

ARYAN SCHOOL OF ENGINEERING & TECHNOLOGY

BARAKUDA, PANCHAGAON, BHUBANESWAR, KHORDHA-752050



LECTURE NOTE

SUBJECT NAME- UNDERGROUND COAL MINING

BRANCH – MINING ENGINEERING

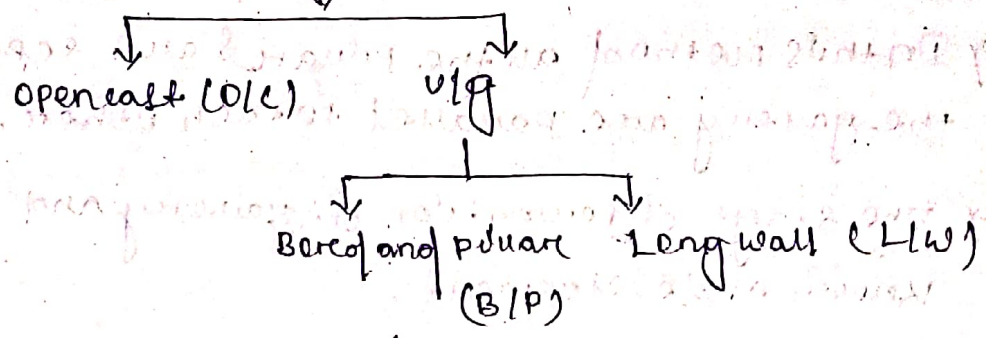
SEMESTER – 4TH SEM

ACADEMIC SESSION - 2022-23

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Introduction to coal mining method of working

Classification of mining method of working

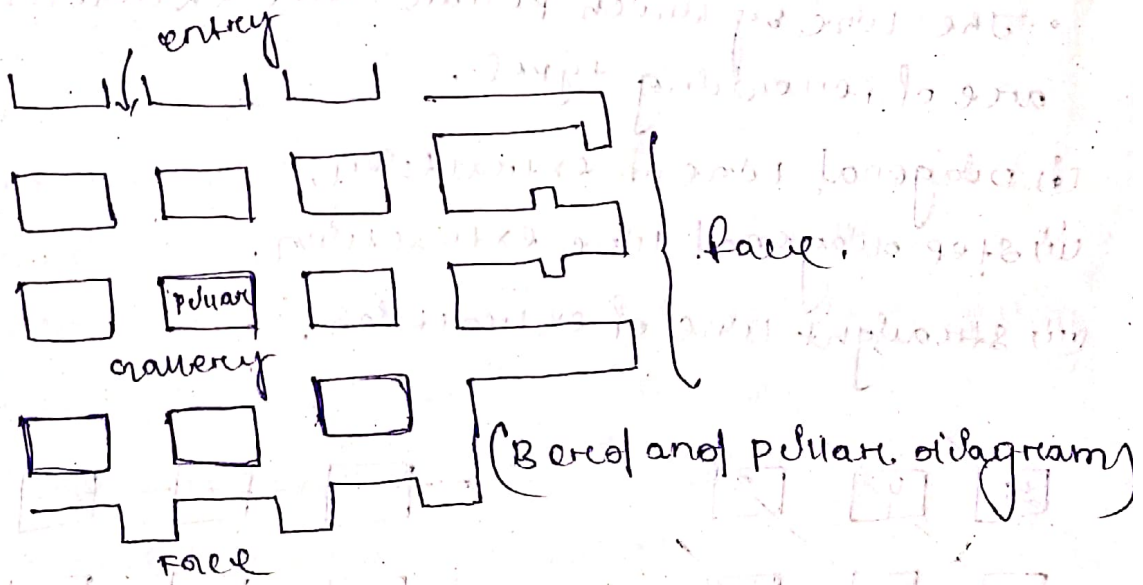


Bored and pillar method

Bored: gallery
 The method of forming pillar by drainage of gallery in cross-cross manner known as bored and pillar method.

Pillar: A solid block of coal which is left for the support of roof in U/G mine.

gallery: A roadway in coal seam is known as gallery



* It comprises of two operations.

- (i) development
- (ii) depillaring

First Working / development $\frac{2}{2}$

→ In this method the galleries are driven to form pillars.

→ In this method all the pillars are separated by the galleries are parallel to each other.

→ The stage of formation of gallery and pillars known as development.

→ extraction percentage rate 20-30%

Second Working / subducing $\frac{2}{2}$

→ In this method the pillars are extracted after hebbed out.

→ subducing $\left\{ \begin{array}{l} \text{subducing with stowing} \\ \text{(padding with incombustible material)} \\ \text{subducing with caving.} \end{array} \right.$

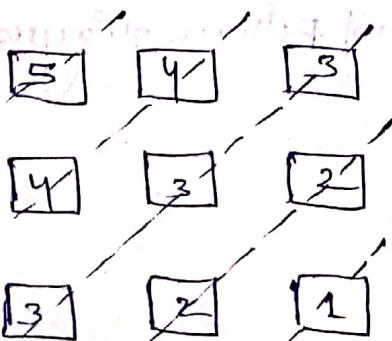
→ Line of extraction $\frac{2}{2}$

• The line by which pillars are extracted are of following types.

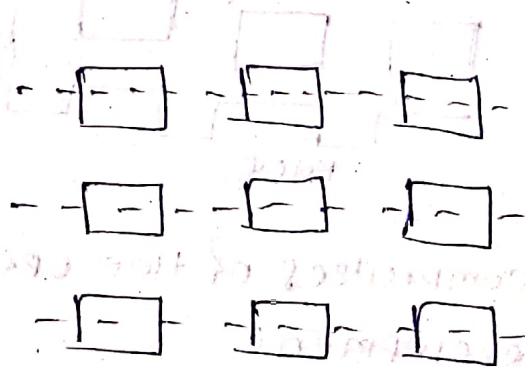
(i) diagonal line of extraction,

(ii) step diagonal line extraction,

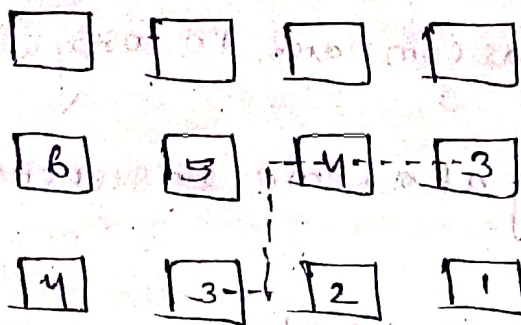
(iii) straight line of extraction.



(diagonal extraction)



(straight extraction)



(step diagonal extraction)

Application condition of bored and pillar

- thickness of seam is more than 1.5m. (खुदबखुद)
- depth of the seam should be shallow to moderate.
- seam with strong roof and floor which can stand for a long period after development stage is over.
- seam free from dirt band or stone. (खुदबखुद)
- seam free from geological disturbance.
- seam free from spontaneous heating.
- free from weathering action.

Advantage

- maintenance cost is low.
- operating cost is low.
- we can perform our mining in all season.
- Agri culture is not affected by UG mining.
- deterioration does not takes place.
- It does not cause soil erosion.
- pillar acts as a natural support.
- production starts from development stage.
- NO unproductive work & requires such as removal of OB.
- Residential area need to be relocated.
- applicable for geologically disturbance.

Disadvantage \downarrow

- Ventilation is not good as compare to long wall method.
- No. of faces are running at a time so supervision is not easy task.
- Danger is more as compare to O/C.
- Light are required at day time.
- Production is slow as compared to long wall and O/C.

* Oppurating by carving is done by two way.

(a) plan extraction by splitting and stacking method.

(b) plan extraction by splitting and subbing method.

* Bored \downarrow It is the drubage made perpendicular to the direction of the main cleat. The moving end of the bored is called face bored.

* Wall \downarrow It is the drubage made parallel to the direction of main cleat the moving end of the wall is called face of wall.

short all

* Contiguous seam $\frac{1}{2}$

→ When parting betⁿ two seam is less than 9m it is known as contiguous seam.

→ For developing both the seams at a time or one by one permission have to taken from DMS.

Elements of Band P method

- (i) Crannery (Bord) or head.
- (ii) heading
- (iii) face
- (iv) pillar
- (v) cover
- (vi) obstacles / panel.

* Crannery $\frac{?}{\text{mm}}$ A road ways of coal seam is called gallery

Types of gallery

(i) Dip gallery $\frac{?}{\text{mm}}$ A road driven along the dip of the seam is called a dip gallery

(ii) Rise gallery $\frac{?}{\text{mm}}$ A road driven in rise is called rise gallery.

(iii) Level gallery $\frac{?}{\text{mm}}$ A road driven along the strike of a seam is called a level gallery.

(iv) Drift $\frac{?}{\text{mm}}$ A road in stone connecting two ore more seam is called drift.

* Heading $\frac{?}{\text{mm}}$ A gallery in the process of being driven is called a heading.

* Face $\frac{?}{\text{mm}}$ The working front of any working place is called face.

* Pillar $\frac{?}{\text{mm}}$ A solid block of coal surrounded by crannies.

* Obstacles or panel $\frac{?}{\text{mm}}$ It is an area of mine having a number of working place.

→ It is separated from other districts by a natural coal barrier / anti-federal barrier

* Cover → cover is the vertical depth of a place in the mine from the surface

→ Underground coal mining →

→ mines acting are 2 types (i) Incline (ii) shaft.

→ mainly 2 types of method used in coal mining (i) longwall method (ii) Block and pillar method

→ Block and pillar method mostly used in India. This method is divided by 2 types.

→ In the initial stage we apply development method and after development we started depilation

→ This are the cyclic operation process of development stage.

- | | |
|-----------------------|--------------------|
| (i) dressing the face | (iv) transport |
| (ii) drilling | (v) support system |
| (iii) blasting | (vi) ventilation |
| (v) mucking | (vii) Installation |

→ This are 2 types of power factor

- (i) power factor.
- (ii) pull factor.

power factor → How many explosive are used in one drill hole.

(ii) pull Factor \rightarrow kg explosive used in drill hole
how many are ore body are produced in one
day.

\rightarrow What is O.M.S? (Output Man per shift.)

Output in terms per man per shift. It is a
method of expressing the productivity of mine

\rightarrow D.S.I \rightarrow Impact strength of index.

