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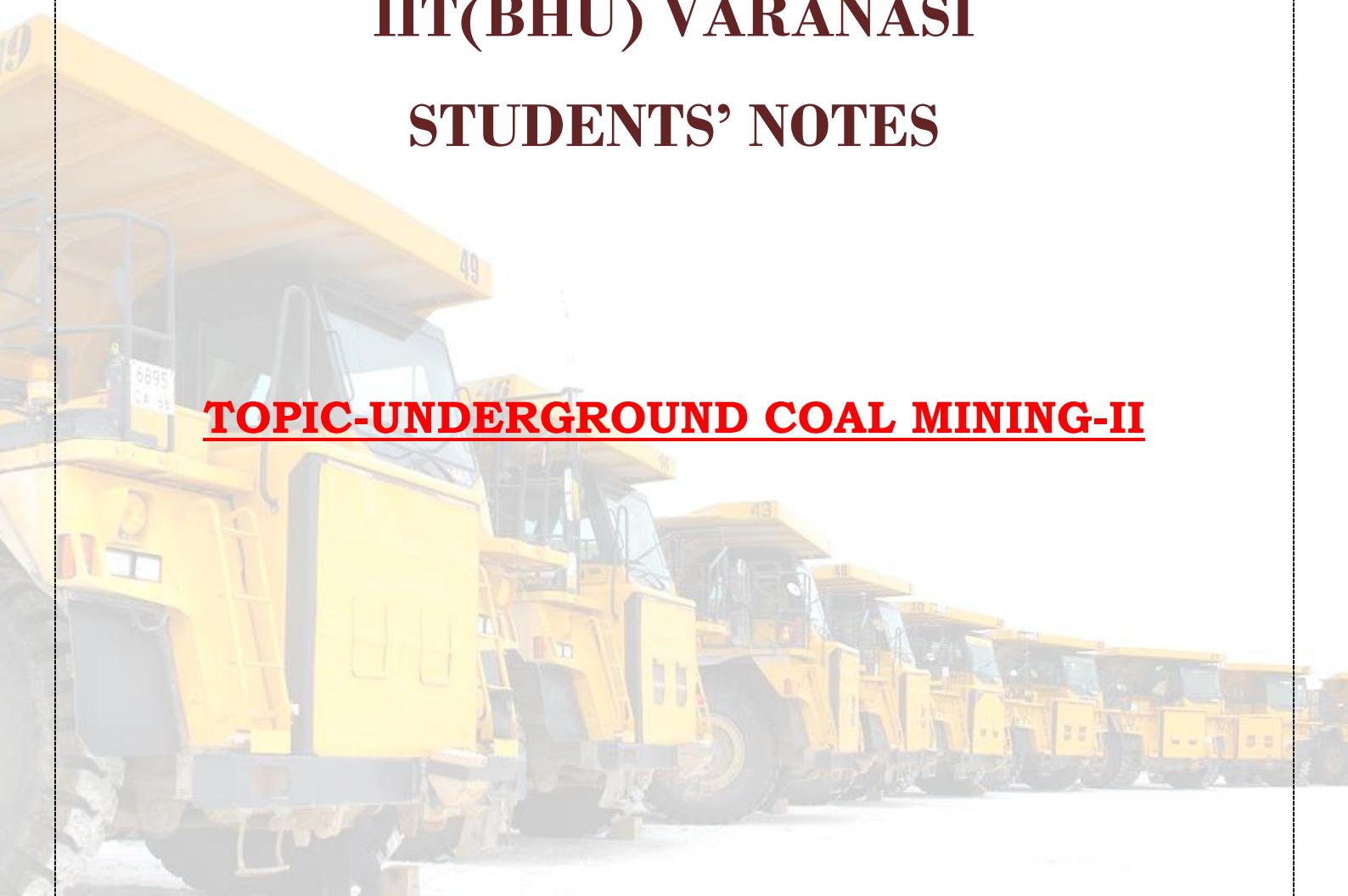
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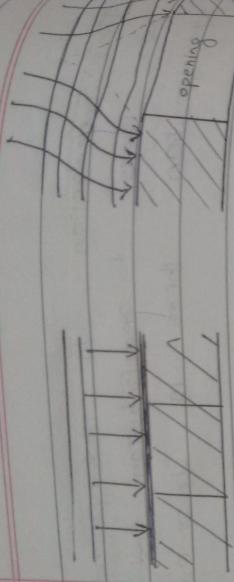
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**IIT(BHU) VARANASI**  
**STUDENTS' NOTES**

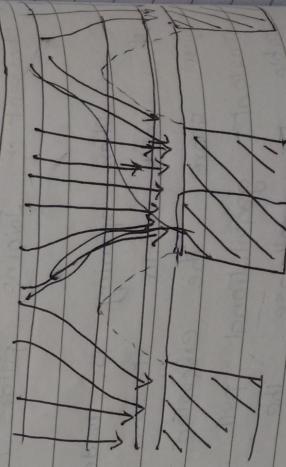
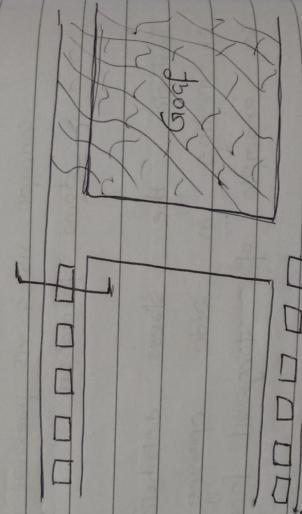
**TOPIC-UNDERGROUND COAL MINING-II**

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Pre-mining  
stress distribution

