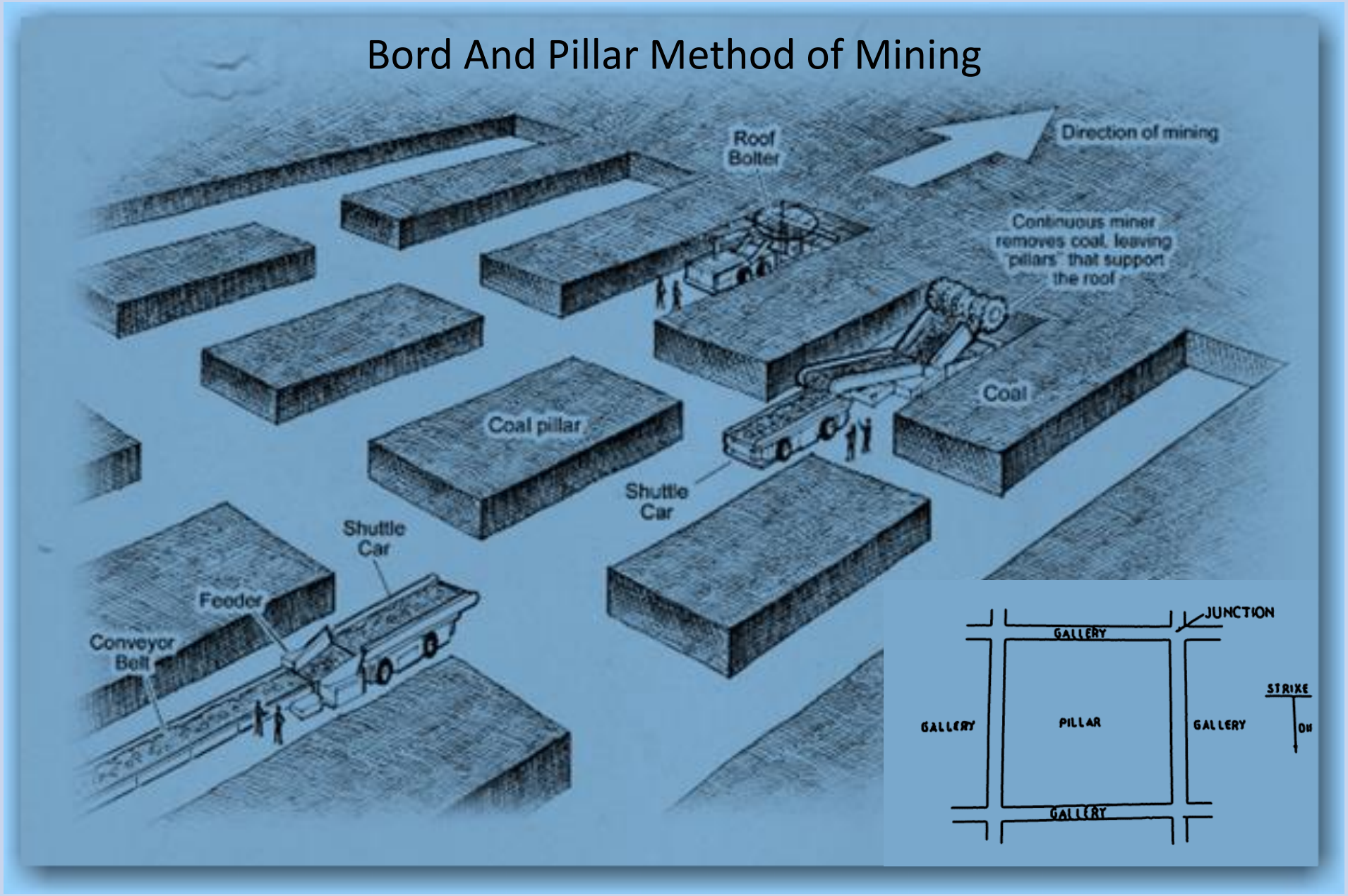
Pillar Design in Bord and Pillar Mining using Tributary Area Method

