UNIVERSITY MINING METHODS SPECIALIZATION IN BLASTING GALLERY
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ABSTRACT
The difficult job of a mining expert in the mining business is to extract the greatest amount of natural resources while maintaining the miners' safety. When the coal seam thickness is greater, this job gets more difficult. The “Blasting Gallery” approach is a one-of-a-kind technology for depillaring thick seams and increasing coal recovery. The comprehensive literature review clearly demonstrates that the method's full potential has yet to be discovered. Despite the efforts of a number of academics, academicians, and other stakeholders, the effect of many important factors has yet to be determined.

Many choices affecting the Blasting Gallery operation in a mechanised underground mining system are affected by geotechnical factors, which are often interleaved with intrinsic stratum configurations. The goal of this research was to look at the BG technique operational systems in Indian geo-mining settings.

The GDK 10 incline, 3A panel of Singareni Collieries Company Limited (SCCL), Ramagundam was chosen to investigate the blasting gallery of coal mines with thick seams. This mine has an 11-meter thick coal seam at a depth of 350 metres, and it uses the Blasting Gallery technique to the fullest degree possible. Throughout the life of the BG panel, the convergence behaviour with respect to goaf edge distance (GED) was measured using high-tech (calibrated) equipment.

The field research, which collected data from the BG mine, particularly linked to natural falls, induce blasting, and other factors, received a lot of attention. The significant effect of various layers with changing overburden pressure was evaluated by measuring the convergence of roof strata in mm, the associated goaf edge distance (GED) in metre (m), the corresponding distance from face in metre (m), and the depth of panel in metre (m).

1. INTRODUCTION
Only underground mining techniques are used to extract about 70% of India's total coal reserves. However, owing to the challenging geo-mining conditions of coal deposits and the lack of sufficient technical assistance to satisfy the necessary level of safety and pace of production, underground coal extraction has not gained much momentum. Although underground coal extraction is considered part of CCT (clean coal technology), opencast mining has steadily increased its share of coal output in the nation over the past 50 years. The increase of coal output via opencast mining is mostly due to rapid mechanisation of mines, a quick set-up gestation time, and high production and productivity.

As the amount of coal deposits suitable for opencast mining decreases, mining techniques for safe and efficient underground coal winning will become more essential in future coal production. Coal seams with a thickness of 4.8 metres or more are referred to be thick in India. Thick coal seams account for almost 60 percent of the country's total coal reserves that may be mined underground. Most of these thick coal seams have been substantially exploited in single or multiple slices/sections to meet the growing demand for coal.

Around 30% of the established thick seams lie under a protected surface, with the remaining 70% accessible for caving if a viable mining technique to extract coal under the current difficulties of severe geo-mining circumstances can be found. Many nations, including the former Soviet Union, France, Spain, China, the former Yugoslavia, Canada, and India, have thick seams. In India, thick seams hold more than 60% of all known coal reserves. Some of the seams are over 30 metres thick. In the Singrauli Coalfield, one particularly thick seam measures 162 metres.
2. LITERATURE REVIEW

In India, Blasting Gallery technology, a popular and effective technique of extracting a specific set of inputs, has been a good source of subterranean output. The moderate to heavy overburden is usually a challenge to deal with in day-to-day operations with the stratum. This system's comprehensive literature scan has been a key component, and it has been given top priority above all other subroutines examined for this purpose. Blasting gallery method is a one-of-a-kind technology that was invented in France and used in virgin thick seams at Carmaux colliery. The Bharat Coking Coal Limited's East Katras colliery and the coal India Limited's Eastern Coalfields Limited's Chora colliery had previously used the blasting gallery technique. Overriding at East Katras colliery resulted in the loss of supports as well as coal, raising doubts about its future use in the Indian coal industry. However, in the Singareni Collieries Company Limited in Andhra Pradesh and the Chirimiri colliery of South Eastern Coalfields Ltd in India, this technique has shown to be successful and popular. (R.D. Singh, 1998)

PROBLEMS ASSOCIATED WITH MINING OF THICK COAL SEAMS:
Thick seam mining is linked to the following issues:
1) Difficulty controlling strata and monitoring them.
2) There's a chance that pillars will be overridden, causing the structure to collapse prematurely (in case of bord and pillar workings)

<table>
<thead>
<tr>
<th>Table 2: Thick Coal Seams in India</th>
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<tbody>
<tr>
<td>Jharia coalfields</td>
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<td>Raniganj coalfields</td>
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<td>Singareni collieries</td>
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<td>Chirimiri colliery</td>
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<td>Chinakuri colliery</td>
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<td>GIDIA mines</td>
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<td>Tipong mines</td>
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3) Low extraction percentage, typically less than 50% when using the bord and pillar technique.
4) Possibility of excessive spontaneous heating due to significant coal loss in goaf.
5) In deep seams and longwall methods of working, more support is required.
6) Subsidence management is difficult owing to large magnitude subsidence.

