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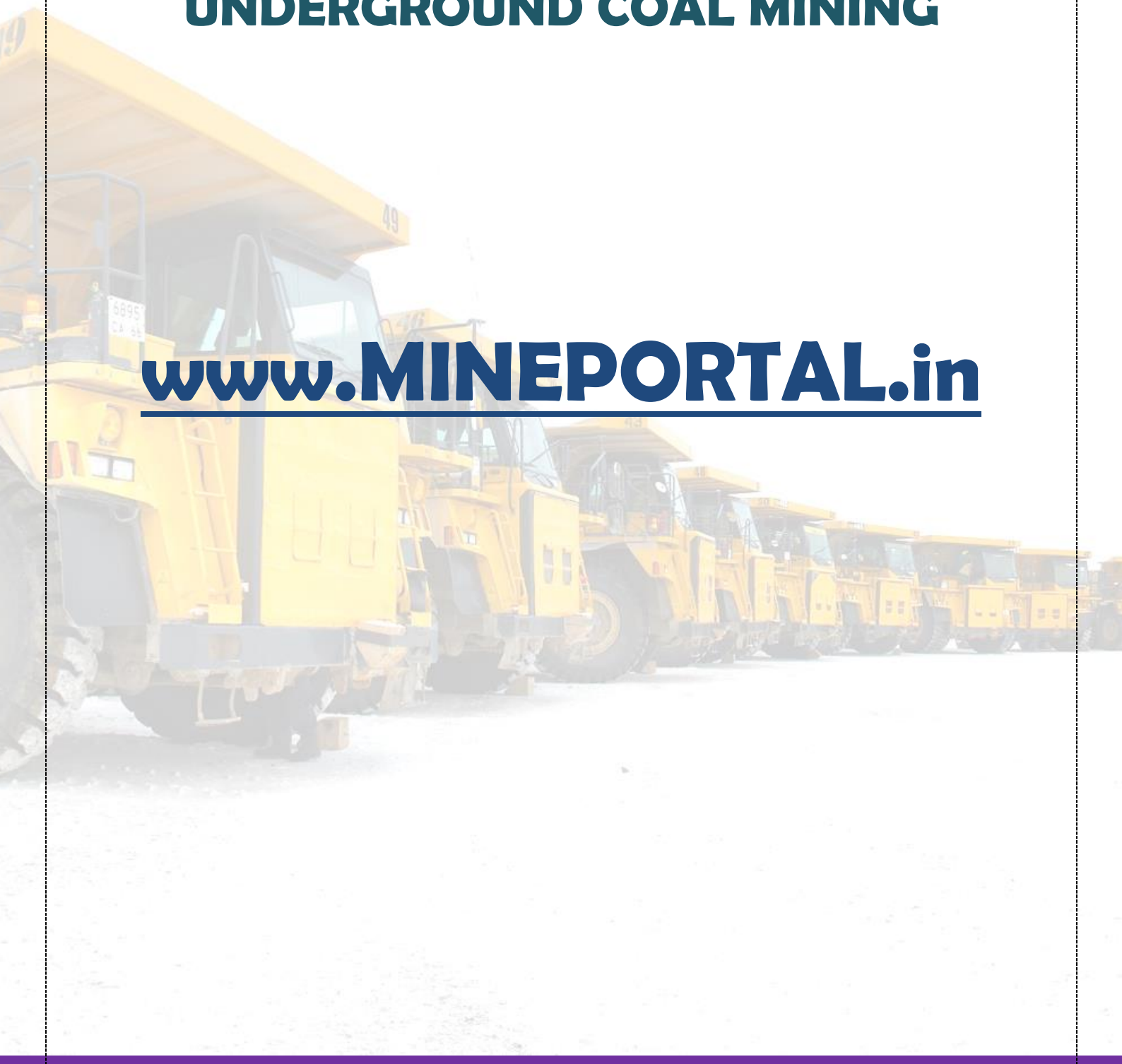
UNDERGROUND COAL MINING



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Coal Mining-II

by Abhijeet

Date 03/1/2014
Page

SYLLABUS

GLOBAL AND INDIAN STATUS:-

global and Indian status of different underground coal mining methods and scenario of coal production in India.

MINING UNDER DIFFICULT GEOLOGICAL SITUATIONS:-

Winning of contiguous, steeply inclined and thick seams - slicing methods, sublevel caving, integral sublevel caving, blasting gallery method and wide - stall method. Winning of thin seams - methods, equipment and associated problems. Situations of stress concentrations during winning of seams. Stress relocations. Winning of seams prone to gas outbursts. Winning of fractured and crushed seams.

HYDRAULIC MINING:-

Concept, hydro - monitors, coal fumes and pipes, hydraulic elevators and pumps, coal sumps. Layout of working or district and level systems.

IN-SITU GASSIFICATION:-

Concept, chemestry and applicability; Methods using underground excavations - vertical and directional linkages and ignitions.

Highwall Mining, Longwall Top coal Caving, Tilting and Blasting methods of N-E coal seams)

Thick Seam Mining (GSPS Sir)

- In India, a coal seam more than 4.5m thick is called thick seam.
In classification of coal seams in India according to their thickness is as below:—

- Thin seam : <= 1.5m
- Medium thick seam: >1.5m, <=4.5m
- Thick seam : > 4.5m, <=10m
- Very thick seam: >10m

However, the classification according to thickness varies from country to country.

Poland is the leader of hydraulic mining

Problems of thick seam mining by Conventional methods:-

1) DGMS restrictions, max. ht = 3m
Supports are not effective at greater heights.

- Mining of thick seam, fluidly very thick seam possess numerous problems. Unlike thin and moderately thick seam, thick seam is not mines in one section except in certain special methods like Blasting gallery method, hydraulic mining method, Sublevel caving method, etc.

Poland is the leader of hydraulic mining

~~The following problems arise in mining of thick coal seam~~

07/1/2014.

PR Sir :-

Room and pillar	Board and Pillar :-
→ strength of coal should be soft	→ any strength
→ wider pillars and galleries	→ narrow pillars and galleries
→ continuous miner is deployed for huge production	
→ supporting should be equally fast in match with cutting	
→ inclination of seam is a decisive factor in choosing this method	

In our country:-

→ hard, coal, thick coal seams ~~and dip dapes~~, prone to rock bumps, prone to rock bursts.

→ A seam ~~which~~ which is 5.5m thick can be cut by PERD in a single lift.

→ A seam greater than 4.5m is called a thick seam because

1.) it cannot be extracted in a single lift

2.) Beyond 4.5m it is beyond the reach of machinery.

3.) Powered supports are not effective, hydraulic ~~seal is not effective, efficient.~~

→ The limit of 4.5m ~~is~~ depends on technology and economy of the mining methods in a country.

→ Roof fall is a static failure, rock burst is a dynamic failure matches with explosive levels.

GSPS Sir

Benefit of thick seam mining:-

With a lower level of development cost we are able to get a higher level of production but we are able to reap this benefit only if we are able to extract the entire coal seam:-

Q) A 10 Km^2 coal seam 3 m thick is extracted upto only 70%. What is the volume of coal extracted.

A) Volume = $2.1 \times 10 \times 10^6$

= 21×10^6 m^3

If the seam is 10 m thick and recovery is 40% and 70%.

Volume (40%) = $0.4 \times 10 \times 10 \times 10^6$ m^3

Volume (70%) = $0.7 \times 10 \times 10 \times 10^6$ m^3

Any method that we want to implement to exploit the thick seam should be focussed the maximum amount of

coal ~~because~~ or else the potential, that the thick seam has is not realized.

The problems of thick seam mining:-

1) Selection of proper method:-

- Many methods have been tried for mining of thick seams from time to time but all the methods could not prove successful.
- About 27 different methods have been so far tried with certain limited success. All the methods suffer from high loss of coal, strata control and ventilation problems (larger amt. of gas liberated into the mine working)
- Among these 27 methods, ~~it~~ becomes very difficult to select a particular method in a specific condition ~~for~~ with a certain level of effectiveness because there are ~~some~~ problems in more than one dimension. This gives us the ambiguity to select a method of working.

2) Loss

- During the recent years, Blasting gallery method by Board and pillar system and integrated Sub level caving by longwall (only 1 mine) method have been tried with limited success.
- Conventionally, thick seam is mined in lifts or sections in ascending order in conjunction with stowing. Due to shrinkage of stowing material, usually the parting fails after 2-3 lifts are extracted.

each lift corresponds to 2.5 m. The highest lift that we have achieved is 4 lifts.

2.) Loss of coal:-
Huge amount of coal has to be left as parting between two lifts. Coal also needs to be left against protection of entries from one section to other section where simultaneous workings are made. Normally, not more than 40% of reserve is possible to extract in a thick seam.

Conventional method of thick seam mining (multiple bell B and P). We have multiple sections but access to each section is through the lowest section so irrespective of the section we are working, we have to structurally protect the lowest section. This increases the maintainance cost, higher and better support at the lowest section and all the access routes for assessment of the working sections have to be maintained by protective pillars and as development progresses the no. of access routes increases. and multiple routes are established. also all the transport routes for outbye transportation of coal have to be established in the lowest section and so these have to be maintained throughout the life of the mine. Inbye transportation systems are only in the working section which brings down the coal to the lowest section for outbye transportation. These transport routes have to be

~~existed~~ maintained throughout the ~~work~~ life of the mine. To add to this if 2 sections ~~workings~~ are worked out simultaneously then there is a lag to be maintained between the workings and if 2 sections are worked out non-simultaneously even there there is a strict schedule to be maintained.

Due to the above problems, recovery is not more than 40%.

3) Strata control problem:-

- Working of a thick seam in one section is limited to maximum 4.5m if coal has to be loaded manually as it is not possible to put supports more than 4.5m higher (there ~~is~~ axial stiffness decreases).

- Higher the thickness of the working, more is the problem of strata control. It becomes ~~the~~ difficult to control the strata in 3rd or 4th lift of working.

- When working in multiple sections the integrity of the floor is lost beyond 3 to 4 lifts and strong competent floor is required for multi section workings.

4) Problem of ventilation:-
When the coal is extracted in sections simultaneously, the air from one single intake route needs to be directed to different sections. Lot of air leakage is inevitable and minimum air reaches to the face. The working faces becomes hot and uncomfortable.

5) Problem of transport:-

- Coal from different lifts needs to be transported to a common point in a particular section. This needs elaborate and complicated transport system in each lift/section.

- Problem of supervision (supervision is required for safety) and coordination of works in each room (coordination is required to check weather the development is as per planning and if there is a problem in progress, then it can be mitigated with minimum cost)

If working 2 sections simultaneously then a particular log is to be maintained in the 2 workings. So in order to have a proper coordination in the 2 section, both should be supervised by a single person but there are 2 B and P workings with staggered faces at each level. So due to distant faces the same supervisor is unable to supervise the working in 2 B and P workings worked out simultaneously.

Classification of thick seam mining methods:—

1) Thick seam mining by Bord and pillar method
(one lift extracted only when (1st) lift is worked out)

- Non simultaneous extraction in lifts in ascending order with stowing. (1st lift is the bottom lift)

- From the floor of the seam, a lift of 3m high (on bord and pillar system) is developed and depillared with stowing. A parting of 0.5m is left and then the 2nd lift is developed and depillared in the same way and so on.

- Simultaneous extraction in section with stowing

- The bottom section is developed along the floor upto 3m height and then the 2nd section is developed up to 3m height from the entries of the first or bottom section. Then, both the sections are depillared with

stowing. while depillaring, both top and bottom sections can be heightened upto 4.8 m. But the parting between two consequtive sections should not be less than 3m.

- There is a definate lag to be maintained between the workings of 2 sections one above the other.
- The developed roadways of both the sections must be superimposed with each other. The bottom section may load by about one pillar during depillaring.
- Non-simultaneous extraction in sections in descending order with caving.

- A 3 m high section is developed along the floor and depillared with caving. The working is left for sufficient time (more than 2 years) to settle the goaf. Now, the 2nd and 3rd and subsequent sections are also developed and depillared one by one in the similar manner leaving sufficient time between two sections to settle the goaf.
- You have to have a very large mining property because of its slow pace.

- Simultaneous extraction in sections with caving

• In this case, the line of extraction of both the section must lie vertically one above the other. No lead or lag is allowed.
  - Blasting gallery method
  - Hydraulic mining method

2.7 Method of thick seam mining by longwall method -

• Access to all the above sections has to be from the bottom most section, 0.3 m section of coal is left between 2 sections. Longwall mining in lifts in ascending order with stowing by non-simultaneous extraction (conventional Longwall is used, no mechanized used)

• Longwall mining in lifts in ascending order with caving by simultaneous extraction (mechanised and non-mechanised both can be used)

• Longwall mining in descending order with caving by non-simultaneous extraction, leaving sufficient time to settle the goaf of previous lift.

- Simultaneous extraction of multi-lift powered support longwall in descending order with caving with artificial roofing / wire netting

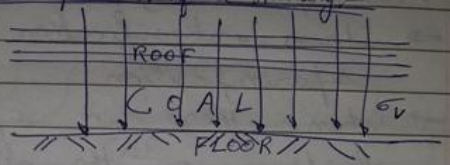
- Sublevel caving

- Integral sublevel caving.

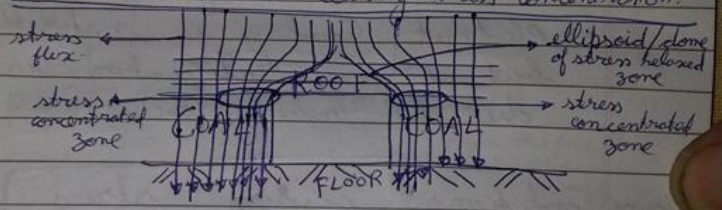
Blasting Gallery method of thick seam mining

Illustration of basic concepts of stress redistribution and stress concentration and superposition:-

Insitu state of stress before mining:-



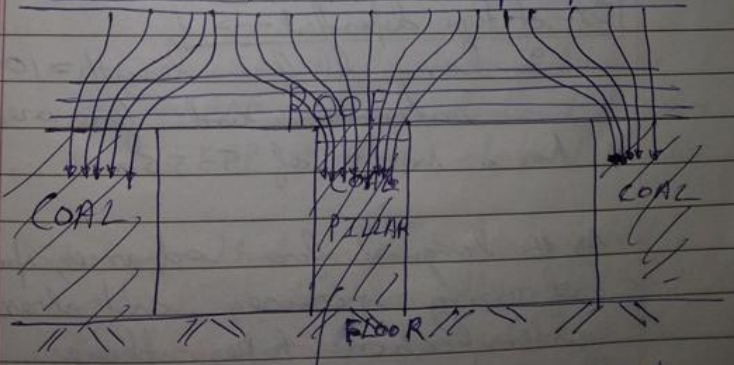
Stress redistribution causing stress concentration:-



→ Due to a narrow excavation, the insitu state of stress is disturbed and it causes stress redistribution.

→ All stress flux pass through the coal abutments causing stress concentration (abutment loading) on the abutments.

Stress Intensification due to superimposition:-



This pillar is subjected to extreme stresses due to intensification.

20/01/2014

PR Sir

→ Abutment loading is stress concentration.
→ Stress intensification is stress superimposition
→ When there is superimposition of stress on the abutments then stress is intensified.
→ Abutment loading is natural but stress intensification is due to mining practices.

dip ↓ RAP

Mining Conditions causing stress intensification:-

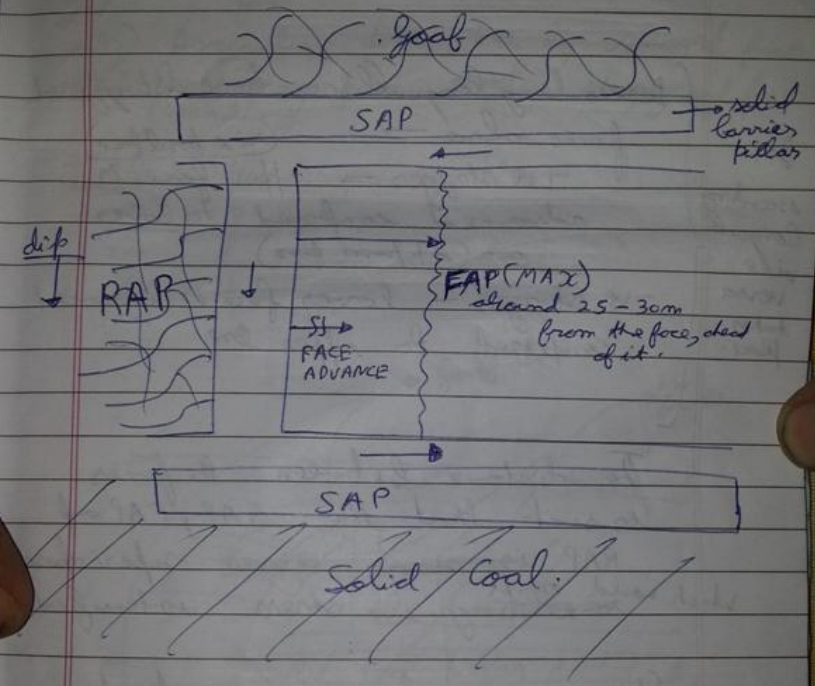
Stress intensification is due to:-
(a) superimposition
(b) time dependent

Ex. of time dependent →
In longwall face length = 100 m minimum and face area has a width of 5-5.5 m

As the longwall face advances, span of mining increases and stress intensification takes place.

In longwall there are 3 types of abutment loading

1.) front abutment
2.) rear abutment
3.) side abutment.



SAP → Side abutment pressure
RAP → Rear abutment pressure
FAP → Front abutment pressure

Stresses that are redistributed ahead of the face, the abutment loading (stress concentration) is called FAP.

Similarly there is stress concentration on the sides and rear of the face.

⇒ Stress that has redistributed behind the face in the goaf area is called RAP.

The example shown here is a descending longwall — the upper part is the goaf area.

In descending longwall vice versa takes place.

Descending longwall can have staggered faces also → (rise panel face)

+ve stagger = upper face is advanced compared to lower one (dip panel face)

-ve stagger = lower face is advanced compared to upper one.

The distance between the faces is such that the SAP, FAP of RAP ~~is never~~ never superimpose which would result ~~in~~ in stress intensification.

dip

Staggering is done in order to avoid stress superimposition. Minimum stagger is 25-30 m because FAP is max at a distance of around 25-30 m ahead of the L.W. face.

In case of zero stagger → there is stress intensification due to superimposition of FAP, SAP and RAP and thus should be avoided as it is a dangerous situation.

GOAF

FIG:

I | Retreating Longwall

1.) Descending LW positively staggered faces
2.) Descending LW negatively staggered faces
3.) Ascending LW, +ve ly staggered faces
4.) ~~Descending~~ Ascending LW, -vely staggered faces.

II | Advancing Longwall:-

1.)
2.)
3.)
4.) } Same as above.

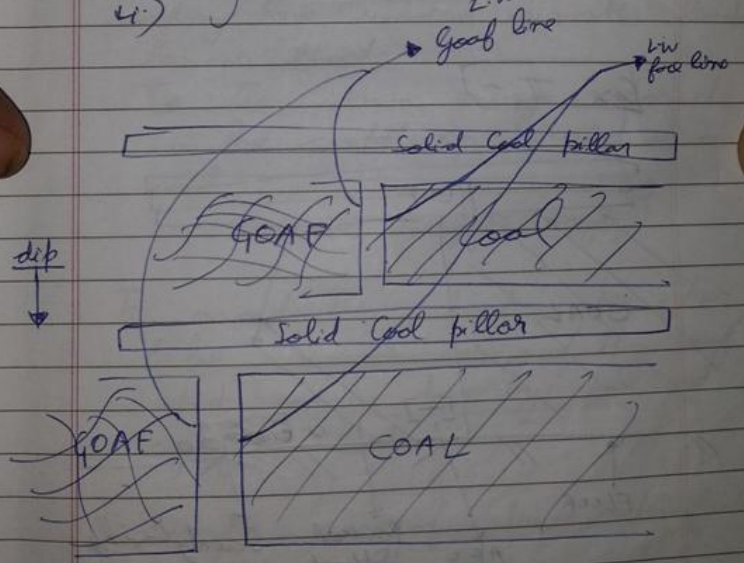
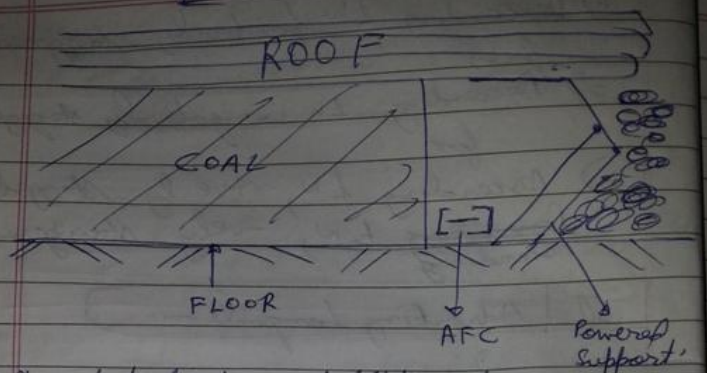


FIG: tvely staggered Longwall panels

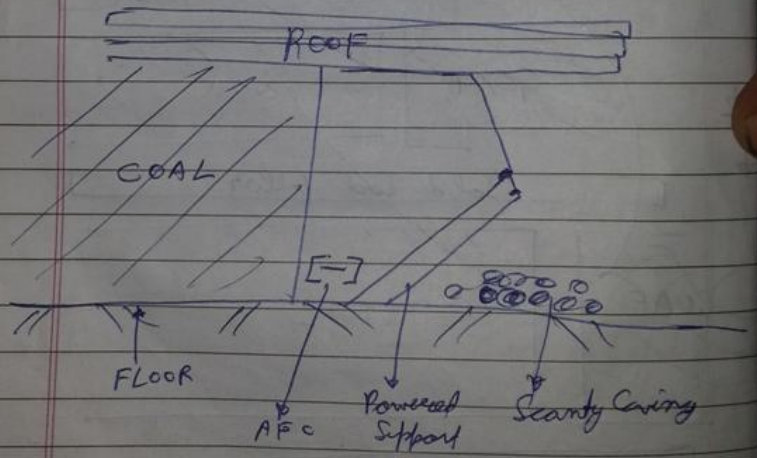
Case I:-



→ Immediate roof caves to fill the goaf area.

Sectional view of a LW face

Case II:-



In this case the roof is massive, competent and it is not caving. The roof behaves as a cantilever keyed at the face.

As the face advances the span of hanging roof increases and so it stores more and more strain energy and stress intensification takes place.

And after a time the roof undergoes dynamic failure leading to a sudden disaster leading to air blast.

The strain energy stored in the cantilever keyed at one end :-

$$\text{strain energy} \propto (\text{Length})^5$$

To avoid this situation there has to be regular caving of the roof which can be done by induced caving methods.

This is the case of stress intensification in L.W. with time.

Next situation of stress intensification is :-

Staggering Vis-à-vis aligned faces in multi level longwalling

If forces are alligned then there will be superimposition of stress concentrations.

