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Extracting Residual Coal by Auger Highwall Mining at Mae Tan Coal Mine, Thailand

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1. Introduction

Mae Tan Coal Mine is the only two coal mines left in Thailand. This mine consists of two coal seams (lower seam is 4 m and the upper is 2.5m), top soil red clay, sandstone, shale, ball clay, carbonaceous shale and rhyolitic tuff with the elevation of 288 and 120-meter height at the top and bottom respectively. The overall pit angle is 45 °C. The rock properties are demonstrated as in Fig.1. To extend the mining life from the recent surface mining, Auger Highwall Mining (AHM) is an altered technology.

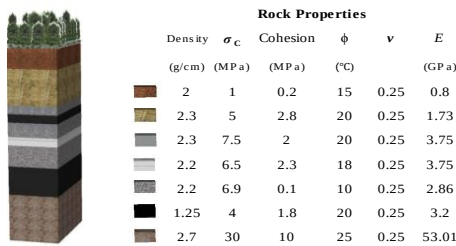


Fig.1 Stratigraphy and rock

2. Overview of Auger Highwall Mining

AHM is the semi surface and underground mining with the concept of horizontal drilling in the circular shape into the coal seams. The auger machine drilling heads comprise of different diameters according to the commercially available. There are three types of AHM, single, double and multi passes (Fig. 2). The single pass is one row of hole drilling into the coal seams. Double passes is the two-row holes drilled into the seams, the lower first holes and the upper second holes and the multi passes applies auger miner in the different coal seams.

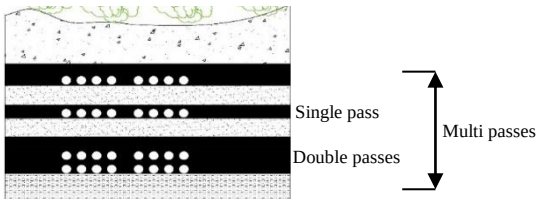


Fig. 2 Auger Highwall Mining Types

Two types of pillar support system in AHM. Web pillar is the pillar support in each panel and barrier pillar helps to prevent the continual collapses if any web pillars are not strong enough [1]. The design of pillars is conducted into numerical analysis by FLAC3D (Fast Langrangian Analysis of Continua) to demonstrate the stress and strength on the pillars and ending up with safety factor which is the ratio of strength and stress. The rock properties (Fig. 1) are the inputs for FLAC simulation. In addition, the grids, initial boundary, elastic-plastic for stress and strength softening for strength estimation were set up.

Furthermore, coal for each extracted hole was followed Eq. 1 where T , V and γ_c are the tonnage, volume of drilling hole and coal specific gravity respectively. The recovery ratio (% R) is estimated by eq. 2 where D , W_p and h_c are the auger diameter, web pillar and coal seam height.

$$T = V \times \gamma_c \quad (1)$$

$$\%R = \frac{\pi D^2}{4} / ((D + W_p) h_c) \quad (2)$$

3. Numerical Analysis of AHM at Mae Tan Coal Mine

The multi passes was assigned for Mae Tan. The upper coal seam designed as the single pass and the lower seam conducted as double passes with the vertical distance, septum, of 0.8 m. [1] made the comparison between septum of 0.8 m and 1.0 m on the displacement on the top and the tunnel's crown of the drilling diameter of 1.5 m. The result showed the small displacement on both the top and tunnel's crown for septum of 0.8 m compared to 1.0 m (Fig. 3).

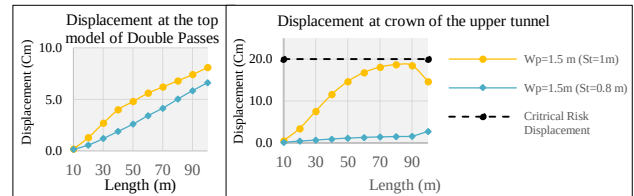


Fig.3 The displacement at the top model (left) and at the tunnel's crown (right) of the septum of 0.8 m and 1.0 m of diameter of 1.5 m.

