# THE INDIAN MINING & ENGINEERING JOURNAL

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

www.theimejournal.com

VOLUME 57: Number 12 **DECEMBER 2018** ISSN 0019-5944

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**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*

IME PUBLICATIONS

**Corresspondance Address**
**The IM& E Journal** 1457, Fishery Tank Road, Chintamaniswar, Laxmisagarpatna, Bhubaneswar - 751006, Odisha **Mobile:** +919861008387
**Mail:** indianminingjournal61@hotmail.com
**Branch office**:Near TV Tower, JODA, Dt. Keonjhar 758034
Phone: 06767-273173

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# Persons in the News

**Shri Manoj Kumar** took charge as Director (Technical) in Western coalfields Limited, Nagpur. Prior to elevation as Director (Technical) he had served in various capacities in WCL / SECL and ECL since 1985. Shri Kumar did his B.Tech (Mining Engineering) from Indian School of Mines, Dhanbad in 1st class with distinction in the year 1985. He got First Class Mine Managers' Certificate of Competency in the year 1989. He also did M. Tech in Rock Excavation Engineering. He joined Coal industry in the year 1985 in Old Rajnagar Colliery of Hasdeo Area. Since then he worked in various mechanized and manual coal mines around 17 years in WCL/SECL.

**Shri Prabhakar Chowki** has been as Director (Mines) of NLC India Ltd. Prior to joining NLC India Ltd, he was working as General Manager in Coal India Ltd (CIL). Shri Chowki is an Engineering graduate in Mining from Osmania University passed out with Distinction. He holds, a 1st Class Certificate of Competency (Coal) under the Indian Mines Act. He is a life member of Mining, Geological & Metallurgical Institute of India (MGMI). Shri Chowki joined Coal India ltd (CIL), as a Junior Executive on 18th August, 1984. He has rich work experience, spanning 35 years in the field of mine planning, production, management, supervision, direction and control of underground as well as opencast coal mines. All along, he has been working in Coal mines rendering 13 years of specialized service in Surface Mining and Inpit Crushing Conveying System. He had worked in different capacities at Western Coalfields Limited, Central Coalfields Limited, (the subsidiaries of Coal India Limited) and Head Quarters of Coal India Limited at Kolkata & Delhi. His professional achievements include rehabilitation of one village at Ashok OCP, CCL in 2003 and introduction of Surface Miners at Ashok OCP in 2003, which is a Green Mining Activity.

**Dr Alka Mittal** has joined as Director (HR) of Oil and Natural Gas Corporation Limited. A post graduate in Economics,

MBA (HRM) and Doctorate in Commerce and Business Studies, she joined ONGC as a Graduate Trainee in 1985 and brings with her an extremely rich experience spanning over three decades. Dr. Mittal is the first woman to hold the charge of a full-time Director in ONGC's history. She is also on the board of ONGC Mangalore Petrochemicals Limited as ONGC nominee Director since August 2015. Prior to joining as Director (HR), Dr Mittal held the post of Chief Skill Development of the Company. In her capacity as Chief Skill Development she streamlined the activities and brought in uniformity in the working of the Skill Development Centres of ONGC. During this period, she has also implemented the National Apprenticeship Promotion Scheme in ONGC engaging more than 5000 apprentices across all work centres. Previously she worked as Head CSR at Corporate Office and took up major CSR projects across India. Earlier, she has led the HR-ER functions in various capacities across regions including Vadodara, Mumbai, Delhi ad Jorhat, and was also the Head of Corporate Communications of ONGC during 2009. She has a special penchant for training and mentoring, and has trained more than 11000 GTs of ONGC since 2001 on "Corporate Governance" as part of their induction program. As a senior HR specialist, Dr Alka Mittal has made rich contributions in various professional forums and bodies. She is an Executive Committee meber of National Institute of Personnel Management, and was President of Forum for Women in Public Sector Northern Region till recently and heads the Women Development Forum of ONGC. Dr. Mittal has always strived to foster the philosophy of equal opportunity employer and has contributed towards creating an inclusive workplace ecosystem in ONGC.

**Shri Amitava Mukherjee** assumed charge as Director (Finance) of National Mineral Development Corporation Limited. Prior to joining NMDC, he was holding the post of General Manager (Finance) in Rail Vikas Nigam Limited for a period of around two and half years. Shri Amitava is a Cost Accountant and also hold Master of Commerce Degree from Guru Ghasi Das University, Bilaspur. During his service in IRAS, h held various key positions in the Eastern Railways from 1997 to 2016. Before joining IRAS, he worked in Indian oil Corporation Limited as Accounts Officer from 1994-1997

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# Indian Mining Industry News

## MINING NEWS

### IMFA MINE INSPECTED

Deputy Director of Mines Safety, Bhubaneswar region, Nagendra Kumar Sriram, inspected Mahagiri Chromite Mines of IMFA at Kaliapani during the annual Mines Safety Week celebration. Sriram appreciated the safety measures taken by IMFA Mines for its workers. The week started with distribution of safety badges among the employees and safety flag hoi8sting by Mines Manager Lalatendu Mohapatra followed by an address to the workers and officers. Competitions in poster making, speech, slogan and trade test were also conducted. The inspection team, led by Anang Mohapatra from FACOR, along with Rajesh Ekka from Tata Steel and Ranjeet Naik from Nalco, inspected the mines. A fire mock drill by security team, led by Hruday Ranjan Biswal, and first aid wxercise by Malay Jena, was demonstrated before the visiting team. Prizes were distributed among the winners of competitions.

### L&T Q2 NET PROFIT JUMPS 28% TO ₹2,593 CR

Larsen and Toubro reported 28.36 per cent jump in its consolidated net profit to ₹2,593.41 crore for the quarter ended September 30. The company, however, said private sector investments in the country remained recovery of non-performing corporate debts through insolvency resolution has improved the business sentiments. The infrastructure conglomerate had clocked a net profit after tax of ₹2,020.30 crore in the year-ago period. The company's total consolidated income of the company rose to ₹32,506.10 crore in the July-September quarter from ₹26,846.41 crore in the same period previous fiscal, the company said. Total expense rose to ₹29,225.10 crore from ₹24,308.17 crore. The infrastructure segment secured orders of ₹23,406 crore during the quarter ended September 30, registering a substantial growth of 69 per cent on a year-on-year basis.

### VEDANTA Q2 NET PROFIT DIPS 34% TO ₹1,343 CR

Vedanta Ltd reported a 34.32 per cent decline in its consolidated net profit to ₹1,343 crore for the July-September quarter. The company had clocked a "Profit attributable to owners of Vedanta Ltd" of ₹2,045 crore during the corresponding quarter previous fiscal. Its total income during the quarter rose to ₹23,297 crore as against ₹22,509 crore in the corresponding period last fiscal. The total expenses also rose to ₹20,999 crore during the quarter under review as against ₹18,854 crore in the year-ago period. The company said in a statement that its balance sheet was strong and the net debt reduced by ₹3,553 crores in Q2 FY2019. "I am pleased with the growth in volume this quarter at our businesses. The company is uniquely poised to grow the commodities that have rising demand especially in India with an enviable growth pipeline which is systematically being brought to fruition," Vedanta Chief Executive Officer Srinivasan Venkatakrishnan said.

### HPCL NET PROFIT DIPS 37% ON LOWER RUPEE, FALLING MARGINS

Hindustan Petroleum Corporation Ltd. (HPCL) record a 37 per cent fall in its profit for the second quarter of the current financial year. The company posted net earnings of ₹1,092 crore compared to ₹1,735 crore during the same period last year. "The profit was impacted on account of increase in crude prices and consequent increase in the fuel and loss component besides exchange rate fluctuations," HPCL CMD Mukesh K Surana said. While the company's revenue from operations increased 34.51 per cent to ₹73,790 crore for the quarter, compared to ₹54,855 crore last year, expenses due to foreign exchange losses swelled substantially during the first half of the financial year.

"Other expenses for the April-September period, 2018 includes ₹1,424.36 crore towards loss on account of foreign currency transactions and translations. During, April-September, 2017 a gain of ₹132.33 crore on account of foreign currency transactions and translations was included in other income," the company said. The rupee has depreciated 13 per cent versus the US dollar since the end of March 2018. HPCL's gross refining margin during the six months period ended September meanwhile, also decreased to $5.93 per barrel from $6.75 per barrel in the previous year. As for domestic sales during the quarter, they increased to 8.82 million tonne, compared to 8.37 million tonne last year, while exports decreased marginally to 0.32 million tonne as compared to 0.36 million tonne.

### IMFA REPORTS STEADY NUMBERS FOR Q2FY19

Indian Metals & Ferro Alloys Ltd reported a net profit of ₹21.49 crore in the September quarter of the 2019 financial year, against ₹7.37 crore it saw in the same quarter of FY18. The company's revenue stood at ₹394.77 crore for the second quarter, against ₹416.03 crore it reported a year ago. Exports rose marginally from ₹344.94 crore in Q2FY18 to ₹347.99 crore in Q2FY19.

**PETROLENT LNG NET PROFIT FALLS 4.39%**

Petronet LNG reported a 562.95-crore net profit for the second quarter, down 4.39 per cent from the ₹588.78 net profit recorded for Q2FY18. The lower profit comes despite a 37.91 per cent rise in its total revenue at ₹10,856.82 crore. The company said the lower net profit was due to tax benefits received under Section 80(IA) of the I-T Act during Q2FY18. The company's board has also declared a special interim dividend of ₹5.50 per equity share.

**INDIAN OIL SECOND QUARTER NET PLUNGES 12.6%**

Indian Oil reported a 12.6 per cent drop in its second-quarter net profit. The company reported a net profit of ₹3,246.93 crore in the July-September quarter compared to a net profit of ₹3,696.29 crore a year ago. IOC suffered a foreign exchange loss of ₹2,600 crore in the quarter as rupee depreciated, making repayment of loans as well as crude oil purchase costlier, said Sanjiv Singh, Chairman of the company, which saw a 78 per cent jump in raw material prices during the second quarter. The gross refining margin during the September quarter was $8.45 per barrel, compared to $6.08 per barrel in the corresponding period of FY18. Sales rose 47.9 per cent to ₹1,32,357.08 crore during the quarter under review against ₹89,498.77 crore in the previous quarter.

**ONGC Q2 NET RISES 61% TO ₹8,265 CR**

Indian Oil and Natural Gas Corp (ONGC) posted a 61% jump in its September quarter net profit as higher prices offset a dip in oil production. Its net profit was ₹8,265 crore in Q2FY19 against ₹5,131 crore net profit it saw in Q2FY18, according to a statement from the company. ONGC got ₹73.07 for every barrel of crude oil it produced and sold in the second quarter, up 48 per cent from $49.43 per barrel realisation a year ago. Because of the depreciation in rupee, ONGC's realisation soared 61 per cent to ₹5,117 per barrel. The PSU oil major's turnover was up 47.6 per cent at ₹27,989 crore.

**INDIA CEMENTS NET PROFIT FALLS ON LOW PRICES**

India Cements reported a 94 per cent fall in net profit for the quarter ended September 30 at ₹1.43 crore, against ₹23.67 crore in the same quarter the previous year. The company attributed the fall in net profit to low prices in the market. But, with its capacity utilisation increasing, the firm is also looking to expand it production capacity, with a planned 1,000 crore plant sent to come up in Madhya Pradesh. Elaborating on the Performance, N Srinivasan, Vice-Chairman and Managing Director, said, "While the capacity utilization is going up, the price of the cement is less when compared to the increase in fuel prices. This increases the the transportatin costs". He went on to point out that the company had increased total cement sales to 30.77 lakh tonnes in the same quarter last year. "We are now operating at 80 per cent capacity." The company saw net plant realisation fall during the quarter by about 3.6 per cent due to the increased expenses. As for demand, the south Indian region has seen a 22 per cent rise in demand due to infrastructure projects coming up in Andhra Pradesh and Telangana, and post-flood construction in Kerala, said Srinivasan. The company is also embarking on Capacity expansion, with plans to set up a new facility in Madhya Pradesh at a cost of around ₹900-1,000 crore.