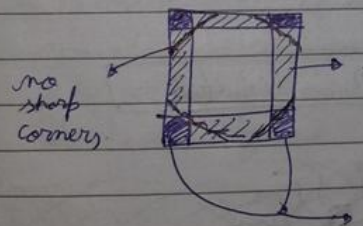
23/01/2013.

PR Sir

When the coal seam is thick then it is worked in several lifts. In between the lifts there is a parting whose thickness depends on the surrounding rocks and coal. This is called multi lift mining.

Situation of stress concentration:-

1. cantilever situation
2. Due to load on undersize pillar, they are subjected to stress concentration due to abutment loading and will lead to its failure. (given due to the natural stress distribution)
3. In longwall → staggering of faces
4. Sharp Corners.

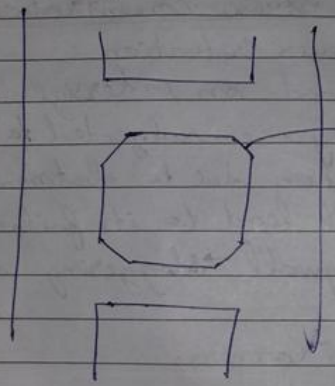


the sharp corners in the pillars are regions of stress superimposition leading to stress intensification.

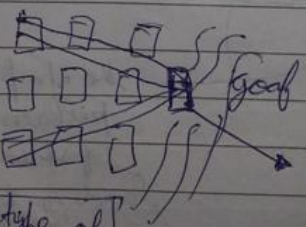
So in case of deep mines which are highly prone to stress concentration the pillars are rounded at the

Same situation takes place with rectangular shafts so circular shafts are preferred.

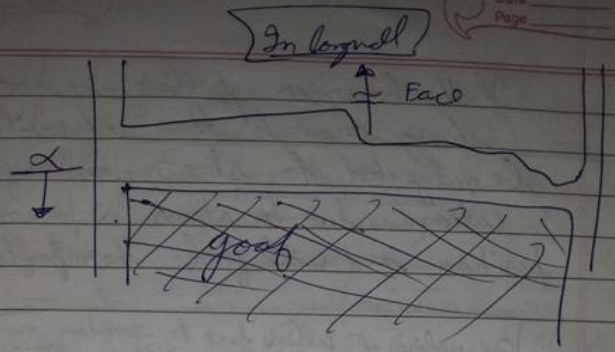
So depending on rock condition, rock strength pillars are chamfered to avoid stress concentration and hence subsequent stress intensification due to superimposition.



5.) Angles and Discontinuities :-



depillaring V-type of extraction



Due to operational inefficiency if a straight line of face is not maintained then there is a geometrical discontinuity in the line of extraction. Stress distribution picture changes. Such situation arises because in LW the shearer operator is unable to see whether the shearer is cutting in a straight line or not due to high coal dust production.

In B and P → if we are unable to maintain a diagonal line of extraction then we end up in ~~this~~ geometrical discontinuity.

6)

If the barrier pillar is not strong enough then it will be subjected to stress intensification due to stress superimposition and will fail thereafter.

Overriding of pillars due to random mining practices:

7) Chowkidaar pillars are left irregular pillars (w.r.t. shape, size and location) in the goaf area will randomise the stress distribution and will create problems in the panel area. They will lead to overriding of pillar due to improper distribution of stress if they suddenly fail.

30/01/2014. PR Sir

overriding of pillars ~~⊛~~ When load on the pillar is greater than the designed capacity. ⊛ When load of a pillars is transferred to other pillars. It leads ~~pillar in the smaller unit of extraction~~ & to stress ~~concentration of~~ intensification ~~on~~ finally leading to failure of the pillars.

Reason:- Random mining practices. No particular line of extraction is followed.

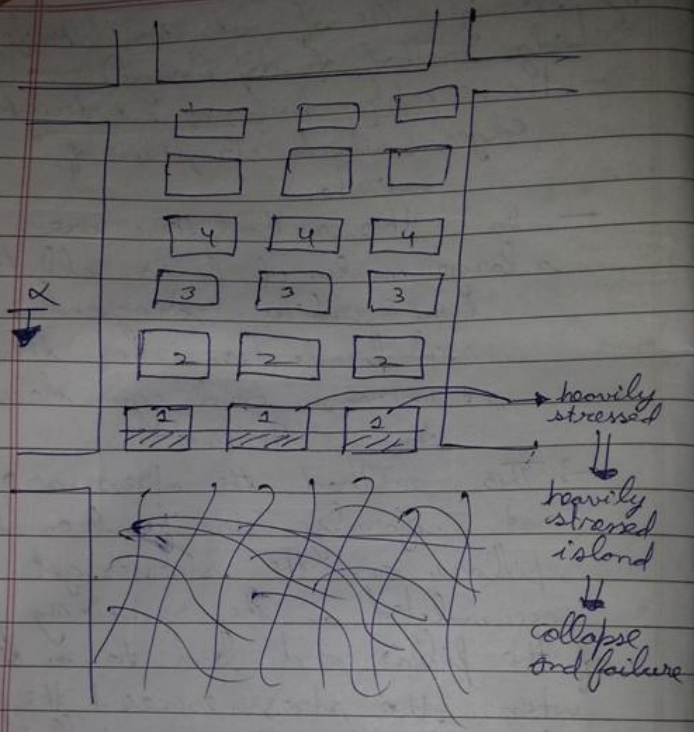
8.) **Straight line of extraction (knife edge method of depillaring) →**

– When we cut by a knife, we cut straight edges similar to straight line of extraction

– In this method there are a large number of faces all the time unlike diagonal where initial production is low then it increases and again decreases towards the end

– In this method the stress are not uniformly transferred on the pillars. and the stresses get accumulated on the remaining part of the pillar and lead to collapsation when the stresses exceed the designed strength of the pillars.

In diagonal and steep and step diagonal line of extraction due to the obliqueness of the line of extraction the stresses are uniformly distributed over the remaining pillars and there is no overriding of pillars as in the case of a ~~stray~~ straight line of extraction.

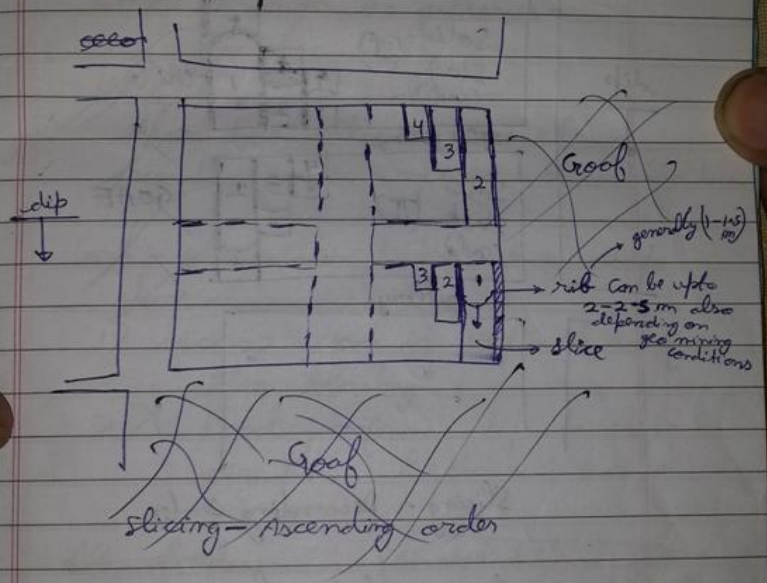


As the extraction continues the pillars become thinner and thinner and they become islands which are highly stressed and then these remnant pillars will suddenly fail and there will be a sudden transfer of stress onto the other pillars.

If the first pillar is strong then it is safely extracted but at some

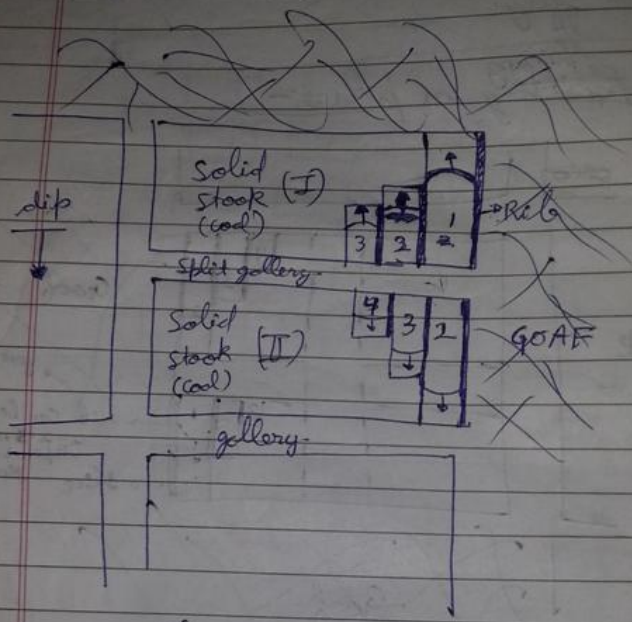
point the pillars will fail and we will not be able to extract all the pillars safely

9) ~~Splitting~~ Slicing of pillars:-



As we move from Goaf → solid → it is okay; as we go on extracting the goaf can be isolated

but extraction from solid to goaf is dangerous as there is stress concentration ~~and~~ leading to stress intensification since again island like situation is created.



Slicing - Descending order

goaf → solid coal → OK

solid coal → goaf → Not OK → the slice will become an island and it will get crushed.

→ For extraction of stook (I) we drive rise slices through split gallery because to drive dip slices we have to move in goaf which is not possible.

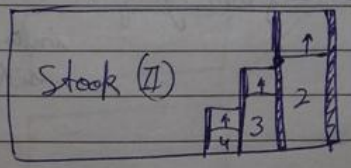
→ While extraction of stock (II) we ~~will~~ can drive dip slice from split gallery but we have to work close to the goaf area, which is dangerous so it is avoided so we drive rise slices through the galleries.

Hence we can conclude :-
descending order → rise slices
ascending order → dip slices are driven

rise slices are better than dip slices :-
1) because coal is exposed easily after blasting
2) loading from dip to rise direction becomes easier.

~~No of slices~~

correct diagram for 2nd stock with rise slices :-



No of slices in a pillar are fixed according to the maximum allowable area of exposure of slices:

In case of caving it is around $60-70-80\ m^2$ area

In case of stowing it is $120-140\ m^2$ area

This area can be exposed in 1 slices or 2 slices or more.

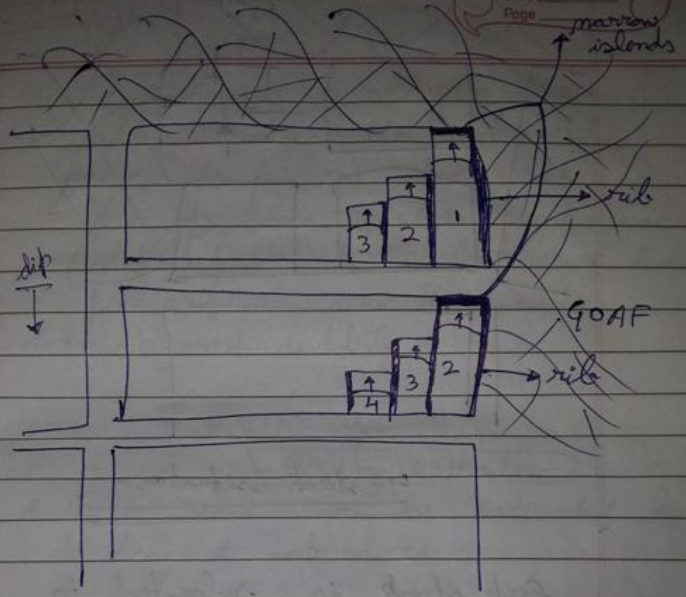
∴ generally in Indian geomining conditions:-

stowing → 2 slices

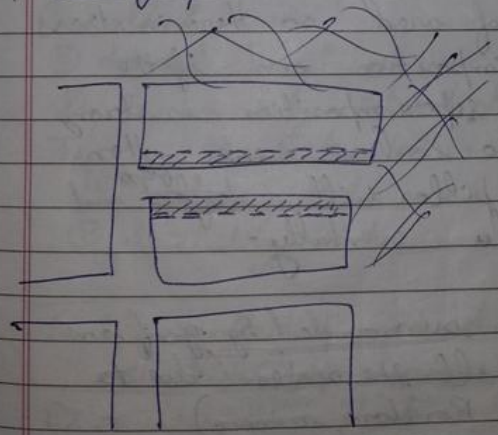
caving → 1 slices

10.) narrow island at the end of slice → Heavy stress concentration from goaf → stress intensification situation

11.) Rib also behaves as a narrow island and is subjected to stress concentration from goaf on 3 sides and will get crushed.

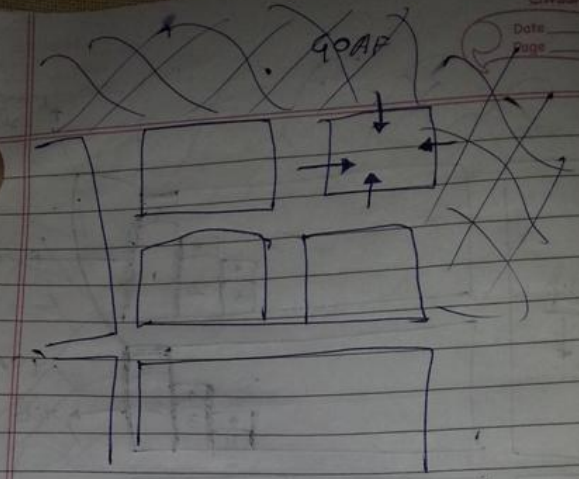


12.) Stoking operation :-



2 - stook situation

splitting of pillar results in stress concentration and stress intensification

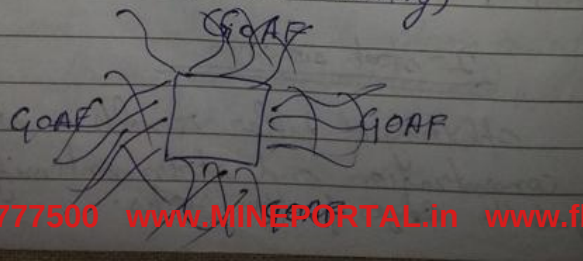


4-stock situation:

Each stock is subjected to stress from all 4 sides due to cross galleries and the goaf area so there is stress superimposition and if the stress superimposition is strong and the coal is weak then the pillar will collapse and fail eventually.

Chowkidar

13?) ^ Pillar surrounded by goaf on all the sides (due to Random mining)



Because when it will fail, it will suddenly transfer the load onto the other pillars which will be a problem of stress intensification and potentially cause failure of those pillars (Furthermore the load is transferred suddenly.)

31/01/2014. R Nath Sir

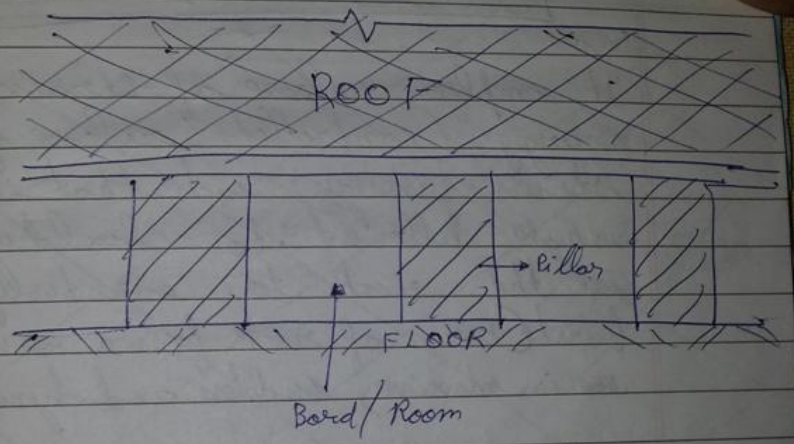
Slicing Methods:-

A thick seam can be extracted by dividing it into slices.

In 2nd and 3rd slice – the roof behaves as a dead mass and yield of friction props has only upto 15 cm.

20/02/2014. PR Sir

14.7



Multiple opening under strong cover –

* Under strong roof we are very sure so we tend to extract pillars without support. But when this roof will fall then it will create a havoc and there will be loss of coal and it will be a hazard.

Since this leads to stress concentration so it will fail eventually as pillars are extracted. So we should be very cautious for support.

(*) We cannot go for Roof bolts since it is a load support instead we should go for filling the void, ~~But~~ Partial Extraction.

STRESS RELAXATION

It implies release of strain energy (controlled release of strain energy) such that it is not allowed to build up in the rock to eventually burst (Form of rock failure ~~is~~ which ~~is~~ is massive, sudden and dynamic)

How is stress released??

By making some drill holes or light blasting or other methods, cracks and fractures are ~~are~~ are created so that

weak and it yields to release strain energy.

Techniques of stress relaxation:-

(i) Destress Drilling
(ii) Destress blasting
(iii) Destressing by undercutting
(iv) Destressing by induced caving
(v) Stress relaxation ellipsoid method
(vi) Destressing by augerholing.

03/03/2014. PR Sir

Stress Relaxation Techniques:-

AIM:- Making structure weak by inducing ~~Destressing by drilling~~ weakness ~~in the~~ planes in the structure so that it fails.

Stress relaxation techniques are:-

1) Destressing by drilling
2) Destressing by blasting
3) Destressing by undercutting
4) Destressing by induced caving
5) stress relaxation ellipsoid method
6) auger drilling.

Destress drilling → In all situations we can go for all the methods of ~~fail~~ ~~for~~ destressing in all the structures except undercutting. When we have to induce minor cracks, small cnt of fissures, fractures are required. Structures ~~with~~ which are not very strong they can be weakened by drilling. We can go for destressing by drilling in pillars, splits, stoops, web of longwall face etc.

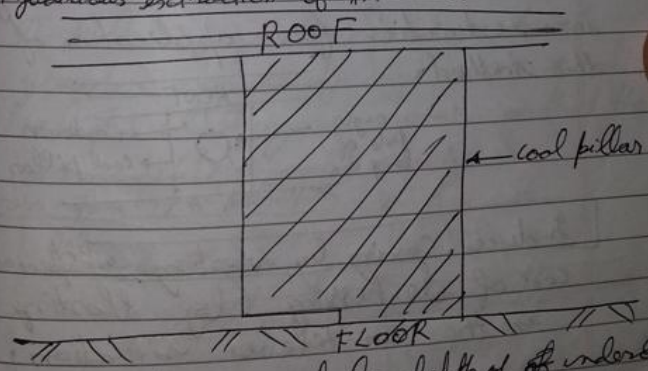
The rocks/coal should not be very strong so that it

In case of strong rocks, light blasting is done.

Destress blasting → If By drilling, weakness cannot be induced in structures. It is not production blasting only light blasting is done to induce cracks, fissures etc. In cantilever, pillars, rib, web etc. destress blasting can be done. Decoupling of charges is done for light blasting i.e. large diameter holes are filled with small diameter charges ex) 38 mm holes charged with 19 mm explosive column (50% decoupled)

Coupled charge → dia of explosive = dia of hole

Undercutting → strong pillars in hard and brittle coal is subjected to undercutting. It is not adopted in all structures. It can also be done in ribs while retreating from the slice for judicious extraction of the ribs.

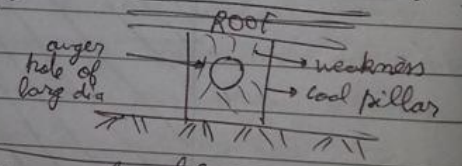


The thickness and depth of undercut depends on the governing conditions.

If coal is strong, length and thickness of hole is increased. Thickness is ~~width~~ can be upto 1/3rd of the pillar

To depth is not upto 1/2 the pillar width because the stress concentration takes place only on the ~~sides~~ edges of the pillar.

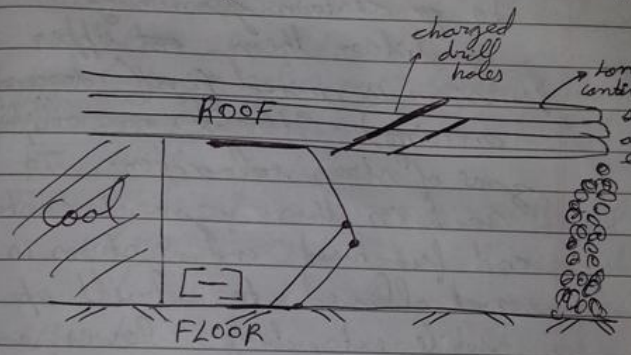
auger holing → A very large dia hole (around 57 mm) hole is made in the centre of the pillar. Around this hole weakness planes starts ~~from the~~ and destroys the integrity of the pillar. Auger holing is done when augering is done for development for the faces of bords or depillaring also. That same machine can be used for this technique as well. Machinery is a restriction for application of this method.



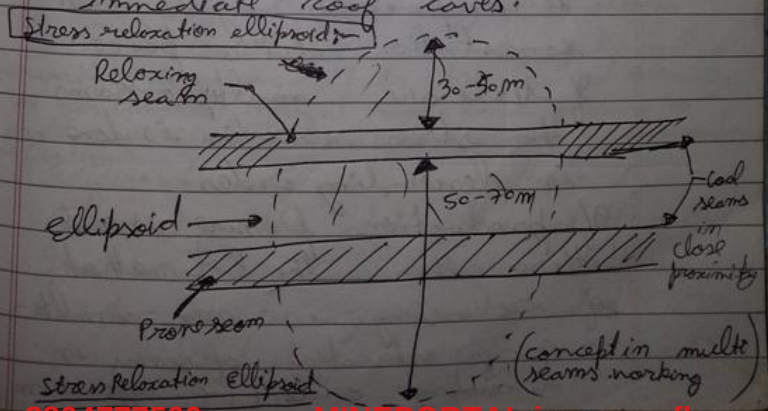
Induced caving by blasting → special case of destressing by blasting in the cantilever situation.

Strain energy in cantilever $\propto$ (length of cantilever)^5

The cantilever becomes is supported at only one end. In longwall if the cantilever remains non-yielding and the strain energy accumulated in this cantilever is released by induced caving by blasting using inclined holes made from the openings between powered supports.



The holes are inclined to touch greater length of cantilever and light blasting is done so that the immediate roof caves.



If both seams are mined simultaneously then:-

Minimum staggers = 2S

$S = 12t + 3.5t^2$ → t = thickness of relaxed seam

S → spacing between the coal seams.

In case caving is adopted (normally caving of upper seam is done) then minimum spacing between the seams should be this

The staggering should be +ve i.e. upper seam face should be ahead of lower seam face

Suppose lower seam is prone to stress concentration due to certain geomining condition then upper seam is mined first (descending mining). It creates an elliptical zone of stress relaxation. The rock in this zone is crushed and fractured and stress is not allowed to built up while extracting lower seam. But the stress relation period is finite. If after a long time the second seam is mined out then due to compaction again stress concentration takes place.

If there are multiple seams then stress relaxation is done in descending order.

