



GOVERNMENT POLYTECHNIC JAJPUR

Lecture Note on
Underground Coal Mining

Prepared By :

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(LECT. IN MINING)

DEPARTMENT OF MINING ENGINEERING

(Introduction to Underground Coal Mining)

1.1. Define mine and different methods of mining.

What is Coal ?

- ❖ Coal is a combustible black or brownish-black sedimentary rock, formed as rock strata called coal seams.
- ❖ a combustible black or dark brown rock consisting chiefly of carbonized plant matter, found mainly in underground seams and used as fuel.
- ❖ Coal is a fossil fuel, formed from vegetation, which has been consolidated between other rock strata and altered by the combined effects of pressure and heat over millions of years to form coal seams. The energy we get from coal today comes from the energy that plants absorbed from the sun millions of years ago.
- ❖ Coal is classified into four main types, or ranks: *Peat, Lignite, Bituminous Coal & Anthracite Coal*. The ranking depends on the types and amounts of carbon the coal contains and on the amount of heat energy the coal can produce.



Rock - Any natural combination of minerals; part of the earth's crust.
Example- Igneous, Metamorphic and Sedimentary

Mineral - A naturally occurring homogeneous substance having definite physical properties and chemical composition and, if formed under favorable conditions, a definite crystal form.

Or

a naturally occurring inorganic element or compound having an orderly internal structure and a characteristic chemical composition, crystal form, and physical properties.
All Minerals are not ores.

Some example- quartz, calcite, sulfur and the clay minerals such as kaolinite and smectite etc.

Ore - A mixture of ore minerals and gangue from which at least one of the metals can be extracted at a profit.

All ores are minerals.

Example-

Ore	Mineral
Aluminium	Bauxite Kaolinite (a form of clay)
Iron	Haematite- Fe_2O_3 Magnetite- Fe_3O_4 Siderite- $FeCO_3$ Iron pyrites- FeS_2
Copper	Copper pyrites- $CuFeS_2$ Malachite- $CuCO_3 \cdot Cu(OH)_2$ Cuprite- Cu_2O Copper glance- Cu_2S
Zinc	Zinc blend/Sphalerite - ZnS Calamine- $ZnCO_3$ Zincite- ZnO

Mine: an excavation made in the earth to extract minerals.

Mining: the activity, occupation, and industry concerned with the extraction of minerals.

Mining engineering: the practice of applying engineering principles to the development, planning, operation, closure, and reclamation of mines.

Type of Mineral resources-

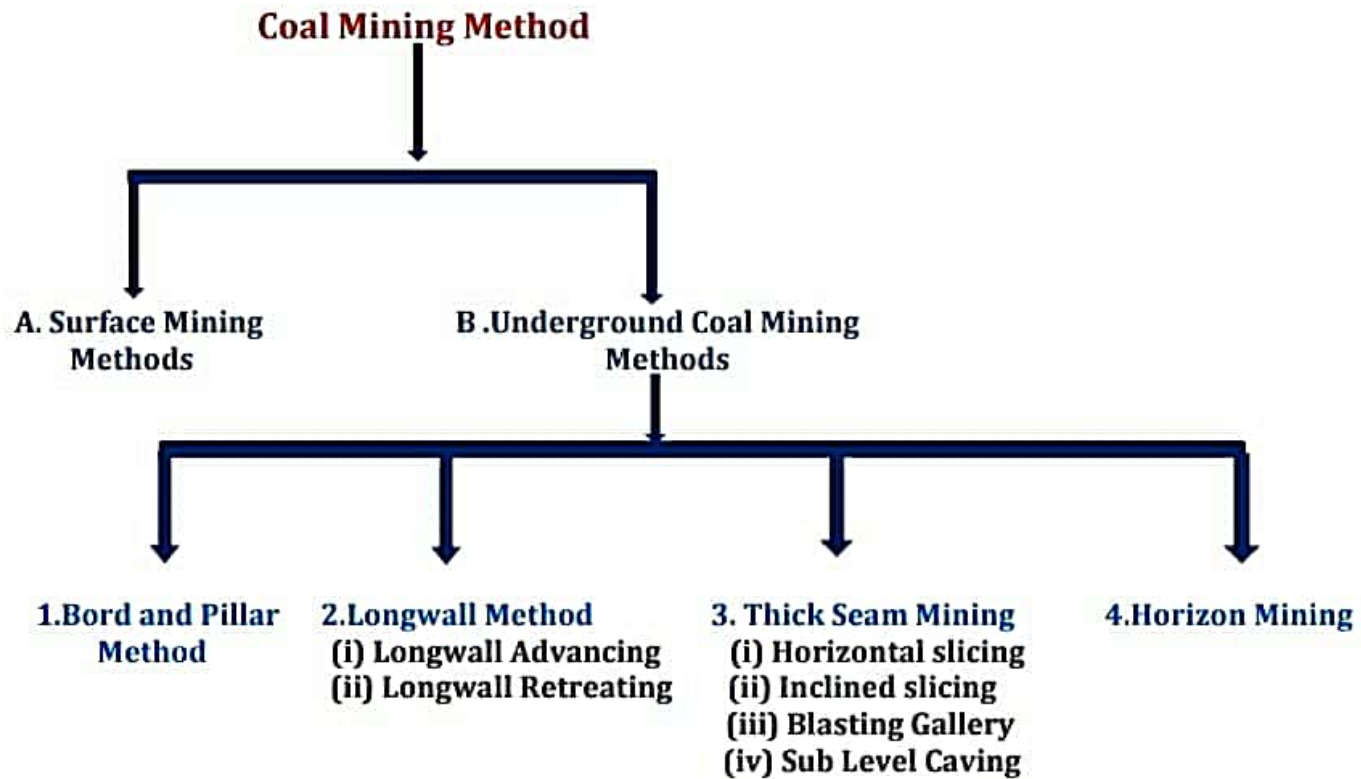
1. Metallic ores: Metallic minerals exhibit lustre in their appearance and consist of metals in their chemical composition. those ores of the ferrous metals (iron, manganese, molybdenum, and tungsten), the base metals (copper, lead, zinc, and tin), the precious metals (gold, silver, the platinum group metals), and the radioactive minerals (uranium, thorium, and radium).

2. Nonmetallic minerals (also known as industrial minerals):

Non-metallic minerals are minerals which either show a non-metallic lustre or shine in their appearance. Extractable metals are not present in their chemical composition. Limestone, gypsum, and mica are examples of non-metallic minerals.

3. Fossil fuels (also known as mineral fuels): the organic mineral substances that can be utilized as fuels, such as coal, petroleum, natural gas, coalbed methane, gilsonite, and tar sands.

1.ii. Classify Underground Coal Mining Methods.





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Lecturer note on Underground coal Mining

CHAPTER-2

(2. BORD AND PILLAR METHOD)

2. I. DESCRIBE THE VARIOUS APPLICATION OF BORD & PILLAR METHOD.

APPLICABILITY OF BORD AND PILLAR METHOD –

The Bord and Pillar method is adopted for working.

1. A seam thicker than 1.5 m.
2. A seam free from stone or dirt bands. Stone or dirt bands, if present in a seam, can be easily disposed of for strip packing in long wall advancing method of mining.
3. Seams at moderate depth,
4. Seams which are not gassy,
5. Seams with strong roof and floor which can stand for long period after development stage is over,
6. Coal of adequate crushing strength.