**HINDALCO PLANS ₹8,600 CR INFUSION OVER NEXT FIVE YEARS**

Hindalco Industries will infuse ₹8,600 crore in downstream expansion in the country over the next four to five years. The company is considering investments in setting up of an aluminium flat rolled product unit in Sambalpur district of Odisha at a cost of ₹5,000 crore, along with the country's biggest aluminium extrusion and recycling plants in Gujarat. "We have committed to set up a downstream facility between Hirakud and Lapanga (in Odisha) taking the capacity to 300 kilo tonnes of downstream products, Satish Pai, Managing Director, Hindalco Industries, told the sidelines of Make in Odisha conclave. The Aditya Birla Group company has recently signed two memorandums of understanding (MoU) entailing a total investment of ₹3,600 crore, including ₹2,100 crore for the extrusion plant and ₹1,500 crore for the recycling plant in Kutch. While the extrusion plant will have an annual capcity of 1.37 lakh tonnes per annum, the recycling plant will be set up with a capacity of 300,000 tonnes per annum. "We will be developing these projects in phased manner," Pai noted.

Commenting on the expansion in the domestic marked, Pai said the company would be looking at coal mine auctions for linkages scheduled in November, as availability of coal remains a concern. "We have started putting some volumes, about 0.5 million tonnes, fr import at this stage. The company is waiting for auctions that are going to happen by November end," he said adding that the company operates three coal mines two in Chhattisgarh and one in Jharkhand. The fourth mine at Dumri (Jharkhand) is under development "Besides coal shortages, furnace oil is his hitting us in terms of input cost," he pointed out. The company's capex for FY19 stands at ₹1,600 crore, of which Pai said about ₹800 crore will go towards maintenance of its facilities. That apart, the company expects its ₹1,300-crore Utkal Alumina project, which includes ramping up of the facility by 0.5 million tonnes to 2 million tonnes per annum, to commission by 2021.

# Mining Events Diary

**04-05 December 2018, "1st International Conference on High Performance Mining - HPM2018".** For further detailed contact: SuperC Conference Center, RWTH Aachen University Templergraben 57, Aachen, 52062, Germany. Ph.+49 241 80 94522, Web: hpm@amt.rwth-aachen.de

**13-16 December 2018, "Mining Turkey 2018".** For further detailed contact: Tüyap Istanbul Fair, Convention and Congress Center, Cumhuriyet Mahallesi, Istanbul, Turkey. Ph.:+90 212 867 11 31

**14-15 December 2018, "International Conference on "Opencast Mining Technology & Sustainability" ICOMS2018.** For further detailed contact: Mr Satish Jha, General Manager (Corporate Planning), NCL. Ph.: 07805-266961, +91 9406711655 email: icoms.ncl@coalindia.in OR Dr. G K Pradhan, Prof. of Mining & Dean, Faculty of Engineering & Technology, AKS University, Satna (M.P.), Cell No.: +91 8120003355 Email: gkpradhan58@gmail.com OR Mr. Bhartendu Kumar, Chief Manager, Nigahi Area, NCL, Ph.: +91 9425176789 Email: bhartendu100@gmail.com OR Mr. Pradeep Kumar, Asst. Manager, Technical Secretariat of CMD, NCL. Ph.: +91 9406965039 Email: pradeep.1090@coalindia.in OR Mr. Himanshu Wadhwani, MT(Mining), Amlohri Area, NCL. Ph.: +91 7828688930 Email: himanshu.wadhwani@coalindia.in

**6-7 March 2019, "Mining Investment Nigeria".** For further detailed contact: Spire Events Pte Ltd. 2019 Mining Investment Nigeria Mahesh Babu, Speaking, registration & general queries, 24 Peck Seah Street#02-09 Nehsons Building, Singapore, Phone: +65 6717 6018, Fax: +65 6717 6015 Email: Mahesh.babu@spire-events.com, Web: https://www.spire-events.com

**7-8 March 2019, "MiningTech Africa."** Venue: Johannesburg, South Africa, For detailed contact: Spire Events Pte Ltd. MiningTech 2019 Africa, Mahesh Babu, 24 Peck Seah Street #02-09Nehsons Building, Singapore, Phone: +65 6717 8500, Fax: +65 6717 6015, Email: mahesh.babu@spire-events.com, Web: https://www.spire-events.com/conferences

**25-26 March 2019, "Future of Mining Australia 2019".** For detailed: Sydney, New South Wales, NSW 2000, Australia, Ph.: +44 (0) 207 216 6071, Web: events@ aspermontmedia.com

**26-28 March 2019, "Mining Investment Asia".** Venue: Marina Bay Sands, Singapore. For further detailed contact: Spire Events PTE Ltd., Tel: +65 6717 6014 I Fax: +65 6717 6015 I Email: chinchye.ng@spire-events.com, www.mininginvestmentasia.com

**8-9 April 2019, "Mining Investment South America."** Venue: Buenos Aires, Argentina. For detailed contact: Spire Events Pte Ltd. 2019 Mining Investment South America, Mahesh Babu, Speaking, registration & general queries, 24 Peck Seah Street#02-09 Nehsons Building, Singapore, Phone: +65 6717 6018, Fax: +65 6717 6015, Email: Mahesh.babu@spire-events.com, Web: https://www.spire-events.com

**10-12 April 2019, "Mongolia Mining 2019 International Mining & Oil Expo - 9th Edition".** Venue: Ulaanbaatar, Mongolia. For detailed contact: Mongolia Mining Expo Organizers, Ulaanbaatar, Mongolia, Phone: +976 11344010, Fax: +976 11343757, Email: info@mongolia-mining.org, Web: http://mongolia-mining.com/contact-us

**15-16 April 2019, "MiningTech South America"** Venue: Santiago, Chile. For further detailed contact: Spire Events MiningTech South America, Mahesh Babu, Speaking, registration & general queries, 24 Peck Seah Street#02-09 Nehsons Building, Singapore, Singapore, Phone: +65 6717 6018, Fax: +65 6717 6015, Email: Mahesh.babu@spire-events.com, Web: https://www.spire-events.com

**15-16 April 2019, "2nd Annual MiningTech South America".** Venue: Crowne Plaza Santiago Hotel, Ave. Libertador Bernardo O'Higgins 136, Santiago, 8331030, Chile. Contact: Ph.: +65 6717 6016, Web:enquiry@spire-events.com

**17-19 April 2018, "Marrakesh Mining Convention 2019".** Venue: Mövenpick Hotel, Boulevard Mohammed VI, Hivernage, Marrakesh, Morocco. Contact: Ph.: +44 (0)208 242 6566, Web: enquiry@marrakeshminingconvention.com

**18-25 May 2019, "ALTA 2019" Nickel-Cobalt-Copper, Uranium-REE-Li and Gold-PM Conference & Exhibition. Venue:** Perth, Australia. For further detailed contact: ALTA Metallurgical Services - ALTA, Allison Taylor, Conference & Exhibition Manager, PO Box 1211, Blackburn North, Australia, Phone: +61 411692442, Email: allisontaylor@altamet.com.au, Web: https://www.altamet.com.au/conferences/alta-2019

**21-22 May 2019, "Mining Investment Botswana".** Venue: Gaborone, Botswana. For detailed contact: Spire Events Pte Ltd. 2019 Mining Investment Botswana, Michael Lim, Speaking, registration & general queries, 24 Peck Seah Street#02-09 Nehsons Building, Singapore, Phone: +65 6717 6018, Fax: +65 6717 6015, Email: Michael.lim@spire-events.com, Web: https://www.spire-events.com

**28-29 May 2019, "Mining Investment West Africa".** Venue: Accra, Ghana. For detailed contact: Spire Events Pte Ltd. 2019 Mining Investment West Africa, Mahesh Babu, Speaking, registration & general queries, 24 Peck Seah Street#02-09 Nehsons Building, Singapore, Phone: +65 6717 6018, Fax: +65 6717 6015, Email: Mahesh.babu@spire-events.com, Web: https://www.spire-events.com

**27-30 May 2019, "EXPONOR Chile 2019".** Venue: Antofagasta Industrial Association Event and Community Activity Ground, Pedro Aguirre Cerda 17101, La Portada Sector, Antofagasta, Chile. Contact: Ph.: +56 55 2454335 Web:exponor@aia.cl

**18-19 June 2019, "Mining Investment Europe"** Venue: Frankfurt, Germany. For further detailed contact: Spire Events Pte Ltd. 2019 Mining Investment Europe, Daniel Radziszewski, Speaking, registration & general queries, 24 Peck Seah Street#02-09 Nehsons Building, Singapore, Phone: +65 6717 6018, Fax: +65 6717 6015, Email: daniel.radz@spire-events.com, Web: https://www.spire-events.com/

**16-20 September 2019, "PRUMIN 2019".** Venue: Institute of Mining Engineers of Peru, Calle Los Canarios 155 - 157 Urb. San César II Stage, La Molina, Peru, LIMA 12, Peru. Contact: Web: perumin@iimp.org.pe

*The Indian Mining & Engineering Journal, Vol. 57, No.12, December 2018, pp.09-16*
*Printed in India, @ IME Publications, ISSN 0019-5944*

# Cost Optimization through Technological Innovation in Blasting - A Case Study at Bailadila Iron Ore Mine (BIOM), Kirandul Complex for Improvement in Powder Factor, Environmental & Safety Standards

A.K. Prajapati* B. Venkateswarlu** Ramveer Singh*** S. Ramteke*** Haldhar Patel***

**ABSTRACT**

***Blasting in mining operation is being carried out from long time back. Today technology has turned blasting what was once an art into a science as conducting blasting in a systematic manner involves a lot of science & technology and play a crucial role in cost optimization as it impacts the efficiency of the entire downstream mining process.The main emphasis in use of technology in blasting is to make best use of explosive energy and there is a huge potential for technological innovations in blast designing to get desired fragmentation, muck profile & throw with controlled ground vibrations, noise, fly rocks, air blast, dust & fumes.***

***This paper is a case study at Bailadila Iron Ore Mine(BIOM), Kirandul Complex, a unit of NMDC Ltd under ministry of steel, Government of India where a lot of innovation has been done in terms of optimizing blast design by using latest technologies such as High-speed video camera, Burden finder, in hole explosive VOD recorder, seismographs and other innovative ways. The paper highlights the marked improvement in powder factor at desired fragmentation, muck pile profile, ground vibrations, reduction in noise & fly rocks etc. The results were meticulously registered in the field and clearly depict improvement in blast performance in terms of powder factor which ultimately resulted into reduction of blasting cost and fulfillingenvironmental parameters & safety standards.***

***Key words: Powder factor, fragmentation, ground vibrations, high speed camera, VOD recorder, Burden finder, seismograph.***

## INTRODUCTION

Bailadila Deposit-14 mine is the first large scale open cast mechanized iron ore mine in India commissioned in April-1968. Presently Bailadila Iron Ore Mine(BIOM) Kirandul Complex consist of Deposi-14, Deposit-11C & Deposit-11B pits. Bailadila is the range of hills in south Baster in Dantewada district in Chhattisgarh, 420 Km south of Raipur. BIOM Kirandul Complex is fully mechanized mine and has the distinction of having unique down-the-hill conveyor system passing through a tunnel to transport iron ore from crushing plant to processing plant.

Being a heavily mechanized open cast mine, deep hole drilling and blasting is used in excavation of iron ore and blasting is one of the important activity as it impacts the efficiency of the entire downstream process.

In blasting performance,Burden, spacing, stemming and sequence of detonation play a vital role for proper relief of the successive burden rock mass and therefore are pre-requisites for the success of any blasting programme. Stemming the upper portion of blast hole which has been packed with inert material such as drill cutting confines and retains the gasses produced due to the explosion inside the blast hole. Confinement and retention promotes the rock fracturing by transmitting a major portion of shock as well as gas pressure through the broken rock mass prior to the release of stemming. Improper confinement results not only in wastage of explosive energy and poor fragmentation, but also creates environmental problems such as air over pressure,noise, fly rocks, dust etc.Over all of this, firing pattern plays a vital role because it decides the movement and direction of rock by creating free face i.e. burden relief for subsequent blast holes / rows.Therefore, the basis of this case study is to optimize all the basic blast design parameters by utilizing the latest technology so as to maximize the utilization of explosive energy which consequently results in optimization of

**G.M (Production), BIOM Kirandul Complex, NMDC Ltd*
***Jt. G.M (Mining), BIOM Kirandul Complex, NMDC Ltd*
****Sr.Manager (Mining), BIOM Kirandul Complex, NMDC Ltd*

powder factor and at the same time results in achieving environmental parameters & safety standards.