\rightarrow Dephasing is divided into 2 ways,

(i) Dephasing by caving.

(ii) Dephasing by stowing.

Conventional Method

\rightarrow When the dephasing by caving is done by
2 ways.

(i) pillar extraction by ^(or) splitting and stowing

(ii) pillar extraction by splitting and sliding

\rightarrow In longwall method handling in 2 ways.

(i) longwall advancing

(ii) longwall retreating

\rightarrow Both method can be done by either caving or
stowing.

\rightarrow Some other method used in coal mines. Like

(i) thick ness mining (ii) horizon mining,

(iii) sublevel caving

(iv) block caving

(v) top & w caving

Non-conventional method $\frac{2}{6}$

(i) gasification method.

(ii) hydraulic mine.

(iii) bore hole mining.

Factors affecting the selection of method of working \rightarrow

- \rightarrow surface topography. (सर्वोच्च स्थिति)
- \rightarrow depth of coal seam.
- \rightarrow thickness of coal seam.
- \rightarrow Inclination and gradient strata.
- \rightarrow nature of adjacent strata. (समाश्रित शैल)
- \rightarrow nature of strength of coal seam. (सिखर शक्ति)
- \rightarrow presence of crease fold or disturbance.
- \rightarrow seam able to spontaneous heating. (सहज)
- \rightarrow Presence of stone band. (पत्थर बैंड)

Other Factor's are \rightarrow

- \rightarrow mechanism of recovery.
- \rightarrow cross section of the seam.
- \rightarrow no. of recoverable seam.
- \rightarrow effect of weathering.
- \rightarrow availability of skilled and unskilled labour.
- \rightarrow availability of capital.
- \rightarrow presence of water.

Face fall way

An drainage made act on angle to the direction of material the working end is called face fall way.

Local Fall / Fast roof Form

The lower strata of immediate roof separated and fall in the gash the fall which takes the place seen after with amount of support is called local fall.

Main Fall

→ When the area of extraction or void area is nearly equal to or more than the square of depth the caved due to deteriorating extent up to the surface.

→ The roof fall which effects the surface is known as main fall.

Line of gash

It is the line or plane along which the roof break occur easily when the coal pillar are extracted is known as line of gash.

Air Blast

It is sudden explosion of air from a caved area with high speed causing damage to mine property and injure to person is known as Air blast.

* State and describe various machines used
in Working Face.

There are various types of machine used
in underground coal mines such as

(i) SOL (Side discharge loader)

(ii) LHD (Loading haul dumper)

(iii) UOM (Universal Ore Machine)

(i) SOL (Side discharge loader)

→ It is used to transport coal loading machine
underground mine.

→ which can unload coal to the right or left of
the coal.

→ SOL takes blasted coal to the face with bucket
at front of the machine and dump coal on
to chain conveyor.

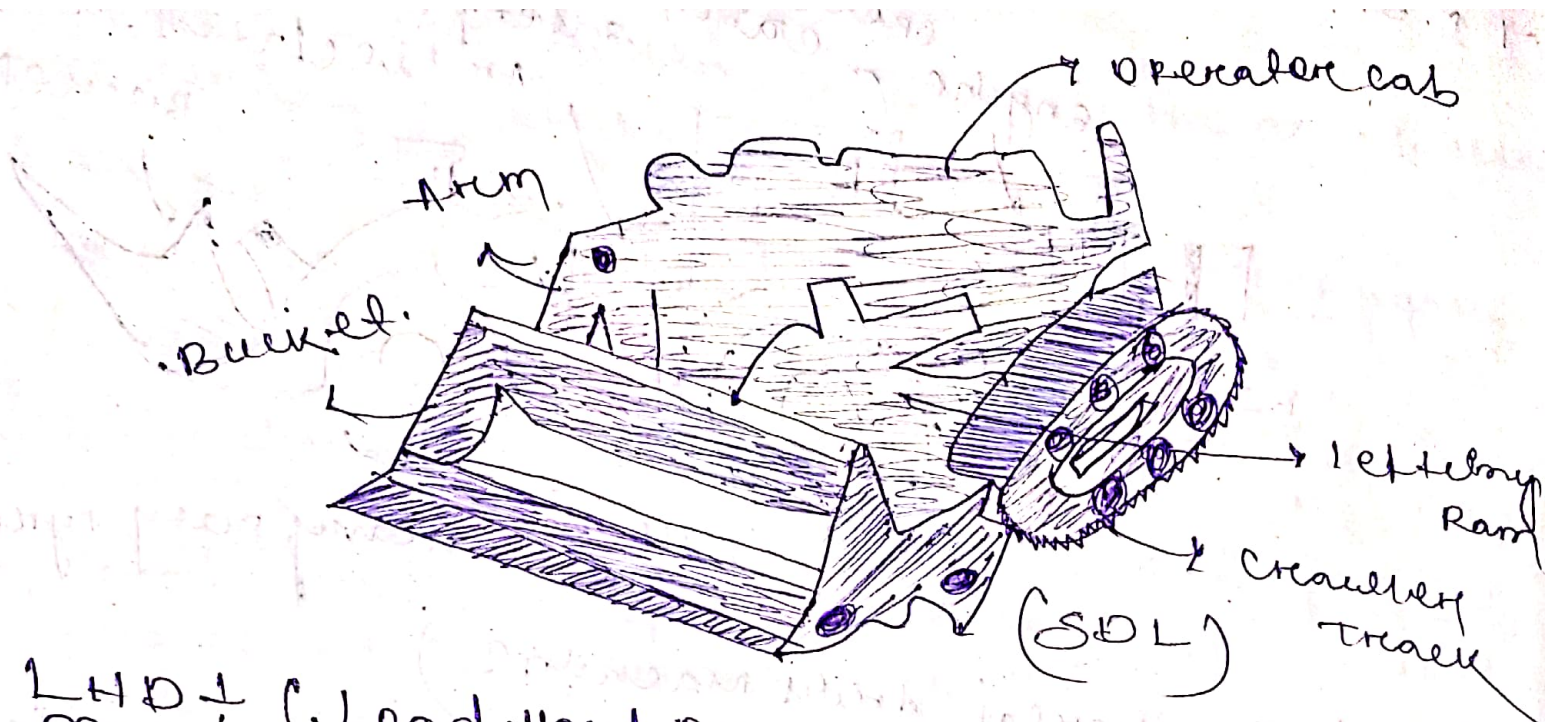
→ It is generally chain mounted,

→ It can be working on gradient up to 1 in 4.

→ Height of the machine over conveyor 2.1m
special model for working seen as high as
1.3m.

→ The machine is powered by 550V
electric motor.

→ Movement of the bucket are hydraulic
power.



LHD (Lead Haul Dumper)

→ LHD is a type mounted lead haul machine which takes blasted coal from the face by its bucket, transport and dumps on the belt conveyor or chain conveyor.

→ It runs faster than the SDL because it is type mounted.

→ It speeds up to 4 km/h.

→ LHD can work on gradient up to 1 in 7 where floor is dry and not weak.

→ Its bucket discharge is 4 types.

(i) tilting front of discharge

(ii) pushing front of discharge

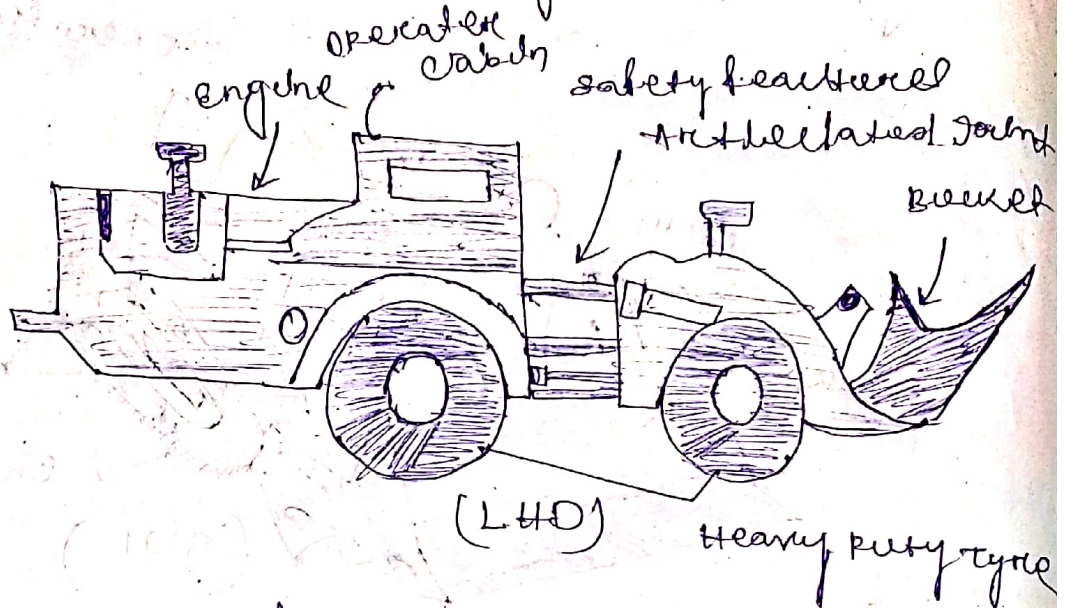
(b) Trolley side discharge.

(c) chain side discharge.

→ LHD can work on seam upto 2.4 m thick.

→ It has haulage capacity 1.5 m^3 , 2.7 m^3 .

→ 1.5 m^3 LHD is powered by 50 HP / 550 V HP.



DOM (Commercial drum machine)

→ It has crawler mounted electrohydraulic machine.

→ It can work blast hole in the face and also haul from rock benching.

→ DOM is provided with a 22 kW / 550 V flame proof motor.

→ movement of drum beam and feed with hydraulic rollers.

→ The machine can work 38 mm hole upto 1.8 m.

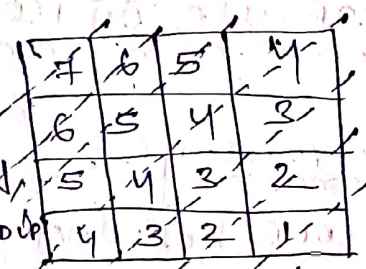
→ It can work on gradient upto $1:1$ in seam height upto 3.5 m .

→ The machine is 1.6 m height 4.6 m long and width in 2.5 km/hr travelling speed.

