

working face is put forward. At present, the key technical problems in the optimization process of advance support of thick and hard roof working face mainly include the optimization of support parameters of advance hydraulic support of thick and hard roof working face.

The support parameters of the advance hydraulic support in the thick and hard roof working face will directly affect the stability of the surrounding rock of the advance roadway in the thick and hard roof working face. The situation of the two roadways in the thick and hard roof working face is different from that of the working face. The support distance of the advanced hydraulic support in the two roadways along the working face is relatively long. Due to the different distance from the working face, the stress distribution and deformation state of the surrounding rock are also different. However, the support distance and parameter selection of the existing advanced hydraulic support are still determined according to the concept of the hydraulic support on the working face, which leads to great safety hazards. Therefore, it is necessary to optimize the support parameters of the advanced hydraulic support in the thick and hard roof working face according to the thick and hard roof conditions of the working face, select the best support parameters, improve the support efficiency, and ensure the stability of the surrounding rock of the roadway.

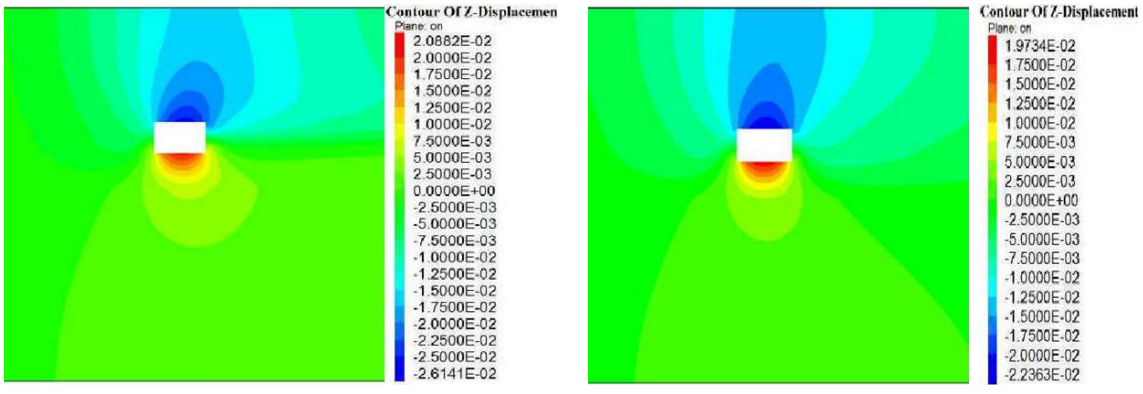
3.1. Optimization of Support Distance of Advanced Hydraulic Support in Thick and Hard Roof Working Face

The advanced hydraulic support is analyzed and calculated by Elastic constitutive model. In the process of numerical simulation, the plastic zone, displacement deformation and stress distribution of roadway under the condition of five different advance hydraulic support support distances are compared. The support distances of five different advance hydraulic supports are 5 m, 10 m, 15 m, 20 m and 25 m respectively.

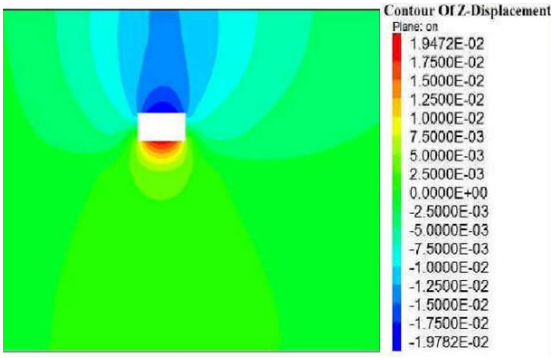
The plastic zone, stress distribution and displacement subsidence of roadway under different support distances of advanced hydraulic support will be different. Each scheme will obtain the plastic zone diagram, stress distribution cloud diagram and displacement distribution cloud diagram. Through the comparison and analysis of cloud diagram, the most reasonable value of support distance of advanced hydraulic support in 1033 working face will be selected.