CONVENTIONAL METHODS OF MINING THICK COAL SEAMS

Figure 1 shows a broad categorization of thick seam mining techniques. Several variations/modifications to these techniques are also being tested in various mines.

**Fig.1 General classification of thick seam mining methods (Singh, 1997).**

Single-lift mining is usually restricted to a maximum height of 4.8 metres. Thick seams, on the other hand, are usually mined in several slices. This is referred to as slice mining, and each slice is mined in the manner of a complete seam of the same thickness. There is even more severe coal loss. Longwall mining (with multi-slicing) is thus the favoured technique of coal extraction from thick seams. This is also appropriate for mining thick and steep seams.

**Slice Mining:**

In this technique of mining, a coal seam is cut into slices of the proper thickness, and each slice is worked in the same way as a complete seam of the same thickness. Coal may be retrieved in ascending, descending, or mixed (both ascending and descending) order from the slices (Fig. 2)
Figure 2: Different orders of slicing thick coal seams (Singh, 1997)

**Descending slicing:**
Descending slicing can be done with or without stowing. In case of descending slicing with caving, spreading of wire netting is required to make artificial roof to arrest material of the broken goaf of the upper slice and this wire netting serves as the roof for the lower slices; i.e., lower slices are worked below the broken goaf. Stowing is rarely practiced in descending slicing (Fig. 2a).

**Ascending slicing:**
In ascending slicing method, the first slice is the bottom most slice which is excavated first. Working of this slice is like working a seam of average thickness. Subsequent slicing is done with stowing, i.e., the upper slices are worked on the filled surface of the bottom slice and therefore ascending slicing cannot be adopted with caving. The last slice can be worked either with stowing or caving (Fig. 2b)

**Mixed order slicing:**
In this method coal seam is divided into blocks, each block consisting of a number of slices. The slices in the block are worked in ascending order with stowing, while the blocks are worked in descending order. This method is commonly practiced in horizontal slicing method of thick seam mining (fig 2c).

**Sublevel Caving:**
Sublevel caving is applicable to thick seams with caveable roof and soft coal, though by blasting, hard roof can also be caved and hard coal seams can be softened. This system is consists of (i) mining a slice along the roof by normal long wall method with caving with flexible artificial roof laid on coal along the floor of the first slice; (ii) mining of another slice along the floor of the seam, and (iii) taking down the coal parting between the two slices by long hole blasting which is loaded out in a conveyor laid along the floor of the seam. Figure 3 shows the method of mining a 6.6 m thick coal seam by sub-level caving. In this method a long wall face takes a slice of 1.8 m along the roof of the seam. As the face retreats wire netting over steel bands is laid on the floor to form artificial roofing. Some 30 m behind the top face, another long wall face takes a slice of 1.8 m along the floor. The middle coal plate which is usually thicker than the top and bottom slices is mined at a distance of 3.5 m behind the floor long wall face by blasting with long shot holes drilled from under the support of the lower face. The slope of the long wall face of the middle slice should be tilted back with respect to the face by 5-10° from the vertical in the direction of advance of the face. The artificial roof prevents the caved stone from mixing with the coal of the middle plate. The mining in the lower and upper slices can be mechanized shearsers.
3. **BLASTING GALLERY METHOD**

- Only 30-40% extraction is feasible in thick coal seams using the traditional technique.
- CDF France has developed the "BLASTING GALLERY METHOD," which allows for the extraction of about 80% of coal.
- This technique was originally used at India's EAST KATRAS & CHORA Mines.
- In the AQUITINE COAL FIELDS, FRANCE, the idea of mining thick seams using the BG technique was established (1979).
- Seams as long as 11 metres were worked. Working distances of up to 15 metres are feasible.
- The BG technique is a difficult technology for mining engineers since it is the only way to recover a high percentage of coal from thick seams.
- Working thick seams using the Bord and Pillar technique leads in a loss of coal reserves and a lower extraction percentage.
- This necessitates the complete excavation of massive coal seams.
- With the advent of sophisticated technologies such as Blasting Galleries and Long Wall Sub-level Caving, France has gained competence in thick seam underground mining.
- The CDF (CHARBONNAGES DE FRANCE) has helped India implement the Blasting Gallery technique at East Katras (Bharat Coking Coal Limited) and Chora (Eastern Coalfield Limited).
- SCCL has taken on the GDK-10 (Block B) and GDK-8 incline projects to introduce blasting gallery technology in cooperation with France.
PRINCIPLE OF B.G METHOD
The basis of this method is to recover the coal of thick seam by drilling and blasting around Galleries located in the bottom of the seam and placed at regular intervals. The width of the pillar left between two adjacent rooms is between 8 to 15 mtrs. Holes up to 10 to 12 mtrs long are drilled in fan cut around the galleries at regular intervals of 1 to 1.5 mtrs, by means of crawler mounted jumbo drill. Blasting is made with specially developed explosive cartridges separated by inert spacers and detonating fuse. Loading is carried out by 3 Cu.mtrs bucket capacity remote controlled Load Haul Dumpers which discharge coal on to armoured chain conveyors fitted with Lump Breaker to crush the coal to < 200mm size. These armoured chain conveyors feed the coal on to belt conveyor network, which transport coal to surface. All rooms are supported with roof bars placed at 1.0 mtrs interval and placed on placed on 40 Tonne Open Circuit hydraulic props at both ends.