Line of extraction

(i) Diagonal

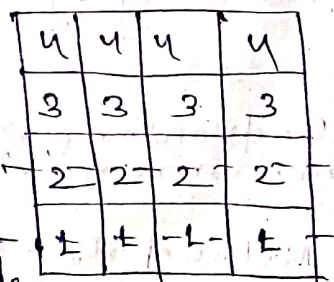
- It is a starting great line making an angle of 45° with the direction of dip of the seam.
- It is the most adopted line because it is the long line provided very large number of working faces and stability.
- Every stack under extraction has an adjacent unworked stack by the side for support.
- Depend upon behavior of the rock, any angle other than 45° may also be chosen.



(Diagonal line extraction)

(ii) Straight line of extraction

- This line is along or at right angles to the direction of dip of the seam.
- A line along dip-rise is adopted where the rock is very hard and difficult to leave.
- extraction line in the strike direction is used where rock is very reliable.
- It is very convenient when details are being taken with stalling.



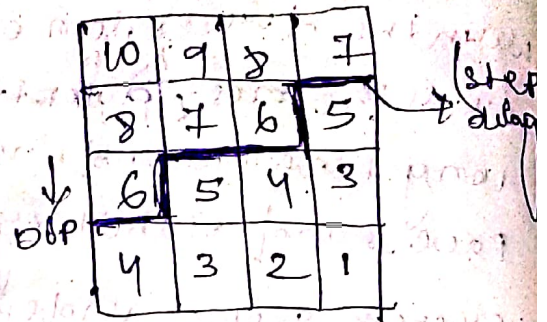
(Straight line of ex.)

(iii) Step-diagonal line of extraction

- In this type, there is one odd of stack between two stacks under extraction at a time.
- The odd stack provides support.
- Hence step-diagonal line of extraction is

adopted where rock is weak,

→ step diagonal wire can all be rearranged to have two solid steel between two steel under extraction.



* Advantage and Disadvantage of Resin Capsule in rock bolting

Advantage

- rock bolting are run very easily.
- setting time very short.
- load bearing capacity very high.
- simple and easy method supporting.
- this is the best method of bolting for weak strata having RMR - 40 or less (Rock mass rating).

Disadvantage

- method is costly.
- there is limited haul like.
- very skilled and manpower is required.

Hydraulic Mining

Date 03.04.23

Hydraulic mining of coal compared the operation.

(i) hydraulic, cutting of coal seam.

(ii) hydraulic transport of the resultant mixture of coal and water from mine.

→ Hydraulic breaking of coal at the face by the high pressure water jet effected by the hydraulic monitor is the basis of hydraulic mining.

→ The effectiveness of hydraulic monitor depends upon water pressure at the nozzle (40-1000 kg/cm²) the jet diameter and distance of monitor from the face.

→ First of all the coal gets fractured and broken by continuous flow of water jet at high pressure.

→ The broken coal is then transported away from the face by water and is collected at the pit bottom.

→ The coal and water slurry is then pumped out to the surface and hydraulically transported to the dehydrator plant where coal is separated out from water.

→ In India it was tried in Orissa (Jharkhand) in collaboration with Germany but it was not successful. (Shankar coeking coal limited)

Advantage :-

- It can be deployed from thick seam up to 9 m and in thin seams also.
- No electric power needed at the face thus highly suitable for gassy seam.
- OMS is very high.
- Strata control is easy.
- Very high rate of extraction.
- No chance of spontaneous heating of coal.
- No conventional transport system necessary.
- Manless operation is possible.
- Less maintenance of the equipment.
- Flexible with geological irregularities.

Disadvantage :-

- High quantity of water needed.
- Heavy amount of coal losses in the U/gueery.
- Can not be applicable in low dipping seams.
- There are some limitations of gradient.
- Difficulties of supplying material in the face.
- Coal is degraded during transportation.
- Danger of spontaneous combustion of coal is more because of the oxidation of coal that are left in the

Hydraulic mining equipment

- High Pressure water pumps,
- High pressure water pipe line with facilities for extension and cutting within short time,
- Hydro monitors capable of issuing compact jets with a high velocity and pressure ~~power~~,
- Hydraulic elevators and coal crusher,
- Pumps,
- coal pump and
- coal pipeline,

Horizon mining

- Horizon mining is a system of mining applicable to inclined or undulating seams.
- It also to relatively flat seams where they occur in groups where by all coal seam are extracted from predetermined horizon level or plane.

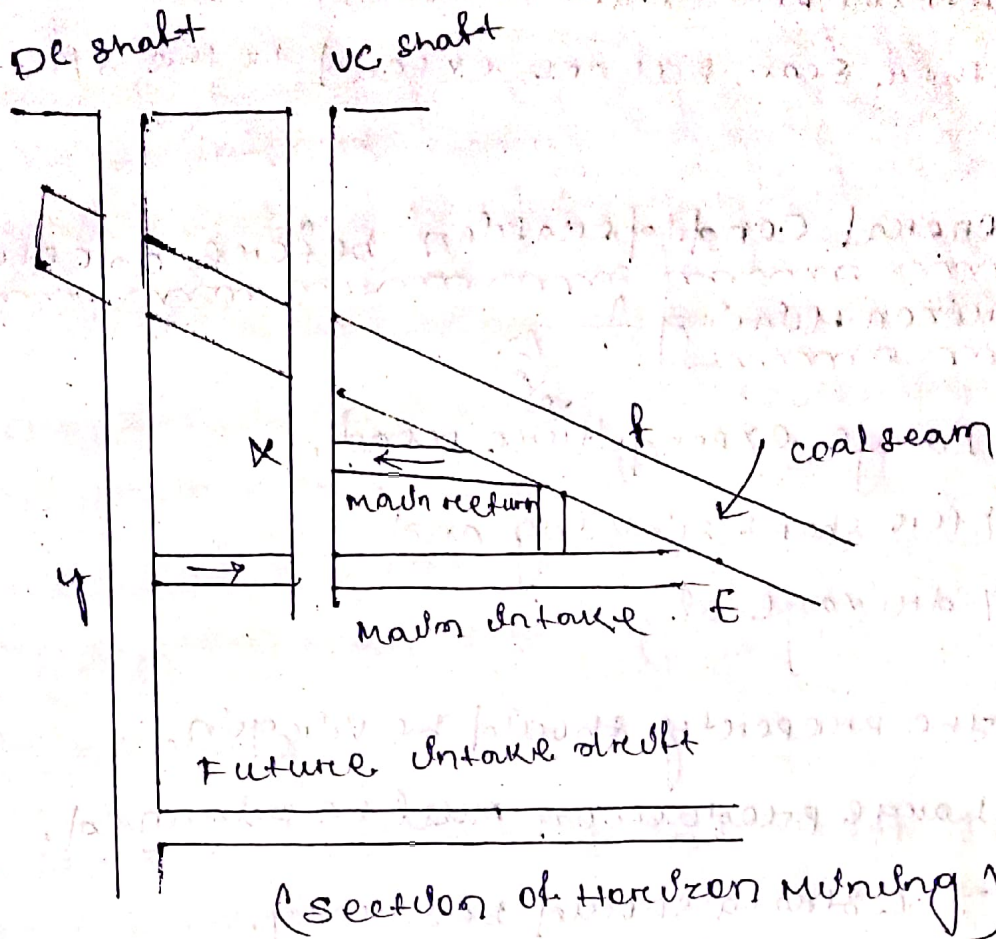
Horizontal mining

Introduction

- Horizontal mining is not a method of mining.
- It is a ^(Case) approach / access to coal seams by level roads (horizontal) driven through (steric).
- system consists of more than one level (horizontal).
- The method of mining may be ~~both~~ ^{L or Lw} or Lw.
- normally Lw method is widely adopted because large vol. of production road in this system to recover capital expenditure on shaft sinking and drainage of horizon in stone.

Applicable conditions / Applicability

- Applicable to supply inclined seams with a gradient in excess of 15° . (ex: Charnata and Sudamarta in India).
- Applicable to undulating seams.
- on a flat measure when a number of seams occur (old in bet 75° to 10°)
- ~~ex: ...~~



Development of horizon mining

Purpose of development

To divide the mine into blocks (panels) for
 find coal extraction.

Development

Drivage of horizon and stable pit

- (i) First step is to drive two horizons in the stone
 from the shaft to intercept the coal seam (VF and
 VE)
- (ii) VF is used as main return airway.
- (iii) VE is used as main intake airway.
- (iv) HR is stable pit.

Stable pit $\frac{1}{2}$
~~~~~

Vertical pit (shaft) driven from one seam to another seam but not extend to the st.

General consideration before adopting  
horizontal  $\frac{1}{2}$   
~~~~~

- (i) Large expenditure ^(cost) need.
 - for shaft sinking and
 - drainage of
- (ii) The property should be regular.
- (iii) Large production must be planned.
- (iv) The strata should be strong.

* Subsidence due to mining?

Extraction of coal by big mines will cause effect on the surface. Where the rock particles suffer vertical and horizontal displacement creating a basin of subsidence.

The term subsidence means the lowering of surface ground due to mining operations. The amount of subsidence is much higher in caving system than stowing system of mining.

* Theories of subsidence?

There are different theory which state the effect of subsidence, but there is not definite theory of which show how the subsidence occur.

- (i) Normal theory.
- (ii) Vertical theory.
- (iii) Dome's theory.
- (iv) Heuse's theory.
- (v) R ziba's theory.

* Factor effecting the subsidence?

The subsidence occur on the surface due to mining operation are governed by the following factors:

- (i) Angle of draw
- (ii) Method of working
- (iii) Depth of working
- (iv) Inclination of the strata.

→ Effect of fault and other geological disturbances

→ Effect of time.

* Damages due to subsidence

→ The ground subsides even at time & it is undulating and later become a pond and water body.

→ building, railway, power line, water main etc. will get damage due to subsidence.

→ Cracks are developed on the surface as a result water from any water body or even rain water may get entry in the mine.

→ Dangers to the men's life and animal due to cracks developed on the surface.

→ The ground becomes totally useless for cultivation.

→ The air may get entry into the UG working through cracks may cause spontaneous heating of coal and later fire.

→ Possibility of firing i.e. dry leaves, weed in the cracks on surface which may cause fire in mine.

→ The subsided area becomes unsuitable for township and men dwelling.