If production pressure is not there then the best method of relaxing is non-simultaneous extraction of seams in

is fully extracted and then the lower seam is mined out.)

Underground Coal Gasification OR Insitu Coal gasification

Insitu gasification → Primary gasification technique, the coal is extracted in its place of existance and is gasified.

Secondary gasification → coal is cut, loaded, hauled to surface and then converted into gas.

~~Secondary gasification~~

Insitu Gasification:-

Technique of conversion of coal in its place into gas by sending air enriched with oxygen without sufficiency of air at very high temperature.

Reasons:-

1.) greater depth seams
2.) difficult geomining conditions
3.) Clean coal technology, the coal is converted into gas and it is transmitted directly to gas powered thermal ~~stat~~ power plants. No problem of CO_2 and CH_4 released in air due to secondary gasification.

CMM → when coal is cut, methane is released in the atmosphere of the mine. It is called coal mine methane. Due to Insitu gorification the CMM is inhibited from being released.

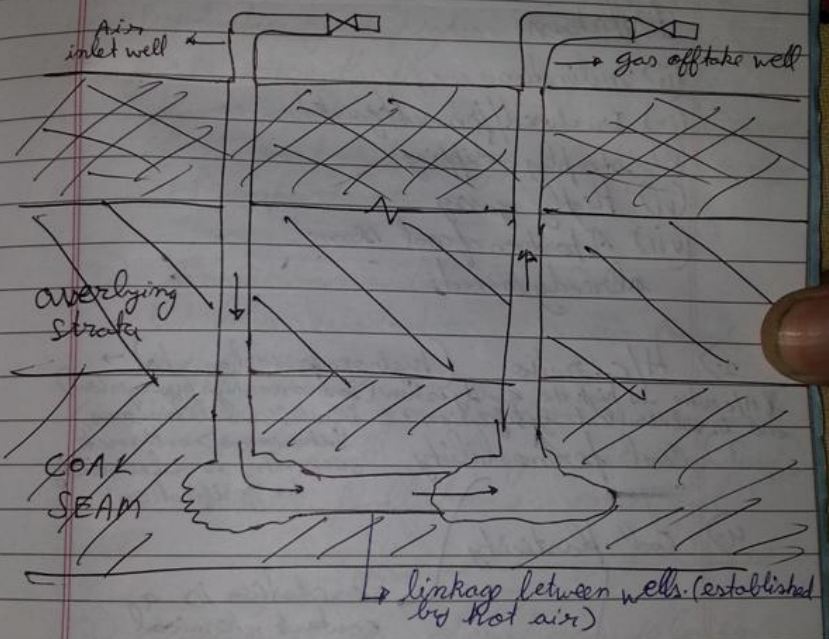
And ~~method~~ methane is:-

1) dangerous
2) Ventilation problem is erected
3) It is a green house gas so increases temperature.

Hence to prevent these problems, Insoto gassification is adopted.

In brief → large diameter holes (wells) are drilled called injection well and production well. Through injection well air at around ~~600°C~~ 250-900°C is sent enriched with O_2 which causes controlled oxidation of coal and from the production well the coal gas is obtained.

A representative scheme of in-situ gasification by non-mining (percolation method):-



⇒ The face in this mining method is called a "fire-face".

⇒ This 2 well pattern is repeatative in a grid pattern in 3-D giving large scale gasification.

Applicability Conditions:-

1) Seaming Conditions
   (i) Depth
   (ii) Thickness
   (iii) Inclination
   (iv) Fractured/fissured/jointed
   (v) steeply dipping
   (vi) Highly gassy
   (vii) A portion of coal seam already mined

2) H/C ratio (hydrogen to carbon ratio) →
   (low carbon, high hydrogen coal)
   lignite > sub-bituminous > bituminous > anthracite
   according to vulnerability to gasification
   If H/C ratio is high the quality is low and is vulnerable to gasification.

3) Coal permeability

4) Coal plasticity

oxidation is a contact chemical reaction and so the coal permeability is important for effective gasification. So cracks, fractures, etc. are catalytic to gasification.

When the coal has a high plasticity then its swelling tendency is more so permeability of coal is reduced ~~but it is~~ so plasticity is deterent to gasification. Plasticity causes closure of the cracks inhibits ~~from~~ traverse of hot air in the coal matrix.

Insitu

Merits of gasification:- (non-mining)

1.) Safety and productivity is enhanced due to gasification. Productivity is higher because the gas is directly transmitted to the plants and there is not requirement of support, drilling, blasting, loading, transport etc

2.) Environmental benefits.
(i) less evolution of green house gas
(ii) land degradation is minimal (no coal washing units required)
(iii) water pollution is minimal

3.) Economy of operations is lower. (operational economy, environmental economy)

4.) Flyash generation in thermal power plant is eliminated

5.) Increased inventory of the coal → unmineable coal seams are put under the domain of minable coal seams due to insitu gasification.

6.) Lesser labour required.

Limitations :- (non-mining)

1) Control on the process of gasification is difficult from the surface
2) Continuous flow of gas is hampered if a stone or dirt bond in the coal seam
3) quality of gas is not ensured
4) quantity of gas is not ensured
5) Ground water pollution and any aquifer nearby is heated up and so it dissolves more impurities causing AMD problem.
6) The method is very restrictive in nature. (Floor and roof of the seam should be non-permeable, drilling upto higher depths is difficult)

03/02/2014.

PR Sir

Mining method of gassification — 1) huge / modest amount of development work is required in the Underground.
2) Manpower requires to go underg

3.) Productivity may be low
4.) Safety aspects play a critical role

Non-mining methods are considered more suitable particularly for coal seams at deep horizons (900m or 1000m) for in-situ - gasification.

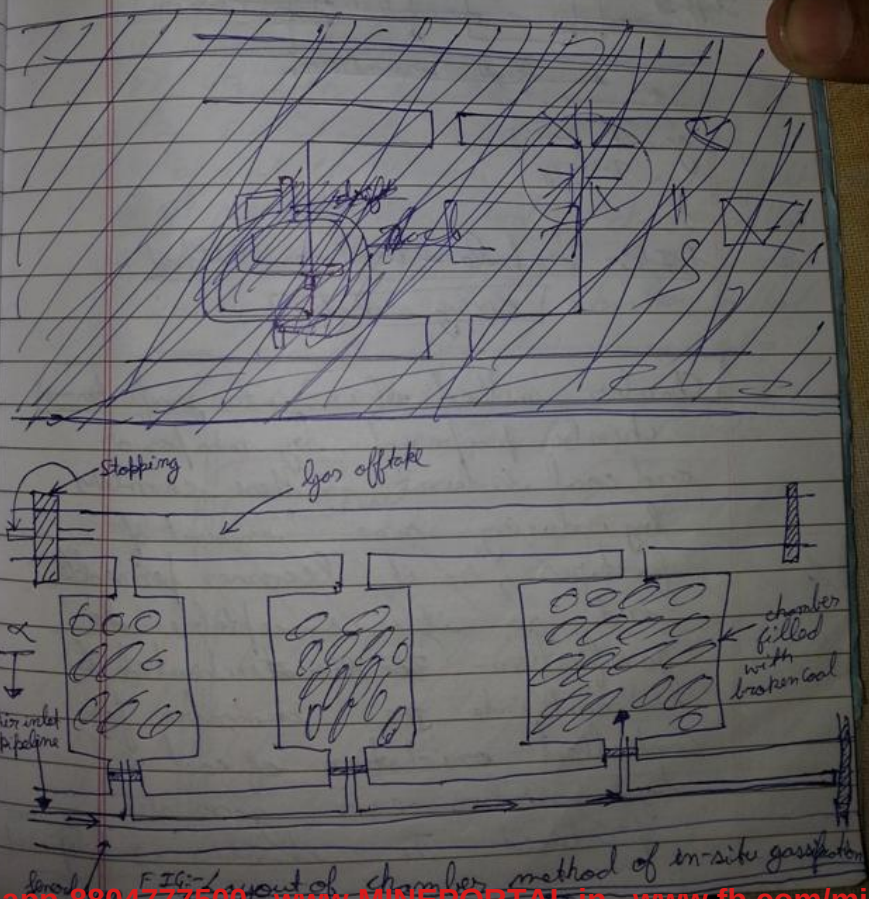


Fig:- Layout of chamber method of in-situ gasification

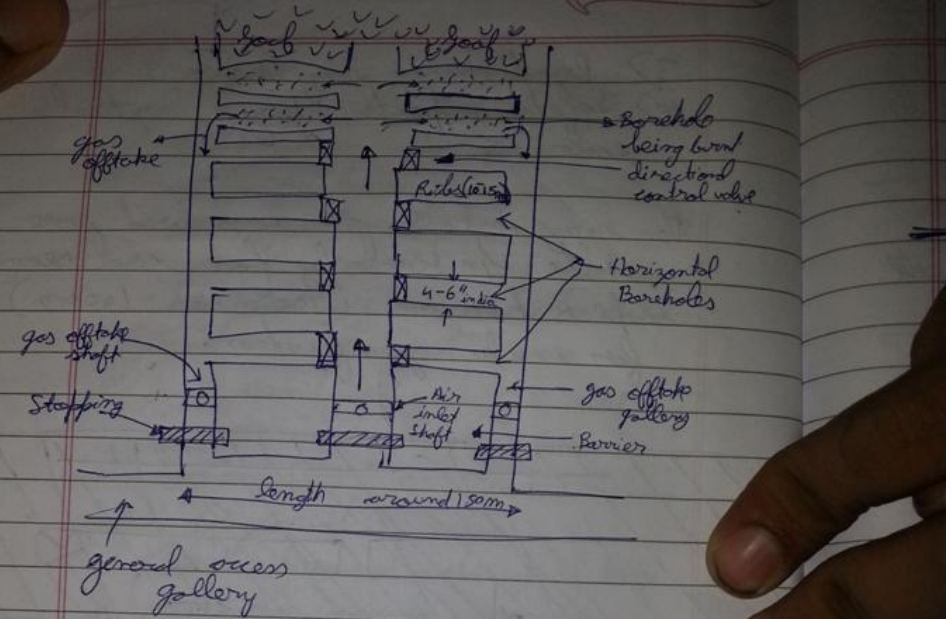


FIG:- Borehole - Producer method

Mining methods:-

Chamber method of in-situ gassification →

chambers prepared by man power and coal is burnt in these chambers by inducing some amount of fractures, so it becomes permeable and so it is susceptible to gassification. ~~The~~ Air ~~at~~ in heated ~~to~~ and sent into the chamber for controlled oxidation of coal and hydrocarbonaceous gases are produced. The chamber is prepared

overlying strata

coal seam

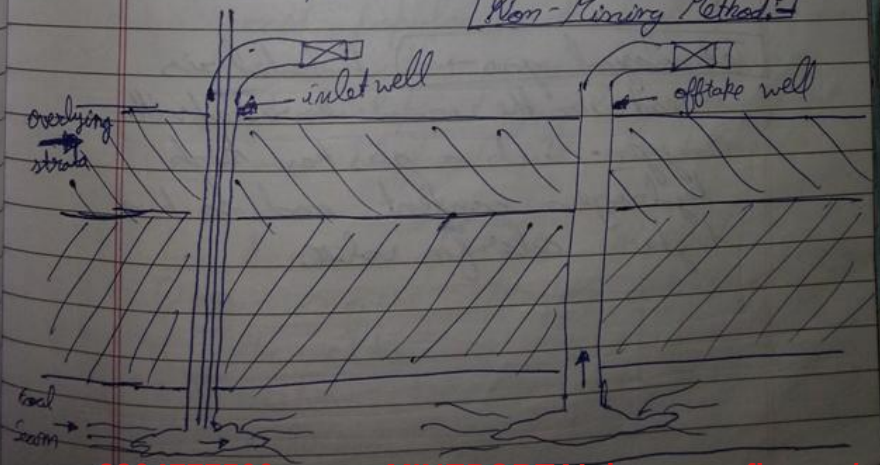
by light drilling and blasting, so fractures are induced and surface area for oxidation increases improving efficiency of gasification.

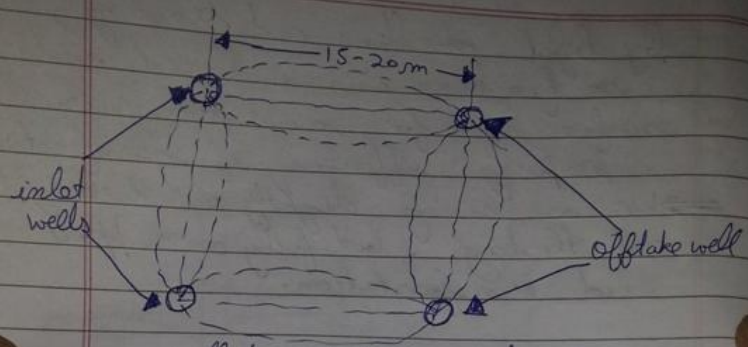
→ We are saving slightly on drilling and blasting, but fully on support and transportation.

Bore-hole producer method:→

- Huge development work.
- 3 shafts required → unlike 1 or 2 in chamber method and sinking of 3 shafts is very costly and difficult.
- Moderate development in chamber method.
- Bore hole method requires higher permeability of coal while chamber method can be applied in case of a low permeability.

Non-Mining Method:-





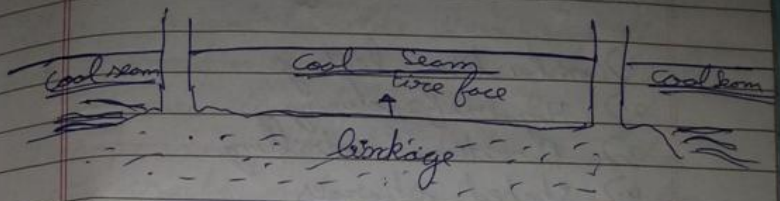
Smallest repetitions grid of inlet / offtake well

* Production wells around 20" in diameter

Power gas → Preheated air is sent into the seam last oxygen content is normal.

Technological gas → Preheated air is sent in the seam enriched with Oxygen. Such a gas has high hydrogen content and so have higher calorific value.

With passage of time :-



- First a linkage between the wells is established and a fire face is formed
- Then the fire face progresses to result in full scale production
- Minimum distance between the wells is 15-20m and if permeability of coal is less than distance between the wells is reduced.
- Percolation method is the most popular method of gassification because other methods require shaft development, gallery development are are difficult to implement.

For the success of this method :-

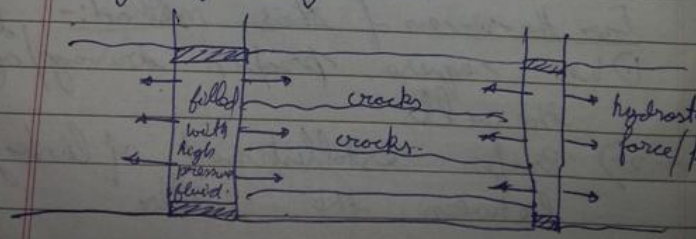
1) We require proper drivage/development of the wells
2) Proper establishment of linkage between the wells

Establishment of linkage between the intake and offtake wells:-

1) Combustion linkage
2) Hydrofracturing
3) Directional drilling
4) Shaped charges
5) Electro - linkage

1) Combustion linkage → Initially the heated air sent percolates through the cracks and then establishes the linkage between the wells which were initially not connected. This method is used when coal is permeable and has large no. of cracks and fractures. Due to controlled combustion, a combustion front has been developed which advances to form a linkage between the wells.

2) Hydrofracturing →



Applicability:-

(i) Coal seams which are very impermeable where combustion linkage alone is not possible then the portion ~~location~~ of the well in the coal seam is filled with high pressure fluid which generates cracks and fractures and then this is followed by combustion linkage. But this method becomes expensive.

(ii) If the coal seam is very soft, weak and friable then hydrofracturing alone can form a linkage between the wells. The process of hydrofracturing is liberal enough to form a proper linkage between the wells.

3) Directional Drilling →

With the help of adaptors and diverters the vertical hole drilled from the surface is diverted in the horizontal direction to form a linkage between the wells.

(weight and shape of charges controlled, charges decoupled)

4.) Shaped charges → We adopt for light blasting and depending upon the shape of charges (spherical, cylindrical, conical) the intensity of blasting is controlled so as to form cracks and fractures and not to entirely break the seam.

5.) Electro-linkage → Electrodes are sent to the bottom of the wells and a high potential difference is maintained between the intake and offtake well. Due to the potential difference, a large amount of directional current flow through the coal and heats it. This converts coal into ash which is blown out by a flushing air current and linkage is established between the wells.

R. Nath Sir (28/03/14)

Inclined Slicing with Caving in descending order:-

The method discussed till now involves non-simultaneous extraction of slices but production level is reduced to a large extent as instead of extracting one slice and then extracting next full size slice is given [illegible] and then next slice is opened; so generally a distance of 50 feet

10/04/2014.

PR Sir

Hydraulic Mining Of Coal

→ Hydraulic Jet assisted cutting
→ Very popular for placer deposits which are soft and friable to be cut by water jet pressure
→ Coal is also soft which can be cut by a strong water jet which impinges into the coal and then coal is also transported using water pressure.

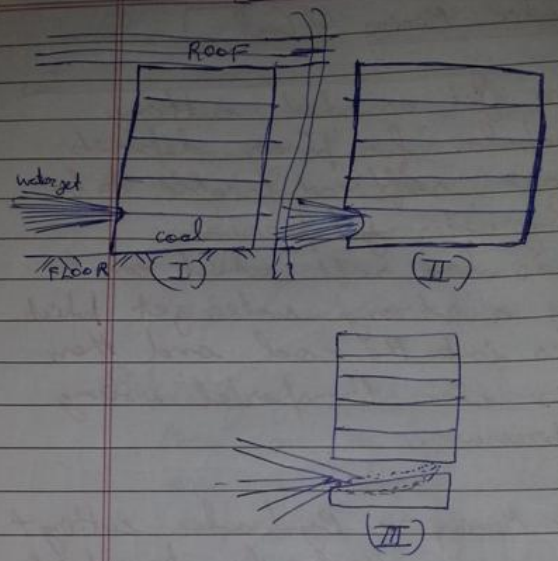
Hydraulic Mining → Hydraulic cutting + Hydraulic transport

→ But Indian coal is very hard and in one of the mines of BCCL, it was implemented unsuccessfully. Because coal was hard enough so energy (power requirement was very high.

Basic phenomenon:-

1.) Strong water jet impinges the coal and cuts it
2.) Coal should ~~be~~ have sufficient number of weakness planes.

STAGES OF Hydraulic Mining



→ The coal is extracted in a wedge-manner because at the entry point the pressure of water is very strong while its energy reduces as the water cuts into the coal.

FIGURE-I:-

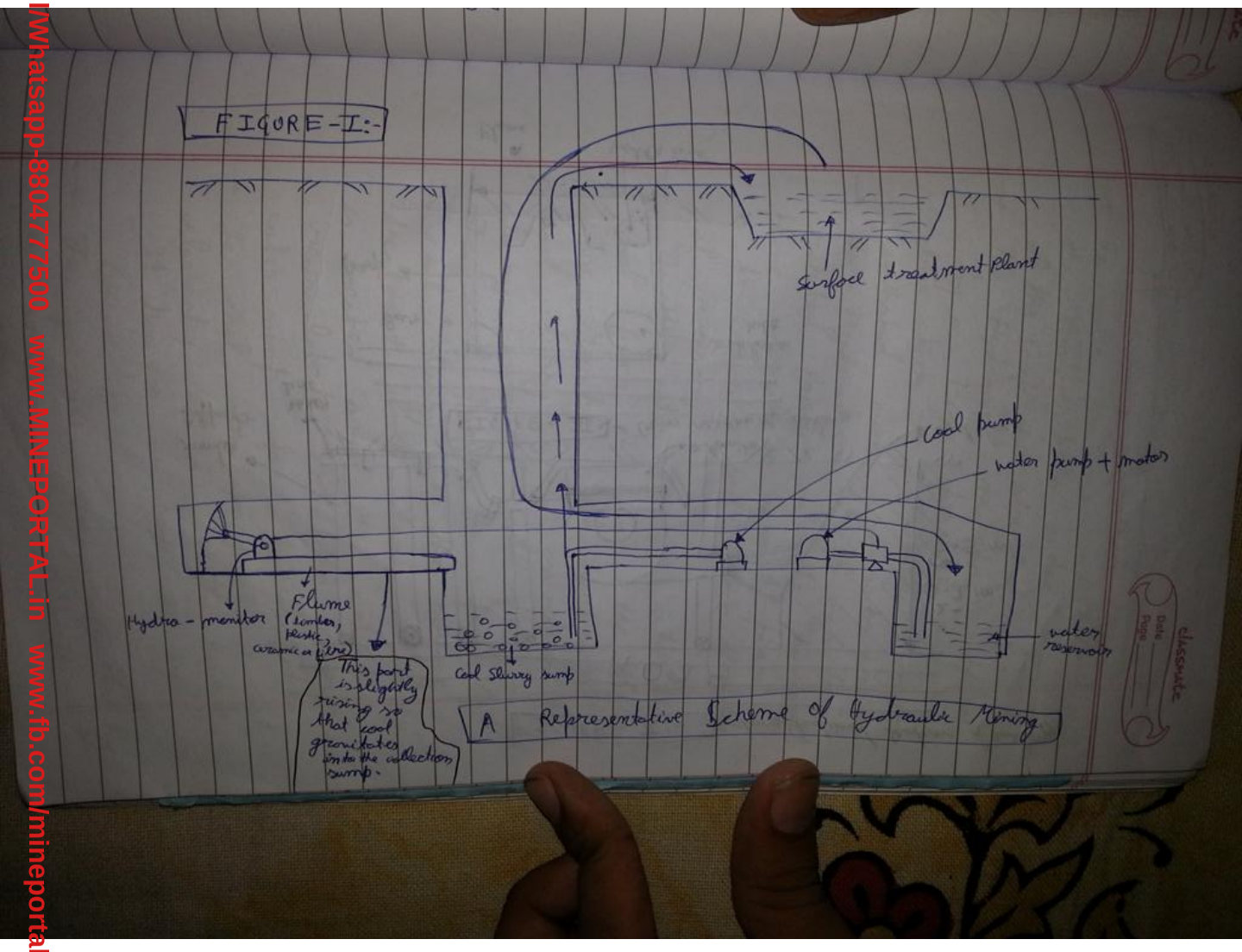


FIGURE – II :- – Longitudinal section of gallery

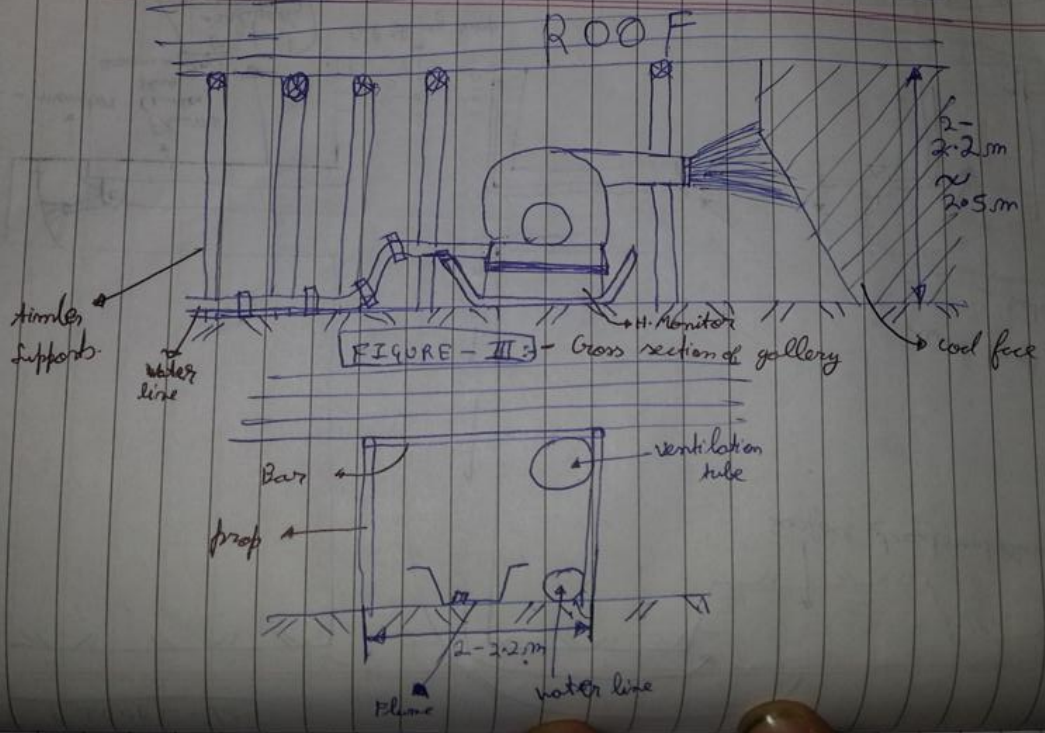


FIGURE – III :- Cross section of gallery

WORKING OF Hydraulic Mining:-

→ The water pressure should be 50 times the Protodyakonov index (a measure of the Compressive strength of coal)

→ The Hydraulic monitor is supplied by a high pressure water line which is sufficiently strong to withstand such high water pressures

→ The Hydraulic nozzle can be rotated freely in the horizontal plane as well as vertical plane to cut the coal from the walls if necessary.

