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CASE STUDY ON BLASTING GALLERY METHOD

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ABSTRACT - *In the mining industry, the challenging task of mining professionals comprises the extraction of maximum natural resources along with the safety of the miners. A comprehensive study of this method of mining in the technical and technological analysis is allowed for its effective application. Conventional bord and pillar mining in thick seams is associated with a very low percentage of extraction [around 30% in a panel] even under favorable conditions. Due to the low percentage of extraction of reserves by B&P, most of the mines have chosen the Blasting gallery method of extraction to improve their rate of extraction. so, A detailed view of the Blasting Gallery method, Design of blasting technique, and mechanization works in the blasting Gallery method is carried out in this paper. Here, around 50% of coal reserves in India are found to have a seam thickness of about more than 4.5 mts which considered and called as thick seams. The exploitation of thick seams by underground methods arises certain difficulties and problems. The blasting gallery method is the appropriate method for the extraction of thick seams having 8 to 11mts. Mining by this method produces around 1000Tonns/day with 85% of extraction. At present in India, Telangana state is implementing the B.G. Method in SCCL, GDK—11, and no. 21 incline Yellandu.*

Keywords: Natural Resources; Blasting gallery method; Unique Techniques; Exploitation;

1. INTRODUCTION

Commencing into the theme Blasting gallery method. For most, we have to familiar with mining. Generally, mining is a process of extraction of valuable minerals from the earth, usually, from an orebody, lode, vein, (or) reef. Generally, the mining industry contributes nearly 80% of civilization throughout the world. As we go with the normal method of mining i.e. Bord and pillar method. It is barely used up to 5mts Only and the percentage of extraction is less. To get the better of these, the blasting gallery method used for a seam up to 20mts. The method is most successful for the percentage of extraction as well as safety and mechanization. The method was very successful resulting in 85% of extraction with high productivity.

Strata control or roof control implies the control of the strata to facilitate mining operations to be done efficiently and safely. Not only we are concerned with the roof falls and uncontrolled failure of strata or structure in the rock but also with the harnessing of the strata pressure to advantage so that there is the ease in coal getting. There is less emission of gas and less production of dust and also the caved strata fill the goaf solid so that the risk of spontaneous heating is minimized.

The strata on the face, and in the adjoining area, i.e. in front and behind, must require attention so that no uncontrolled failure of the ground takes place. To design satisfactory strata control measures, it is essential first to have a clear understanding of the mechanics of the movement of the ground as a result of the mining operation.

In thick coal seams, coal bed forms the roof of the lower slices. A coal layer at the roof normally forms a good roof. But coals with joints and cleats are prone to fail without warning. Some seams have coal balls, nodules, or rounded fragments, and these may fall unnoticed and cause fatalities. When coal bed is undermined, it may also develop induced cleavages and fractures and in such situations roof falls are common. So for complete or maximum extraction of such coal seams, the Blasting Gallery method is introduced.

The first Blasting Gallery method of extraction was introduced in SCCL in 1989 at GDK No.11 Incline and being worked successfully. Although the first BG in India was introduced in East Katras Colliery of Jharia Coal Fields, BCCL and Chora Colliery of Raniganj Coal Fields, ECL in 1987, the workings were abandoned in East Katras Colliery due to Strata Control Problem and were discontinued in Chora Colliery due to premature Spontaneous heating problem. GDK-11 Incline mine falls in Godavari Valley Coal Fields of Singareni Collieries Company Limited and is situated in Telangana.

1.1. OBJECTIVES

The main objective of the blasting gallery method is to extract valuable minerals with a high percentage of extraction and mechanization along with better safety to workers by implementing a high standard of support.

The primary objective is as follows:

- To study about the mechanization involved in blasting gallery method.
- Brief study about the jumbo drill machine.
- To study the blasting design and method of blasting.
- Brief study about spacers and explosive.