* Precaution against subsidence

◆ On the surface

- All important building should be constructed on reinforced raft or mat foundation.
- Foundation wall should be built with a gap and reef strⁿ should be provided with three joint construction.
- A trench is provided around the building at a distance one yard and is filled with concrete slab.
- All embankment should have sufficient permeation width so that they can easily be constructed.
- Railway track should be laid with expansion joints and welded track should not be used.

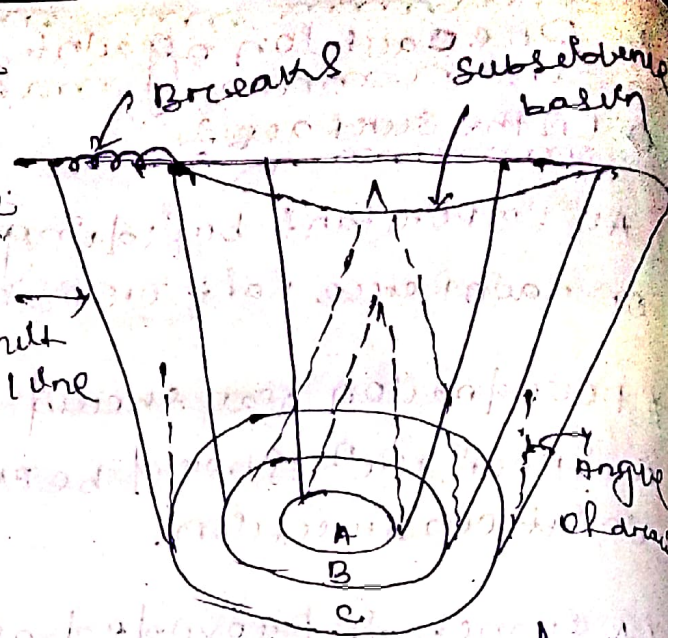
◆ Precaution in underground

- Solid stowage is to be practised which minimises the magnitude of ground movement and ground strain.
- When working with two seams, the harmonic extraction should be done.
- For protecting the surface structure it is kept within the shaft pillar which is never heaved.
- The working are laid down in such a way so that the buildings are at the centre of the panel of maximum width.

* Terminology

Subsidence Factor

It is the fraction of full subsidence and thickness of the seam.



Critical Area

It is the area of excavation in UG which may cause subsidence on the surface at the one point.

A = sub-critical area
 B = critical area
 C = super-critical area

Sub-critical Area

It is the area of excavation in UG which is too small to cause subsidence on the surface.

Super-critical Area

It is the area of excavation in UG which may cause subsidence on the surface at more than one place.

* Angle of draw

Angle of draw is the angle betn the vertical and limit line. This may be -ve or +ve, but for all practical purpose the angle of draw

is taken as +ve,

the angle of draw for different strata are

+

(a) coal - 8°

(b) sand stone and shale - 25° to 35°

(c) Alluvium - 45°

Full subsidence $\frac{0}{0}$

this is the greater amount of subsidence on the surface due to mining.

Subsidence basin $\frac{9}{0}$

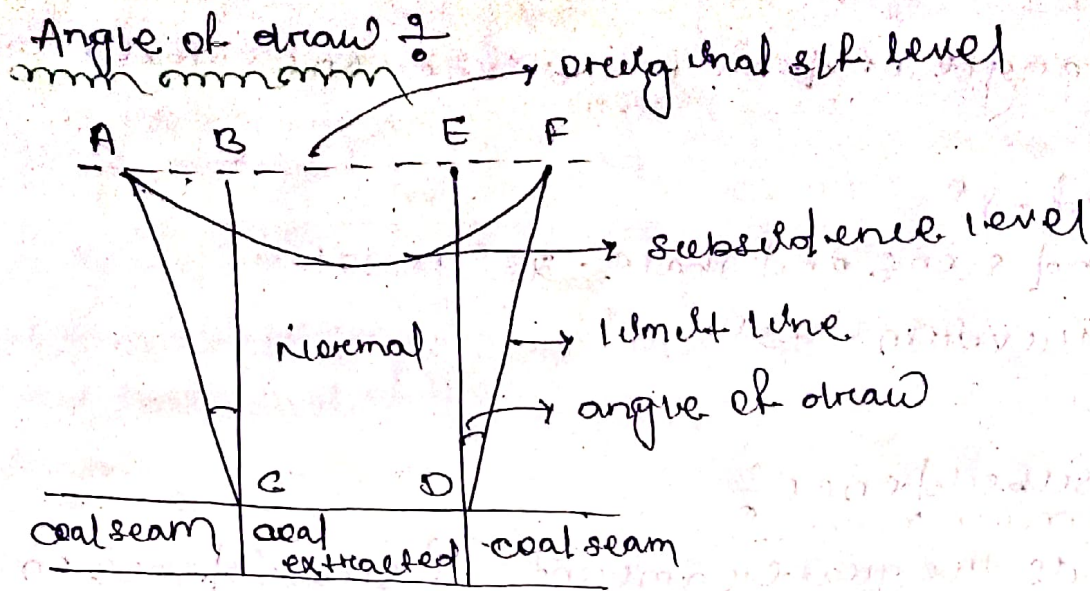
this is the surface depression resulting from subsidence. Its shape is like a trough or basin.

partial subsidence $\frac{1}{0}$

any subsidence which is less than full subsidence is called partial subsidence.

Maxⁿ subsidence $\frac{2}{0}$

It is a maxⁿ amount of subsidence in a subsidence basin due to minimum operation



The angle betⁿ limit line and vertical line is known as angle of draw. It is θ to 45° in India.

Limit line θ

The line joining the edge of excavation and the point of zero subsidence at the surface.

the angles of draw θ

If the subsidence area on the surface is larger than the excavated area the subsidence is known as +ve subsidence and the corresponding angles of draw is known as +ve angle draw.

-ve angles of draw θ

If the subsidence area on the surface area is smaller than the excavated area the subsidence is known as -ve subsidence and the corresponding angles of draw is known as -ve angle draw.

Angle of draw depends upon the following factors

→ seam thickness & magnitude of angle of draw is more in thick seam.

→ nature / strength of overlying strata

(i) less in hard rock,

(ii) more in soft rock,

→ Mt of cement / of working

more in covering zone or less in steepling.

→ Dip inclination of seam → more on dip side less on rise side.

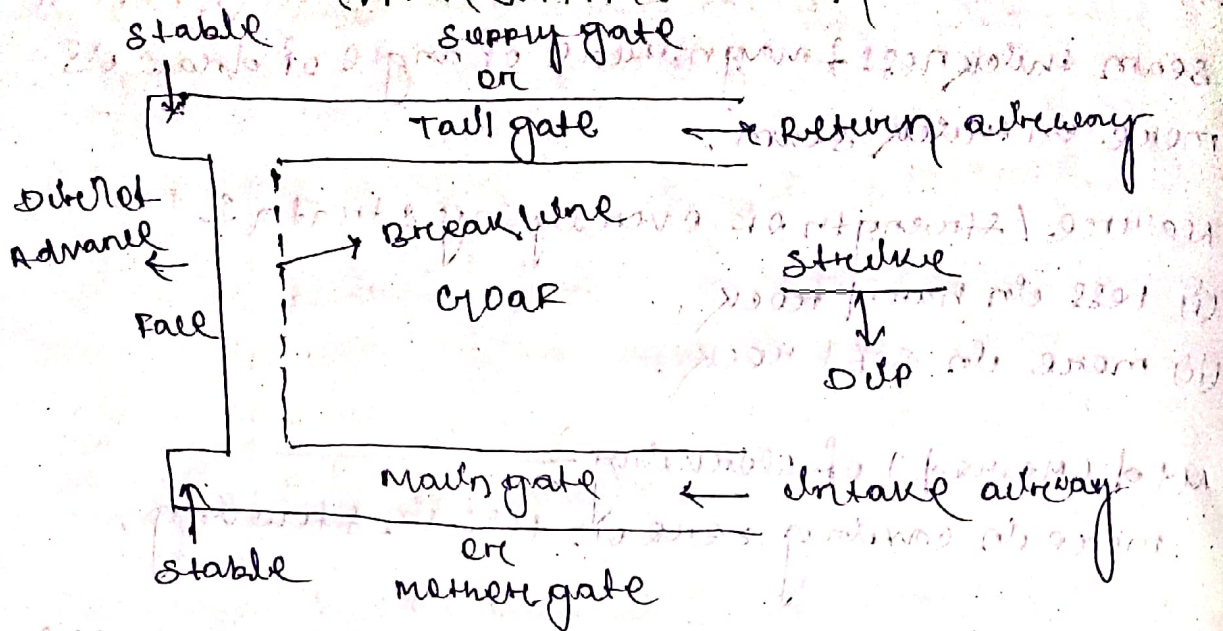
→ more in near fault.

→ more in shallow working.

Relevance of angle of draw

It indicates the limit upto which subsidence takes place.

Module 2 Longwall Method



Face \downarrow Moving front of any working face is called Face.

Main gate \rightarrow The roadways used for transportation of coal and for the intake airway.

Tail gate \rightarrow The roadways used for supply of material and for the return airway.

Span \downarrow The width of workings from the gate line support to the face.

Stable \downarrow A partition at the end of face, prepared to accommodate machine to cut the face.

