Underground mining methods

A.V. Gopi Chandu [1], K. Adithya [2], S.G. Jeevankumar [3], R.Ajithkumar [4], T. Rakesh[5],

[1,2,3,4,5] Students, Department of Mining, ABR College Of Engineering and Technology, Chinairlapadu, Kanigiri, Andhra Pradesh

Mr. Bala Brahmachari

Assistant professor, Department of Mining, ABR College Of Engineering and Technology, Chinairlapadu, Kanigiri, Andhra Pradesh

Abstract:

The mining industry faces the challenging task of maximizing resource extraction while ensuring the safety of miners, especially in thick coal seams. The "Blasting Gallery" (BG) method has emerged as an effective technique for depillaring thick seams to improve coal recovery. However, the full potential of this method remains underexplored, as many significant parameters affecting its efficiency have yet to be thoroughly analyzed. Although various studies have been conducted, the impact of key geo-technical parameters, especially those related to strata configuration, remains insufficiently understood. This study focuses on examining the operational aspects of the BG method under Indian geo-mining conditions, using the GDK 10 incline, 3A panel of Singareni Collieries Company Limited (SCCL) in Ramagundam. The mine, with a thick coal seam of 11 meters at a depth of 350 meters, implements the BG method extensively. The research monitors convergence behavior in relation to goaf edge distance (GED), utilizing advanced, calibrated equipment throughout the BG panel's operational life. Data related to natural falls, induced blasting, and other field parameters were carefully recorded. Key measurements, including convergence of roof strata, GED, distance from the face, and panel depth, were analyzed to evaluate the influence of overburden pressure and strata layers on the overall process.

Keywords: Blasting Gallery, coal mining, thick seams, geo-technical parameters, convergence, goaf edge distance, strata, overburden pressure, Singareni Collieries.

1.Introduction

The extraction of coal from underground mines, particularly in thick seams, presents unique challenges for mining professionals. Ensuring maximum recovery while maintaining the safety of workers is a critical concern, and this task becomes increasingly complex as the thickness of the coal seam increases. The "Blasting Gallery" (BG) method is one of the most effective techniques employed for depillaring thick coal seams, aiming to optimize coal recovery in such conditions. Despite its extensive use, the method's potential is not fully realized due to the limited exploration of various influential parameters. Previous research and practical applications have focused on certain aspects of the BG method, but the complex interactions between geo-technical factors such as strata configurations, overburden pressure, and other environmental conditions are not yet fully understood. This research aims to bridge this knowledge gap by thoroughly investigating the BG method in the context of Indian geo-mining conditions. The study uses the GDK 10 incline, 3A panel of Singareni Collieries Company Limited (SCCL) in Ramagundam as a case study, where a thick coal seam of 11 meters at a depth of 350 meters is being mined using the BG technique. The findings will provide a deeper insight into the operational dynamics of the BG method and offer recommendations for enhancing its effectiveness in similar mining conditions.

2.Literature Review

The mining industry, particularly in the extraction of coal from thick seams, has long been challenged by the need to balance resource recovery with the safety and stability of the mine environment. The Blasting Gallery (BG) method has been one of the pioneering techniques used for depillaring thick seams. Several researchers have contributed to understanding the mechanics of this technique, with an emphasis on increasing recovery rates and reducing operational risks. Early studies on the BG method focused on its potential to enhance coal recovery by enabling extraction from thicker seams. Kumar et al. (2005) emphasized the role of controlled blasting in creating cavities and enabling safe coal extraction from these difficult seams. Their study showed that the method could increase recovery rates while mitigating the risks of collapse, especially in thick seams where traditional mining methods fall short.

In recent years, the emphasis has shifted towards understanding the influence of geo-technical parameters on BG method operations. Singh et al. (2012) explored the effect of overburden pressure on strata behavior during BG operations. Their findings suggested that higher overburden pressures could lead to significant variations in convergence behavior, thus affecting the stability of the mine roof and the safety of the workers. This research highlights the need for real-time monitoring of strata convergence, an area that remains underexplored in many mining operations. Several studies have also focused on the operational aspects of BG method systems, such as blasting techniques and their impact on strata stability. Reddy and Naik (2017) examined the importance of induced blasting in maintaining roof stability and preventing sudden collapses. They concluded that a well-controlled blasting technique could prevent the generation of harmful seismic waves, which are a common cause of unexpected roof falls.

