THE INDIAN MINING & ENGINEERING JOURNAL

(Incorporating Mineral Markets: The Founder Publisher & Editor: J.F. De. Souza, Mumbai)

www.theimejournal.com

VOLUME 61: No.02 **JANUARY 2022** ISSN 0019-5944

Published Monthly by IME Publications.
Annual Subscription : Rs.650/- (Incl. Postage), Unit Price: Rs.50/-
FOREIGN: £ 75 OR US $ 150 (By Air Mail)
*Payment by Cheque/Draft. Cheques drawn outside Bhubaneswar must include Rs.50/- (Overseas £1 or US$2) as bank charges and should be drawn in favour of "**The IM& E JOURNAL**" payable at Bhubaneswar*

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Contents

Technical Papers

The IME Journal Readers' Forum

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Prof.(Dr.) S. Jayanthu

Persons in the News

Dr. Danda Srinivas Rao did his M.Sc. in Geology in 1986 from Berhampur University, Odisha, with two Gold Medals, and did his Ph.D. at CSIR-IMMT, Bhubaneswar, as a Research Fellow, investigating "Mineralogy and Geochemistry of the Precambrian Manganese ore deposit of Nishikhal, Koraput district, Orissa". After his doctorate, he continued to work in the same Institute as a Fellow Scientist (QHFS) for three years, and after that, worked as a geologist for a short time in Geomin Consultants Pvt. Ltd., Bhubaneswar. In June 1997, he joined, as a Scientist 'C', CSIR-National Metallurgical Laboratory at Jamshedpur and subsequently went over to NML-Madras Centre, Chennai, and remained in its employment till December 2007.

As a career scientist, Dr. Rao came over to his former workplace, CSIR-IMMT, and gradually stepped up to Chief Scientist in June 2015. He is also Professor & Dean Physical Sciences, Academy of Scientific and Innovative Research (AcSIR), India. His primary interest is in applied mineralogy & mineral beneficiation – the area in which he has investigated more than 100 research projects of various agencies and contributed over 125 research papers in National and International journals.

He was conferred with the "National Geoscience Award-2018", of the Ministry of Mines, Govt. of India for his outstanding contributions in Mineral Technology. Over the years, Dr. Rao's basket of awards and laurels include (i) Sitaram Rungta Memorial Award-2015 & SGAT Award of Excellence-2018 from Society of Geoscientists and Allied Technologists, (ii) R.P. Bhatnagar Award-2017; Lala Ramkishore Singhal Award-2018; & Dr. J. Coggin Brown Memorial Gold Medal-2019 from The Mining, Geological & Metallurgical Institute (iii) Mineral Beneficiation Award-2017 from Indian Institute of Mineral Engineers (iv) MEAI-NMDC Award-2019 & MEAI-Smt. Kiran Devi Singhal Memorial Award-2020 from Mining Engineers' Association of India (v) S. Narayanaswami Award-2020 from Geological Society of India. (vi) Technology

Award-2017 (as one of the team members) from CSIR, (vii) Altekar Award-2006 (as one of the team members) from CSIR-NML, Jamshedpur. Other than these awards, he has also received nine best paper presentation / publication awards for his outstanding R & D contributions from various organisations/ professional societies. He is a life member of various scientific and professional societies like IIME, IIM, ISAG, SGAT, SAAEG, IGC, IIChE, MGMI, OBA, MEAI, EMSI, and Fellow of GSI.

Md Anzar Alam is set to be the next Director (Finance) of Eastern Coalfields Limited (ECL). He is currently serving as General Manager in Rashtriya Ispat Nigam Limited (RINL). Md Alam has been recommended for the post of Director (Finance) of ECL from a list of seven candidates, who were interviewed by the PESB selection panel in its selection meeting held on February 21. Out of seven candidates, two candidates were from Bharat Coking Coal Limited (BCCL) and one each from Western Coalfields Limited (WCL), Eastern Coalfields Limited (ECL), Rashtriya Ispat Nigam Limited (RINL), National Aluminium Company Limited (NALCO) and Ratnagiri Gas and Power Private Limited. Md Alam is a Science Graduate (B Sc) from BIT Sindri, Ranchi University. He has also completed a Post Graduate Diploma (MBA in Finance and Operations) from the Indian Institute of Management (IIM), Calcutta. He has been serving in RINL-VSP since December 1991. As Director (Finance) of ECL, Alam will be a member of the Board of Directors and will report to the Chairman and Managing Director (CMD). He will be overall in charge of finance and accounts of the organisation and will be responsible for evolving and formulating relating to finance and accounts as well as implementation.

Shri Kalasani Mohan Reddy takes charge as Director (Planning & Projects) of NLC India Limited on 21st February, 2022. He is a Mining Engineer from the reputed "Institution of Engineers (India), Kolkata". He holds a First Class Mine Manager Competency Certificate (Coal) from the Directorate General of Mines Safety and an MBA degree in Finance. He did a course on "Advanced Programme in Strategic Management for Business Excellence" from prestigious Indian Institute of Management, Lucknow. Prioe to his appointment, he was Chief Executive Officer of Neyveli Uttar Pradesh Power Limited (NUPPL), a joint Venture between NLC India Limited and Uttar Pradesh RajyaVidyutUtpadan Nigam Limited ((UPRVUNL). Shri Reddy started his initial career with Western Coalfields Limited of Coal India Limited, served in Singareni Collieries Company Limited for over 24 years holding various responsible positions in Mining Sector prior to joining NLC India Limited in 2013. Hailing from an agrarian family in Mahbubabad District of Telangana, he has worked his way from humble moorings to reach the pinnacle of success with dedication and perserverance.

Shri Ramesh Chandra Joshi has taken charge as the new Director (Finance) of National Aluminium Company (NALCO) Limited, a Navaratna PSU under the Ministry of Mines. He has taken over the charge of the post, just a day after the Appointments Committee of the Cabinet (ACC) gave its approval for the appointment to the post. Before assuming his present assignment as Director (Finance), he was working as Group General Manager (Finance). Shri Joshi is an experienced finance professional. He has rich experience in various areas of finance spanning over 32 years, which includes 27 years in NALCO in the core areas of finance coupled with in-depth understanding of financial, contractual and regulatory issues. He is also a nominee director on the Board of Angul Aluminium Park Pvt Ltd, a joint venture of NALCO and IDCOL.

Indian Mining Industry News

MINING NEWS

MINISTRY OF STEEL HOSTS INTERACTIVE SESSIONS ON POLICY INTERVENTION AND IMPROVEMENT OF SECONDARY STEEL SECTOR

NMDC, India's largest producer of iron ore organised a two-day Conference and Interactive Session, hosted by the Ministry of Steel, Government of India on 25th and 26th of February at Konark, Odisha with the objective to provide mineral-rich states an opportunity to present and deliberate on matters related to mining leases and environmental clearances of ongoing and new mining projects. Shri Ram Chandra Prasad Singh, Hon'ble Minister of Steel, inaugurated the conference in the presence of Shri Faggan Singh Kulaste, Hon'ble Minister of State for Steel, Shri Prafulla Kumar Mallik, Hon'ble Minister for Steel & Mines, Odisha and Shri Rajvardhan Singh, Hon'ble Minister of Industrial and Investment Promotion, Madhya Pradesh. Senior officials from Central and State governments and Chairpersons of CPSEs under the Ministry of Steel were also present. 1 st day of the conference concluded with discussions on issues pertaining to mining put forth by the Central and State governments.

On the second day, the Ministry of Steel had an interactive session with steel companies based in Odisha. Shri Ram Chandra Prasad Singh, Hon'ble Minister of Steel chaired the meeting which saw participation of officials of steel companies based in Odisha. Concerns of the industry were put forward by representatives from the companies which included a better environment for the industry especially in finance, logistics, environment, support for the small-scale industries in the sector. Speaking during the session, the Minister lauded the government and the people of Odisha for their development initiatives such as the World Skill Centre. The Minister further stated that steel consumption will continue to increase due to the various programmes and schemes of the government, such as the Gatishakti Master Plan, in which the contribution of the secondary steel sector will be very high.

NMDC hopes to expand its base in states like Odisha, Jharkhand and Madhya Pradesh that have a high production of iron ore. Congratulating the team for organising the successful event, CMD Sumit Deb said, "Grateful to the MoS for hosting the 'Conference of Ministers of Mines and Industries from States' that saw participation from States and PSEs. This opportunity will keep inspiring us at NMDC to continue serving the nation by leveraging our social and production capital."

INDIA'S MINERAL PRODUCTION UP 3% IN DECEMBER

India's mineral production rose 2.6 per cent in December 2021 over the same month a year ago, the mines ministry said on Wednesday. The index of mineral production of mining and quarrying sector at 120.3 was 2.6 per cent higher in the month under review as compared to the level in the same period of 2020, the ministry said in a statement.

As per the provisional statistics of Indian Bureau of Mines (IBM), there was a cumulative growth of 16 per cent during April-December period of 2021-22 over the year-ago period, it said.

The production level of important minerals in December 2021 includes coal 748 lakh tonne, lignite 39 lakh tonne, natural gas (utilized) 2,814 million cu m and petroleum (crude) 25 lakh tonne.

The production of important minerals that showed year-on-year growth during December 2021 includes magnesite (73.2 per cent), gold (71.0 per cent), bauxite (27.1 per cent) and lignite (21.4 per cent).

"The production of other important minerals showing negative growth is: petroleum (Crude) (-1.8 per cent), zinc conc (-4.3 per cent), iron ore (-6.2 per cent)...and diamond (-97.6 per cent)," it said.

STEEL CONSUMPTION WILL CONTINUE TO INCREASE DUE TO VARIOUS SCHEMES AND GATISHAKTI MASTER PLAN

Minister of Steel had an interactive session which steel companies based in Odisha. The Union Minister of Stee, Shri Ram Chandra Prasad Singh Chaired the meeting which saw the participation of officials of steel companies based in Odisha. Concerns of the industry were put forward by representatives from the companies which included a better environment for the industry expecially on finance, logistics, environment, support for the small-scale industries in the sector.

Speaking during the session the Minister lauded the government and the people of Odisha for taking lot of strides in development. Through institutions like the World Skill Centre, Bhubaneswar, Odisha governmenty has rightly focused on skill development which is the need of the hour. The Minister further stated that steel consumption will continue to increase due to the various programmes and schemes of the government, such as Gatishakti Master Plan, in which the contribution of secondary steel sector will be very high. A mission to develop the secondary steel sector is in the making, he said. Ministry officials emphasised that the Government has been actively taking all efforts to address the concerns of the steel industry and welcomed inputs and comments on specific issues hindering the sector, especially the secondary steel companies.

The Indian Mining & Engineering Journal, Vol. 61, No.02 February 2022, pp.05-11
Printed in India, @ IME Publications, ISSN 0019-5944

Blasting for Urban Construction - A Case Study from Bengaluru Metro Project

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ABSTRACT

The construction of large infrastructure projects such as tunnels, hydro power stations, canals, underground metro stations, etc., includes a large quantity of soil and rock mass excavation. Drilling and blasting method is utilised to excavate hard rock mass for such projects since it is the cheapest way of excavation. The metro rail projects involve excavation of hard rock mass, specifically for excavation of underground station boxes, near old sensitive structures, and important historical buildings. Blasting operations in such projects become extremely difficult to carry out since they must be carried out without causing any damage to neighbouring structures. This paper describes the controlled blasting methods used in carrying out in metro rail project where underground station was being excavated near to old and sensitive structures. At some places the structures were only at a distance of 15 metre to 20 metre from the blast location.

Keyword: Urban Infrastructure, Rock excavation, Blasting, Sensitive structure, Peak Particle Velocity

INTRODUCTION

Drilling and blasting method (DBM) is most efficient and economical for mining operations and is not restricted to mining industry but also common in various civil engineering projects wherever hard rock formation is encountered. The explosives in the form of chemical energy is utilised for fragmenting and dislodging the rock mass. Blasting rocks is always accompanied with adverse side effects such as blast induced ground vibrations, flyrock, and air blast. It is therefore necessary to do a detailed consideration and careful examination of all the factors that influences the blasting operations, statutory regulations, environmental restrictions, public complaints etc. Sastry and Ramchandar (2004) presented the influence of side effects and its control due to blasting operations and presented as Table-1.

In blasting operations, the major problems encountered are blast induced ground vibration, flyrock and air blast. When ground vibrations surpass the threshold value, they cause structural damage and discomfort to nearby occupants. The ground vibration threshold value varies depending on the types of structures. Table 2 shows the Indian standard damage classification as approved by DGMS.

The Metro rail projects are becoming a most important mode of transportation for urban cities. The success of Delhi Metro rail projects paves way for other cities to follow similar mass transit system. A number of new metro projects are upcoming in various cities of India. However, the Mumbai and Bengaluru metro project are the most challenging among all due to presence of very hard rock mass as basement rock material.

The construction of urban metro system in the densely populated cities has a number of challenges. The excavation of rock for construction of underground metro station is one among them. When such project encountered very hard rock, engineers have to conduct drill and blast operation for rock excavation. However, the drilling and blasting method pose problems such as dust, fumes, flyrock, ground vibration, air blast etc. CSIR-CIMFR being a premier organisation supporting drill and blast research for nuisance free metro construction activity. The organisation provides the control blast design, excavation guidelines and monitor the ground vibration in the critical structures nearby to support both industry as well as regulatory body.

Although ground vibrations are well within acceptable limits in the majority of cases, complaints continue to flood in due to psychological reasons. Noise or Air blast is the major concern as humans are extremely sensitive to noise despite the fact that it is just for a very short period of time. Flyrock is another important issue that damage structures in the surrounding areas. If proper attention to the flyrock has not been given than it may result in consequential incidents to fatal accidents.

