

Underground Coal Mining Method

Board and pillar

Long Wall Method

or
Room and pillar

Selection of Method

The Method of working will depend upon the

- (i) Thickness of seam (layer of coal) and strata
- (ii) Inclination of the strata (1:10) and the nature of roof and floor.
- (iii) Depth of the seam from the surface.
- (iv) Physical and chemical property of the coal.
- (v) The vicinity of other seams or of other workings should not be interfered.
- (vi) The presence of disturbance of the field.

Board and pillar Method

- (i) This method is sometimes known as room and pillar method.
- (ii) The pillars are left at regular interval pattern while the rooms are mined out.

(iii) Board and pillar method is adopted for working

- a) seam thicker than 1.5m
- b) seam at moderate depth
- c) seam which are not glassy.

(iv) There are three types of gases.

- a) Degree I = 0-1 m³ / tn
- b) Degree II = 1-10 m³ / tn
- c) Degree III = >10 m³ / tn

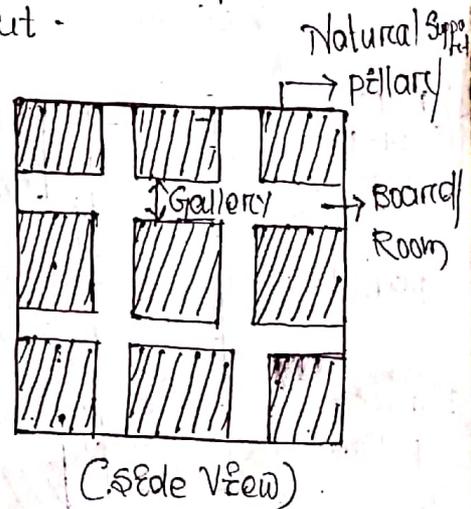
(v) seams with strong roof and floor which can stand for long development period after development stage.

Design of board and pillar working

1. size of pannel size of pannel depends upon
2. size of barrier the incubation period to starting of the crack in the seam
3. size of pillar to burning (takes 10-12 months)

Pannel allows continuous excavation even if work of any area stops.

Separate Pannels are constructed.