3.1.1. Analysis of Displacement Field Distribution Characteristics of Advance Roadway Under Different Support Distances

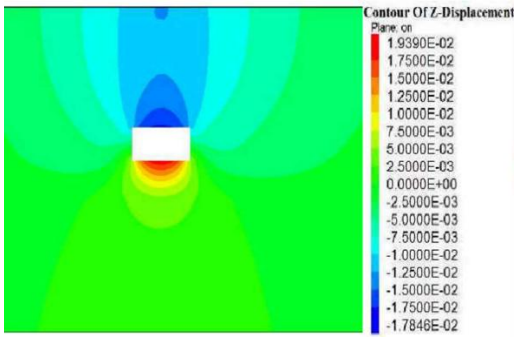
Figure 1 is the vertical displacement distribution cloud diagram of roadway surrounding rock when the support distance of advanced hydraulic support is 5 m, 10 m, 15 m, 20 m and 25 m respectively.



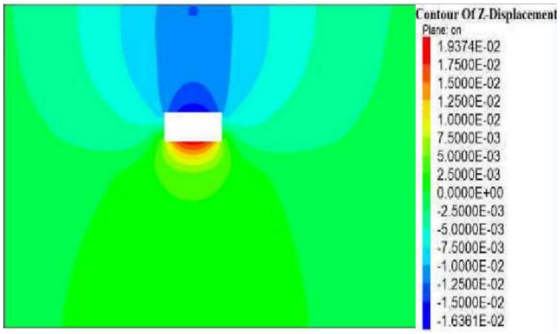
(a) Supporting distance 5 m (b) Supporting distance10 m