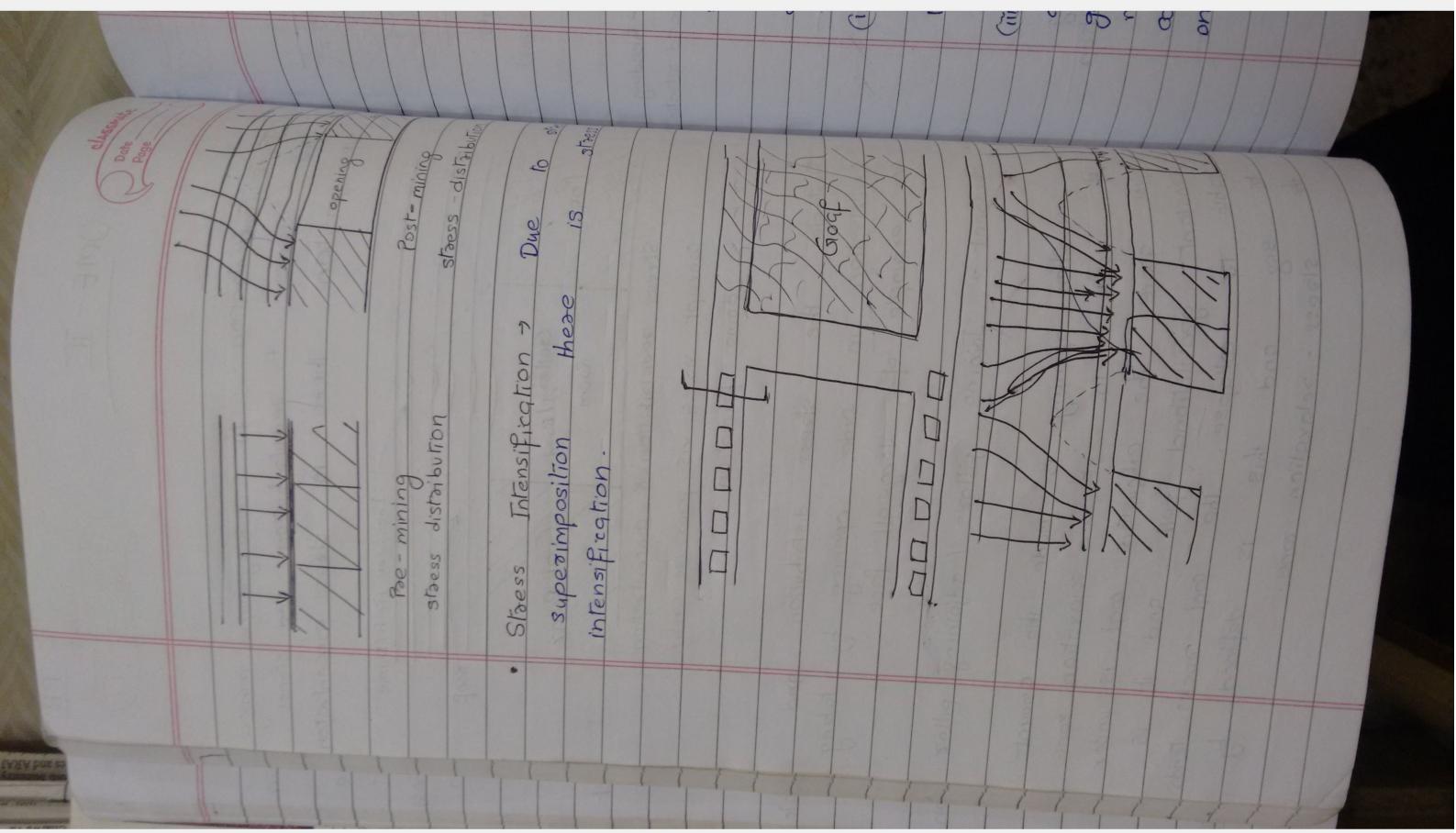
- Stress Intensification  $\rightarrow$  Due to superimposition there is Intensification.



classmate  
Date \_\_\_\_\_  
Page \_\_\_\_\_

Page No. \_\_\_\_\_

Page No. \_\_\_\_\_



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Date \_\_\_\_\_  
Page \_\_\_\_\_

Every mining condition leads to stress redistribution which may lead to failure of structures.

During the development in Board and Pillar.

(i) Board and Pillar headings moving toward each other. The headings are connected partially from rise and partially dip side so the intervening pillar will be subjected to high stress concentration toward the rise and dip faces.

(ii) Multiple heading longwall gate roads inter connection are also subjected to some stress concentration

(iii) In the longwall panel, when the connection between main gate and tail gate is made from both the main gate and tailgate side. The stress concentration situation will be impending on intervening pillars

Every mining condition leads to stress redistribution which may lead to failure of structures.

During the development in Board and Pillar.

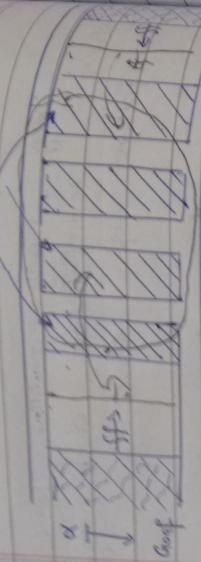
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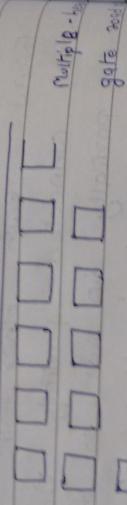
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P.B



B. Lateral Loop with Extract front moving toward each other (Plan)

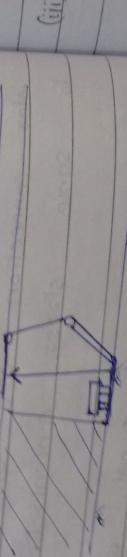
(i)



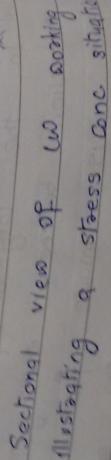
Multile

gate 2nd

(ii)



(iii)



Sectional

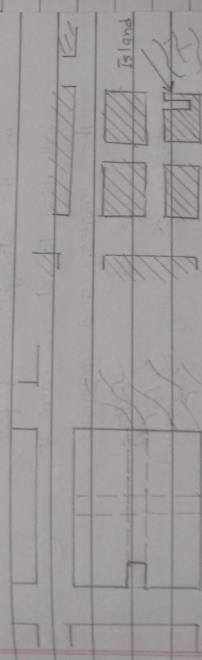
view of working illustrating a stress conc situation

Stress Energy or LS

### Conditions of high stress concentration

Junctions : Stresses are very high and high stress conc. takes place at abutments i.e. corners of pillars.

(b) Splitting of pillars :



(i) Plan view (Splitting)

(ii) Slicing.

(iii) Slicing : There is goaf on both sides of the rib. This is a very difficult situation.

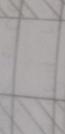
Final slice is like an island goaf on atleast 3 sides subjected to very high stress conc. Slicing is followed from goaf edge towards the workings otherwise island will be formed every time a slice is driven. But if we follow goaf to the working direction, one side will always be solid coal.

## Slicing $\Rightarrow$ Groaf $\rightarrow$ Solid

### (iv) Multiple Opening

The Pillar will not be able to bear such a heavy load and will get crushed.

Massive Roof



Roof behaves as a massive cantilever giving multiple opening under a load on one side.

By this

### (v) Straight Faces - discontinuities

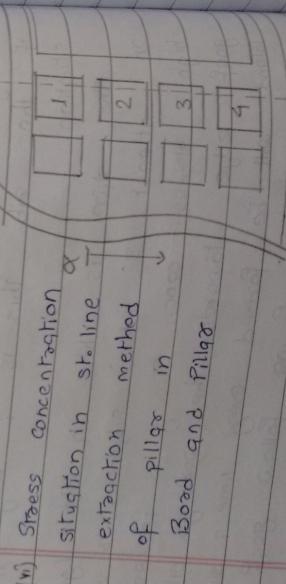
in the straightness of face will lead to stress concentration at the angles and corners.

Due to cutting stepped faces may be formed.