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Table1: Adverse effects of rock blasting and control measures (Sastry and Ramchandar; 2004)

Parameter	Effect	Control
Ground Vibration	1. Damage to structures 2. Annoyance to people 3. Migration of wildlife 4. Rehabilitation of settlements 5. Judicial proceeding	1. Proper blast design 2. Increase delays 3. Proper initiation system & sequence 4. Reduced maximum charge per delay 5. Reduced confinement 6. Create a split/channel between blast site and structure
Flyrock	1. Damage to structures/machinery 2. Injury to people 3. Fatal accidents 4. Frequency	1. Blast design 2. Change explosive 3. Change initiation system 4. Reduce confinement 5. Muffling arrangement
Noise/Air blast	1. Inconvenience to people 2. Structural damage 3. Frequency	1. Cover the D-cord with soil 2. Use short delay detonators 3. Use sequential blasting machine 4. Change initiation from conventional to shock tube system

Table2: DGMS (India) standards for structural damage criteria (Anon, 1997)

Type of structure	Dominant excitation frequency, Hz		
	<8 Hz	8-25Hz	> 25Hz
(A) Buildings /structures not belonging to the owner			
1. Domestic houses / structures (Kuchcha, brick & cement)	5	10	15
2. Industrial buildings	10	20	25
3. Objects of historical importance and sensitive structures	2	5	10
(B) Buildings belonging to owner with limited span of life			
1. Domestic houses / structures	10	15	25
2. Industrial buildings	15	25	50

There are several factors that affect the ground vibrations intensity but maximum charge per delay (MCD) is the main among these. Various research papers have shown that ground vibration is influenced by increase in MCD (Panda *et al.,* 2013, Ramulu and Singh, 2017; Shastry, 2014; Venkatesh *et al.,* 2013 etc.). To reduce the ground vibration MCD should be decreased without changing the total explosives used between the holes using delay element.

BENGALURU METRO RAIL PROJECT

Bengaluru is the capital city of Karnataka state in India. The city is known worldwide for its IT industry. It is one of the fastest growing metropolitans with population of 20.1M in urban area and 12.6 M people in city area. The city is developing its own metro-based mass transit system which is having both elevated and underground components. Twin tunnels are excavated with Tunnel Boring Machine (TBM) whereas box excavation is made to construct the underground metro station. Drill and blast method are utilized to construct the station boxes. The present study has been conducted at upcoming 'Cantonment Station' of the underground metro section. The work is being carried out by L&T ECC division. CSIR-CIMFR is involve in providing the technical guidance as well as monitoring of the blast vibration at the critical

structure nearby. Figure 1 shows the Google Map image of the Metro station site. The figure clearly shows the densely populated area very near to the metro boundary. Figure 2 shows the images of the site showing various sensitive and critical structures nearby the upcoming metro station. These critical structures are at a distance ranging from 15 to 50m from the boundary of the upcoming metro station. The sensitive structure involves are Abdul Bari High School, Masjid-E-Abu Huraira Ahle Hadees, Karnataka Nataka Academy etc. with one of the structures being designated as a 100-year-old heritage structure.

The hard-granitic rock encountered at the cantonment metro site is mostly crystalline of metamorphic origin. A thin soil layer of about 1 to 1.5m thickness was deposited on top followed by moderately weathered granite upto the depth of 6m. The completely hard layer of granite formation follows the weathered layer. The foliation of the rock strata is toward toward North east and rock strata is dipping at 30.50 N. There is no major fault in the area with few irregular joints. The RQD is 40-50% for the weathered zone and more than 80% for the hard rock zone. The area of the station box to be excavated was 5200 m^2 (Length 200m & Width 26m) with depth around 20 m for the construction of underground railway station. The hard-granitic rock mass formation of cantonment metro station of Bengaluru Metro rail project was planned to be excavate by bench blasting method. Controlled blast has been designed based upon the geotechnical properties of the rock mass, as well as the condition and distance of buildings from the blast face.

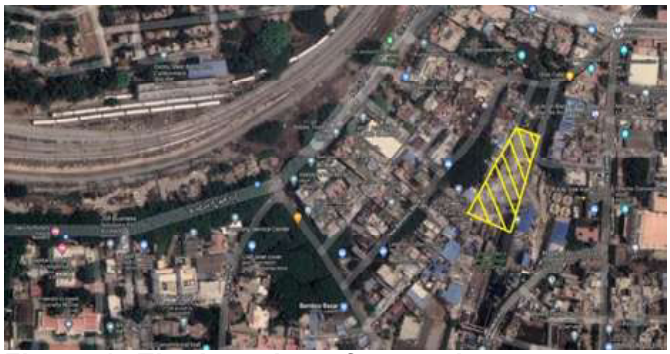

Figure 1: The Location of upcoming cantonment metro station of Bengaluru Metro (Source: Google image)

(a) (b) (c) (d)

Figure 2: Important structures near the cantonment metro station's rock excavation site

METHODOLOGY

Before beginning of the blasting operations, a Pre-Blast survey was conducted. All of the structures in the immediate neighborhood of the Experimental area were meticulously inspected to evaluate the type and state of structures. Some existing cracks were identified and marked. Ground vibration thresholds of 2mm/s, 5mm/s, and 10mm/s were assigned for different structures depending on the structure's type and state, following DGMS standards (Table 2).

The trial blasts were planned and executed at a safe distance from the surrounding structures before commencing the actual blast to know the attenuation characteristics of the excavation area. The soil and loose stone pieces were cleaned from the blasting area before the marking of drill holes to minimize the risks of flyrock and dust. Blast location was marked and drilled using Jackhammer drills of diameter 32mm. Accuracy in drilling operation was maintained for hole depth, hole position, verticality, burden and spacing. To avoid the choking of drilled holes from drill cuttings, mud and water, plastic plugs were used. Each blast hole was charged with cartridge emulsion explosives. To initiate the blast, non-electric detonator (NED) system of initiation was used. Surface trunk line delay was used for connection between the rows. Nine number of blast round has been conducted. The trial blast has been conducted with three different MCD based upon the previous experience of CSIR-CIMFR. The MCD used varied from 0.125kg to 0.375kg in different blasts. The total quantity of explosive ranges from 1.75kg to 16.74kg for each blast round. Burden has been kept as 1.0m and spacing has been kept as 1.25m. The depth of hole has been kept 1.5m Coarse sand was used as stemming material. The hole-to-hole delay has been kept as 25ms and row to row delay was 42ms. The down the hole delay was 250ms. Figure 3(a) shows the drilling operation with the help of jack hammer rotary drill. Figure 3(b) shows the charging process at the metro station.

(a) (b)

Figure 3: Drilling and Charging operation at Cantonment metro station

Ground vibrations and flyrock has been major concern along with air blast as the excavation area was surrounded by busy road traffic from the three sides and important buildings around. A three-layer muffling was done using sand bags, wire mess and blasting mats. Old rubber tyres of trucks as well as conveyor belts having total weight of 1.2T has been used to prepare the blasting mat which serve as a trap for the flyrock and provide cushioning effect to minimize the air blast. Figure 4 shows the muffling arrangement as well final blast site after all the muffles are properly placed.

For monitoring blast induced ground vibrations and noise at the sensitive structures three seismograph (model: Micromate; make: Instantel, Canada) were used.

(a) (b)

Figure 4: Muffling arrangement at the blast site

For monitoring blast induced ground vibrations and noise at the sensitive structures three seismograph (model: Micromate; make: Instantel, Canada) were used. The instruments were kept at critical location and building near to the blast face. Figure 5 shows the seismograph placed at some critical locations.

(a) (b) (c)

Figure 5: Seismograph placed at some critical locations near to the blast face

Figure 6 shows the blast vibration attenuation curve obtained from the trial blast conducted at the site. The vibration attenuation equation obtained from trial blasting is:

$$PPV = 373.83\left(\frac{D}{\sqrt{Q}}\right)^{-1.549} \quad \text{--------- (1)}$$

RECOMMENDED CONTROL BLAST TECHNIQUE AND PRODUCTION BLAST MONITORING

Based on the trial blast, the final design of blast has been provided for carrying out production blasting. Table 3 shows the recommended blast design to be used for the production blasting.

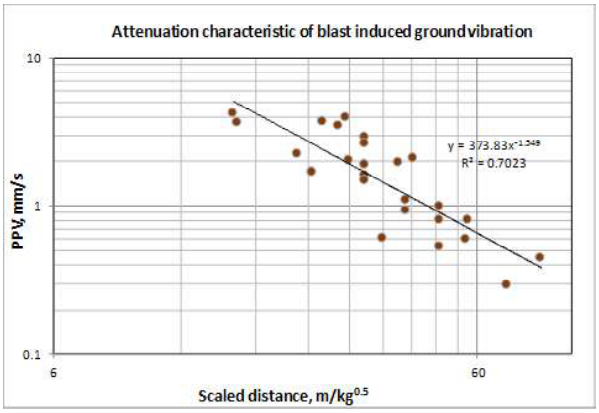

Figure 6: Vibration attenuation curve for cantonment metro station project site

Table 3: Design parameter for production blast

Sl. No.	Parameter	Value
01.	Diameter of Hole	32mm
02.	Angle of Hole	90°
03.	Burden	1.0m
04.	Spacing	1.25m
05.	Depth of hole	1.5m
06.	Charge per hole	0.375 kg
07.	Initiation pattern	Bottom initiation
08.	Initiation System	Shock tube with 250ms DTH HTH – 25ms RTR – 42ms
09.	Stemming Column	0.9m - 1.0m
10.	No. of hole per delay	1

It is also recommended to drill 110mm diameter ROC hole having depth of 6m at c/c distance of 30cm near the boundary of sensitive structure as line drilling. The line drilling provides a plane of weakness which will reflect the shock wave created by the blast thus reducing the blast vibration observation. Figure 7 shows the lone drilling at the boundary of the project site.

The blast analysis was carried out intermittently after each 10 to 15 blasts to check and verify the sample cracks that were recorded during the proposed design analysis. Data generated from more than 75 blasts conducted at the Cantonment Station is presented in Fig. 8. A total of 225 blast event has been recorded and presented in figure. It

(a) (b)

ROC line drilling at the boundary to control the blast shock wave and vibration

has been observed that 9 out of the 225 blasts conducted have the peak particle velocity (PPV) at various structures which exceeded the allowable levels of 5 mm/s. However, the FFT of the event shows that the dominant frequency observed at these locations is much higher than 25Hz indicating that the vibration is well within the permissible limit. The data clearly indicates the implementation of safe blasting methodology at cantonment station of the Bangalore Metro Rail project.

CONCLUSIONS

Blasting is a necessary part of any rock excavation project. The Explosive energy is always coupled with negative side effects such as ground vibrations, flyrock, and sound. These considerations are especially important when blasting activities are being carried out in urban as surrounding environment. Blasting shots should always be designed with keeping the properties of the rock mass in mind, as well as the safety of neighbouring structures and people. In such circumstances, pre-blast and post blast studies, as well as risk assessments, constitute the foundation of blast design. Ground vibrations, flyrock, and noise might be reduced by using a contemporary initiation system and managing the delay system in blast shots, as well as proper muffling arrangement. Any infrastructure project requiring large rock excavation activity operating in a constrained area might benefit from such planning and execution of blasting activities.

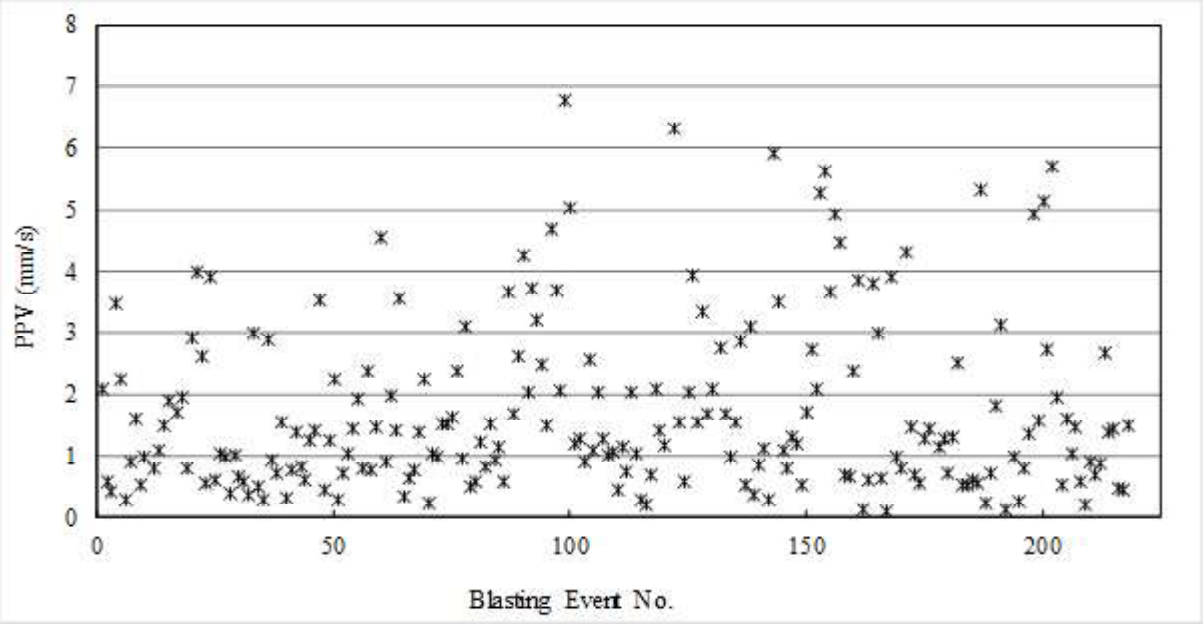

Figure 8: Vibration event record for the blasting conducted at cantonment metro station project site

ACKNOWLEDGEMENT

Scientists and technical staff of CSIR-Central Institute of Mining and Fuel Research are thankful to the management and officials of M/s L&T ECC and BMRCL for their kind help and co-operation extended during the course of the investigations. Thank is‘ also due to Director CSIR-CIMFR for allowing to publish the paper.