(c) Supporting distance 15 m



(d) Supporting distance 20 m



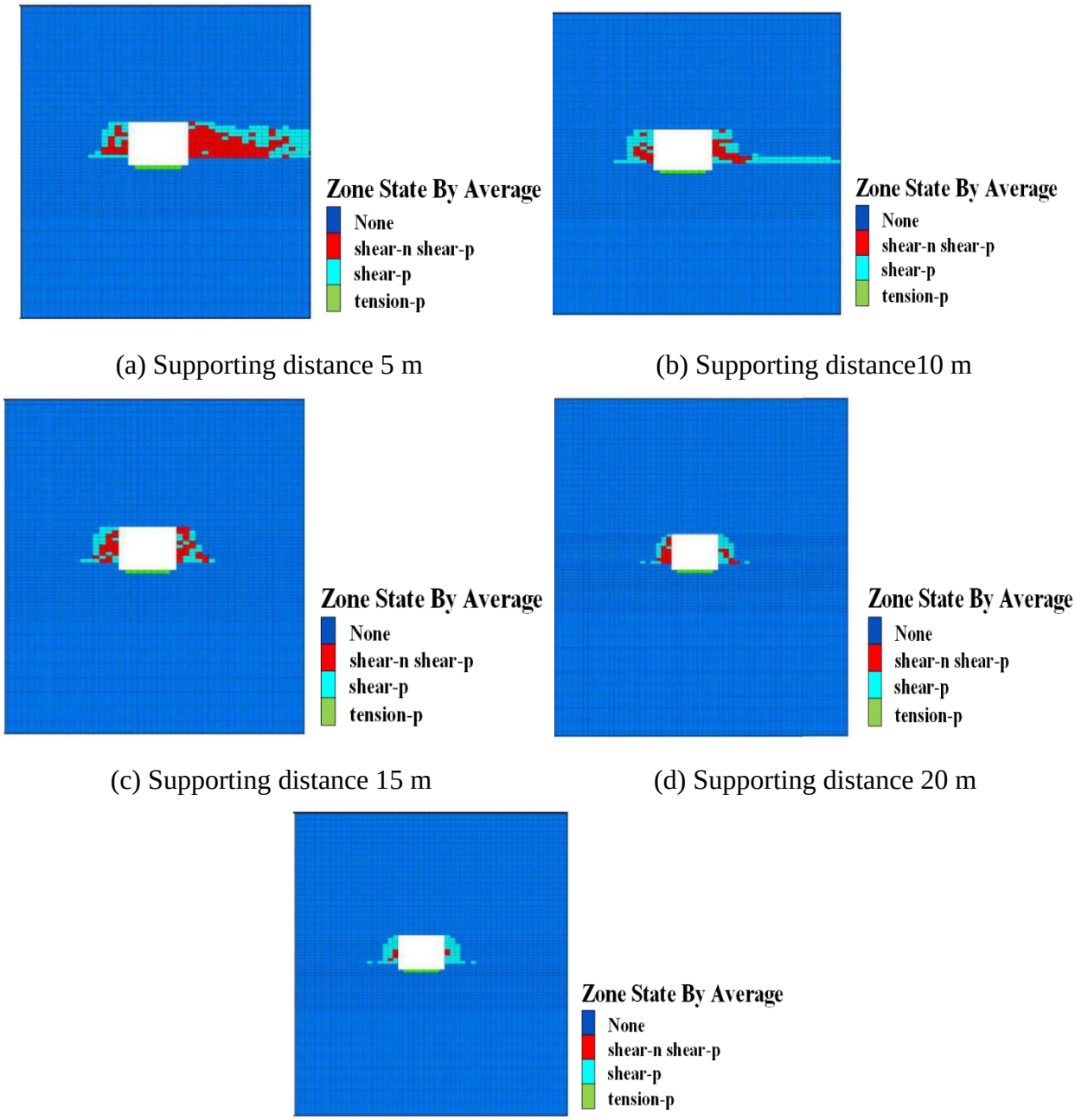
(e) Supporting distance 25 m

Figure 1. Distribution of displacement field of advance roadway under different support distances

It can be seen from Fig.1 that with the increase of the support distance of the advance hydraulic support, the deformation of the surrounding rock of the advance roadway increases first and then decreases. When the support distance of the advanced hydraulic support is 5 m, the deformation of the surrounding rock of the roadway is serious, and the surrounding rock of the roadway is less affected by the support effect, and the convergence of the roof and floor reaches 367 mm. When the support distance of the advance hydraulic support is 10 m, the advance hydraulic support has a certain effect, and the deformation of the roof and floor of the advance roadway is obviously reduced, but the overall deformation is still large. When the support distance of the advance hydraulic support is 20 m, the deformation of the surrounding rock of the advance roadway is small due to the support of the advance hydraulic support at this stage, and the convergence of the roof and floor is 124 mm. When the support distance of the advanced hydraulic support increases to 25 m, the excessive support force aggravates the damage to the roof due to the repeated support in the advanced roadway area far away from the working face, which makes the roof and floor convergence of the advanced roadway increase slightly.

3.1.2. Analysis of Distribution Characteristics of Plastic Zone in Advance Roadway Under Different Support Distances

Fig. 2 shows the distribution of plastic zone of roadway surrounding rock when the support distance of advanced hydraulic support is 5 m, 10 m, 15 m, 20 m and 25 m respectively.



(a) Supporting distance 5 m

(b) Supporting distance10 m

(c) Supporting distance 15 m

(d) Supporting distance 20 m

(e) Supporting distance 25 m

Figure 2. Distribution of plastic zone in advance roadway under different support distances

