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An Improved Algorithm of Coal Pillar Yield Zone Width based on Strip Mining of Thick Unconsolidated Seam

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Abstract: The tribes in mines are an effective method in green mining. In order to ensure the sustainable use of coal resources, this method has attracted much attention and research at home and abroad. During the mining of the application band, the stability of the strip coal pillar is an important factor in the deformation of the surface of the trusteen to minimize the surface of the surface, so that the surface sinking is limited within a certain range, and the adoption rate is as good as possible to reasonably determine the width and width and the width and the width and reasonableness and the width and the width and the width and the width and reasonableness. Leave wide size to ensure the long -term stability of coal pillar. This article is mainly aimed at the mining zone of the giant loose layer mining area. Considering the influence of the loose layer, the effect of adding a loose layer thickness, and improving algorithm on the width formula of the A.H. Wilson yield area. It is proposed to replace the calculation of γH to the improvement of γ1h+γ2(H−h), γ1and γ2 are loose layers of capacity and base rock capacity, and propose simplifying the assumption Y=λ1mH+λ2mh for the formula. The algorithm is applied to practice. The yield width Y= 12.33m and the remaining width amin = 75.8m calculated by the algorithm are 1.8m wider and 12m wider than those calculated by the traditional algorithm, the feasibility of the improved algorithm of coal pillar yield zone width is verified.

Keywords: Thick Alluvium; Strip Mining; Width of the Coal Pillar Yield Area; Stay Width; System Development.

1. Introduction

Coal is China's main energy source, but it is mainly distributed in North China, Central China, and East China, where the geology is characterized by thick, loose layers. Therefore, during mining, surface subsidence and environmental disasters can occur, and the economic costs of entire village relocation and backfilling of mining areas are required [1-8]. Therefore, strip mining is a relatively effective method, which can effectively restrict the serious surface subsidence problems in thick loose layer mining areas.

Under the premise of meeting certain safety factors and not forming a wavy subsidence basin on the surface, when using the strip-mining method, the coal body's strength is first estimated, and then the stress or load generated on the coal pillar is calculated, thereby determining the strip mining scheme and calculating the reasonable width and reserve width of the strip.

2. The Main Body of the Essay is Divided into Three Parts

In order to ensure that the surface will have a single, gentle subsidence basin after the strip is mined, it is crucial to calculate the strip mining dimensions in such a way that the key rock layers in the overburden are not broken, effectively controlling surface subsidence and surface deformation. For the special geological conditions of thick loose layers, it is important to consider this special factor in the strip mining optimization design and use the calculation method under the condition of coal pillar three-dimensional stress state.

In Britain, A.H. Wilson envisaged the coal pillar divided into two zones: the nucleus zone and the yield zone[9]. The central nucleus zone is in a state of three-axis stress, and is surrounded by the yield zone and constrained by it. The key to the success of strip mining lies in retaining the stability of the strip coal pillar. After indoor and field studies, it was found that the sides of the strip coal pillar are Y in the yield zone, the middle is s in the nucleus zone, and the central nucleus zone is in a three-dimensional stress state.

Coal pillar stress zone in Figure 1.

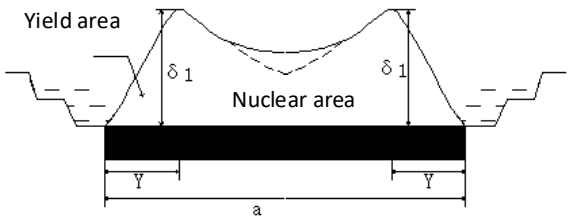


Fig 1. Coal pillar stress zone

According to the Kulun standard equation:

$$|\tau| = c + f\sigma = c + \sigma \tan\varphi \tag{1}$$

c—The adhesion of the coal body, Mpa
f—Internal friction factor
φ —Circuit in the coal body,

According to Figure 2, there are balanced formulas in the three -way stress state (2), which can be launched (3).

$$\frac{1}{2}(\sigma_1 - \sigma_3) = \left[\frac{1}{2}(\sigma_1 + \sigma_3) + c \cdot \cot\varphi\right]\sin\varphi \tag{2}$$

$$\sigma_1 = \frac{2c \cdot \cot\varphi}{1-\sin\varphi} + \frac{1+\sin\varphi}{1-\sin\varphi}\sigma_3 \tag{3}$$