**COMMON BLASTING CONCERNS**

Explosives manufactures would prefer to sell the maximum quantity of explosives for a blast, production manager would prefer to buy the least amount of explosives to keep costs as low as possible, while crushing plant manager would like a steady and uniform feed size to maximize the throughput. In addition, environmental and community concerns need to be correctly addressed and monitored at the same time. To keep the balance between all these mining / blasting engineers always fight for ways to balance all these concerns and the best way is measurement. Like if we can't measure something, we can't understand it. If we can't understand it, we can't control it. If we can't control it, we can't improve it. In blasting measurement is usually based around muck pile throw & shape, fragmentation, ground vibrations, fly rocks and the requirement for secondary breakage. Blast designs are altered to improve these parameters. So, measurement, understanding and control is the main basis of this case study at BIOM Kirandul Complex.

Rock mass fragmentations depends on two group of variables; rock mass properties which can't be controlled and drill & blast design parameters that can be controlled. It is very well demonstrated in the figure 1.

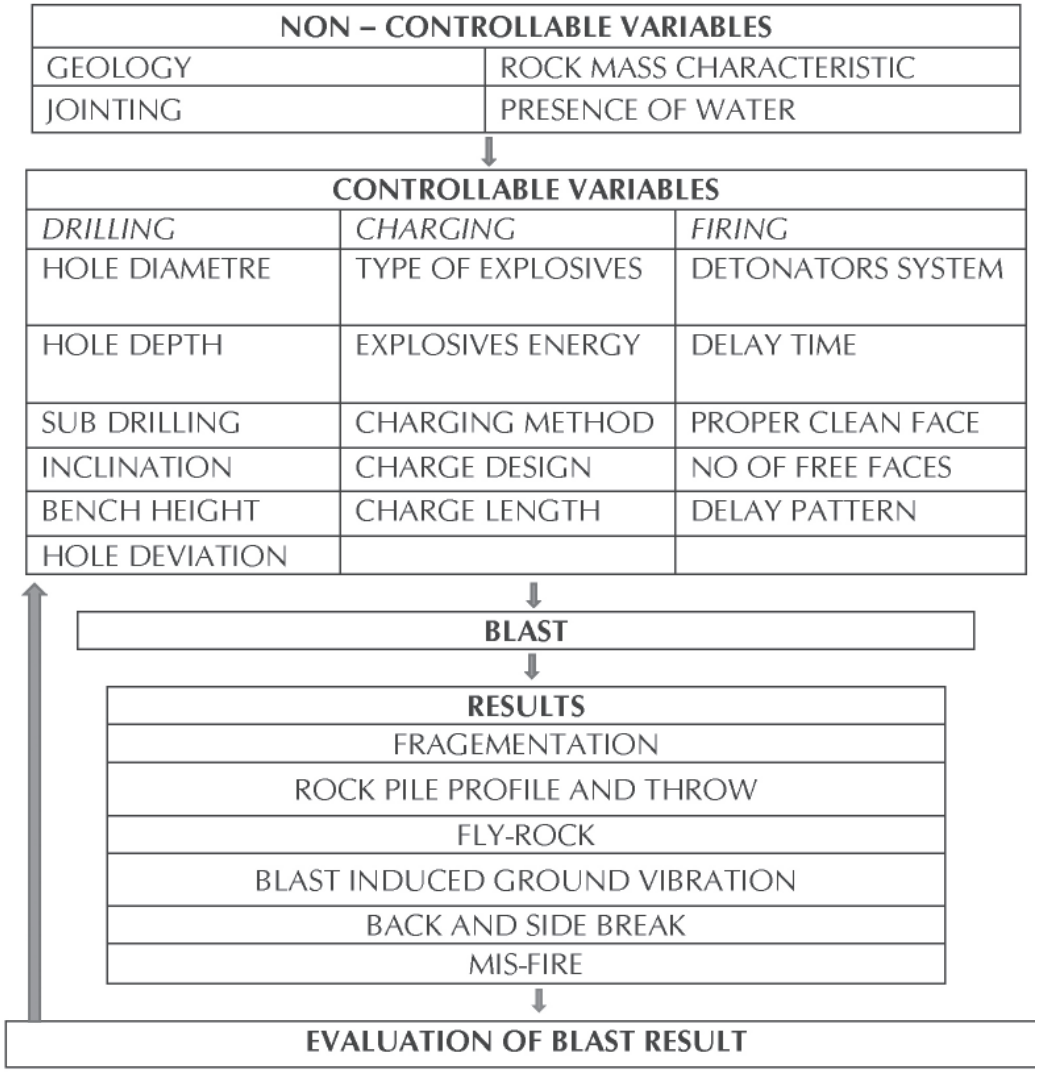


**Fig. 1: Flow diagram illustrating the continuous optimization process**

**BLASTING PRACTICES JOURNEY AT BIOM KIRANDUL COMPLEX**

BIOM has always been eager in adopting latest technological development in blasting arena. Mine production started in 1968 with conventional deep hole drilling & blasting with use of ANFO, slurry cartridges and later switch over to Site Mix Slurry and finally switched to Site Mix Emulsion (SME) in the year 2004-05.

In the same way BIOM Kirandul Complex has successfully adopted changes in firing pattern and delay initiation system. Earlier, it involved use of cord relays and now down-hole delays & trunk line delays with the use of NONEL system is being practiced.

**METHODOLOGY OF CASE STUDY**

The work of blasting section starts from marking of drill points as per predefined burden & spacing parameters according to the hardness of the ore. At the time of charging, each & every block is charged meticulously in the presence of blasting site in-charge who decides subgrade, charge per hole and charge per delay and pattern of firing etc. Every blast is monitored precisely in terms of fragmentation, fly rocks, noise generation, ground vibration, boulder generation, blow out of stemming etc.

**BLAST MONITORING AND ANALYSIS PROCESS**

a) Videography of each blast by using High Speed Video Camera
b) Ground vibration measurement
c) Recording of in hole Velocity of Detonation(VOD) of explosive column.
d) Burden finder to calculate stiffness ratio of bench.

Each and every equipment has its own importance in blast design and preformation evaluation of a blast and after evaluation the results what we get provide a way in designing the subsequent blast and so on till the best meet the needs of the operation.

**High-speed videography of blasts**

To optimize or control blast effects, we need to measure & understand the actual happenings during the blasts and their effects occurs to quickly to be captured with standard video camera. To see what we have been missing- we need to record our blast with high speed video camerafor which BIOM Kirandul Complex is usingTRI-VIT make AOS High-speed video camera to determine the scattering of delay detonators and the nature of the blasted rock movement, blowouts, fly rock trajectory and many more. Based on the analysis of the images/video, causes of variance in actual happening from designed parameters are find out and accordingly subsequent blast design are modified to deliver improved blasting performance.

**Figure 2: Picture showing video recording of blasting**

**Figure 3: Image of Initiation of zero delay**

**Figure 4: Image of Trunk Line Detonators Initiation**

**Figure 5: Image of sequential firing of holes**

**Figure 6: Image of rock movements during blast**

**BENEFITS OF HIGH SPEED VIDEOGRAPHY**

a) Quality check for all sorts of NONELs to ensure scattering of delay detonators
b) To assess the movement of fly rock
c) To know the movement of blasted rock as per designed delay pattern.
d) Analysis of fragmentations.

**Measurement of ground vibrations**

Generally Blasting seismographs are used with intention to establish compliance with regulations to prevent damage to public and private property from blast induced ground vibration and air overpressure. However, in addition to this high value of ground vibrations indicates some error in blast design which means the explosive energy which could have been used for breaking of rock is diverted somewhere else. Therefore, continuous measurement of ground vibrations in one way helps in complying with regulation and in other way it helps in subsequent blast designs to optimise blast design.

**Benefits of measurement of blast induced ground vibrations**

a) A check on explosive energy utilization.
b) A check on damage to structure/ buildings.
c) Compliance to statutory requirements.
d) To improve on blast parameters.

**Recording of velocity of detonation (VOD) of explosive column**

The rate at which the detonation wave travels through an explosive column is called velocity of detonation. It is the most important property of explosive and fragmentation of blasted material depends on its optimum rate. VOD monitoring is carried to confirm detonation, deflagration or failure, to study the influence of primer size on explosive performance and to investigate effectiveness of decking. A decrease in VOD emphasises the detonation pressure drop/release due to change in strata or encounter of cracks in charge length.

Keeping in view importance of VOD, BIOM Kirandul complex has taken step to measure VOD to check quality of explosive in order to evaluate performance of explosive being used in the mine. In this test a special coaxial cable is attached with cast-booster during charging of holes and data of burning rate of this cable during blasting is captured

**Table 1: Showing some recent ground vibrations data**

| Blast Location | Rock Type | No of holes | Ave. Burd.X Specing (m) | Ave. Charge per hole (kg) | Stem. (m) | Total charge (kg) | Location of instrument | App. Dist. (m) | Max. Charge /delay (kg) | Resultant PPV (mm/s) | Frequency (Hz) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1066 MB | BGH +BD | 11 | 5.2 X 5.8 | 321 | 5.0 | 3210 | Dumper Platform 11c | 120 | 720 | 7.19 | 5.1 |
| 1042 MB | BH+ BHQ | 18 | 5.4 X 5.7 | 302 | 4.8 | 5430 | C/P - 11C | 250 | 660 | 10.9 | 2.69 |
| 1030 MB | BD | 24 | 5.9 X 6.4 | 250 | 6.0 | 5980 | C/P - 11C | 100 | 520 | 8.27 | 2.98 |
| 1113 MB | LAT | 22 | 5.2 X 5.7 | 320 | 5.4 | 7010 | Dep-14 Service centre | 110 | 660 | 3.52 | 3.82 |
| 1089 MB | BHQ | 26 | 5.5 X 6.0 | 345 | 5.3 | 8970 | dumper platform 14 | 180 | 670 | 10.9 | 7.32 |

in the VOD recorder attached with this cable. The stored data are shifted in the computer using software and corresponding VOD graph is drawn. Results achieved during study are correlated to the rock environment and subsequent blast design etc. VOD was monitored by Micro trap of MREL Inc., Canada. The VOD monitoring set up is shown in Figure 8.

**Fig. 8: Picture showing lowering of probe cable, stemming & setting VOD recorder for measurement**

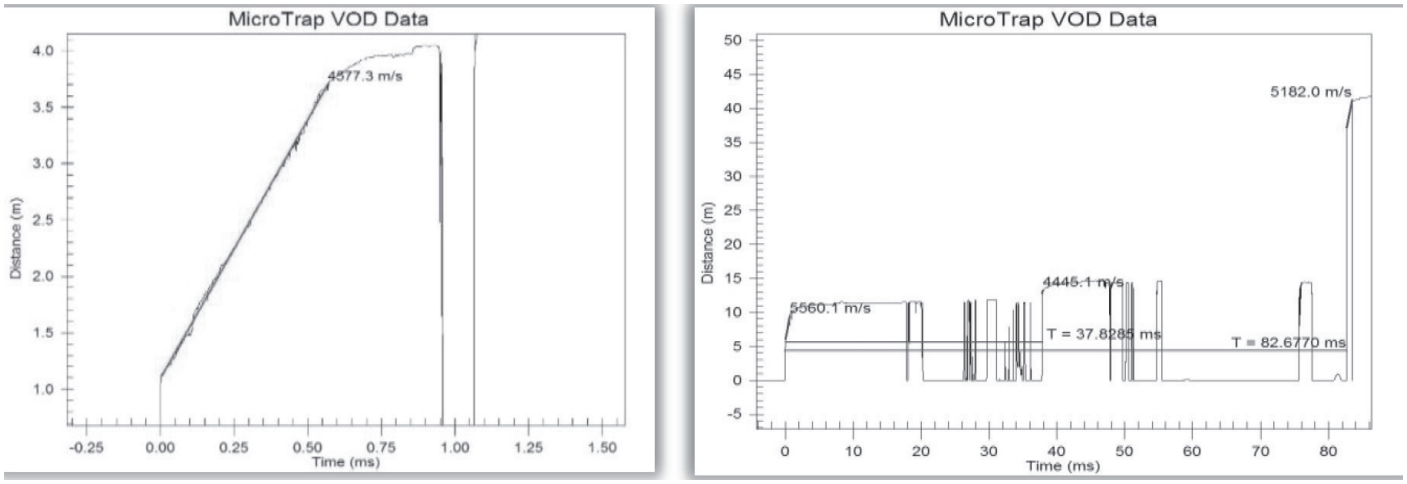


**Fig. 9: VOD Measurement of single hole and Multiple holes**

**Benefits of VOD recording**

a) A strict check on the quality of SME supplied by the supplier as per required technical specifications.
b) To monitor characteristics of explosives in different strata.
c) To evaluate scattering in delay-detonators through VOD measurement of multiple holes.