→ As the water pressure cuts the coal from the face the flume of the Monitor recieves all the coal slurry and gravitates the slurry into the coal slurry sump.

→ The coal pump then pump the coal slurry to the surface treatment plant where the slurry is treated and the water is recirculated into the underground water sump for re-utilization.

→ The coal pump is a cost element, it is costly to use. It has a high energy Consumption.

→ The galleries are supported by wooden supports.

→ A wooden support set consists of a pair of timber props which supports on its top a timber bar pressed against the roof.

→ The galleries are only 2.2 m high and around 2.2 m wide because:
(i) Energy Consumption becomes a restriction
(ii) Hydraulic monitor is the only development device and there are no LHD(s)/SDL(s).

→ The coal face is cut from bottom to the top because as the toe of the coal face is cut the upper coal is automatically weakened and dislodged (a concept of undercutting)

→ The galleries is ventilated by auxiliary tube because it is highly misty in the galleries so proper ventilation is required necessarily.

→ Development is by level System for steeply inclined coal seams.

Each level has number of blocks and each block is extracted in sequence

→ Development may be by district and panel system for gently dipping or flat coal seams.

→ Applicability for Hydraulic Mining:-

1.) Nature of Coal Seam → Soft, friable, fissured, fractured, cleated, no hard/dirt band should be there

2.) Inclination → minimum inclination should be 2°, preferable inclination should be 10-15°.

3.) Thickness → upto 10 m, because the limiting hydraulic pressure can be upto 10m height under weakest roof condition. The development of 10m thick seam is like integral covering upto 3-4 m is best

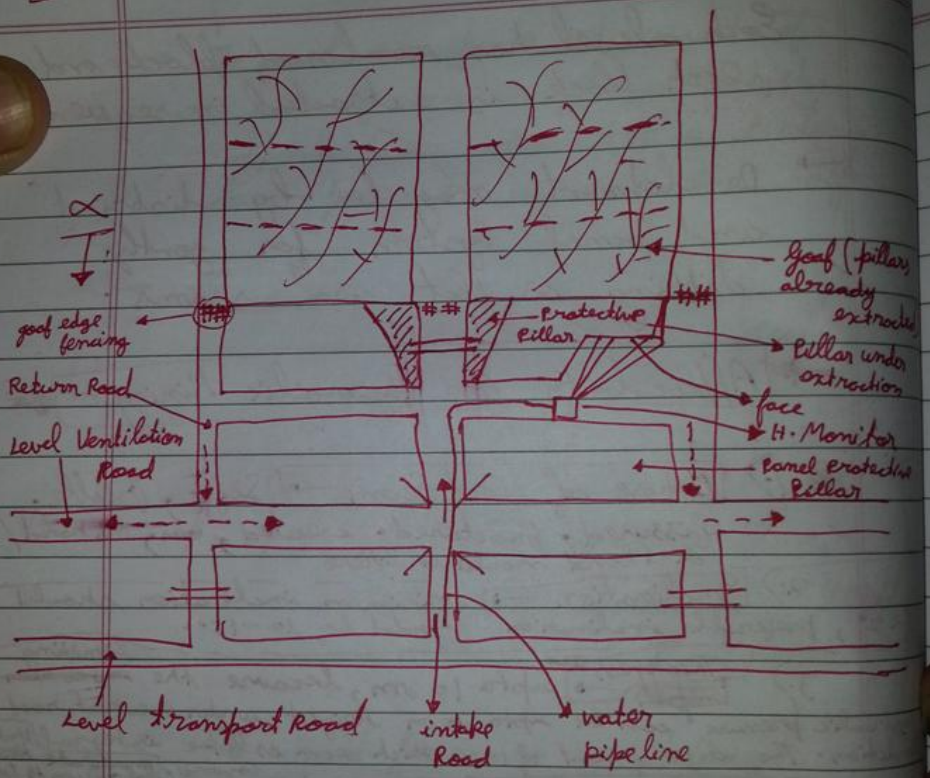
4.) Roof and floor condition → should not get dissolved in water, should not react with water

5.) Depth → < 200m because of high humidity condition at greater depths.

6.) Huge quantity of water is required

→ Roof should be strong enough to allow extraction under it while floor should retain its strength when wetted, it should not swell.

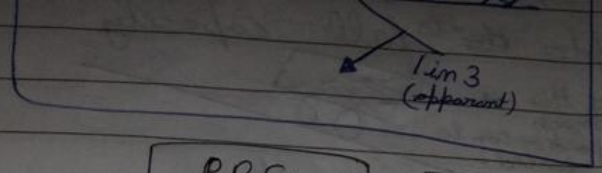
Panel layout of HM for flat/gently dipping Coal Seams :-



Thin-Seam Mining (R Natta Sir)

Thin Seam ≤ 1.5m

- 0.3m – 0.5m . very thin Seam
- 0.5m – 1.5m



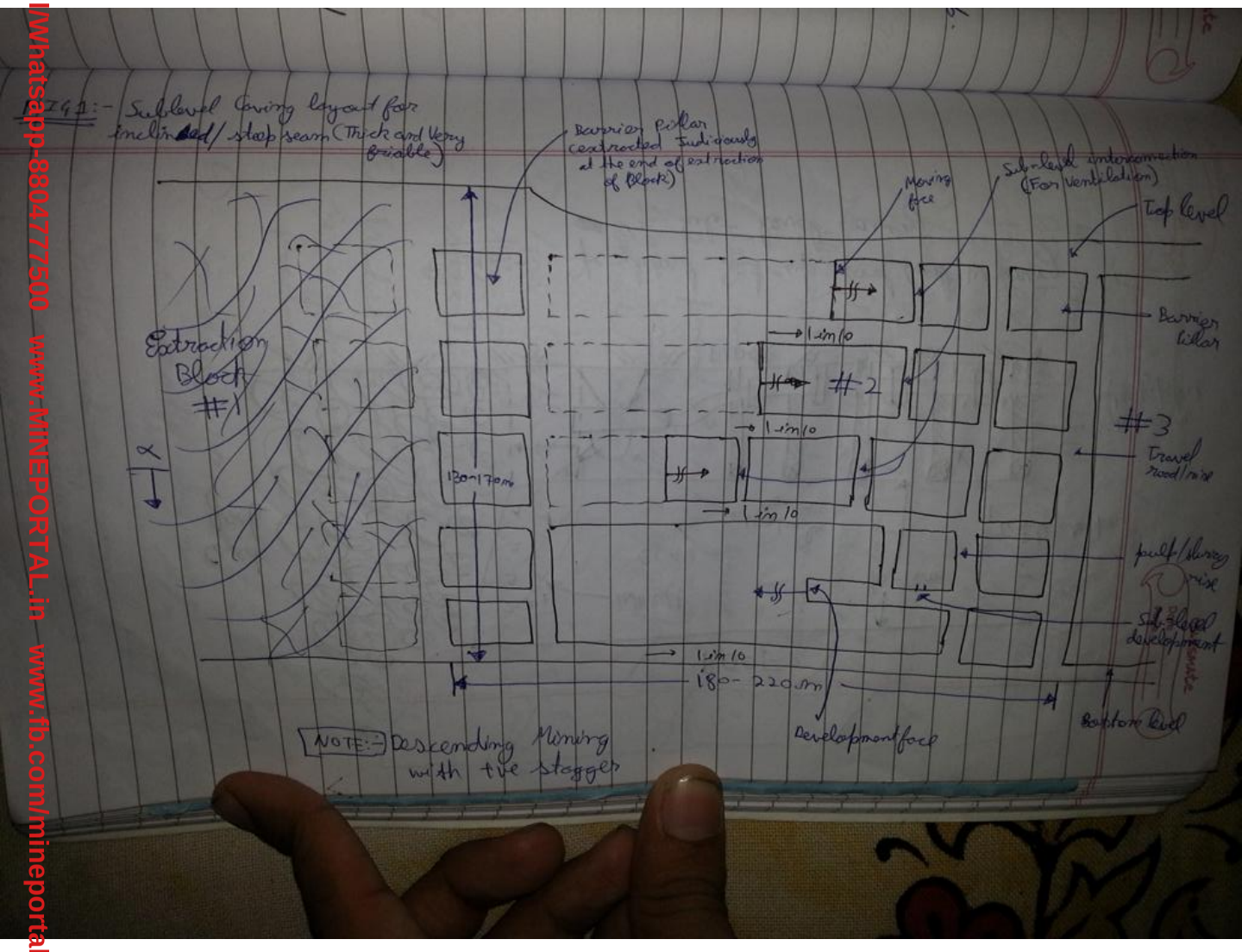
PR Sir

12/04/2014

Hydraulic Mining:-

Such coal seams which are thick and inclined or steeply inclined then these are extracted by the level system using Hydraulic mining.

Fig 4:- Sublevel caving (vertical face)



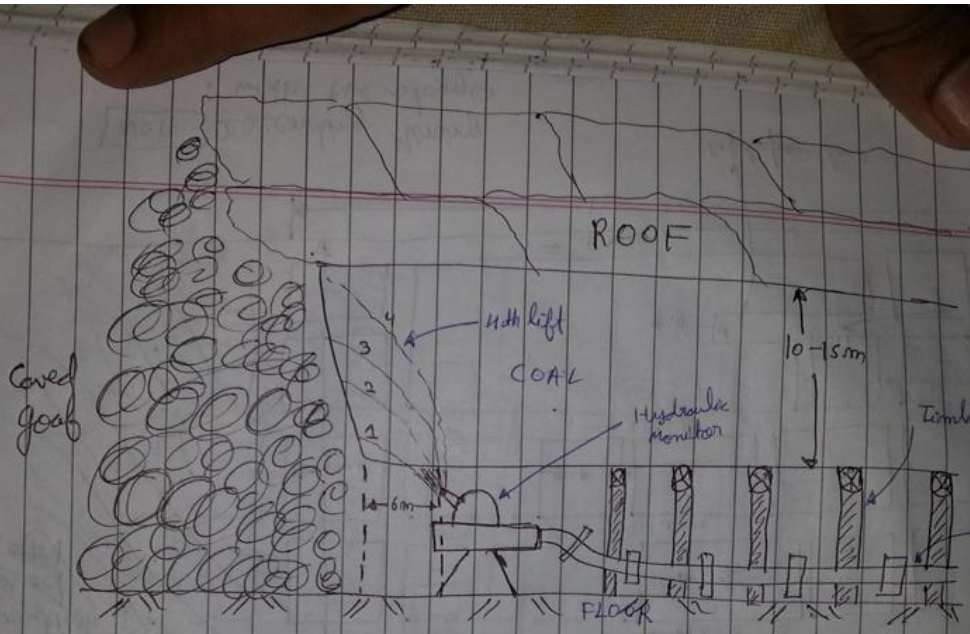


FIG2:- Operational Set-up and Coal winning in Sub-level caving

Advantages of hydraulic mining:-

1) Elimination of drilling and blasting so less hazardous and less strata control problem (no cracks developed)

2) Loading and transportation is easy. No loading and transportation equipment are required. Their cost elements are eliminated. Dependence on gravity.

3) Less manpower because of less equipments. In the favourable conditions, method is highly production oriented method

4) Low Capital investment (50% of conventional mining method in initial stages)

5) Productivity is very high (production is very high and cost to give that production is low)

6) Low dust, noise — These problems are mostly eliminated

7) Under Indian opening Condition - Coal seams which are under fire are greatly mined by hydraulic mining methods

8) Less [illegible] heating / combustion.

Limitations of the Method:-

1) Highly restrictive in nature (restriction in coal seam conditions; restriction in terms of roof and floor; restrictions in terms of water availability.

2) Non-selective mining → We cannot go ~~into~~ to the goaf side because as soon as coal is extracted, the area becomes a goaf.

3) Large amount of coal lost in the form of unmined coal → If seam has a dirt band then as soon as stone comes, the operator assumes that entire coal is ~~dislog~~ dislodged so he retracts back. So operator judgement is supreme. Poor recovery may be there.

4) Visibility infront of water monitor is very poor due to mist so control of operation becomes very poor.

5) Extremely high energy consumption and continuous supply of high energy should be ensured.

6.) Continuous constant production of coal is not ensured.

8.) Humidity in working area is very high so Ventilation becomes very important. The Ventilation has to be proper (VEO should be very high)

$$(VEO)_{face} = \frac{\text{Amount of air comming to face}}{\text{Amount of air sent from the fan.}}$$

9.) If dirt band is present then quality of coal is greatly effected.

10.) Hydro winning and Hydro ~~hoisting~~ = transport does not produce fines but Hydro -hoisting produces lots of fines (because coal is crushed for hoisting)

11.) The strength of roof greatly reduced due to wetting by water so chances of roof fall increases.

Mining of Coal Seams Prone To FIRE:-

Reasons for Fire:-

1) Spontaneous Combustion (auto-oxidation)

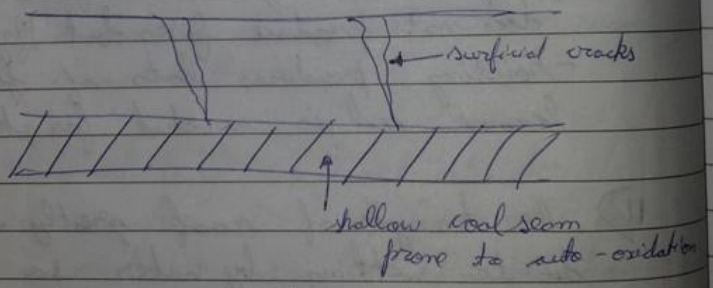
2) Coal-dust explosion → Coal dust concentration in mine atmosphere becomes alarming, then slight initiation causes explosion

(stone dusting done to prevent such explosions)

3) Gassiness of seam

4) Poor recovery of coal (leaving of coal inside the goaf) - due to leakage Ventilation, fire may be caused in the goaf area

5) Leakage of air from surface through pre-existing cracks or subsidence cracks



Through surficial cracks the air leaks and this feeble air current causes auto-oxidation and the heat of oxidation is not dissipated properly and is accumulated and

the ignition temperature then a fire is set-up.

6) Un-systematic system of mining (pocket mining / slaughter mining)

Preventive Measures:-

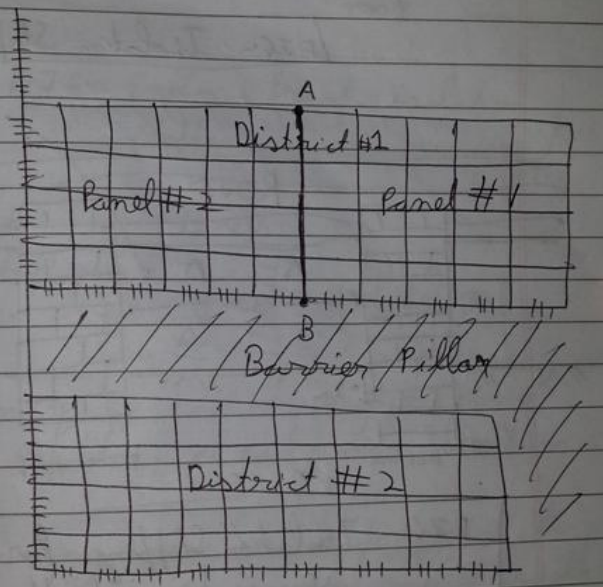


FIG:- Organisation of district and Panels.

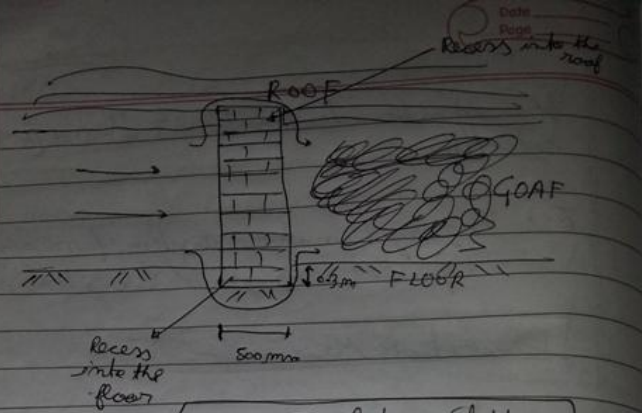


FIG:- Isolation Stopping

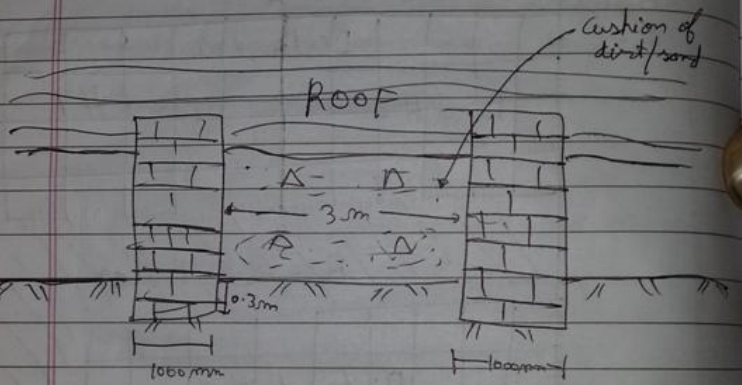


FIG:- Isolation Stopping for coal seams prone to bursts/ air blasts/ bumps etc.

NOTE:- These stoppings are used to seal off old workings and the condition in these workings is monitored regularly by air sampling and analysis.

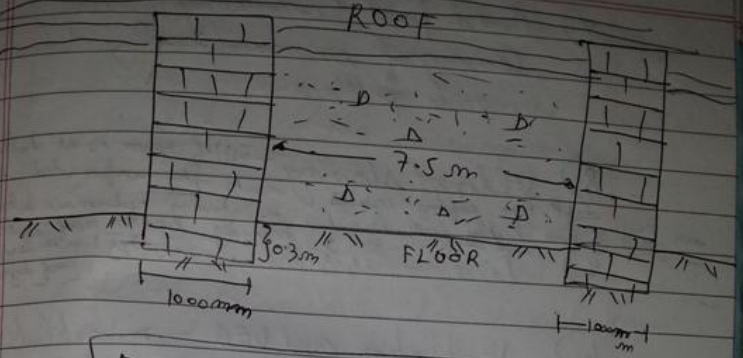


FIG:- Explosion proof isolation stopping

1.) Districts and Panels
2.) Stoppings
3.) Air-tight walls → goaf sealing

4.) Increase coal recovery → avoid spilling of coal while blasting

5.) Breathing air be stopped from the surface cracks → Mouth of cracks can be sealed by mud and sand plastering

6.) Depillaring → (i) Commence from dip side towards rise side so that in case of fire, we can flood the area with water)
(ii) Regular caving must be ensured so that increased weighting on the extraction front does not cause crushing of coal

7) Avoid partial mining and leaving of unmined coal, dislodge rib pillars.

8) Filling / stowing → (i) if seam is at shallow depth then caving creates cracks upto surface which leads air (ii) if seam highly friable in nature the stowing reduces air leakage to ~~seam~~ roof providing better roof control with less roof degradation.

9) Fire - resistant timbers

10) Ventilation and VEQ → Ventilation should be highly efficient, leakage should be reduced. It should be ensured that the heat of oxidation is properly dissipated and no temperature rise is allowed. 11) Minimum openings for accessing the districts and panels. and protect access roads by preparatory fire stoppings.

Organisation of Districts and Panels:-

1) Depending on extent of fire we have the liberty to decide districts of different sizes.

2) Each district is divided into panels.

3) Districts are isolated from each other by thick barrier pillars and isolation stoppings

4) Each District has minimum number of entries so that in case of an emergency the district can be sealed in the minimum time.

5) The size of panel is decided such that the pillars can be exploited within the incubation period.

6) Once a panel is extracted, it is sealed by isolation stoppings and the next panel is worked out.

17/04/2014. PR Sir

Winning Of Coal Seams prone to inundation:-

Inundation → Sudden in rush of water into the mines

Sources of water:-

1) above the coal seam there can be sand, river, pond etc.

2) aquifer above the coal seam in the strata

3) Seam itself may be watery.

(*) Burnside Boring apparatus is used to do advanced exploratory drilling to drain out water from water-logged workings into mining workings.

Water Seepage from Surface:-

(*) Water from bodies above can seek in to the seam through pre-existing cracks at the bottom of the water bodies.

(*) Water from surface can also enter into the seam through any fault plane which connects the surface to the underground.

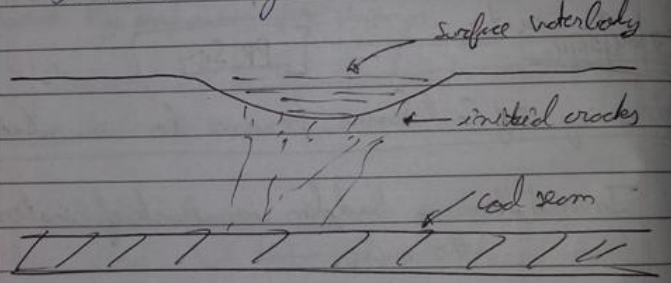


FIG:- Water seepage from cracks and finally a sudden rush of waters takes place when the cracks widen.