Stepped (Wise)

Rhombs in (plain view)

To provide more areas of stress concentration



### (vi)

Stress concentration in st. line extraction method of pillars in Board and Pillar

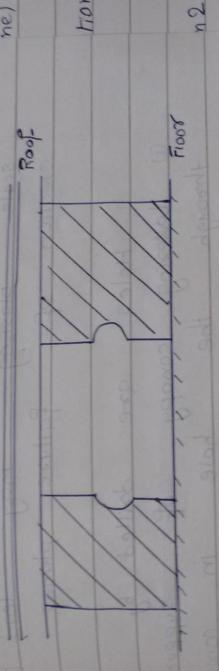


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Date 21/1/15  
Page

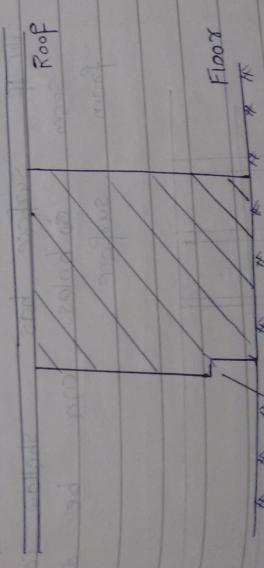
### Preventive measures

By erection of support and support may give information about the stress on the pillars

Destressing by drilling hole in the center of the pillar



Ques no 3 Under cutting all of pillar



Under cut allows the pillar to yield and releases the stress concentration

classmate  
Date & Month  
Page

### 1. Dethressing by Blasting :-



Highly uncoupled blasting ie scale blasting may lead to creation of failure planes

Holes are drilled by workers to drill through the hole in canopy

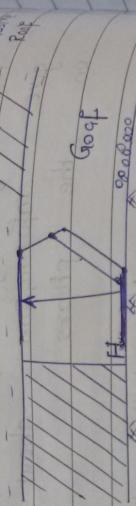
(i) If surface has shallow canopy then holes can be drilled from surface



Dethressing from the surface & blasting thru a shallow cover of massive super incumbent roof for seam

Classmate  
Date 2/10/13  
Page

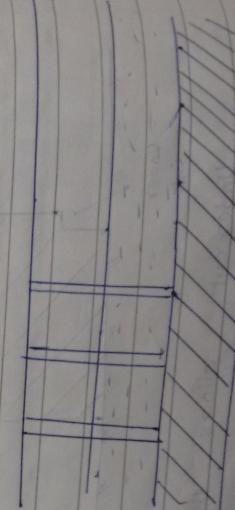
### 5. Destroying by Blasting :-



Highly uncoupled blasting ie scale blasting may lead to creation of failure planes

Holes are drilled by workers through the hole in canopy inclined holes

(i) Lancing canopy if support workers drill the inclined holes



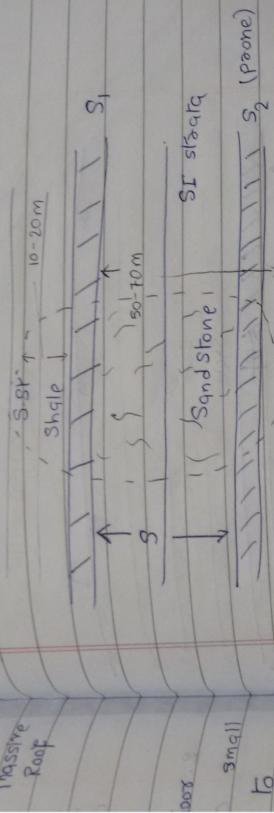
(ii) If surface has shallow coal seam holes can be drilled from surface

Drilling from the surface & blasting the massive super incumbent coal for seam a shallow cover

~~CLASSMATE~~

~~10/15~~

massive  
Roof



### (Protective Seam Mining)

- $S_2$  is prone to stress concentration and can be saved by

cut and  
stop  
hole.

- (i) Extracting Seam 1 prior to seam 2 creates a stress relaxation zone of ellipsoid is created and this method is called Protective Seam Mining

Stress & Relaxation is limited in nature ie for only 1 - 2 year

- (ii) By continuously and simultaneously extraction but with a minimum stagger of twice the distance between seams (2s) or 30m

100 foot  
under  
seam

- Diagram showing the sequence of events during a coal seam outburst:*
- 
- The diagram illustrates the sequence of events during a coal seam outburst. The vertical axis represents the height of the rock layers. The layers from bottom to top are:
- Coal seam
  - Sandstone
  - Shale
  - Silt
  - High arc area
  - Shaking zone
  - Gas mine
  - Impact zone
  - Sudden release of gas
- A horizontal arrow at the bottom indicates the direction of increasing height from left to right.
- (i) In case of no staggering by simultaneous extraction should be done
- (ii) Sudden release of gas
- (iii) Impact zone
- (iv) High arc area
- (v) Shaking zone
- (vi) Gas mine
- (vii) Impact zone
- (viii) Sudden release of gas
- (ix) Coal seam prone to outburst
- (x) Outburst is sudden release of gas with high energy and is a dynamic process
- (xi) Sudden release of gas with large amount of coal
- (xii) Sudden release of gas with large amount of coal

ing and  
ing should

Sudden release of gas without release  
of coal (Gas Blower)

### Indications of Outburst

- (i) High quantity of gas in the return air
- (ii) Shaking of ground
- (iii) Uprooting of supports followed by an imminent roof fall then airblast

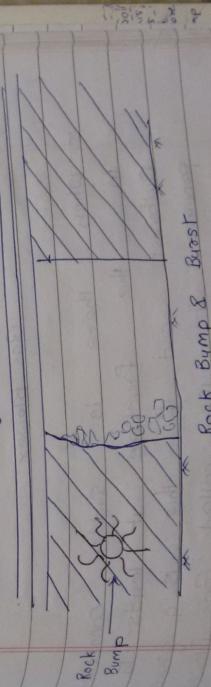
### Airblast or Rockblast or Outburst

Possible occurrences are :-

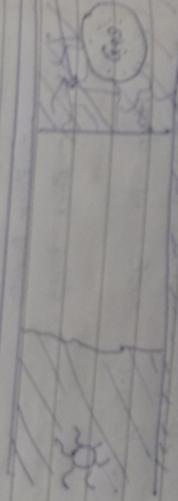
- Airblast
- Outbursts
- Rock bursts
- Rock bump

Rock Bump is seismic activity (event and  
burst is a dynamic spelling)

Rock bump  
process  
small  
large



- It depends upon - weight
  - thickness
  - nature of rock
- which affect the effect of rock bump.
- If it is really difficult to numbers case to be none and less gas
- Faults get interconnected and to the outburst coming of gas (N) also called gas holes.



