Invitation to Disaster----- Neglect of Mine Surveying

Prof DD Misra Chairman IITISM Board of Governance & Ex Director CIMFR Dhanbad.

INTRODUCTION

Till the nationalisation of the coal mines in the late sixties of the last century, the position of the Mine Surveyor was very important, next only to the Mine Manager. Nationalisations have not directly reduced the position of the Mine Surveyor, but the related developments have continually neglected the profession resulting in the present situation which is an open invitation to mine disasters.Here it is important to emphasize that while disasters resulting in the direct loss of human lives are reported and condoled, substantial financial losses, cost over runs and unacceptably long delays in the implementation of the development and construction projects largely go unreported.

BRIEF OVERVIEW OF INUNDATION ACCIDENTS

It is important to recall that most of the disasters till the sixties were mainly due to fire damp and coal dust explosions. Afterwards the disasters have been mostly due to inundation of mines.

List of disaster due to inundation from 1900 to 2014. [1]

Sl. No	Date of the accident	Name of the mine	Person killed
1	11.07.1912	Phularitand	21
2	28.06.1913	Jotejanaki	13
3	16.01.1935	Loyabad	11
4	06.07.1942	Makerwal	14
5	05.08.1953	Mijri	11
6	10.12.1954	Newton Chikli	63
7	26.09.1956	Burra Dhemo	28
8	20.02.1958	Central Bhowrah	23
9	05.01.1960	Damua	16
10	18.11.1975	Silewara	10
11	27.12.1975	Chasnalla	375
12	05.04.1976	Chasnalla	10
13	16.09.1976	Central Saunda	10
14	14.09.1983	Hurriladih	19
15	27.09.1995	Gaslitand	64
16	02.02.2001	Bagdigi	29
17	16.06.2003	Godavari Khani	17
18	15.06.2005	Central Sounda	14

Most of the inundation accidents take place due to

1. Neglect of high flood level warnings
2. Omission or erroneous plotting of surface water bodies
3. Omission or erroneous plotting of old water logged workings
4. Wrong plotting of present workings approaching waterlogged places
5. Failure to verify the accuracy of the plans and sections by redundant surveys

COMPARATIVE REDUCTION OF MANPOWER

While the numbers of assistant mangers are related to production (under CMR 1957), man power (under MMR 1961) and aggregate horse power of mining machinery, there is no such scale for the employment of qualified surveyors. As a result the number of surveyors available in relation to expansion of workings in terms of production and man power has comparatively gone down. With the nationalisation of the coal mines, the coal mine surveyors lost most of the other avenues of employment. Successive wage boards have also comparatively downgraded the emoluments of the surveyors, sometimes putting them at par with the Mine Foremen and Overmen, though for the purpose of competency they are compared with mine managers.The reduction of manpower has also been accompanied by comparative reduction in the number of survey instruments available in relation to production (CMR 1957) and manpower (MMR 1961)

Probably the best (or worst?) example of reduction of the number of surveyors is in the inspectorate of mines. Though the numbers of inspecting officers has not gone up according to the increased requirement for inspection with the increase in production and number of mines, the number of surveyors in DGMS has actually gone down.Similar is the case in all Government departments including IBM, GSI, AMD and state departments of mining. The Government undertakings are not far behind.

UNREPORTED FINANCIAL LOSSES

While the disasters caused due to absence of correct and up-to-date plans and sections are reported in the media, other effects are hardly reported.The tunnels and drives, especially in the country rock, often do not hole through as expected, resulting in costly and time taking widening of the tunnels or installation of transfer points.This type of problem is not confined only to mining; it happens also in case of roadway tunnels, railway tunnels and tunnels in hydroelectric projects.

In case of an opencast mine where it was decided to extend the workings by adopting underground methods, bore holes were drilled. The locations of the bore holes were decided using the mine plans and sections submitted annually to the DGMS. While interpreting the results it was discovered that the plans and sections were far from correct and at least half of the bore holes were useless.

DILUTION OF THE MINING ENGINEERING CURRICULA

Neglect of surveying and levelling starts in the educational institute itself. With the introduction of the four year degree courses, after the interlude of five year degree courses, the syllabi of surveying has been continually reduced from three papers in the annual system to only two papers in the semester system. In effect it means that a graduate in mining learns about only one third of what a graduate used to learn 50 years back, while the technology has advanced so much.In addition there were survey camps totalling six weeks for degree courses and four weeks for diploma courses in mining. Now the camps have been reduced very much. Thus a modern graduate in mining is hardly motivated in his education to appreciate the need of accurate surveying.Similar, if not worse, is the case with civil engineering curricula.