BASIC PRINCIPLE OF BORD AND PILLAR METHOD-

- The development of mine by the method of working known as Bord and Pillar consists of driving a series of narrow roads, separated by blocks of solid coal, parallel to one another, and connecting them by another set of narrow parallel roadways driven nearly at right angles to the first set. The stage of formation of a network of roadways is known as **development or first working**. And these roadways are called **BORD or GALLERY**.
- When the gallery are developed a solid block of coal is left surrounded the gallery are known as **PILLAR**. The coal pillars formed are extracted after the development of the mine leasehold and this later stage of extracting coal from pillars is known as **de-pillaring**. This method is sometimes called room-and-pillar mining.



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DESIGN OF BORD AND PILLAR WORKING

The main elements of Bord and Pillar workings are as follows -

1. Size of the Panel
2. Size of the Barrier
3. Size of Pillars

1. Size of the Panel-

- When developing a seam, sets of 5-7 galleries are driven which are separated from adjacent sets by a coal barrier (one wide pillar) this is known as panels.
- The main consideration in deciding the size of the panel is the incubation period of the coal seam. The size is so fixed that the entire panel can be extracted within the incubation period without the occurrence of spontaneous fire. The period in Indian coalfields generally varies between 6 to 12 months.
- The other factors that influence the size is the rate at which extraction is done. With high rates of extraction made possible by mechanization, the size of the panel can be significantly increased.
- The extraction rate from de-pillaring districts in Indian coalfield averages about 250-300 tons per day per panel. Sometimes panel sizes are determined by strata control considerations

2. Size of the Barrier-

- The width of the barrier depends on the load which it has to carry and its strength. Greater the depth of working, wider is the barrier and also softer the coal, the more, the width of the barrier. In practice, the width of the barrier enclosing pillars in a panel is usually the same as is the width of the coal pillars which are enclosed within the panel.
- In deep mines the width of the barrier may become quite large (up to 45 m) and so during extraction they are thinned down consistent with safety. Too much reduction in the width of the barrier is not advisable as in that case the barrier may be crushed and two goaves may be joined, thus encouraging safety.

3. Size of Pillars-

The size of the pillars is influenced by the following:

1. Depth from the surface and percentage extraction in the first workings or development.
2. Strength of the coal: Seams with weak coal require large pillars.
3. Effect of atmosphere and escape of gas also influence the size of pillars
4. The nature of the roof and floor: These influence the liability to crush and creep. A strong roof tends to crush the pillar edges whilst a soft floor predisposes it to creep and both calls for large pillars.

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5. Geological Considerations: In the vicinity of faults, large pillars are required. Dip and presence of water also influences the decision as to the size of pillars.

6. Time dependent strain: With time the strain goes on increasing, the load remaining constant and if the size of the pillar is not sufficiently large, then it may fail under the time dependent strain, although initially it might be stable

2. II. DESCRIBE VARIOUS LAYOUTS OF BORD & PILLAR METHOD

Some Types of Mines

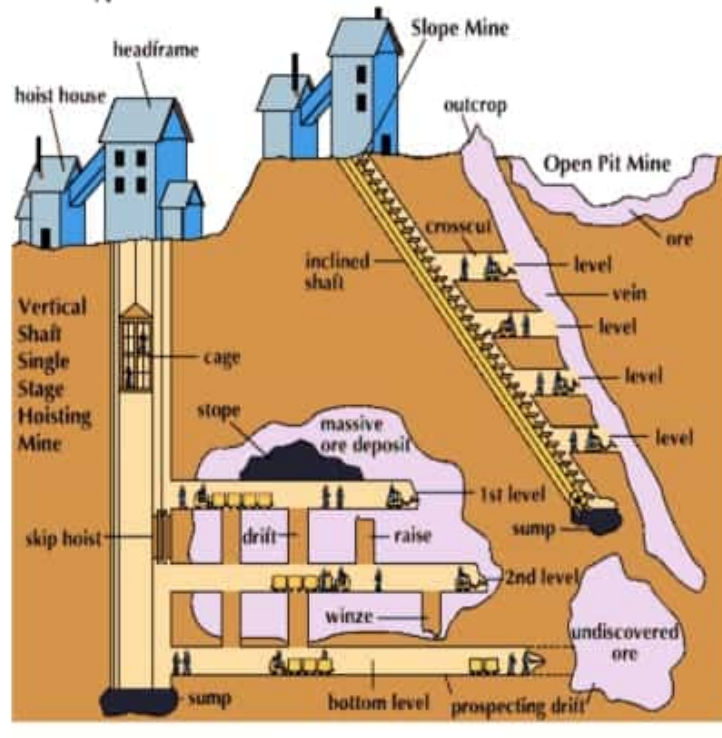


Slope Mine

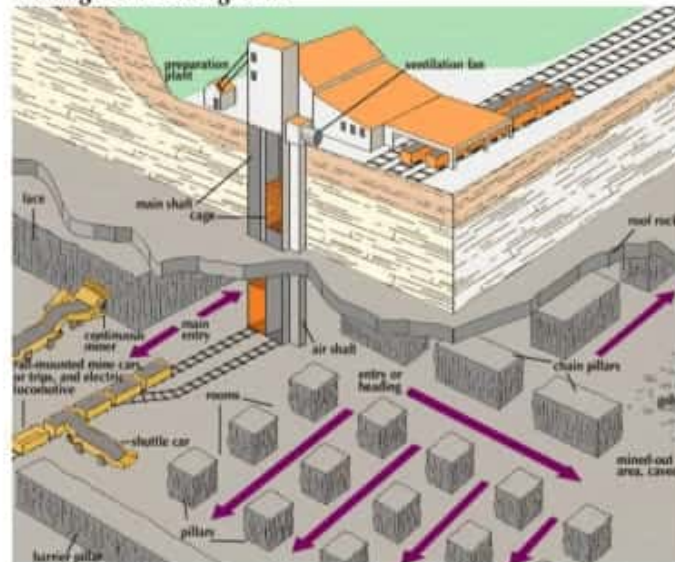
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Some Types of Mines



Mining Coal Underground



- A road in a coal seam proper is called **Gallery or Bord**.
- A road which driven along the dip of the seam is called a **dip gallery or dip**.
- A road which is driven along the strike of seam is called a **level gallery or level**.
- A road way in stone connecting two or more coal seams called a **drift**.
- A solid block of coal surrounded on all side by galleries is known as **pillar**, it forms the natural support of the roof in a mine.
- Where the galleries in a seam are generally along the dip and strike forming square and rectangular pillars, a gallery which cuts the pillars, due to its drivage along an apparent dip is called **crosscut**.
- A borehole directed so as to cut through a rock strata or ore vein essentially at right angles to the dip and strike of the rock strata, a vein, or a related structure.
- Such crosscut is sometimes required for facility of ventilation, drainage, haulage and stowing.
- A gallery in the process of being driven is called **heading**.
- The moving front of any working place of any gallery roadway or drift is called **face or working place or working**.
- A district is an area in a mine having a number of working places, it is also sometimes called **"section"**.

- Panel is known as or also sometimes used to denote a district which is separated from other district by an artificial barrier of brick wall or by a natural barrier of coal.
- Extraction of ore from block and pillar from during the development and supported by filling some incombustible material like sand, mill tailing, block of granite etc. known as **stopping**.
- When mineral is extracted from an from an underground mine the void space/goaf is packed with sand or other packing material whatever it conveniently and cheaply and available in sufficient quantity this process is known as **stowing**.