Gas Bubble

- When there is sudden collapse in the fracture if leads to outburst and if it is a slow process, it is called gas bump.

classmate  
Done Page

### Factors Responsible

presence of gas and the manner in which gas has been trapped vis-a-vis method of working

depth of working i.e. with increase in vertical and horizontal stress may lead to sudden release

occurrence of fractures

and lead to gas due to stress redistribution and concentration

(ii) sudden transfer of abutment loading due to stress superimposition or intensification

### Abutment Loading & Stress Concentration

Due to working, the load on the adjoining pillar increases called abutment loading while stress concentration is built up of gradual & greater stress due to many reasons including abutment loading.

classmate  
Date \_\_\_\_\_  
Page \_\_\_\_\_

- Precipitations while winning of seams liable to outburst
- (i) Additional section already before entering the coal seam which can provision for additional section already.
  - (ii) A provision for additional section already.
  - (iii) Removing the gas by puncturing the gas called Coal Bed Methane (CBM) extraction re by.
    - (i) Using borehole from surface but should be economic ( $18 \text{ m}^3/\text{ton}$ )
      - (ii) While driving in seam driving we can take boreholes
  - (iv) Erection of air tight logs and air tight coil in goafs (stopping) with man bars.
  - (v) To combat stress concentration of coal to avoid excess concentration of stress.
  - (vi) A direct revenue loss (loss of rent) source) and then indirectly by managing the outcomes
    - pumping of the gas

of coal  
burst  
before

- release of greenhouse gas

Drawing of Coal Seams prone  
to Rock Bumps / Burst

Rock Bump is a seismic activity  
which are related to fracture in  
remote areas and gas not controllable  
Seam fails suddenly and violently e  
with lot of energy

- may lead to burst of rock and shaking
- sudden gases may erupt
- Coal pelting may occur
- Upending of supports

methane (gas)  
in surface  
(18 m<sup>3</sup>/tonn)  
29 m drives

Coal seam with stress intensification  
gas and  
P<sub>s</sub> (stoppage)  
intensity ie  
burst of the rock burst.

large overhang 300ft may also  
lead to rock burst . Depth of working  
and abutment loading may  
lead to rock burst.

loss of energy  
by

Coal Blows occurs at the end between the shifts as due to drilling lot of energy is released.

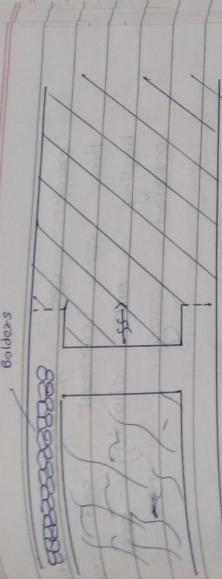
### Ways To overcome

- Protective Seam Mining should be practised for extraction of Coal phone To rock burst
$$S = 12F + 3.5t^2$$
- In case of simultaneous extraction second stroking should be used
- Shock or Induced Blasting should be practised. It brings weakness in strong structures
- Planning of face operation instead of a day that drilling and blasting may occur at the end of shift.
- Replacement of chain pillar with stop packing technique ie using books from surface to pack pillars

classmate  
Date \_\_\_\_\_  
Page \_\_\_\_\_

the end  
between the  
rolling a  
closed

Goldens



coal

Gunny bags filled with sand  
can be used instead of rocks

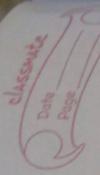
- Always or to the extent possible extraction  
with shooting should be done however  
if the method involves, carving. Then  
it should be ensured that besides  
the immediate roof a part of main  
roof also caves.

should be  
ness in

in such  
and blasting  
shift,

Factors making coal seam vulnerable :-  
Size of panel  
Incubation period - the time lag between  
first local fall and eruption of  
the first sign of heating (self). Local  
fall is taken into account as

Drawing of coal seam  
to prove to free



cracks are generated leading to  
Hin air current and insitu  
heating not allowing heat to  
escape away.

Subsidiary

Surface

Due to rapid heating  
breakage of coal blocks

Vertical shearing of pebbles due to current  
of air and spontaneous heating

(ii) Due to very feeble air current  
in breakage cracks may  
be spontaneous heating

(iv) Poor recovery of coal and  
of coal and non-flame  
packing of goaf may lead  
self heating of coal

(v) Spilling of coal during loading  
and transportation in goaf  
panels which are later sealed  
and may cause self heating

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Page \_\_\_\_\_

Fire Damp ( $\text{CH}_4 + \text{O}_2$ ) may cause  
explosion followed by fire

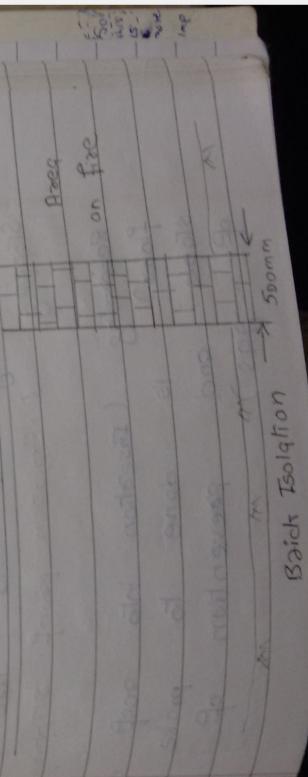
Because of stress concentration these  
may be fractures resembling the  
local fall and again self heating

Improper information about incubation  
rate or failure of achievement of  
production rate may lead to overheated  
panel.

### Overcoming of Coal Fire

may Fire extinguishers sand water should  
be regularly stored

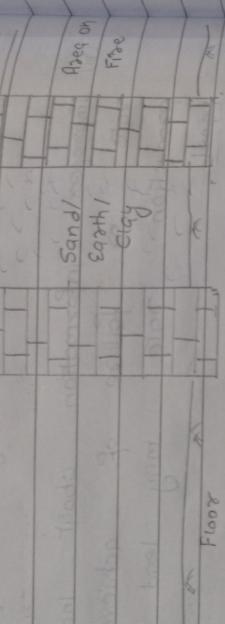
Prevent the occurrence of fire by the  
sealing of coal by making stoppers  
to roof



(iii) Block the Isolation Stopping in mines which are non gassy in nature and donot have chance of fire.

Roof

Recessing



Isolation Stopping in Coal

Seam prone to fire and blast (iv)

(iv) In case of coal seam prone to fire and blast, a cushion of sand is provided to sustain the shock.

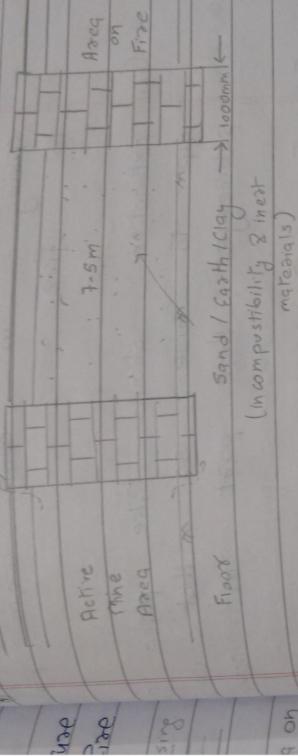
If thickness is 7.5m for same sand ( clay ) If is Fire Proof Stopping / Explosion proof stopping.