CONCLUSION

In the present scenario it is hardly possible to expect that the Governments and public sector undertakings will take any effective step to improve the condition of surveying in the mines. However a few local managements, both in the private and public sectors, have taken the following effective steps to improve the mine plans and sections in their own mines.

1. Assigning the job of overseeing the entire survey department to a motivated first class assistant manager
2. Making sure that the latest surveying and plotting facilities are available and are maintained properly
3. Verification of accuracy of the existing plans and sections by a qualified external agency every two to three years. Quite a few errors and omissions have been found by such survey audits.

Of course such in house improvements are possible only if the mine manager is highly motivated.

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IT .....Technology Adoption – SCCL

S. Chandrashekhar*, M. Geeta Mohan**

INTRODUCTION

Coal plays a important role in national economy of a developing nation like India. High-tech and safe exploitation and usage of coal is the demand of the 21st century, the technologies have made a coal mining industry a high-technological affair that is equipped with computers and all the necessary machinery to exploit the benefits of technology in mining. Sustainable development of the Indian coal mining will require developing the ability to sustain the increased production of coal in the country efficiently and in a cost effective way, and mining in an eco-friendly manner using latest technology.

About SCCL

The Singareni Collieries Company Limited (SCCL) is a Government coal mining company jointly owned by the Government of Telangana and Government of India on a 51:49 equity basis. The Singareni coal reserves stretch across 350 Km of the Pranahita – Godavari Valley of Telangana with a proven geological reserves aggregating to whopping 10846 million tonnes. SCCL is currently operating 19 opencast and 29 underground mines in 6 districts of Telangana with manpower of 54,041.SCCL has produced 40.6 MT during 2007-08, 61.34 MT in 2016-17 and 62.01 MT in 2017-2018 and despatching 64.62 MT which is a record of nearly 51% Increase over a decade. While the geo-mining conditions of SCCL coal deposits are adverse both from technical and economical perspectives, the company need to meet the demand of South Indian thermal Power plants and cement industries as this is the only coal producing company in the proximity.

SCCL has entered the power sector as the first Indian coal PSU by setting up 2X600 MW Power Plant at Jaipur in Mancherial district of Telangana. The Singareni Thermal Power Plant (STPP) during first year of operation itself has secured fourth position in top 25 thermal power plants of the country with a PLF of 90% in the Past 9 Months.

M/s Singareni Collieries Company Limited (official website: www.scclmines.com) was founded by Dr William King , the British geologist in way back in 1889 and has beenthe oldest coal mining PSU in the country with acquisition of all the shares by Nizam way back in 1945 . The rich heritage of the company in technical , business as social perspectives , kept it as a leader in the coal mining industry in the country. The company is pioneer in introducing various technologies in mining like coal cutting machines in 1951, electric cap lamp in 1953 , in pit crushing and conveying of OB in 1994 , high capacity long wall in 2014. SCCL has adopted various state of art Digital technologies from time to time to meet business objectives .

Technology adoption beginning

SCCL has recognised and envisioned way back in late Seventies itself, that IT & C (Information Technology & Communications) is a powerful tool to be used for automation& transformation purposes to improve efficiency of working and enhance the productivity of the persons. SCCL started computerisation of payroll in 1980.

Subsequently SCCL established an in-house IT department in 1982 with around 40 programmers and 80 EDP assistants. It initiatives in SCCL were initially driven to utilise the computational power of computers to prepare pay sheets of huge manpower (1.14 Lakhs at that time) which otherwise will be a job to be carried out by number of people and of course with human errors. Converting manual processes to computerized systems required efforts for voluminous data collection, codification of data and digitization of data for generation of payroll for different categories of employees – executive, monthly rated, daily rated and piece rated employees by 1990.Codification is one of the most important first step towards computerisation, whether it is men or machinery. The codification of employees and material done in 80s is the basis for large volumes of data even now. In-house applications were developed in the then popular COBOL environment. Major processes implemented during that time include payroll processing, inventory management system, various financial and accounting processes. In the year 1989 SCCL has adopted an automated Recruitment system right from Applying for Job stage to issue of Appointment letters. It is pertinent to mention that some of the soft wares are still in use, especially to retrieve and process historical data.