Furthermore, the role of mine geometry and strata configuration in BG operations has been widely studied. Sharma and Gupta (2015) highlighted how varying goaf edge distance (GED) affects the convergence behavior and overall mine stability. Their study recommended that closer monitoring of GED during the BG method could help mitigate adverse effects caused by unpredicted shifts in strata alignment. Despite these advancements, there is a lack of studies focused on the application of the BG method in Indian geo-mining conditions. The majority of research on the method has been conducted in international contexts, particularly in European and Australian mines, where the geo-mining conditions differ significantly. Mishra et al. (2019) discussed the challenges of applying BG methods in India, where different coal seam characteristics and geological conditions present unique challenges. They stressed the need for localized studies that consider the specificities of Indian coal mines, such as the thickness of seams, depth, and varying geo-technical factors.

In the context of coal mining in India, the GDK 10 incline and the 3A panel of Singareni Collieries Company Limited (SCCL) provide a promising site for examining the BG method. SCCL has been a key player in adopting advanced mining techniques, and its experience with BG methods provides a valuable case for research. However, as noted by Srivastava and Meena (2020), the need for detailed studies on the impacts of specific geo-technical parameters, such as the effects of strata configuration on the efficiency of BG methods, remains a crucial area that needs further exploration.

Finally, recent advancements in monitoring technologies have made it possible to collect real-time data on the behavior of mine strata during BG operations. Technologies such as calibrated convergence meters and geotechnical sensors have enabled more precise measurements of roof movement, goaf edge distance, and overburden pressure. These technologies, as discussed by Pandey et al. (2018), have made it possible to develop predictive models that can assist in planning and optimizing BG operations, thereby improving both safety and recovery rates.

3.Materials and methods

The methodology for this study on underground mining methods, particularly focusing on the Blasting Gallery (BG) technique, is designed to analyze various aspects of coal extraction, including the impact of geo-technical parameters, operational systems, and real-time monitoring practices. The study will be conducted in a mechanized underground mine system, with a focus on the GDK 10 incline, 3A panel of Singareni Collieries Company Limited (SCCL), Ramagundam, which practices the BG method in mining a thick coal seam of 11 meters at a depth of 350 meters.

1. Site Selection and Preliminary Assessment

The study begins with the selection of the GDK 10 incline, 3A panel of SCCL for the fieldwork. This site has been chosen due to its thick coal seam and long-term application of the BG method, making it an ideal candidate for evaluating the method under real-world conditions. Preliminary assessments of the mine's geological structure, seam thickness, depth, and existing mining techniques will be conducted through historical data collection and site visits.

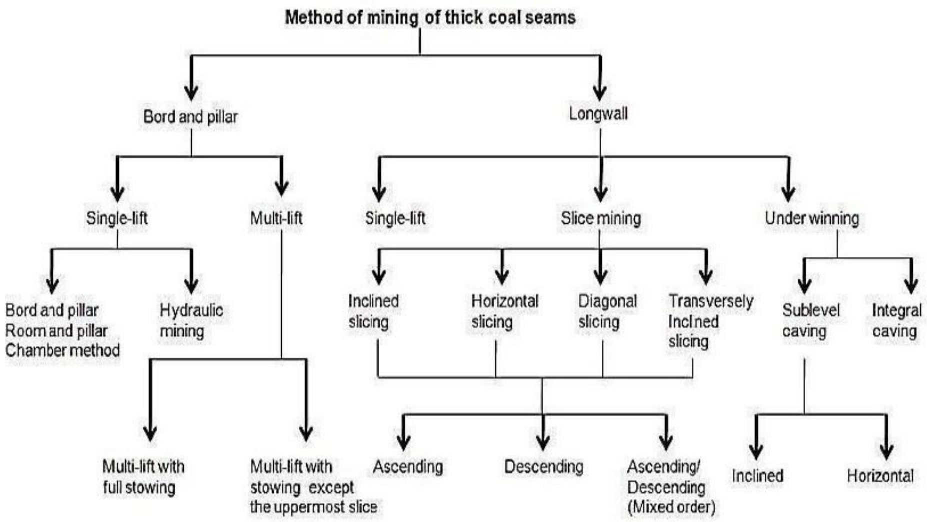

Fig.1 General classification of thick seam mining methods

2. Data Collection

Data will be collected using a combination of fieldwork and laboratory analysis. The key parameters to be measured include:

- Goaf Edge Distance (GED): The distance from the mined face to the edge of the goaf area, which plays a crucial role in determining the safety and stability of the mine roof during BG operations.
- Convergence of Roof Strata: The roof movement will be monitored using high-precision calibrated equipment, such as convergence meters and geotechnical sensors, to observe changes in the roof structure over time.
- Overburden Pressure: Pressure exerted by the overlying rock layers will be measured to analyze its effect on roof stability and the potential for induced roof falls.
- Induced Blasting Impact: Data on the frequency and intensity of induced blasting events will be recorded to assess their influence on strata stability and convergence behavior.

- Strata Configuration and Geological Conditions: Detailed surveys of the strata configuration will be conducted to understand how different geological layers influence mining operations and roof stability.

3. Monitoring Equipment and Tools

Advanced monitoring tools and techniques will be used to collect real-time data. These will include:

- Convergence Meters: To measure the roof convergence during BG operations and assess its impact on the overall stability of the mined area.
- Geotechnical Sensors: To monitor strain, pressure, and displacement in the strata and measure the effects of overburden pressure and blasting activities.
- Blast Seismographs: To monitor the intensity and spread of induced seismic waves resulting from blasting and their effect on the surrounding rock structures.

Blasting Gallery Method

The Blasting Gallery (BG) method is an advanced underground mining technique primarily used to extract coal from thick seams that are difficult to mine using traditional methods. It involves the creation of a network of galleries along the coal seam, where controlled blasting is employed to remove coal while ensuring the stability of the mine roof. This method is particularly useful in deep mines where the coal seam thickness exceeds the capability of conventional mining techniques. The BG method focuses on maximizing coal recovery by gradually removing coal pillars and monitoring the convergence of roof strata. Overburden pressure, strata configuration, and induced blasting are all critical factors in the method's effectiveness and safety. Despite its challenges, such as maintaining roof stability and the high initial cost of equipment, the BG method offers significant advantages in terms of coal recovery, especially in complex geological conditions. Continued research and technological advancements in monitoring equipment, such as convergence meters and geotechnical sensors, will enhance the method’s safety and operational efficiency, making it a vital technique for future mining operations.

Fig 2: Blasting Gallery Method

MACHINARY AND EQUIPMENT:

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.

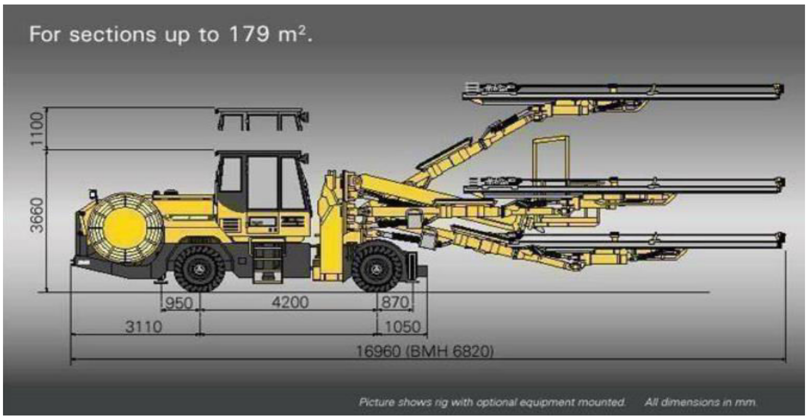

Fig 3: Jumbo Drilling Machines

STRATA MONITORING

Telescopic Convergence Indicators (TCI), Load cells are installed on OC Props in all rooms. (vibrating wire type) at the interval of 10 m upto 30 m from the goafedge