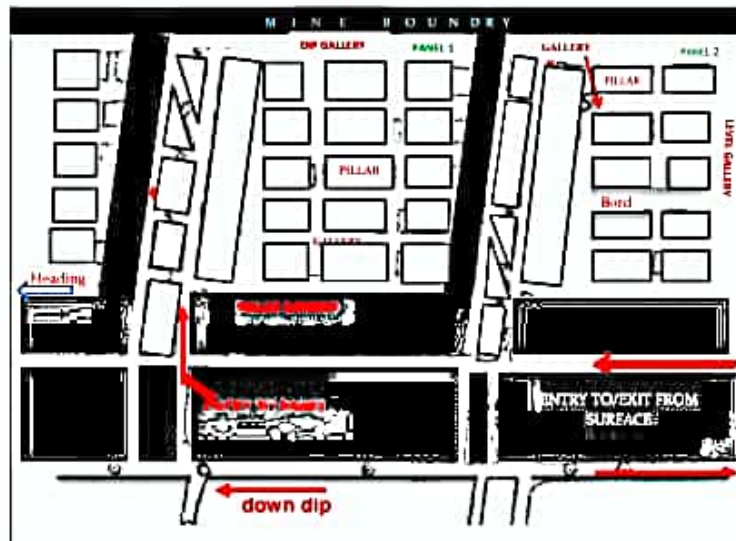
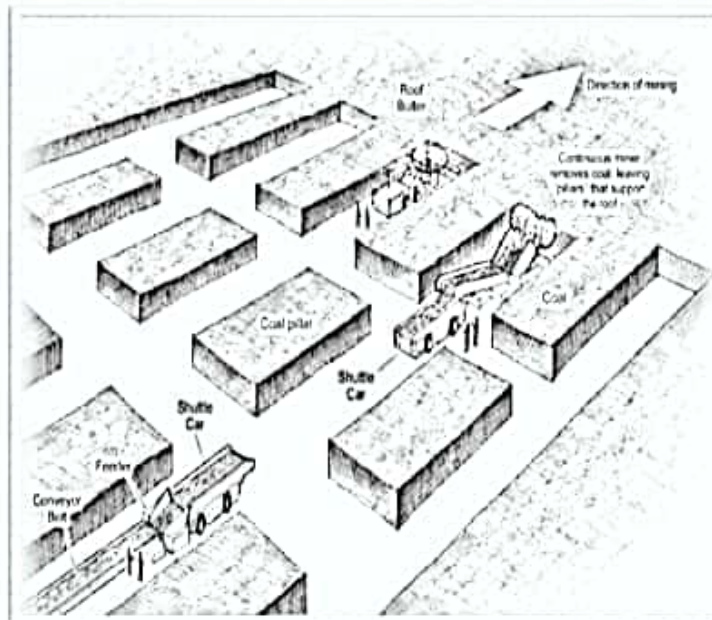


Fig-2.1.(Layout Of Bord & Pillar Method)



CLASSIFICATION OF BORD AND PILLAR MINING SYSTEM-

The bord and pillar system of mining can be done in three ways, namely:

1. Develop the entire area into pillars and then extract the pillars starting from the boundary.
2. Develop the area into panels and extract pillars subsequently panel-wise. This is called **panel system of mining**.
3. "Whole" followed by "broken" working in which the mine is opened out by a few Headings only and thereafter development and depillaring go on simultaneously starting from the boundary.

DEVELOPMENT OF ENTIRE AREA FOLLOWED BY PILLAR EXTRACTION-

The first system is attractive in that more number of working faces can be made available and thus more number of miners can be given employment. Large output can be quickly built up. In the past this system was practiced widely in Indian mines and in certain mines with very few coal cutting machines high outputs were obtained.

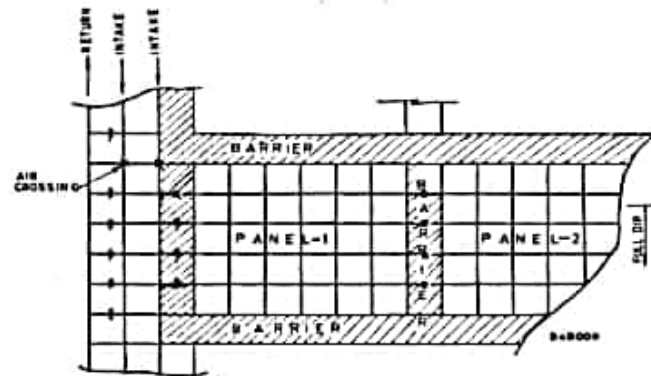
But this system has the following **disadvantages**:

- As the pillars have to stand for a long time before they are extracted, spading takes place and they get weakened. Consequently, they may get crushed and there is the risk of premature collapse.
- Ventilation may be sluggish due to greater percentage of air leakage.
- Treatment of coal dust is costly and difficult.
- There is greater risk of fire spreading in the whole mine.
- Coal dust explosion cannot be contained; if it occurs, it spreads throughout the mine.
- Crush and creep cannot be localized.
- The work is scattered. Consequently, the output per man-shift is low.

Due to these disadvantage this system is not used these days.

PANEL SYSTEM OF MINING-

In the Panel system of mining the coal seam is divided into a number of panels separated from one another by solid barrier of coal

**Advantages:**

- Risk of loss of coal through spontaneous heating is limited. In the event of fire occurring, the panel can be isolated from other parts of the workings. Similarly, explosions can be limited to the panel of occurrence.
- Crushing of pillars is avoided.
- 'Whole' and 'broken' workings can be done at the same time i.e., in one panel development and in another panel depillaring can be done at the same time.
- Ventilation is improved. Each panel can be provided with its separate intake and return. Also number of air stoppings can be substantially reduced.
- Control of subsidence is possible. By working panels of sub-critical width, magnitude of subsidence can be reduced.
- By suitable design using yield pillar techniques percentage extraction can be improved.

Disadvantages:

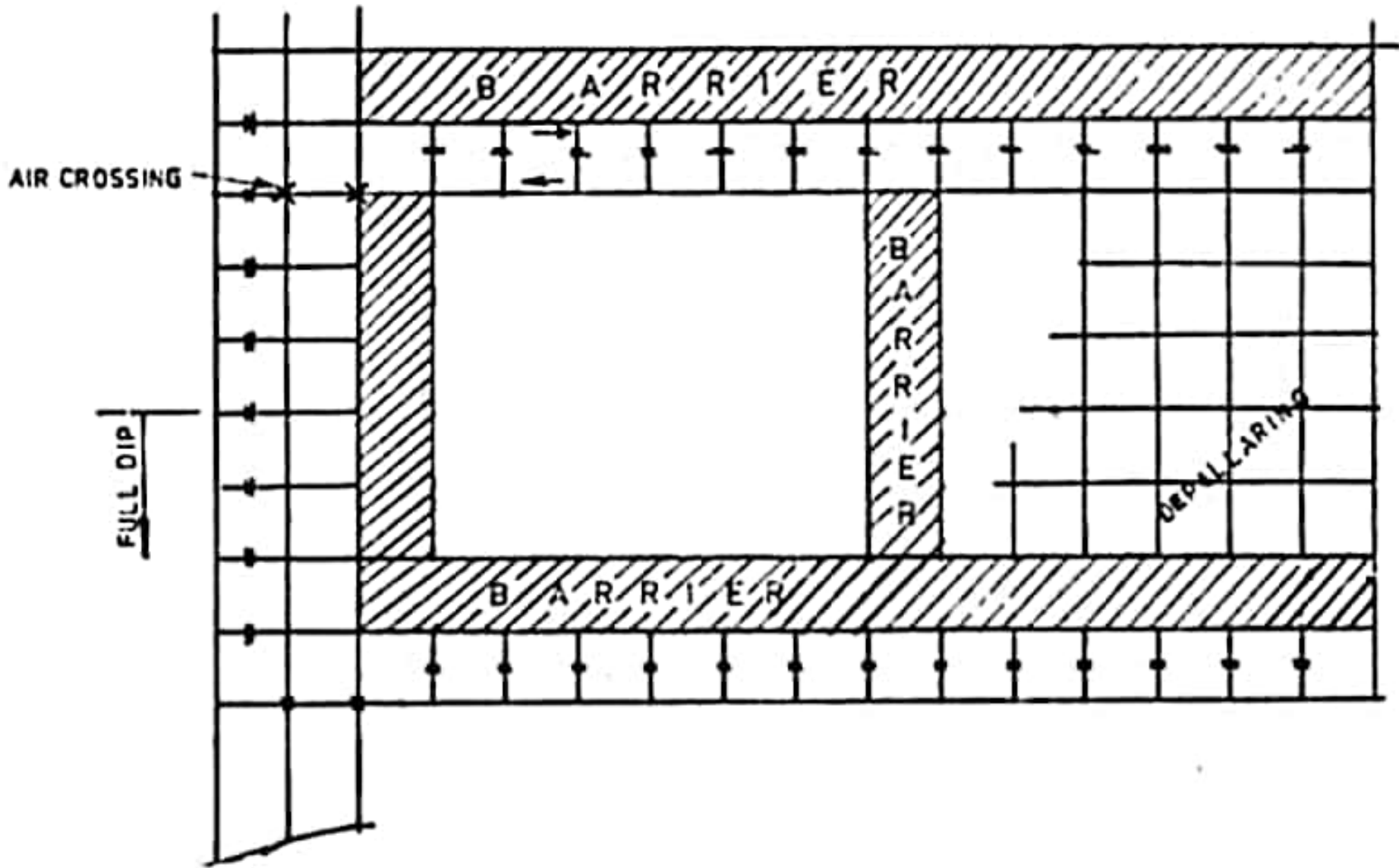
- Considerable amount of coal is lost in barriers. Generally, in Indian practice roughly 20% of coal is lost in the barriers.
- More number of air crossings are required for ventilation purposes.
- Each panel must have its own independent coal cutting machine and haulage. Flitting (easy movement) of coal cutting machine from one panel to the other panel is not practicable.
- Crushing of barriers may result in joining of two panels with consequent spread of fire (if it existed in any one of the panels) and delayed and sudden subsidence.