METHOD OF WORKING:
- In this method coal is extracted by drilling & blasting around galleries located in the bottom section of the seam.
- Blasting the entire thickness of the seam by successive blastings while retreating along level gallery driven along the floor in a diagonal line.
- Sub paneling depends upon size of panel considering incubation period of the coal seam
- The sub panel, after extraction of the coal, is to be sealed off effectively
- III seam incubation period is between 12-18 months
- A barrier of about 15 m is left in between the panels
- The sub-panel is further divided into two parts by driving a central main to reach the boundary of the panel.

- All the development is done along the floor of the seam, to a height of about 3m.

MACHINARY AND EQUIPMENT:

LHDs:

LHD loaders are similar to conventional front end loaders but developed for the toughest of hard rock mining applications, with overall production economy, safety and reliability in mind. They are extremely rugged, highly maneuverable and exceptionally productive. More than 75% of world's underground metal mines use LHD for handling the muck of their excavations.

Constructional details:
LHD have powerful prime movers, advanced drive train technology, heavy planetary axles, four-wheel drive, articulated steering and ergonomic controls. Their narrower, longer and lower profile make them most suitable for underground application where height and width is limited. As the length is not a limitation in underground tunnel and decline LHD are designed with sufficient length. The length improves axial weight distribution and bucket capacity can be enhanced. The two-part construction with central articulation helps in tracking and maneuverability. In mining there is limitation for shifting heavy equipment. Sometimes, an LHD has to be shifted through a shaft while dismantled.

Safety provisions:
Service, emergency and parking brakes with fire resistant hydraulic fluid is used. Head lights, audible warning signal, back up alarm and portable fire extinguisher are provided. Special cabin/canopy is also provided for safety of operator. A safety device is provided to shut off the engine if exhaust gases exceed temperature of 85 °C (or as per set value).

For electric shock safety these LHD's power source (gate end box) are equipped with earth conductivity protection using pilot core in electric trailing cable, which isolate complete power when earth continuity is broken.

LHDs are available with remote controls. These are essential to remove the material where the stope is unprotected from top. There can be fall of loose muck from top. There are LHD available with remote tramming facility and these can handle 8000 tons of ore per day.
This lump breaker will be mounted on 1500mm long×640mm wide×190mm height line pans of chain conveyor and large size lumps of raw coal entering between the line pan deck plate and the crusher rolls will be crushed to required size by impact of picks.

The drive to crusher will be provided with an electric motor through a fluid and flexible coupling. Other side of the crusher will be provided with a fly wheel.

The crusher roll will be provided with 6 impact drum wheels and each will be fixed with 3 number of picks at the periphery of arms. The output is controlled automatically by the spacing between picks and spacing between the picks and deck plate.

The breaker unit is covered with guard plates. To suppress dust generation and reduce picks temperature, water spray arrangement has been provided.

<table>
<thead>
<tr>
<th>MAKE</th>
<th>APHMEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>200 TPH</td>
</tr>
<tr>
<td>Input Coal</td>
<td>1 Mtr. X 1 Mtr. X 1 Mtr.</td>
</tr>
</tbody>
</table>
Output Coal | -200mm
---|---
Motor Rating | 90 KW 1440 RPM, 550 V
Gear Box | 90KW, Gear Ratio 7:1

ACC:

4. DEVELOPMENT

All of the development takes place along the seam's floor, up to a height of 3 metres. According to the panel's report, this development is being carried out via conventional drilling, blasting, and coal hoisting by LHD.

SUPPORTING OF THE WORKING PLACE AND JUNCTIONS:

- The supporting work begins after the rooms are linked to the final rise.
- The chambers are supported by steel ceiling bars measuring 200mm by 200mm.
- The roof bars are kept in place by two OC hydraulic props with a 40-tonne capacity.
- Such roofs are spaced 1.5 metres apart and held together with steel bracing designed specifically for this purpose.
- In each blasting gallery, a distance of 40 metres from the face must be
Maintained at all times throughout the extraction.