Applicability of LW mining

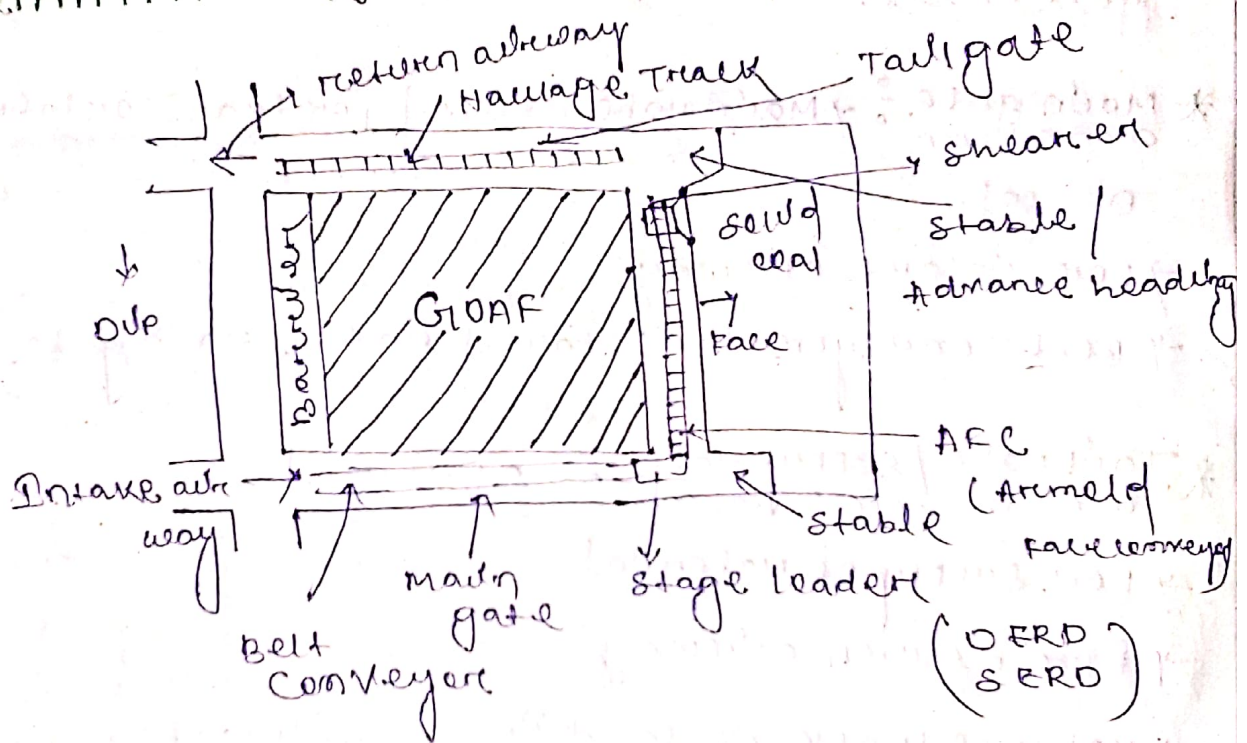
The longwall mining method can be applied in following conditions,

- \rightarrow Thin seam.
- \rightarrow Thin seam - easily extracted sublevel can be (later extraction) of
- \rightarrow Seam liable to spontaneous heating.

- Gassy seams,
- seams at greater depths, even more than seam,
- seams with outcrops,
- in contiguous seam,
- seams are reliable and weak,

↓ 4th page.

Describe Longwall advancing working



(L/W advancing)

- * In-dip panel width - 100m to 180m
- * 100m x 1000m
- * 150m x 1000m

→ The two parallel roads (gate roads) are formed at a 100m to 180m apart.

→ A third road is formed to connect the above two roads to provide a L/W face,

→ Main gate and tailgate are advanced 8 to 10m ahead of the L/W face, this is known as "stable",

→ From the L/W face, wall extraction is started and proceeds towards the panel boundary.

→ Great management of by pack walls or sand stowing or caving.

* Gate roads
The roads at either end of the face are known as gate roads.

* Main gate
Main gate is used for transport of coal.
→ For intake airway.
→ Belt conveyor is installed in the main gate.

* Tail gate / supply gate
→ For supply of material
→ For return airway
→ Haulage track is laid in the tail gate.

Protection of gate roads by line of packs

* Barrier
Each panel is separated from the adjacent working with a solid barrier.

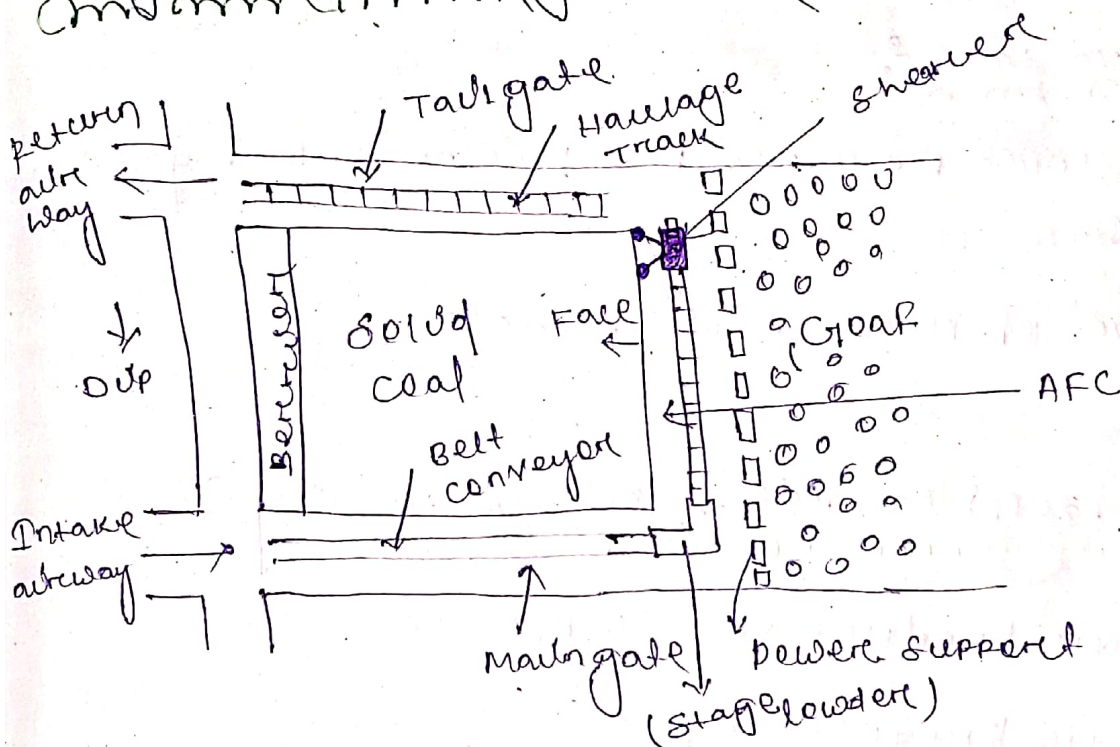
Advantage of L/W advancing

→ After all the development work, coal production can be started.
→ Pay back period is less.

Disadvantages $\frac{2}{2}$

- maintenance of gate roads are of difficult and costly.
- poor (sluggish) ventilation,
- changes of spontaneous heating in great in gate management in by caving.

Longwall retreatment method $\frac{2}{2}$



(LW retreatment)

- Two parallel roads (gate roads) are driven at a 100m to 180m apart upto panel boundary where they are connected by a third road to provide a LW Face.
- extraction of coal then starts from the boundary and the coal face retreats.

* Gate management

Caving or stowing but stowing is not essential unless to protect surface features.

Advantages

- Gate roads are supported by solid coal.
- Better ventilation.
- Applicable for thick seam.

Disadvantage

- Much time required for development of gate roads.
- Removal of methane is obstacle.

↑
V.V.P

* Advantages (merits) of LW mining

- Higher productive (O/P)
- Higher production.
- Higher OMS.
- Less manpower.
- Good ventilation.
- Good supervision because of concentration of working area.
- Maxⁿ extraction is possible.
- Higher degree of mechanisation is possible.

→ chances of spontaneous heating can be avoided because all coal are extracted.

Disadvantages (demerits) of LW mining

- Capital cost of LW equipments are very high.
- maintenance cost is very high.
- cost of powered support, hyd. props and friction props very high.
- If the coal is very hard shearer may not work properly.

* Longwall Method

- Longwall method of working consists in laying out long faces (60-200m long).
- When all coal underlying section of the coal seam is removed by a series of operations, maintaining a continuous line of advance in one direction and leaving behind the voids.
- The roof over the goaf is partially or completely supported by walls of stone and (called palmed sand or other materials like crushed stone to prevent collapse of roof and only a small strip 3 to 6 m wide and parallel to the face is supported by timbers or steel props.
- bars or chocks in a systematic manner

→ Alternatively the reef over the gear is allowed to cave in but the roadways are secured by rock walls and checks if they have to be used.

Describe cyclic and non-cyclic L/W layers on a conventional longwall face equipped with coal cutting machine, face conveyor (belt or scraper chain type), the operations at the face follow a definite sequence and a cycle of operations operates of 24 hrs.

→ A straight line of face is essential for installation of belt or scraper chain conveyor.

→ Where sand stowing is adopted for stowing the goaf, the maxⁿ distance betⁿ the faces of goaf edge and the face is restricted generally to 6m.

→ The cycle of operations is usually as follows on a stowed face if coal cutting machine and manual loading of coal on the face conveyor are adopted.

* Shift coal cutting and dressing.

* Shift - shot firing, dressing down reef and sides and reef supporting by knees and checks.

* Shift coal loading and erecting extra support at local places of bad reef after coal removal.

* Shift - same as A shift.

* Shift - same as B shift.

→ Where stowing of goaf is not practised, and the reef is allowed to cave in.

→ systematic timbering rules approved by the
D.M.S.

Non-cyclic Longwall $\frac{2}{5}$
among $\frac{2}{5}$

→ It may be noted that in a cyclic longwall system
each phase of operation like cutting, blasting,
, loading, etc.,

→ should be completed in the shift allotted for
the work,

→ this is unavoidable for smooth operation of the
working cycle.

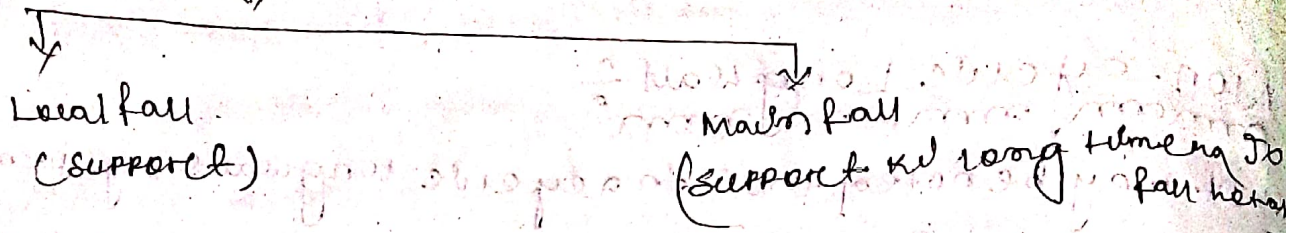
→ coal is available however only in one shift in
a day of three shifts.

→ The supports and conveyor are installed in
straight lines parallel to the face,

→ such straight lines are marked on the rock by
stretching a string covered with chalk powder

2 Fall in creak?

\geq more than or equal to



Local Fall?