"WHOLE" FOLLOWED BY "BROKEN" WORKINGS

The current trend, however, is to open-out the mine with as few headings as possible (say three to five) and retreat back from the boundary, 'broken' workings following the 'whole' workings (see figure) in suitable size panels.

This system is superior over others in the following respects:

- Ventilation is efficient.
- Coal dust treatment is simpler.
- With intensive machine mining high outputs can be obtained. Even in the opening out stage high outputs can be obtained using intensive mechanization and output per man shift (OMS) can be high.
- Organization is simpler.
- Crush and premature collapse of pillars is a remote possibility.
- Haulage can be simpler.
- As the development and extraction of pillars go together, same transport system as for development can be used for extraction work also in its retreating passage.
- Control of fire is comparatively easy.



2. iii. STATE AND DESCRIBE VARIOUS MACHINERIES USED IN WORKING FACE.

VARIOUS FACE MACHINERIES-

1. Load Haul and Dumber (LHD)
2. Side Discharge Loader (SDL)
3. Gathering Arm Loader (GAL)
4. Coal Cutting Machine (CCM)
5. Continuous Miner
6. Coal Drills Machine
7. Roof Bolting Drills
8. Belt Conveyor
9. MDCC (Medium duty chain conveyor)
10. HDCC (Heavy duty chain conveyor)
11. Scraper Loader

DEVELOPMENT

Development of bord and pillar workings involves drivage of a set of galleries in the seam cut by another set of parallel galleries generally at right angles to them thus forming pillars surrounded by bords.

The drivage of galleries can be done in one of the following ways:

- Manual drivage, this method is now almost non-existent.
- Drill and blast, i.e., blasting off the solid and manual or mechanical loading.
- Cut, drill and blast and manual or mechanical loading.
- Cut and load mechanically by continuous miners.

DEVELOPMENT BY BLASTING OFF THE SOLID-

- In this method, shotholes are placed on the face by electric drills and coal is blasted off the solid, using P5 explosives.
- On a face 4.2 m wide x 2.2 m high generally 12 shotholes 1.5 m long each are drilled which yield 10-12 tonnes of coal per round of blasting and give a progress of 1.2 m.
- Coal thus got is hand-loaded. Blasting off the solid is especially suited for drivages in steep seams in which use of coal cutting machines is difficult.

DEVELOPMENT WITH COAL CUTTING MACHINES-

- In the development of a panel with five headings on the strike, the headings are undercut by a coal cutting machine and shot holes are then drilled and charged with explosives and blasted.
- Blasted coal is hand loaded on to scraper chain conveyors which transport the coal from the face to a central belt conveyor.
- The central belt conveyor conveys the coal to the pit bottom.
- Each heading can be cut twice a shift, thus making a progress of 3 m per shift.

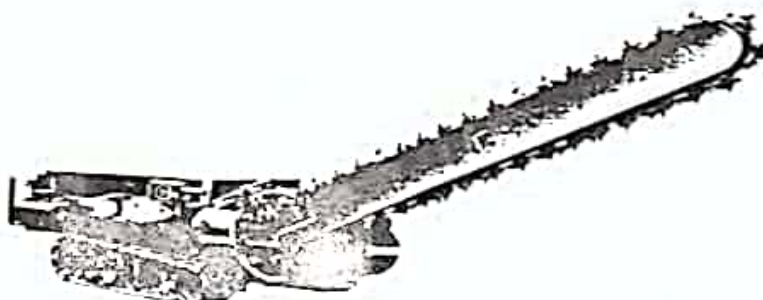


Figure 9.4 : Ariswall and Shearing coal cutter (courtesy : Anderson Strathclyde PLC)

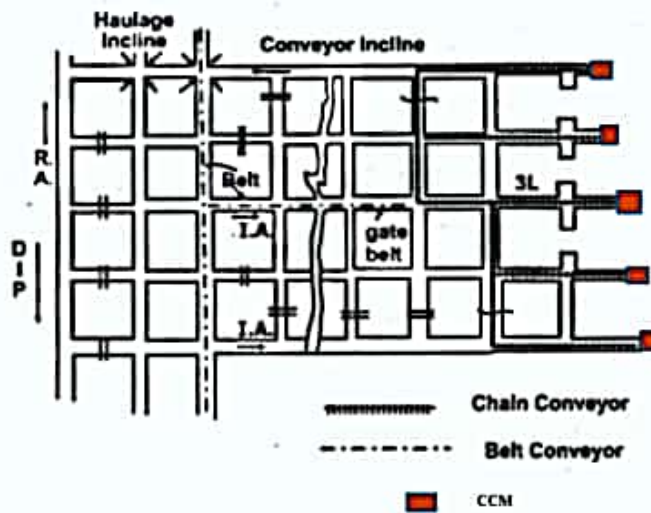


Fig. Development with Coal Cutting Machine

- The equipments used are coal cutting machine, hand held electric drill, chain conveyors, and a central belt conveyor which brings coal to a direct rope haulage installed in the main dip of the district to transport coal to the pit bottom.

DEVELOPMENT USING CONTINUOUS MINERS-

- Standard continuous miners can extract coal at a rate of up to 38 tons a minute depending upon the seam thickness. New, more powerful continuous miners are highly productive and are remotely controlled being designed for a variety of seams and mining conditions.
- These make possible even fuller recovery of the available coal, while removing the machine operator further from the working area.
- Following figure shows a panel with five headings on the strike in a seam 8.53 m thick dipping at 1 in 14. The galleries were 4.8 m wide x 3 m high driven along the floor and the pillars were 27.4 m x 27.4 m from centre to centre. The miner cut the full width of a gallery in two settings. First, 2.59 m was cut and then the miner was shifted to the next position to cut the other half of the gallery, the overlap being 30 cm.