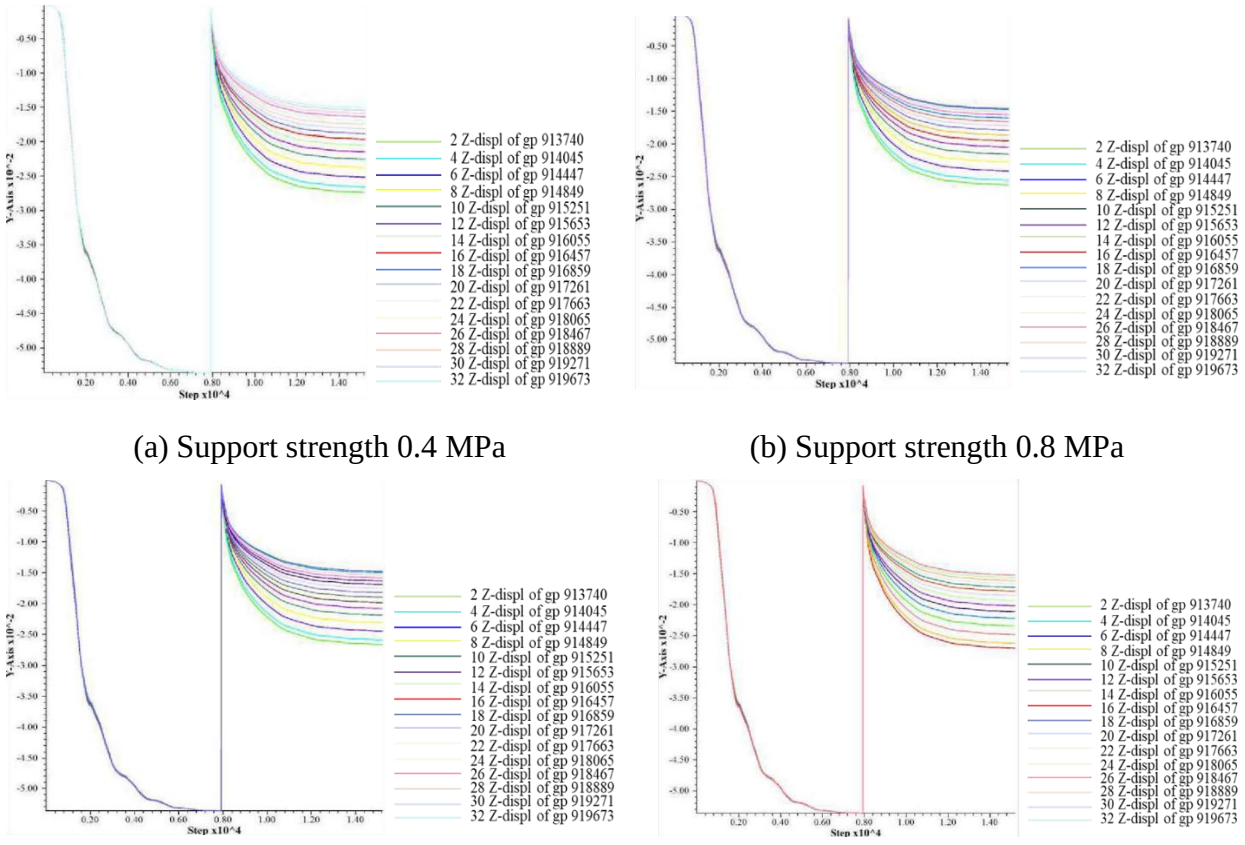
It can be seen from Fig.2 that with the increase of the support distance of the advance hydraulic support, the range of the plastic zone of the surrounding rock of the advance roadway is gradually increasing. When the support distance of the advance hydraulic support is 5 m, the surrounding rock of the advance roadway, especially the plastic zone on the mining side of the roadway, is large, and the effect of the advance hydraulic support is small. When the support distance of the advance hydraulic support is 10 m, the advance hydraulic support has a certain effect, and the range of the plastic zone of the advance roadway is reduced. When the support distance of the advance hydraulic support is 20 m, the plastic zone of the surrounding rock of the advance roadway is small due to the support of the advance hydraulic support. As the support distance of the advance hydraulic support increases to 25 m, the range of the plastic zone of the surrounding rock of the advance roadway continues to decrease, but the decrease is small.

3.2. Optimization of Support Strength of Advanced Hydraulic Support in Thick and Hard Roof Working Face

The advanced hydraulic support is analyzed and calculated by Elastic constitutive model. In the process of numerical simulation, the plastic zone, displacement deformation and stress distribution of the roadway under the support strength of five different advance hydraulic supports are compared. The support strength of five different advance hydraulic supports is 0.4 MPa, 0.8 MPa, 1.2 MPa and 1.6 MPa, respectively.