Bord And Pillar Method of Mining



Pillar Design Approach

- The traditional approach to the pillar design is to determine its strength and compare it with the applied stress.
- Factor of Safety (FOS) during the development is defined as

$$\text{FOS} = \frac{\text{Pillar Stregth}}{\text{Pillar Stress}}$$

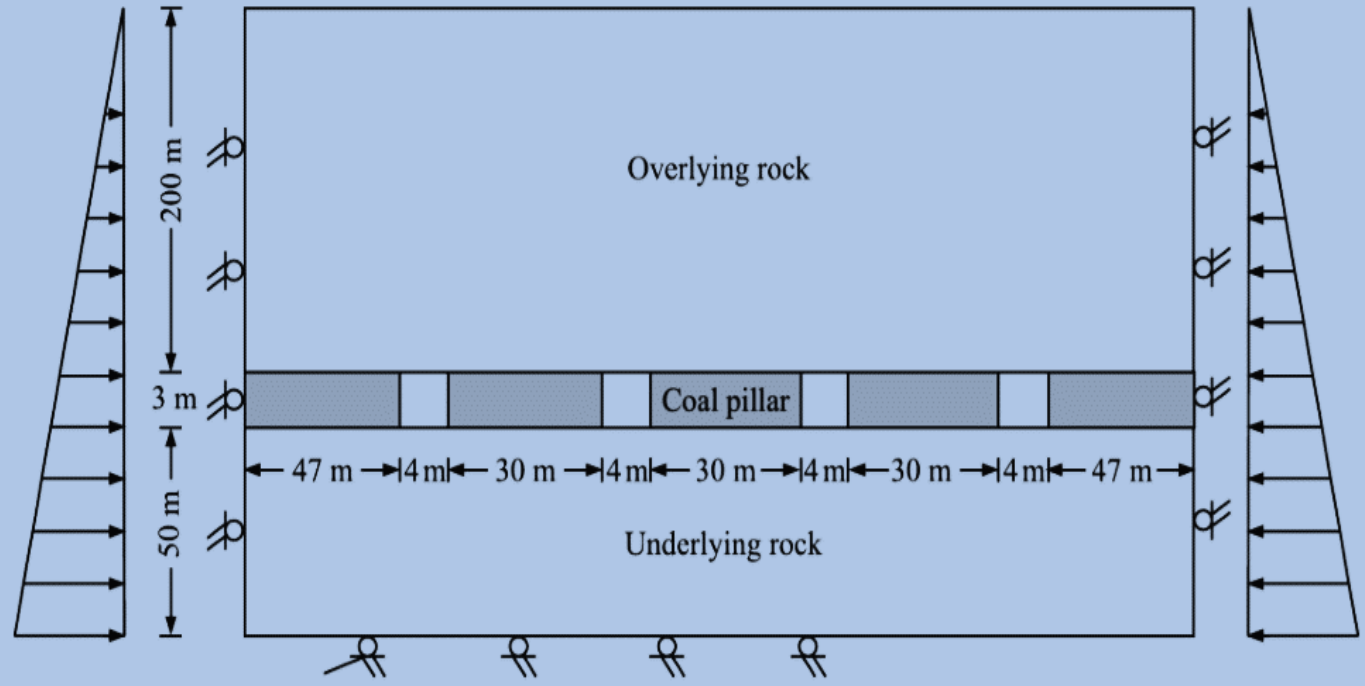
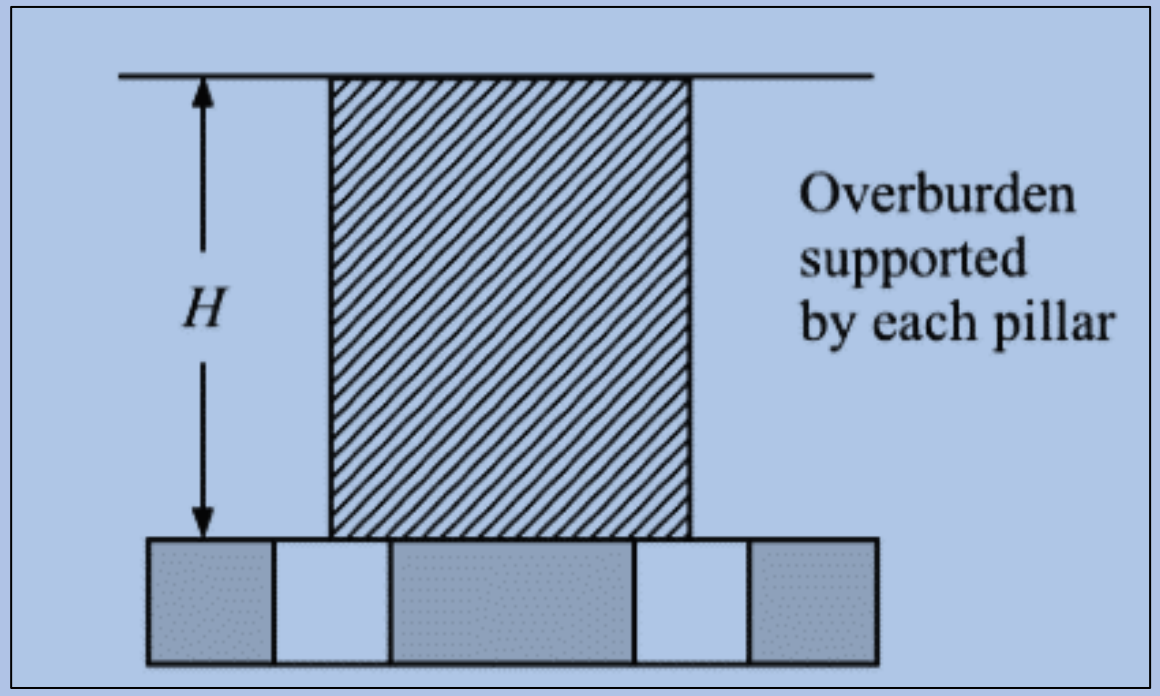