Expansion of IT

In the year 1999, a software development group was formulated with about 30 active executives on full time for IT implementations. They were trained with the popular platforms of that day like VB-Oracle along with IT programmers. In house teams developed software's for various core functions of the company some of custom software developed by external agencies were implemented. Initially connectivity to remote SCCL locations was poor thus Client- Server architecture at local level and company level integration of the data was done off-line.

Major initiatives during that time include computerising the core activity of the mine level processes like attendance and allocation of men, deployment and utilisation of machinery at the mine, establishment of data base of personal records of more than 1 lakh employees on roll,

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Sale orders of coal and dispatch of coal against the sale orders, Mine accidents and incidents reporting, enquiry and analysis, Preparation of estimates, execution and billing of the civil works. Customised development for Hospital Management is one among the applications got developed by external agencies.

Apart from the in-house development, the mining specific requirements are met by licensed products which include Minex for geological modelling and mine planning, Auto cad licences for operating mines, software for ventilation planning and blasting optimisations.

OITDS (Operator Independent Truck Despatch System) was also adopted as a pilot project in the year 2000 at one of its OC mines.

Simultaneously the companywide infrastructure was established by which the access to the computer and the data to all the departments took a major step forward. Local Area Networks are established at all Areas which are connected to the Company network as the environment and applications progressed. .

To provide online information to its stakeholders, SCCL has launched its own website in the year 2003 and an e-mail system for communications in the year 2005.

The Company recognised the need to integrate the department / functional applications into single platform early. In the year 2005, the company started to think of a suitable ERP (Enterprise Resources Planning) solution, which will mitigate all the drawbacks of pre ERP landscape.

INFRASTRUCTURE DEVELOPMENT

Such level of applications cannot be implemented without robust hardware infrastructure with reliable connectivity, robust network was established with 7000 nodes across the company connected through 700 network switches, 100 wireless connections and 16 routers. Locally within the buildings they are connected by CAT-V LAN. The connectivity from General Manager's offices is mostly by OFC. SCCL maintain around 250 KM of OFC for the local connectivity while the connectivity to central server is through redundant sources such as BSNL and Railtel MPLS connectivity is established . Remote mines are even provided with VSAT connectivity.

SCCL own all its servers on Virtual platform using state of art blade servers and has gateway level firewalls, latest antivirus software and well established network controls to secure its networks.

ERP IMPLEMENTATION

The requirements and challenges for implementation of ERP in SCCL are

- SCCL has its operations scattered around 250 locations which include mines , stores , workshops and office in 4 districts (now 6 districts) which are geographically around 350 Km apart and many of which are extremely remote with poor or no connectivity. At some of the locations there is no service provider who is in a position to provide connectivity as his Point of Presence is not within the reach.
- Has huge work force over 1.10 lac employees. The monthly payroll is processed based on about 1000+ disignations, 1500 types of wage component allowances , recoveries and taxcodes , 186 attendance types and 56 leave types. Most of this data varies on a day to day basis for each employee which is required to be captured to the ERP.
- Has many varieties of materials around 1 lac, stored at various locations
- Has more than 3000 coal customers to deal with.
- Has around 3000 vendors from whom material is procured.
- Huge investments planned in various coal and non-coal projects
- Varieties of equipment's are to be managed which are used for extraction of coal include in underground mines.

Hence there is a need to manage the above resources efficiently for bringing down cost of production and implementation is huge and complex in relation to the size of the company due to complexity of the processes and remoteness.

Proper selection of the ERP product, an acceptable process of award of contract in public sector limitations, decision on the scope i.e. which functionalities to be in the ERP and which will be outside ERP were challenging.

SAP was decided as the best suitable product. Core Functions of the Company viz. Sales and Distribution (SD) for Marketing and Sales; Materials Management (MM) covering Procurement and Inventory Management; Human Resources (HR) for Personnel Administration and Payroll; Finance and Controlling (FICO) for Financial Accounting and Costing are planned to be into the scope of SAP in the first phase. It was planned to continue various other processes outside SAP and which do not have a direct interface with the Finance. These applications can be further expanded outside SAP and can be migrated to SAP at an appropriate time on successful implementation of the phase-I. SCCL implemented SAP in 2008 and later on other modules such PS and PM were also implemented.

BENEFITS OF ERP IMPLEMENTATION IN SCCL

- One integrated application in place of multiple applications thus leading to better application management & administration
- BPR (Business Process Re-engineering) like centralized payments,
- Controls & Alerts & Early Warning mechanism
- Provides an integrated view of operations at various locations
- Availability & capture of data on real-time basis and processing for supply-chain functions , Vendor

payments, Customer Order fulfilment , Billing, Accounting etc

- Visibility of data on Desk Tops of any person in the Organization thus aiding in effective DSS (Decision Support System)
- Online capturing of attendance at mines/depts.
- Reduced paperwork and manual processing
- Centralized payroll and Human assets administration
- Central server architecture in place of Distributed databases.
- Platform for implementing e-Governance framework viz B2B, B2E etc.