The plastic zone, stress distribution and displacement subsidence of roadway under different support strength of advanced hydraulic support will be different. Each scheme will obtain the plastic zone diagram, stress distribution cloud diagram and displacement distribution cloud diagram. Through the comparison and analysis of cloud diagram, the most reasonable value of support distance of advanced hydraulic support in 1033 working face will be selected.

At the same time, the distribution characteristics of displacement field in advance roadway under different support strength are analyzed. As shown in Fig.3, the monitoring results of vertical displacement of roadway roof at different distances along the direction of working face under four kinds of support strength are shown. It can be seen from the figure that the maximum vertical displacement of roadway roof is negatively correlated with the support strength of advanced hydraulic support, and the maximum vertical displacement decreases first and then increases with the increase of support strength.



(a) Support strength 0.4 MPa (b) Support strength 0.8 MPa

(c) Support strength1.2 MPa (d) Support strength 1.6MPa

Figure 3. Monitoring results of vertical displacement of advance roadway roof under different supporting strength

With the increase of support strength, when the support strength is 0.4 MPa to 0.8 MPa, the maximum vertical displacement of the roof of the advance roadway decreases, and the vertical displacement of

the roof decreases with the increase of support strength. When the support strength is 0.8 MPa to 1.2 MPa, the vertical displacement of the roof begins to stabilize and change little, while when the support strength is 1.2 MPa to 1.6 MPa, the vertical displacement of the roof increases with the increase of the support strength. The above shows that the appropriate support strength has a good supporting effect on the roof. The smaller support strength will make the support not in place, and the higher support strength will make the roof damage. Therefore, for the support of the advance section of the working face, it is necessary to design the appropriate support strength according to the specific situation.

3.3. Calculation of Reasonable Support Strength of Hydraulic Support

Combined with the actual situation of the 1033 working face and the theoretical calculation results of the support strength of the advanced hydraulic support, the analysis is carried out. The support strength is calculated according to the empirical method :

$$P_t = H \times \gamma \times k \times \cos\alpha \tag{1}$$

In the formula : Pt−Reasonable supporting strength of roadway，kN/m2；

H−Maximum support height of bracket，fetch 3.3m；

γ−Roof rock bulk density，KN/m3，fetch 25KN/m3；

k−The ratio of overlying strata thickness to support height of pillar support，fetch 8；

α−Minimum inclination angle of support，fetch 0°；

Get :

$$P_t = 3.3 \times 25 \times 8 \times \cos 0^\circ = 660 kN/m^2 = 0.66 MPa \tag{2}$$

Therefore, the maximum support strength of the selected hydraulic support should be greater than 0.66 MPa. The measured maximum support strength when the first pressure of the reference working face is selected (the reference surface is 1033 mile working face) Pc=860 kN/m2=0.86 MPa.

In summary, according to the numerical simulation and theoretical calculation, the measured results of the reference surface, it is determined that the reasonable advance hydraulic support support strength range of the working face in 1033 is 0.8 MPa ~ 1.2 MPa.

4. SUMMARY

According to the lithology analysis of the overlying roof of the working face in 1033, it is found that the advance stress of the roof of the working face has a serious impact. In order to achieve the purpose of preventing and controlling the mine pressure disaster of the thick and hard roof, effective measures need to be taken to ensure the stability of the roadway. Therefore, the numerical simulation software was used to simulate and optimize the support parameters of the advanced hydraulic support in the thick and hard roof working face, and the stress deformation and plastic zone distribution characteristics of the surrounding rock of the advanced roadway in the thick and hard roof working face under different support distances were analyzed. The distribution characteristics of the displacement field of the advanced roadway under different support strengths are explored, and the optimal support distance of the advanced hydraulic pressure in the thick and hard roof working face is determined to be 20 m, and the support strength range is 0.8 MPa ~ 1.2 MPa.

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