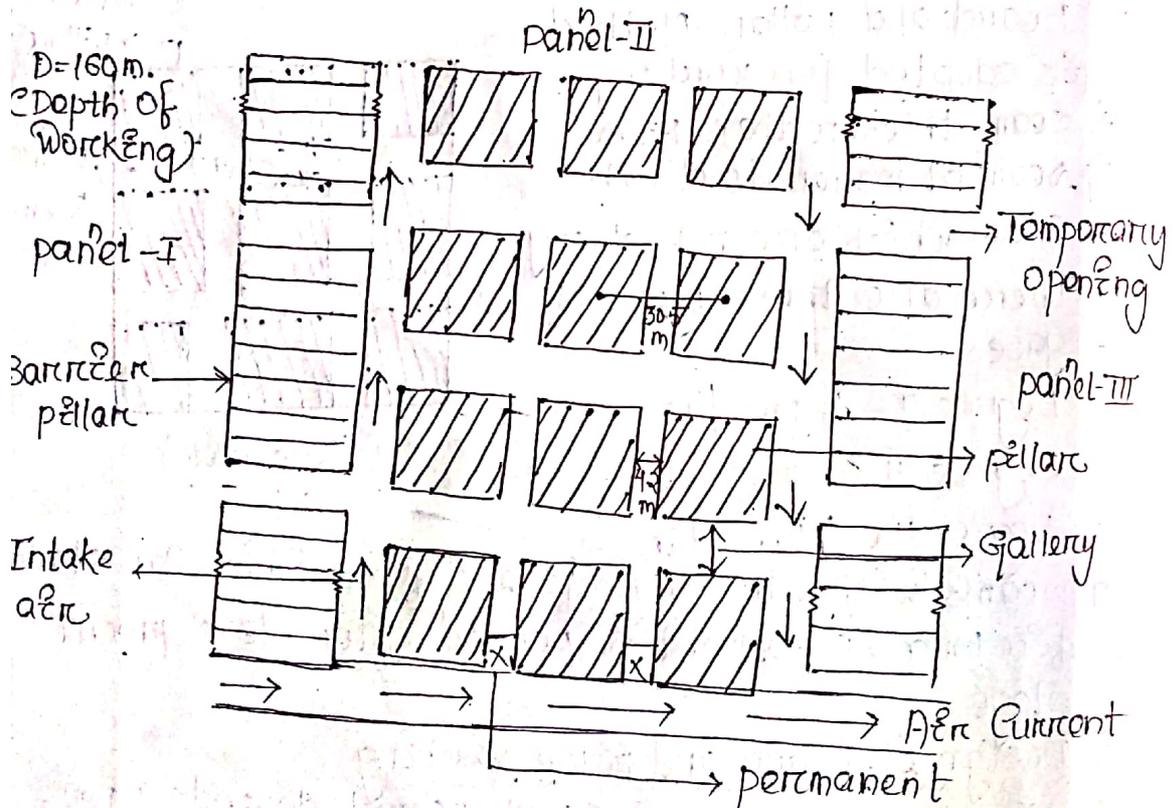


Development
 In case of board and pillar two sets of gallery are one normally perpendicular to the other are driven, forming pillar between them of size that depends upon depth and width of the gallery.

* CMR No-99

(Dimension of pillar and gallery)

Depth of seam from surface	Width of gallery from Center to Center			
	< 3m	3-6m	6-9m	> 9m
< 60m	12	15	18	19.5
60 < D < 90m	13.5	16.5	19.5	21.0
90 < D < 150m	16.5	19.5	22.5	25.5
150 < D < 240m	22.5	25.5	30.5	34.5
240 < D < 360m	28.5	34.5	39.5	45.0
> 360m	39	42.0	45	48



- (i) A group of such pillar form is known as pannel.
- (ii) One pannel is separated from another pannel having a solid coal barrier in between have in the form of a long rectangular barrier pillar.

(iv) Connection between two panel should be as 'low' as possible.

(v) such connection should be cut off by having permanent stopping for the complete isolation of one panel with other as soon as utility of 'low' enters connection between two panel is over.

* Size of the panel depends upon

1. Incubation period

(i) The size is so fixed that the entire panel can be extracted within the incubation period without the occurrence of spontaneous heating.

(ii) This period in Indian coal field generally vary from 8 to 12 months.

2. Rate of extraction

(i) In India 250-300 tonne/day/panel is extracted.

3. Size of the barrier

(i) The width of the barrier depends upon the load which it has to carry and its strength.

(ii) Greater the depth of working wider is the barrier and as softer the coal more the width of the barrier.

Width of the barrier \geq Width of pillar

Percentage of extraction (R)

(i) Percentage of extraction is the ratio of Volume Coal extraction to the during development to the total in situ Volume of Coal.

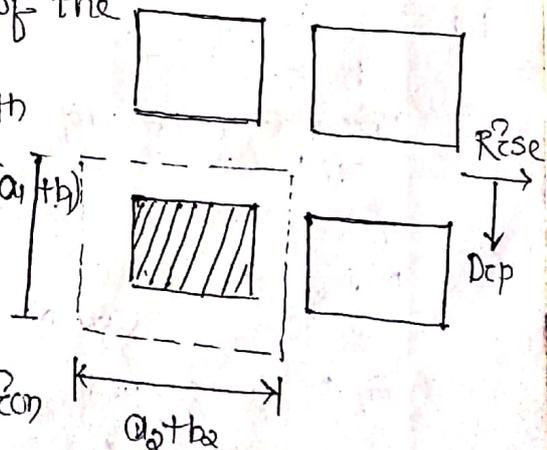
(ii) In the figure the size of the pillar is $(a_1 \times a_2)$.

(iii) Where a_1 and a_2 are length and breadth of pillar. $(a_1 + b_1)$

(iv) The width of the gallery in dip and rise direction is b_1 and b_2 respectively.

* The percentage of extraction can be determined by

$$R = \frac{(a_1 + b_1)(a_2 + b_2) - a_1 a_2}{(a_1 + b_1)(a_2 + b_2)}$$



If the pillar is square i.e. $a_1 = a_2 = a$

$$\text{Now } R = \frac{(a+b_1)(a_2+b_2) - a_1 a_2}{(a+b_1)(a_2+b_2)}$$

$$\Rightarrow R = \frac{(a+b)^2 - a^2}{(a+b)^2}$$

$$\Rightarrow R = 1 - \frac{a^2}{(a+b)^2}$$

Tributary Area

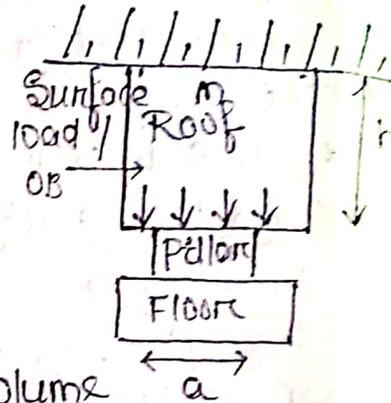
$$T.A = (a+b_1)(a_2+b_2) - a_1 a_2$$

Load Acting On pillar
(By Tributary Area Method)