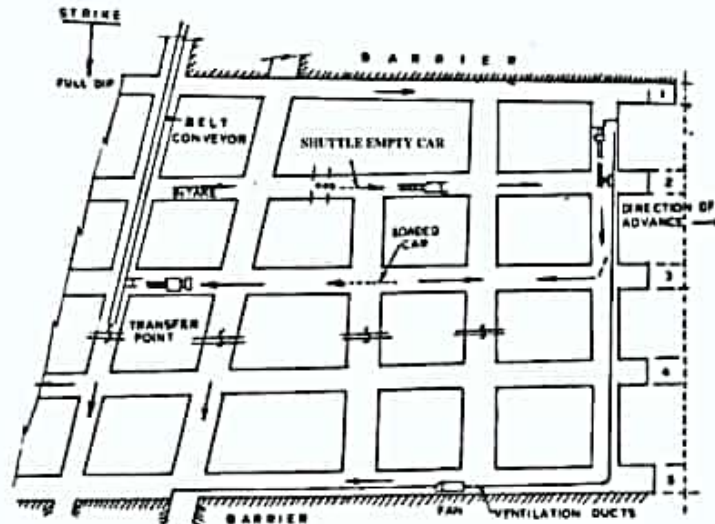


Fig. Development with continuous miner & shuttle car

- The coal cut by Continuous Miner and loaded into a shuttle car, three of which were provided to a miner such that when one was being loaded the other was discharging coal on to the belt conveyor and the third was standing in 'Queue' to be loaded.



DEVELOPMENT WITH LHD

- Coal seam/face shall be drilled by coal drills and extracted by solid blasting.
- P-5 explosive and delay detonator shall be used.
- The blasted coal from face is loaded by LHD & it shall drop coal into chain conveyor.
- Chain conveyor carries the blasted coal and drop into the belt conveyor, then the belt conveyor shall transport the coal directly to surface.

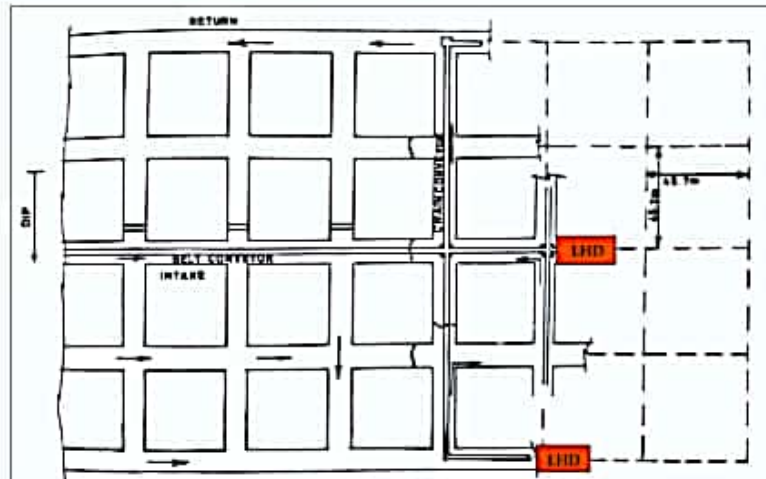


Fig. Developments with Load haul dumber (LHD)

**DEVELOPMENT WITH GATHERING ARM LOADER**

- The development board & pillar with conventional blasting and loading or transport with Gathering arm loader and shuttle car combination.
- This is apply where seam 2.5 to 3 m thick and nearly flat(1 in 30) was developed with 6-7 heading panel.
- Panel length varies 1200m to 1400 m and pillar length varies 30 to 35m,
- Initially face are cut by CCM, then blasting with conventional method and finally by the loading out operation by means of gathering arm loader.
- The latter machine feeds alternatively two shuttle car which carry the coal and transfer to belt conveyor.

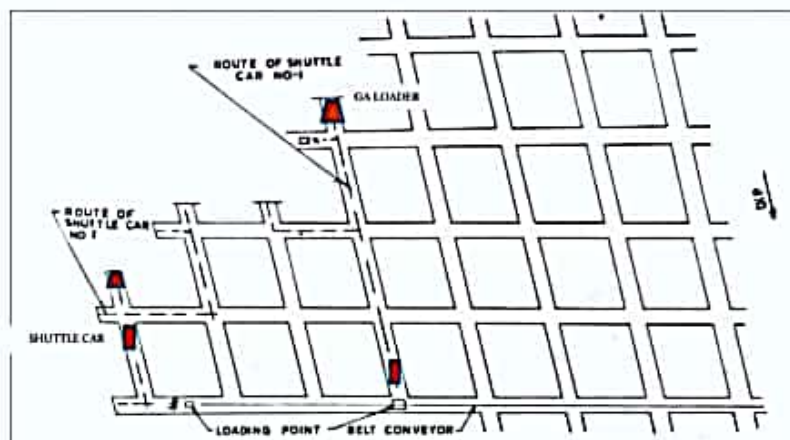


Fig. Development with Gathering arm loader



2. iv. DESCRIBE DEPILLARING METHOD WITH STOWING AND CAVING.

PILLAR EXTRACTION

- After pillars have been formed on the bord and pillar system, consideration has to be given to the extraction of coal from the pillars; the operation is known as **pillar extraction**. It is also referred to as **depillaring**, pillar-cutting or broken working.
- Basically pillar can be extracted by two methods.

1. Depillaring by caving- the coal of the pillars is extracted and the roof is allowed to break and collapse into the voids or the decoaled area, known as **goaf**. As the roof strata above the coal seam break, the ground surface develops cracks and subsides, the extent of damage depending upon depth, thickness of the seam extracted, the nature of strata, thickness of the subsoil and effect of drag by faults.

2. Depillaring with stowing- Depillaring with stowing is a method of pillar extraction in which the goaf is completely packed with incombustible material and is generally practiced where it is necessary to keep the surface and strata above the seam intact after extraction of coal.

STOOKS-

In the process of depillaring a pillar is formed during development is split in 2 to 4 parts depending on its size, these parts of pillars are known as stooks. Then stooks are extracted one by one.

METHOD OF EXTRACTION OF STOOKS-

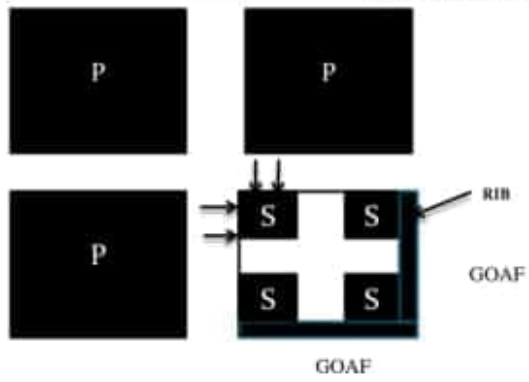
Basically three types of methods are used.

1. Attacking of entire stooks.
2. Half-moon method.
3. Fender (chowkidar) method.

1. Attacking of entire stooks-

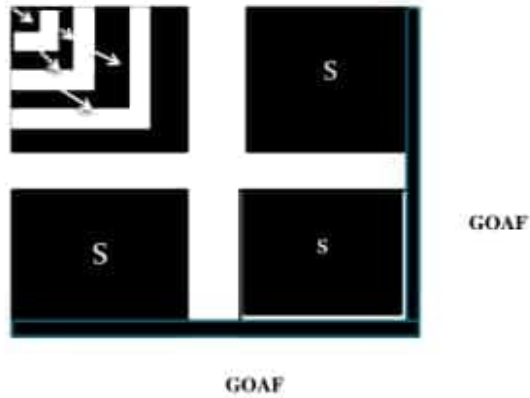
Where roof is good, leaving a rib of 2m against a goaf, the stooks are extracted from two sides.