2.0. CASE STUDY

2.1. Selection of site:

study was conducted in the mines practicing the blasting gallery method of working. As such one of the Singareni collieries company limited has been selected. For the study, the GDK No. 11 incline 3A panel was selected.

2.1.1. History of GDK-11 Incline

GDK 11 Incline mine is located in the north-central part of the Ramagundam area, lies between north latitude 180^0 41^0 41.25^0 and $180^044^020.98^0$ and east longitude 790^032^0 30.8^0 and $790^034^047.4^0$. The full dip of the seams is 1 in 8 to 1 in 10 in the direction of N 600 E.

This mine was opened on 15-02-1979. Production started on 25-09-1985. The total mine take area is 9.01 Sq. km with an idea to develop only No.1 seam by longwall method. 8 No of longwall panels were developed with Road headers, and extracted with 3 Units.

In the year 1998 regrouping of mines took place and GDK 6B IGM was formed having two sections namely GDK 6B and GDK11A section. Again, GDK 11A section of GDK 6B IGM was renamed as GDK 11 Incline in the year 2009 while annexing some property of GDK 6B section to RG-OC III extension project.

At GDK 11 Incline four numbers of Seams are existing namely 1, 2, 3 & 4. At present A-4 Depillaring Panel with Continuous Miner Technology is under progress in No.1 Seam. In No. 2 Seam present Trunk Roadways development by LHDS and in No.3 seam present BG-K4A panel is being worked by Blasting Gallery method and No. 4 Seam is being worked by Depillaring 4SS-6 panel with sand stowing LHD (811) and development beneath BG-caved out panel (1A,1B,1C).

Introduction of Technologies

- Longwall Technology :1991
- Blasting Gallery Method : 2002
- Continuous Miner Technology : 2008
- Depillaring with Hydraulic Sand Stowing by LHD (811 models) :2011

2.1.2. About the Workable Seams (As on 31.03 .2019)

Name of the seams	Parting	Thickness (m)	RMR	Grade	Extractable Reserves(Mt)	Method of working
1. seam		6.0	51	G9 G11	16.7	Developme nt and depillaring with coal mining technology
2. seam	15.28 to 22.64	6.0	41	G11	14.20	Developm ent with LHD
3. seam	49.71 to 71.25	8-10	50. 40	G8	55.37	Depillaring by BG with LHD
4. seam	8.15 to 13.17	3.0	42	G7	13.50	Development & Depillaring by stowing with LHD
		Total		G9	99.77	

2.2. MINE VENTILATION

As per the permission condition specified that ventilation shall be adequate to bring down the concentration of NO_2 and CO_2 in post-detonation fumes at the face to5ppm and 50ppm respecting within 5 minutes. In no case, the quantity of air at any working place shall be less than $284m^3$/min. No shot shall be charged or fried if 0.1% or more inflammable gas is found. No persons shall be allowed to remain on the return side of the false when blasting is done till the concentration of oxides of Nitrogen and Carbon. Ventilation shall be adequate to bring down the concentration of NO2 and CO2 in post detonation fumes at the face to 5ppm and 50ppm respecting within 5 minutes.

Table 2.2. Ventilation fan details

DESCRIPTION	FAN NO. 1	FAN NO. 2	FAN NO. 3
Make	voltas	Voltas	Voltas
Fan capacity	3lakhs cft(8500m^3/ min)	3lakhs cft(8500m^3/ min)	3lakhs cft(8500m^3/ min)
Motor	Kirloskar	Crompton	Kirloskar
Motor capacity	225kw	250kw	250kw
Water gauge	68mm	68mm	68mm
Amperage	48A	38A	32A
No.of.blades	8	8	8
Blade angle	125^0	15^0	15^0
No.of.blades	Poly v-belt	8	8

- 3 Nos. of 3 Lakh Cft/min fans are existing. Out of 3Nos. always two are under operation and one is kept as stand-bye.