$$P = \frac{mg}{V} \times h \times (a+b)^2$$

$$\Rightarrow P = \frac{\gamma \times h \times (a+b)^2}{a^2}$$

Where γ = Weight per Unit Volume
 h = depth of pillar from surface
 a = length and breadth of pillar
 b = width of gallery.



We know, $R = 1 - \frac{a^2}{(a+b)^2}$

$$\Rightarrow R = 1 - \frac{\gamma h}{P} \Rightarrow 1 - R = \frac{\gamma h}{P} \Rightarrow P_{load} = \frac{\gamma h}{1 - R}$$

Q. A seam is worked at a depth of 120m from surface and has width of galleries is 3.4m. The percentage of extraction should be restricted to?

Ans: $h = 120\text{m}$

$b = 3.4\text{m}$

From EMR No. 99

$a = 19.5\text{m}$

$$\Rightarrow a = 19.5 - 3.4 = 16.1\text{m}$$

$$\text{Now, } R = 1 - \frac{a^2}{(a+b)^2} = 1 - \frac{(16.1)^2}{(19.5)^2} = 0.318$$

$$\Rightarrow R = 0.318 \times 100 = 31.8\%$$

Strength of the pillar

The strength of the pillar can be determined by the empirical relationship given by Salamon and Munro

$$S_p = 7.2 \frac{w^{0.46}}{h^{0.66}} \text{ Mpa}$$

Where,
 w = width of the pillar
 h = height of the pillar
 extraction (pillar)

Bieniawski Formula

$$S_p = S_1 \left[0.64 + 0.36 \frac{w}{h} \right] \text{ Mpa}$$

Where,
 w = width of pillar
 h = height of extraction

Find the strength of pillar in the above question?

Ans: Given h of pillar = 30m (h = 200m)
 at $w = 25.5$ m

$$\text{Now } w = 25.5 - 3.4 = 22.3 \text{ m (a)}$$

$$S_p = 7.2 = \frac{w^{0.46}}{h^{0.66}} \text{ Mpa}$$

$$= 7.2 \times \frac{(22.3)^{0.46}}{(30)^{0.66}} = 14.54 \text{ Mpa}$$

Q: The average vertical stress in a coal pillar of a B and P panel is found to be 8 Mpa. The depth of the pillar and the avg. density of overburden rock are 200m and 2500 kg/m³ respectively. Find the extraction ratio of the panel?

Ans $P = 8 \text{ Mpa} = 8 \times 10^6 \text{ N/m}^2$

$$h = 200 \text{ m}$$

$$\gamma = 2500 \text{ kg/m}^3$$

$$P = 8 \times 10^6 \times 9.81 = 7848 \times 10^4 \frac{\text{kg}}{\text{m}^3} \times \frac{\text{m}}{\text{sec}^2}$$

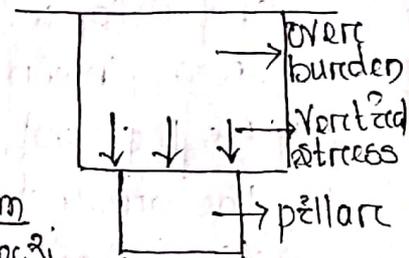
$$= 7848 \times 10^4 \times \frac{\text{N}}{\text{m}}$$

We know, $P_{\text{load}} = \frac{\gamma h}{1-R}$

$$\Rightarrow 8 \times 10^6 \frac{\text{N}}{\text{m}^2} = \frac{2500 \times 9.81 \times 200 \times \frac{\text{kg}}{\text{m}^3} \times \frac{\text{m}}{\text{sec}^2} \times \text{m}}{1-R}$$

$$\Rightarrow 1-R = \frac{2500 \times 9.81 \times 200}{8 \times 10^6} = 0.613$$

$$\Rightarrow R = 1 - 0.613 = 0.387$$



$$\Rightarrow R = 0.3869 \times 100 = 38.69\%$$

Factor of safety

$$F.O.S = \frac{\text{strength of the pillar}}{\text{load/stress acting on the pillar}}$$

Now, Given, strength of pillar = 14.54×10^6 pa.

load/stress acting on pillar = 8×10^6 pa

$$\text{Now, } F.O.S = \frac{14.54 \times 10^6}{8 \times 10^6} = 1.817 \text{ (Ans)}$$

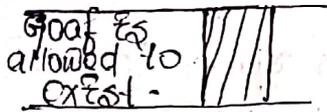
DEPILLARING OR PILLAR EXTRACTION on the B/p system

- (i) After the pillar has been formed, considerable ^{of} has to be taken for the extraction of pillar. This method is known as pillar extraction.
- (ii) It is also known as depillaring.