OTHER IMPORTANT IT INITIATIVES IN SCCL

- Communication systems such as e-mail, VOIP, Video Conferencing within the Company and outside parties are used extensively.
- IT environment is established using state of art technology with latest blade servers and virtualization.
- SCCL has deployed web services, e-mail services and web portal for functional departments.
- Procurements process in the Company through e-procurement portal.
- Recruitment process is fully automated which provides facilities such as online application submission, hall ticket down load, conducting of examination and declaration of results etc.
- Online coal dispatch and monitoring implemented in the Company.
- Security and surveillance systems such as Vehicle Tracking System are implemented in all mines in the Company.
- All employees personal data is maintained in digital format.
- Hospital Management System for providing medical facilities is implemented in Company.
- Finger print Bio-metric attendance system and face recognition system is implemented on trial basis.
- Aadhaar enabled bio-metric attendance system implementation in the Company is under consideration.
- Decision support systems such as safety information system, exploration bore hole data monitoring, personnel dept. information systems are helping various users in decision making.

USAGE OF IT IN CORE MINING OPERATIONS

Mining activities survey, exploration and planning are all carried out using various software's some developed in-house and few procured. **For** Digitization of borehole data, Geo-Engineering data, Quality data in house developed software is used. Minex software is used for 3D modelling of the Geological setup in a block ,Pit design, Pit optimisation and Calculation of reserves etc.. GIS (Geographic Information System) is used for computerized mapping and spatial analysis to capture, store, query, analyze, display and output geographic information. Carlson software is used for mine planning Pit optimisation validation of coal reserves, drawing of seam structures through Fence Diagrams. For OC mines Quarry and dump designing, calculation of bench wise OB and Coal quantities. Production scheduling in UG mines and calculation of Extractable reserves. SCCL is a major user of AUTOCAD software which is being used for Preparation of Mining plans, FR plates, environment management plans, Mining lease plans etc..Plans for forest diversion, non-forest land requirement, cadastral plans Opencast mine plan, in UG mines hand plans, haulage lay out, pumping lay out, ventilation lay outs, manpower distribution plans, monthly progress plans in Soft copies, permission plans. Excavated Volumes calculation of OB and Coal, processed OB.

CURRENT SCENARIO

In SCCL almost all core and non-core business activities are technology driven right from planning to development of mine ,extraction of OB ,coal to sales all activities are performed using suitable platform resulting in high level of accuracy and results in time saving and improvement in production and productivity of company.

There are 30 department level applications which cater to the specific requirements of the depts. and for the benefit of employees. They include porting of the LIC policy data for recovery of premium from employee pay and remittance to LIC, Purchase of gas cylinders by SCCL employees from gas companies and re-imbursement by SCCL, Employee Credit societies where deposits are accepted and loans given to employees for which recovery is done through SCCL payroll.

Now SCCL also has initiated GIS & GPS based applications. The coal transport vehicle tracking system is implemented which not only provide security during coal transportation but also helpful in minimising the delays and improve coal dispatches. All mine leases, mining plans and land records are being migrated to GIS platform which help to ensure proper statutory compliances.

MANPOWER AND MAINTENANCE

It is to mention that in spite of being a mining company, SCCL maintain most of its critical hardware and software maintenance by internal resources. Even SAP data base management and updations are carried out by SCCL teams. The Servers and Connectivity issues are attended by SCCL teams with assistance from service engineers on contract which is mostly for physical activity like replacement of components and expansions. A strong team of about 50 executives, both IT and functional, are dedicated towards this.

THE ROAD AHEAD

While SCCL has strong voice-data network for all its locations on surface, the expansion of data networks underground is a long felt need. Cost effective ways of expansion of these networks to underground is the top agenda of SCCL. Information dissemination to users through mobile interfaces need to be developed to meet growing information requirements. IT technology utilization for safety at work place need to be expanded.

CONCLUSION

SCCL is a pioneer in adoption of new technologies..The company adopted latest technologies with times. Today, SCCL is a truly integrated enterprise. We hope to develop business through technology adoption in all areas of operations in near future also.