**Burden stiffness ratio of bench**

Stiffness is the bench height to burden ratio and it has big influence on the resultant fragmentation. Although, the bench height is usually decided on the basis of the working specification of the loading equipment, the bench height should also be adequate to achieve optimal burden, spacing. Generally, stiffness value remains between 2 to 3.5 and stiffness less than 2 gives coarser fragmentation. After this study with the help of instrumentation, we have optimized the stiffness value around 3 with desired average fragmentation size of 250mm.For this purpose, to get real time burden and face height BIOM blasting section uses a very handy laser-based instrument called Burden finder.

| Total Hole Depth = 10.7 | | |
|---|---|---|
| | | |
| Burden Values: | | |
| Depth | Burden | |
| 0 | 2.34 | CREST * MIN |
| 1 | 3.3 | |
| 2 | 3.73 | |
| 3 | 4.48 | |
| 4 | 5.13 | |
| 5 | 5.74 | |
| 6 | 6.36 | |
| 7 | 7.21 | |
| 8 | 8.91 | |
| 9 | 8.93 | |
| 10 | 8.98 | |
| 10.7 | 9 | TOE * MAX |

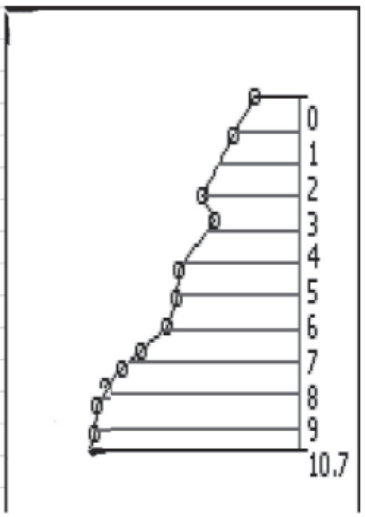


**Fig 10: Measurement of burden stiffness using Burden Finder, Values and Burden Graph**

**Benefits of burden finder**

a) Optimise burden
b) Gives real time burden, horizontal distance& face height calculations
c) Measure inaccessible or dangerous areas safely
d) Direct readings, no external computers required
e) Lightweight and portable
f) No need ofexternal reflective targets (reflector lens etc.).
g) One-person operation
h) Single integrated unit + data collector can be used.

**RESULTS & DISCUSSION**

**Improvement in Powder factor**

Powder factor is the ratio between the amount of rock broken in tonnes per kg of explosive consumed. Higher powder factor causes oversize and lower powder factor results in crushed rock. Optimization of powder factor with desired fragmentation is the main concern for blasting executives and with this moto blasting section of BIOM Kirandul Complex tried to utilise the technological innovation to optimize blast design parameters to maximise the utilization of explosive energy which in turn resulted in improvement in powder factor from 4.16 in the year 2015-16 to 5.45 in the year 2016-17

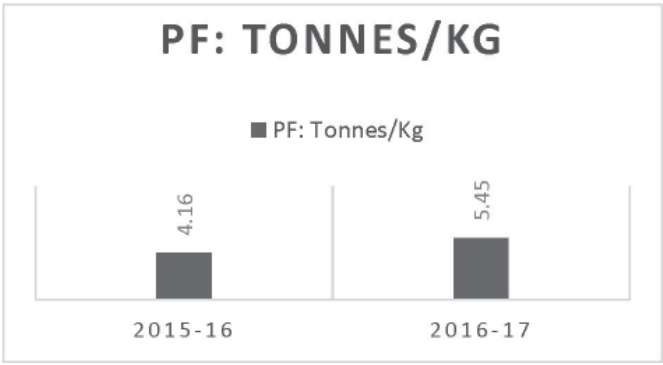


**Fig 11: Improvement in powder factor during study periodas a result of continuous blast design parameters during the study period**

**Reduction in Blasting cost**

Blasting cost per tonne of rock breakage always remains the main concerns for any mining/blasting engineer. At BIOM Kirandul Complex blasting cost per tonne of excavation in the year 2015-16 was ?14.94 which reduced to ?13.08 in the year 2016-17 &?11.33 in the current financial year up to December 2017 with gradual optimization of blast parameters after evaluating each and every blast performance through the use of instrumentations, meticulous planning and charging of each blast.

**Achievement in environmental & safety standards**

Noise generation is very much controlled with the use of NONELs without Detonating fuse during main production

blast and by optimizing the other blast design parameters such as burden, spacing & stemming to control blow out of holes. Blast induced ground vibrations have also been controlled and are within safe prescribed limit by the statute. From environmental & safety point of view dust generation and fly rock generation were monitored within limit like during main bench blast fly rocks rarely go beyond 50 meters and during secondary boulders blasting fly rock remains limited to 150 meters.

## CONCLUSION

In the entire study every blast data was recorded, analysed and evaluated meticulously. Based on previous blast evaluation successive blast were design by varying the influencing parameters of blasting with a view to maximize the use of explosive energy and continuous review of the same. In this process blasting section of BIOM Kirandul Complex has taken a lot of technological support by using different instruments for measurement of different blast parameters and evaluation after blast which played a guiding forced to achieve improvement in powder factor year after year and consequently resulted in to reduction in blasting cost per tonne of iron ore.

However, blasting is a vast subject and continuous learning process where we need to plan and review the blast results continuously for further improvement as measurement, control and improvement is an endless process.

## ACKNOWLEDGEMENT

Authors are sincerely thankful to BIOM Kirandul Complex, NMDC Ltd management for giving kind permission to present and publish this paper. We are especially thankful to blasting & mining department for giving all technical inputs, analysis, guidance and full support in preparation of this paper.

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*The Indian Mining & Engineering Journal, Vol. 57, No.12, December 2018, pp.17-21*
*Printed in India, @ IME Publications, ISSN 0019-5944*

# An Innovative Method of Explosive Energy Distribution for Optimizing Blast Performance – Case Study of an Iron Ore Mine

Vineeth Balakrishnan* Manoj Pradhan* Khanindra Pathak** G.K.Pradhan***

**ABSTRACT**

***Explosive energy utilization for desired level of fragmentation is the key to success of any blasting operation vis-à-vis cost of blasting, and overall mining cost. In order to achieve this goal institutions engaged in blasting studies, explosive manufacturers, and mines have adopted innovative approaches globally. Devising cost effective means to develop explosive use methodologies have been enumerated in this paper. This paper presents an innovative blasting method to reduce the explosive requirement simultaneously improving the fragmentation. Two trials were conducted in an iron ore mine where the explosive consumption could be reduced substantially. The fragmentations achieved were also observed, monitored and it can be concluded that the innovative approach had been quite different from the conventional blasting practices of the mine.***

***Keywords: emulsion explosive, velocity of detonation, air decking, non-explosive air deck material, fragmentation.***

## INTRODUCTION

Blasting is an essential part of the mining cycle. Most of the mines use drilling and blasting for overburden removal. The explosive cost is among the biggest contributors of day to day expenses of any mine. Hence it is necessary to do some cost cutting in this field. Explosives provide energy and the efficient use of this energy is a major factor in keeping the rock blasting costs under control. In India, ANFO, slurry and emulsion are the popular commercial explosives. All these explosives can be used in bulk form. Bulk emulsion explosive is predominantly used in Indian mines and is being used by all major explosive consumers namely; Coal India Limited, NMDC, SAIL, Tata Steel, UltraTech Cement Limestone Mines etc. Emulsion explosives have comparatively high detonation parameters and exceptionally good safety characteristics. The VOD for site mixed emulsion (SME) varies between 4000-5500 (depends upon the diameter of blast hole) hence it produces more shock energy (Pradhan, 2007). Emulsion explosive is extremely insensitive to initiation and hence requires gas bubbles for sensitization.

The conventional blast practices include charging of blast hole with explosive to a two third height so that the boulder formation can be avoided. This increases the consumption of explosive as extra explosive is poured into the hole for column build up. This problem has magnified after the introduction of SME for blasting as the density of SME is about 1.15 g/cc which is higher than that of ANFO and slurry. Hence for the same hole, more quantity of SME is to be poured into the blast hole than ANFO and Slurry. This will not only increase the cost of explosive but also add extra energy which will produce more fine. The environmental issue such as air blast, noise, ground vibration etc. will also increase due to overuse of explosive. Explosive energy distribution could be achieved by using bulk Site Mixed Slurry Explosives, where three different density, energy level explosives can be pumped from the pump truck right at the site of blasting. For several years, this system was adopted at Kudremukh, Mines of Coal India, SCCL, Rajashree Cement Limestone Mines, NALCO's Bauxite Mines at Panchpatmali, NMDC-Bailadila group mines, Rampur-Agucha mines of HZL. This system is currently in use only at HCL:Malanjkhand and some mines of SAIL:Barbil region by SMS Explosives manufactured and delivered by IndianOil. Use of SMS Explosive is gradually replaced by SME owing to its numerous operational difficulties.

The above-mentioned problem (scientifically known as *'explosive energy distribution'*) is one of the main reasons for higher blasting cost as well as wastage of explosive energy in excessive crushing of the blasted material. Several experiments and researches have been done on this topic and few improvements such as decking are commonly used in mines. Pradhan(2018) had introduced and successfully executed the cost effective and eco-friendly concept of

**Department of Mining Engineering, National Institute of Technology, Raipur 492010, India*
***Department of Mining Engineering, Indian Institute of Technology, Kharagpur721302, India*
****Prof. of Mining Engineering & Dean, Faculty of Engineering & Technology, AKS University, Satna (MP)*
*Corresponding Author: gkpradhan58@gmail.com*

explosive energy distribution by using empty plastic bottles in the blast hole (both in explosive column and in stemming region) in many Indian Limestone, Copper, Bauxite, Iron Ore and Coal Mines.

This paper presents an innovative method of rock blasting in which hollow spherical air gaps are poured in the explosive column while charging. Two blasts were conducted in an iron ore mine and the results of these blasts were also discussed.

## POPULARLY KNOWN APPROACHES DEVELOPED FOR EXPLOSIVE CONSUMPTION REDUCTION

### Decking

Decking is mainly of two types namely solid decking and air decking. In this method a deck of drill cuttings (solid deck) or wooden spacers (air deck) are provided in between the explosive column for reducing the explosive consumption (Figure 1).

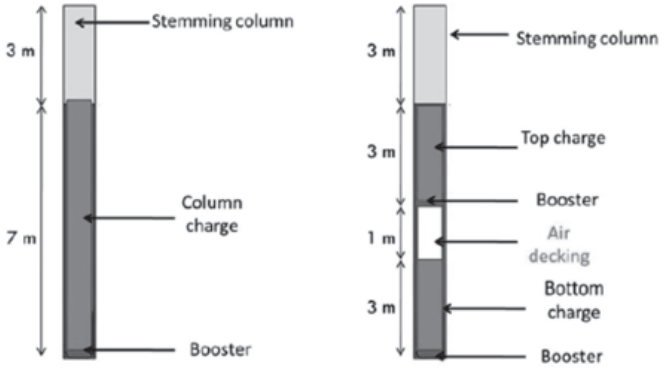


**Figure 1: (a) Blast hole charged without decking; (b) blast hole charged with an air deck in middle portion of the explosive column**

The conventional deck blasting method suffers from various disadvantages such as; the method is time-consuming as charging must be stopped for inserting deck and this makes the process labour intensive too. The dual initiation required for initiating both parts of explosive column increases cost of blasting. More over this method makes the column inconsistent and boulders may be resulted from the region where deck is introduced. Some of the Indian limestone mines have attempted to provide deckling by using wooden spacers, hollow plastic pipes, bamboo baskets etc.

### Plastic bottles

Discarded plastic bottles generated in billions of numbers, had been a source of several environmental problems in India. To effectively destroy them in blasting, these bottles were used following the concept of 'air-deck'. Although chemically activated gas bags are in use, their high cost, need for skill/precision in lowering inside the blast hole and effectiveness to use in water holes had diminished its use.