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The Indian Mining & Engineering Journal, Vol. 61, No.02 February 2022, pp.12-17
Printed in India, @ IME Publications, ISSN 0019-5944

Geotechnical Parameters of Slope Stability : A Case Study of Singhori Opencast

Khadse Ashwin Ajay* B K Mishra*

ABSTRACT

This Slope stability is a most important characteristic of open cast mines throughout the whole life of project. The Mechanism of failure is mainly depending on the geo-technical parameters of area, rock mass strength, etc. The design of slope is totally depending on the field investigation & knowledge of rock mechanics. In the past, excluding the vanishing of extraordinary knowledge of ancient era, the mining by development of benches were a toughest task because of the slope failure used to happen due to lack of technology and simulation processes. But with time the various developments took place and the problems are resolvable in today's time. With the very help of the designing software and skilled personnel handling the software, it is very easy to resolve the issues regarding slope stability of an opencast mine bench. It needs highly skilled candidates to collect the data accordingly and arrange & simulate the things in proper sequences and but obviously to operate the software thereby highlighting the perfect combination of human knowledge and technology to resolve the issues for designing of the slopes for opencast mines. So, in this project we have tried our best to understand the pit slope designing skills by acquiring the data simulated by other research agencies and government bodies before our research at the same site i.e. Singhori opencast project of WCL and carried out some numerical modeling by using GEO-5 software as discussed in this report further.

Keywords— Slope stability, internal friction angle, geo-technical parameters, factor of safety, rock mass strength, slope angle, numerical modeling

INTRODUCTION

Slope stability analysis is an indispensable part of any activity in opencast mine during the whole project's life. In our country, concern to surface mining, rules for the slope design are not yet formulated for different types of mining practices, and there is an escalating need to develop approaches to maintain safety & increasing production simultaneously. Even now, many of the designing methods are mostly based on field knowledge and rules of thumb followed by critical engineering judgment. In last few decades, the concept of slope stability analysis has developed under the field of rock engineering mainly to address the difficulties in designing and stability of excavated slopes.

Pit slopes which are steeper needs to be maintained on apriority basis to reduce the stripping cost as it directly impacts the overall mining cost. To work on the final pit limit design, distribution of an ore grade, the costs of production & the overall rock mass strength and stability are need to be considered. The potential for failure must be assessed for every possible mining plans and it should be integrated into the design of the ultimate pit.

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Considering these thoughts, it is mandatory to adopt the numerical modeling systems with computer programs on a priority basis for designing and managing the pit slopes to take the preventive measures for minimizing slope failures of various kinds before they occur.

There are many slope stability analyses are performed by computer programs. So, to perform this stability analyses the following criteria's are to be considered mandatorily: a) strength of the material, b) water pressure in pores, c) slip surfaces if any, d) analysis process e) reinforcement of the material, etc. All these criteria's also have some combinations that tends to many more probabilities of combinations for respective software programs to be deal with. It is but obvious that all the computer software will have their unique arrangement for processing and calculating also it depends on the selected method of calculation for available data. (Duncan and Wright,2005).

Duncan and Wright explained that the shear strength of the soil must be more than the shear stress requirement for equilibrium to skip slope failure. (Duncan and Wright, 2005).

It may be possible that many computer programs have not been tested for the exact combination. Also, it is

possible to input incorrect data due to different program assumption and human errors too. Hence, independent inspection should be made for slope stability computations.

Budhu concluded that the failures of slope cccurs due to following criteria's: a) type of soil, b) strata of soil and stratification, c) presence of ground water, d) presence of seepage, and e) the geometry or shape of the slope (Budhu, 2000).

Duncan realized that a rotational slide failure occurs commonly in homogeneous a fine-grained soil which has its point of rotation on an imaginary axis parallel to the slope (Duncan, 2005).

Spencer in 1967, when trying to get a best model for his cases to be studied under the influence of linear and non-linear material and various types of slopes, at that time he generated such a method which considers and justifies the force and moment equilibrium both and the method then known as Spencer's method. This method can be used for circular slip surface and polygonal surfaces as well. He do formulated this method in such a way to calculate any type of geometrical shape of the failure because he found that there are many slope surfaces which are failing in circular manner or shape always. (Spencer, 1967).

So, overall meaning of this declarations and assumptions is that, along the sip surface a FOS will be the same at all the points. Hence, the result that we get in terms of the values gives an idea of an average or identical results for the assumed slip surface. Wright et al. concluded that, the shear strength and shear stress both would be equal along the surface of failure at all the points with FOS to be considered as constant. But in case of stable slopes, the FOS will get vary along the slip (Wright et al., 1973). Cheng et al. (2006) have worked on a several slope conditions by adopting slope stability analysis by limit equilibrium method and strength reduction method. In their study they compared the results from limit equilibrium method with the SSR method. They performed this experiment with the materials having various properties and said to be homogeneous and non- homogeneous. They were satisfied with the result that they get in case of homogenous material as good. So they come to an conclusion that both the limit equilibrium method and strength reduction method have their own merits and limits.

In another study, Hammah et al, 2004 worked on a finite element analysis of a soil slope through SSR technique. They compare the method's results with the most widely used limit equilibrium on large range of slope cases. The author thinks that the SSR is a strong and recommended method for analyses and designing the slopes. Also, they stated that further research work shall be conducted on their statement and research work they had done in the meanwhile.

Griffiths and Lane (1999) worked on 6 generated simplified slope conditions. They compared finite element slope stability analysis with the other traditional limit equilibrium methods by considering the impact of layering and free surface on slope and dam stability. So finally they came to a conclusion that mathematical numerical modeling is better to get good results rather than by using the traditional limit equilibrium methods and they also stated that the numerical modeling should be considered as standard platform for slope designing and for any geotechnical practices.

A case study was carried out by Prasanta Kumar Behera, Kripamoy Sarkar, Ashok Kumar Singh, A. K. Verma & T. N. Singh at Talcher coal field of Angul district, Odisha state India in 2016 to analyze the slope stability of dump by using limit equilibrium method. In this case study they have concluded that the main reason behind failure of dump in the study area is increasing pore water pressure because of rain water pass through filtration from the dump material. (Prasanta Kumar Behera, Kripamoy Sarkar, Ashok Kumar Singh, A. K. Verma & T. N. Singh-2016)

Another slope stability analysis is carried out by Geetanjali Lohar, Sushmita Sharma, Apu Kumar Saha, & Sima Ghosh in 2020 by using Metaheuristic Algorithms Technique. They used this algorithm technique because they thought that conventional optimization techniques are not so correct and to get best solution. So, to neglect these problems of inadequacy they used different metaheuristic optimization methods such as DE- Differential Evolution, BOA- Butterfly Optimization Algorithm, SCA- Sine Cosine Algorithm, and PSO- Particle Swarm Optimization. (Geetanjali Lohar, Sushmita Sharma, Apu Kumar Saha, & Sima Ghosh in 2020).

REGIONAL GEOLOGY OF THE STUDY AREA

The Mines area is surrounded with Kanhan River in zigzag shape from Kamptee via Sillewara village.

The regional geology of the study area is described briefly in the table no. 1 given below: -

Table1: Formation of layer in the Singhori OCP

Formation	Thickness Range(m)	
	Minimum	Maximum
Soil	2.00(MKSG-4)	11.00(CMKSG-8)
Weathered Zone	11.00(MKSG-4)	28.00(CMKSG-19)
Kamptee	Nil(CMKSG-19&26&36)	21.00(MKSG-4)
Barakar	34.50(CMKSG-36)	156.00(CMKSG-21)

NUMERICAL MODELING (LIMIT EQUILIBRIUM METHOD)

For the investigation of equilibrium condition and analysis of slope stability with changing geotechnical data and geometrical shape of the slope material, the method which is conventionally used is Limit Equilibrium Method. This method based on the assumption that the linear (Mohr-Coulomb) or non-linear relationships between the shear strength and the normal stress on the failure surface governs the material's shear strength along the potential failure. The most common methods for limit equilibrium analysis are methods of slices. The slip surface is divided into vertical slices for purpose of analysis. There are different methods of slices available to analyze the circular and non-circular failure condition.

The method is used in GEO-5 software for calculation of factor of safety for slope and designing the slope accordingly. The results show that the maximum dump bench height should not be more than 20 m for the present case as it can be seen in the figure 9 & 10.

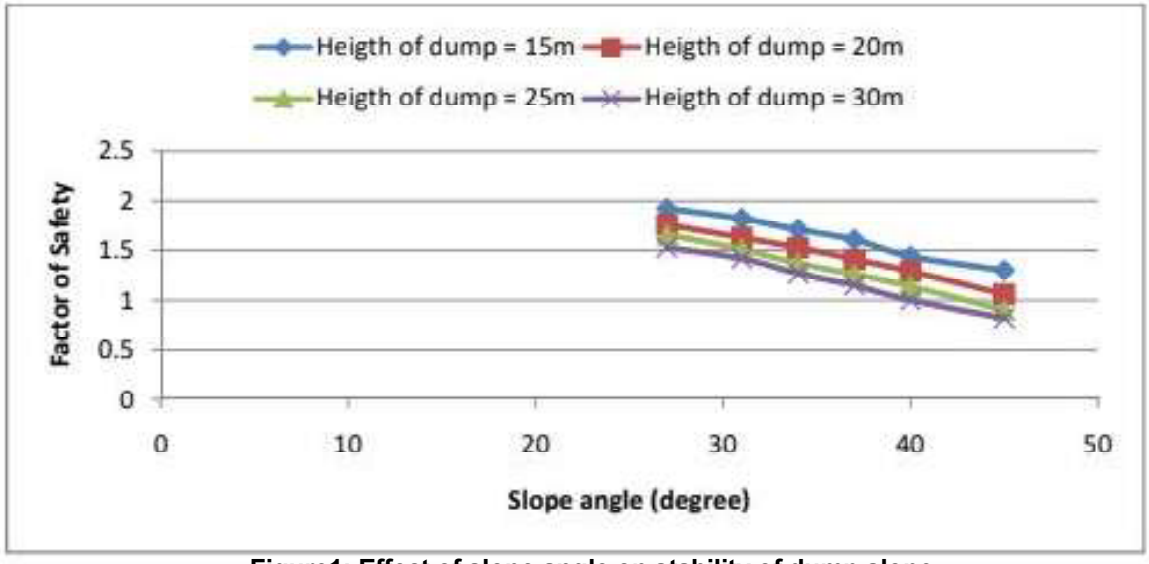

Figure1: Effect of slope angle on stability of dump slope

CONCLUSION

The stability for sections of dump slopes in different conditions of overburden dump was carried out for Singhori Opencast Coal mine. Finite element method and limit equilibrium method have been used for analyzing the dump slope for different geo mining conditions with the help of GEO-5 software. The factor of safety of 1.2 to 1.5 has been taken as short term stability and Factor of safety > 1.5 for long term stability. The factor of safety of hard rock and dump slope has arrived at by analyzing various sections along them.

The conclusions and suggestions of the present study are summarized below:

- The maximum bench height in overburden dump should not be more than 20 m for long term stability. The overall height of external dump slope may reach up to 75 m with overall slope angle around 23 degrees

Table 2: Factor of safety of external dump by Finite element and limit equilibrium method

Sr. No	Model details	Factor of Safety by FEM	Factor of Safety by LEM
1	Bench height=15m, Bench width=15m Bench slope angle = 37^0 Overall slope angle=25^0 Total Dump Height=75m	1.41	1.89
2	Bench height=15m, Bench width=20m Bench slope angle=37^0 Overall slope angle=23^0 Total Dump Height=75m	1.50	1.982
3	Bench height=15m, Bench width=25m Bench slope angle=37^0 Overall slope angle=20^0 Total Dump Height=75m	1.52	2.107
4	Bench height=15m, Bench width=30m Bench slope angle = 37^0 Overall slope angle =19^0 Total Dump Heig:ht=75m	1.55	2.482

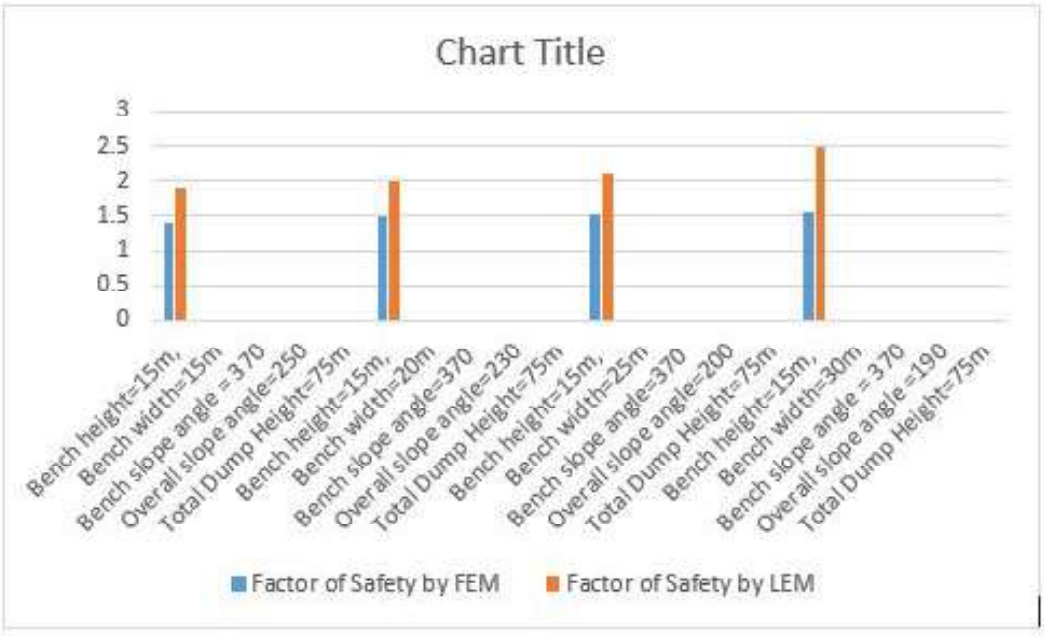

Figure 2: Factor of safety of external dump by Finite element and limit equilibrium method

The recommended design of dump slope is given Figure 3. The optimum height of dump is 90 m with overall slope angle 23 degree. The bench width is 20 m and bench slope angle is 37 degree.