In this research, the multiple passes were designed on the auger diameter of 1.5 m for both layers, the web pillar widths from 0.5 m to 4.0 m, septum of 0.8 m (for the double passes at the lower coal seam), safety factor of 1.6 and 1.0 for web and barrier pillar [2]. Stress was analyzed along the horizontal drilling hole of 100 m depth, and strength was analyzed based on the pillar widths. Fig. 4 illustrated the analysis result of: (a) the stress of each web pillar based on the drilling length, (b) the strength of each web pillar width, (c) the safety factor of each web pillar showing with the safe drilling length (d) the safe drilling length from the safety baseline of 1.6 for web pillar and (e) the %Recovery versus coal tonnage. When $W_p=0.5$ m, the safe entry length about 20 m, $\%R = 35\%$, and amount of coal was about 50 tons. When $W_p=1.5$ m, the safe entry length of almost 60 m, $\%R=24\%$, coal about 130 tons could be extracted. $\%R$ and Tonnage kept linearly decreased. The wider W_p , the lower $\%R$ but the higher tonnage of coal. Thus $W_p=1.5$ m was the optimal web pillar for the single pass at the upper

seam.

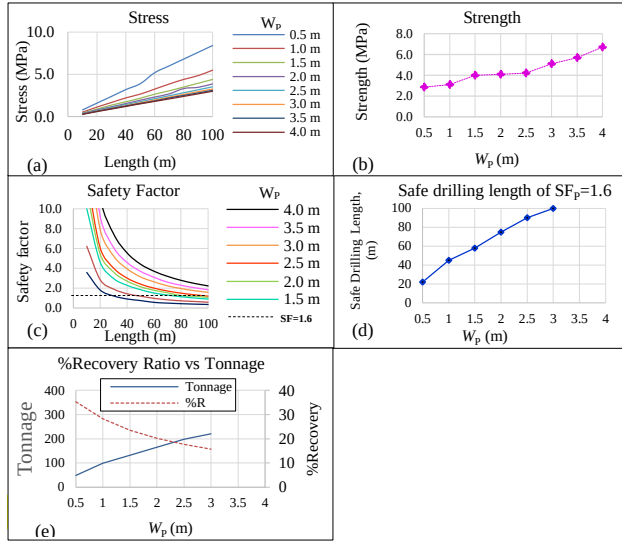


Fig. 4: The analysis result of each web pillar.

The Auger machine 1.5 m, the web pillar of 1.5 m with 2 holes per panel, and barrier pillar of 2.0 m were the mining layout of the single pass for Mae Than Coal Mine based on [1].

The analysis result of stress, strength and factor of safety of double passes were demonstrated in Fig. 5-(a), (b) and (c) respectively. From Fig. 5-(c), the safe entry length was about 50 m from the safety baseline of 1.6.

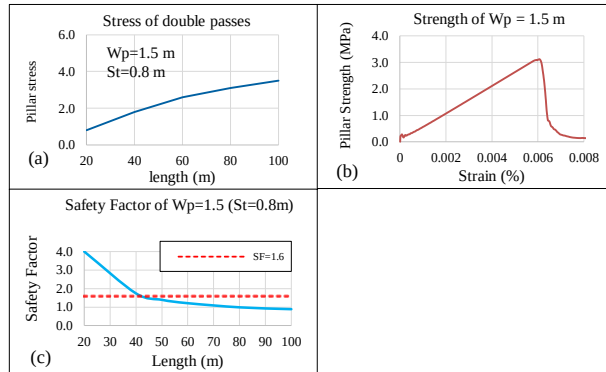


Fig. 5: Analysis result of double passes design of $W_p=1.5$ m.

The number of web pillars in a panel “N” of 1 and 2 were analyzed from the result of web pillar, safe entry length and the barrier pillar of 2.0 m.