Pradhan et el (2007) introduced this for the first time at the Bandhuranga Uranium Mines of UCIL, with bulk emulsion explosives. Later it was adopted on regular basis at Dunguri Limestone Mines of ACC:Bargarh, Joda East Iron Mines of Tata Steel, and several other mines. (Pradhan et al, 2013). Discarded plastic water bottles are used to introduce air gaps in the explosive column. The plastic bottles were inserted manually in the explosive column while charging to save explosive. The bottles were inserted in a constant pace so that uniformity of the air gaps in the explosive column can be maintained. Use of discarded water bottle in blasting was found to be an effective technique in reducing explosive consumption. It was found that the total explosive cost was reduced by 7-16% when discarded water bottles were used as air gaps in between the explosive column (Pradhan et al, 2015). Figure 2, shows the cross section of the blast hole charged with plastic bottles as air gaps.

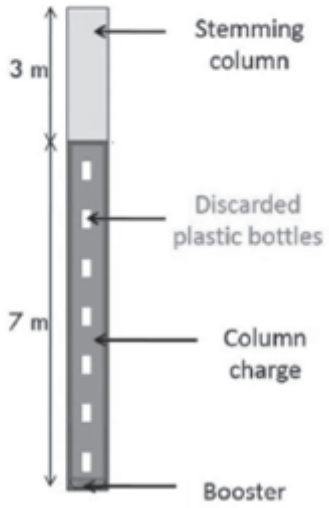


**Figure 2: Cross-section of blast hole when charged with plastic bottles in the explosive column**

## DISTRIBUTED SPHERICAL AIR GAP (DAG) BLASTING

The disadvantages of above mentioned methods created a research gap. This is an innovative method which was

conceptualized by the authors for overcoming the demerits of other known methods of explosive consumption reduction. In this method, small hollow plastic balls, which are locally available in the market, were poured into the blast hole along with explosive in such a way that these balls get uniformly distributed throughout the explosive column.

Figure 3 shows the cross section of the borehole when charged using DAG in charge column (Balakrishnan, 2017). Experiments were carried out in an iron ore mine of Singhbhum region. For experimental purpose, the face was divided into two parts; one charged using the general practice of the mine and other using the innovative DAG technique. The results from two halves were then compared. The lower formation of the mine was of shale-phyllite and tuff (Lower Shale) and an upper formation was of shale, chert, and tuff (Upper Shale) between which is sandwiched a thick banded hematite jasper (BHJ) formation. Vast deposits of iron ore formed in these two hill ranges in association shale and quartzite. The dip of the ore body varies from 22° - 28° and dips towards west. The thickness of the iron ore deposit is about 100m. The iron ore of this area is mainly hematite in nature with a minor quantity of goethite, siderite, specularite and limonite - the basement rock being Banded Jasper Quartzite. The ores are intercalated with chert and shale. Often the cherty bands are replaced by hematite to give high-grade ore. Iron ore deposits overlying the BHJ are mainly the product of supergene alteration and exploration and exploitation continues up to the BHJ zone. Thus the ores are confined only to the top portion. The ores are laterised to varying degree by the action of weathering and percolating into the iron ores through cracks and cavities. The specific gravity of rock varied from 4.5-5.5m.

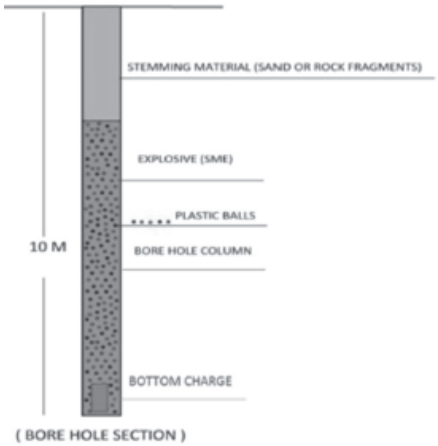


**Figure 3: Cross section of blast hole for DAG blasting**

Figure 4 shows the snapshots of the face and the scaled digital photograph used for fragmentation analysis.

**Figure 4: Snapshots of face and fragmentation of the second trial blast in iron ore mine**

The first blast consists of total 72 holes divided in three rows, comprised of and 8 holes in the first row, 31 holes in the second row and 33 holes drilled in third row. The hole depth ranges from 10 m to 13 m and hole diameter was 165 mm. The holes were drilled in staggered pattern. 36 holes were charged with air gaps and 36 holes were charged without air gaps. The average spacing was about 4.8 m and the average burden was about 3.8m.

The second blast consists of total 61 holes divided in three rows, comprised of and 23 holes in the first row, 21 holes in the second row and 17 holes drilled in third row. The hole depth ranges from 10 m to 13 m and hole diameter was 165 mm. The holes were drilled in staggered pattern. The average spacing was about 5.0 m and the average burden was about 3.8 m. 30 holes were charged with air gaps and 31 holes were charged without air gaps.

## RESULT AND DISCUSSION

The results of two trial blasts are summarized below:

**Table 1 : 1st Trail Blast – explosive consumption & PF achieved**

| Sl. No. | Parameters | Normal Blasting | DAG Blasting |
|---|---|---|---|
| 1. | Bulk SME Qty. used (in kgs) | 5760 | 4860 |
| 2. | Total No. of holes | 36 | 36 |
| 3. | Qty. of Booster (in kgs) | 27 | 13.5 |
| 4. | Average charge/hole (kgs) | 160 | 135 |
| 5. | Powder Factor ($m^3$/kg) | 1.71 | 2.02 |

**Table 2 : 2nd Trail Blast – explosive consumption & PF achieved**

| Sl. No. | Parameters | Normal Blasting | DAG Blasting |
|---|---|---|---|
| 1. | Bulk SME Qty. used (in kgs) | 5425 | 4350 |
| 2. | Total No. of holes | 31 | 30 |
| 3. | Qty. of Booster (in kgs) | 23.25 | 11.25 |
| 4. | Average charge/hole (kgs) | 175 | 145 |
| 5. | Powder Factor ($m^3$/kg) | 1.69 | 2.04 |

**Powder factor**

Powder factor is an important parameter which is used to analyse the blast performance. It indicates the explosive consumption of the blast which is associated with mine economy. Table 1 and Table 2 summarises the explosive consumption reduction for first and second trial blasts respectively. Due to decrease in explosive consumption of the part where DAG blasting was used, the powder factor of first blast has improved to 2.02 $m^3$/ kg from 1.71 $m^3$/ kg and for second blast it was improved to 2.04 $m^3$/kg from 1.69 $m^3$/kg.

**Resulted fragmentation**

The sole objective of the blasting is to break the rock into desired fragments. Detailed fragmentation analyses were performed using Wipfrag 3.1.13.0 software for each trial blast. This software is used for digital image analysis of blasted fragments for finding size distribution. As the faces were divided into two parts; one charged using the conventional practice of the mine and other using the innovative DAG technique; for both parts scaled digital photographs were taken after the blast. The fragmentation achieved in these halves were then compared with each other. Figure 5 and Figure 6 shows the comparison of size distribution in both the parts for first and second trial blast respectively. It is evident from the graph that the portion charged using DAG blasting technique is resulting a steeper curve and indicates significant reduction in fine generation and boulder formation.

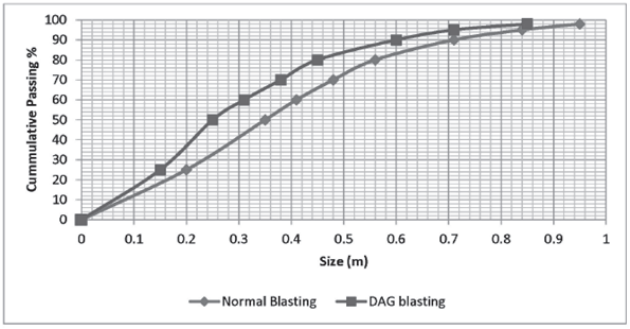


**Figure 5: Comparison of fragmentation for first trial blast**

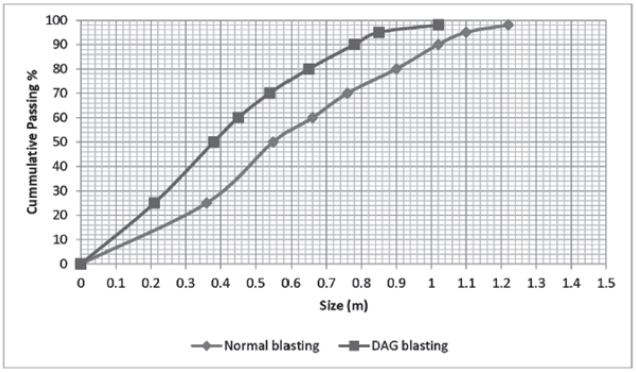


**Figure 6: Comparison of fragmentation for second trial blast**

**Cost reduction**

The total cost of blasting considering the various cost of blasting for the DAG and normal blasting are compared keeping all the other costs same for both cases and only variations due to change in explosive consumption and cost of air gaps introduced were considered. It is assumed that in the experimental blast labour cost was also same. No indirect benefits of the technique are considered for calculating cost benefits. The average cost reduction due to introduction of spherical air gaps are summarized in Table 3.

| Trial Blast | Average cost reduction |
|---|---|
| Trial blast conducted in Iron Ore Mines - I | 12.08 % |
| Trial blast conducted in Iron Ore Mines - II | 13.33 % |

**CONCLUSION**

Explosive energy distribution in the blast holes, continues to be an area of continual research and field application assignment. While some manufacturers are working for reducing explosive density in the bulk SME, it has not yet found commercial adoption. DAG blasting system is one such innovative methods currently being tested, to achieve improved fragmentation. The R-R plot of DAG blasting is steeper than for normal blasting which infers that most of the fragments are in between a narrower size range. For DAG blasting the particles between 0.1 to 0.8 m size ranges are more when compares to the general practice of the mine. This also indicates a better muck pile profile for DAG blasting.

These experiments show that the innovative DAG method is an economic method of blasting which gives better results when compared to the conventional blasting. There was significant saving in explosive consumption with similar or better fragmentation. However more trials can be conducted and semi mechanical or mechanical charging methods can be developed for further optimisation.

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*The Indian Mining & Engineering Journal, Vol. 57, No.12, December 2018, pp.22-30*
*Printed in India, @ IME Publications, ISSN 0019-5944*

# Sustainable Development in Dalmiapuram Limestone Mines

V. Karthikeyan* R.Kamaraj**

**ABSTRACT**

***The extraction of Mineral Reserve has always resulted in varying degrees of environmental resource degradation and social impacts including displacement, all across the globe. The Indian mining Sector has been facing severe criticism on several issues relating to its performance vis-à-vis sustainable development. A working definition for Sustainable development in mining sector was outlined based on consultation with experts all across the country. Accordingly "Mining is financially viable; socially responsible; environmentally, technically and scientifically sound; with a long term view of development; uses of mineral resources optimally and ensures sustainable post closure land uses. Also one Based on creating long term, genuine, mutually beneficial partnership between government, communities and miners based on integrity, cooperation and transparency". Based on the above context, this paper throws light on the following sustainable development measures adopted in Limestone Mines of Dalmia Cement (B) Limited in Tamilnadu***

- ***Conservation of minerals***
- ***Eco-Friendly Mining with Hydraulic Rock Breakers***
- ***CSR activities around Mining area***
- ***Quarry Rehabilitation***
- ***Integration of Environment & social Impact assessment in the decision making process***

## INTRODUCTION

Historically, the extraction of Mineral Reserve has always resulted in varying degrees of environmental resource degradation and social impacts including displacement, all across the globe. Whilst acknowledging that no mining can be entirely free of all negative impacts, there is sufficient ground to suggest that all-round performance on this subject in the mining sector needs to be substantially improved in the country. The Hoda committee, in their review of the National Mineral Policy 1993, recommended that apart from introducing the best practices in implementation of Environment Management, there is also a need to take into account the Global Trends in sustainable Development. The High Level Committee specifically studied the impact of mineral development with the need to develop principles in mining, best practices and reporting standards which may be measured objectively.

## SUSTAINABLE DEVELOPMENT IN MINING: A WORKING DEFINITION

Mining is financially viable; socially responsible; environmentally, technically and scientifically sound; with a long term view of development; uses of mineral resources optimally and ensures sustainable post closure land uses. Also one Based on creating long term, genuine, mutually beneficial partnership between government, communities and miners based on integrity, cooperation and transparency*".*

- **Socially Responsible –** Mining Operation that have a broad based social license to operate –creating lasting social & economic wealth which will outlast the life of the mine.
- **Environmentally, Technically & Scientifically Sound –** Implying Proper management of natural resources
- **Long term view of Development –** As opposed to short operational point of view
- **Uses Mineral Resources Optimally –** Conservation & systematic development of minerals

Mining can become more environmentally sustainable by developing and integrating practices that reduce the environmental impact of mining operations. These practices include measures such as reducing water and energy consumption, minimizing land disturbance and waste production, preventing soil, water, and air pollution at mine sites, and conducting successful mine closure and reclamation activities.