σ_3 -Side stress, Mpa

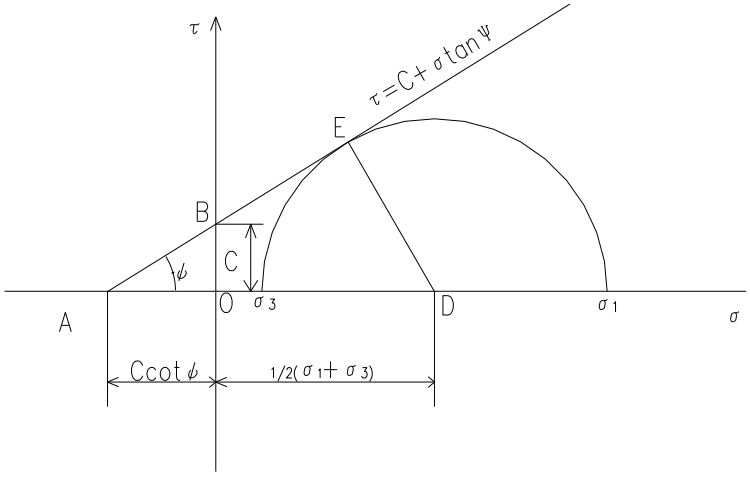


Fig 2. Under three -way stress conditions, limited balance conditions

Before the mining of the original rock, the self -gravity of the original rock is $\sigma_3 = \gamma H$. Because the thickness of the loosening layer in the mining area with a large thick and loose layer is large, the assumptions adjustment of σ_3 formulating a formula is made to order:

$$\sigma_3 = \lambda\left[\gamma_1 h + \gamma_2(\mathrm{H}-\mathrm{h})\right] \tag{4}$$

Among them, γ_1 is a loose layer, γ_2 is the rock capacity, λ is the maximum side stress coefficient (λ general value of 0.4 ~ 0.8) to bring σ_3 to the upper formula to get the σ_1 expression:

$$\sigma_1 = \frac{2c\cdot\cot\varphi}{1-\sin\varphi} + \frac{1+\sin\varphi}{1-\sin\varphi}\lambda\left[\gamma_1 h + \gamma_2(\mathrm{H}-\mathrm{h})\right] \tag{5}$$

Based on A. H. Wilson's on the basis of the Elastic Law, assumes that the relationship between destruction intensity and limited compression stress:

$$\sigma = \sigma_0 + \sigma_3 \tan\beta \tag{6}$$

σ -Destruction, Mpa

σ_3 -Destroy stress when there is no side pressure

$tan\beta$ is the slope of a straight line between the two when the side pressure is zero and the side pressure reaches the limit intensity. The relationship between it and the inner friction angle A is as follows:

$$\tan\beta = \frac{1+\sin\varphi}{1-\sin\varphi} \tag{7}$$

When the coal pillar is damaged, the value of A is zero.

Perform stress balance analysis of a unit coal pillar, as shown in Figure 3:

$$2\sigma_V \cdot \tan\varphi \cdot \delta_y \cdot l = \delta\sigma_H \cdot m \cdot l \tag{8}$$