Recessing (Intersection into roof and floor) is done to make it stable and prevention of leakage of gas)

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Date \_\_\_\_\_  
Page \_\_\_\_\_

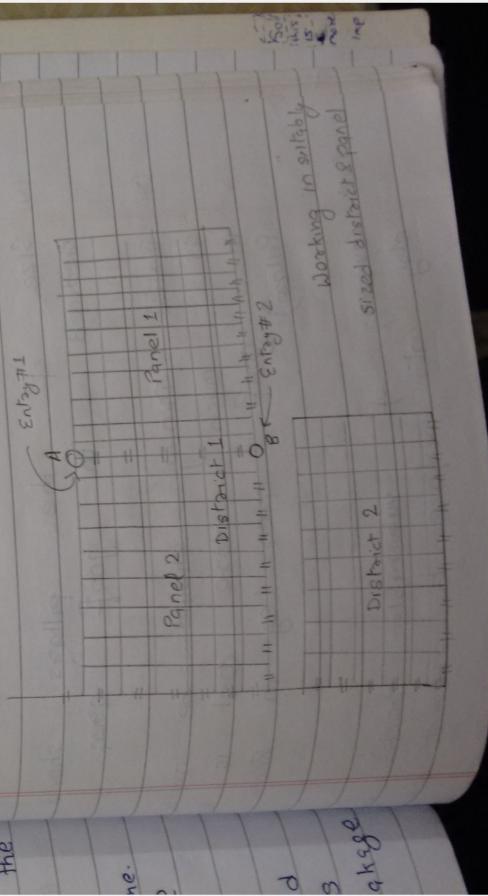
## Explosion Roof Stoppings

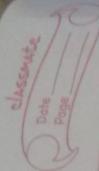
Roof



- i) Provides stability
- ii) Reduces breathing of air

b) Division of mine into district panels such that mine can be extracted within incubation period.  
to of the





(vi) Stowing should be preferred over  
caving in coal seam prone  
to fire

(vii) Extraction should take place from  
dip to rise so that we can  
submerge that part in water (ix)

(ix) Fire Resistant Support - as timber  
help in spreading of fire  
by some special treatment by  
applying some chemical and paper  
seasoning on the surface of  
timber

(x) Reduced spilling of coal in the  
gallery during transportation

(xi) Size of the pillars should be  
reduced in goaf area.

(xii) Partial mining should be avoided  
as much more coal is left  
in goaf area (eg in Room 10  
Pillar)

(xiii) Covering of vulnerable cracks by  
clay at surface to prevent bursting

classmate  
Date \_\_\_\_\_  
Page \_\_\_\_\_

Clay plaster on the surface for visible cracks.

red over  
Zone

From

we can  
dates

Updating of mine plan and demolishing  
the danger zone

as timber  
fire  
ent by

and proper  
ace of

Inundation - Flooding - Water Rush  
Coal seam below water bodies (like  
lake, ponds, surface waters, rivers etc), there is a  
chance of development of cracks which may lead  
to sudden inrush of water in mine

Inundation

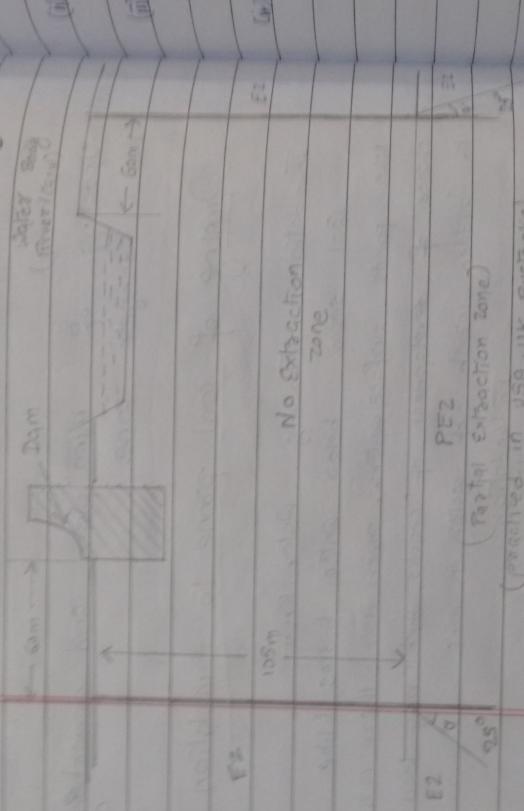
water coming from  
cracks, sources like  
mining below  
water bodies

CMR - 126 - says no working shall be  
made in any mine vertically below the  
following -

- (i) Any river, canal, lake, tank, reservoir
- (ii) At any place lying within a horizontal  
distance of 15m from either banks of  
a river, canal or from boundary of a lake  
or reservoir except by the permission

In writing from Chief Inspector of Mine

### Extraction Zone below Waterbody



100m  
No Extraction  
Zone

PEZ

(Flood Extraction Zone)

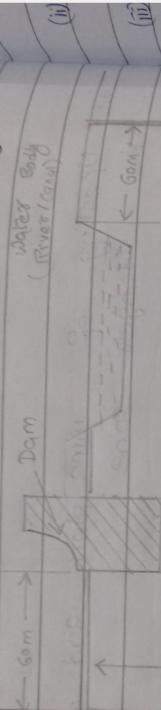
[Prohibited in USA, UK, Australia]

### Precautions / Preventive Measures

- (i) Clearly indicate water bodies in plans
- (ii) update plans and sections
- (iii) of is normally kept  $28^{\circ}$  In Total it may be upto  $30^{\circ}$
- (iv) Highest flood level (HFL) should be known and working should be planned accordingly

In writing from Chief Inspector of Mine

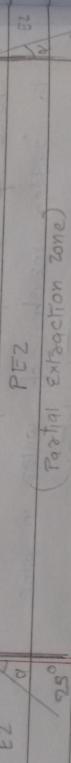
### Extraction Zone below Waterbody



105m

No Extraction  
Zone

Anti-seepage



### Recommendations / Preventive Measures

- (i) Clearly indicate water bodies in plans
- (ii) Update plans and sections
- (iii)  $\alpha$  is normally kept  $26^\circ$ . In India it may be up to  $30^\circ$ .
- (iv) Highest flood level (HFL) should be known and working should be planned accordingly.

classmate  
Date \_\_\_\_\_  
Page \_\_\_\_\_

## Sources of Water

of mine

Ground water may get connected  
to coal

Coal may be itself after being

In the rainy season, if the mouth  
of the mine is below HFL

Abandoned after logged mine in the  
base side

## Winning of Seam Zone To inundation

I seams below water bodies

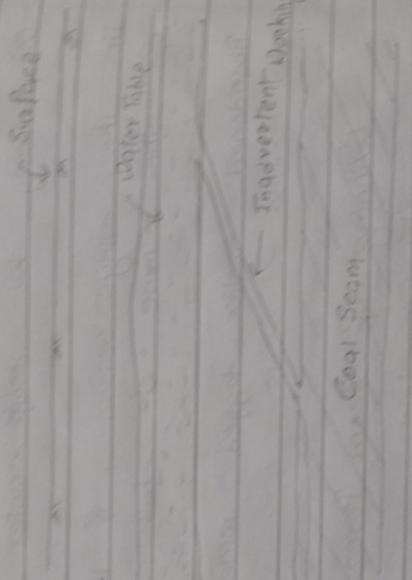
II Seam likely to be inundated during  
mining by

(i) Monsoon / Heavy mine  
(ii) Ground water - liable in the close proximity  
may be continuity of coal seam