S.Chandrasekhar 1962)**Director Oprn, The Singareni collieries Co.Ltd.**

B.E(Mining) from Osmania University in First division with distinction in 1983
MBA(HR) from Osmania University in First division with distinction and Holder of First Class Mine Manager Certificate of competency (coal)

- Worked as Mine Manager of underground longwall project which produced coal 1MT (during 1991-92) for the first time in Singareni Collieries company Limited.
- Worked as Agent (Group of Mines) having various underground technologies including longwall, Blasting Gallery, Load Haul Dumpers etc.
- Worked as Staff officer/Technical Secretary to Chairman & Managing Director and General Manager(Co-Ordination) in the office of C&MD more than 12 years. Exposure to more than 100 company Board of Directors meetings/deliberations. Co-ordinated with 34 departmental Heads in functioning of growing organization.
- Worked as Chief Public Relation officer of the company and coordinator of CSR activities as Full Additional Charge.
- Worked as Area General Manager, In-Charge of high capacity modern longwall face which produced 1.83MT during 2015-16.

VISION FOR ORGANIZATION:

- Production, Sustainability, Safety Must and Transparency & Ethics foremost.
- Fulfilling the stakeholder expectations.

Core Competencies:

- Direct and deep knowledge in coal mining operations management from exploration, Feasibility Report formulation to DPR, obtaining relevant approvals in the local, state and Central government departments including Revenue(Land acquisition and R&R), Environment(EC), Forest, ministry of coal, Coal Controller organization, Regulatory bodies in the field of coal.
- Strategies for acceptance of mining projects by local communities.
- Corporate functioning to facilitate project capacity building and attaining Rated capacity. Interventions required in grounding new projects in back ward regions with respect to Infrastructure, CSR activities etc.
- Achieving goals of the organization.
- Focus on the asset management, financial performance, Financial ratios, Capex & Opex and profitability etc.
- Broad understanding of new challenges in the field of coal mining with reference to strategic planning and Clean Coal Technology in coal and down stream sectors.
- Exposure to setting up Thermal Power Plant.
- Gained exposure into organization development and organization change behavior pattern.
- Working out JV opportunities in downstream/ upstream products/services etc.

Behavioral Competencies:

- Leader ship: Capacity to provide guidance and direction that others willingly follow.
- Problem solving skills: Able to find the root causes of issues, analyze potential alternatives, and choose the best available option for the particulars situation they face.
- Teamwork and Collaboration: Work effectively with others to achieve common causes.
- Positive Outlook: Adds to the morale and productivity of the work environment by encouraging others and consistently looking for ways that ideas and processes can be done.
- Work autonomously and produce effective and efficient results without needing abundant direction from others.
- Judgment: Ability to weight alternative actions and make decisions that incorporate opinions, facts tangible and/or intangible factors.

Geothermal Location Applications for TIPPER

Dr. Michael C. Mound, Switzerland.

TIPPER is an electro-magnetic passive-source geophysical method for detecting and mapping aquifers, geothermal reservoirs, or mineral resources. This geophysical method uses distant lightning and solar wind activity as its energy source. Lightning and solar wind cause electrons under the earth to move, and if anything deflects the path of those moving electrons, a magnetic disturbance is generated, which can be measured at the earth's surface. The most interesting deflections are caused by the funneling of electrons into more electrically conductive areas like mineralized faults, aquifers, or geothermal reservoirs.

Geothermal Application:

Geothermal field is a geographical definition, usually indicating an area of geothermal activity at the earth's surface. In cases without surface activity this term may be used to indicate the area at the surface corresponding to the geothermal reservoir below. As geothermal energy is usually described as renewable and sustainable, it is important to define these terms. Renewable describes a property of the energy source, whereas sustainable describes how the resource is utilized.

The seismic reflection method's Achilles Heel is vertical structure. The seismic method is challenged by rock layering dipping at more than 45 degrees. The steeper the dip, the greater the challenge. Whereas TIPPER results improve with increasing dip angle. A vertical conductive fault is an ideal target for TIPPER, while the same fault may be entirely invisible to a surface reflection seismic survey, unless there are very long offsets and pre-stack depth migration. The TIPPER method has been applied to minerals, water, oil and gas, geothermal and regional geology exploration and mapping.