Fig: Pillar loading in rock mass with or without horizontal stresses.

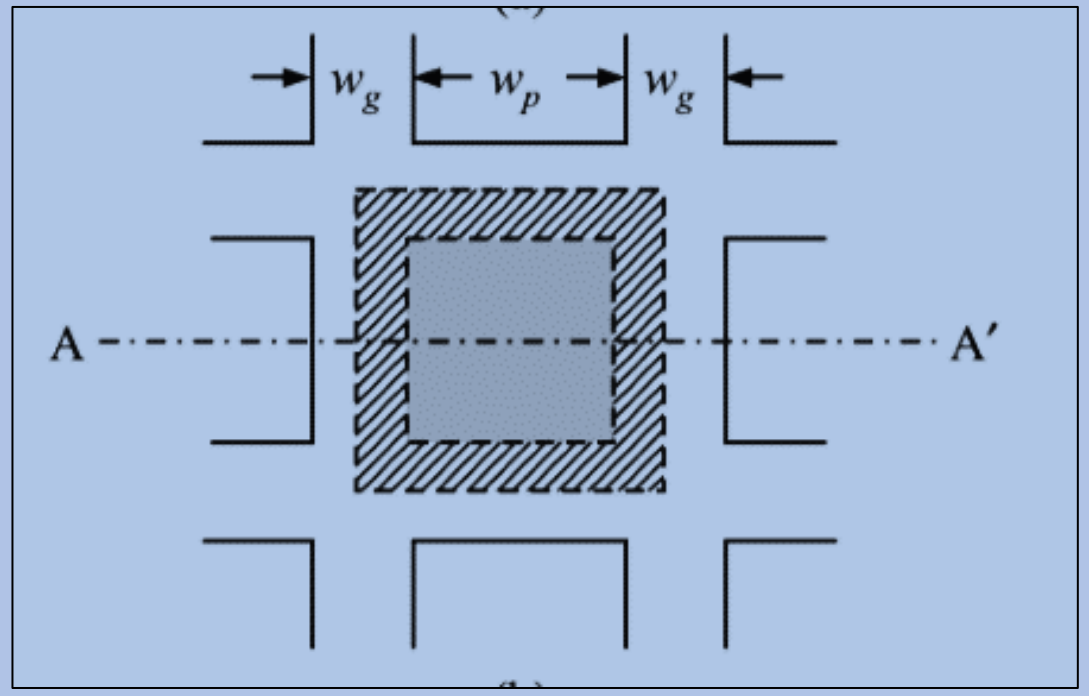
Factors Affecting Pillar Size

- Strength of coal
- Depth of cover
- Factor of Safety
- Average density of overburden
- Width of the gallery
- Height of gallery/ Mining width

Tributary Area Method



(a)



(b)

Fig: Tributary area method for pillar stress in flat opening: (a) Vertical section along line (A-A’) and (b) Top view of pillars.