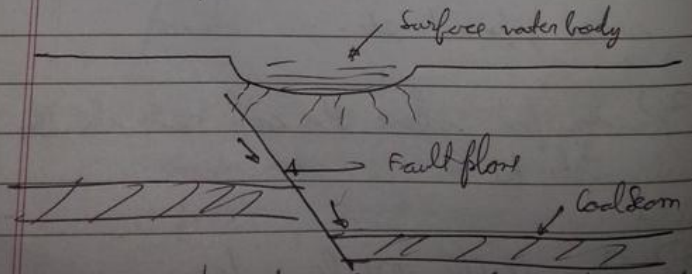
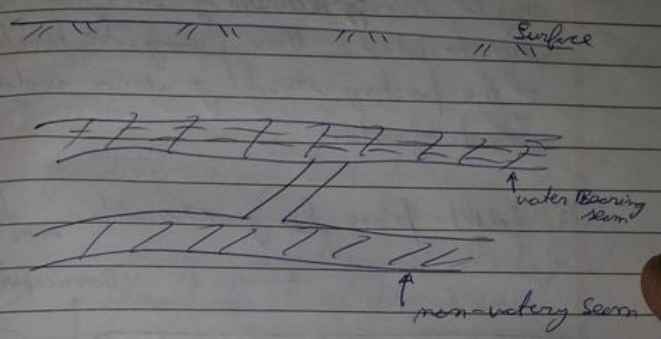


FIG:- water seepage from surface through

Coal Seam itself water Bearing:-

(i) Undesirable Connection



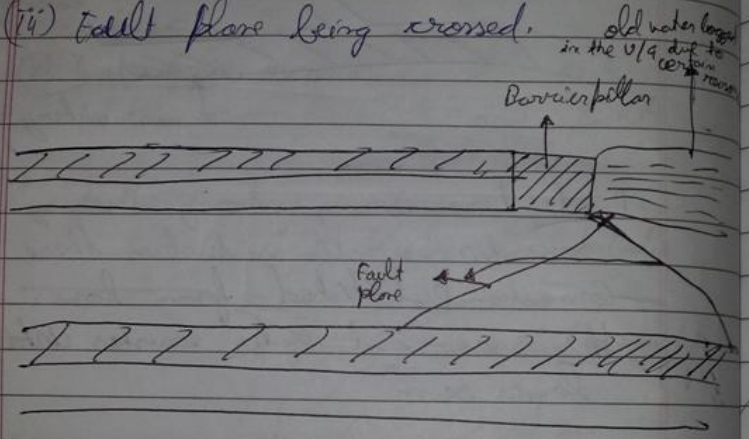
Due to human error, wrong surveying or some undesirable situation there is a connection established from lower to upper seam and water rushes into the lower seam.

(ii)

Fig:- Thinning of parting

Parting between the coal seams should be of certain minimum thickness as stipulated by the CMR, 1957. Parting may be unintentionally thinned down due to which there may be puncturing of the parting resulting in a sudden rush of water.

(iii) Fault plane being crossed.



→ Fault plane acts as inclined roadway to the passage of water which connects the working place to some water-logged working above

Other Reasons:-

1.) Failure of the water dam or Barrier if size of Barrier pillar is inadequate (robbing of pillars)

2.) Poor design of the Barrier pillar may lead to collapse of pillar. (Pillars are empirically designed)

3.) Capacity of pump may be inadequate

4.) Heavy rainfall and sudden flooding may lead to in rush of water, so the entry of the mine is always kept above the highest flood level of the area.

PREVENTIVE MEASURES:-

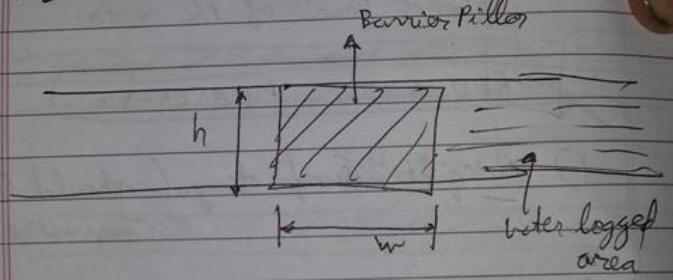
1.) Adequate Sump design (should be Conservative)

2.) Adequate pump Capacity to deal with the water and of adequate reserve Capacity to act in situations of emergency.

3.) Preparation of updated mine plans showing any pre-existing inundated working has to be properly demarcated.

Mine plans → Pre-mining stage → 1.) Regular updated
→ During mining stage
→ Post mining stage → 2.) Distinct demarcation of strategic locations, old workings, water logged workings
3.) Distinct demarcation of geological anomalies.

4.) **Barrier Pillars:**



Normal workings should not be extended to within 100 m or so of the old water-logged workings. However regulation 127 (3) states that no working should be approached within 60m of any disused or abandoned working except with the prior permission in writing from the chief Inspector of mines.

Furthermore if there is abnormal seepage, while approaching the old ~~on~~ U/G working even beyond 60m then working shall be stopped immediately.

5.) Exploratory Headings:-

within 100 m normal working (ht of 3m) have to be stopped and exploratory headings are developed and the water is drained out through these headings and then the coal seam is worked out.

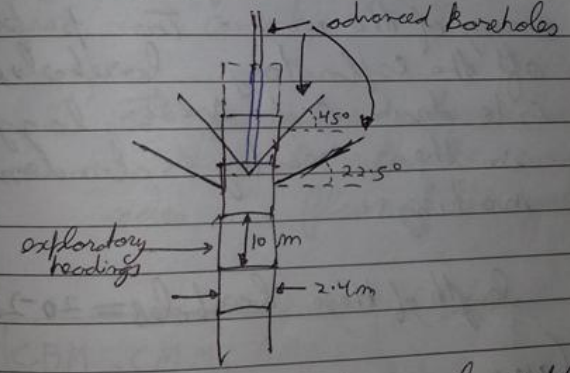
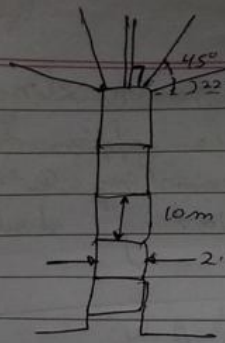


FIG:- A scheme of exploratory heading while approaching old (disused /abandoned / water-logged working.



Another Scheme of exploratory heading (2.4 m wide, 2 m high)

Exploratory headings are driven in sections of 1.0 m and after every 10 m, exploratory boreholes are driven so as to cover the entire area of the seam. The purpose of the exploratory boreholes is to drain out water, logged in the nearby abandoned workings.

Length of these boreholes = 20-25m (max)

(using Burnside Boring machine) CBM

6) Construction of dams:-

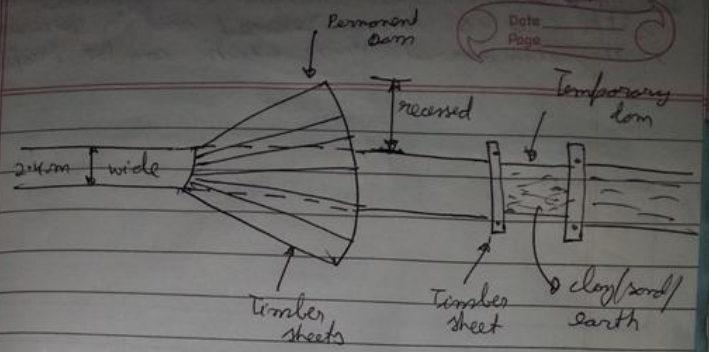


FIG:- Timber Dam (Plan View)

1.) Dams should be on stable ground or else instability of ground becomes cause of inundation.

2.) To stabilize the ground, sometimes the floor is grouted with cement.

3.) The permanent dams should be recessed into the roof and sides and floor of the galleries.

CBM, CMM, AMM:-

CBM → CH_4 is trapped in coal during Coalification, this is called Coal Bed methane. As depth increases more and more CH_4 is trapped because with increase in depth coal permeability gets reduced so trapping efficiency of coal improves.

CMM → When a coal seam is mined out the CH_4 is

Coal mine methane.

AMM → Some times mines are abandoned but still CH_4 is being released and is present in this abandoned mine which can be trapped and utilized. This is called Abandoned mine methane.

IMPORTANT NOTES

PR Sir

18/04/2014.

~~Working of Mines Prone to Rock Bursts and Bumps~~

Disadvantages of CMM:-

- Mine fire
- explosion
- reduces ventilation efficiency
- Green house gas so degrades mine atmosphere
- ~~CMM~~ methane is a energy source so its loss into the mine atmosphere is loss of energy.

- CBM and Insitu gassification → These are clean Coal technology because ~~the~~ CH_4 and CO_2 are released into the atmosphere.

In India Coal bed methanation is done if coal emission is $> 18\ m^3$ per ton of coal extracted.

CBM Techniques:-

1) GOB WELL Method
2) Hydrofracturing and Percolation through these wells

IMPORTANT NOTES

Mining of Seams Prone to outbursts:-

1) Outburst is sudden release of Huge amount of gas along with small amount of coal.

[OR]

2) Sudden release of small quantity of gas with large amount of coal.

[OR]

3) Due to crushing and squeezing of coal.

[OR]

4) Gas Blowers. (Where gas alone is passed without coal)

Reasons for outbursts:-

1) stress concentration
→ crushing and squeezing takes place
2) Depth of seam
3) cracks and fractures in roof
4) Geological anamolies like faults, etc.

IMPORTANT NOTES

(*) Working of seams prone to outburst:-

1.) CBM extraction

2.) If CBM is not economically viable the ventilation can be improved.

3.) Exploratory Borehales atleast 10m before any gas pocket

4.) Protective seam mining. (If separation between seams is within 80m) If a seam above the seam prone to outburst is within 80m then it is worked first to release stress on the seam prone to out burst.

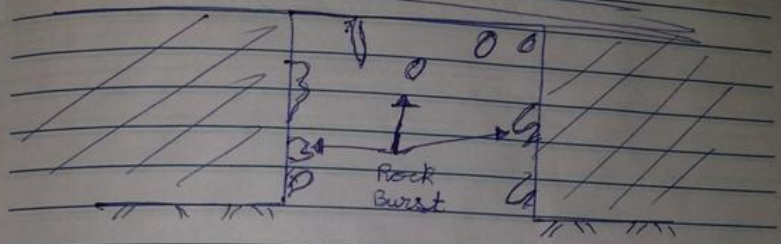
5.) Induced Blasting or shock blasting → It is heavier blasting to release stress.

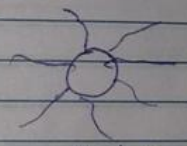
6.) Return airway → Before entering the seam make the return airway for proper drainage of gas.

7.) Air-tight walls → when working in District and Panel System then as soon as outburst takes place the district or panel can be sealed off.

IMPORTANT NOTES

Rock Burst and Rock Bumps:-





Rock Bump

Rock Burst ⟹ Rock Bump

→ Study from ~~[illegible]~~ Rock Burst from ppt's

Mining of Seams Prone to Inundation:-

CAUSES:-

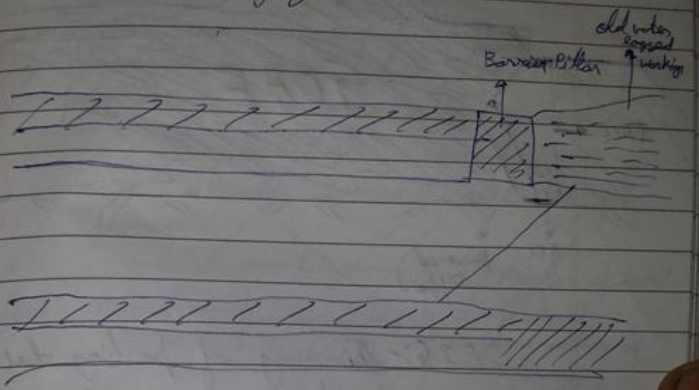
(a) Water Bodies on Surface:-

- flooding may result in heavy flow into the mine through entries or unprotected Boreholes
- water may seep through cracks, faults, or fissures from water body to shallow workings worked with caving.
- Seepage due to presence of permeable bed above the seam
- U/g workings may hole into an open-pit, filled with water.

(b) Water bodies Underground:-

- Workings may hole into water logged workings in the same or neighbouring seam due to errors in surveying; error in judgement; neglect of precautions.
- Workings may hole into faults or dykes, which may put them in communication with water

logged workings at higher levels in an overlying seam.



* Parting between workings and water-filled goaf's of neighbouring seams may take place due to changes in geology or caving. Puncture of such parting causes inundation.

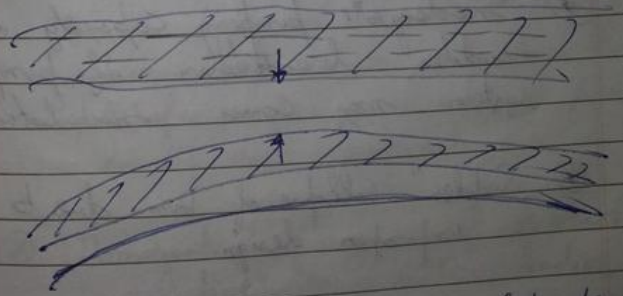


FIG:- Thinning of parting due to changes in Geology

FIG:- Thinning of parting due to dances in caving

(*) Due to robbing of barrier pillar they may collapse cause sudden in rush of water from the other side.

(*) Inadequate pumping capacity or sudden breakdown of pumping system may cause inundation.

(*) Sudden collapse of Dam due to improper design

PREVENTIVE MEASURES:-

(a) Mining Under Water Bodies:-

* Plans are updated showing any pre-existing water-logged workings. The water logged workings are clearly demarcated on the plans.

Mine Plans — Pre mining, During mining, Post mining
1) Regular updated
2) Distinct demarcation of strategic locations, old workings
3) Distinct demarcation of geological anomalies

* Plans must be made representing contours on the floor of water bodies which helps us to ascertain the depth of cover over any point in the U/G working.

* Demarcation of zones of extraction relative to water bodies on the surface.

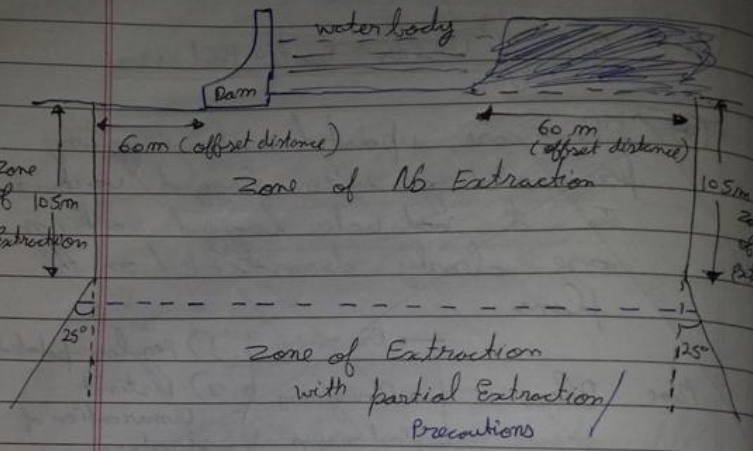


FIG:- A Scheme of demarcation

As per CMR (126):-

No working shall be made in any mine vertically below (a) any part of any river, lake, tank or reservoir or (b) any spot lying within a horizontal distance of 15m from either bank of river or canal or from the boundary of a lake, tank or other surface reservoir; except with the permission in writing of the CI and subject to such conditions as he may specify therein

- Coal barrier of adequate thickness are left around dangerous zone and with minimum number of headings (for haulage and ventilation) so that in case of emergency they can be sealed off quickly.

- Districts protected by dams with Bulk-head doors facilitating access.

- Exploratory headings protected by advance boreholes are driven 50-100 m ahead of main working to locate dykes, faults, etc.

- Total extraction of seam in dangerous areas is not allowed if overburden thickness is less than 60 he where he = extraction height. Partial extraction methods are adopted.

Working approaching old Workings:-

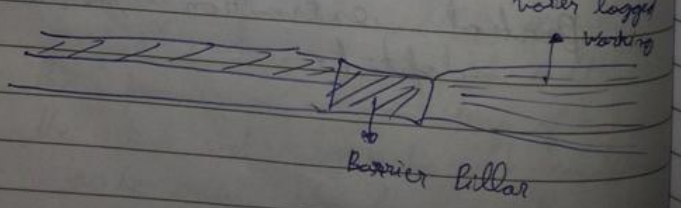
(b)

* Plans of U/G workings should be regularly updated and should clearly indicate any water-logged working (extent and position) in U/G nearby the present working.

Mine plans
- Pre-mining
- During mining
- Post mining

(1) Regularly updated
(2) Distinct demarcation of strategic locations, old water logged working.
(3) Distinct demarcation of geological anomalies.

* Depending of strength and permeability and head of water, Barriers of suitable width are left to separate from water-logged workings.



(#) Provision of sump of adequate capacity and high pumping capacity at strategic locations.

(#) Exploratory ~~Bore~~ Boreholes :- ~~As per~~ Normal workings should not be extended to within 100m or so of the old water logged workings. However regulation 127(3) states that no working should be approached within 60m of any disused or abandoned working except with the prior permission in writing from the Chief Inspector of mines. Furthermore if there is abnormal seepage, while approaching the old u/g working even beyond 60m then working should be stopped immediately.

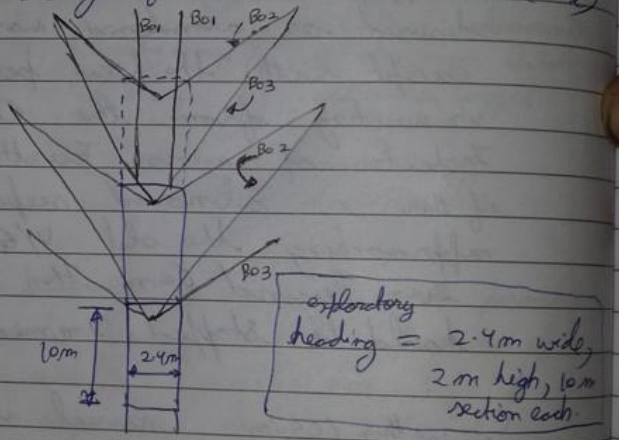
So within 100m normal workings are stopped and the old water logged working is approached by ~~a~~ Exploratory headings, under the cover of advance borehole and flank holes.

Exploratory headings with advance boreholes are driven in ~~...~~ of 10m and after every

10m, flank exploratory boreholes are driven so as to cover the entire seam area. The purpose of boreholes is to drain out water-logged in the nearby abandoned workings.

Machine used → Burnside Boring Machine

length of Boreholes = 20 - 25m (max)



Bo1 ⇒ 90° (advance boreholes)
Bo2 ⇒ 45°
Bo3 ⇒ 22.5° } (flank holes)

FIG:- A scheme of exploratory heading approaching water-logged workings (abandoned working)

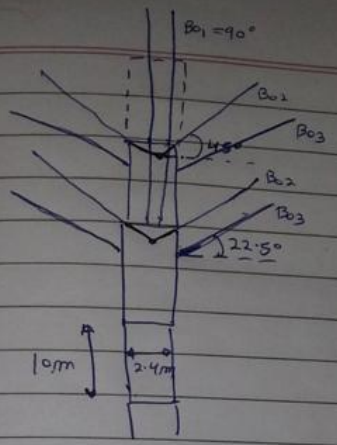


FIG:- Another Scheme

* Construction of Dams to protect other working from getting inundated.

→ See FIG from earlier class notes.

pillars (Furthermore the load is transferred suddenly.)

31/01/2014. R Nath Sir

Slicing Methods:-

A thick seam can be extracted by dividing it into slices.

Slicing can be:-
- Horizontal
- Inclined
- ~~diagonal~~ diagonal
- Transversely inclined slicing.

They can be extracted in:-
- ascending order
- descending order.

Criteria affecting ~~the~~ decision of thickness of slices:-

1.) greater the thickness of seam more will be the no. of slices
2.) thicker seam permits greater thickness of slices
3.) thickness of slices varies from 2-4m because it is a convinient

Height of working.

4) Slices are not less than 1.8m due to difficulty in standing and operation of machinery.

5) Greater thickness of slices has an advantage as development work is less as no. of slices reduces.

6) If inclination of seam is more than thickness of slice is less because management in inclined seams becomes difficult. In poland it has been seen that upto an inclination of 25° thickness of slices can be upto 2.5m but if inclination is greater than 25° then thickness is reduced to 2m.

7) A higher thickness of slices means a large gas emission volume during extraction (In highly gassy seams)

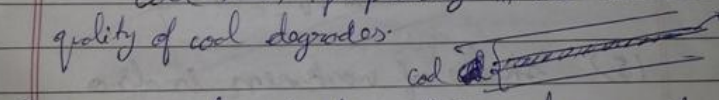
8) incubation period → period between the creation of suitable condition for autoxidation and the first onset of mine fire is called incubation period.

The suitable condition for oxidation is created when depillaring starts (during caving). The broken coal is left in the goaf area on which the roof caves. The ventilation is enough to cause autoxidation

of broken coal but not sufficient to ventilate the heat of ~~combustion~~ excitation. Hence after a period of time combustion of coal begins. So we have to extract the panel between this time period. This is the incubation period.

In a highly liable to spontaneous heating ~~seams~~, less coal has to be left in the goaf so the thickness of slices is kept low.

9) In case of presence of dirt bands, we can make these dirt bands/stone bands as the floor ~~of~~ or roof of the slices. ~~If dust is~~ The thickness of slices is ~~suitably~~ suitably adjusted. If dirt band is extracted along with coal then impurity in coal increases and quality of coal degrades.



10) Face production falls down if ~~the~~ the thickness of slice is more as the % of extraction is less. It has be observed. If thickness is more than 3.2 m then a ~~decrease~~ decrease in productivity is observed.

11) Support cost also increases as thickness of slices increases as higher and stronger supports are required.

12.) characteristic of roof and floor — In case of weak roof we have to leave a layer of coal to support the roof and in case of weak floor like clay or in case of storing where floory is eroded easily then a layer of coal is left along the floor to provide good floor to provide restraint ~~resistance~~ ~~support~~ for the installation of supports. Here effective thickness of slice reduces

~~Hardness of Coal~~:-

13.) harder the coal greater can be the thickness of slice

14.) intended mechanisation determine the thickness of slices.