3. Existence of old & abandoned v/g  
underground working located the base  
side of the coal seam.

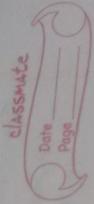
known  
accordingly

4. Fault in the overlying strata
5. inadvertent holing connecting with the water body.

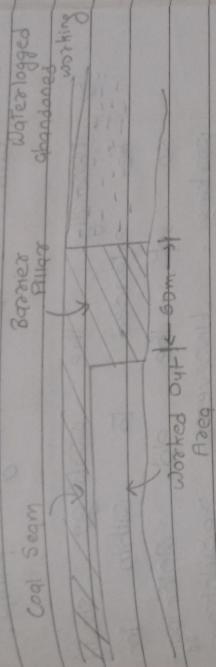


### Preventive Measures

- (i) Preventive measure for old after body in old workings. The idea is mining of such seam is to safeguard the inadvertent holing situation
- (ii) The borer filler should not be drilled to prevent sudden inrush of water



C Surface



014

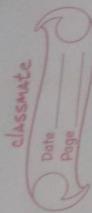
To safeguard the investment working connection with the water logged position. For this, following preventive measures should be adopted

i) Position and extent of old underground workings must be available on the mine plan and plans must be updated diligently as per CMR Reg 58 (3)

If old workings are not shown distinctly on the mine plan but they are suspected to occur then delineation of their location must be ascertained by suitable method

not the Coal Barriers should be marked on the plan

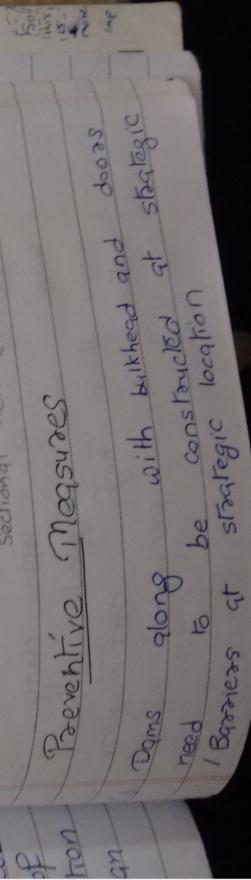
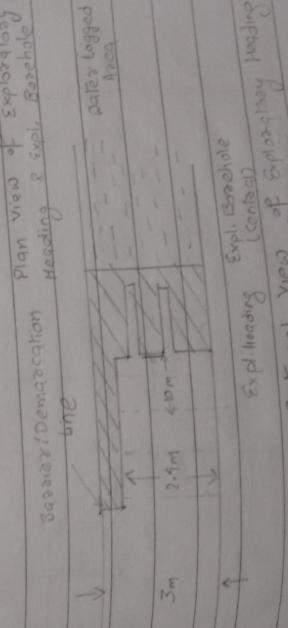
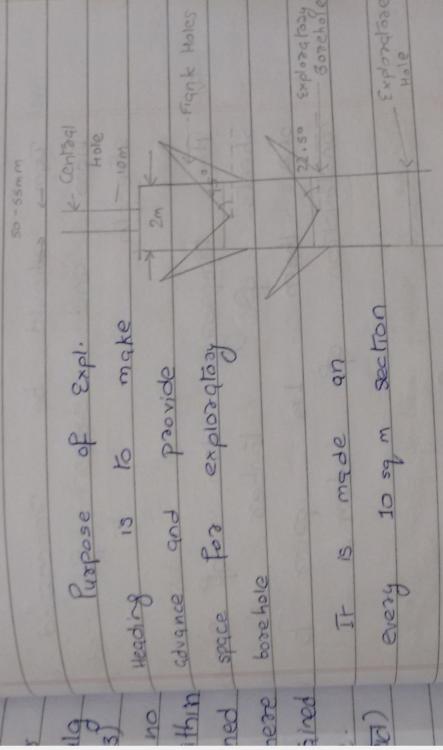
## Burn Side Horing Apparatus



Date \_\_\_\_\_

Page \_\_\_\_\_

## Drainge of Exploratory Heading for Exploratory Booring

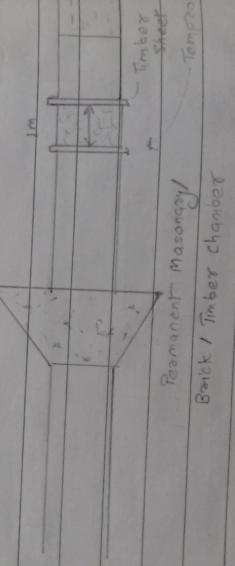


## Preventive Measures

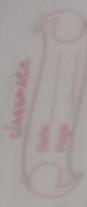
Dams along with bulkhead and doors need to be constructed at strategic locations at strategic locations.

- (ii) Dams must be strong enough to hold the maximum head.
- (iii) Material can be timber / Bark / Concrete
- (iv) Dam should be recessed on roof floor and sides for adequate strength.
- (v) A temporary dam of 2 retainer sheets of timber with thickness b/w them 1m prior to the construction of dam.

(Plan view of gallery showing permanent & temporary dam)



Barrier is left along rise side water logged area and a thick high coal pillar toward water to prevent sudden rush



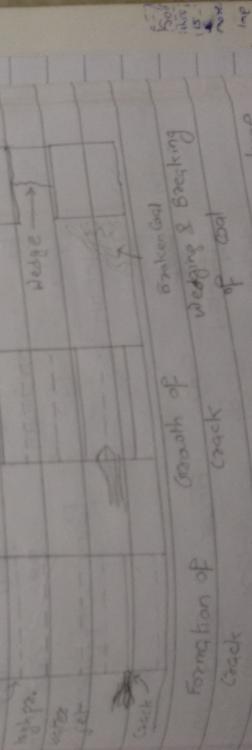
Hydraulic

Sectional View  
of Survey  
Station

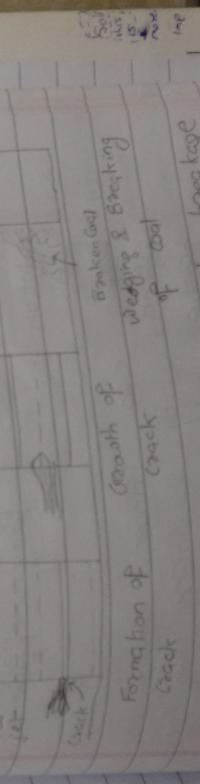
## Hydraulic Mining

Hydraulic mining is method in which water is used to break the coal and it can also be used for alluvial placer deposit.

(dams) It produces cracks and fractures and wedging of coal occurs.