2.3. STRATIGRAPHIC SEQUENCE

Age : Recent

Formation : Breaker

General Lithology : Soil dominantly coarse to feldspathic.

Maximum thickness : 3.95m

Structure:

- The general trend of formation is NE-SW with South-Westerly dips. The general gradient of the seams varying from 1 in 3 at the outcrop side to 1 in 10 in the middle.
- Brief description of a coal seam being worked: Seven seams are existing in this area namely from top to bottom.
- Index-II, Index-I, Queen seam, B-Seam, C-Seam, D- Seam, and King Seam. Out of above only index-I, Queen Seam and king seam are workable.

3.0. METHODOLOGY

3.1. Development for BG Panel

The blasting gallery method is used in the case of a thick seam whose thickness varies from 9-15m. In this method, the entire thickness of coal deposited is blasted by blasting a level gallery that is driven along the floor of the seam. A large panel of 1000m X 120-150mt is divided into a sub-panel of 150 X 120-150mt by dividing the raise. A barrier of 20m coal is left between the sub panels so that the problems present in one panel can't affect the production in other panels. The sub-panels are separated to enable them to complete the extraction within the incubation period. The central drive is also provided with a conveyor or main haulage system for transport the blasted material.

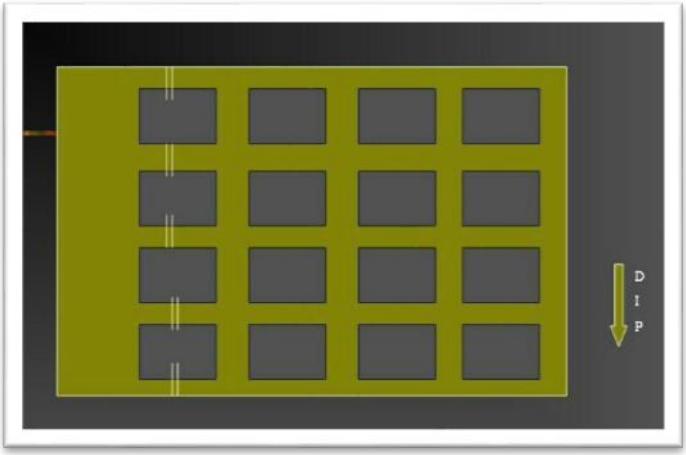


Fig.3.1. Development for BG Panel.

3.1.2. DEPILLARING BY JUMBO DRILL MACHINE

Fig.3.2. Drilling by Jumbo Drill Machine.

TECHINCAL DETAILS OF JUMBO DRILLING MACHINE, 37KW

- Versatile can drill at any angle up to 30 M in coal
- Model : Secoma CTH-17, Tam rock
- Type : Flip Crawler Mounted Hydroelectric Operated
- 100M Cable Reeling Capacity (32 mm O.D.) Max, Operating Grade :25%
- Tramming Speed:2Kmph
- Drilling :1m/min
- Drill rod :39mm
- Overall Length :6050MM
- Height :2650MM
- Weight :7000 KG

3.3. BLASTING PRACTICE

❖ DRILLING

- The dia. of the drill rod is 43mm. Water is injected into the central hole of the rod to eliminate dust produced while drilling. The holes are drilled in such a way that they cover half of the pillar. The number of holes in a ring is 36 holes. The drill rods are hollow type and about 1.2 mts in length. These drill rods are male and female attachment and about 32mm dia. The ring holes formed after jumbo drilling.

Fig.3.3. Jumbo Drill Rods.

Note: The length of the hole depends on its position and seam thickness.