Derivations

Let $D \rightarrow$ Depth of cover

$\gamma \rightarrow$ Unit wt. of overburden

$\sigma_p \rightarrow$ Stress induced in pillar

$R \rightarrow$ Percentage extraction

Then,

$$\sigma_p = \frac{\gamma D}{1 - R} \qquad \text{---------- eqn (1)}$$

R is given as :-

$$R = 1 - \frac{(W_p)^2}{(W_p + W_g)^2} \quad \text{---- eqn (2)}$$

where,

$W_p \rightarrow$ Width of pillar

$W_g \rightarrow$ Width of gallery

FOS is given as :-

$$FOS = \frac{\text{Strength}}{\text{Stress}} \quad \text{---- eqn (3)}$$

Strength (S_p) can be obtained from Bieniawski's formula

$$S_p = S_1 \left(0.64 + 0.36 \frac{W_p}{h_p} \right) \quad \text{---------- eq}^n \text{ (4)}$$

where, $S_1 \rightarrow$ Strength of coal of $1 m^3$

$h_p \rightarrow$ Height of the gallery

S_L can be obtained from :-

$$S_L = k l^{-a} \quad \text{---------- eq}^n \text{ (5)}$$

where k l a are constants

We can determine different values of S_L for different l as

S_L	S_{L_1}	S_{L_2}	S_{L_3}	S_{L_4} ..
l	l_1	l_2	l_3	l_4 ...

Take ln both sides of eq^n ⑤

$$\ln S_L = \ln k - a \ln l \quad \text{---- eq}^n \text{ ⑥}$$

Let us represent

$$\ln S_L \to y, \quad \ln l \to x$$

then

$$\ln_k = \frac{\left(\sum_{i=1}^{n} y_i\right)\left(\sum_{i=1}^{n} x^2_i\right) - \left(\sum_{i=1}^{n} x_i\right)\left(\sum_{i=1}^{n} x_i y_i\right)}{n\left(\sum_{i=1}^{n} x^2_i\right) - \left(\sum_{i=1}^{n} x_i\right)^2} \quad \text{...eq}^n \text{ ⑦}$$

$$-a = \frac{n\left(\sum_{i=1}^{n} x_i y_i\right) - \left(\sum_{i=1}^{n} x_i\right)\left(\sum_{i=1}^{n} y_i\right)}{n\left(\sum_{i=1}^{n} x_i^2\right) - \left(\sum_{i=1}^{n} x_i\right)^2} \quad \text{---- eq}^n \text{ (8)}$$

Therefore,

$$S_1 = K\left(1000\right)^{-a} \quad \text{---- eq}^n \text{ (9)}$$

From eq^n (3)

$$f_S = \frac{S_p}{\sigma_p}$$

$$= \frac{S_1\left(0.64 + 0.36\,\frac{W_p}{h_p}\right)}{\gamma D} \times \frac{W_p^2}{(W_p + W_g)^2} \quad \text{---- eq}^n \text{ (10)}$$

Now, Let $G_1(W_p) = A_1 W_p^3 + A_2 W_p^2 + A_3 W_p + A_4 = 0$ --- eqn (11)

Apply Newton Raphson Method :-

$$W_p^{n+1} = W_p^n - \frac{G_1(W_p^n)}{G_1'(W_p^n)} \quad \text{---- eqn (12)}$$

Coefficients of eqn (11) can be found out by comparing it with eqn (10)

$A_1 =$ $A_2 =$

$A_3 =$ $A_4 =$

Hand Problem

- Calculate the coefficients of equation 11, or in words, find out the value of A_1, A_2, A_3 and A_4.

Please note: We don't expect that it will take more than 20 minutes.

Coding Problem

- The vertical depth of Bord and Pillar district is 200 meters below. The surface and average density of overburden is 2.6 tones per cu.m. The desired mining height is 3 meters. Upon testing of coal blocks, the following data is acquired.

Size (mm)	25	50	75	100
Strength (MPa)	18	10	7	6

Width of the gallery is 4.5 meters. Ask the user to input the desired Factor of Safety (FOS) in the computer code and determine the width of pillar for that FOS (Ex. FOS values like 1.35, 1.4, 0.75 etc..).

Please note: The coding test will be conducted in Hackerrank. The contest will be started at 02:30 PM and the submission deadline will be 05:00 PM same day.

Assignment

With the same data as given in previous slide for Average density of overburden, Mining height, Size and length values and FOS = 1.35, fill in the blanks with calculated value of width of pillars. Use your code for this problem. * represents the last digit of your roll number (Ex. 125 for Roll No. 16MI31025).

Vertical Depth	Width of gallery				
	3	3.6	4	4.2	4.8
6*_					
9*_					
12*_					
15*_					
24*_					
36*_					

Please note: This assignment will be created in MS Teams at around 04:00 PM and the deadline will be 11:59 PM same day.

Thank You

Hackerrank links:

Contest Link: https://www.hackerrank.com/pillar-design

Challenge Link: https://www.hackerrank.com/contests/pillar-design/challenges