Conceptual Drawing Illustrating the basic stage  
of hydraulic mining



Formation of Crack

Toward Push

Wedge

Breaken Coal

Smooth of Crack

Wedge & Breaking of coal

Breaken Coal

Smooth of Crack

Wedge & Breaking of coal

Breaken Coal

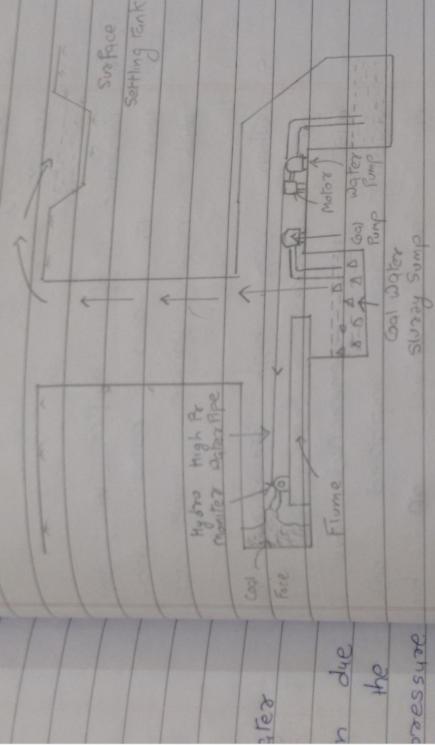
Conventional HM  $\rightarrow$  High P & Q for Jc + Thick  
 / Classmate / Flank  
 q'st sleeve  
 Secondary HM  $\rightarrow$  Drill & Blast  
 + Shovel Transportation

Minimum pressure should be  
 80 times of  $P_T$  (Poisson's ratio  
 Index)  $(1.2 - 1.6)$  but on the  
 1.5 so que pressure =  $80 \times 1.5$   
 = 120 ton

### Conditions suitable

- (i) Soft coal with low UCG
- (ii) Presence of abundance of water
- (iii) Coal seam should be thin due to pressure gradient. As the thickness increases more pressure would be required which should be economically viable
- (iv) Gradient of coal seam should be minimum upto 1% for efficient transportation
- (v) Roof and floor should not get dissolved by water e.g. clay would

Depth should not be very high due to increased cost and moisture inside the mines should increase.



- (i) Generation of high pressure capital investment  
(ii) Coal pump transportation

### Limitations of Hydraulic Mining

Energy requirement is very high constantly required high capacity motors for coal pump and water pump as electricity should be available

classmate  
Date \_\_\_\_\_  
Page \_\_\_\_\_

2. This method is highly restrictive  
method cannot be used for hard  
coal as it is cost inhibited.

3. Availability of large amount of  
water

4. Presence of Sulfur in coal may  
lead to acid mine drainage  
which may poison mine water (ii)

5. When very high pressure water  
jet strikes the coal face  
mist is generated due to which (iii)  
visibility is impaired and there  
is no control on breakage  
of coal.

- Gopalganj, BCCL, the coal  
was hard, so Secondary  
Hydrodynamic Method was attempted  
(Drilling + Blasting + Water Spraying)  
but was highly unsatisfactory  
as it was very economic

Misham Coalfield of Assam  
Misham soft fusible coal which  
will be broken by water  
and due to high S content it could  
not be used.

Active area  
for hard  
hibited

### Advantages

- 1) of Drilling and Blasting was eliminated as these are hazardous in nature and creates practices unnecessary.
- 2) Elimination of cumbersome system of loading and transportation at pittop and pitbottom.
- 3) Safety is better and can be used as there is no danger in gassy mine and the machinery is minimised.
- 4) It can be automated.
- 5) The size of the gallery is small so support problem is less and there is less maintenance ( $2m \times 2m$ ) as no machine is required.
- 6) The method is deployed optimally.
- 7) It is capable of giving high productivity OMS  $\approx 151 \text{ man shift}$  if it is below 1 for India.

(vii) Capital cost is 40% of the conventional mining method (initial) and operational cost is low.

(viii) Surface coal handling arrangement is very simple as it is very complex in conventional mining. A central surface gangue can be very easily deployed for a group of mine.

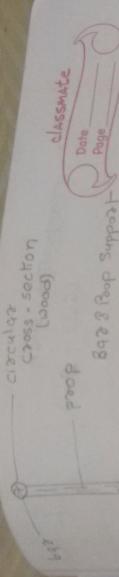
### Development of Hydrodynamic Mining

If coal is strong, then we go for Pre-Coal Softening. Some methods are

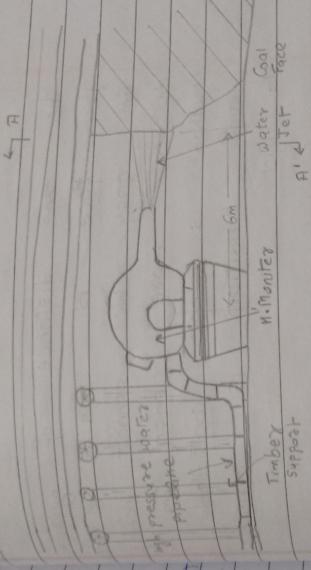
- Pulse - Inducing
- Pulverisation by Drilling
- Light Blasting
- Hydrodynamic Mining Fracturing

We rely mostly on hydro mining but we can also use tunneling machine for dewatering in coal seam by road heading machines.

Continuous miners can also be used but these should be some gradient



minimum (1 m 20) for hydro - legno - support -  
size is of 2m x 2m  
can be upto 2.5m x 2.5m



engement  
it is  
only  
one  
engagement  
ed for

mining  
e go  
methods  
capable

The hydro monitor is capable of  
rotating in horizontal plane and is  
capable of sawing in vertical plane.

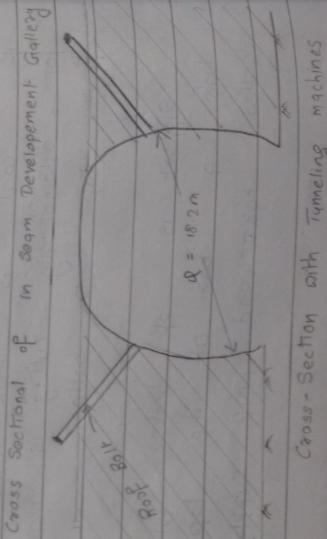
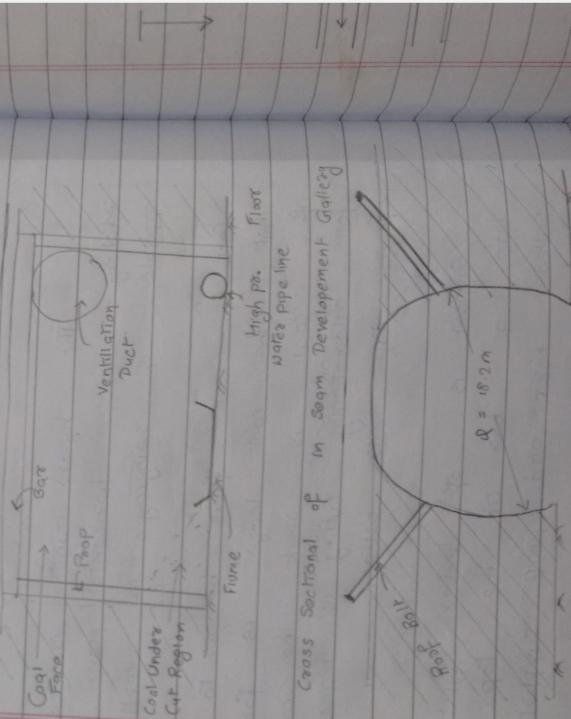
Coal is cut from bottom to top so  
that the coal ledge is formed and  
the coal is weak. The coal may  
fall automatically. Cutting is never done  
tunneling from top to bottom.

Support is of timber type and  
has a bar at the top. It is  
used called bar and prop support.