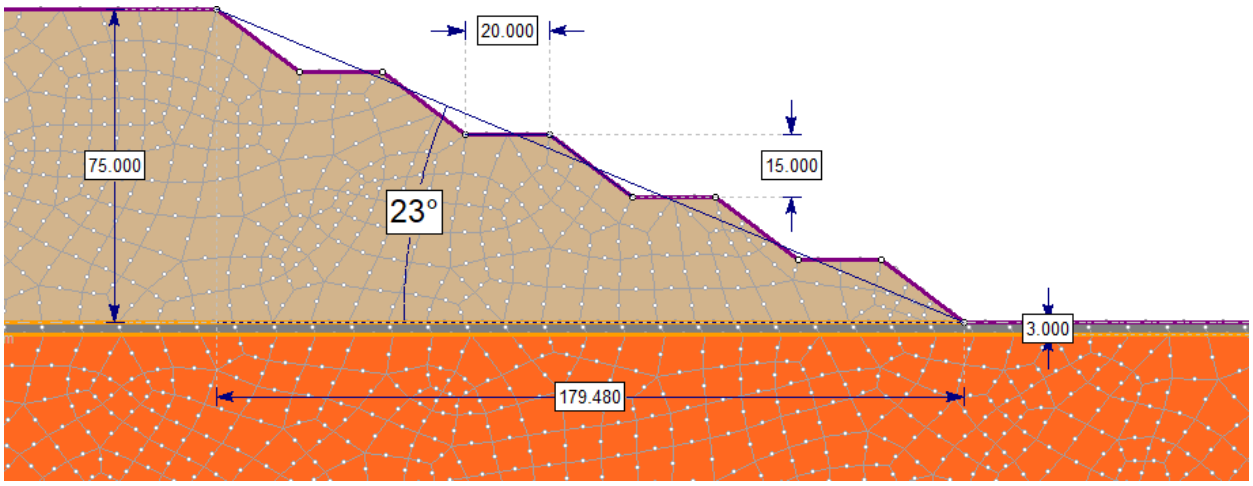

Figure 3: Typical layout of mine dump of overall height of 75 m

with bench height of 15 m and bench width of 20 m each.

- The Maximum height of the slope in black cotton soil is 5 m with slope angle of 60 Degree. The factor of safety is 1.51 in this case.
- The Maximum height of the slope in alluvial soil is 4 m with slope angle of 60 Degree. The factor of safety is 1.26 in this case.
- The Maximum height of the slope in sandy soil is 5 m with slope angle of 30 Degrees. The factor of safety is 1.28 in this case.
- The Maximum height of the slope in clayey soil is 4 m with slope angle of 60 Degrees. The factor of safety is 1.24 in this case.
- The factor of safety of the Embankment is 2.38 without considering effect of blasting and 1.50 after considering the blasting. It indicates that the embankment is stable in long term. Therefore, there is no significant effect of blasting on embankment stability. The blasting charge per delay should not be more than 30 kg/delay for the distance between embankments and blasting point are less than 100 m.

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The Indian Mining & Engineering Journal, Vol. 61, No.02 February 2022, pp.18-22
Printed in India, @ IME Publications, ISSN 0019-5944

Performance Appraisal of Surface Miner in Opencast Mines: A Case Study

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ABSTRACT

Earlier opencast coal mining activities were done or being carried out only by conventional system of mining which includes drilling, blasting and crushing. All these operations are resulting a lot of adversative impacts on the environment and the surrounding atmosphere. The adverse impacts that the conventional mining system results are ground vibration, noise pollution, air pollution, land degradation, ecological disturbances etc. This generates necessity of additional machineries and manpower, eventually cost of mining coal rises. And also due to existence of villages adjacent the mines, blasting is limited as a result massive quantity of coal is blocked. And we all know that quality of coal has great concern in our country since most of the coal seams comprise low-grade quality of coal due to drift origin. Government legislation also forbids the dispatch of coal for more than 1000 Km if coal comprises more than 36% ash. In these circumstances, surface miner was being introduced which can capable of solving the above declared problems. This allows the operator of the mine to ensure selective mining of coal so that quality of coal develops. The variety of thinner seams which are unworkable in conventional system of opencast mining now converts workable and the whole reserve of nonrenewable source of fossil fuel rises. It also decreases cost of production so that total profit of a mine growths.

INTRODUCTION

As we know that, in the whole world India is the third largest coal producing country and at about 88% of production of coal being extracted from these open pit mining. As usual the conventional system of mining coal by open cast mining method includes drilling, blasting, excavating and crushing. The HEMM which comprises in those various processes are Shovel, Drill machines, Grader, Dozer, Dumper, and Dragline. Earlier, as it is mentioned that mining operations are always associated with fatal effect of land degradation, environmental disorders, noise and air pollution and it results to overall environmental corrosion. Blasting process which is also carried out, give rise to blast-induced ground vibrations, disturbance to water regimes., air-blast, fly rock, blasting fumes, dust cloud, noise, and damage to nearby structures. Crushing and drilling operations also cause a lot of dangerous environmental complaint and harmful results such as air and noise pollution. And also, the quality managing with the layers of grey shale/carbonaceous shale, stone bands, dirt bands etc in opencast coal mines has become a problematic work by the conventional method of mining. All these issues have provoked the mining communal to look for a new method which is different from the conventional method so that the quality of production as well as the quantity of production increases as well as meeting the requirement of being environmentally safe operations.

Surface miner at Penganaga O/C mine of WCL was introduced keeping in view its numerous advantages over conventional drilling and blasting method of excavation. From soft rock continuous mining by the bucket wheel excavators, the current state-of-art of opencast mining technology has been shifted towards mining of harder materials like coal, gypsum, limestone etc. by the recently developed continuous surface miners. These highly powered continuous surface miners not only give continuity of operation in hard rock mining but also can be used for selective mining of thin seams, for loosening of consolidated layers, being a supporting equipment for the bucket wheel excavator; where ripping is impracticable due to high material strength and where blasting operation is prohibited etc.

The most important feature of the machine is the complete elimination of drilling, blasting, or ripping. The Continuous Surface Miner (CSM) is a continuously operating mining equipment, where with the help of a rotating roll the rock crushed into designed sizes. The roll comes in addition to the crushing often the function of the load on a conveyor. Surface miners are specialized mining methods that are often used where drilling and blasting is not possible or when drill is to be mined matches the requirements. The machines do not require drill or blast or subsequent crushing as the cutting drums break and size rock. These

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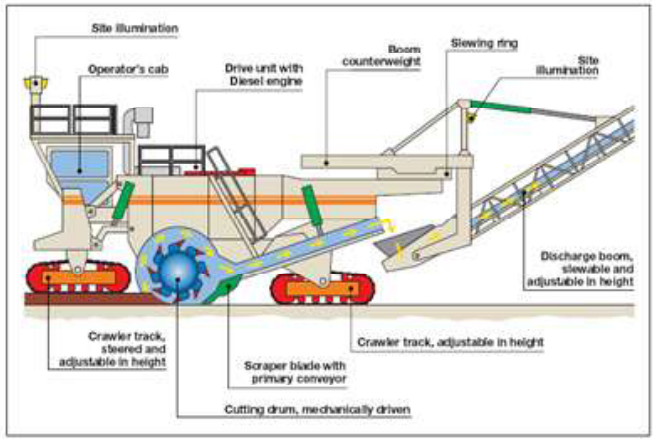
machines can load into conveyor belts or directly load into trucks.

SURFACE MINER

Mainly there are three kinds of surface miners available on market today:

A) Machine with middle drum configuration
B) Machine with front cutting boom
C) Machine with front cutting wheel



MACHINE WITH MIDDLE DRUM CONFIGURATION

Its cutting width varies from 250-4200mm, weight 40-90tonn, and installed power 450-1250KW. Their manufacturing companies are Wirtgen, Bitelli, Huron. Now all over India and the world, only the "machine with middle drum type configuration" is used because the cutting drum is situated under the Centre of the machine and in between the length of crawler track. Four crawler tracks are situated, two at the front and two at the rear so that the big machine can resist its balance.

MACHINE WITH FRONT CUTTING BOOM

From application point of view this machine is as important as other two. Its cutting width is 5250mm, cutting depth 1000 to 5500mm; weight 135tonn, installed power is 750 kw. Its manufacturing company is Voest Aalpine. Earlier these type surface miners were used but not it has been stopped because the big cutting drum is situated at the front side of the machine and the machine has also a very big cutting boom attached for loading the material and this machine has only two crawler tracks. So, the machine can't maintain the balance properly.

MACHINE WITH FRONT CUTTING WHEEL

This type surface miner was also used earlier but now it has been stopped because this machine contains a giant like cutting wheel which is situated on the front side of the machine and this machine consists of only three crawler tracks, two at the front and one at the rear. As a result, the machine cannot resist its balance or stability throughout the operation

PRODUCTION CALCULATION

In Indian coal mines, we have attained extensive expertise in the adoption of surface miner technology in coal seam operations. After making due analyses of the coal seam from geological view point and its geo-technical parameters the machine type, engine HP, distribution of picks in the cutting drum, hardness of picks, RPM of the drum, hydraulic power etc and other operating variables are determined. In addition to the above actual field working conditions significantly influences in the production and productivity.

A record of working hours (WH) idle hour (IH), maintenance hour (MH) and break down hour (BH) maintained by mines are essential components which influences in the production and productivity of this system.
Calculation of availability and utilization by:

A= SSH-(BW+MH)/SSH

U= SSH-(BH+MH+ID)/SSH

Where,

SSH is scheduled shift hour,
MH is maintenance hour,
BH is breakdown hour and
ID is idle hour.

Calculation of OEE by:

OEE = Availability × Performance × Quality

In case of any coal mine, the coal seam in most cases is interspersed with shale & sand stone band of varying thickness because of which the product from the mine gets lower ranking in Coal Grade. This also influences in final price of the coal based on GCV.

REASONS FOR DEPLOYMENT OF SURFACE MINER

Surface miner at Penganaga O/C mine of WCL was introduced by condidering the following conditions -

A) Improvement of quality by selective mining of coal:

Coal in this mine is interspersed with shale & sand stone band of varying thickness because of which the product from the mine was marked as grade Lower 'F'. Presence of dirt bands (1 to 5 Nos.) is the major concern for quality deterioration of coal seam.

B) Eco-friendly mining of coal:

Drilling & blasting operation on large scale produces a lot of noise, dust, vibration, fly rock formation etc. This has prompted the mining community to look for a viable alternative of rock breakage for overcoming these deficiencies & to increase the production & productivity while meeting the requirement of environmentally safe operation. Surface Miner fulfilled the required search.

C) Proximity of villages:

Ghanamal (a hemlet of Khairkuni village) and other villages are situated almost at the middle of quarry No. 1 and 2 of the mines. Due to restriction imposed by Directorate of Mines Safety, Bhubaneswar region, for carrying out blasting operation beyond 150 Mtrs. from the houses/structures, resulted in locking up of huge amount of Coal. Since no drilling and blasting is required for coal winning with Surface Miner, not only the coal production has been enhanced tremendously but it has also changed the attitude of villagers and R&R finalization has become easy and smooth.

D) To Improve quality of coal:

No washing of coal is required to improve the quality of coal. Techno economically the coal from Surface Miner will be cheaper in view of the size of coal produced within the range of (+) 20 mm to (-) 100 mm which does not require secondary crushing. It eliminated double handling by eliminating the process of crushing. Direct dispatch from coal faces to various destinations has resulted in meeting the increased demand of coal in the country.

E) To Meet the High Demand of Coal due to growth of new industries:

Due to the industrialization policy of the State Government the demand of Coal has been highly increasing. To meet the high demand production through conventional method was inadequate. By introduction of Surface Miner, we can fulfil the demand of coal in reduced time and resources.

CONCLUSIONS

Surface miner being a new technology is yet to be adopted by mining technologists for medium hard/hard coal and overburden as encountered at Surface miner at Penganaga O/C mine of WCL. Due to various disadvantages and hazards of the present conventional mining method, as reported by its users in other coalfields of India, WCL management has adopted this technology.
.
Many coal mines in India are suitable for applying this technology due to higher production demand, favorable seam gradient, long strike length, multi-seam mining and also presence of villages in close vicinity of the mines. It may not be prudent to use surface miners only for the purpose of selective mining due to the following reasons:

1. Use of surface miners only for the purpose of selective mining of thinner bands within coal seams shall reduce overall production of mine due to low output for such selective mining. The extent of such reduction shall depend upon the nature and thickness of the inter bands and the production capacity of the surface miners. Hence, it should be necessary to assess, whether there will be grade improvement of coal (not only improvement in kcal/kg of output) for such selective mining. Grade improvement of output may prove economic viability to compensate the investment for such surface miners and also for the loss of overall production.
2. Due to smaller output size (< 100 mm), conveyor can be adopted with surface miner. The various advantages of conveyor system have been explained above. Dumper transport, on the other hand, essential for conventional mining for carrying bigger lumps. Mixing of two mining system, i.e. selective mining by surface miner and main production by conventional method in the same mining block, shall compel using dumper transport for surface miner also. This will obviously reduce the productivity of surface miner.
3. Surface miner needs different kind of planning for mining coal seams in layers from top to bottom & each layer in various strips. The slope of negotiating ramps shall be different for surface miner. Conventional mining, on the other hand, follows benches of more height. Height and width of benches depend upon size of shovels & dumpers. Hence, it may be difficult to make proper mining layout for adopting two different kinds of mining methods in the same mining block.

Adopting this new technology in Indian coalmines had immensely improved coal quality, conservation of coal which were very thin seams, thereby increasing grade of coal and GCV.

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The Indian Mining & Engineering Journal, Vol. 61, No.02 February 2022, pp.23-27
Printed in India, @ IME Publications, ISSN 0019-5944

Challenges of Strata Control in Continuous Miner Districts in Indian Mining Conditions

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ABSTRACT

Though India is the 3rd largest coal producing nation in the world, the level of underground coal mining technology in Indian coal mines is comparatively low predominated by conventional Bord & Pillar mining with SDL/LHD. As a result of that for last five decades of post nationalization era, the underground coal production practically remained stagnant. But presently the Indian coal mining industry is preparing a road map to enhance coal production by under ground method as a growing necessity to optimize coal production by mining from deeper deposits containing comparatively better quality coal and for optimization of the use of our huge coal reserves. But for that purpose it is required to deploy world acclaimed mass production technologies for under ground coal mining, namely Continuous Miner and powered support Longwall technologies. For efficient and safe deployment of these technologies in Indian geo-mining conditions, it is required to make a thorough scientific study of the strata movement which is a prime factor for adopting these technologies in our coal mining conditions successfully. The major portion of ground control problem encountered in underground coal mines can be attributed to geological discontinuities in the coal seam and the strata surrounding the seam.