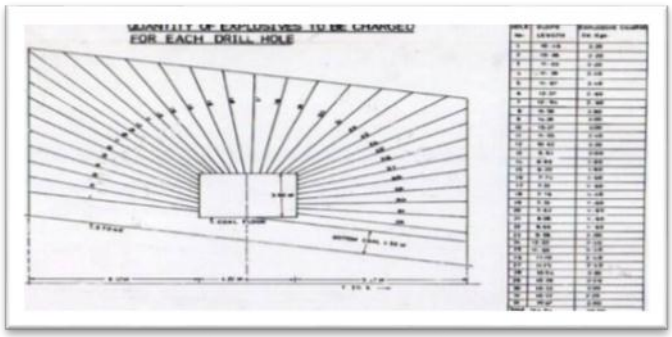


Fig.3.4. Drilling pattern and Quantity of explosives to be charged.

- The jumbo drill can drill up to 30m. long incline hole with a speed of 1m/minute. The drill rods are 1.13m long with connecting features with rope tread at the end. The diameter of the drill rod and drill bits are 32mm. On average,30-34 holes are drilled in-ring pattern. Each pillar shall be split into two equal parts by level split of width, not more than 4.2 meters.

- splitting of pillars shall be restricted to one pillar form the pillar under extraction. The long hole blasting shall not be practiced at any place where two free faces are not provided

❖ CHARGING:

- After drilling is completed short hole was charged with explosives approved by DGMS. The total no. of short holes in a ring is 36. Charged PVC pipes are inserted into the holes along with a pair of g-cord stemming by spacers and clay pills. The delay detonator and P5 explosive are used.

❖ DETONATOR:

Fig.3.5. Detonator.

- High explosives are initiated by a detonator or detonating fuses. It is a small copper or aluminum tube containing a small auxiliary charge of special explosives. Due to the chemical reaction initiated by flame or electric current in the special explosives, an explosion of sufficient intensity results throughout the high explosive enclosing the detonator.
- It is of plain ordinary electric detonators. It is having a ⅓rd with A.S.A. composition and P.E.T.N. No.6 detonator is suitable for the normal requirement of mining work. No.8 is more power full than No.6.
- The current of 0.5amp is required for ignition of fuse-head so a single detonator can be blasted with a minimum voltage of 3.5 volts. Delay detonator is used for more efficient blasting due to the supply of immediate free face for multi-row blasting.

NOTE: The shot firer must take at least two right Angles from the face while blasting.

❖ **EXPLOSIVES USED**

- BELGEX Coal-R 32 mm Dia.185 G/Cartridge
- Detonating Fuse : G-Cord
- Dia. : 6mm
- PETN :3.6g/m

Fig. 3.6. Spacers Connected with an Explosive Cartridge.

- **SPACERS:**

Spacers are two types:

1. Larger spaces.
2. Shorter spaces.

- Length of the long spacer : 600 mm
- Length of The shorter spacer : 250 mm

Fig. 3.7. Spacers

- Base charge : PETN Priming charge –ASA
- Type & Manufacture
- Range : 1
- Number : 6
- **Preparation of Spacers and Cartridges**
- The detonating chord should along the side of cartridges with strong adhesive tape. Connected with detonating chord a strong tape first, then the detonating chord should be wrapped.

3.4. PREPARATION OF PRIME CARTRIDGES

- Last cartridges can be connected to the other and the detonators and detonating cord. A traversal hole has to be made in these cartridges. Detonating chord a strong tape first, then the detonating cord. The explosive is linked together by detonating cord and 50cm spacers.

❖ **STEMMING**

- About 0.5-0.6m in the length of all holes are stemmed with clay at the end by the using wooden stemming rods Stemming is performed by 5 workers in 3 hours in 1shift, use of LHD for the stemming is not performed The CH4 content shall be measured in the room before stemming.

❖ **BLASTING**

- Connection of the round shots, detonators leads to be connected in series after connecting the leads guards shall be placed at every access of the area.

- Checking the shot firing cable. Check the circuit with an ohmmeter for resistance. Removal of supporting. After stemming, and before blasting, the last roof support shall be removed. After opening braces, props are withdrawn along with roof bar and wooden slippers, load in the bucket of LHDs by a term of support man.
- The blasting gallery method is used in the case of a thick seam whose thickness varies from 9-15m. In this method, the entire thickness of coal deposited is blasted by blasting a level gallery that is driven along the floor of the seam.
- A large panel of 1000m X 120-150mt is divided into a sub-panel of 150 X 120-150mt by dividing the main by the raise.