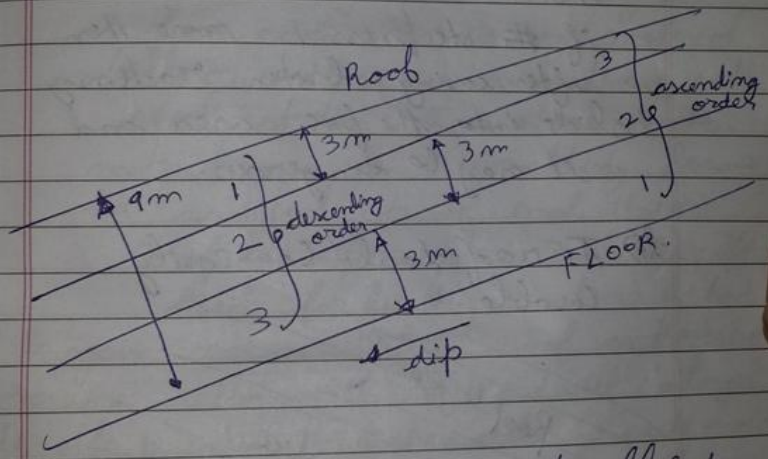
15.) skills of workmens is also important as they should be ~~able~~ able to handle the machinery and support. Thicker slices requires more skilled labours.

Disadvantages of a too thick slice:-

1.) coal getting is more diffjcult
2.) roof control is more difficult
3.) Heavy and long supports are ~~are~~ required.

4.) Caving may faced difficulty
5.) packing of too high voids presents difficulty. Packing should be tight to provide support above but as slice height increases packing is not efficient.

Inclined slicing:-



The slices are taken parallel to the roof and floor along the full dip of the seam.

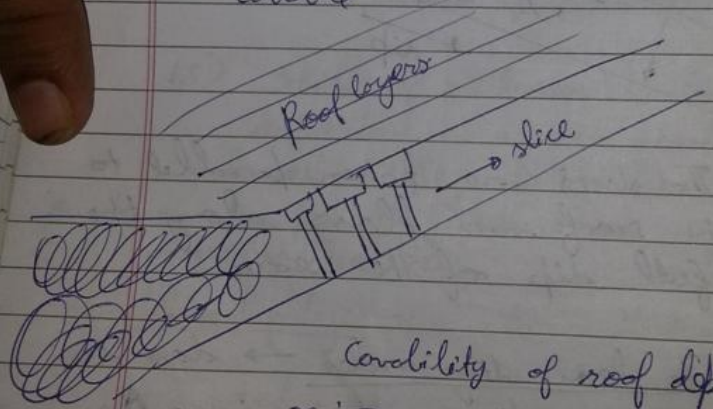
In descending order → done in conjunction with caving. An artificial roof is created along the floor of the above slice and the lower slice is worked under the

In ascending order → done with stowing. For the above slice the packed & void acts as floor.

Applicability.
Conditions suitable for inclined slicing ~~or~~ in descending order with caving.

a) inclination of seam should not be more than 35° because if ~~the~~ steepness is more then after caving broken rock may slide into the face area and it may be dangerous.

b) The roof should be easily cavable



Cavability of roof depends on:-

(a) strength of layers
(b) thickness of individual layers.

The roof layers should not be more than 3 m thick or else there will be difficulty in caving and Compressive strength of layers should not be more than 50 MPa.

c.) the number of slices should not be more than 3.
As the face is extracted a wire netting is laid along the floor and the caving material falls on these wire netting and steel strips. Then these broken material on wire netting becomes the artifical roof and this roof lasts for upto 3 slices. After that for further slices we have to again create an artificial roof as the previous wire netting will bend and will no longer be able to support the broken material. So to avoid this problem the maximum thickness of seam should not be more than 8-9 m so that it can be efficiently extracted in 3 slices.

d.) The thickness of seam should be reasonably regular.

e.) Coal should be reasonably hard

2) inclined slicing with filling in ~~ascending~~ order:-

(a) Seam thickness should be 8-9m so that more than 3 slices are not required because efficiency of packing decreases as height increases.

(b) Dip should not be more than 60°. We can work higher dip seams as the danger of roof rock coming to the face area is not there.

(c) Coal should be firm and not liable to spontaneous heating.

(d) roof and floor should be firm and compressibility of filling material should be low so that they offer sufficient resistance to the roof from ~~falling~~ deforming.

28/02/2014.

R. Nath Sir.

Inclined slicing with caving in descending order:- (Continued)

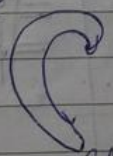
Gidi A Colliery

Length of face = 90 m friction props of 42 ton capacity was used with conjunction with hinged bars or cantilever bars for support. At that time powered support was not available.

Method of mining → L.W. retreating.

1st work → laying of the artificial roofing on the floor of the 1st slice.

Old haulage rope was fixed by steel hooks along the boundry of the panel.



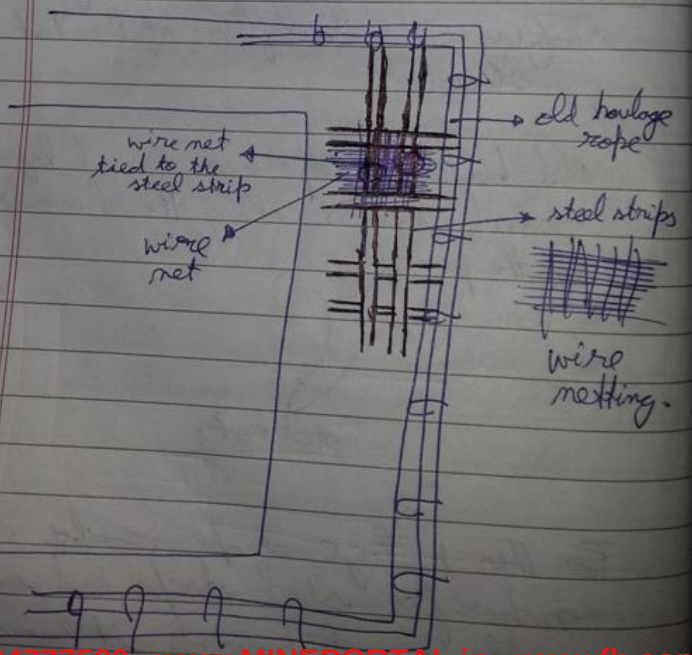
steel hooks

The haulage rope acts as anchor for steel strips and wire netting and prevents it from shifting [illegible] on it.

Then 2 rows of steel strips perpendicular to the face and 2 rows of steel strips parallel to the face are worked at a time. They are interlinked to forme a mesh.

→ Steel strips are 50-60mm wide and 3mm thick.

→ Above these wire netting is laid. The wire netting rolls were 1.5m wide and 25m long.



→ To make the roofing strong 2 layers of wire netting we laid on the steel strips. They were tied to the steel strips by wire hooks. ~~small diameter rods~~ at every 50 - 60 cm interval.

→ Above the wire ~~to~~ nets the supports are installed and machinery is used.

→ The wire netting is just upto the AFC and not upto the face, while the supports are installed on the netting.

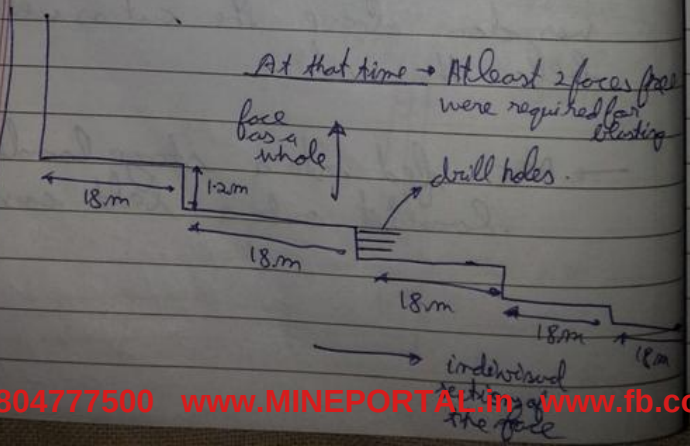
→ At that time a longwall coal cutting machine was used. The cutting jib is at 90° to the body of the machine mounted on the AFC. The cut was 2m above the floor of the seam. Blasting was done above the cut as well as below the cut.

→ AFC fed into a stage loader which loaded onto a belt conveyor.

For the 1st slice → rigid roof was there and so rigid cantilever bars were used but

For the 2nd and 3rd slice → flexible bars were used because if rigid bars are employed then as the wire nets bend due to pressure from above then these rigid bars will penetrate into the wire nets. So flexible bars were made by using 1.5m long flat wire ropes on both sides of which steel plates were fixed.

For 2nd and 3rd slice → Coal cutting machines were not used. The face was serrated.



In 1st slice → the friction props yield max. upto 40 cm before the 1st main fall after which the yield was around 20-30 cm.

In 2nd and 3rd slice → the roof behaves as a dead mass and yield of friction props was only upto 15 cm.

20/02/2014.

PR Sir

14.7

flows through the coal and heats it. This converts coal into ash which is blown out by a flushing air current and linkage is established between the wells.

R. Nath Sir (28/03/14)

Inclined Slicing with Caving in descending order:-

The method discussed till now involves non-simultaneous extraction of slices but production level is reduced to a large extent. Instead of extracting one slice and then extracting next, sufficient time is given for the roof to cave and consolidate and then next slice is opened; so generally a distance of 50-60 m is maintained between faces of each slice. The 1st slice is 50-60 m ahead of the subsequent slice face and so on.

Inclined Slicing in descending order with stowing:-

@ Normally not practiced but used when coal seam is highly fractured and roof cannot be caved easily. It is also used if the seam is highly liable to spontaneous combustion

so energy / power requirement very high.

Basic Phenomenon:-

1) Strong water jet impinges the coal
2) Coal should have sufficient no of weakness planes.

because with stowing we have very little coal in the goaf area.

* For stowing wooden planks are laid over rails and on these planks, stowing material is loaded. Now this becomes the roof for the 2nd slice.
* generally slices are taken simultaneously with a stagger of 50-60m between faces in each slice.
* If seam is moderately inclined the faces advance along rise direction but if seam is highly steep then face

advances in strike direction.

(*) For success of this method, the stowing material should consolidate properly to form a good roof.

Inclined slicing in ascending order with stowing:-

Practised in Sudamdih Colliery, BCCL:-

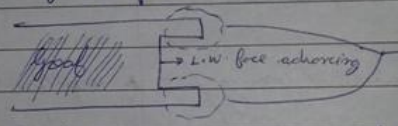
Seam thickness = 7.3 m; Dip = 35°; Depth from surface = 260 m; Hydraulic sand stowing was practised.

Immediate Roof → medium grained sandstone
Immediate floor → 0.7 m sandy shale and 3 m medium grained sandstone.

Face length → 110 m along strike progressing towards rise. Seam was extracted in 2 slices and ht. of each slice was 3.5 m.

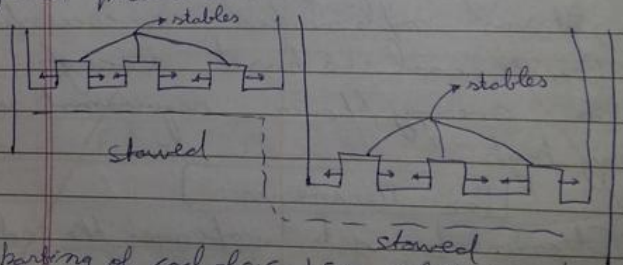
➡ Each panel had 2 L.W. faces on either side of a central gateway.

➡ Each panel had 2 faces because stowing in cyclic process and during stowing no production is there. So with 2 faces when one face is stowed then other face gives production.

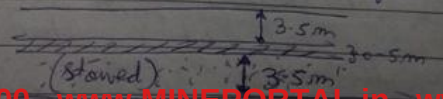


➡ Support is by timber props and bars and distance between support bars is 1.2 m.

➡ After face has advanced by 6 m, production at one face is stopped and stowed while other face gives production.



➡ Parting of coal of 0.5 - 1.5 m is left sometimes between slices if stowing is not good. It provides a good floor to work on for the machines. It is difficult for machineries to work on roof floor.



Horizontal Slicing:-

- It can be opted for irregular seams which are thick.
- The face length is along the transverse direction of the seam (horizontal) and the face advances along the strike direction.
- Transverse direction is the horizontal direction to strike ~~as well as dip~~ and at some angle to the dip ~~to that~~.
- If seam is thin then the transverse length of seam is small so length of face will be too small for profitable production so the seam should be thick.

IMPORTANT NOTES

B. Nath (Thick Seam Mining)

→ lower limit of thick seam fixed such that the thickness of the seam which can be extracted in a single pass or in one lift with the present technology and equipments.

exceptional thick Seam of India → Singrauli Coal Seam, 162 m thick.

Problems of Thick Seam Mining by O/G methods:

1.) Strata Control is difficult.
2.) Heavier and longer supports are required which are less efficient and difficult to handle and install.
3.) Inspection of roof is difficult.
4.) Risk of overriding of pillars and premature Collapses.
5.) with Collapse of workings, large volumes of gases are displaced resulting in air blasts.
6.) Percentage of extraction is low, oven less than 50%.

IMPORTANT NOTES

7) More chances of Spontaneous heating as large amount of coal is left in the goaf area.

8) Due to high workings, ventilation becomes sluggish & usually in depillaring area and it may result in methane roof layering.

9) Magnitude of subsidence is higher. Subsidence control is difficult.

Advantages of Mining a thick seam:-

1) For the same amount of reserves, establishment of a mine is less expensive in a thick seam than in a multi-seam basin.

2) Vertical Concentration is possible, thereby development costs and transport charge is saved.

IMPORTANT NOTES:-

2-11

Reasons for opting for longwall methods to mine thick seams:-

Bord and pillar method was a failure due to:-

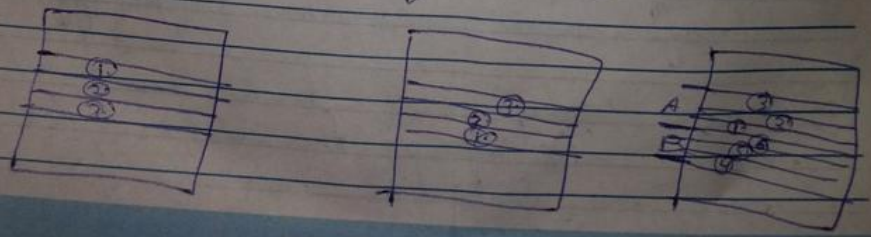
(i) inefficient strata control
(ii) irregular settlement of strata
(iii) & heavy losses of coal

So longwall mining become the only choice.

Slice Mining:-

→ Seam divided in slices of suitable thickness and extracted in a similar manner as a seam of that thickness would be worked.

→ Slices can be taken in ascending order, descending order, or mixed order.



IMPORTANT NOTES

~~Ascending Slicing~~

~~Descending~~

(b) Ascending Slicing →

(*) First slice taken along the floor of the seam in a conventional manner.

(*) Then other slices are extracted with stowing, caving is not possible

(*) However the last slice may be worked with or without stowing.

Disadvantages of ascending slicing with stowing:-

1) Due to Compression of stowing material the roof lowers and gets fractured and fissured and after 3 slices roof control becomes very difficult.

2) Due to Compression of stowing material, cracks develop in the roof rock and these are potential sources for initiation of spontaneous heating - so if the seam is prone to fire then danger increases

IMPORTANT NOTES

3.) Props installed in sandy floor do not offer required support & resistance. (Problem of prop penetration can be minimized by using sole plates of adequate size)

4.) Stowing is inevitable in ascending mining and it hamper the production cycle, requires extra cost and unproductive labours have to be employed so productivity reduces.

Descending slicing →

* First slice is worked along the roof of the seam like a conventional seam of similar thickness.

* Subsequent slices can be worked under the broken roof of the 1st slice → In such a case wire netting is laid along the floor of the 1st slice on which the roof is allowed to cave, and under this artificial roofing subsequent slices are worked.

IMPORTANT NOTES

(*) Stowing is rarely done → But if done then timbers planks are laid along the floor of the 1st seam onto which the stowing material is loaded and allowed to consolidate to form a artificial roof under which the subsequent slices are worked. (This consolidated roof may become stronger than then the original roof)

(*) Working is always on firm ground so support is better and mechanization at the face is easier.

(*) Laying of wire - netting incurs extra cost and additional manpower is needed so OMS is reduced.

IMPORTANT NOTES

Ascending slicing Vs Descending slicing:

We prefer Descending slices because:
(i) it allows us to work with caving
(ii) less chances of spontaneous heating of coal.

Mixed order of slicing →

The Coal seam is divided into Blocks and the slices in each Block are extracted in ascending order ~~which~~, while the blocks are liquidated in descending order.

- Specially adopted in Horizontal slicing method
- ~~The~~ Stowing is essential in this method.

IMPORTANT NOTES

Deciding the thickness of slices:-

1) Greater the thickness of the seam more will be the no of slices.
2) Thicker seam permits greater thickness of slices.
3) Thickness of slice varies from 2 to 4 m because it is convinient height of working.
4) Slices should not be less than 1.8 m due to difficult in standing and operation of machinery
5) Greater thickness of slice is advantageous as development work is less as no. of slices are reduced
6) If inclination of seam is more than thickness of slice is less because management is difficult in inclines seams.

In poland if dip $< 25°$ → thickness upto 2.5m
if dip $> 25°$ → thickness upto 2m

IMPORTANT NOTES

7) In highly gassy seam, thickness of slice is kept low to control the gas emission during extraction to permissible levels.

8) Seams which are highly prone to spontaneous heating are extracted in thin slices as less amount of coal loss in the goaf area becomes our prime motive.

9) In case stone/dirt band is present in the seam then thickness of slice is so selected so as to make these bands the roof/floor.

10) Face production falls if thickness of slice is more than 3.2 m.

11) Support cost increases in thicker slices as higher and stronger supports are required.

12) In case of weak roof/floor a layer of coal is left along the roof/floor to provide better working conditions hence effective thickness of slices is reduced.

IMPORTANT NOTES

13. Harder the coal, greater is the thickness of slice
14. Intended mechanization determines the thickness of slice
15. Thicker slices requires more skilled labours to handle support and machinery.

Main Slicing Methods:-

1. Inclined Slicing
2. Horizontal Slicing
3. Diagonal Slicing
4. Transversely Inclined Slicing

Inclined Slicing Methods:-

* The slices are taken parallel to the roof and floor of the seam.
* Slices may be taken in ascending or descending order

IMPORTANT NOTES

CSR

* Ascending slices worked with stowing while descending can be ~~worked~~ worked with or without stowing.

Applicability of inclined slicing with caving in ~~with~~ descending order:-

1.) Dip of the seam should not be more than 30 - 35° as in steep ~~seam~~ seams there is a danger of caved ~~no~~ stone sliding down upto the face.

2.) The roof should be easily cavable (thickness of beds should be less than 3m and UCS should not be more than 5 MPa)

3.) Maximum thickness of seam is upto 9m so that it can be worked in 3 slices, as after 3 slices roof becomes sufficiently degraded.

IMPORTANT NOTES

4.) The thickness of the seam should be regular.
5.) The coal may be hard.

Applicability Conditions of inclined slicing in ~~ascending order~~ with stowing:-

1.) Dip should not be more than 60°
2.) The max. thickness of the seam should be upto 9m so that it can be extracted in 3 slices because packing efficiency decreases significantly after 3rd slice
3.) The coal should be firm and should not be liable to spontaneous heating.
4.) The roof and floor should be strong.
5.) The ~~thick~~ Compressibility of the stowing material should be low.

IMPORTANT NOTES

Inclined Slicing with Caving:-

(*) Longwall retreat mining is done.

Reasons:-

1.) easy strata control
2.) early settlement and compaction of roof rock and in a regular manner.
3.) Due to early settlement of roof, less chances of fire.

Formation of roof →

1.) Presence of stone or dirt bands should be utilized judiciously while formation of roof, timbering below the band should also be done in such a manner that it does not disintegrate.

2.) A layer of coal of adequate thickness between slices can act as a roof for lower slice, But
(i) chances of fire
(ii) Recovery of coal is less.

IMPORTANT NOTES

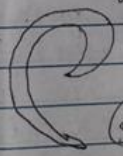
3.) A 30-50cm of clay layer is spread along the floor of the last slice and allowed to consolidate for sufficient time ~~so~~ so that it forms a good roof

4.) Wooden planks or bambags have been used to make false roofing.

5.) ~~Ste~~ Wire netting laid on steel strips:- (long lasting and offer more flexibility)

At Gidi 'A' Colliery, Karampura Coalfields:-

→ old haulage rope was fixed by steel hooks along the boundary of the panel.



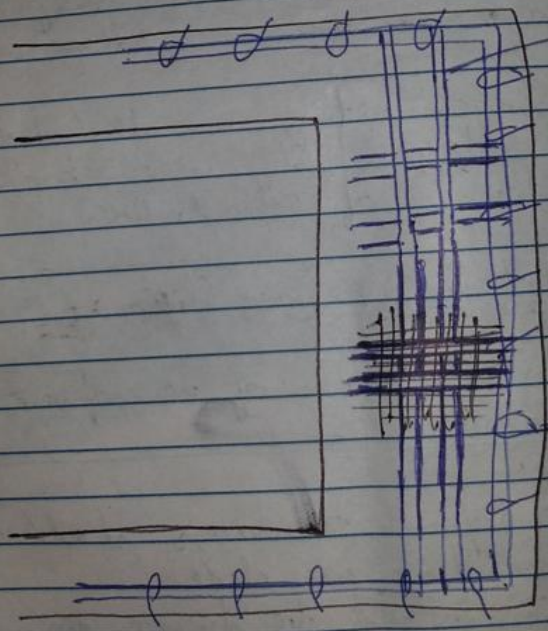
(Steel hook)

→ The haulage rope acts as anchor for the steel strips and netting and prevents them from shifting when pressure comes on them.

be hard.

IMPORTANT NOTES

→ Steel strips 50-60 mm wide and 3 mm thick were used. They were interlinked to form a mesh. 2 Rows of strips parallel to the fence and 2 rows of strips ⊥r to the fence were worked at a time. A mesh of 40 cm x 40 cm was formed.



IMPORTANT NOTES

→ above the steel strips galvanised wire netting rolls 1.5m wide and 25 m long with 20mm mesh was laid and adjacent rolls were made overlapping by >5cm.

→ To make the roof strong 2 layers of wire netting was laid.

→ The wire netting was tied to the steel strips by wire hooks at an interval of 50cm to 60cm.

Development for Inclined Sliding :-

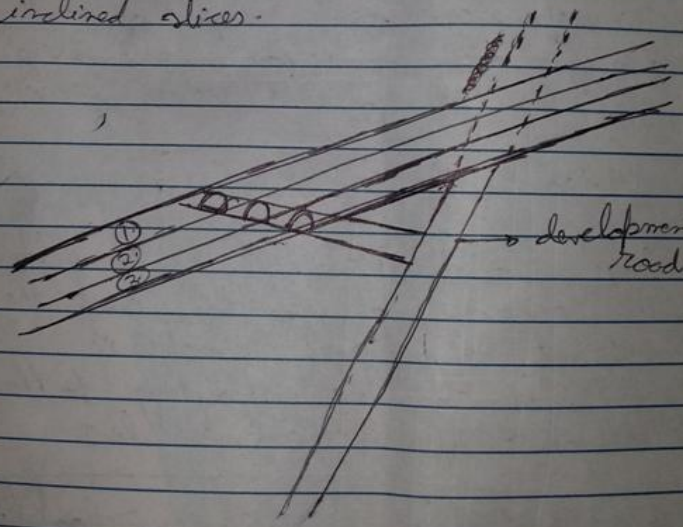
Principles of driving of development roadways:-

1) Development roadways should serve more than one slide
2) They should be driven on firm ground
3) They should be driven in rock so that in case of fire, the panel can be sealed and isolated.