Now a substitute has been introduced in extraction method i.e. NEVID extraction method which is developed in response to the unpredictable roof behavior and goaf overruns into the production section associated with their coal seams working beneath overlying dolerite sills.

INTRODUCTION

India has a large resources of coal in existing coal mines with ideal conditions for extraction by mechanized continuous miner technology. Although the productivity is generally high with continuous miner technology, there are cases in India of Strata Control like pillar spalling, roof falls, strata control difficulties. The role of geological discontinuities becomes more crucial in continuous miner panel due to increased gallery, line of extraction , high depth of cover , pressure of overlying goaved out working and barrier pillars. Extraction can also be planned for smooth caving considering the orientation of geological discontinuities.Mapping helps in understanding the stress conditions prevailing on developed working and re-orientation of roadways accordingly for improving mine safety and achiving higher production.

Effect on Production due to Geological Disturbances

The structure of mine is affected by natural weakness or discontinuities that effect the roof and pillar. Increased frequency of geological discontinuities reduces the overall Rock Mass Quality like Rock Mass Rating (RMR) of the roof. Geological discontinuities can originate while the material is deposited by sedimentary or intrusive process or later when it is being subjected to tectonic forces.

The Strata Control should be chosen based on the following criteria

1. Geological formation of beds.
2. Time span during depillaring.
3. Crushing of pillars.
4. Cleats of pillar.
5. Spils of cracks.
6. Geo Mining Conditions such as – Roof , Floor , RMR

Support System

For the safety of men and extraction of coal under roof, support system (roof bolting) has been designed with due consideration of RMR and other techno – geological parameters. Anchorage Testing will be done after installing the roof bolts.

Support in Roadways

The roadways are supported by roof bolts and props. W – Straps are also being used. The distance between bolts are 1.5m and 0.75m from roof boundary. There are 4 bolts in one horizontal line.

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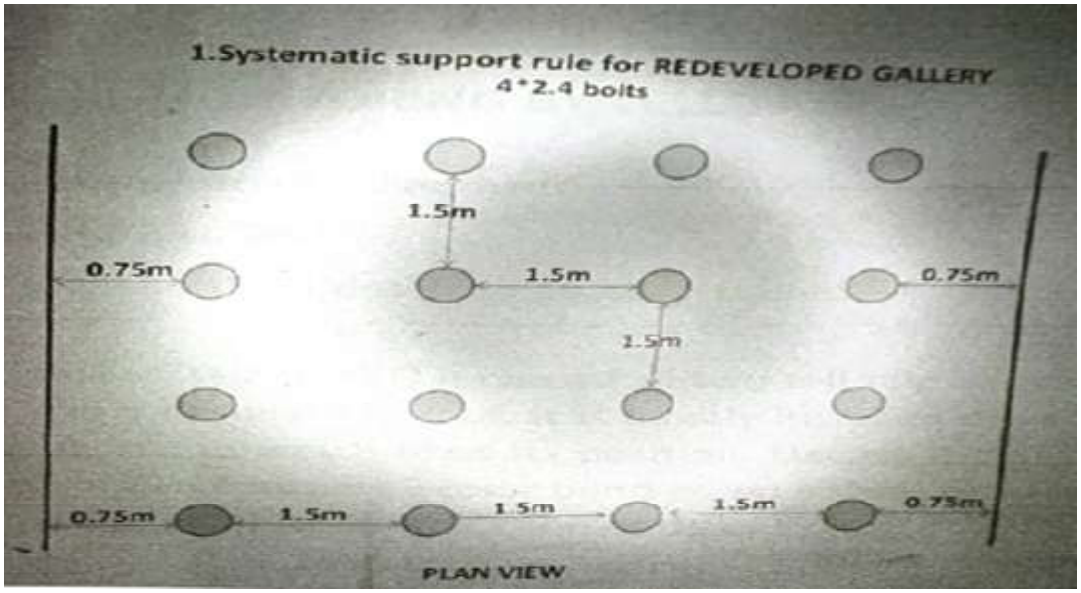

Figure 1: Plan View of Roof Bolting in Re-Developed gallery (Churi Mine,CCL)

Support in Junction

At the junction extra support need to be required which includes 25% more support as compared to roadways support.

Break Line

To arrest goaf encroachment during roof fall , high capacity pre-tensioned roof bolts were applied as break line support. This active support is found to control the roof efficiency during the final excavation as it allows caving roof up to this support.

Methodology of Strata Monitoring

Dual Height Tell Tale (DHTT) – Dual Height Tell Tale is designed to be installed for monitoring bolted strata.

Dual Height Tell Tale (DHTT) it consists of two Tell Tale which is installed at 1.5m and 5m height in roof. It is mostly installed at junctions. It has a spring in top which fixed its position. Having 2 dial of 75mm each, each of the dial contains 3 color bends green yellow and red (25 mm each). There are different indications of these colors if it is green then it is safe when there will be separation starts which is more than 25 mm green color will hide and shows yellow color which indicate roof started separating. When it shows red color roof can fall any time and unsafe to working below that place and we need more support to make that region stable.

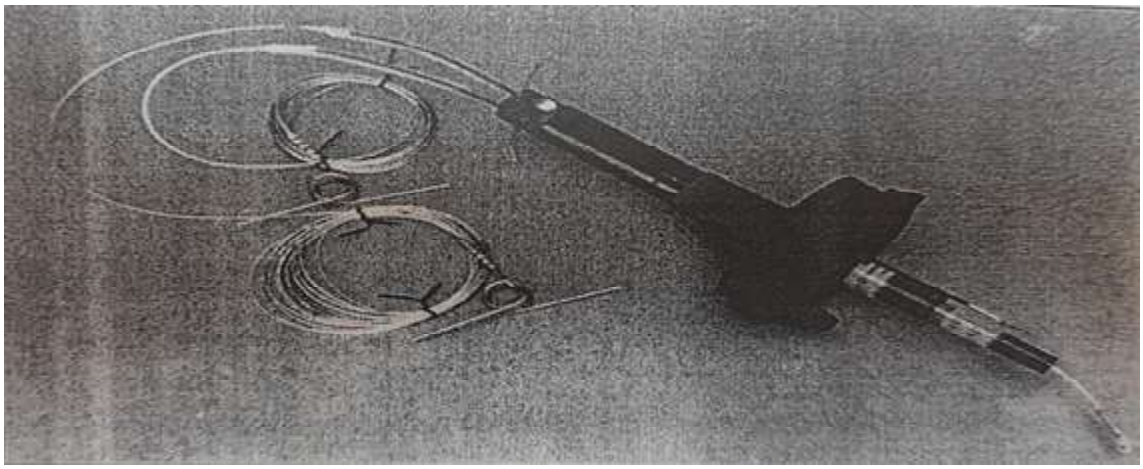

Figure 1: Dual Height Tell tales

Auto Warning Tell Tale (AWTT) – This provides a warning of impending goafing in depillaring operation via high visibility flashing LED's.

At the time of depillaring we put the auto warning tell tales (AWTT).Which consists of electronic sensor which sense and indicate when there is separating of layers by 5 mm. This limit is decided by study of geological condition of strata and the past experience.

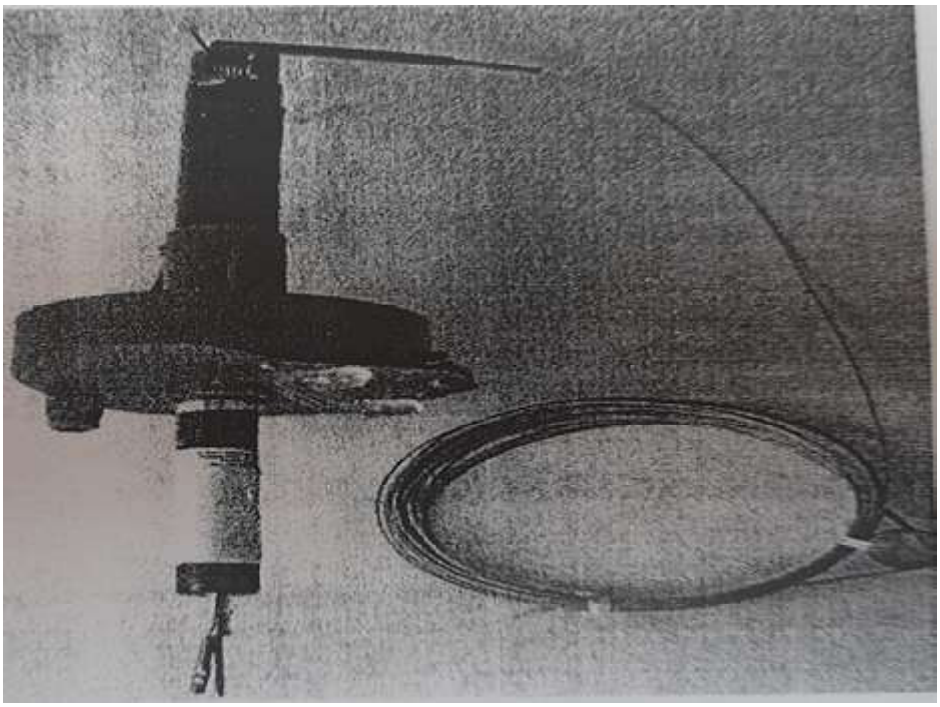

Figure 2: Auto Warning Tell Tale

Anchorage Testing – It should provide minimum anchorage of 3 tonnage after 30min, 5tonne after 2 hours and 10 tonne after 24 hours.

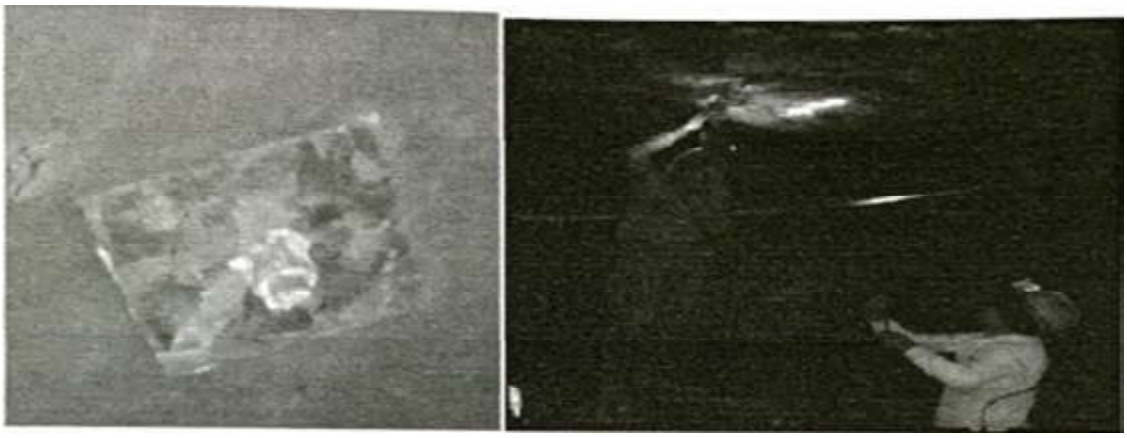

Figure 3: Anchorage Testing

Four - Way Multi Point Remote Reading Extensometer – It can be used to determine roof and rib movement. It works on the principle of inductance and measure displacement of Ferrite rod through coil with the change in inductance. These units can read individually or connected together by a single cable for remote reading with a resolution better than 0.1mm and each anchor can measure up to 75mm resulting in total measurement from four such anchor up to 300 mm.

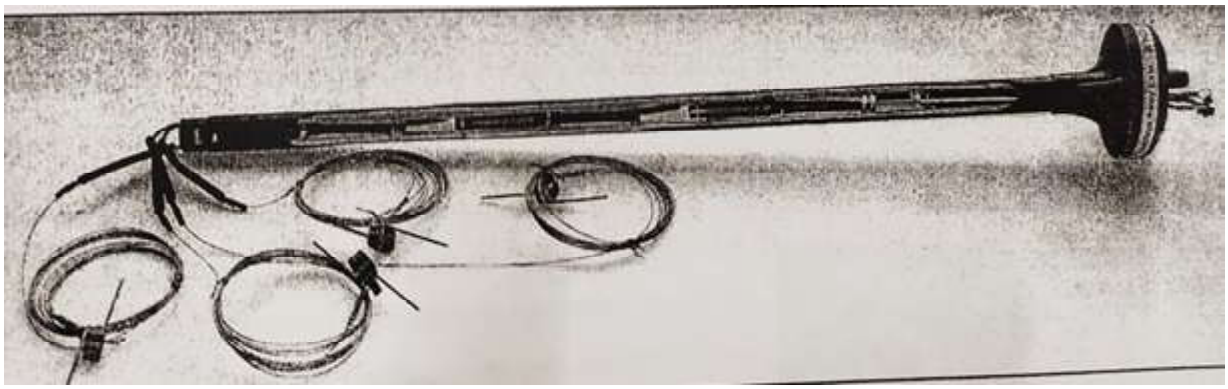

Figure 4: Four – way Remote Reading Extensometer

Vibrating Wire Type Stress Cell - The Stress Cell works on the principle of Vibrating Wire and can measure change in stress up to 40 MPa with a least count of 0.01 MPa. These instruments are installed into the pillar sides to monitor pillar stability and stress redistribution as mining proceeds. They can be read remotely through cable during operation as they continue to provide information from inside the goaf area.