3.5. LOADING AND TRANSPORTATION

Coal is lifted using LHDs which are having a bucket of 3 cu.m capacity. These LHDs are fitted with remote control facility to load coal from the goaf. About 50% - 60% of the coal will be lifted with remote control operation. The LHDs unload coal into chain conveyors installed in the raises. The chain conveyors will be unloading the coal on to belt conveyors located at the top levels. Transportation of materials into the district is through endless haulers installed in the panel.

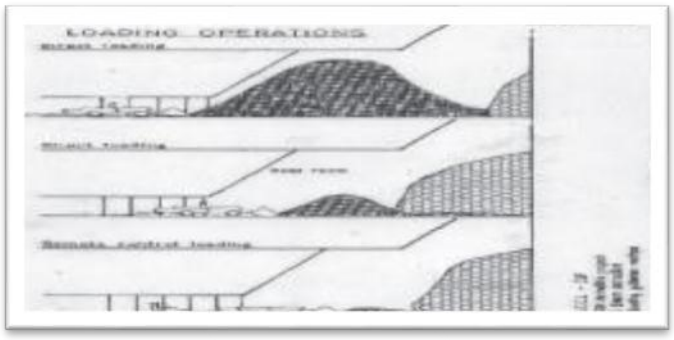


Fig.3.8. Loading operation of a BG panel.

3.6. Instrumentation for convergence test

The instrument like telescopic convergence indicator were fixed in predetermined place to get convergence. All the instrument as used for this purpose were calibrated prior to use in the field. The fig3.9 shows the typical instrumentation setup for general study or installation point of the instrument were chosen judiciously.

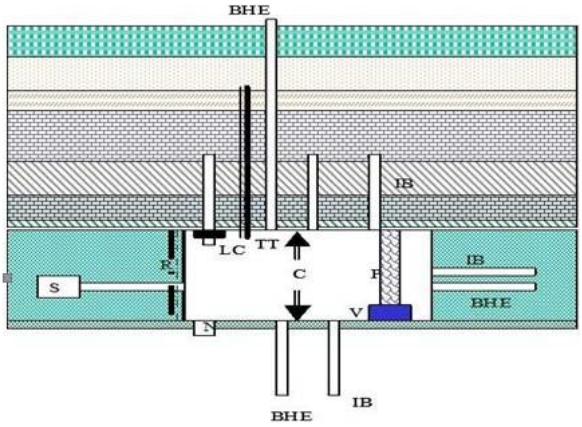


Fig.3.9. Typical Instrumentation Setup for strata behavior study.

- IB – Instrumented Bolt

  BHE–Bore Hole

  Extensometer M –

  Magnetic ring Anchor

- C – Convergence Indicator.
- LC – Anchor Load Cell P – Prop Support
- R–Remote Convergence Indicator in a grove
- TT – Tell-Tale Instrument

Fig.3.10. Convergence Indicator

The figure 3.10 shows the instrument used to measure convergence in the field. The pointer pointing to the number was initially noted while installing in the field and the reading was taken once every day. The difference between the initial and final reading gives the convergence observation for the day. The figure 3.11 shows the insitu measurement of convergence by using the convergence.

Fig.3.11. In-situ measurement of convergence.

- Indicators were installed in 66 AL, 66 BL, 67L, 67AL, 67 BL, 68L, 68AL, 68BL, and 70 Level in the 41 to 43 dips at an interval of 10 m along with the levels. Figure 3.12 shows the instrumentation layout of the GDK 11 Incline's BG-3A panel practicing the Blasting Gallery Method.