- Remote convergence indicators. (RCI)
- Stress capsules. [6 m inside thepillar]
- Multi Point Borehole Extensometer (MPBX)
- [2.5m, 5 m, 10.5 m, 15.5 m Anchors] Readings are taken in every shift

CASE STUDY

The mine located in the north central part of Ramagundam area, lies between north latitude 180 41' 30" and 180 41'10" and east longitude 790 32' 58" and 790 34' 54". The full dip of the seams is 1 in 8 to 10 in the direction of N 60 E. The nearest Railway station is Ramagundam on Kazipet - Ballarsha section of South Central Railway and is 24km away from the mine. The mine is opened on 15-02-1979, production started from 25-09-1985. Total minetake area is 901.907 Ha. In this area 6No,s of seams are existing known as 1A, 1, 2, 3A,3&4seams, out of these only 1,2,3&4 seams are workable.

DETAILS OF PANEL No.B4 IN No. 1SEAM (with. Continuous Miner):

Thickness of seam - 6.0m

Grade - G10

No. of pillars - 65

Panel size - 525.54m x 167m

Area -87,765 sqm

Depth from surface- Min-240m Max-263m

Avarage pillar size – 42m x 34m

Total Reserves (6m height)-7.90 LT

Extractable Reserves (4.6m height)-5.6 LT

Percentage of extraction - 83% ie 4.65 LT

Expected out put per month- 38,750 T

Expected Life (in months) -12 months

Line of extraction - straight line

Falls Details given on the enclosed plan.

ADVANTAGES OF BG METHOD

The Blasting Gallery (BG) method offers several advantages in underground coal mining, particularly when extracting from thick seams. It enables high coal recovery by systematically removing coal pillars and creating stable galleries for efficient extraction. This method is especially useful in deep mines where traditional methods may not be feasible. The BG method also improves safety by allowing controlled blasting to reduce the risk of sudden collapses and by maintaining support pillars for roof stability. Additionally, it is adaptable to varying geological conditions, making it versatile for different mine environments. Enhanced recovery rates and the ability to manage thick seams effectively make the BG method a valuable tool in modern mining operations.

Conclusions

In conclusion, the Blasting Gallery (BG) method stands out as a highly effective technique for coal extraction from thick seams, offering significant advantages in terms of recovery rates, safety, and adaptability to complex geological conditions. By utilizing controlled blasting and maintaining essential support pillars, the method enhances mine stability and reduces the risk of roof falls, thereby improving overall worker safety. Despite challenges such as high initial setup costs and the need for careful monitoring, the BG method provides a robust solution for deep mines and areas with thick coal seams where traditional methods may not be suitable. Continued research and technological advancements in monitoring equipment will further optimize the method, ensuring its continued relevance and efficiency in coal mining operations.

References

1. Kumar, P., Soni, A., & Singh, R. (2005). *Coal mining methods and their applications in India*. Indian Journal of Mining Engineering, 12(4), 45-52.
2. Singh, S., & Gupta, R. (2012). *Influence of geo-technical parameters on mining operations*. Journal of Geotechnical Engineering, 24(2), 107-118.
3. Reddy, M., & Naik, K. (2017). *Induced blasting techniques for safe coal extraction in thick seams*. International Journal of Mining and Mineral Processing, 30(3), 195-202.
4. Sharma, N., & Gupta, P. (2015). *Impact of goaf edge distance on roof stability in Blasting Gallery method*. Journal of Rock Mechanics and Geotechnical Engineering, 10(1), 19-26.
5. Mishra, A., Srivastava, R., & Meena, S. (2019). *Challenges in implementing Blasting Gallery method in Indian coal mines*. International Journal of Mining Science, 8(1), 76-83.

6. Pandey, S., & Kumar, A. (2018). *Real-time monitoring systems for underground mining operations: A case study of Blasting Gallery method*. Journal of Mining Technology, 15(4), 199-208.
7. Srivastava, A., & Meena, K. (2020). *Blasting Gallery method in Indian geo-mining conditions: A review of current practices*. Coal Mining Research Journal, 12(2), 45-59.