Max unsupported span  
(6.25 - 9 m)

Also there is no support in front of the face. As the air can carry a higher jet is 60-80 tons.

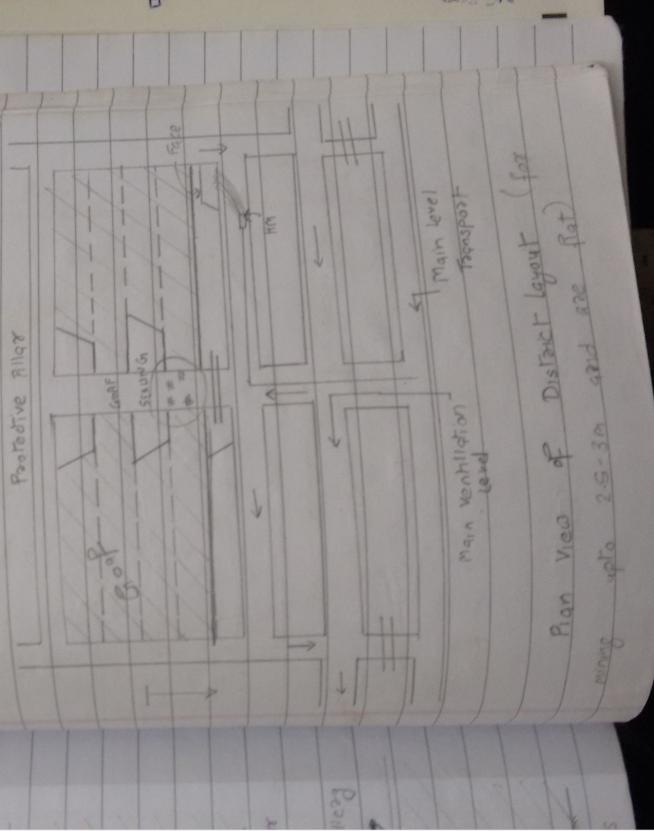
The safe distance of hydro monitor from face is 6m. ie almost distance more than 6m as this method is not controllable and only suitable to mist.



Cross-Section with Tunnelling machines

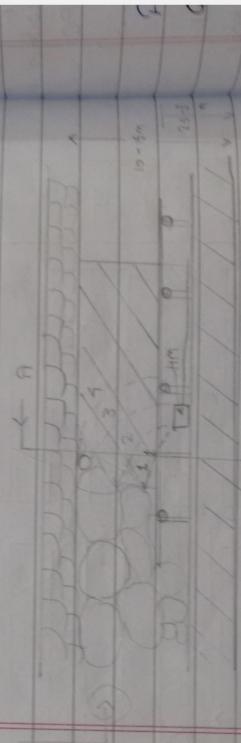
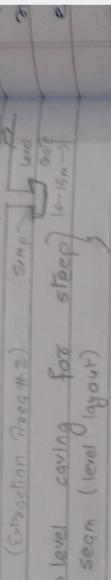
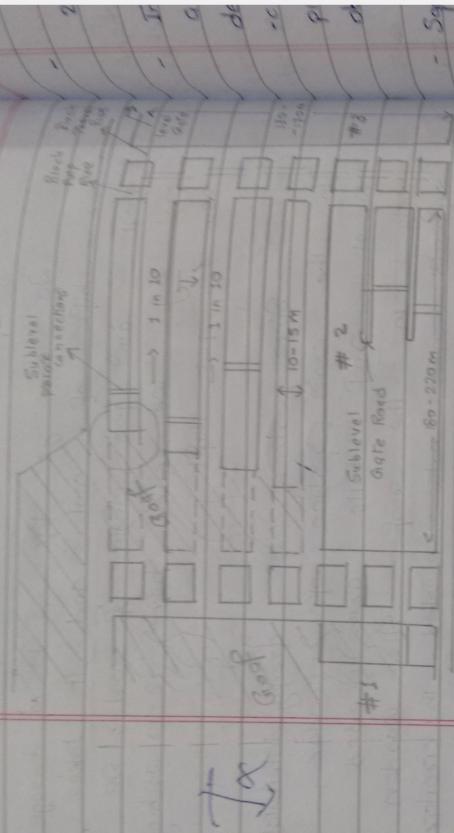
We can go for 8-10 m drive per shift of coal and it takes 80 gms per tonne of coal. We can say we can have 8-10 mining rounds per shift.

Since stress is evenly distributed in the cross-section of circular tunnel, roof bolts are needed only in the roof. Also wooden supports are not erected in circular cross-sections.



classmate  
Date \_\_\_\_\_  
Page \_\_\_\_\_

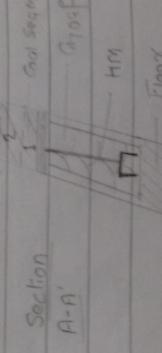
### Front Elevation view



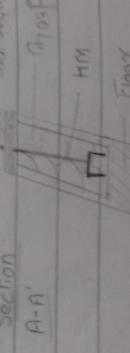
A'

Sequence of operation

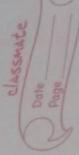
for open lifts



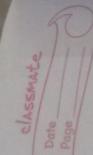
Section A-A'



Floor



Date \_\_\_\_\_  
Page \_\_\_\_\_

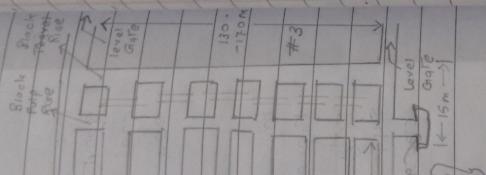


Date \_\_\_\_\_  
Page \_\_\_\_\_

The distinct layout is suitable for seam  
2.5 - 3 m thick and gently dipping.

In general mining, rectangular pillars  
are used because for square pillars  
development is costly and several jun-  
ctions will be encountered in square  
pillars. Whereas continuous cutting is  
deemed in case of rectangular pillars.

Square pillars have higher stiffness and  
square pillars are soft so can be  
easily cut by water.

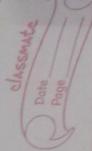


### Tinplate Classification

Also called Underground classification of  
coal.

Clean Coal Technology - Environment friendly  
methods avoiding air, action, land  
pollution. Dust, CH<sub>4</sub> are released into  
atmosphere. GHG gases are released into  
atmosphere.

- release of energy i.e. loss of energy
- carbon tax has to be spent on
- energy has to be spent on pumping ie cost factor



- greenhouse effect

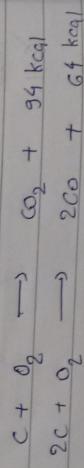
Coal liquification, Coal Bed Methane are some of the clean coal technology.

In situ Gasification means conversion of coal into gas at its place of origin.

Primary Gasification is the controlled heating and oxidation of coal at its place of occurrence.

Gasification is heating of coal with or without oxygen within the temperature range of 250°C.

Hydrocarbonaceous gases ( $C_nH_{n+2}$ ) is released



The energy released is used for the evaporation of moisture.

When air is enriched with oxygen it releases  $H_2$ .  $H_2$  enriched with  $O_2$   $\rightarrow$  Technological (50 - 65%  $H_2$ )