## PRINCIPLES OF SUSTAINABLE DEVELOPMENT

Although a number of variations exist, Sustainable development is most commonly defined as development

**Asst. Executive Director, Dalmia Cement (B) Ltd, Chennai*
***Asst. Manager (Mines), Dalmia cement (B) Ltd, Dalmiapuram*

that meets the needs of the present without compromising the ability of future generations to meet their own needs. The principles of sustainable development involve

- Integrating economic activity with environmental integrity
- social concerns
- Effective government systems.

These principles have had a growing influence on the development of environmental and social policy in recent decades, and have been adopted and promoted by a number of international organizations.

## SUSTAINABLE MINING IN DALMIA CEMENT (B) LIMITED, DALMIAPURAM UNIT – A CASE STUDY

M/s.Dalmia Cement (Bharat) Limited (DCBL), one of the leading cement manufacturing companies in India operating its cement plants at Tamilnadu, Andhra Pradesh, Orissa& North East. In Tamilnadu, two plants are located at Trichy and Ariyalur districts. The production capacity of each plant is 2.4 million and 2.0 million tonnes per annum respectively. The raw material requirements of these plants are accomplished from its captive mines operating at various locations in Trichy and Ariyalur districts.

## LIMESTONE MINES OF DCBL IN TAMILNADU

In order to cater the Limestone requirement for the Cement plant located in Dalmiapuram & Ariyalur we are operating 4 Limestone Mines. The General Informaion about the mines are gives as follows

| Name of the mine | Kallakudi Limestone Mines (KLK) | Kovandakurichi Limestone Mines (KVK) | Periyanagalur Group of Limestone mines (PAK) | Periyathirukonam Limestone Mines (PTK) |
|---|---|---|---|---|
| Lease Hold Area | 116.45 Ha | 81.845 Ha | 167.605 Ha | 61.365 Ha |
| Distance from DPM (One way) | 3 Km | 3 Km | 40 Km | 35 Km |
| Terminology | Local mines | | Remote mines | |

## SUSTAINABILITY DEVELOPMENT –MANAGEMENT COMMITMENT

The Management of DCBL is committed towards the sustainability development. Being a Member company of Cement sustainability Initiative, a part of World Business Council for sustainability Development (WBCSD), DCBL group is committed towards the following initiatives

- $CO_2$& Climate Protection
- Fuels & Raw Materials
- Employee Health & Safety
- Emissions Reduction
- Local Impacts & Biodiversity

The Key performance indicators in each of the Initiatives are given in the following table

| $CO_2$& Climate Protection | Fuels & Raw Materials | Employee Health & Safety | Emissions Reduction | Local Impacts & Biodiversity |
|---|---|---|---|---|
| Total $CO_2$ Emission (Gross & Net) | Sp. Heat Consumption | No. of Fatalities | Absolute & Specific emissions for all pollutants mentioned in emission guidelines | % of sites with Quarry rehabilitation plans in place |
| Specific $CO_2$ Emission (Gross & Net) | Alternative Fuel Rate (%) | No.of Lost Time Injuries | Coverage Rate - % clinker produced with monitoring of all pollutants | % of sites with community engagement plans in place |
| | Biomass Fuel Rate (%) | Total No. of Lost Time Injuries | | No.of Quarries within/adjacent to High Biodiversity value |
| | Alternative Raw Materials Rate (%) | Lost Time Injuries per 1 million manhours | | % of Quarries with high biodiversity values where biodiversity Management plans are implemented |
| | Clinker/Cement Ratio (%) | | | |

## SUSTAINABILITY INITIATIVE AT MINES

In Line with top management commitment, various sustainability initiatives were taken and implemented. Some of the breakthrough initiativesare as follows

1. Mineral Conservation through Utilization of High Ferruginous Limestone
2. Quarry rehabilitation through Backfilling of Mined out area
3. Eco-Friendly mining with the help of Hydraulic Rock Breakers
4. Social Responsibilities
5. Environment Management & Impact evaluation

## MINERAL CONSERVATION – UTILIZATION OF HIGH FERRUGINOUS LIMESTONE

Among the four Limestone Mines, the two Mines located in Ariyalur district contain high ferruginous limestone having iron content more than 6% which cannot be directly used for manufacturing cement. Hence this limestone is treated as non-usable mineral and will be stacked separately.
With the advent of computers in Mining industry lead to development of a Mining Software Package named Computer Aided Deposit Evaluation (CADE) & Quarry

Scheduling Optimization (QSO) being used in our mines. The objectives of CADE Model are

- Quality control at Mines
- Raw Mix Design
- Increasing the Mine Life.

QSO expert is a interactive, graphic oriented program for materials blending, Production scheduling & quarry planning tasks. It combines Linear Programming production with search & heuristic techniques of artificial intelligence.

With the help of the Software packages, the blending of High ferruginous Limestone from remote mines with Low ferruginous Limestone at Local Mines in certain ratio to meet the plant raw mix requirement made possible.

**Block Model Showing the Chemistry of Each Blocks Level wise**

| Year | High Fe Limestone consumed, in MT | | | Overall % |
|---|---|---|---|---|
| | PNR | PTK | TOTAL | |
| 2011-12 | 226889 | 0 | 226889 | 13% |
| 2012-13 | 225744 | 0 | 225744 | 13% |
| 2013-14 | 145196 | 241659 | 386855 | 14% |

**BENEFITS**

1. The Mineral Limestone, having been became scarce mineral, the available limestone though it was a low grade reject mineral, is put to better utilization results in Mineral Conservation
2. The Life Span of the Cement Plant gets enhanced
3. The Government earns royalty equivalent to limestone during consumption which may otherwise lays as the reject in dump yard of mines
4. Helps in Waste dump management, as major quantity will be mined and supplied directly

View of High Ferruginous Limestone Dump at PNR Mines

**Exploration & Block Model Development Using CADE**

In order to have complete knowledge about the Limestone Deposit in DPM Mines Exploratory Bore holes were drilled as per the Guidelines of UNFC.

The details about the boreholes are given as follows

| Description | DPM Mines | | | |
|---|---|---|---|---|
| | KLK | KVK | PAK | PTK |
| Extent Covered | 100% of ML area | | | |
| Grid | 200 X 200 M | | | |
| No. of Bore Holes Drilled | 86 | 58 | 177 | 50 |
| Total Meterage Drilled | 2967 m | 2501 m | 5692 m | 1552 m |
| Adequacy | Adequate. Drilled Upto the Basement rock. Also Proposed to go for Reassessment from Existing Floor Level | | | |

**BLOCK MODEL DEVELOPMENT USING CADE**

- Mine Planning & Reserve optimization carried out through CADE & QSO Software package
- Bore Hole data (200X200 m) is incorporated in the CADE model.
- Radical wise level wise quality of every 40 m X 40 m block is available.
- Long term Planning carried out (5 years) for better utilization of reserves & enhancing mines life.
- Short term planning (6 monthly plans) carried out to maintain the optimum Raw Mix Design with due consideration of all mine working parameters.
- Daily planning is carried out to meet the raw mix parameters.

**Salient Features of CADE Package**

- It can give the chemistry of each block of size 40 m × 40 m level wise.
- Whole deposit can be seen radical wise with 3D sectional views of the deposit.
- Topographic view of the deposit can be seen.
- Maximization of Limestone Reserves at Various parameters
- Cost factor can also be included

**Process Up gradation in the Cement Manufacturing Process**

With the advent of Technology in the Cement Manufacturing process, Fuel Mix used in Kin &Optimization of Process parameters, the raw mix design required for manufacturing cement also varies which facilitates in consuming the Limestone which was treated as reject previously. This helps mining industry greater extent in the Mineral conservation point of view.

The Raw mix parameters used in the Cement manufacturing process are as follows

| Parameters | Range |
|---|---|
| CaO | 42.0 – 43.0 |
| $SiO_2$ | 13.0 – 13.5 |
| $Al_2O_3$ | 3.30 – 3.40 |
| $Fe_2O_3$ | 3.40 – 3.60 |
| $SO_3$ | < 0.05 |
| Lime Saturation Factor (LSF) | 0.99 – 1.02 |
| Silica Modulus (SM) | 1.85 – 1.90 |
| Alumina Modulus (AM) | 0.90 – 0.95 |

**QUARRY REHABILITATION – BACKFILLING OF MINES OUT AREA**

In our Periathirukonam Limestone mines, the top layer consists of Black Cotton coil which needs to be handled as overburden in order to win the rich limestone deposit lying below the Overburden. This Black cotton soil serves as backfilling material after completely removing the usable grade & High ferruginous grade Limestone. So far 21.74 ha were reclaimed and afforestation developed in Periyathirukonam Mines. The details of reclamation done in the past three years are as follows.

| Year | OB Qty Handled, in Cu.m | Area Backfilled, in Ha |
|---|---|---|
| 2011-12 | 324820 | 1.32 |
| 2012-13 | 124579 | 1.84 |
| 2013-14 | 492695 | 5.30 |

View of OB Backfilling & Afforestation in Backfilled area - PTK Mines

**ECO – FRIENDLY MINING AT LOCAL MINES WITH HYDRAULIC ROCK BREAKER**

In Kallakudi & Kovandakurichi Limestone Mines, Conventional Method of Mining with Drilling & Blasting cannot be adopted due to nearby location of National Highways, Villages, Archeologically important church etc. In Order to win the Limestone Deposit, non-conventional method of mining with the help of Hydraulic Rock breakers was adopted since 2000. The Major advantages of Mining with Non-conventional Method of mining is as follows

- Locked-up reserves can be mined easily
- Sump-deepening an easy affair
- Digging of foundation pits adjoining the kiln / valuable structures
- More environmental friendly working & maintaining better social relationship with villagers
- Effective working in area nearby highways, habitants compared to conventional working methods
- Selective mining is possible

View of Rock Breaker working at KVK & KLK Mines

**SOCIAL RESPONSIBILITY**

Due to the existing mines, there is a positive impact by way of employment, education, better socioeconomic conditions, improved local and regional economy, etc.
Tamil Medium State Board Higher Secondary School, English Medium Matriculation School and a Industrial Training Institute are available in Dalmiapuram to cater the need of the **Education** to employee's children and the other villagers children living in and around the factory and mines. Scholarship facilities for employee's children, as well as the school toppers are given for pursuing Higher education.

Medical Camps, treatments including supply of specialist cares, medicines, etc. are being extended to the employees as well as local public living in and around he mines and factory a free of cost. For the welfare of children of the employees and villagers living around mines and factory, vaccination camps are regularly organized at DC(B)L dispensary.

Bore wells (for Drinking Water Supply) are dug in the nearby villages in and around the mines at company's cost to cater to the need of the villagers.

The lakes in the in around villages are desilted/deepened with mine machineries regularly every year just before the onset monsoon season in order to accumulate and store the rain water in the lakes for agricultural activities.

For the villages in around the mines and factory, permanent roads laying works are taken from time to time by the company. Bridges are also constructed at critical points wherever need arises.

The standard of living of the villagers has drastically improved as most of them are employed in the factory and in the mines. Most of the employees who are presently employed in mines and factory are the third generation in the family working for the factory and mines continuously. Thus they are able to improve their quality of life.

Indirect employment opportunities are created for the local people living in and around the mines area motivating them by giving suitable contractual jobs like transportation of limestone from mines to factory, afforestation work at mines etc.

Company is tasking utmost interest in renovating the existing temples in around the mines area and factory at company's cost enabling the villagers to celebrate their temple functions every year in a grand manner. The management grants donations to various temples for *View of CSR activities around Dalmiapuram*

conducting scheduled annual poojas.