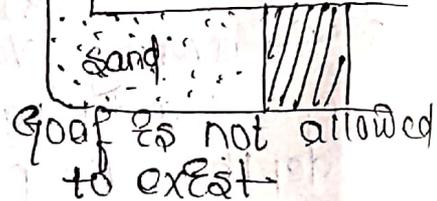
Depillaring

Subsidence

Depillaring
with caving



Depillaring
with stowing



Depillaring with caving

- (i) In this method the coal pillar is extracted and the roof strata is allowed to break and collapsed on the voids or the decaoled area known as goaf.

(ii) As the roof strata above the coal seam break, the ground surface develops crack and subsidence.

(iii) The extent of damage depends upon the

- a). Thickness of the seam extraction,
- b). Nature of roof strata
- c). Depth of working.

Depillaring with stowing

(E) In this method of pillar extraction, the goaf is completely packed with incombustible material to keep the surface and the strata above the seam intact after the extraction of pillar.

The following circumstances are required for the adoption of depillaring with stowing

1. presence of water bearing strata above the coal seam to be extracted.
2. Railway, river or roadway are available on the surface that can't be diverted.
3. presence of one or more seam of marketable quality extractable in the near future.
4. Extraction of full thickness of the seam thicker than 6m as thicker seam can't be extracted fully by caving method.
5. Extraction of seam very prone to spontaneous heating of very gassy nature.
6. presence of surface building, tanks, reservoir which can't be diverted.

Problems in the extraction of pillars

Q Given, Depth of working = 200m
Gallery width = 3.4m
height of extraction = 3m

Per day extraction from a panel = 300th/day

Incubation period = 6 months

Day of working in a month = 25 days

sp. gravity of coal = 1.4

Recovery = 80%

Find the no. of pillars in a panel?

Ans No of working days in 6 months = $6 \times 25 = 150$ days
per day extraction of coal from a panel is = 300 t/days
 \therefore Extraction of coal from a panel in 150 days
= $150 \times 300 = 45000$ t.

Again recovery = 80%.

Hence actual amount of coal extracted
= $\frac{45000}{\frac{80}{100}} = 56,250$ tonne.

Again, Given depth of working = 200 m
Gallery width = 34 m

From EMR No-99, width of pillar = $25.5 - 34 = 22.1$ m

Area of pillar = $22.1 \times 22.1 = 488.41$ m²

Volume of pillar = $488.41 \times 3 = 14625.23$ m³

sp. gravity of coal = 1.4

Density of coal = $1.4 \times 1000 = 1400$ kg/m³.

Amount of coal per volume = 1400×14625.23
pillar = 2051322 kg

Number of pillar = $\frac{56250}{2051322 \times 10^{-3}} = 27$ (Ans)

Problems in the extraction of pillar

- (i) If the operation have not been design scientifically, there are danger of strata movement setting in, which may result in overloading of pillar and premature collapse.
- (ii) In some seams, the roof does not cave in over a large area for quite some time and when it does cave in archblasts occurs resulting in accident.
- (iii) Maintenance of the acceptable environment is not easy. Splitting of the pillars provide many leakage routes and heightening and widening of the gallery may increases

Cross-sectional area. Hence the velocity of ventilating air is reduced.

- (v) Air borne dust concentration increases and the climatic condition become uncomfortable.
- (vi) Usually some coal are left in the goaf, which may be 15-20% of the panel reserve. This get crushed, oxidation takes place and eventually fire may break out.



Principles of pillar extraction technique

- (i) Roof exposure at one time should be minimum. In Indian coal field, where caving is practised generally 80-90 m² roof exposure is allowed. But in case of stowing district (panel) the roof exposure is increased to 90-100 m².
- (ii) The size of the panel should be such that depillaring can be completed within the incubation period. This period usually varies between 6 to 9 months.
- (iii) The diagonal line should be so arranged as to fascilate roof control. In practice the diagonal line or step diagonal line of face is common.