→ The fall which takes place soon after withdrawal of support is called local fall.

→ It does not extend to the surface.
→ The intensity of booming sounds in the creak due to rock movement gradually increased after withdrawal of support and comes after local fall.

Major Fall (Major Fall)?

→ The rock fall which affects the surface is known as major fall.

→ takes place long after the local fall.

→ Major fall takes place when

$$A \geq D^2$$

where $A = A_{\text{rock extraction}}$

$D = \text{DEPTH FROM SURFACE}$

Crack due to subsidence extend to surface in above condition.

Danger of Major Fall?

→ Subsidence at the surface.

→ Spontaneous heating in the gash due to air leakage through cracks.

Cause of Main Fall

→ Near a fault plane.

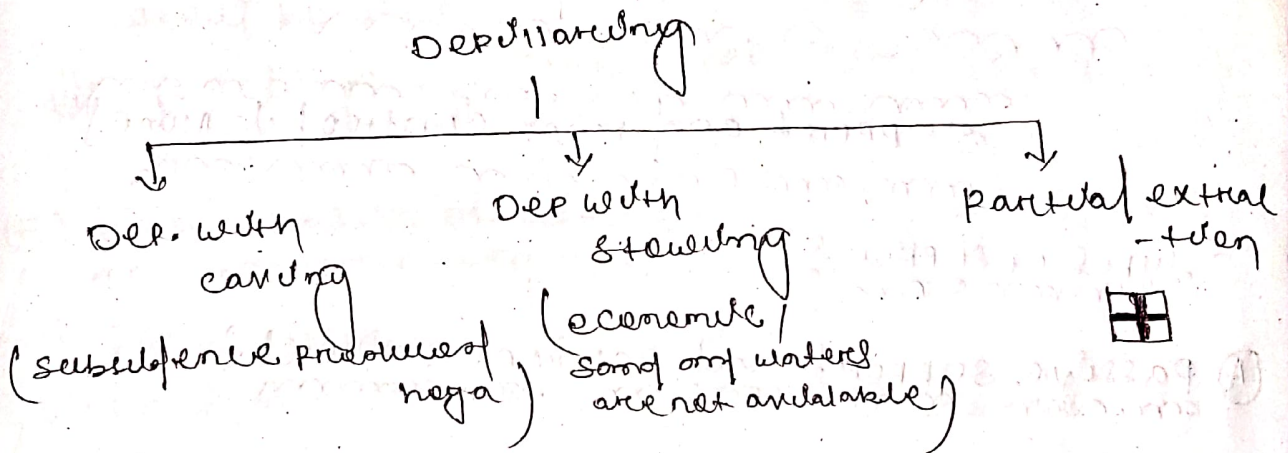
→ If the upper seam has been depiluated.

Precautions

The unsupported roof may slide along a fault plane.

• Leave a barrier of coal near the fault.

* Describe Depiluating method with stowling and caving (ex. or reduction of pillar).



Depiluating (pillar extraction)

The extraction of coal from pillar the operations is known as depilating.

There are two broad methods of depilating.

(i) Depilating with caving

(ii) Depilating with stowling

Besides these, there is another mt of namely

(iii) partial extraction of pillar.

(i) Dephasing with casing $\frac{9}{0}$
~~~~~

In this method coal from pillars is extracted and the part of gear is allowed to leave into the void for decayed area.

(ii) Dephasing with stowage  $\frac{8}{0}$   
~~~~~

In this method, gear is completely filled with inflammable material.

→ To protect the surface features, dephasing with stowage is practiced.



Support and roof control in mines

Roofs of UG working

In UG working to use of different types of support we have to understand types of roof and their properties.

In UG roadway we have to support immediate roof of roadways or work place in a coal seam or ore body which mainly consist of

- (i) coal
- (ii) sand stone
- (iii) shale
- (iv) fine clay

Properties of roof

(i) Coal → coal seam roof is generally common 5 m thick

→ It is very reliable (बहुदुर्लभ)

→ It stand for the long period, approximately even for one year.

→ compressive strength of coal varies, but may be considered as 2.25 kg/mm^2 or $7.5 \text{ t/square inch}$

→ It gives the indication of roof load,

(ii) Sand stone roof

→ sand stone roof bends are slightly before break

→ will give enough warning before fracture,

→ therefore, it is reliable and good.

→ crushing strength of sand stone 13.5 kg/mm^2

(iii) shale $\frac{9}{10}$
 common

- shale rock is fractured and most unreliable
- It gives rarely warning before collapsing.
- It weathers quickly when exposed to air and stays off.

It is good practice to keep 0.6m coal contact near a shaly roof during development

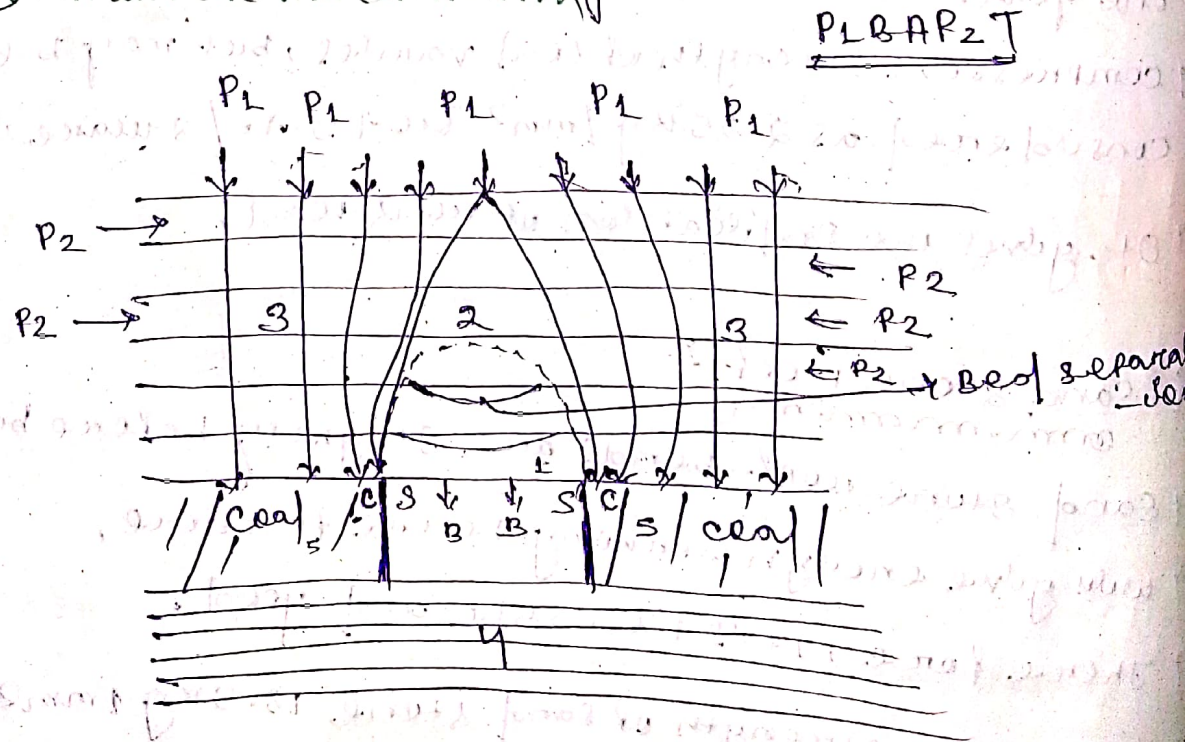
Stress involved in mining $\frac{9}{10}$
 common

- (i) vertical stress
 - (ii) lateral stress
 - (iii) inherent stress
- (Pre-mining forces)

(iv) Induced stress → due to mining

- (a) bending stress
- (b) shear stress
- (c) tensile stress

* Pressure Arch Theory $\frac{9}{10}$
 common



P_1 = Vertical compressive force proportional to the depth.

P_2 = Lateral force increased with depth

B = Bending stress, increases with width of excavation

S = shearing force

C = Abutment pressure
(concentration)

→ When an up roadway is made in the mine, the equilibrium of pre-existing forces is disturbed.

→ There is a re-distribution of vertical and lateral pressure.

→ New kinds of forces come into play.

→ This re-distribution of pressure is explained by the "Pressure Arch Theory" as illustrated by fig.

B = Bending force whose magnitude increases with the width of excavation.

P_1 = vertical compressive force, proportional to the depth.

P_2 = lateral force whose intensity increases with depth.

S = shearing force.

C = Abutment pressure.

Re-distribution of pressure shown by arrows when an up roadway is made in band of roof of working.

(i) The vertical compressive forces are directed to the point of coal.

(ii) The rock on the immediate roof bend down under their own weight and tend to separate from one another. This phenomenon is known as roof separation. This is caused due to bending stress.

(iii) Abutment pressure $\frac{q}{\sigma}$

→ Due to forming of roadway in a coal seam,

→ re-distribution of vertical compressive force (P_1) occurred

→ concentrated at the edge of pillar

→ the concentration of these compressive forces are termed as the abutment pressure (CC).

(iv) Shear stress (P_2, P_2) $\frac{q}{\sigma}$

At the same time lateral pressure / side pressure (P_2, P_2) tend to push the rock into roadway.

→ The sides of coal pillar are subjected to shear or slip forces (SS).

(v) Tensile stress $\frac{q}{\sigma}$

The lower layers of immediate roof are under tension and therefore, liable to fracture.

Redistribution of pressure on formation of a gallery in an old coal mine resulting in five zones of influence.

zone-1 \div Bed separation on immediate interest.

zone-2 \div No bed separation.

zone-3 \div Lateral and vertical pressure build up into the "pre-examination" value.

zone-5 \div P-draw bridge towards the gateway due to release of horizontal stresses at p-draw side.

* Describe testing of reed \div

(i) visually \div with the help of light

(ii) By hearing the sound of the reed and sides when tapped with stick.

(iii) By feeling the vibration when the reed is tapped with a stick.

(iv) visually \div

visual test aims at detecting any cracks in the reed or sides or any signs of weight on supports such as bending of wall or burr of the tapered end of the existing pier, water percolation from reed, or increased flow of water percolation. Hence it gives the idea of extra support.

(v) By hearing the sound of the reed

\rightarrow + good reed or side gives a ringing sound when tapped with a stick; dull andummy sound indicates the need for supports.