[Rib- A long raised piece of supporting material in particular]



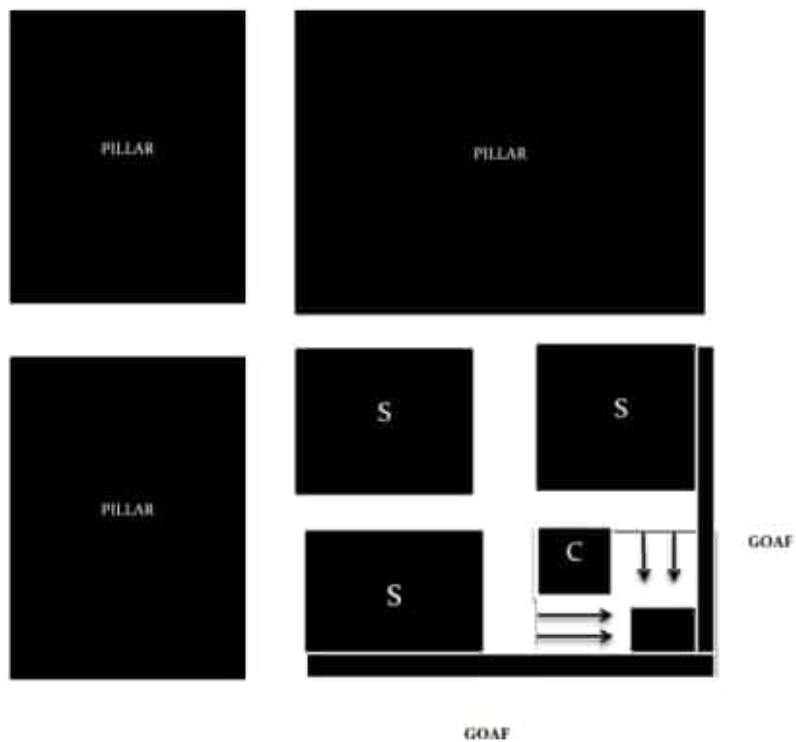
2. Half-moon method-

For good roof stook is attacked from corner in half moon fashion, leaving 2m rib against the goaf. At the end these rib are thinned down as much as possible as per safety.



3. Fender (chowkidar) method-

For bad roof leaving a 10m X 10m fender at corner and 2m rib against goaf, the stook is attacked from two side, on return the rib are thinned ou as much as safety permits and at the end the fender is taken out by half moon method.





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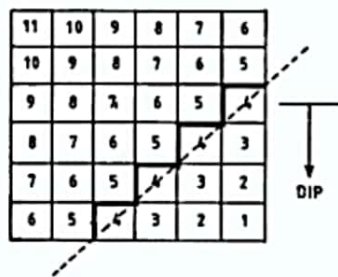
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PRINCIPLES OF PILLAR EXTRACTION TECHNIQUES-

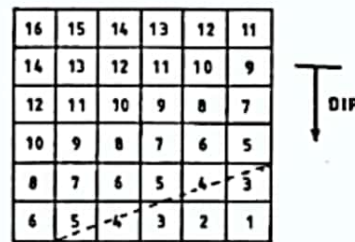
The principles of designing pillar extraction techniques are as given below:

1. Roof exposure at any one time should be minimal. In the Indian coalfields, where caving is practiced, 60 - 90 m² exposure is normally allowed.
2. The size of the panel should be such as depillaring can be completed within the incubation period. This period commonly varies between 6 to 12 months.
3. The extraction line or goaf line should be so arranged as to facilitate roof control. In practice a diagonal line, (Figure A) or step diagonal line of face (Figure B) is common.

[Goaf Line- A line passing through all the corner of stook under extraction at a time is called line of extraction or goaf line]



(Fig. A)



(Fig. B)

Diagonal or step diagonal line of face provides protection as the working places are supported by solid pillars and also when the roof caves, there is less risk of goaf flushing into the working faces. It is also claimed that diagonal line of extraction helps in the caving of the roof.

- In the panels worked in conjunction with hydraulic sand stowing step-diagonal line of face is preferred as it facilitates water drainage without flooding the working faces in the lower level.
- The single-lift extraction is limited to heights of 4.8 m or less. If the thickness of the seam is more than 4.8 m, the extraction is done in multi-lifts and in that case hydraulic sand stowing is insisted upon. Seams up to 4.8 m thick can be mined by caving in one pass.
- Whatever the method of extraction, the working area is systematically supported by cogs and props.
- In Special cases a steep diagonal line of face(Fig. C) or even straight line of face(Fig. D) has been selected.



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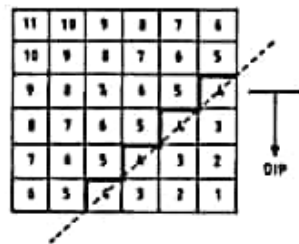
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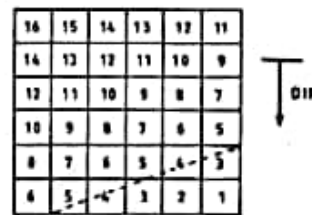
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1. Roof exposure at any one time should be minimal. In the Indian coalfields, where caving is practiced, 60 - 90 m² exposure is normally allowed.
2. The size of the panel should be such as depillaring can be completed within the incubation period. This period commonly varies between 6 to 12 months.
3. The extraction line or goaf line should be so arranged as to facilitate roof control. In practice a diagonal line, (Figure A) or step diagonal line of face (Figure B) is common.

[Goaf Line- A line passing through all the corner of stook under extraction at a time is called line of extraction or goaf line]



(Fig. A)



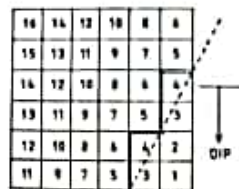
(Fig. B)

Diagonal or step diagonal line of face provides protection as the working places are supported by solid pillars and also when the roof caves, there is less risk of goaf flushing into the working faces. It is also claimed that diagonal line of extraction helps in the caving of the roof.

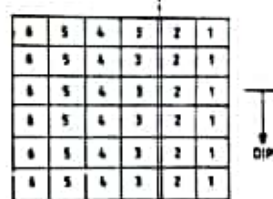
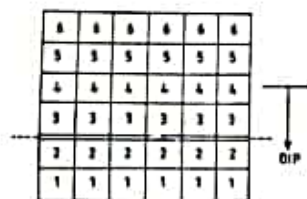
- In the panels worked in conjunction with hydraulic sand stowing step-diagonal line of face is preferred as it facilitates water drainage without flooding the working faces in the lower level.
- The single-lift extraction is limited to heights of 4.8 m or less. If the thickness of the seam is more than 4.8 m, the extraction is done in multi-lifts and in that case hydraulic sand stowing is insisted upon. Seams up to 4.8 m thick can be mined by caving in one pass.
- Whatever the method of extraction, the working area is systematically supported by cogs and props.
- In Special cases a steep diagonal line of face(Fig. C) or even straight line of face(Fig. D) has been selected.