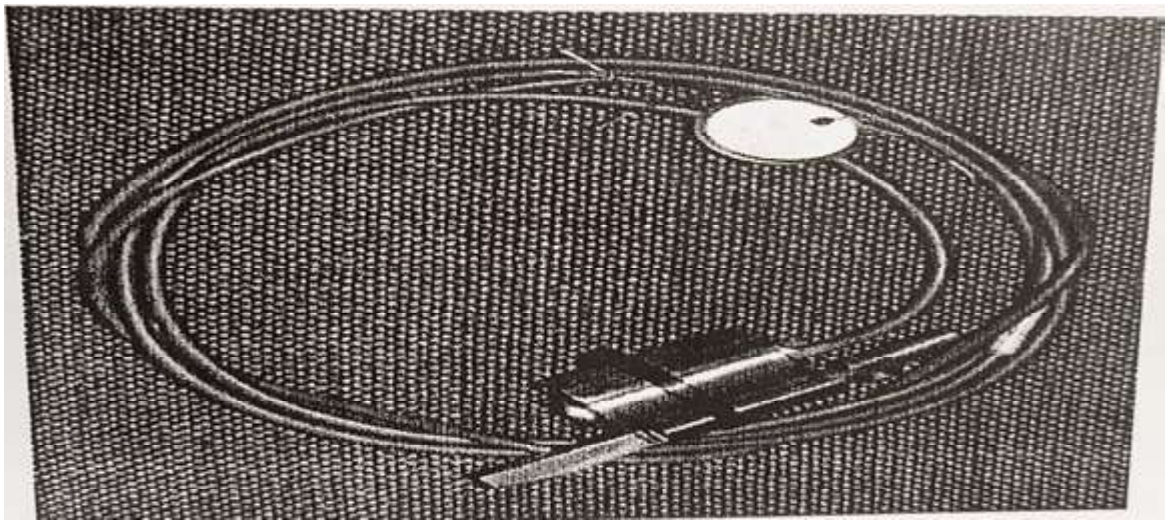

Figure 5: Vibrating Wire Type Stress Cell

Strain Gauged Rock bolt – Whenever rock bolting is used for support, strain gauged rockbolts can be used to measure the distribution of bolt loads for verification purposes. Bolt loads can be monitored along each rock bolt by use of multiple pairs of strain gauges embedded at regular interval along its length. This enables the axial loads and bending moments to be measured along its full length.

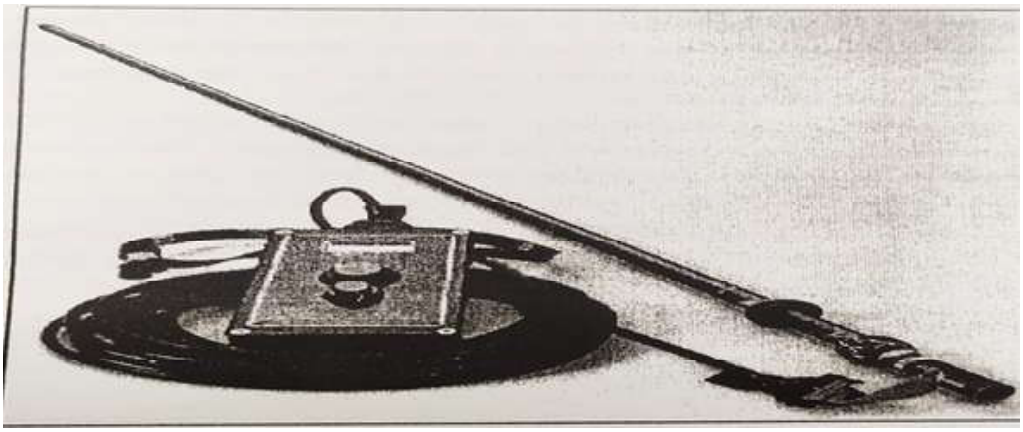

Figure 6: Strain Gauged Rock bolt

CONCLUSION

It has been observed that the influence of geological discontinuities on coal measures is manifested in the form of roof and side falls. On average a continuous miner was being covered by roof falls in the goaf for every three panels at one site, but since the introduction of the NEVID extraction method this has been reduced to less than one in twenty panels.

- It has been seen that the efficiency of the support system was proven with no bed separation recorded during and after redevelopment involving heightening and widening of the original galleries prior to depillaring.
- The Strata monitoring methodology data by different devices will certainly help in working of future panels in this mine.
- Geological mapping should be completed prior to any pillar extraction taking place to establish where geological disturbances may be an issue to mining activity.
- A Trigger Action Plan (TRAP) is made for the decision making with respect to additional support and selective mining based on monitoring and observed conditions during mining operations.
- All mine personnel involved in the continuous miner districts should be fully trained in the theory and practice of high strength support system and their role in maintaining standards and safety in the CM sections.

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The Indian Mining & Engineering Journal, Vol. 61, No.02 February 2022, pp.28-33
Printed in India, @ IME Publications, ISSN 0019-5944

Combating Mine Roadways Deformation: A Review on Supporting Technology

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ABSTRACT

The paper describes some recent technique of support technology to combat mine roadways deformation. Four processes are suggested for this purpose. These are: use of steel acres rather than ring, rock reinforcement, cement injection (grouting) and paste technology. Supplementary roof bolting, reinforcement of the rock with synthetic resin, the injection of cement in the rock and paste technology. A view on these are discussed. The paper also describe Götzeresea and Kammer (1970) research report on roadways convergence and their findings to estimate convergence. Some methods to control which are quite promising
Keywords: Combating deformation, Mine support technology, road way convergence, paste technology

INTRODUCTION

There are many techniques for improving and stabilizing rock include reinforcement by bolt and anchoring , lining with sprayed cement)shotcrete).There are some other methods such as grouting or freezing Rock , good arrangement of water drainage has improved greatly days have to design structures that vary greatly Rock stabilization technology over the years, improved greatly more recently, underground roadways are lined by spraying directly on to the excavated ground. Gunite (fine aggregate concrete sprayed),patented by ;which is much stronger and less expensive are used globly.It is important that the support costs and their quantiles must be reduced to reduce the risk of loss of ground loss of machineries and human life.

The other alternative is to fill the void for which several materials are in use which are not necessarily of high strength. This is known as **'paste** technology`. The major components of paste technology are: mill tailings, aggregate of rock, water and some additives (binder).

Steel arches provide high load carrying capacity and support roadways or tunnels well. This provides support rather than reinforcement. Their efficacy depends largely on the quality of the blocking provided to transport roadways in coal mines, where they are often required to sustain quite large deformations. These deformations are accommodated by using yielding arches containing splayed legs of the arches to punch into the floor.

Resin grouped rock bolts with polyester resin are the strongest form of rock bolt. A ribbed reinforcing rod is cemented into the drill hole by a polyester resin, which changes resin from a thick liquid to a high strength solid by a process of catalyst-initiated polymerization. One or several cartridges are inserted into the hole and is pressed and rotated through the cartridges using a pneumatically or electrical drill.

Cement grouted bolts need time to be hardened and hence cannot be used for immediate support. In comparison with the cement grouts, resin has the advantage of setting and reading its dull strength in a very short time (approximately two minutes).

To arrest floor heave in coal mines or strengthen the friable coal pillars in case of longwall face, fully resin bonded towels made of wood (in place of composite type.

Rock b**olting** by the 1920a began to be used in several parts of the world to improve the stabilizing of underground roadways and roofs. The components that make rock reinforcement systems include lockbolts of various types (the most common type in use is **m**echanical expending shells**,** high capacity grouted ground archers and mesh or the others patented bots

METHOD OF ESTIMATING VERTICAL CONVERGENCE CONVRGENCE

Empirical approaches by Götze and Kammer (1976) have demonstrated the method of estimating the vertical convergence of roadways .They considered four factors: seam thickness, the nature of the floor rocks, the depth of the seam and the nature of packing. Then through tactical evaluation of data proposed the following equation for estimating convergence

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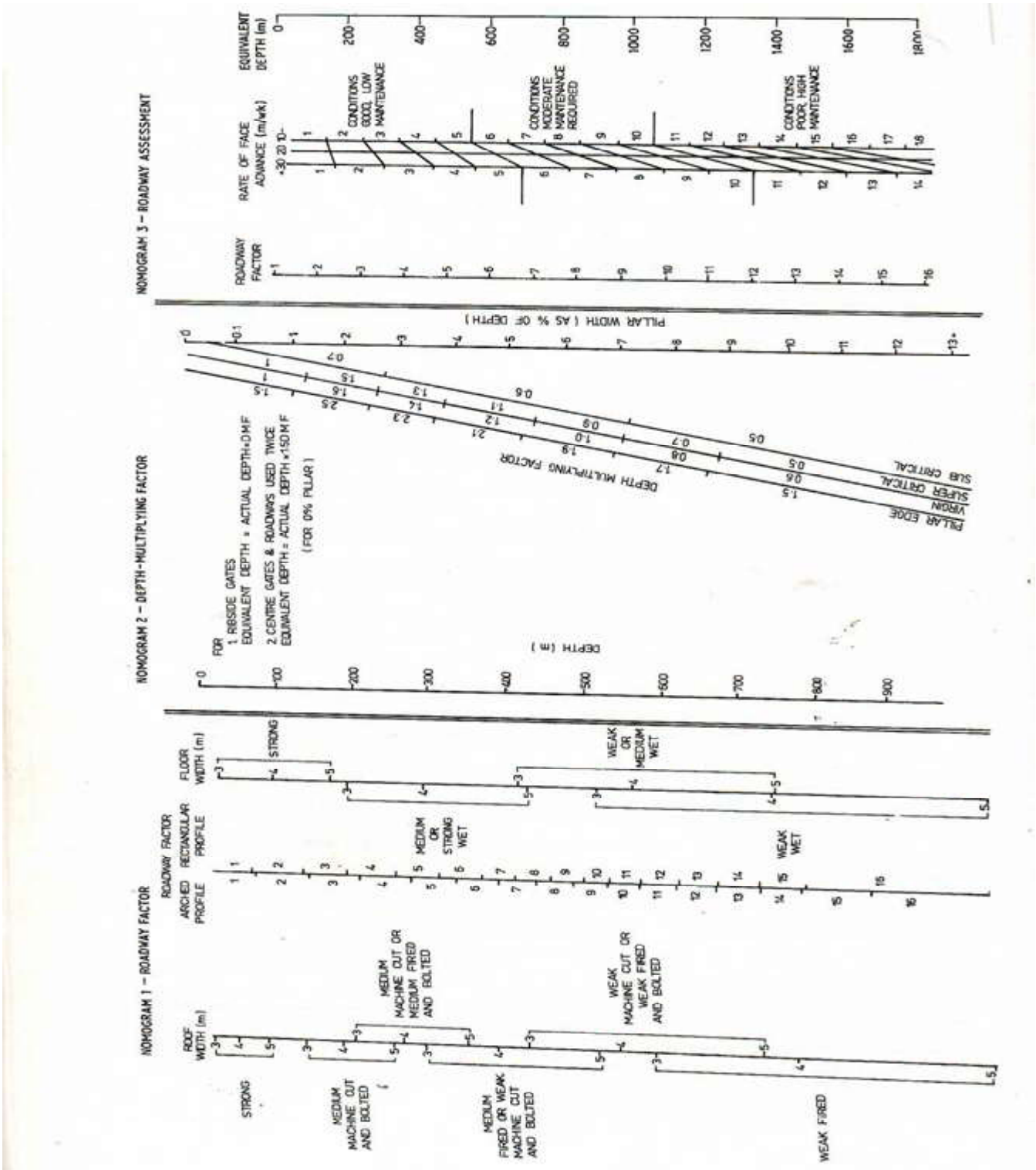

Figure 1 Nomograms to allow assessment of sag and control factors of access roadway (after Johnsons, 1973)

The first nomogram allows a computation of roadways factor roof and floor strength , shape of the roadway, presence watee in the floor etc. The second nomograms consider the depth of the Seam, the width of the pillar, etc. The third nomogram allows assessment of roadway, tey together makes the prediction of convergence easier

PROVEN TECHNOLOGY FOR REDUCTION OF ROCK MOVEMENT IN MINE RODWAYS

Rock reinforcement using bolts

Hobs and Zajic (1983) report bolting mines of Poland te use of roof bolting as early as 1918 in the mines of Poland. Rock bolts anchor by mechanical expanding shell are the most common tpe, being usd about 65-70% of applications.

Also, its patent type the Selex and the split –set steel tubular types is fast replacing the other type.

The expanding shell anchor, Figure 2, unlike others, like slot and wedge, increases the grip and provides better support.

The Spoken Mining research Centre of the US Bureau of Mines has developed a fiberglass threads , which is fed from a spool in to the hole while injecting a polyester grout . This system is much cheaper compared to others, fast in installation and gives better performance and cures faster..

Arch Supports (rather than ring supports)

Reduction of rock movements in the mine roadway by using yield support made up channel-section is giving equally good result as shown in Figure 3(a) being widely used. Figure 3(b) shows the arrangement of the bolts in floor to prevent floor heave As shown in Figure 1 (c)it is possible to achieve rock behavior as in case of steel arches.

Field experiments and model studies carried out by Hobbs reports steel arches rather than steel rings…with steel belts give better results and also states floor heave. These arches are of two forms, one fitted with yielding stilts or boxes and the other with sections which slide over each other. The accepts about 20 tones of rock load.