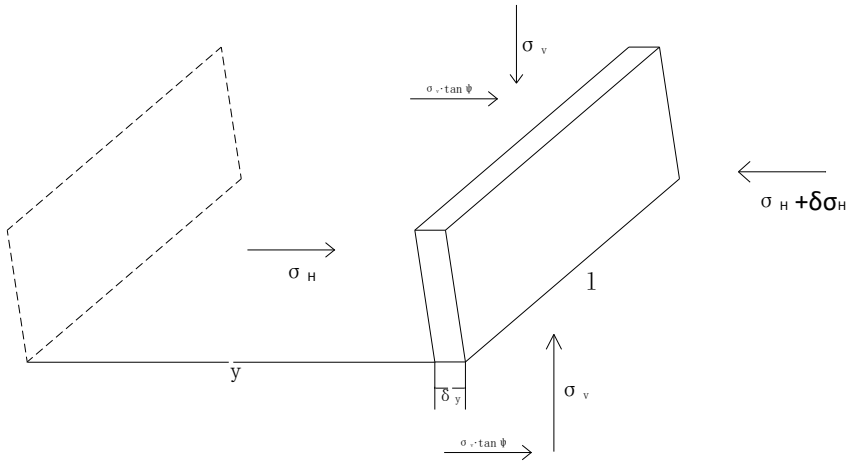


Fig 3. Coal column stress balance analysis

σ_V ——Vertical stress

σ_H ——Horizontal stress

δ_y ——Unit coal pillar thickness

m ——Unit coal pillar high

l ——Unit coal pillar length

From the formula (6), you can draw:

$$\delta\sigma_H = \frac{1}{\tan\beta}\cdot\delta\sigma_V = \frac{1-\sin\varphi}{1+\sin\varphi}\cdot\delta\sigma_V \tag{9}$$

Bring the formula (9) into the stress balance and other formulas (8) and go to l to get:

$$2\sigma_V \cdot \tan\varphi \cdot \delta_y = \frac{1}{\tan\beta} \cdot \delta\sigma_V \cdot m \quad (10)$$

$$\frac{\delta_y}{\delta\sigma_V} = \frac{m}{2\tan\beta\tan\varphi} \cdot \frac{1}{\sigma_V} \quad (11)$$

To simplify calculations, order $\frac{m}{2\tan\beta\tan\varphi} = A$, the formula (11) is simplified as follows:

$$\frac{\delta_y}{\delta\sigma_V} = A \cdot \frac{1}{\sigma_V} \quad (12)$$

Points on the formula (12):

$$\int d_y = A\int \frac{1}{\sigma_V} d_{\sigma_V} \quad (13)$$

$$y = A\left(\ln\sigma_V + b\right) \quad (14)$$

Among them, b is the constant, so that $b = \tan^2\varphi$ is considering the loose layer and the capacity of the base rock, there are:

$$\hat{\sigma} = \sigma_H \cdot \tan\beta = \left[\gamma_1 h + \gamma_2\left(H - h\right)\right] \cdot \tan\beta \quad (15)$$

Institute the formula (15) and $\frac{m}{2\,tan\,\beta\,tan\,\varphi} = A$, $tan\,\beta = \frac{1+sin\,\varphi}{1-sin\,\varphi}$ into the formula (5)

$$\hat{y} = \frac{m\cdot(1-sin\,\varphi)}{2\,tan\,\varphi(1+sin\,\varphi)} \cdot ln\left\{[\gamma_1 h + \gamma_2(H-h)] \cdot \frac{1+sin\,\varphi}{1-sin\,\varphi}\right\} + \frac{m\cdot(1-sin\,\varphi)}{2\,tan\,\varphi(1+sin\,\varphi)}(tan\,\varphi)^2 \quad (16)$$

The expression of the width Y of the coal column yield area is as follows:

$$Y = \frac{m\cdot(1-sin\,\varphi)}{2\,tan\,\varphi(1+sin\,\varphi)} \cdot \left\{ln\left\{[\gamma_1 h + \gamma_2(H-h)] \cdot \frac{1+sin\,\varphi}{1-sin\,\varphi}\right\} + tan^2\,\varphi\right\} \quad (17)$$

Simple treatment of Y: Assuming

$$Y = \lambda_1 mH + \lambda_2 mh \quad (18)$$

λ_1 and λ_2 are the coefficient related to the internal friction angle.

Therefore, the coal pillar is width A should meet the following relationship:

$$a \geq 2Y + s \quad (19)$$

The extreme load expression that the strip can withstand the coal pillar is:

$$P_{\text{limit、strip}} = \sigma_1(\text{a} - \text{Y})\text{L} \quad (20)$$

$$P_{\text{limit,strip}} = \left\{\frac{2c\cdot cot\,\varphi}{1-sin\,\varphi} + \frac{1+sin\,\varphi}{1-sin\,\varphi}\lambda[\gamma_1 h + \gamma_2(H-h)]\right\} \times (a - Y)L \quad (21)$$

$$P_{\text{actual、strip}} = [\gamma_1 h + \gamma_2(H-h)] \cdot \left[a + \frac{b}{2} \cdot \left(2 - \frac{b}{0.6H}\right)\right] \cdot L \quad (22)$$

In the formula: $P_{\text{limit、strip}}$ $P_{\text{actual、strip}}$ are the actual and extreme load value of the coal pillar, and L are the length of the coal pillar.