\rightarrow when testing the pier, the observer should stand to the side of the pier being tested as well as usual of reed or pier may give way when tapped.

→ The roof above gallery height of 2.5 m may be tested with a bomb or with its testing end shed with iron.

→ Caution is necessary when testing the shale roof which emits a ringing sound even when the roof is good. If the thickness of the shale roof is greater than 0.3 m.

→ If already erected, may be tapped together on bodies - iron or weight or with a ringing sound indicates good condition but a dull and heavy sound gives a warning of bad roof conditions. Requiring additional supports.

3. By feeling the vibrations when the roof is tapped with a stick.

→ Vibrations test is done by experienced men by feeling the palm of the hand against the roof when tapping. It is a stick of feeling the vibrations, whether a different feel and good roof conditions, this is possible for height not exceeding 2.5 m.

→ Visual test is carried out at the roof up to 3 m high by a strong focused beam of light from a torch or an electric lamp.

→ A series of workers take the roof by another bamboo & vibrations are felt on the floor.

Classification of support

There are various types of support used in underground coal mines such that:

- (i) Safety supports.
- (ii) Side supports.
- (iii) Support by wooden cap, check or chockmate.
- (iv) Support of roadway.
- (v) systematic timbering.

(i) Safety supports

The conventional method of supporting gullies in coal mines is by means of wooden cross bars.

For fixing these cross bars, holes are to be made in the coal pillar manually by chisel bar.

This is time consuming and the whole operation of fixing one cross bar, this method takes about 2-2 1/2 hours.

Therefore the supports are much behind the working face.

For quick setting of the cross bars, the manual cutting of holes in the coal pillar is eliminated by drilling holes with the usual coal drill & a support, known as safety support, is installed to support the rock.

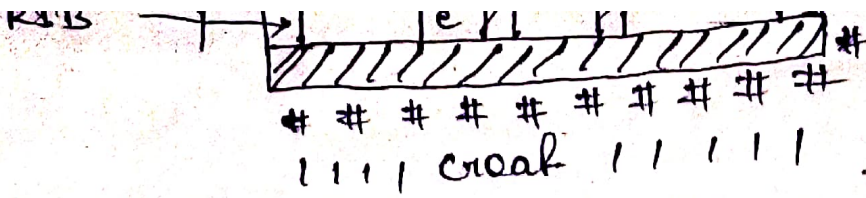
(ii) Side support

Wooden lagging are placed tight between vertical props and pillar where the sides are weak and need support.

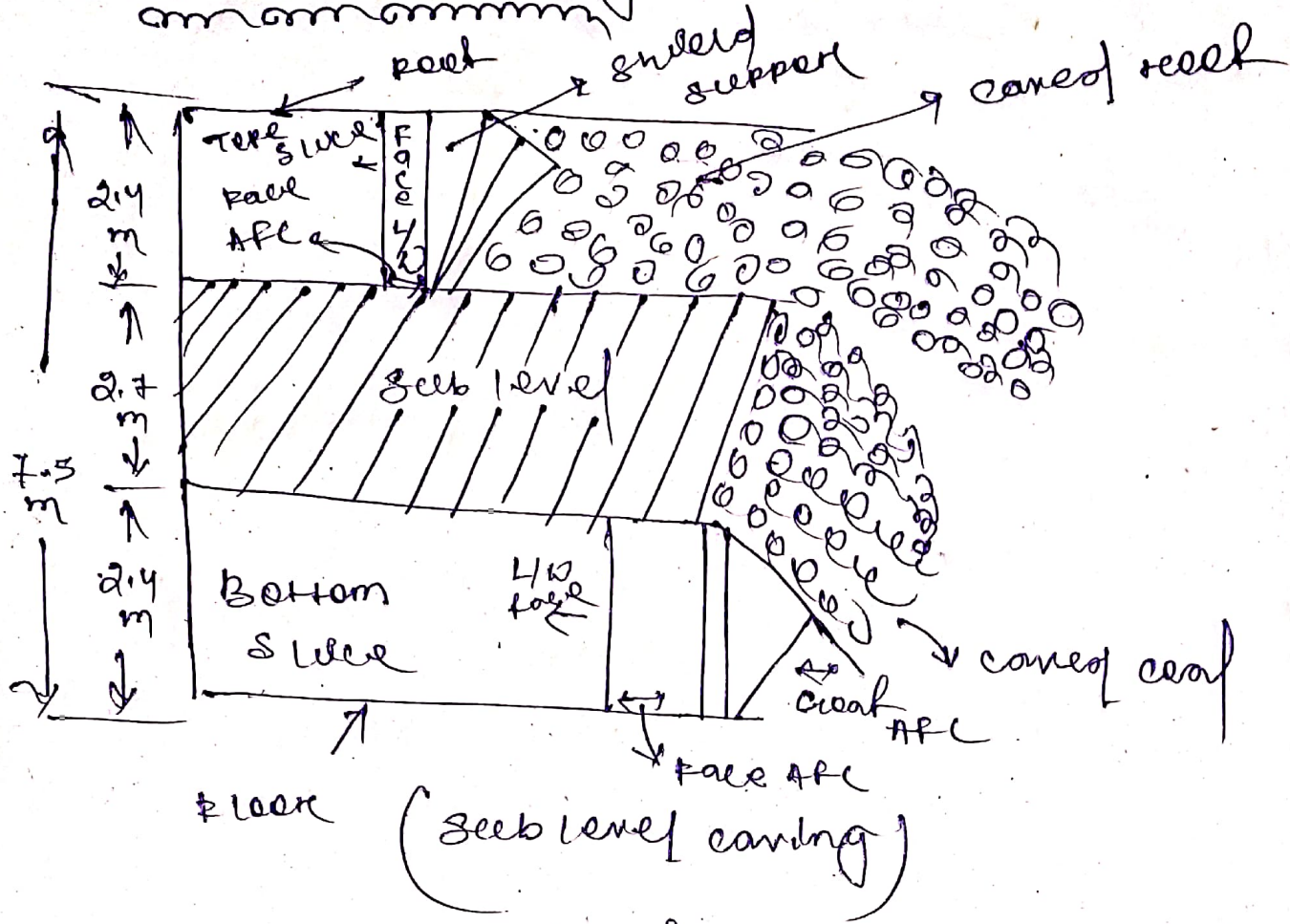
→ Sometimes the timber set of prop and bar have
resist pressure from sides which tend to crush
into the roadways.

→ Notching is useful in such cases. The prop shall
be set at an angle of 45° to 20° off the vertical and
the feet well sunk into the floor.

(1777) support by wooden cap, chock etc chockmate
common



* Sub Level Caving



- first of all a slice of about 2.4 m is taken at the upper most section of roof with the combination of powered support, shearer, APC etc and the roof is allowed to cave in
- Then the bottom most slice is to be worked out by taking a slice of 2.4 m.