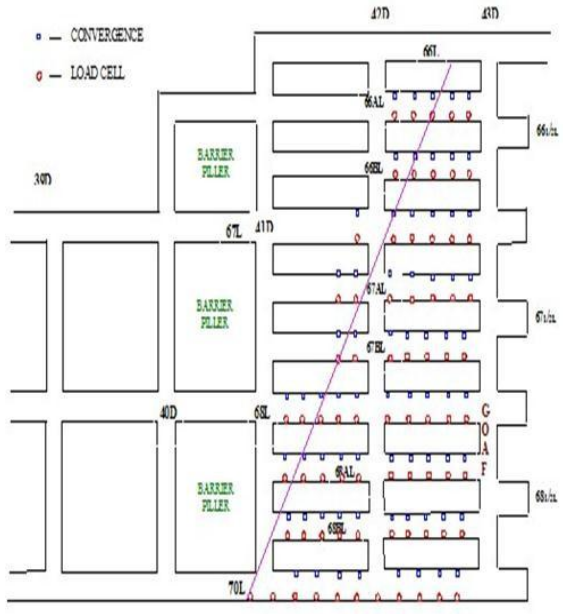


Fig.3.12. Instrumentation Layout in BG 3A Panel of GDK 11Incline, SCCL.

3.7. APPLICABILITY

The faulted deposits where no longwall panels of sufficient size can be developed Blasting Gallery method can be employed.

- The implementation of the BG method required a low level of methane emission.
- Seam up to 18m thickness can be extracted in a single operation in relatively

3.8. ADVANTAGES OF BG METHOD

- Full-thickness of the seam can be extracted in a single lift.
- Higher % of extraction i.e.75-85%
- Capital investment is nominal when compared to the longwall project.
- Easy to train the manpower.
- The safety of the workman can be fully ensured.
- This method can also be adopted in the developed seam.
- The loss of production is minimum while shafting the equipment.
- Even if one of the units is under break down, Production from the district will continue to come.

3.9. LIMITATION OF THE BG METHOD

- This method is not suitable for gassy mines and seams with degree-1 gassiness are most preferable.
- The method is most suitable only for gradient more than 1 in 5 to allow easy movement of a tyre mounted LHDs and crawler mounted electro-hydraulic jumbo drills.
- Though the percentage of extraction is around 75-85%, still coal left in the goaf is likely to create spontaneous heating.

3.10. MEASURES AGAINST STRATA CONTROL PROBLEMS

- The density of supports was increased by decreasing the span between girders. Grouting of 4 rows of 1.8 m. roof bolts were done at 1 m. grid. Side bolting is done in all the galleries. Regular induced blasting is being carried out up to 1.5 m. in the Sandstone roof. Frequent re-setting of hydraulic props is being done due to the probability of disturbance of vertical supports by moving machinery.

4.0. OBSERVATIONS

4.1. PRODUCTION PERFORMANCE

Table.4.1. Production Performance

YEAR	Target (LT)	Achieved (LT)	% of achievement	OMS
2007-08	6.05	5.18	85.60	**1.05**
2008-09	5.50	5.06	91.97	**1.02**
2009-10	5.30	4.77	90.10	**0.94**
2010-11	5.30	3.50	66.04	**0.77**
2011-12	3.30	2.73	88.60	**0.60**
2012-13	2.80	2.71	96.78	**0.63**
2013-14	2.70	2.35	80.74	**0.58**
2014-15	2.20	2.17	98.64	**0.62**
2015-16	2.50	2.21	88.40	**0.72**
2016-17	2.85	2.13	74.90	**0.63**
2017-18	4.80	2.91	60.60	**0.95**
2018-19	**5.60**	**3.11**	**55.60**	**0.95**