IMPORTANT NOTES

In high pressure areas :-

Inclined Seams → Development roadways are made in the foot wall at some distance from the Seam as laterals and crosscuts are made to connect it to inclined slices.



Flat Seams → Development roadways made in footwall and connected to slices by blind shafts or raises.

IMPORTANT NOTES

Non – Simultaneous extraction:–

Development roadways driven in front of the given slice and after slice has been extracted and caved, the strata is allowed to settle and then independent new development openings are made for next slice. except for the level entries.

Simultaneous Extraction:–

Gate roads are sunk simultaneously with advance of slices and the sinking front of gate roads is advanced corresponding to the advance of respective slice.

Gidi "A" Colliery, Karanpura Coalfields

Name of Seam → Sirka
Dip → 1 in 5 to 1 in 3
Depth → 70 m.
Thickness → 12 m

IMPORTANT NOTES

Slices = 5

Thickness of Slice = 2.4 m

roof → shale of seam

floor → shale of seam

Development of Slice panels:-

→ Seam opened by 3 inclines (2 along roof 16 m apart and one along floor of seam placed centrally)

- From the roof inclines gate roads developed upto the limit of panel for the 1st slice.

- For second slice the entries to panel were deepened to the level of 2nd slice

- Gate roads were developed from these entries leaving a rib of 4.5 m from the edge of gate roads of the 1st slice to secure wire netting.

- The 2nd slice face started from the end of the panel where the 1st slice ended leaving a coal block of 6 m to secure wire netting

IMPORTANT NOTES

→ After the 2nd slice, 3rd slice was developed in a similar manner. The gate roads were developed leaving a rib of 2m from the edge of the gate roads of 2nd slice.

→ After the 1st 3 slices were extracted, another slice was developed along the floor of the seam and above 2.4m 4th slice was taken down by sub-level caving as the bottom ~~the~~ face retreated.

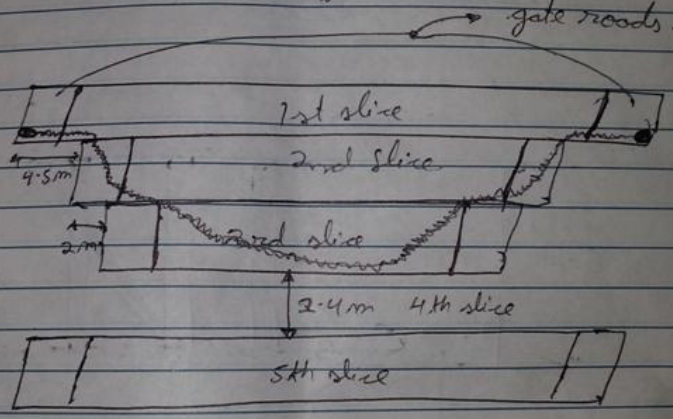
~~Support~~ Support :-

~~42 tonne~~ 42 tonne friction prop with hinged type roof bars for 1st slice. For 2nd and 3rd slices flexible bars were used because rigid bars would penetrate into the waste nets. Flexible bars were made by using 1.5 m long flat wire ropes and fixing steel plates on both sides.

IMPORTANT NOTES

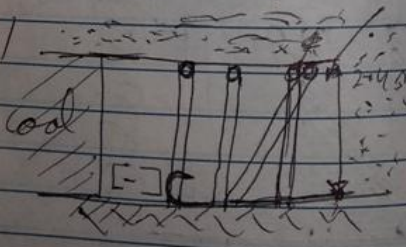
~~Working of face of 1st slice~~

Development of gate roads :-



Working of face of 1st slice :-

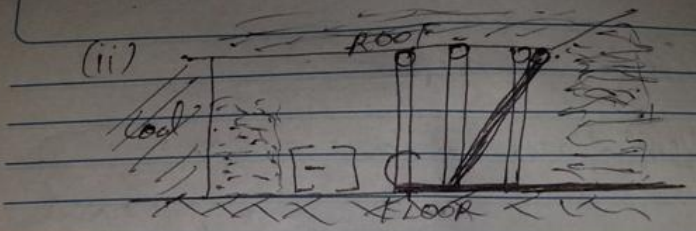
(i)

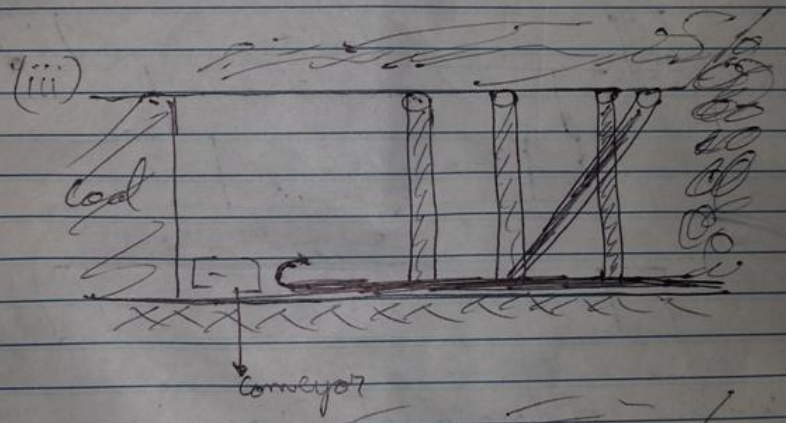


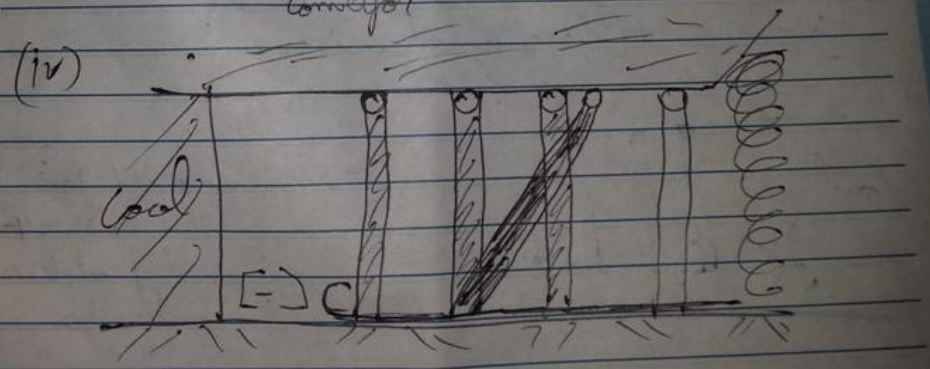
→ face advance = 1·25m

→ roof blasted down by shot holes = 4·5m long at 1·2m intervals.

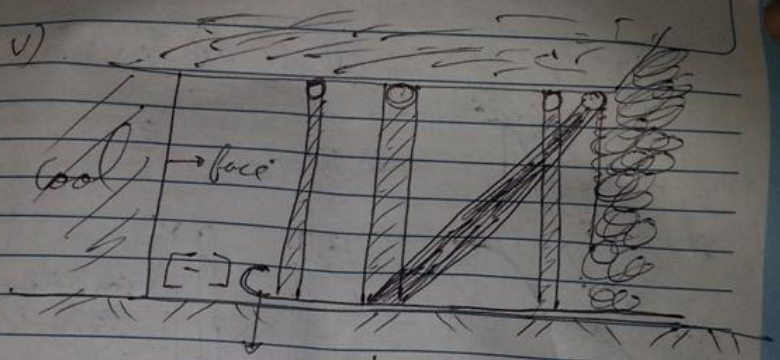
IMPORTANT NOTES







(V)

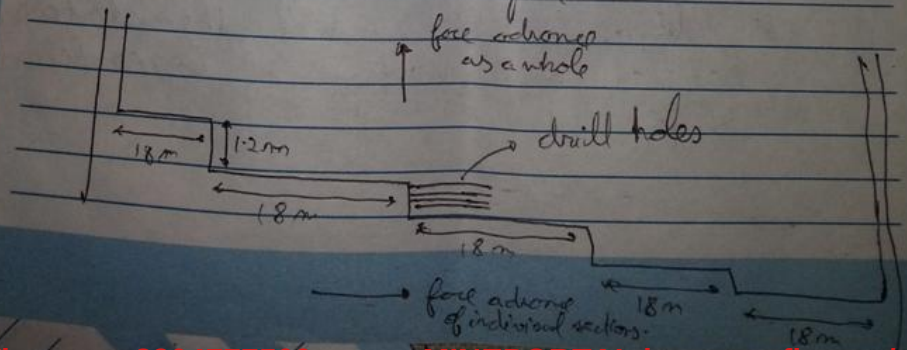


Working face of 2nd and 3rd Slice:-

For 1st slice → Coal cutting machine was used ~~for~~ ~~1st~~.

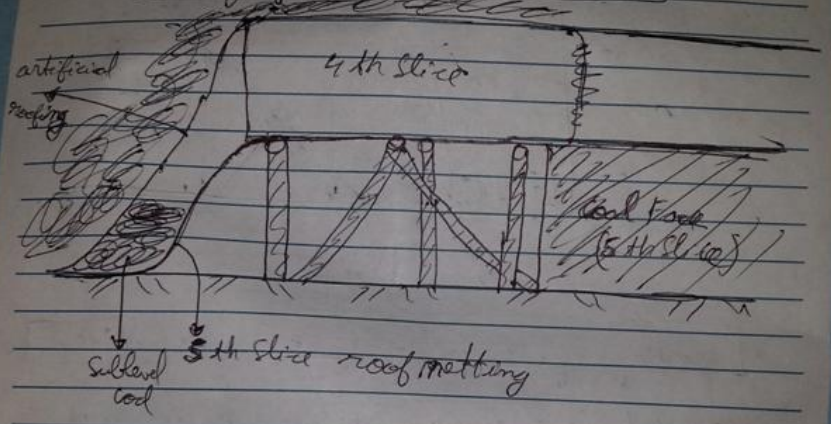
For 2nd and 3rd slice → Drilling and blasting was done.

There was a serrated face:-



IMPORTANT NOTES

Working of 4th and 5th Slice :-



→ Simultaneous extraction of slices is also possible for high production and low maintenance cost of gate roads; but the distance between faces should be sufficient so that the strata settles and working of lower slice is permitted.

IMPORTANT NOTES

Disadvantages of this method:- (Simultaneous)

(i) Many slices are needed to work a thick seam

(ii) work in one slice affects the work in other slices.

(iii) Ventilation is difficult.

Advantages of this method:-

1.) High % age of extraction

2.) Productivity can be improved and total cost is reduced

3.) Full mechanization of the face is possible and lot of slices can be fixed on the basis of machines.

4.) Working of 1st slice degasifies the seam and hence gaseous problem is eliminated in lower slices

5.) Powered supports can be used

6.) Reduced Roof control problem → By caving the roof is destroyed and working under artificial roof is safer.

IMPORTANT NOTES

Inclined Slicing in descending order with stowing:-

[Applicability:-]

1.) Coal seam is broken
2.) Roof cannot be caved easily
3.) Seam is highly prone to self heating.

[Method:-]

⇒ Seam is extracted in slices taken in descending order by longwall mining

⇒ As the extraction is carried out, wooden planks are laid over rails and on these planks, stowing material is loaded. It is allowed to consolidate for sufficient time before the lower slice is opened.

⇒ To generally a stagger of 50-60 m between the faces of each slice is maintained.

IMPORTANT NOTES

→ After felling the rails of artificial roof were removed.

→ In moderately inclined seams face advances in the rise direction but for steeply inclined seams face advances in the strike direction

→ For success of this method, it is necessary that the shrinkage of stowing material is minimum and it forms a good roof.

Inclined Slicing in Ascending order with stowing :-

→ Practiced in Sudamdih Colliery, Jharia.

Thickness of Seam = 7.31m

Dip = 35°

Depth from Surface = 360m

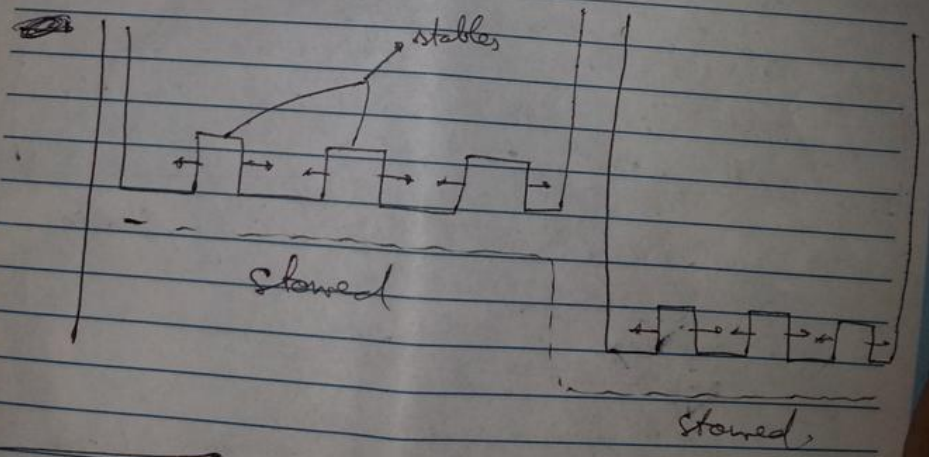
Immediate Roof = medium grained Sandstone

Immediate floor = 0.7m sandy shale and 3m medium grained sandstone

IMPORTANT NOTES

Face length = 110 m.
Slices = 2 each 3.5m thick

→ Each longwall panel had 2 faces, 110m each on either side of central roadway.
→ 3 stables of 6m depth were driven into the face and then coal was blasted off from either side of the stables.



Support:-
→ timber props and bars (2 bars on 4 props)

IMPORTANT NOTES

prop = 3 m long
bar = 3.5 m long.
Distance between bar lines = 1.2 m

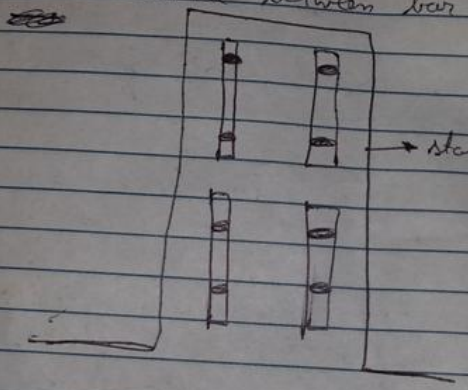


FIG → Support System

Transportation :-

→ Double chain Conveyor at face
→ Retarder Conveyor in the gate roads
→ mine cars in the level galleries.

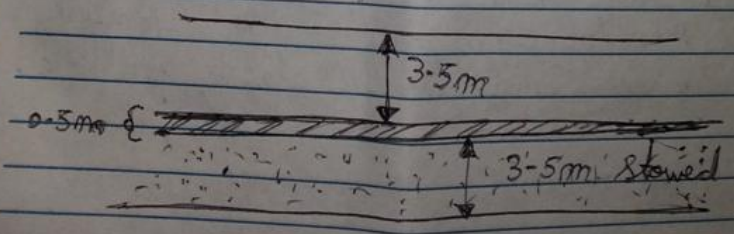
IMPORTANT NOTES

→ After face advances towards the rise side by 6m the production at the face is stopped and stowing is done.

→ While one face is stowed, other gives production.

→ After bottom slice, top slice is extracted in a similar manner.

→ After one slice there is often a coal parting of 0.5 - 1.5 m which is left if stowing is not good to provide a firm floor for the machineries to work on. It is difficult for machines to work on sandy floors.



IMPORTANT NOTES

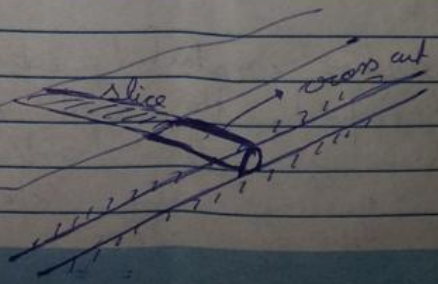
Horizontal Slicing:-

Applicability:-

1) Thickness of seam >15m
2) Irregular shape of seam
3) Steeply inclined thick seams.
4) ~~It~~ Can mine ~~hard~~ soft seams, self igniting seams, ~~too~~ seams evolving fire damp.

Access Roads / Development Roadways:-

(*) Constructed in footwall of the seam and ~~crosscuts~~ drivens from footwall to the seam.



IMPORTANT NOTES

Advantages of access road in footwall :-
(i) In case of fire, panel can be sealed off easily and isolated
(ii) roadways are more stable and require less maintenance.

⇒ Horizontal Slicing in ascending order with stowing :-

Method :-

(#) Through cross-cuts, each level is accessed.

(*) A principal level gallery is driven through the seam along the strike of the seam from the level gallery, longwall faces are developed on either side of the central gallery at regular intervals.

(*) The faces are advanced on the strike.

(*) Conveyors installed at the face transport the coal on to the conveyor in the central level gallery along the strike of the seam.

IMPORTANT NOTES

- The goaf is stowed hydraulically or pneumatically.
- After the first slice the second slice is extracted in a similar manner.
- But development of the 2nd slice is started during the extraction of the 1st slice:-
- For opening the second slice, at 3 or 4 placed along the principal gallery inclined raises are driven over the stowed goaf going up towards the footwall.
- When these raises had gone up 3m above the top of the stowed area levels were driven on both sides of these raises and when such levels joined the similar levels from other raises the principle gallery for 2nd slice is formed.

IMPORTANT NOTES

- After extraction of 1st slice, the principal gallery is also stowed in the lower slice.
- ~~For small seams~~
  Horizontal slicing in descending order with caving :-
- ~~Proceed in a similar manner as earlier~~
- A central level gallery supported by steel arcs and wooden cogs.
- Face is opened across the seam with central gallery driven along the strike.
- Slices are worked simultaneously with a stagger of 70 m.
- As the face progresses, artificial roofing is laid along the floor which is wire netting on steel strips.

IMPORTANT NOTES

- As the face advances the goaf edge supports are withdrawn and artificial roofing and the loose debris is allowed to come down rest on the newly laid artificial roofing and simultaneously new friction props are installed with articulated roof bars.
- After the face has advanced by 60 m, the central gallery is dug in 2 steges of 1.5m each so that its floor is lowered by 3 m. When the floor of central gallery has been lowered, 2 galleries are made at right angles to the central gallery and longwall faces are started below the artificial roofing laid along the floor of the next higher slice.
- Generally 3 slices are worked simultaneously at the same time.

IMPORTANT NOTES

Face conveyors transport coal from the face to the central gate belt conveyor which loads the coal on to the trunk conveyor in one of the inclined galleries. This conveyor brings the coal up to the surface.

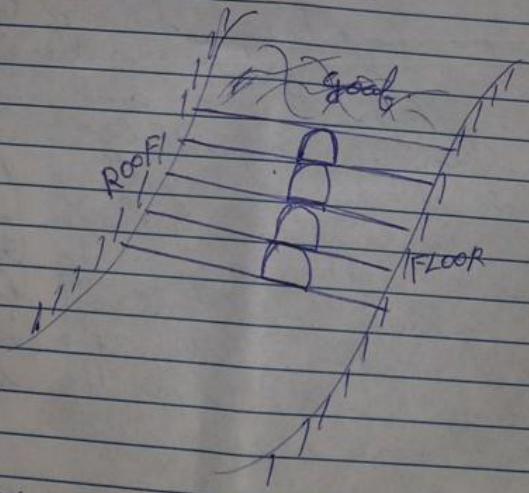


FIG:- Central galleries deepened to open next slice.

IMPORTANT NOTES

Advantage of this method:-

1) Safe
2) High Recovery

Disadvantage of this method:-

1) Entry and Ventilation layouts are complicated.
2) A Amount of development involves huge costs
3) A large quantity of supplies is needed
4) Little scope of mechanization.
5) Working front is small and loading is labour intensive.

Disadvantage of Horizontal Slicing:-

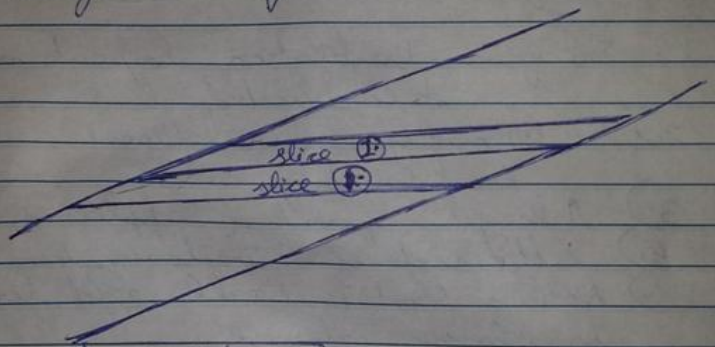
1) Working front is small
2) mechanization is needed
3) Huge development work needed.

IMPORTANT NOTES

~~Diagonal Slicing:-~~

~~Sublevel caving:-~~

Diagonal Slicing:-



Applicability:-

1) Moderately thick seam
2) 50 - 55° dip
3) no rock bands or parting.

⇒ slices of 2 - 2.5 m thick dipping at 35 - 40°
⇒ Taken in ascending order with stowing

IMPORTANT NOTES

Advantages:-
- Gravity flow of coal and filling material in production face
- Low volume of main and subsidiary work

Disadvantage:-
- Filling is essential
- Coal losses are high
- Timber Consumption is high
- Constructional elements of the method are complex
- Working front is small.

Transversely Inclined Slicing:-

⇒ Slices are dipping at 30° to the horizontal but in the direction opposite to the direction of dip of the seam.

⇒ Ascending or descending mining is possible.

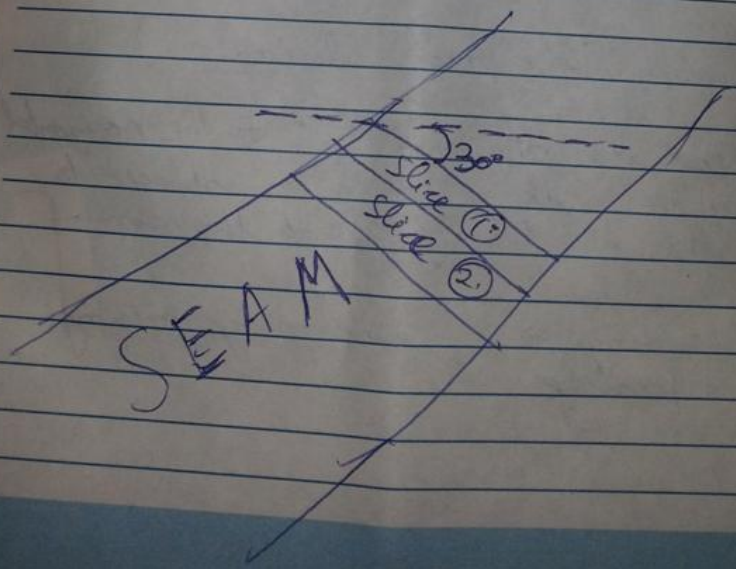
IMPORTANT NOTES

Advantage:-

1) gravity flow of coal and filling material
2) Low volume of main and subsidiary work.