9	8	7	6	5
8	7	6	5	4
7	6	5	4	3
6	5	4	3	2
5	4	3	2	1

Diagonal line of extraction

13	12	11	10	9
11	10	9	8	7
9	8	7	6	5
7	6	5	4	3
5	4	3	2	1

step diagonal line of extraction

13	11	9	7	5
12	10	8	6	4
11	9	7	5	3
10	8	6	4	2
9	7	5	3	1

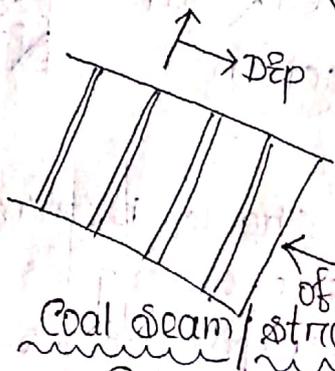
steep diagonal line of extraction

5	5	5	5	5
4	4	4	4	4
3	3	3	3	3
2	2	2	2	2
1	1	1	1	1

5	4	3	2	1
5	4	3	2	1
5	4	3	2	1
5	4	3	2	1
5	4	3	2	1

strike
↓
Dep.

strike straight line of extraction.



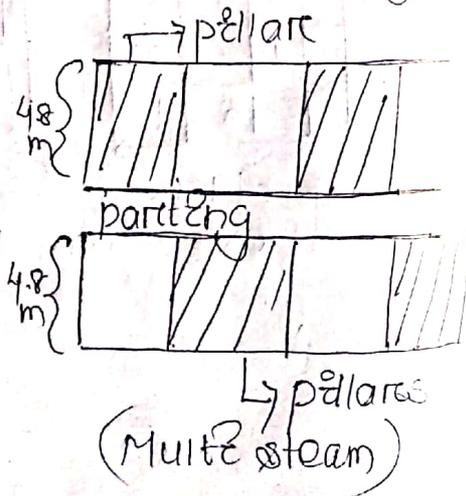
(i) The tendency of CH_4 is towards upward.

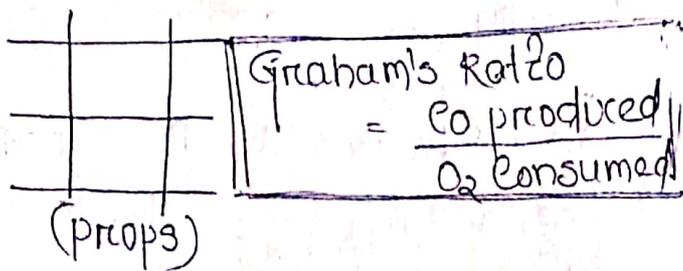
(ii) The water moves towards the goaf.

- (iv) In special cases, steep diagonal line and straight line of face has been selected.
- (v) The diagonal line or steep diagonal line of face provides protection as the working places are supported by pillars and also when the goaf moves, there is less risk of goaf flushing into the working places.
- (vi) It is also claimed that diagonal line of extraction helps in caving of the roof.
- (vii) Single left extraction is limited to height of 4.8m. If the thickness of the seam is more than 4.8m, then the extraction is done by multiple left and in that case hydraulics sand stowing is used.

(viii) Seam upto 4.8m thick can be mined out by caving in one pass.

(ix) Whatever the method of extraction, the working area is systematically supported by logs and props.





Module-I

Short Notes

Q.1 Advantages and disadvantages of Board and pillar working?

Advantages

- (i) Moderate to high productivity.
- (ii) High degree of Mechanisation.
- (iii) It can be operated on multiple fronts.
- (iv) Comparing with long wall method, long wall method requires greater investment and surface subsidence is also more in long wall method.
- (v) Maintenance cost is low.
- (vi) During development of the mine, we know the geological disturbance of and the mine can be accordingly plan for further working.

Disadvantages

- (i) percentage of extraction is poor.
· Coal recovery is less as compare to other method.
- (ii) loss of coal in the pillar.
- (iii) proper ventilation is not possible (due to leakage).
- (iv) Roof control is difficult to manage.
- (v) The subsidence may be occurred.

Q.2 Incubation period (Ignition temp = 140°C)

It is the period between, the coal is 1st subjected to condition favourable for spontaneous heating and the time of endication of heating.

Q.3 Spontaneous heating

The process of self ignition of coal or other combustible material due to auto oxidation resulting eventually in its ignition is known as spontaneous heating.