4.2. MANPOWER DEVELOPMENT

ASST. MANAGER	**- 1**
UNDER MANAGER	**- 1**
OVERMAN	**- 1**
MINING SIRDAR	**- 2**
SHOT FIRER	**- 2**
SHOT FIRER HELPERS	**- 4**
COAL CUTTERS	**- 4**
MULTI SKILLED GANG	**- 5**
ENGINEER	**- 1**
FOREMAN	**- 1**
ELECTRICIAN	**- 1**
FITTER	**- 2**
TECH. HELPERS	**- 3**
LHD OPERATORS	**- 4**
JUMBO OPERATORS	**- 4**
COMPRESSOR OPERATOR	**- 1**
LUMP BREAKERS	**- 4**
CONVEYOR OPERATORS	**- 2**
JUMBO CLEANING	**- 2**
MISC	**- 2**
TOTAL MANPOWER=50	
OMS=300/50=6	

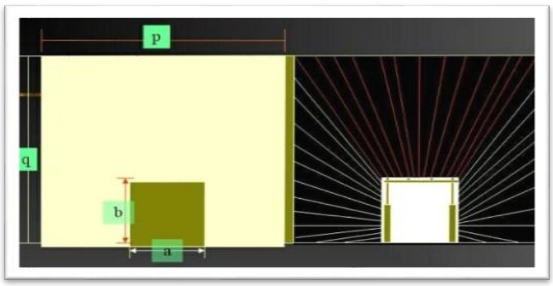
5.0. CALCULATIONS

5.1. POSSIBLE PRODUCTION OF THE PANEL

- After training and start-up period, and once 4 LHDs are in operation, the daily output shall be 600t/day, including, drivage production. It is assumed that the rate of recovery will not be more than 65%.

5.1.2. PRODUCTION PER BLASTING

- Taking into account the here above parameters, the production per blast will be:
- Production per blast = (PQ-ab) × X × sp. g of coal.



- Where, Q- Seam thickness (8.83m)
- P– Distance b/w two galleries: 17m
- Gallery width (4.7m)
- Gallery height(3m)
- Level section: 4.7 x 3.0=14.1m^2
- Total section: 8.3 × 17 =150.11m^2
- X – Distance b/w 2 blasts: 1.7 m
- Specific gravity of the coal: 2.6
- Production per blast = (150.11-14.1) × 1.7 × 2.6 = 602T

5.1.3. PRODUCTIVITY

- TOTAL MANPOWER =50
- OMS =6
- POWDER FACTOR =260T/65 Kg =4
- DETONATOR FACTOR =260/33 =8

6.0. CONCLUSION

- Based on the study of strata behavior during the extraction of pillars by BG method in 3A panel of GDK 11 Incline, the following conclusions were drawn:
- About 65% of coal reserves in India are in seams thicker than 5.5 m. The blasting gallery method of thick seam extraction is rib less and does not have goaf edge support. This method enhances coal recovery and practiced, as it cannot be afforded loss of national resources in terms of poor recovery of coal from the thick seam.
- Blasting gallery method of working can be practiced in the virgin thick seam as well as developed pillars in thick seam achieving a higher percentage of recovery (80-85%) by using LHDs.
- Problems and issues associated with the final extraction of a thick coal seam are important factors during the selection of the horizon for pillar formation during the development of the seam.
- Underground mining at full height in one lift becomes more difficult if the thick seam is already developed on pillars along the roof horizon. It may become more problematic during working below a competent roof stratum which caves with difficulty. The method of staggering development of the bottom section for under winning of roof coal is found to be effective for single lift working of a thick coal seam, already developed along the roof.
- Winning of the overlying roof coal band during depillaring of a developed thick coal seam requires induced caving. Based on simple rock mechanics principles, the idea of using grouted steel rope under tension to support an overlying coal band (as well as a high roof and to improve the safe span of the overhanging beam/ cantilever near the goaf edge of semi-mechanized depillaring of a developed thick coal seam standing on pillars).
- Abnormal strata loading should be overcome by adopting a suitable line of operation. Besides depth, the geotechnical parameters including faults, folds, and inherent weaknesses.
- Should be given due weightage before determining pillar and panel size and suitable line of operation. The future of the above-ground lies below the ground.

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