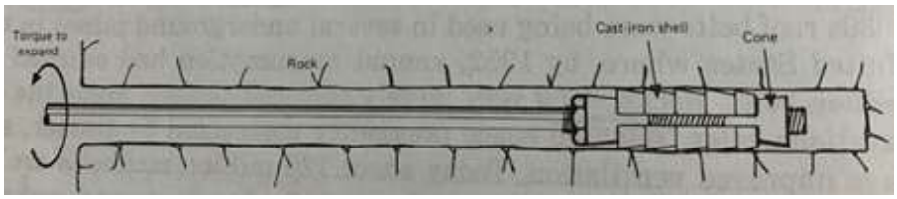

Figure 2: Mechanical expanding shell

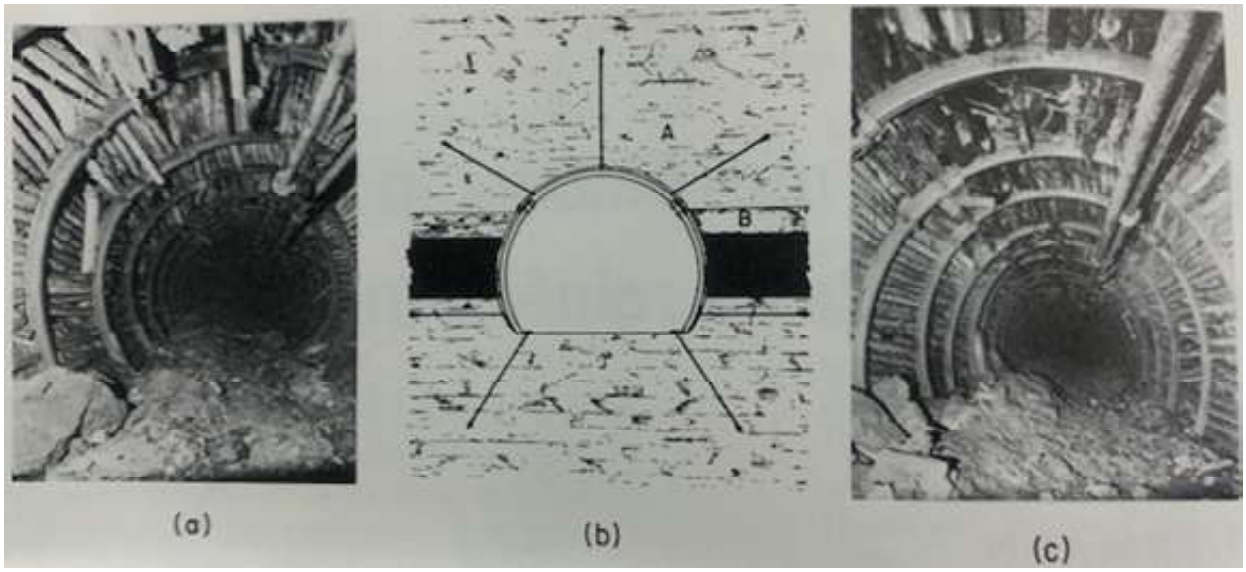

Figure 3: Impact of supplementary bolting (a) ring lining (b) bolt arrangements

Arches and bolls

G**routing** is usually considered essential for soft and highly stressed rock. It also stops rock loosening and dilation along joints. Grouting also protects bolts from corrosion and other kinds of deterioration. Grout towels are self-tensioning. By its use, rocks tend to bind together and support itself. In theory, the bolt should be tensioned and then grouted.

Bolts should be installed on a regular grid and at angles periodically. A sphere grid at 1.2kg by 1.2 m centers is the most common. The US Bureau of Mines (1990) have developed a method in which fibreless threads are fed into the hole together with polyester grout. Cartridges of gypsum based grouts are now also being used which are of lower cost have a faster curving rate (Fabjanczyk, 1992).

Bieniaaraski (1984) proposed an empirical formula for design method for coal mines based on rock mass rating (RMR) rock mass classification system

h_t = B(100-RMR)/100 **(Eq. 2)**

Where h_t is the rock load height, B is the not span and RMR is the rock mass rating. The bolt length is then given as one half of the rock load height or one third the span of the opening, whichever is greater.

The bolt spacing S is calculated from the bolt capacity C_b established by pull out test in the field

$$S = \sqrt{\frac{C_b}{1.5}Gh_t} \quad \textbf{(Eq.3)}$$

Where G = modulus and elasticity of rock and ht is the height of weak zone in which bolts have to be installed. For synthetic bolting in roadways/ tunnel, Schacht et al recommended as follows'

L = 1.4 + 0.184B Unmentioned towel **(Eq 4)**
L = 1.6 + 1+0.012B Tensioned bolts **(Eq 5)**

Where L = bolt length in relation to roadway span B (in metres).

Afrouz (1992), based on his research suggests support pressure based on rock mass quality(Q), for tensioned or grouted bolts (P) is equal to the yield capacity of one bolt (Y, if adequately anchored)divided by the square of the bolt spacing (S) expressed as follows:

P = Y/S^2 where P = support pressure capacity, kPa, Y is yield capacity of one bolt kN
And, S= spacing between bolting in metre.
He further suggests an empirical equation to relate permanent support pressure and Q, is given as follows:

Proof = 66.7 $Jn^{0.5}/J\sigma$ x $Q^{0.3}$ ….. (**Eq 6)**

Pwall = 66.7 x $Jn^{0.5}$ /Jr $QW^{0.3}$ .....(**Eq 7)**

Where Proof = permanent roof support pressure kPa
Pwall = permanent wall Support pressure, kPa

Jn = joint set number
Jr = Joint roughness member
Q = rock mass quality
Qw = wall factor

The above proposed relationship between support pressure and Q provides convenient means for developing classification rules.

SHOTCRETE AND WIRE MESH

There are many techniques for rock stabilizing, eventually controlling mine roadway convergence, using rock bolts, lining with concrete (concreting),frezingand drainage. The wire mesh, also called screen are used which work as a reinforcement with shotcrete.

However, the success of the success of modern ground support stems from the way the rock and support work together in acieving better stability to minimise the underground convergence including surface subsidence. More recently, GUNNITE,(fine aggregate concrete), patented by the Allentown Cement Gun Company, is available with Alliva VS-12 spraying machine are in use

PASTE TECHNOLOGY

Paste technology covers a large range of applications, all of which are founded on one basic concept: reducing the moisture content of tailings to produce a material that remains as fluid to make it possible to be pumped underground Key to the more widespread use of paste technology is due to the development of the deep cone type of thickener. 1 Table on summarises the backfill materials and their relevance to backfill Table 1 Desirable properties of backfill \ material and their application in mining

Table 1: Some Principal properties of backfill and their relevance in mining

No	Property	Brief Description	Relevance
1.	Uniaxial compressive strength (UCS)	Maximum compressive strength that is mobilised by backfill material to resist failure	To ascertain whether the backfill material can flow
2.	Unit weight	If weight of back fill per unit of volume	For determining quantity of fill material required in a stope
3.	Permeability (K)	Rate of flow of water through backfill material	For determining how quickly transport water with drain from the backfill material in stope
4.	Internal angle of friction (Q)	Resistance to mobilised purely by interlocking	Whether backfill will remain free standing
5.	Cohesion (C)	Shows bonding forces of backfill material	Whether backfill will remain free and to determine the bearing of fill material
6.	Elastic modulus €	The relationship between backfill stress and strain	To determine deformability characteristics of backfill under various loading conditions.
7.	Void ratio (e)	To know ratio of voids to backfill material	To determine permeability affected by the particle size of fill
8.	Liquefaction potential	To know behaviour of backfill from solid state to liquefied state	To study the mechanical response of backfill material
9.	Particle size distribution	To know grading of backfill material	The strength and permeability is affected by the particle size.
10.	Mineralogical computation and chemical reactions	The different minerals the rocks as soil compressed	To study possible chemical reactions when additives are added to backfill
11.	Afterberg's limit	To know range of moisture content which will exhibit consistency	To understand the effect of water at different water content
12.	Slump	A measure of the quality of cemented backfill mixture	To determine the …and transportability of cemented backfill

(after Krishna, 2021)

CONCLUDING REMARKS

The mining industry is ever evolving and rock mechanisms are turning to innovate methods to improve the safety productivity and sustainability of the mines with rock reinforcement and the other techniques described.

A number of methods have been developed to reinforce rock stability and maintain strata load bearing capacity of underground excavations. Rock reinforcement refers to internal strengthening of rock using bolts and …of resins or cementations grout to regain competence which is essential squeezing and burst prone strata conditions. External strengthening such as short rate and short rare and mesh is in use universally.

In addition, the D-bolt made by Normet, a unique rock bolt developed about a decade ago has a high strength, low alloy steel can stretch more than 20% enabling greater deformation and a higher load capacity. The D-bolt has proven itself to be quite effective than those which are used currently and are more reliable.

The success of modern ground support stems from the way the rock and support work together. Rock engineers over the years have trying to improve the support structures and have achieved to great extent.

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The Indian Mining & Engineering Journal, Vol. 61, No.02 February 2022, pp.34-37
Printed in India, @ IME Publications, ISSN 0019-5944

Selection of Explosives in Fully Mechanised Underground Metalliferous Mines

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ABSTRACT

Mining of metalliferous deposits by underground mining method has experienced lot of changes in last few years. In India, mines of Hindustan Zinc, MOIL, UCIL, Hutti Gold Mines have laid emphasis on adopting latest techniques and technologies. From the conventional track mining the trend has gone for more of trackless large capacity mines. The operations like mine development and stoping by drilling and blasting, loading and hauling has adopted higher capacity system. In the areas of blasting also there have been many changes and the latest trend is to go for large size excavations and using bulk emulsion and shock tubes. Attempts have been made also to use electronic delay detonators. In this paper, the selection criteria for explosives which are being used in UG metalliferous mines is presented.

INTRODUCTION

In India about 38 mines having underground mining operations, mining major minerals, contribute to only 2.6% of the total number of producing mines for minerals. Copper ore, lead & zinc ore, manganese ore and gold ore are produced from underground operations which are showing an increasing trend in recent past. However, Chromite which was traditionally mined from opencast is now adopting underground mining.

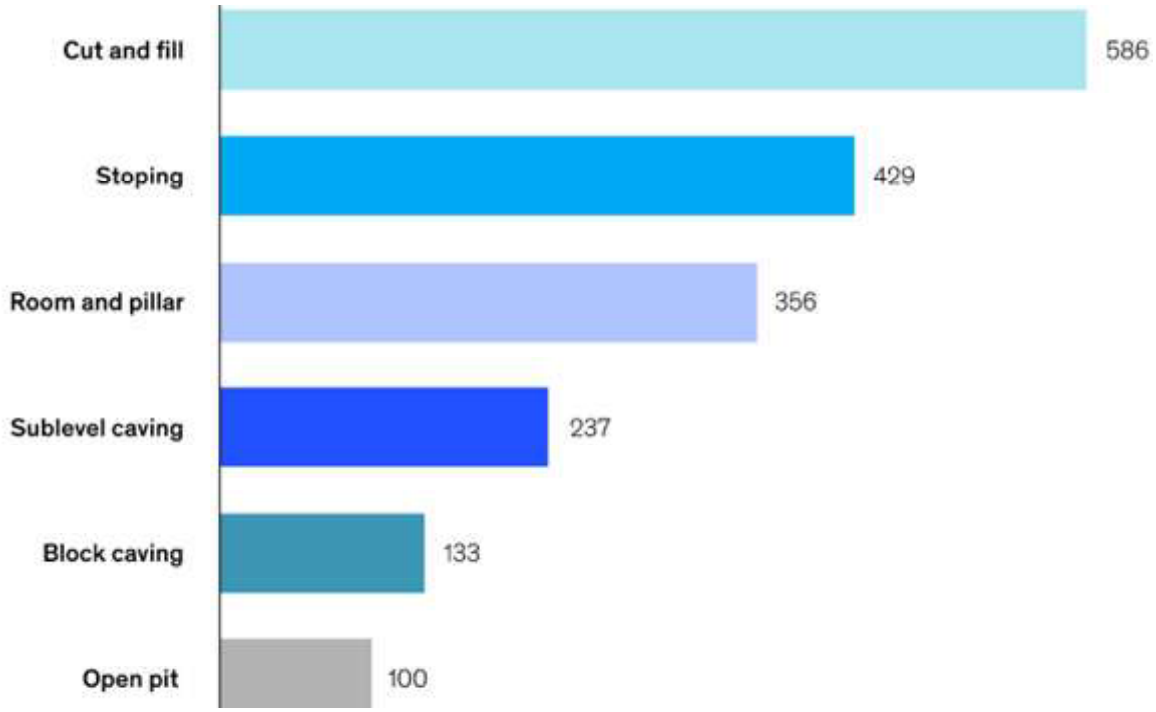

Figure 1 : Showing Method of mining and comparision of various operating costs (Source : Rémi Martino, Remi et el, 2021)

Drilling and Blasting continues to be the sole method of rock breakage in excavations in underground mining. Figure 1, presents the various methods of stoping adopted and the operating cost impact of each method. Cut and fill continues to be the costliest method but it is also very popular. Attempts are being made to optimize on level difference, adopting long hole blasting techniques for higher yield and output.

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The selection of explosives area guided by the following factors –

(a) Geology of the host rock and the ore body(hydrology, presence of folds and faults, geo-technical properties of the rock and ore body etc),
(b) Dimension of the Ore body
(c) Depth of working
(d) Method of work
(e) Dimension of the face
(f) Nature of roof and floor
(g) Types of loading machineries and their capacity
(h) Ore evacuation system
(i) Ventilation standards and system adopted
(j) Strata control, roof support method etc. Strata damage related issues.
(k) Statutory norms laid down in the Permissions granted by DGMS as per MMR 1961
(l) Skill of manpower and technology available in the areas of drilling, strata control and strata monitoring etc.
(m) Cost of explosives and initiation system.

EXPLOSIVES

Mostly cartridged explosives (varying from 25 mm dia. Up to 125 mm dia. for 38 mm and 150 mm dia. blast holes respectively) are used. However, ANFO (manually mixed and loaded or pneumatically loaded) is also used in mines where problem of noxious gasses are suitably taken care of by adequate ventilation.

Bulk ANFO/SMS/SME was used on trail basis in underground excavations for the first time at the below ground cavern excavation near Visakhapatnam for creating storage space for petroleum products. Two caverns of 19 m. Height, 20 m. Base width and 160 m. In length with interconnections were excavated. The 125,000 m^3 cavern has been excavated in hard garnet gneiss bedrock, down to 186m below ground by drilling and blasting method for carving out the cavern. Later, Orica in association with UCIL took up trials at the Narwapahar mine.

Currently, in the underground mines of Hindustan Zinc, Bulk SME is being used on regular basis.also used for blasting. For this purpose specially designed pump trucks are built. The capacity ranges from 0.5 tonne for development headings, up to 12 tonnes for ring firing.