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(FIG. C)



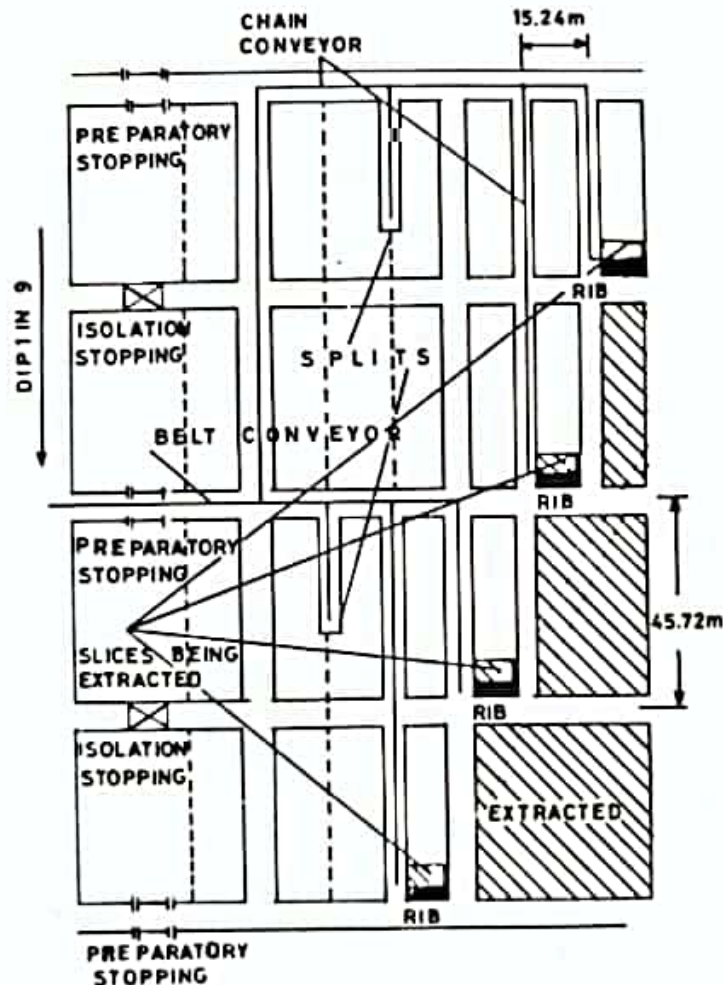
(FIG. D)

FACTORS INFLUENCING CHOICE OF PILLAR EXTRACTION TECHNIQUES-

1. **Thickness of the Seam** If the thickness of the seam is 4.8 m or less, depillaring with caving in one slice may be done. In seams more than 4.8 m thick, pillars must be extracted in lifts in conjunction with stowing. The lifts are normally 3 m thick or so. The last lift may be up to 4.8 m high and could be extracted by stowing or caving.
2. **Depth of the Seam** At greater depths, the pillars must be larger and they are extracted in conjunction with stowing. Splits have to be driven on the strike.
3. **Roof of the Seam** For successful depillaring roof must cave regularly. A roof with compressive strength of less than 500 kg/cm² is normally a caving roof.
4. **Incubation Period of the Seam** A coal seam with longer incubation period may be extracted in larger panels. To achieve the same effect, i.e. to make the panel larger, mechanization of operations is necessary in a seam with shorter incubation period so that rate of extraction is increased.
5. **Dip of the Seam** In steeply inclined seams, special techniques of extraction have to be.

COAL SEAM 3 TO 4.8 M THICK

- Here pillar was divided into three stooks by driving by dip splits.
- Each stooks was then extracted by slices from split gallery leaving rib against the goaf.
- A steep goaf line of face was maintained.
- After driving the slice to full length the rib is reduced as per safety permitted.
- The working is supported by wooden props and cogs systematically.
- When the extraction of a slice was completed, timbers supports are withdrawn and the roof was allowed to cave.

**THICK SEAM-**

- In thick seams the widespread practice has been to divide the pillars in four stooks (equal quarters).
- Each stook was extracted by blasting off the solid. After the withdrawal of the timber the roof was allowed to cave.

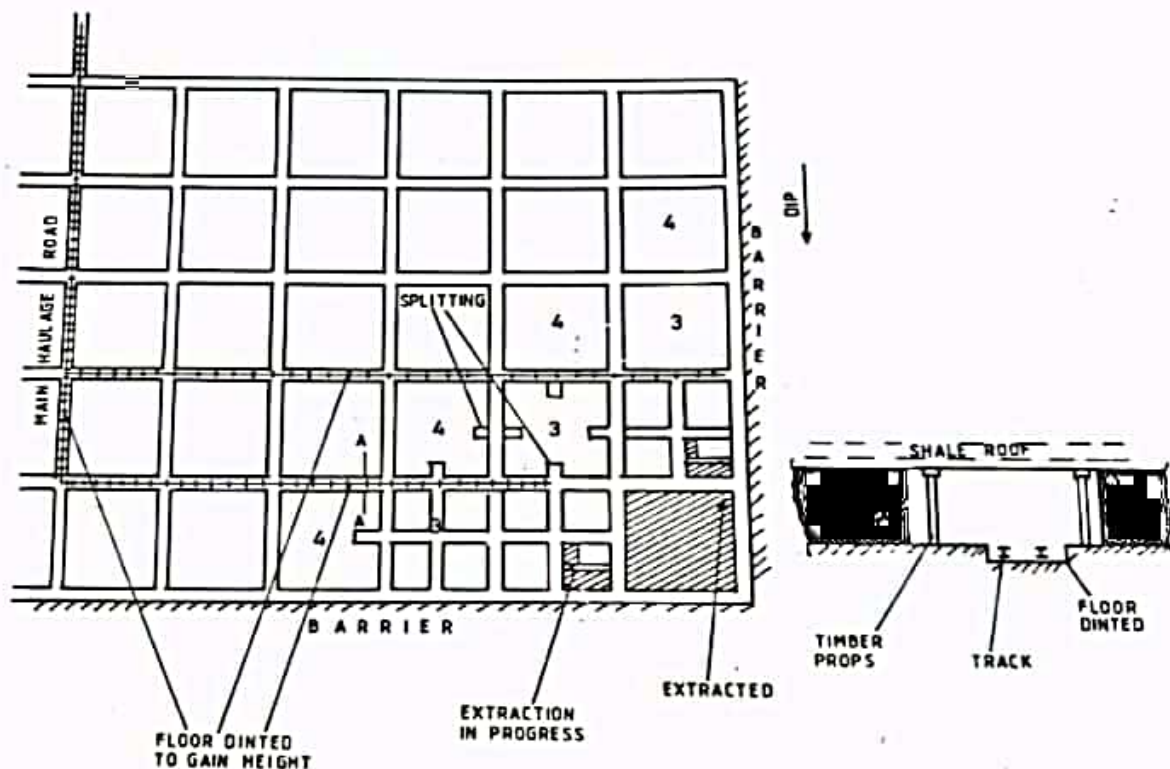
- Methods such as the above resulted in heavy losses of coal and quite often led to spontaneous heating of coal.
- Adverse strata control problems always existed and, in some cases, premature collapses occurred. Hence, this method is not practiced these days.

DESCRIBE DEPILLARING METHOD WITH CAVING-

IN THIN SEAM-

- Depillaring in thin seams (say up to 3m thick) can be done with caving with diagonal line of face.
- The pillar formed during development a split into small pillar called **stooks**.
- A gallery is driven in the pillar for this purpose is called **split**.
- A pillar was divided into four stooks by driving dip and rise and strike splits.
- As per CMR splitting of a maximum of four pillar, when pillar extraction is to begin.
- Pillar shall be extracted as per the goaf line, goaf line shall be such as prevent extension of a collapse or subsidence of the goaf.
- Stooks were extracted by blasting off the solid and the blasted coal was loaded into tubs or conveyor.
- Area under extraction and upto two pillars shall be kept supports as per the approved SSR(Systematic supports rules).
- Once extraction of a stook is commenced , the extraction work shall be done as fast as practicable and soon after completion of extraction , the support shall be withdrawn to permit fall of roof.
- No support shall be left standing in the goaf, if a reason a chowkidar or rib is to be left un extracted , it shall be blasted so as not to prevent collapse of the roof.
- On getting symptoms of fall of roof all persons shall be withdrawn to a safe place.
- As soon as work of extraction in the panel is completed , it shall be sealed by closing stopping and the roof was allowed to cave in.