- Guarantee that the roof bars are linked, iron braces are used. The roof bars' equidistance
- The sturdiness of the supports
- Wooden roof bolts will be installed between the roof bars as an extra support, with a minimum of four bolts in a row.
- Roof bars are strengthened at the ends and equipped with a supporting plate to keep the hydraulic props in place.
- It's constructed up of 12 hydraulic props and 5.5m appropriate roof bars.
- When the faulty edges are nearing the connection, additional support with grouted roof bolts will be supplied.

Support system in the BG-3A panel:
The support system in the district consists of I-section MS cross girders of 200 x 200 mm, set on 40 ton hydraulic props at each end. In each row there are two props and a girder, with a row spacing of 1.0 m. Additional supports including chocks and props are being provided wherever required. The split galleries are supported with 1.8 m long roof bolts with 1m spacing and row is 1.2m apart. Advance supports are installed up to 40m in all the rooms. Junctions are supported by two sets of skin to skin MS girders of 150mm x 150mm and supported by two No. of 40T hydraulic props on each side. In addition to the above cable.
Entries to the central dip rise galleries of panel immediately out bye of the goaf edges was kept supported by cogs set at an interval of 0.25 m. Before commencing drilling by jumbo drills, the goaf edge of gallery was kept supported by a row of props erected at interval of 0.5 m. Wire meshing is fixed where ever the height of gallery made was more than 4m.

Junction support system
5. STRATA MONITORING

In all rooms, Telescopic Convergence Indicators (TCI) and Load cells are placed on OC Props. (vibrating wire type) at 10- to 30-meter intervals from the goafedge

Indicators of remote convergence. (RCI)

Stress capsules. [6 m inside the pillar]

Multi Point Borehole Extensometer (MPBX)

[2.5m, 5 m, 10.5 m, 15.5 m Anchors]

Readings are taken in every shift

UPDATING OF BG TO SUIT INDIAN CONDITIONS:

Change of line of extraction

Safety of junctions

Tying up of props to bars

Induced blasting

Cable reeling mechanism

coolers

Change of line of extraction:

CDF (Charbonages De France) proposed earlier diagonal line of extraction from rise to dip.

As it could allow stone boulders roll in to working place

Hence, the line of extraction was changed from dip to rise, as it helped in avoiding the stone boulders

Safety of junction:

To avoid collapse of junction supports in events of accidental hitting of LHDs

Bolting system with chains have been introduced.

Tying of props to bars:

To avoid fall of hydraulic props due to accidental / due to leakage, hydraulic props are tied with binding wire to roof bars

6. CASE STUDY

BRIEF ABOUT THE MINE:

The mine is situated between north latitude 18°41'30" and 18°41'10" and east longitude 79°32'58" and 79°34'54" in the Ramagundam region. The seams have a complete dip of 1 in 8 to 10 in the direction of N 60° E. The mine is 24 kilometres from the closest railway station, Ramagundam, which is located on the South Central Railway's Kazipet - Ballarsha section.
The mine was opened on February 15, 1979, and production began on September 25, 1985. The total mined area is 901.907 hectares. There are six types of seams in this area: 1A, 1, 2, 3A, 3&4 seams, of which only 1, 2, 3&4 seams are practical.

ABOUT THE WORKABLE SEAMS:

<table>
<thead>
<tr>
<th>Description</th>
<th>1Seam</th>
<th>2Seam</th>
<th>3Seam</th>
<th>4Seam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>6.0m</td>
<td>6.0m</td>
<td>10.0m</td>
<td>3.0m</td>
</tr>
<tr>
<td>Parting</td>
<td>12m</td>
<td>18m-22m</td>
<td>65m-70m</td>
<td>9.5m-</td>
</tr>
<tr>
<td>Grade of coal</td>
<td>G10</td>
<td>G11</td>
<td>G9</td>
<td>G8</td>
</tr>
<tr>
<td>Degree of gassiness</td>
<td></td>
<td></td>
<td>1 Degree</td>
<td></td>
</tr>
<tr>
<td>Extractable Reserves</td>
<td>16.70MT</td>
<td>14.20MT</td>
<td>55.37MT</td>
<td>13.50MT</td>
</tr>
<tr>
<td>RMR</td>
<td>51 (class II fair)</td>
<td>41 (class IIIB fair)</td>
<td>50.40 (class IIIB fair)</td>
<td>42 (class IIIA fair)</td>
</tr>
<tr>
<td>Target for the year</td>
<td>4,50,000T</td>
<td>-</td>
<td>3,00,000T</td>
<td>1,20,000T</td>
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<tr>
<td>2012-13 (8,70,000T)</td>
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<tr>
<td>Men on Roll</td>
<td>1393</td>
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7. CONCLUSION
As a result, we can infer that the blasting gallery technique differs from other traditional thick seam mining methods in the following parameters:
Extraction rate expressed as a percentage.
There is less possibility of spontaneous heating since the greatest quantity of coal is eliminated.
There are less supports needed.
A high rate of output

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