Disadvantage

1) working front is small
2) Huge consumption of Timber
3) Setting of timber is difficult
4) Risk of injury by sliding objects



IMPORTANT NOTES

Sublevel caving:-

~~During instead slicing it becomes difficult to take more than 2 slices.~~

Blasting gallery:-

This method of thick seam mining is ~~modified~~ modification of B and P ~~where~~ where development of the seam is done along its floor and whole thickness of the seam is exploited in single section during the depillaring stage. The method relies on long drilling in conjunction with use of remote controlled LHD for purpose of blasting in thick seam and loading of coal from the unsecured area respectively.

The overlying rock is allowed to cave for filling the goaf, thus it is essentially a caving method.

IMPORTANT NOTES

Applicability Conditions:-

(i) thickness of seam should be more than 6 m but less than 15 m.

(ii) Gradient of coal seam should not be more than 1 in 7

(iii) Coal seam should not be highly gassy.

(iv) The overlying roof must be cavable and there should not be any surface constraints.

(v) Coal seam should have lower susceptibility to auto oxidation

(vi) Floor of the seam should not have soft clay formation. It should be a competant one.

IMPORTANT NOTES

Description of the Method:-

1) Development phase:- During development the coal seam to be extracted is developed along its floor upto 3m on B and P system forming pillar of adequate size confirming with width of gallery and cover depth.

The development can be done either in Conventional, mechanised or semi-mechanized manner.

2) Final Extraction:- It comprises of depillaring of developed pillars upto full thickness of seam in one section with longhole drilling and blasting. The sequence of operation comprises of:-

(a) Splitting of pillar → The pillar under extraction is splitted in 2 equal parts. Splitting is done with conventional drilling and blasting and loading on chain Conveyor using LHD.

IMPORTANT NOTES

(b.) **Depillaring Operations →** It starts from the rise most pillar of the panel and progresses towards the dip following a diagonal line of extraction.

(c.) **Drilling operation →** For the purpose of long hole drilling, we use electro-hydraulic jumbo drills which can drill hole of length upto 12m long for the purpose of blasting. Therefore whether the pillar is required to be splitted or not depends on its size. For a pillar less than 25m wide, no splitting is required because the entire width of pillar can be worked by drilling as it is half width from either side galleries.

Drilling of long hole blast hole is made in ring pattern. In one ring about 20 nos of blast holes, 10 on either side of gallery are

IMPORTANT NOTES

generally drilled. The ~~Vertical~~ holes are inclined at an angle of 35° from vertical plane towards the goaf side so that the blasted coal is thrown towards the goaf. Total length of drilling in a ring depending on seam thickness and pillar size can vary from 100–160 m.

The spacing between 2 consecutive rings is kept 1.4 m – 1.5 m. The holes are drilled by putting the jumbo drill within supported gallery.

Charging and Blasting:-

The blastholes are charged with special type of explosive called GE-85 in conjunction with detonating cord, electric delay detonator, plastic spacer and steaming material. The max. permissible amount of explosive per hole is 3 Kg.

IMPORTANT NOTES

The charging pattern is illustrated below:-

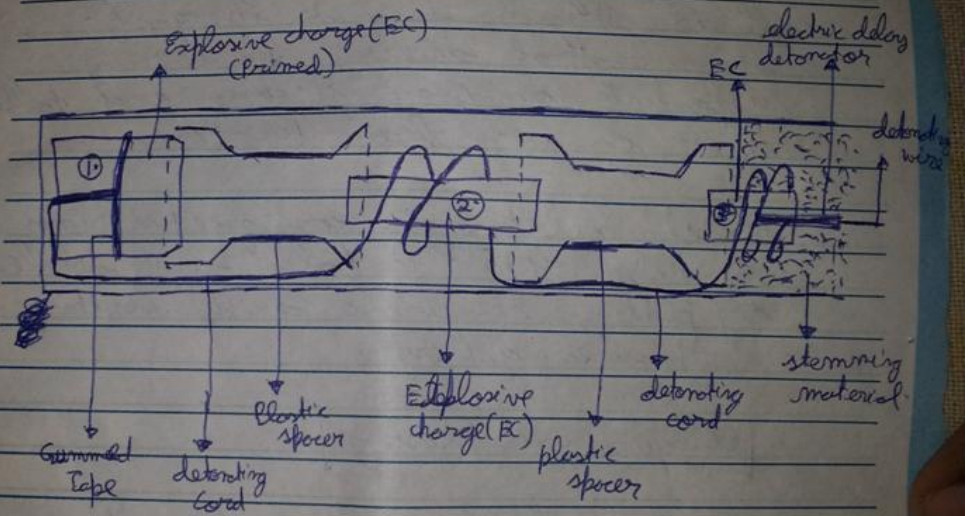


FIG: Charged Blasthole

IMPORTANT NOTES

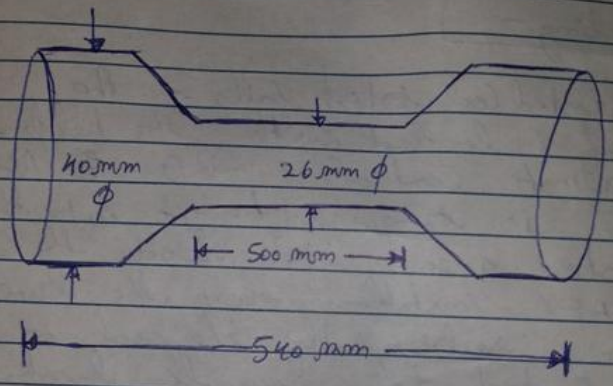
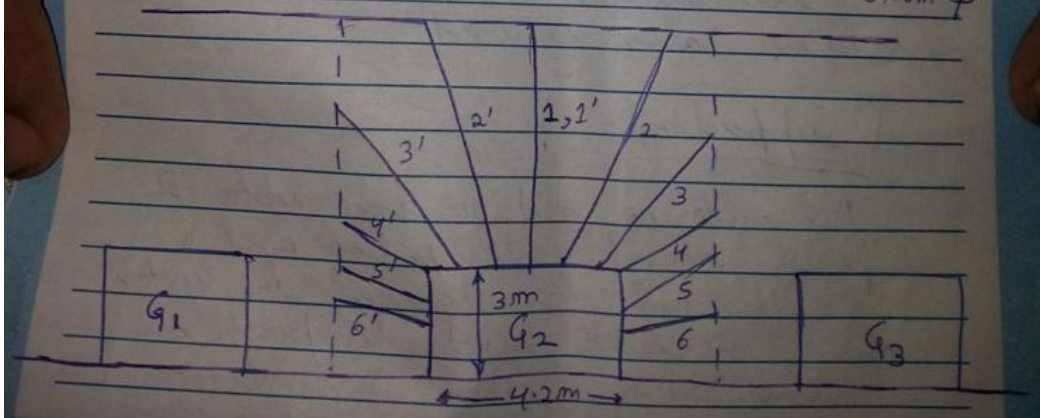


FIG :- Plastic Spacer. (used to decrease ~~the amount of charge~~ in the hole)

max length of holes = 12 m dia = 48 mm ϕ



G :- Galleries FIG: RING DRILLING

IMPORTANT NOTES

Loading:-

The blasted coal which falls in the goaf is loaded with the help of remote controlled LHD. No person is required to go into the blasted area. LHD loads the coal into AFC installed along the level galleries subsequently the coal is transported to a small bunker through a series of chain conveyors from where it is is transported outbye of the mine through a belt Conveyor. U/G Bunker Can also be used.

Supporting:-

All galleries and junctions upto 2 pillar ahead of the pillar under extraction is supported by 40 tons open circuit hydraulic prop in conjunction with I- section

IMPORTANT NOTES

steel girders and steel chocks wherever required.

Advantage of this method:-

1) It makes it possible to win narrow panels or longer panels in which seam conditions are unsuitable for a longwall face.

2) It does not require highly experienced workers as a longwall face with "Sautirage working."

3) Investment is lower than sautirage and equipment can be reutilized if method turns unsuccessful

4) Thick seams upto 15 m can be extracted in one pass with % age of extraction from 65% to 85%.

IMPORTANT NOTES

5.) Method is highly flexible and in a district where several units are in operation, even if one of the units breaksdown, the production from district will continue to come.

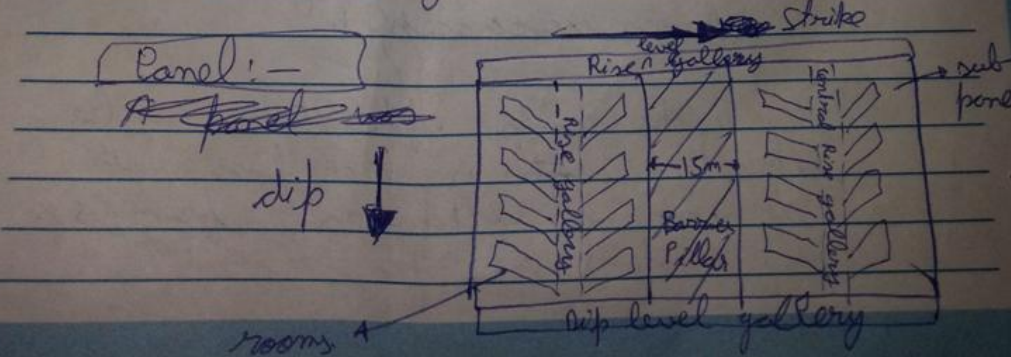
6.) Time required for ~~pan~~ preparation of panel in relation to total life of panel is less than in mechanised methods.

Case Study:-

In India GDK 10 Incline in Godavary Coalfields was ~~worked~~ developed and worked by this method.

Panel:-

~~A panel was~~



04/04/2014

R Nath Sir → (Refer R-D Singh)

Sublevel Caving:-

During ~~inclined~~ inclined slices it becomes difficult to take more than 2 slices:-

1) because the roof (~~artificial~~) degrades sufficiently
2) If stowing is opted then shrinkage of stowing material takes place to large extent.

Requirements:-

1) Roof should be curable
2) Coal should be reasonably soft and moderately hard

If we have a strong roof and hard coal then we can make the seam amenable to caving by opting for blasting → but it is not easy.

So if the seam is very thick then ~~it is~~ we can opt for sublevel caving process:-

Method of Development and Working:-

See diagram (Fig 8.15) from R.D. Singh

3) Along
4) As the
5) After
8) The
9) The

1) There are 2 longwall faces.
2) First a longwall face is developed along the roof of the seam.
3) Along the floor of this slice, wire netting is laid as the face advances to form artificial roof.
4) As the face advances, the roof of the seam caves on this wire netting.
5) After the 1st slice face has advanced by 30 to 40 m (This distance can vary, it should provide sufficient time for compaction of the goaf material of the artificial roof.)
6) , the second slice is marked out along the floor of the thick seam.
6) The intermediate coal plate is extracted by drilling inclined holes at 5-6° from the vertical and blasting the holes.
7) The intermediate coal face has an inclined face which provides some benefits:-
   (i) It gives a natural curve to the wire netting and so prevents its degradation due to severe bending
   (ii) Coal falls in the goaf direction and does not cause damage at the face (to men and machinery)
8) The intermediate coal blasted is loaded onto the ARC (Armoured rear conveyor) at the goaf edge, in the lower slice.
9) The wire netting separates the broken coal from roof rock.

Problems:-

1) If the seam is undulating then working of the slice becomes difficult.

2) Working of 1st slice destresses the intermediate coal plate and so we require blasting to disload the coal.

Integrated Sublevel Caving:-

(SOUTIRAGE)

* Coal seam shatted part of away from the Roof Rock
* Strata provides sufficient pressure to cave down the seam.

Advantages:-

(i) development and investment is least compared to other methods.
(ii) Coal itself breaks by strata pressure so no blasting is required.
(iii) full automation is possible at the face.
(iv) A small no. of faces can produce large quantity of coal.
(v) Although the % of extraction is low but OMS can be upto 40 tons
(vi) Supervision is easier so greater efficiency of engineers and overmens.

→ we get good results upto a gradient of 20% above which results fall down

Disadvantages:-

* large emission of methane (we can carry out nitrogen flushing to make it [illegible])

12m 7m

- Coal is crushed and invariably it is left in the goaf so it is a potential source of spontaneous heating/combustion.
- Lot of coal dust is produced so to avoid this we can carry out water infusion in the top coal.
- Maintenence of yate roadhead of face is difficult, such a thick seam is extracted so due to high pressure convergence is very high.

⇒ Speed of extraction should be high but it should not be too high to leave sufficient coal in the goaf.
⇒ retreat mining system is opted as we leave broken coal in the goaf area and advance further.
⇒ To avoid problem of spontaneous heating, mud flushing is done in the goaf area.
⇒ It requires higher expertise and skilled labours.
⇒ It is risky compared to sublevel caving.
⇒ Large amount of labours are required in sublevel caving but lesser labours in sublevel caving.

Method of Development and Working:-

Here we have only one longwall face along the floor of the thick seam. The support at the face is by shield type powered support. As the face advances the entire coal thickness above the slice is caved due to the strata pressure. The broken coal is loaded on the AFC, at the back end of the powered support by opening the window of shield support. The window is closed when rock starts comming in. The coal cut by the shearer at the face is loaded onto another AFC at the face. A large amount of crushed coal is left in the goaf area thereby increasing the chances of spontaneous heating.

Comparison of Sublevel caving and Integral sublevel caving :-

1.) Thickness of seam
2.) Capital Cost
3.) ~~Mechanization~~
4.) Support and automation
5.) Skill of labours
6.) liability of coal to Spontaneous heating
7.) % age of extraction
8.) Productivity

* Thickness of seam → Higher thickness of seam can be extracted by integral sub-level caving. (Intermediate coal plate is difficult to extract in sub-level method if thickness is too high, long hole drilling is difficult)

* Capital Cost → Capital cost is ~~higher~~ lower in integral-sublevel caving ~~due to steam powered support (Sublevel workings ISLW panels)~~ (only one longwall panel)

* Mechanization → greater mechanisation is needed in integral sublevel caving (shearer and powered shield supports) while ~~is~~ ISLW is used in sublevel caving method

(3) Automation → Integral sublevel caving is more automated compared to sublevel caving and hence labour requirement is low.

(4) skill of labours → Integral sublevel caving is a complicated method and requires more skilled and experienced workforce.

(5) liability of coal to spontaneous heating → More coal is left in the goaf area in integral sublevel caving compared to sublevel caving method so mans liable to spontaneous heating should be extracted by sublevel caving method or if integral method is adopted then frequent mud flushing into the goaf should be done at regular intervals.

(6) % of extraction → Integral sublevel caving has great loses of coal so % age of extraction is lower in it.

(7) Productivity → The productivity of the longwall panel in integral sublevel caving can be as high as 20 tons which is very high compared to sublevel caving panels.

Level transport Road → intake Road → water pipe line

Thin - Seam Mining (R Nath Sir)

Thin Seam $\leq$ 1.5m

- 0.3m – 0.5m . very thin seam
- 0.5m – 1.5m thin seam

$<$ 0.3 m not workable

Disadvantages or difficulties:-

1) Difficulty in opening and development of seam
2) Difficulty in walking and working

3) Difficulty in proper mechanisation for working the seam fast.

4) ~~Less production per unit of face advance~~

5) Lower OMS

6) Convergence further reduces the height of gate roads to very small dimensions.

7) Difficulty in use of transportation systems → loading of coal tubs and belt conveyors becomes difficult. In U.K. the concept of loading the lower belt was introduced.

8) Reduced Efficiency of work.

Advantages:-

1) A higher % age of extraction (loss of coal is less)

2) Because coal left in goaf is minimum so lower chances of spontaneous heating is there

3) Lower gas emission problem.

Method of working:-

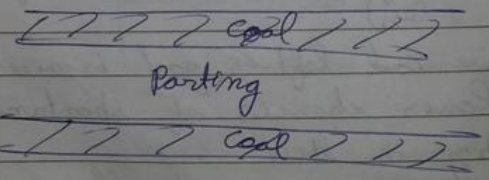
1) 0.5 m - 1.5 m thick → must be worked by ~~through~~ in India

seam of 1·2 m thickness have been worked in B and P System. Longwall is preferred because minimum no. of roadways have to be developed and maintained.

2) Generally travelling roadways and main transport roadways are heightened by roof blasting or floor blasting. Roof blasting is preferred in longwall advancing system because the rock from the roof can be utilized in making the packwalls by the side of gate roads.

3) Very thin seam < 0·3 m is not workable but hydraulic mining can be opted if country is in dyse need of coal.

Working of Contiguous Seams:-



⇒ If 2 coals seams are very near to each other the problems arise in working the seams — Contiguous seams.

⇒ If a thick coal seam is worked in 2 sections with parting in between → Contiguous Sections

⇒ If 2 seams / sections are at a distance less than 9 m apart then they are Contiguous.

If we refer Regulation of 104 of CMR:-

1-) No work in higher seam / section shall be done over an area in a lower seam / section which may collapse

II) (a) No working shall be made in more than 1 section in any seam nor shall working be made in any 2 seams lying within 9 m of each other without the prior permission of the chief Inspector of mines.

(b.) ~~Every application~~ See CMR.

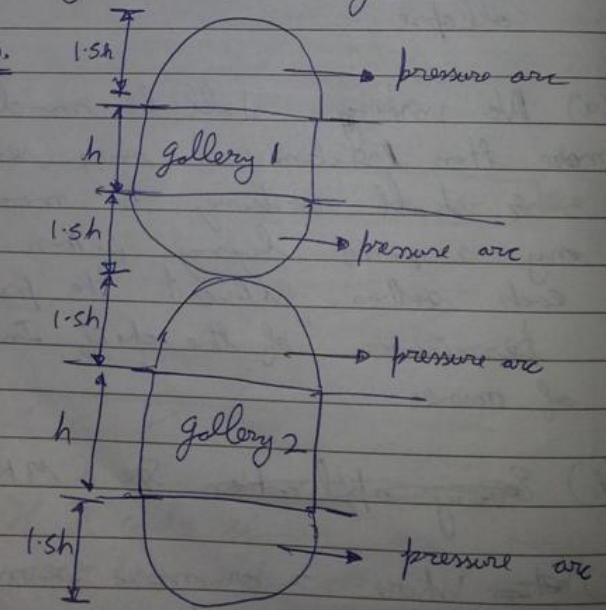
(c.) ~~When~~ Where 2 or more seams or sections are worked in a mine then the pillars in one seam or section

as far as possible be Vertically above or below the pillars in other seam or section unless the seam / strata is inclined at more than 30° to the horizon. (Coincident verticality in the seams / section has to be maintained)

(d) Minimum parting which must be maintained between 2 seams / sections shall not be less than 3m at any place.

Q. Why 9m for contiguous ??

Ans).

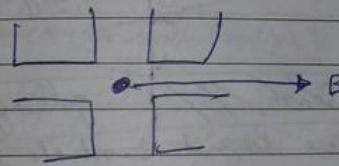


The working of 1 seam should not affect the destressed zone of other seam. We want to avoid mutual interaction of workings. So to avoid such problems the pressure arcs of 2 seams should not merge so since the maximum ht of extraction is 3m so a minimum distance of 3h = 9m is required to work two seams or sections in an independent manner.

Working Contiguous Seams with Caving:-

1) Development has to be carried out with coincident verticality → accurate surveying is required.

Physical checking:-



Bore hole at above junction should also strike the centre of junction in the lower seam/section

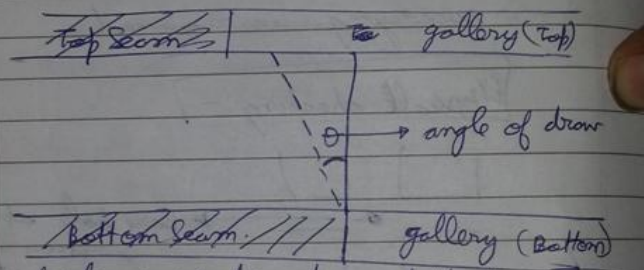
2) Extraction must be carried out simultaneously in both seams ~~but~~ and the ~~to~~ line of extraction in both seams must be ~~vertically~~ ~~and~~ vertically over each other if parting is between 3m to 6m and the top seam face is worked first.

If parting is 6m - 9m then the top seam face leads bottom seam face [illegible] distance.

If parting > 9m then simultaneous extraction is not necessary but top seam is worked first then bottom seam.

Q:) Why a 1/2 pillar distance as the stagger of focesition 6-9m parting??

Ans:)



Due to subsidence we do not want the lower seam face to affect the working at the upper seam face. So depending on the angle of draw, it is seen that a lead of 15-20 m avoids problems at the top face.

Steep Seams:-

25° to 45° → steep seam

45° to 90° → Very steep.

Problems:-

(1) Difficulty in walking and working.

2) Tools and equipment may

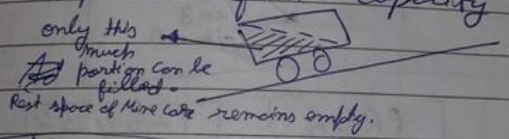
slide down the gradient.

3.) Broken rock from goaf can slide to working face if goaf is on rise side.

4.) There may be creep of supports and conveyors towards the face

5.) Normal ~~belts~~ belt conveyors (max gradient = 18°) are not used in gate roads, HAC are used.

6.) Mine cars cannot be utilized upto ~~its~~ its full capacity



Advantages:-

1.) Gravity haulage can be used if working from rise to dip.

2.) Hydraulic transport can be used if working from rise to dip.

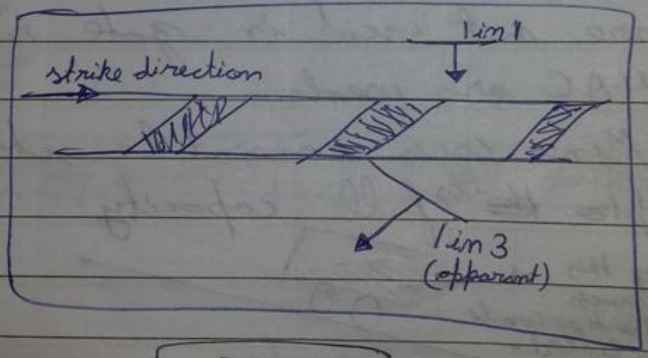
3.) Tight packing of goaf by stowing material can be ensured due to high gradient.

Method of working:-

1.) If thick seam is present → horizontal slicing is done

2.) If seam is thin → metalliferous method

3) Working can be done at an apparent dip of lower value. The ~~strike~~ strike direction remains same but dip-rise galleries are worked at lower dip. If we have diagonal galleries and rombus pillars.



PR Sir

12/04/2014

Hydraulic Mining:-