The advantages are :

(i) Higher loading densities and improved borehole coupling provide major cost saving benefits as hole spacings are widened and required drilled meters are reduced. Loading densities greatly exceed competitive methods such as pneumatic loaded ANFO and cartridge air-loaders.
(ii) Productivity also improves with high speed loading in large firings (ex : VCR mining). time saving with bulk pumpable system is also considerable.
(iii) It alleviates the need for extensive magazine storage areas in underground mining.
(iv) Safety is greatly improved as the need for large quantities of flammable packaging is removed from the usually congested underground environment.
(v) Shelf life may be varied as required. If extensive sleeping time is required in small diameter 50 mm holes then glass micro spheres may be used in place on the usual chemical gassing system (in case of repumpable emulsion).
(vi) Charging into vertical up holes of upto 125 mm in diameter by use of a special homogenising valve is possible.. The valve is fitted at the end of the hose in such a way as the shear the product as it leaves the nozzle. The shearing action increases the viscosity of the material allowing it to hang up in the hole for extended periods of time.
(vii) With a VOD of 5000 m/sec and an increased bulk strength of 1.14 the results are excellent.
(viii) Overall cost savings in the drilling and blasting is quite significant. In these mining conditions rate of penetration, quantity of blasted rock per drilling meterage, consumption of drilling tools etc have great influence on the cost of mining.
(ix) Reduced cycle time and size of the blasting crew when bulk SME is used.
(x) Blast performance – it includes, pull, no. of sockets, disruptions during blasting (like misfires etc), powder factor, charge factor, size distribution of blasted material, cost of secondary blasting, cost of crushing, etc.

PROPERTIES OF BULK SME

Bulk emulsion explosives have an average heat content of 2.5 to 3.0 MJ/kg, 850 to 1000 litres/kg of Gas volume, and wide VOD range of 3000 to 6000 m/s. Besides, by adopting differential gassing, charging in the face is varied depending on the rock type, geology etc. Table …,

presents the properties of bulk explosives being used currently in Indian mines.

Table 3.6 : Presents the properties of the bulk explosives used in UG

Properties	Underground bulk				
Density g/cc	0.80	0.90	1.0	1.1	1.2
Critical dia. (mm)	38	38	38	38	42
VOD (m/sec)	4500	4900	5300	5700	6200
Relative Weight Strength(RWS)	72	78	85	92	98
Relative Bulk Strength(RBS)	72	89	106	127	147
Sleep time	Seven days				

INITIATION SYSTEM

Selection of proper initiation system greatly influences the results obtained from a shot. In development headings long-period delays are preferred, and also in some stoping operations. They leave the muckpile near the face for quicker loading and with minimum air blast effects. In all long-hole blasting MS delay blasting is adopted, and also in some larger room and pillar headings or larger overhand stopes, This result in better fragmentation. Shock tube system in most cases, help in controlling muck pile configuration, minimising environmental impact due to blasting, better safety, minimum effect on the roof-floor and sides of the excavation, etc.

In India, NONEL GT/MS system was tried at HZL Rajpura - Dariba mine at its VCR method of mining. VCR method was adopted in view of the instability problems and cost factors. The VCR method includes drilling of all stope holes, vertically, from one spot. Hole depth vary from 30 to 40m, with a 150 mm dia. drill-hole. Once a stope has been drilled, it plugged up 1.5 from stope bottom, using a wooden plug fastened in a specially designed plastic sing. A one kg weight sand bag is dropped on top of this plug, followed by one meter of explosive. The charge is completed be adding 1.5 meters of packing material in all the holes. The results were quite satisfactory. For the large blasts in the ring-drilling and crown pillar blasting shock tube system also finds application.

'Electronic Delay Detonators (EDDs) in UG Metal Mines

Conventional detonators use pyrotechnic delay elements and the variation of the actual delay periods is at best approximately 1% the nominal delay. The lack of guaranteed precision common to all pyrotechnic systems enhances the likelihood of negative environmental blasting effects.

For example, take a 500 MS in hole delay with EDDs. In conventional detonators this means that 95 % of shots fire within 10 MS of the mean. i.e. a window of 20 MS. Taking a fixed interval between shots of 25 MS, with a range of ± 3 MS, a very ragged firing pattern could be expected which in practice would result in non uniform fragmentation. The electronic detonators have reduced ground vibration enabling large stope blasts and increasing productivity. The total charge could be increased. This has further helped in maintaining surface vibrations below 12mm/sec (>50Hz predominant) in village.

CURRENT TREND OF MECHANIZATION

Most of the large mines in development use single or double boom jumbos and mucking with
10T LHD in combination with 20T LPDT. Development faces are blasted using cartridge emulsion/slurry explosives (25/40mm) with shock tube delay detonators. Lately the charging has been mechanized using pneumatic emulsion charging. After initial trials and

innovations the face pull/blast has been achieved up to 3.8m in 4m long holes with about 1.07kg/ton powder factor.

EHS (Solo- Sandvik) drill machines using 64mm dia. holes for top holes in trough and 102/89mm holes in bottom holes in production rings are being usedf in stopes. For longer holes (>35m) in stopes the ITH drills are used with 165/115mm dia. holes. In stope blasts emulsion explosive (83/125mm) cartridge, using booster charge of 100/250/500 g with shock tube detonators and at a drill factor of 12t/m are in practice, achieving 0.3 to 0.4kg/t powder factor.

The face mechanization using jumbo drill and LHD combination has been very successful giving high rates face advance of 100-125 m/month/face (total monthly development as high as 1200m). Large trackless dumpers are used in many mines where trackless system of ore evacuation has been adopted. Further, passenger carriers, road grader, scissor lift, lubricant truck etc arfe also used.

CONCLUSION

With more large capacity UG mines are being planned and are in operation, use of bulk SME significantly contributes to safety and overall cost savings blasting as compared to the conventional cartridge explosives.

ACKNOWLEDGEMENT

Thanks are due to the management of AKS University for granting permission to publish this paper. Special thanks are due to M/s Orica for assisting in the blast site visits, technical updation etc.

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The Indian Mining & Engineering Journal, Vol. 61, No.02 February 2022, pp.38-40
Printed in India, @ IME Publications, ISSN 0019-5944

Selection and use of Paste Fill as Stowing Material in Underground Metal Mines

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ABSTRACT

Back filling is an important operation in U/G metal , After extraction of ore from U/G mine , it is necessary to fill the void with appropriate filling material . now a days hydraulic stowing is a comman practice to fill the void areas but due to unavailability of sand in nearby areas & also increased transportation cost & several regulation on ban of sand . It is necessary to find the alternative of sand stowing.

There are same alternatives of sand stowing such as fly ash of coal form thermal power plant , waste rock from overburden in opencast mine and mill tailings form processing plant . these alternatives are necessary to proper use because these are accumulate the surface land for its dumping and dengerous to environment or are pollution water pollution

The scientiest, engineers has develop some technologies to use of such alternatives for back filling out of these the paste filling a standard practice for backfilling as it gives many advantages over other. such as it gives high strength to supporting roof strata, to no need of dewatering, high density, gravity flow is possible & stope cycle time is less. It also possible top down mining operation due to paste filling the paste fill is the mixture of mill tailings obtained from processing plant, cement as binder , water and some additives. In India the first plant of paste filling is start in 2015 by Golden association in Sindesar khurd mine and latter in Rampura mine of HZL, Rajsthan. This is a development stage of use of paste fill in indian metal mines . In forgian contreine this method is comman use.

INTRODUCTION

Paste filling method is simple, economical and long life. After processing of ore the large no. of waste are comming out. Such waste are properly crushed and fines are formed. Such fines are known as mill taillings. Such mill taillings are mixed with cement and some amount of water, the mixture is formed is known as paste.This mixture is properly grind with grinder m/c, and make it slurry like consistency with less viscuss nature. Such mixture are pass into voids though pipeline arrangement. The size of mill taillings are used less than 5 micro metre

The void creates after extraction of ore in underground metal mines is necessary to fill. If it is not filled there is chanches of subsidence as well as it does not give any support to other mining operations, also it is dengerous to mine safety.

The paste fill material are Pass to voids created to due to extraction of ore. This paste fill are pass through pipeline arrangement. It is generally gravity fed arrangement.As there is less chanches of accumulation of paste in the pipeline. The pipeline should have such arrangement for its transportation such that the pipe line should have to maintain some gradient so the paste should geavity fed.The components of paste fill are mill taillings, binder, water and some additives are mix with it.The method is summerise as mixing of mill tailling with cement, water & additives followed as transportation of prepared paste through pipelime arrangement, poring it into void areas time required for its setting, bond prepared between material particles , interaction on between the filled rock.

PROPERTIES OF PASTE FILL MATERIAL

(1) Porocity - The paste fill material should not porus in nature. Porocity is the property when the mixture form an air gap in the paste fill material. If there is porocity property then mixture should not properly filled and there is large air gap is form in the strata It is necessary to consider that quantity of paste &qualityof paste should be best. The ingradients of paste are properly mixed with each other.

(2) Grain size - The paste fill should have minimum 15% in the -20 mm size fraction have sufficient quantity of water to flow the paste.There are three types of grain size use in paste fill

a) Course Grain- These are have 15 to 30% minus 20 micron at 18 cm slump. The course tailling of rock or sand is heigher density than medium & fine taillings. It has high distribution Capacity

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b) Medium Grain- It have 35-60% minus 20 micron at 18cm slump. It have less density than course tailings, so it has less distribution capacity.
c) Fine Grain - It contains 60-90% minus 20 micron at 18mm slump. It has less density so it has minimum distribution capacity
(3) Specific gravity – The specific gravity increases the pulp density of solids. For a given slump the specific gravity is maximum at heigher pulp density.
(4) Viscosity — The paste fill should be viscus in nature with uniform flow rate. If it is not viscuss then the compactness of fill material is less It depends upon grinding of material and filling systeme. Viscocity also depends upon pulp density. The pulp desisity is varies as change in specific gravity of tailling material.
(5) Pulp density - It is the density of mixture of paste fill. This density depends up on quality and quantity of solids in the mixture. As the quantity is more & quality is good then. pulp density is more. It is the ratio of total solid weight divided by weight of solid plus water. As the pulp density is more then specific gravity also more.
6) Binder - Binder is the binding material. The binding material is the ordinery portland coment. It is the best binding material but do to increse the backfilling, the cost of binder is also Increse, then it becomes costly process. Some times fly ash, slag. pozzolan can also be used as binding material to reduce the cost.

Present condition at paste filling method : In India the first paste filling plant is start in 2015 by the Golden association in Sindesar khund mine, HZL. After that this method is adopted in Rampura mine of HZL, presently malaykhand mine has develop a plant for paste filling. The parte fill is used with the combination of longhole stoping method of metal mine. The paste fill is used with a slump of 150 to 180 cm with minimum water content the paste fill consist of 63-80% mill taillings, 8-10% cement some amount of water. Before filling the paste fill in voids the barricads to be are constructed, these barricade should be leakage proof. The paste is pass through pipe line at the speed of 240 m³/hr & with density 2T/m3.

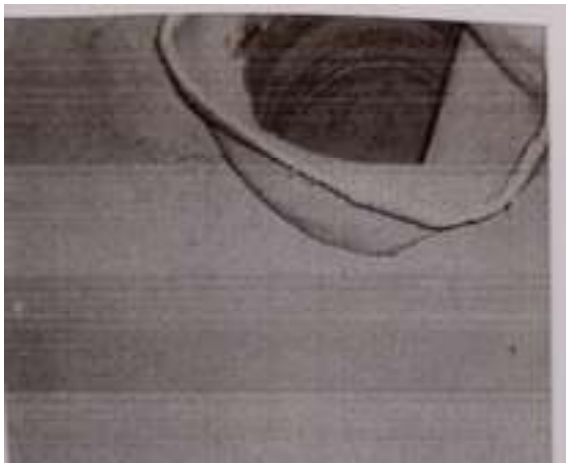

Fig.(a) paste filled stope void

Fig.(a) paste filled stope void

CHARECTERISTICS OF PASTE BILL MATERIAL

(1) It is not sepretes when it is pass through pipe line.
(2) Any excess water not absorb by the paste. It leaves the pool of water when settle.
(3) Slump is less than 23 cm. the slump is the differance in height in slump cone and slump material
(4) It has high bulk density.
(5) The strength of paste filling is very high.
(6) There is dewatering characteristics of mill taillings.

SOME PROBLEMS ASSOCIATE WITH PASTE FILLING

(1) Accumulation of paste fill in pipe line -- In horizontal arrangement of pipeline arries the problems of accumulation of paste in pipeline. So it is necessary the pipe line should be at sutaibre gradient so the paste should properly pass through it The another reason of accumulation of paste is large size mill taillings. So it is necessary the mill twilling should be at required size (5micro metre).
(2) The process of back filling is costly as area of back filling is increses. So large quantity of cement is

required hence incease the cost of Filling. —There is another cost of pipe line arrangement.

(3) The settlement of paste is necessary before starting next stoping operation.

(4) The barricades are constructed before starting the paste filling operation, the barricades should be of good quality & it is leakage proof. so that coment water slurry should not leave from it.

(5) There is possibility of pipeline broken as paste fill is pass with high pressure. It is necessary to maintain the constant pressure.

(6) Water use in paste filling should not be of acidic water or explosive water It make reaction with in U/G rock particles is harmful to mine worker's

CONCLUSION

The mill taellings which is available in large amount form processing plant, is an effective material for back filling the voids in U/G metal mines . . It is one of the good alternative to sand stowing. The paste filling not only provides support to surrounding void area but also give large production by long hole stopping method . It also posible top to down mining operation.

It prevents environment pollution, Due to use of it in U/G metal mines as back filling, it remove dumping facility above the surface . Also the many technologies of crushing the rock / mill taillings pipe line arrangement, pumping systeme, thickners helpful for better use of paste filling.

In india it is a development stage but due to its effectiveness it's use is likely to be Increse in future days.

ACKNOWLEDGEMENT

This study is a part of the M. Tech mining thesis work and fulfill M. Tech mining Course work. This part of course is of AKS university, Satna, M.P. India. The view discuss are of author and not of institution he represent. Thanks to Dr. G.K. Pradhan sir for his guidance.

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