Following figure illustrates the sequence of extraction of pillars.



- Take example of 14.63m thick seam following figure illustrates the method of extracting pillars by using stowing method.
- The dip of the seam is 1 in 6.

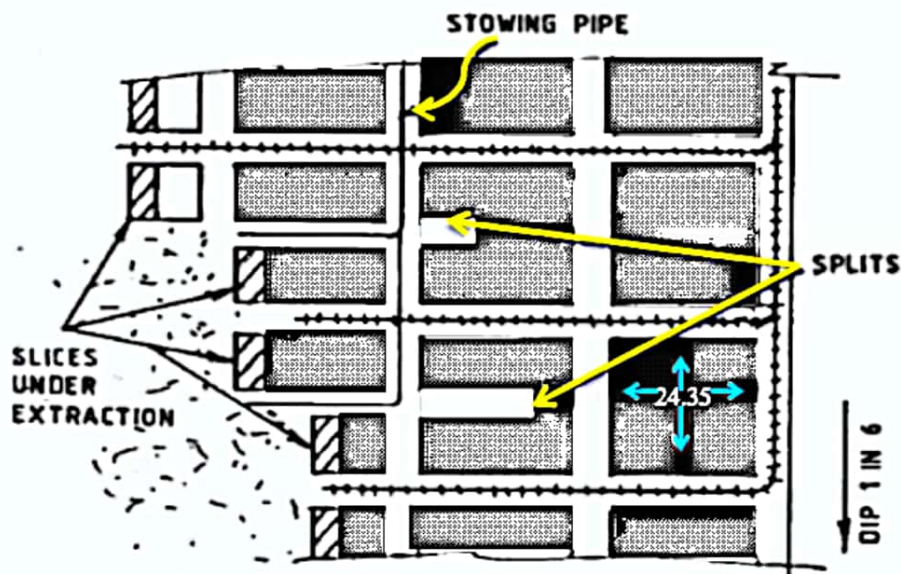


FIG: EXTRACTION OF PILLARS IN A THICK SEAM WITH STOWING

- The seam was developed on bord and pillar method in two sections (a) along the floor, and (b) along the roof with 1.82 m coal left in the roof.
- The pillars were 24.35 x 24.35 m from centre to centre. As shown in given figure, a level split was driven in the pillar to be extracted, dip and rise slices approximately 4.8 m wide were then taken from the original level up to half the distance of the pillar.
- After extraction of the slice the void was stowed solid with sand leaving a rib of 1.8 m.
- The next slice was then taken and so on.
- The diagonal line of face was maintained, the working face in the dip level being kept in advance of the upper level face by half a pillar, i.e. by 12-15 m.
- After the first lift of all the pillars in a panel was extracted and coal replaced with sand up to a height of 2.43 m, the second lift was developed over the stowed goaf of the first lift and was extracted in the similar manner followed by the third lift. The fourth lift was extracted from the top section already developed initially, below which about 3 m coal was left to form a solid floor.

FALL OF ROOF

1. Local Fall-

- In depillaring district, after supports have been withdrawn from an extraction area (stook or slice), the roof fall called **local fall**.
- It does not extend to the surface and roof rocks up to only a few meters break and fill up the goaf.
- Local fall takes place in 24 to 48 hours of the withdrawal of support,

2. Premature collapse-

- In depillaring by caving, after extraction of a stook or slice the supports are withdrawn and the roof fall occur in goaf faces after sometimes is known as normal fall.
- When sufficient large number of pillars is extracted the roof fall is unexpected and dangerous called **premature collapse**.

3. Over-riding pillar-

- If the pillars are not strong enough, they may be crushed due to sudden heavy pressure known as **overriding pillar**.

4. Main fall-

- When the goaf of a caving district extends over a large area, the face in the goaf reaches the surface which is then crack and sudden fall known as main fall.
- Main fall occur comparatively short time.

DESCRIBE DEPILLARING METHOD WITH STOWING-

- Pillars in coal seams more than 4.8 m thick are normally extracted in conjunction with hydraulic sand stowing in lifts of 3 m or so. Stowing is adopted for better roof control and as a precaution against spontaneous combustion which are more frequent in thick seams. Also, stowing results in improved percentage recovery, and conservation.
- Basically, the method of extraction of pillars with stowing is similar to that with caving excepting that-
 - i. The area of exposed roof at any one time may be slightly more than that exposed with caving; with stowing the exposed are of about 100-150 m² may be permitted,
 - ii. The line of extraction is usually kept step-diagonal to facilitate drainage of water so that working faces are not flooded.

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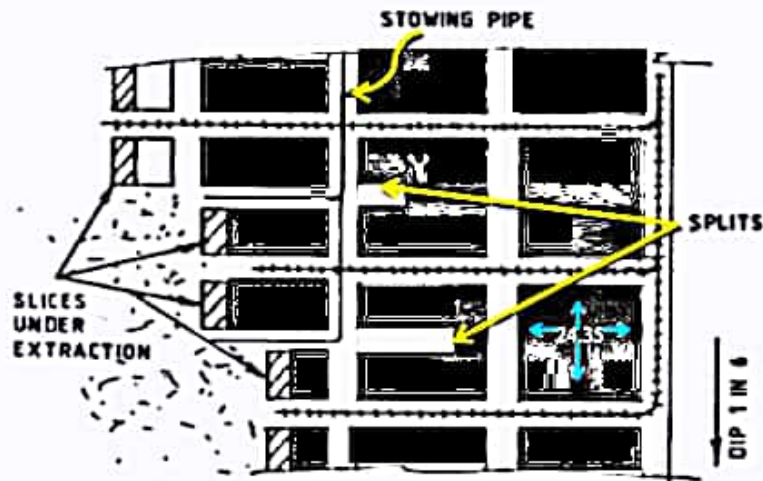


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SPONTANEOUS HEATING:

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

INCUBATION PERIOD:

- It is the period between, when the coal is first subjected to condition favorable for spontaneous heating and the time indication of heating.
- The incubation period changes from coal to coal and place to place
- For Indian coals the incubation period varies 6 months to 12 months.

INNUNDATION:

The sudden inrush of water and flooding into the mines and the overspread with water everywhere known as inundation.

2. v. STATE PRECAUTIONS AGAINST FIRE AND WATER DURING AND AFTER DEPILLARING-**STATE PRECAUTIONS AGAINST FIRE DURING AND AFTER DEPILLARING:**

- i. Coal shall be worked in panels system with proper barrier, depillaring shall not started without making isolation stopping and preparatory stopping.
- ii. Piñar extraction shall be completed within the incubation period.
- iii. Production need to speed extraction.
- iv. Minimum amount of coal left in the coal.
- v. In every depillaring district shall be tested CO(white damp) at least once in 7 days,-.
- vi. Adequate and sufficient arrangement shall be made in every mine for early detection , control and extinguishing any fire.
- vii. Good construction and regular inspection of isolation stopping.
- viii. Regular air sampling and analysis to keep a watch on condition of sealed off area.
- ix. Not leave any coal in the goaf as far as possible.
- x. No person shall light a fire or permit a fire to be lighted in any workings belowground.