- (a) on main section, an AFC is installed at the govt side containing the great coal
 - (b) sublevel coal is allowed to come in at the great end of the powered supports
 - (c) on bottom most slide - face AFC, shearer & power support are used
 - (d) After cutting the coal at the bottom slide by the shearer, the powered support along with the AFC has to be advanced & next coal will be allowed to come in which is to be collected by the great AFC
 - (e) when great AFC runs, then face AFC remains stand still.
- prodⁿ achievable from the top slide - 2000 ton
 prodⁿ achievable from the sub-level canopy - 1200 ton
- Man power (In prodⁿ) shift $\frac{9}{0}$
 ~~~~~

- (i) Asst manager - 1
- (ii) overman - 2
- (iii) mine sardar - 1
- (iv) Electrician - 2 (1 electrical, 1 mechanical)
- (v) electrician = 3
- (vi) electrician helper - 3
- (vii) men. fitter = 2
- (viii) men. helper = 2
- (ix) shearer operators - 2
- (x) power support - 3
- (xi) Belt conveyor - 2
- (xii) misc - 10

Sub level canopy ↓

- (i) applicable for inter beam
- (ii) primary method - the retreating

## Roof bolt

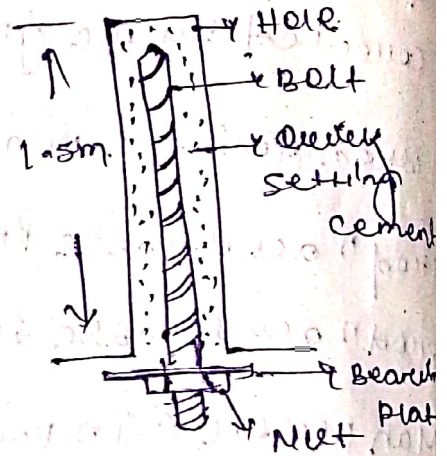
Roof bolt is a type of steel support which is in the form of a long bolt (at least 1.5 m long).

When the bolt is fixed in a hole drilled in the rock and an iron plate is tightened over it at the rock level with a nut, the strength of strata increases and their sagging is reduced.

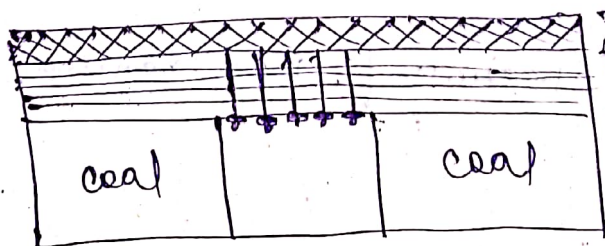
It is a type of rock reinforcement system, bolts are of many types

### Principles of action of roof bolt

- (i) Beam theory
- (ii) Keystone theory
- (iii) Suspension theory



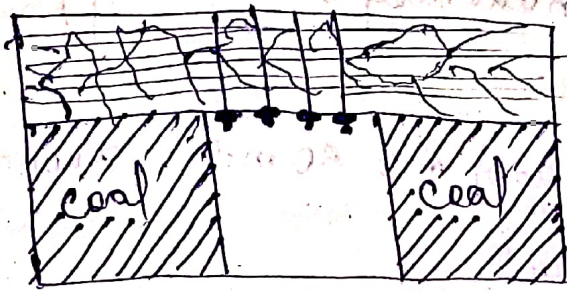
### (i) Beam theory



(Beam theory)

Bolt clamp several thin layers of rock rock into a thick beam, which is stronger than the individual layers. If beam is stiffer, thickness & strength increases by 82 or 2 times.

(i) Key stone theory & its importance



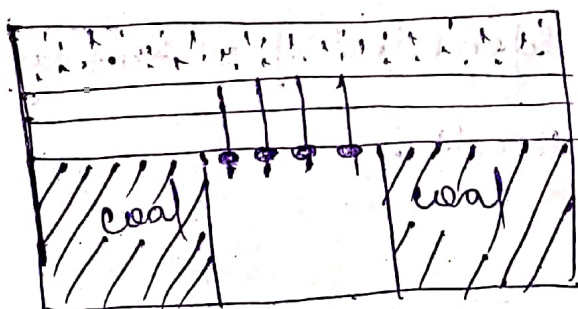
In case of fractured roof.

A belt binds the fractures of block of rock & prevent the movement of roof rock from the wear planes.

or

Sometimes in fractured or jointed blocks in the roof, a piece of stone is so located that, when it is removed, other stones will fall. Belt prevents such key stone from falling.

(ii) ~~Sea~~ Suspension & its importance



The immediate layer of rock are held by suspension - come from a stronger bed above.

\* Anchorage testing of rock bolts -

First 10% of the bolts chosen at random by way maintained and calibrated anchorage testing machine

The bolt should take 3 tone load in 30 min, 3 tone load & 8-tonne in 24 hours.

Rock bolt Performance

→ 10% of the installed bolts shall be subjected to anchorage testing.

→ 9% bolts shall be tested upto designed capacity

→ Rest 1% bolts may be subjected to destructive testing.

Under the supervision of Asset manager.

→ The tested bolts shall be identified with tags bearing the word applied on it.

## Shaft sinking

What is shaft?

shaft is a vertical or inclined opening to the underground. men, material, ore hoist, water pump, ventilation provide the purpose of vertical opening.

What is sinking?

sinking is shaft excavating process.

Shaft sinking

It may be described as an excavation of vertical or inclined opening from the earth for conveyance of men, material, ventilation, pumping water, in addition to hoisting of ore and water haul.

Shaft sinking purposes

- removing the mineral deposits.
- temporary storage and treatment of sewage.
- bridge and other steel foundations.
- Hydraulic lift pits.
- wells.
- To serve as intake & return airways for the mine.
- Drilled shaft mooring is used in such process.
- Storage of nuclear waste.

\* Special method of sinking  $\frac{9}{10}$

(a) Piling system  $\frac{9}{10}$  It is used with loose & running

ground [soft mud, sand or alluvium]

→ It is suitable up to 20m depth of sinking.

→ Piles are welded & riveted to each other helping to create a water tight lining.

→ Piles are driven down by heavy mallets (of plates of edge to edge helping create a circular lining).

(b) Caisson's method  $\frac{9}{10}$

\* Drop shaft method  
\* useful for running ground

- open caisson (driving drum)
- force caisson
- pneumatic caisson

(c) open caisson method  $\frac{9}{10}$

Determine shape and size of shaft  $\frac{9}{10}$

→ shafts are circular in shape & rectangular shafts are rare in this country.

→ the exceptional cases being some of the shafts in metal mines.

→ A circular shaft is best able to resist heavy side pressure for a given cross-section.

→ It is easy to sink and line with boards or concrete

→ The finished diameter of the shafts varies from 1.2m to 6.7m.

A rectangular shaft sunk in recent years at the main shaft at Mochila magra mine, Zawar, Rajasthan. It is of 5.2 m x 8 m in cross-section, vertical, 321 m deep from the shaft collar with 30 cm thick concrete lining.

Surface arrangement & equipment required during shaft sinking

- steam boiler or diesel engine for winding engine, pumps etc.
- winding engines and winches fitted with locked coil ropes.
- Air compressors for Jack hammer drill.
- Generator with diesel or steam engine for lighting purposes.
- fan nearly 30 m<sup>3</sup> per minute capacity.
- shaft center of arrangement
- Lamp room, first aid room, magazine, store etc etc.

\* Location of the shaft

Selection of a production shaft location is governed by many factors. The most important factors are, suitable for transport link with the thermal power plant.

- shaft location in relation to mining advance & associated change of the haulage distance.
- working conditions (methane producing capacity)

hydro-geological and geotechnical conditions at the

Potential shaft location,

→ Construction costs,

→ convenient location relative to the mine surface

reference object.

The location of the production shaft

→ The topography,

→ the position of the mill site or point of landing on the

shipment

→ The facility of the construction a surface plant consisting of hoist house, shops, change house and other buildings near the opening.

→ The center of gravity of the known ore bodies plan and vertically.

Conventional method of shaft sinking

(1) Drilling (2) Blasting (3) Mucking (4) Support

(5) Auxiliary operations,

(a) shaft centering

(b) dewatering

(c) ventilation

(d) lighting or illumination

\* Excavation method

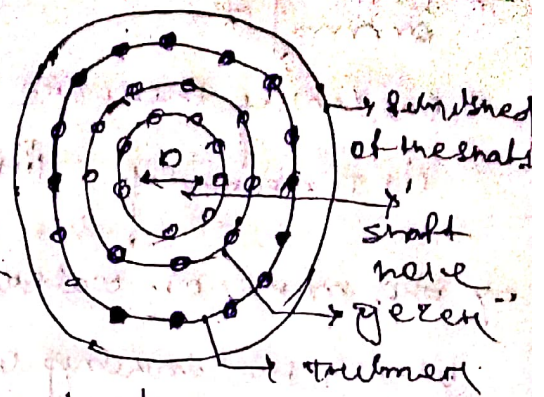
(1) Drilling & blasting

→ A shaft is constructed by drilling holes and filling them with explosives.



→ using this method, drilling and blasting can be done around 5-10 meters in one blast

→ 0.6 to 0.9 one here explosive amount the blast here



→ the explosive blast hole dependent upon the diameter of the shaft.  $(D)^3$

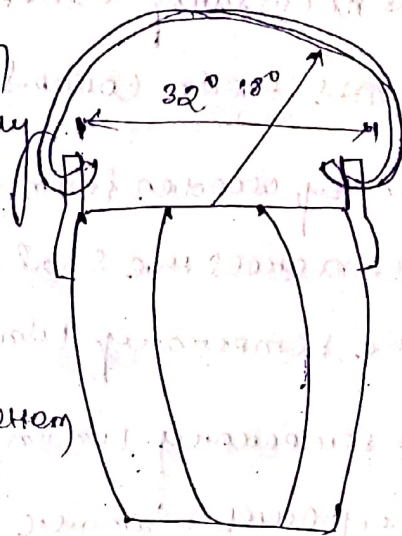
### (ii) Mucking

→ the operation of loading broken rock by hand or machine usually done shaft of tunnels.

→ muck, any useless material produced by mining.

→ mucking out cutting from the bottom of the shaft.

→ usually this work require some sub-levelling, bucket levelling or clam-shell grab equipment.



### (iii) Rock bolting and meshing

→ A wire mesh is fastened to the walls with evenly spaced rock bolts.

→ rock bolting is a commonly used, cheap method.

→ The rock bolting increase normal stresses on joints, so that shear failure along joints become more difficult.

→ often rock bolts and mesh are used as abutts for shoring.

\* Lining  $\frac{9}{10}$   
 0mm 0mm

Basically there are two types of lining  $\Delta$

- (i) Temporary
- (ii) permanent

→ The make of water and strength of the tract through which the flowing operation is being carried out governs the choice

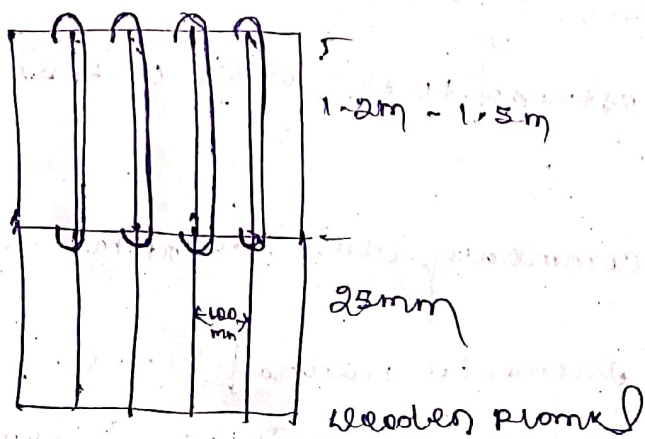
(i) Temporary Lining  $\frac{9}{10}$   
 0mm 0mm

→ It is necessary to support the side of the excavation to prevent their collapse

→ A heavy wooden frame or a frame of steel girders is built across the shaft from which the first lining of the temporary lining is suspended. (for most)

→ The temporary linings consist of skeleton work called curb, stringer, and plants.

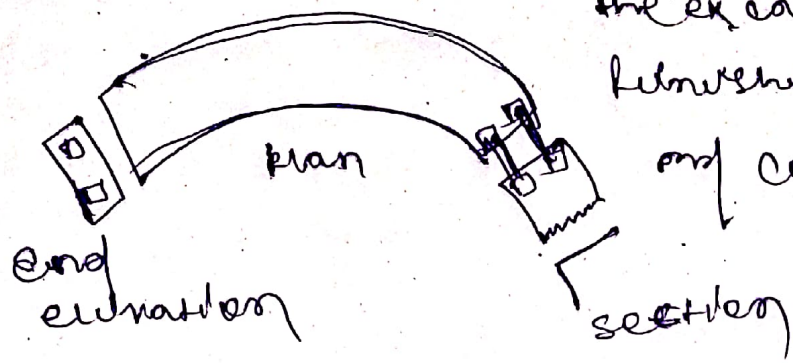
→ The segments of 100mm x 25mm dimension are joined together by fish plates.



→ The height of the supported are 1.2m - 1.5m

→ It is not suitable for blasting

## Permanent Lining



→ When string level is reached the excavation is reduced to the finished diameter of the shaft and centred thus for better balance.

→ Arrangements are then made for construction of permanent linings which may be of brick, concrete or special steel tubing.

→ Brick walling is a common practice for soft to very compact & moderately wet strata.

→ The brick of best class and well burnt quality of size of 225 mm length  $\times$  115 mm breadth  $\times$  75 mm height.

→ A 150 mm layer of concrete is then laid to form a level bed and the inside edge of the concrete being the finished diameter.

→ The brickwork arch is made at least three.

→