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Optimizing the width and compressive strength of artificial protective pillar in the mining of medium-thick coal seams in Quang Ninh using the numerical model

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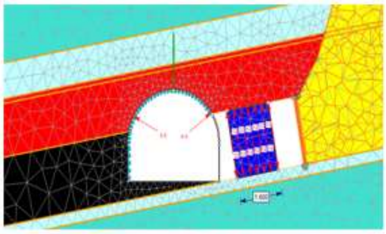
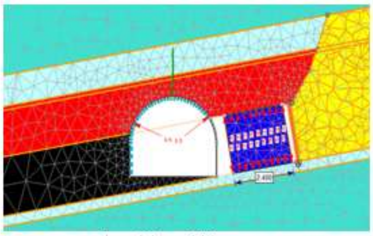
Abstract. This research uses Phase 2 numerical simulation software to analyze the stability of artificial protective pillar of the roadway prepared in the mining of medium-thick coal seams in the Quang Ninh coal region (Vietnam). The research results show that the relationship between the width of the artificial pillar and the slope angle follows the rule of a linear function. The size of the artificial protection pillar increases according to the mining depth. When the mining depth is 350m, the size of the pillar changes from 1.0 ÷ 2.4m, and to 1.4 ÷ 2, 8m at a depth of 500m. When the slope angle increases, the required pillar width also increases. That is due to the fact that at a large slope angle, the pressure acting on the pillar is not at the center, but deflects to the side adjacent to the entry gate road that needs to be protected, the compression force is not distributed evenly. The required compressive strength of the artificial pillar varies according to the condition of the slope angle, when the seam slopes 10⍰, the required compressive strength is from 8 to 12 MPa, when the slope angle increases to 20⍰, the required compressive strength of the pier increases to 18 ÷ 28 Mpa, but when the slope angle increases to 35⍰, the required compressive strength of the pillar tends to decrease to 16 ÷ 17 MPa. Thus, when operating in the corresponding conditions, it is necessary to choose the size and required compressive strength of the artificial pillar to ensure the working capacity of the pillar.

1. The optimal compressive strength of artificial pillars to protect roadway

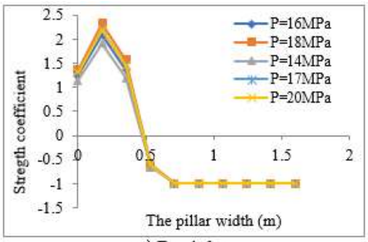
The working capacity of the artificial pillars is influenced by various geological and mining engineering factors such as the thickness and dip angle of the seam, the mechanical properties of the surrounding rock. These parameters greatly affect the working capacity of the artificial pillar, namely the seam thickness, dip angle, and mining depth. Specifically: a case study with an average thickness of 2.2m will be chosen. For the dip angle factor, the range of dip angles will be limited to 35 degrees, with intervals of 10 degrees, 20 degrees, and 35 degrees.



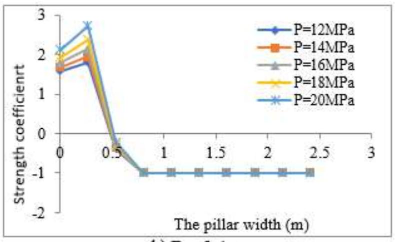
The pillar width: B=1,6m



The pillar width: B=2,4m



a) B = 1,6m



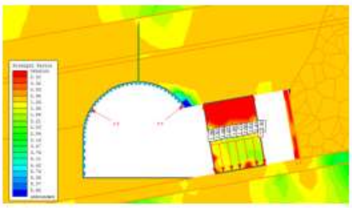
b) B = 2,4m

Tab. 1.1. Research results on the optimal compressive strength of the artificial pillar under conditions of medium-thick coal seam.

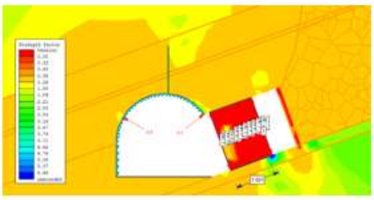
Pillar width	Seam slope angle		
	10°	20°	35°
1,6m	12 MPa	28 MPa	17 MPa
2,4m	8 MPa	18 MPa	16 MPa

2. The optimal size of the artificial protective pillar for roadway protection

The selection of the optimal width of the protective pillars under the assumption of predetermined compressive strengths of 20 MPa and 30 Mpa is based on the following figures:



a) Slope angle α = 10°



b) Slope angle α = 20°

Figure 2.1. The distribution of strength coefficient, mining depth of 500m

Table 2.1. Summary of the optimal width of the protective pillar for mining in medium-thick coal seam

Slope angle	Optimal width of the protective pillar, m					
	α = 10°		α = 20°		α = 35°	
H = 350m	B =1,2	B = 1,0	B = 2,0	B = 1,6	B = 2,4	B = 2,2
H = 500m	B = 1,6	B = 1,4	B = 2,8	B = 1,8	B = 3,0	B = 2,8
Compressive strength of pillar, MPa	P = 20	P = 30	P = 20	P = 30	P = 20	P = 30

Table 2.2. Results of key parameter values from numerical modeling

α (°)	m (m)	H (m)	P (MPa)	B (m)
10	2,2	350	20	1,2
10	2,2	350	30	1
10	2,2	500	20	1,6
10	2,2	500	30	1,4
20	2,2	350	20	2
20	2,2	350	30	1,6
20	2,2	500	20	2,8
20	2,2	500	30	1,8
35	2,2	350	20	2,4
35	2,2	350	30	2,2
35	2,2	500	20	3
35	2,2	500	30	2,8

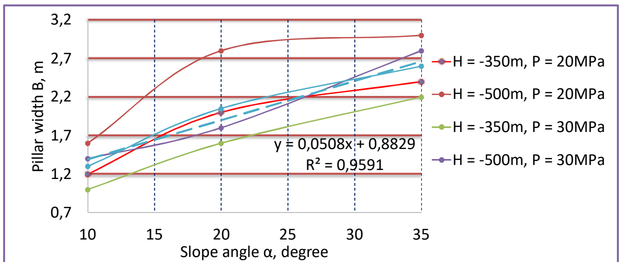


Fig. 2.2. The relationship between the parameter of artificial pillar width and the slope angle

3. Conclusion

The research results on the basic parameters of the artificial pillar in the case of the medium-thick coal seam in coal mining reveal the following:

1) The size of the artificial pillar varies with the increasing depth of mining. For a mining depth of 350m, the pillar size ranges from 1.0m to 2.4m, while for a mining depth of 500m, it increases from 1.4m to 2.8m. This finding agrees well with the theoretical and practical aspects of coal mining in the Quang Ninh region.

2) As the slope angle of the seam increases, the required pillar width also increases. This is because, at higher slope angles, the pressure on the pillar shifts away from the central axis towards the side adjacent to the mining face (downward along the slope direction). Consequently, the compressive force is not evenly distributed throughout the entire pillar body. To ensure the required internal stability, the pillar width needs to be increased.

3) Increasing the pressure or compressive strength of the protective pillar results in a reduction in the width of the artificial pillar. The relationship between the width of the artificial pillar and the slope angle in the case of a medium-thick coal seam follows a linear function: y = 0.0508x + 0.8829.