Based on the improved parameter formula and leaving width optimization design formula, combined with MATLAB to achieve the integration of leaving width design, verification, and mining of mining of the sub-loose layer with the unnecturantia [10-11].

When designing the width, the improvement of the formula for calculating the width of the A.H. Wilson surrender area above, and the widening B = 0.1H0 can be designed to design the minimum width.

Table 1. Parameters of rock layer physical mechanics

Rock layer	Internal agglomeration (MPa)	Internal friction (°)	Capable (KN/m^3)
Sandy clay	2.45	30	24.1
Pink sandstone	2.75	38	24.6
Fine sandstone	4.95	38	24.2
Sandy mudstone	2.22	24	26.4
Mudstone	1.33	30	26.2
coal	1.96	25	16

According to the width of the formula (18) and the formulas (23), (24), (25), etc., the actual and extreme load P_{limit} and Pactual solving this case.

$$Y_g = \frac{m\cdot(1-sin\,\varphi)}{2\,tan\,\varphi(1+sin\,\varphi)} \cdot \left\{ln\left\{[\gamma_1 h + \gamma_2(H-h)] \cdot \frac{1+sin\,\varphi}{1-sin\,\varphi}\right\} + tan^2\,\varphi\right\} \quad (23)$$

$$P_{g\ limit} = \left\{\frac{2c\cdot cot\,\varphi}{1-sin\,\varphi} + \frac{1+sin\,\varphi}{1-sin\,\varphi}\lambda[\gamma_1 h + \gamma_2(H-h)]\right\} \times (a - Y)L \quad (24)$$

$$P_{g\ actual} = [\gamma_1 h + \gamma_2(H-h)] \cdot \left[a + \frac{b}{2} \cdot \left(2 - \frac{b}{0.6H}\right)\right] \cdot L \quad (25)$$

Order: $\begin{cases} \frac{2c\cdot cot\,\varphi}{1-sin\,\varphi} + \frac{1+sin\,\varphi}{1-sin\,\varphi}\lambda[\gamma_1 h + \gamma_2(H-h)] = K_1 \\ \gamma_1 h + \gamma_2(H-h) = K_2 \end{cases}$

When $P_{g\ limit} = P_{g\ actual}$, the expression of the minimum value of amin can be reversed.

$$a\ \frac{K_2\left(b-\frac{b^2}{1.2H}\right)+YK_1}{K_1-K_2}\ _{min} \tag{26}$$

3. Engineering Experiment

This mining area is located in the southern part of Juye Coalfield. It is the north of Zhao Lou Coal Mine and its south is Wanfu Coal Mine. The east is the fault of the field bridge.

The mining area belongs to the Luxi formation partition in the North China Stranger District. The coal -containing formation is the Shanxi group and the Taiyuan group. The coal seams are stable and mostly available. The thickness is 495.2m, and the rock is loose. In this area, the coal seam can be 3 coal seams, 3300-5100m in the north and south, 2600-4700m width, 12.03km2, the ground elevation+ 40.2～+41.8m, the bottom plate elevation -650m to -1000m, the average coal thickness 2.6 2.6 M, which is a relatively stable coal seam; the coal seam incision angle is 3.2 to 9.5 °, with an average of 6 °.

Case models are performed according to the Calculation formula of Wilson's classic model.

$$Y_j = 0.00492mH \tag{27}$$

$$P_{j\ limit} = 40\gamma H(a - 4.92mH \times 10^{-3}) \tag{28}$$

$$P_{j\ actual} = 10\gamma[Ha + \frac{b}{2}(2H - \frac{b}{0.6})] \tag{29}$$

$$a_{j\ \min} = \frac{b}{3} - \frac{b^2}{3.6H} + 6.56 \times 10^{-3}mH \tag{30}$$

Finally, the nuclear area rate is calculated based on the improved solution model and the classic solution model.