• N=1.0

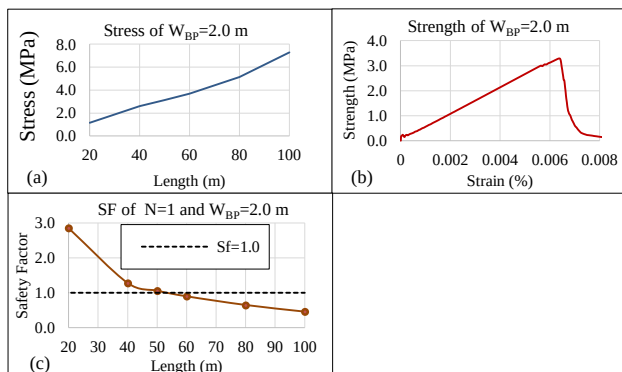


Fig. 6: Analysis result of $N=1$ for double passes

• N=2.0

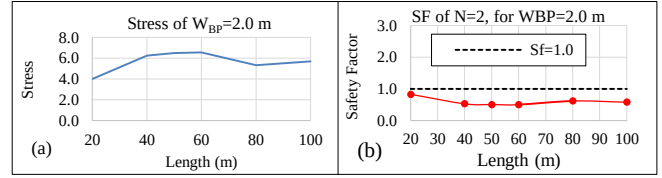


Fig. 7: Analysis result of $N=2$ for double passes

When $N=1$, $W_{BP}=2.0$ m, the safe entry length was about 50 m, from the safety baseline of 1.0 for the barrier pillar (Fig. 6-(b)). Within the same condition, when $N=2$, the unstable situation occurred; no safe entry length reached the safety baseline (Fig. 7-(b)). Thus, the barrier pillar of 2.0 m, and the number of web pillar $N=1$ were assigned for the design. The tonnage and recovery of coal in the twin holes were as below and the multi passes mining geometry as in Table 1. The optimal multiple passes mine layout is in Fig. 8.

$$T = 1.25 \times 2 \times 50 \times \frac{\pi \times 1.5^2}{4} = 220 \text{ tons} \quad (\text{From Eq. 1}) \text{ and}$$

$$\%R = \left(\frac{2 \times \pi \times 1.5^2}{4} \right) / ((1.5 + 1.5) \times 4) = 29\% \quad (\text{From Eq. 2})$$

Table 1: Multiple passes design geometry

Seam	Design	Geometry				
		D	W _p	W _{BP}	L	N
Upper	Single pass	1.5	1.5	2.0	60	1.0
Lower	Double passes	1.5	1.5	2.0	50	1.0

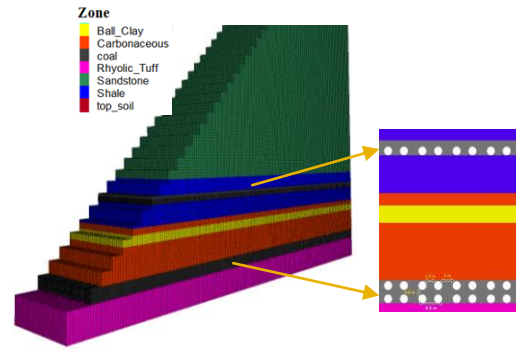


Fig. 8: The optimum multiple-pass layout

4. Conclusion

AHM was available to extend the mine life and some amount of coal production for Mae Tan Coal Mine. The criteria of $D=1.5$ m, $W_p=1.5$ m, $W_{BP}=2.0$ m and 2 drilling holes in a panel were the optimal in this research. For long term sustainability, the backfilling system should be conducted for the next.

5. References

- [1] B. Sophea, "Design of Auger Highwall Mining: A case study of Mae Tan Coal Mine, Thailand," Department of Georesources Engineering, Chulalongkorn University, 2016.
- [2] NSW, "Technical Reference Mine Safety CTR-001 For A Notification Of HM and AHM," NSW Department of Primary Industries, 2008.