*View of CSR activities around Dalmiapuram*

The Total expenditure for CSR activities is furnished below.

| Programme | Year | Amount Spent, in Rs. | Total Amount, in Rs. |
|---|---|---|---|
| Livelihood Training & Support | 2009 – 10 | 6,52,750 | 63,18,250 |
| | 2010 – 11 | 13,27,000 | |
| | 2011 – 12 | 18,42,500 | |
| | 2012 – 13 | 24,96,000 | |
| Education | 2009 – 10 | 1,66,000 | 10,03,600 |
| | 2010 – 11 | 1,96,000 | |
| | 2011 – 12 | 3,24,000 | |
| | 2012 – 13 | 3,17,600 | |
| Health & Sanitation | 2009 – 10 | 512500 | 33,32,050 |
| | 2010 – 11 | 442000 | |
| | 2011 – 12 | 928800 | |
| | 2012 – 13 | 1448750 | |
| Infrastructure | 2009 – 10 | 6156666 | 99,97,666 |
| | 2010 – 11 | 516000 | |
| | 2011 – 12 | 1850000 | |
| | 2012 – 13 | 1475000 | |
| TOTAL | | | 2,06,51,566 |

**ENVIRONMENT MANAGEMENT**

Environmental Management Plans are suggested to mitigate the possible negative impacts that maybe caused to the various attributes of environment due to the proposed mining operations.

**Dust Suppression Arrangements Loading & Transportation**

- Haul Road Dust suppression is carried out by spraying water using water tanker having capacity of 12KL. Water spraying will be carried out every day from morning 6AM onwards.
- All the Limestone Transport vehicles are covered with tarpaulin before leaving the mine premises.

**CRUSHING SITE**

- There is a separate arrangement to water spray when the trucks unload the material on to the crusher point.
- In addition Bag House provided at crusher to collect the dust generated during crushing.

**GENERAL LAYOUT**

- Fugitive emission in the mines is suppressed by sprinkling water on haul roads with the help of mobile water tanker with sprinkling arrangement.
- All vehicles carrying limestone material is being covered by tarpaulin.
- Green belt has been developed all along the mining lease area To prevent the fly dust more no of trees are planted, all along the lease boundaries and along the haul road.

View of Water Sprinkling & Tarpaulin Covering Activity to control Fugitive dust Emission

**NOISE AND VIBRATION**

- Planting of trees with thick foliage along roads and around the lease boundary to act as acoustic barriers.
- Proper maintenance of compressor, drilling machine, loader and tippers trucks.
- Blasting noise can be minimized by using optimum burden, charge and milli second delay detonators.
- The explosive energy should be used for rock breakage than wasting on noise generation and making rock fines.
- Regular preventive maintenance of machineries and transport vehicles.
- Provision of the silencers to modulate the noise generated by the machines.
- Provisions of ear muffs / ear plugs to Mine Workers.

**STEPS TAKEN TO CONTROL NOISE LEVEL AT MINES & NEIGHBOURHOOD**

In our mines noise is generated due to the following process:

a. Rock Breaking &
b. Loading

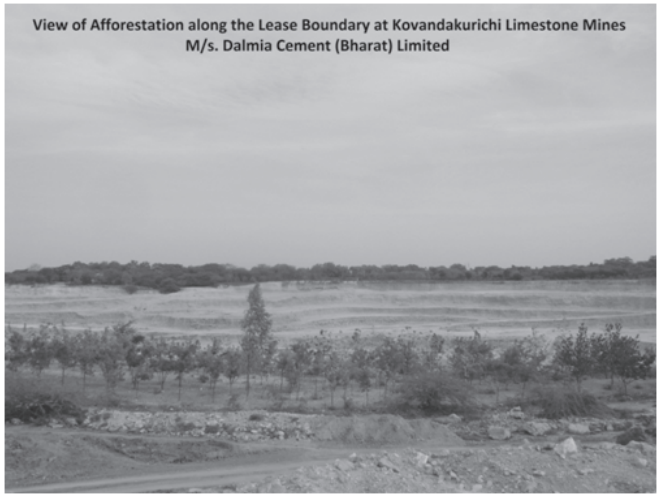
Noise level monitoring carried out once in every three month by external agency Ensyscon, Chennai. In addition noise level monitoring at 5 to 10 m interval and their operator cabin for major mining equipments like Rock Breakers and Loading Equipments were carried out internally by our department once in every six months and the results are reported and recorded.

- ❖ Better mining and operational practices, good preventive maintenance schedules for mining equipments and green belt development all along the lease boundary.
- ❖ Planting of trees would be confirming to the guidelines for noise abatement.
- ❖ A study was conducted at different locations in the mines and data were collected.
- ❖ The data reveals that the values are well within the limits prescribed by DGMS for mine working vide DGMS circular no. 18(tech) of 1975.

**STEPS TAKEN TO CONTROL VIBRATION LEVEL AT MINES**

Since in KLK & KVK Mines, Mining is carried out with Rock Breakers, vibration survey is not applicable.However in Rock breakers, the operator cabins are specially designed for breaker application and mounted on viscous mounting pads to arrest the vibration transferred to the operator.

In Case of PNR & PTK Mines, Mining is carried out by Drilling & Blasting. Regular Vibration monitoring with Vibrograph – Minimate is carried out. Minimate helps to study the Vibration levels & peak particle Velocity generated. However the study shows that the level well within the limits stipulated.




**Ground Water**

- ➢ Provision of garland drain to regulate and drain the rain water from the mining areas.
- ➢ Providing sufficient check dams to check silt flowing along with the surface run off.
- ➢ Provision of retention walls at the foot of the existing dumps. These will help in arresting loose particulars getting carried away.

**Land Afforestation**

- ➢ The land is to be reclaimed and restore to the original ecological condition to the possible extent by adopting:
- ➢ Refilling of the mined out areas
- ➢ Green belt and afforestation
- ➢ Reclamation of dumped areas.
- ➢ The rest Pit Area will left as reservoir and used for pisiculture. Local Women Self Help Groups/Panchayat may be permitted to maintain and enjoy the benefits.

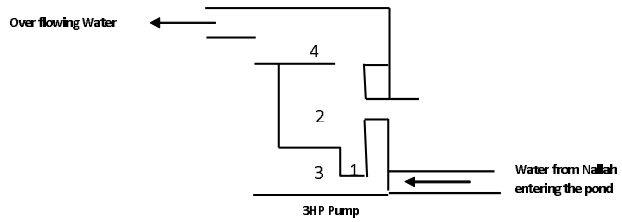
| Year | Afforestation Details |
|---|---|
| Upto 2003 | 34839 |
| 2004 | 2460 |
| 2005 | 4000 |
| 2006 | 6600 |
| 2007 | 6100 |
| 2008 | 6250 |
| 2009 | 6350 |
| 2010 | 13300 |
| 2011 | 11000 |
| 2012 | 4100 |
| **Total** | **94999** |

**RAIN WATER HARVESTING PROGRAMME AT MINES**

A seasonal nallah flows adjoining pit no.4 of KVK Mines and it passes through our afforestation area. During rains there is heavy flow of water in this nallah. Earlier the entire rainwater will flow through this nallah as run-off and there was no provision to preserve this run-off water. Further, the excess water collected in the sump of pit no.4 was also pumped out into the same nallah. Hence, we thought of preserving this rainwater by forming a pond on the downstream side of the nallah.

The Pond was designed in such a way that it has four storage areas. The design of the rainwater-harvesting pond is depicted below. The numbers indicated in the diagram is four different storage areas.

From the diagram it may be noticed, the rainwater from the nallah enters the storage area 1 and the overflow from storage area 1 goes to storage area 2 and the overflow from the storage area 2 goes to storage area 3 and similarly storage area 4 also gets filled. Finally, excess rainwater flows back to the nallah after the storage area 4.




Layout of Rain water harvesting area at KVK Mines

***Details about the Catchment Area***

Catchment No: 1 – 10 x 7 x 4.0 $m^3$
Catchment No: 2 – 31 x 15 x 3.0 $m^3$
Catchment No: 3 – 45 x 27 x 0.75 $m^3$
Catchment No: 4 – 16 x 15 x 1.0 $m^3$
Total Capacity – 2826000 Liters

Of Reservoir – 6, 22,466.96 Gallons

View of Rain Water Harvesting Pond in KVK Mines

**TOP SOIL MANAGEMENT**

The average thickness of the topsoil is about 2m in the whole area envisaged for mining. The upper layer of topsoil, which is oxidized and contains organic matter will be stripped first and used for spreading over the slope of the peripheral bund to facilitate revegetation and also for tree plantation over the areas beyond the peripheral bund. Also Sapling were planted over the Top soil Dump in order to increase the dump stability and prevent the soil erosion due to rain.

**IMPACT EVALUATION**

The widely adopted Matrix Method is used for evaluating the Impacts Data generated from Existing Environmental Status (EES) studies formed the basis for the Matrix method. The impacts on different components of environment and other related issues are fully assessed and classified as:

Impact I : Mitigated by environment management plans
Impact II : Not yet fully, qualitatively assessed
Impact III : Not yet fully, quantitatively assessed
Impact IV : Positive impacts on the environment.

The impacts are studied on classified environmental components viz. Physicochemical environment, biological environment and human environment as listed in the matrix (Table The potential significance of impacts are denoted as S,L and P viz, short term(S), Long term(L) and Permanent(P). The prevention strategies and mitigatory measures are discussed in details earlier.

Impact Quantification : To quantify the assessed impacts which are qualitatively described in the EIA Matrix on the basis of MoEF guidelines, they are assigned certain arbitrary weightages and the impacts with positive or negative co-efficient values as below:

| Sl. No | Coefficient Criteria | Coefficient of Impact |
|---|---|---|
| 1 | No Impact | 0 |
| 2 | No appreciable impact | 1 |
| 3 | Significant impact – short term | 2 |
| 4 | Minor Impact - Long Term Irreversible | 3 |
| 5 | Major Impact – Long Term Reversible | 4 |
| 6 | Permanent Impact | 5 |

The value of the importance of the environmental parameters are related to the impacts of the proposed activities of the project. To sum up impact score, the weightage factor is multiplied with the coefficient values.

| ental ters | Impor tance Value | Operation phase Activities | | | | | | | | | | | Impact Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Drilling & Blasting | Excava tion | Load ing | Transp ortatio n | Fugitive Emissio n | Waste Water s | Solid wastes | Green Belt | Rain water harvestin g | Occup . Health Measu re | Soci al Mea sure | |
| l nent | 100 | -1 | -1 | | | | | -1 | +2 | | | | -100 |
| r nent | 100 | -1 | -1 | | | | -1 | | +1 | +2 | | | 0 |
| nment | 100 | -1 | -1 | -1 | -1 | -1 | | -1 | +4 | | -1 | | -300 |
| e | 100 | -1 | -1 | -1 | -1 | | | | +3 | | -1 | | -200 |
| orests | 100 | -1 | | | | | -1 | +1 | +1 | | | | 0 |
| Wildlife | 100 | -1 | | | -1 | | | | +1 | | | | -100 |
| h | 100 | -1 | | | -1 | -1 | | | +1 | | +2 | +2 | +200 |
| omics | 250 | | +1 | +1 | +1 | | | | +2 | | | +2 | +1750 |
| ics | 50 | | | | | | | | +2 | +1 | | | +150 |
| l | 1000 | -7 | -3 | -1 | -3 | -2 | | -1 | 17 | 3 | 0 | 4 | +1400 |

The total impact value is listed as follows. The total impacts source is an assertive, positive score of +1400 due to increased employment, social welfares, local & regional economy, etc. which favors the society.

## WAY FORWARD

### Proposed sustainability Development charter Exclusively for DPM Mines

- Evaluation of the deposit in existing operating Mines.
- Maximize the utilization of resources available in the existing mines
- Use of correct technology for mining
- Potential to increase the resources / identification of newer deposits catering to the existing plants
- Monitoring the impact of mining activities on Environment and society & action taken to reduce the impact.
- Activities undertaken in and around the mine to improve the life of the people, so that they support our mining operations.
- Addressing Land & other social impacts
- Compliance to various statutory provisions – DGM, DGMS, IBM, MoEF, COE, PCB & other Government agencies.
- Mine Closure & Post closure Mining.
- Potential risks and challenges.

## CONCLUSION

Mining Activity has significant environmental & social foot prints much beyond the physical boundaries of mining leases. The integration of sustainable development concepts at the earliest phases of mining life cycle and helps the mining companies evaluate the risk associated with different or alternative leases available against the potential value of the mineral and take business decisions accordingly. This will ensure sustainable development to the maximum extent possible.

***"Social involvement . . . . . A matter of tradition in Dalmia Cement"***

Dalmia Cement - being located in a rural area, has undertaken the responsibility towards society at large to uplift the standard of living in and around Dalmiapuram. DCBL Management takes ownership for the Corporate Responsibility for Environmental Protection (CREP) and Corporate Social Responsibility Norms.