Nuclear area rate:

$$\frac{a-2Y}{a} = P_c = \begin{cases} P_{c\ soft} \geq 0.65 \\ P_{c\ Medium\ hard} \geq 0.85 \\ P_{c\ hard} \geq 0.90 \end{cases} \tag{31}$$

Its solution results and model comparison are as shown below.

Apply the improved coal pillar yield width algorithm to reality, the traditional model PC = 0.0.518 <0.65, and the nuclear area rate is verified by the improvement algorithm PC = 0.679> 0.65, and the width of the surrender area is y = 12.33m. = 75.8m, 1.8m width width width than the traditional algorithm, and 12m wide width. The feasibility and accuracy of the width improvement algorithm in the coal column surrender area is verified, and it has practical significance for mining in the mining area.

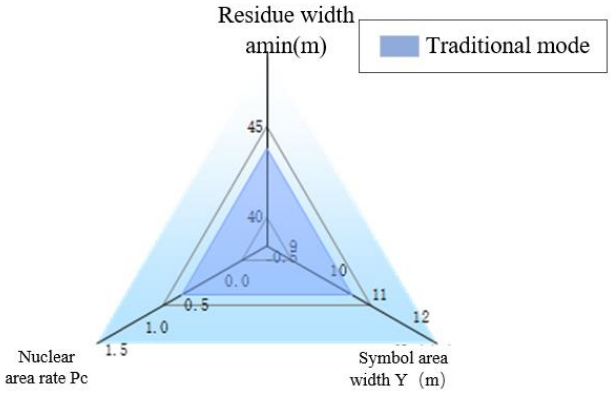


Fig 4. Traditional model

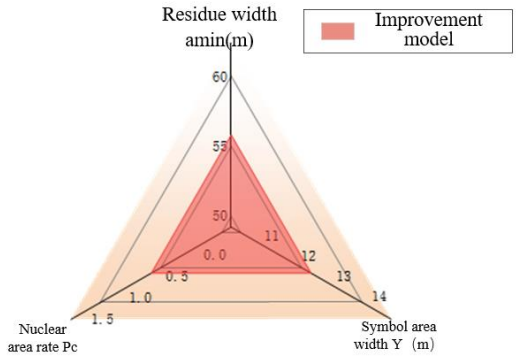


Fig 5. Improvement model

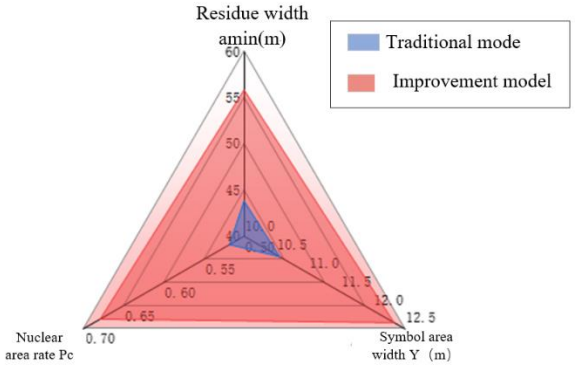


Fig 6. Two model comparison

Table 2. Conversion model comparison

Model	Loose layer thickness h(m)	Average depth H0(m)	Adopt thick m(m)	Side stress coefficient λ	Width b(m)	Residue width amin(m)	Symbol area width Y(m)	Nuclear area rate Pc
Improvement model	650	825	2.6	0.7	82.5	75.8	12.333	0.679
Traditional model	650	825	2.6	0.7	82.5	43.8	10.553	0.518

According to the specific expected needs and the predicted parameters of the design and probability points method, the valuable line diagrams of the expected area of the mining area sink, inclined, and horizontal deformation are separated by

the expected area of the mining area, as shown in Figure 4 ~ Figure 9.

Each two -dimensional graphic drawing generates an expected text file, which is recorded to save the expected results in the current operating directory. In this way, comparison and analysis can be performed according to the estimated values and measured values.

4. Conclusion

For the verification of engineering application examples, the optimization design of the mining area is widely collected and left wide, and the width values of the yield area and the minimum width value of the inhabitation area are solved according to the improvement model and the classic model, and the rate of recovery and minimum width of the nuclear area is on the nuclear area rate. The verification of the solution of the model and the classic model was verified by the improvement of the model and the classic model.

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