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*The Indian Mining & Engineering Journal, Vol. 57, No.12, December 2018, pp.31-34*
*Printed in India, @ IME Publications, ISSN 0019-5944*

# Techniques for Improving Coal Mine Waste Dump Stability Using Geogrids: A New Concept

I L Muthreja* Dr R R Yerpude* Dr. J L Jethwa**

**ABSTRACT**

***Minerals are essential raw materials in industrialization and economic development. Coal, being a primary source of energy plays a vital role in an energy-intensive economy such as India. The current work assumes that India works on coal option only for its energy needs. The characteristics of a coal seam such as its thickness, depth, inclination, and ratio of coal to overburden largely influence the mining method to be employed. Surface mining outsmarts underground mining not only in terms of productivity but also from the safety point of view. Surface mining is preferred for greater recovery of in-situ resources, high productivity, low costs and labor intensity, and better workplace conditions. Typically, Surface mining is used for coal seams within 300m of depth, although deeper mining is possible. Currently 90% of total production in India comes from surface mines. Though common in civil industry, the geogrids have not been tried in Indian mineral industry so far and dump stability is one area where the goegrids should find wide applicability. In this paper, behavioral aspect of geo-grid reinforced mine waste dumps is analyzed backed by numeric modeling. Different options of geo-grid application are used to study their effect on mine waste dump designs.***

## INTRODUCTION

Mining generally results in the production of large quantities of waste. The overburden material being a non-marketable product, it is removed and dumped. The primary aim in the design and construction of overburden dump is to provide an effective stable working environment for the workers and the machines.

The average depth of surface coal mines in the country is 80 m and the deepest surface coal mine has reached a depth of 160 m. Many mines in India have been planned to go upto a depth of 200 m. Higher depth means higher stripping ratio. Overall Stripping ratio in India for the year 2012-13 was 2.11. With rapid advancement in the field of extraction technology, surface mining is assuming an increasing important role in the Indian coal mining industry. The coal production in India from underground and opencast mines as shown in Table-1 indicates rise in production from surface mine. One of the most important aspects of an opencast coal mine planning is the design of waste dumps. The storage of waste materials should be done for safety of man and machines, and economy. Increasing trend in production from open cast mines has aggravated the stability problems of waste dump. The amount of waste materials is increasing at an alarming rate and can pose stability problems in future, if not taken care of, immediately.

Table-1: Coal Production in India

| Year | COAL PRODUCTION IN INDIA | | |
|---|---|---|---|
| | Underground Production | Opencast Production | Total |
| 2000-01 | 66.068 | 247.628 | 313.696 |
| 2001-02 | 64.816 | 262.970 | 327.786 |
| 2002-03 | 63.159 | 278.113 | 341.272 |
| 2003-04 | 62.750 | 298.490 | 361.240 |
| 2004-05 | 62.350 | 320.270 | 382.620 |
| 2005-06 | 60.965 | 346.074 | 407.039 |
| 2006-07 | 57.698 | 373.134 | 430.832 |
| 2007-08 | 58.900 | 398.180 | 457.080 |
| 2008-09 | 58.972 | 433.785 | 492.757 |
| 2009-10 | 58.52 | 473.52 | 532.042 |
| 2010-11 | 54.86 | 477.84 | 532.694 |
| 2011-12 | 51.96 | 487.99 | 539.95 |
| 2012-13 | 52.206 | 505.501 | 557.707 |

*Dept of Mining Engg.,Visvesvaraya National Institute of Technology,Nagpur
**Former Director-level Scientist, and Scientist-in-charge, Central Mining Research Institute, Nagpur Regional Centre, presently a Tunneling Consultant

Higher depths of surface coal mines will produce larger volumes of overburden material and large land will be required for dumping.The land acquisition is one of the biggest problems for coal mining industry in India. To save space, the dumps will be required to have higher heights and steeper slopes.

Steepened slopes with higher dumps have become increasingly advantageous due to better land usage and lower site development costs. The proven concept of tensile reinforcement allows construction of dumps with improved stability, than are possible with the present practice with poor dump stability. Dumps reinforced with geo-synthetics/ geo-grids can reduce land requirement substantially, provide a natural appearance, and improve dump stability.

Geo-synthetic reinforced soil walls have been in use for more than 25 years and in the vast majority of cases have performed very well in the civil sector. The use of geo-synthetics has not been applied in the Indian coal mining industry as yet. Its use will definitely help in improving the stability of waste dumps.

## USE OF GEO-GRIDS FOR ENHANCING MINE WASTE DUMP STABILITY

For millennia, civilizations have sought effective methods to construct stable soil retaining structures. The technique of reinforced soil is not a new concept, but reinforced soil has become a viable and cost-effective technique only over the last 25 years. This has been possible by the development of geo-synthetic reinforcements engineered from strong and durable polymers. These geo-synthetic reinforcements enable substantial tensile loads to be supported at defined deformations over extended design lives of structures.

### Mechanics of reinforced soil

Reinforced soil is the technique where tensile elements are placed in the soil to improve stability and control deformations. To be effective, the reinforcements must intersect potential failure surfaces in the potentially failing soil mass. Strains in the soil mass induce tensile stress the reinforcing elements (Fig.-1). These tensile loads restrict soil movements and thus impart additional shear strength to the soil mass. This results in the composite soil/ reinforcement system having significantly greater shear strength than the soil mass alone, leading to better soil stability. The analogy applies to the coal mine waste dumps.

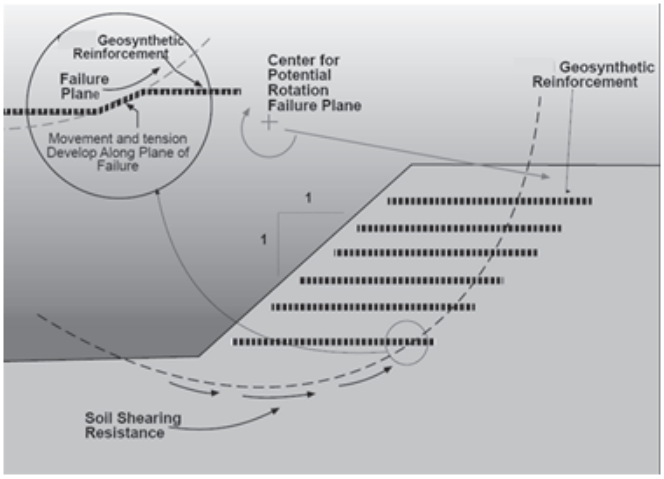


Fig 1- Geosynthetic reinforcement of slope

Coal mine waste dumps consist of loose broken rock material mainly consisting of sandstone, shale, and soil. The behavior of this material is similar to soil as discussed above. Hence these dumps have lower slope angles and limited heights from stability considerations. The dump design must be undertaken with a view to have improved slope and greater heights in new mines. Generally the area covered by mine dump is more than 50 ha. Improved stability with better slope angle will save on required dump area.

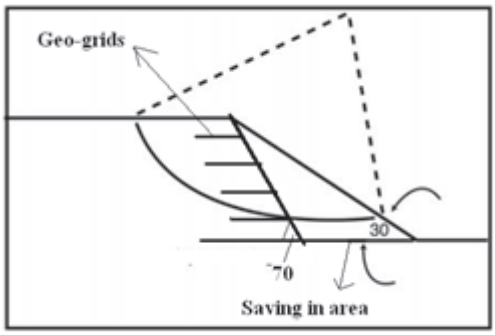


Fig.2- Saving on area with improved slope angle

The use of geo-grids in Indian coal mines is practically non-existent. A study is being carried out for justifying the application of geo-grids in improving the stability of coal mine waste dumps, in view of advantages described earlier.

## NUMERICAL ANALYSIS

The study was conducted for a coal mine waste dump having following characteristics:

| Mine | Sample | Density, $kN/m^3$ | Cohesion, $kN/m^2$ | Friction Angle, Degree |
|---|---|---|---|---|
| Mine No.1 | Dump | 20.02 | 24.0 | 27.5 |
| | Floor soil (B.C.Soil) | 20.96 | 39.0 | 20.9 |

The properties of Geo-grid used are:
Bond Cohesion= 1000 N/m
Bond Friction angle= $10^0$
Thickness = 5 mm

FLAC SLOPE software of M/s Itasca Inc. has been used for waste dump stability analysis and calculation of factor of safety.

Results of analysis are shown in the following table:

| Sr. No. | Dump configuration | Factor of safety |
|---|---|---|
| 1. | 100 m height without geo-grids | 0.97 |
| 2. | 100 m height with single layer of geo-grid at 50 m height | 1.03 |
| 3. | 100 m height with a layer of geo-grid at every 10 m | 1.38 |

Figures 3 to 6 show the output of FLAC SLOPE numerical modeling.

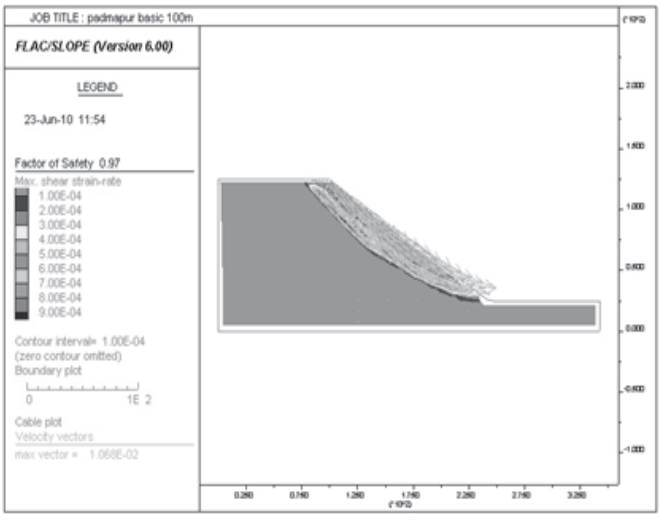


Fig.3 – Analysis for a 100 m dump without Geogrid

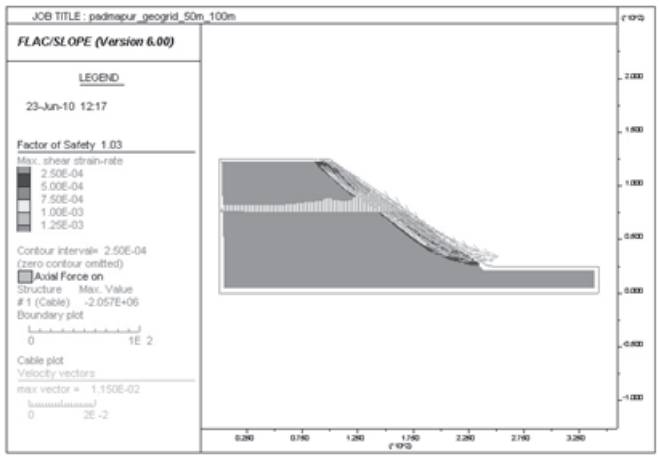


**Fig.4 –** Analysis for a 100 m dump with a single layer of geo-grid

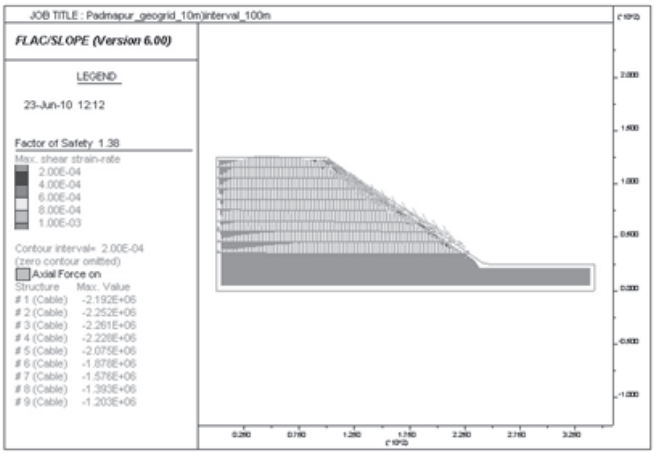


Fig.5 – Analysis for a 100 m dump with Geo-grid layer every 10 m

## CONCLUSIONS

The study has shown potential for increase in safety factor of coal mine waste dump by using geo-grid reinforcement. This reduces the land required for dump area considerably. The coal mining company could potentially gain from reduced land acquisition problems and cost, improved safety of dumps, and reduced environmental problems from improved dump stability.

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