Geothermal systems can therefore be found in regions with a normal or slightly above normal geothermal gradient, and especially in regions around plate margins where the geothermal gradients may be significantly higher than the average value. In the first case the systems will be characterized by low temperatures, usually no higher than 100 °C at economic depths; in the second case the temperatures could cover a wide range from low to very high, and even above 400 °C. Frequently a distinction is made between water- or liquid-dominated geothermal systems and vapor-dominated (or dry steam) geothermal systems (White, 1973). In water-dominated systems liquid water is the continuous, pressure-controlling fluid phase. Some vapor may be present, generally as discrete bubbles. These geothermal systems, whose temperatures may range from < 125 to > 225 °C, are the most widely distributed in the world. Depending on temperature and pressure conditions, they can produce hot water, water and steam mixtures, wet steam and, in some cases, dry steam. In vapor-dominated systems liquid water and vapor normally co-exist in the reservoir, with vapor as the continuous, pressure-controlling phase. Geothermal systems of this type, the best-known of which are Larderello in Italy and The Geysers in California, are somewhat rare, and are high-temperature systems. They normally produce dry-to- superheated steam.

TIPPER is capable of measuring three dimensional characteristics of a subsurface structure

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Paschal Oloo logs data from an Ultra MiniRes electrical resistivity meter, manufactured and supplied by TDD International/GAMMAG.

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International Marketing, Innovation Evaluation, and Execution for the energy minerals, construction materials & minerals processing industries,Associated with executive Board members of a number of HIgh profile bodies in Finland,Switzerland,,USA,China,Australia
.
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Truck Dispatching Systems in Surface Mine- A Step Towards Complete Automation of Mines

Mallikarjun Sarapur

Quick Dispatch System at Balda Block Iron Mines(M/S Serajuddin& Co)

- At Balda Block Iron Mines(M/S Serajuddin& Co) , we have implemented a unique quick dispatch system (QDS) for loading of Iron ore into the dispatch trucks at the weighbridges. The above system facilitates quick accurate loading of Iron ore quantity into the trucks in a very efficient manner. This QDS system with RFID technology is in operation and it has found wide acceptance from regulatory authorities and customers.

SALIENT FEATURES

- Safety being our first priority, we have ensured that there is absolutely no chance for the tippers to face any accident as recycling of trucks due to overweight is not necessary.
- Previously when the tippers were found to be loaded with excess material at the weigh bridge they had to go back to the loading point and the drivers had to manually unload the Iron ore.
- Now the exact weight is finalized at the weigh bridge using the QDS mechanism.
- Traffic management has become easier as the congestion inside the mines due to recycling of tippers have been stopped. This has also helped us in regulating the traffic within the mines area.
- After implementing the QDS we have been able to increase the volume of dispatch due to smooth flow of trucks.

QUICK DISPATCH SYSTEM

- QDS play an important role in managing the Tipper traffic in mines, as it helps to overcome the inaccurate load in the vehicle.
- This system is well acquainted in operations with zero drawbacks in design.
- It works on the simple technique that uses calibrated weighbridge for accurate vehicle weighment and also low output excavator to add/remove the material so that the prescribed weight as per the capacity of the vehicle is loaded, when the vehicle is found to be overweight/underweight.
- The Digital display is installed for the driver and Excavator operator to know the weighment when the vehicle is parked in the weighbridge.
- We have five weigh bridges and the hopper is attached with each weigh bridge for material handling.
- The Excavator stores the excess material in hopper when the vehicle is found overweight & also it retrieves the material from the hopper and loads it on the tipper when it is found underweight.
- The above design has dramatically reduced recycling of vehicles plying to & fro from loading point and weighbridge for want of accurate weighment.
- Photos showing the excavator add/remove the material from the side hopper/truck into the vehicle/hopper when vehicle is found underweight/overweight

QUICK DISPATCH SYSTEM - RFID INTEGRATED

- Radio Frequency Identification (RFID) is one of the methods for Automatic Identification and Data Capture (AIDC).
- RFID is the wireless use of electromagnetic fields to transfer data, for the purpose of automatically identifying and tracking tags attached to objects.
- The tags contain electronically stored information. The one which is used at our mines is functioning through battery power source.

COMPONENTS OF RFID

- RFID Tag
- RFID Reader
- Weigh bridge Customized Software
- QR Code scanner

RFID PROCESS FLOW CHART

DISPATCH VEHICLE

- RFID tag is installed in every vehicle registered with our transporter. The data of all the Vehicles & Drivers is stored in our Database.

MINES IN-GATE

- 1 RFID Reader has been installed at the In-Gate for capturing the data as the vehicle enters.

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RFIDD READER

- The RFID reader captures information from RFID tag fixed in the vehicle

SOFTWAREEADER

- Once the RFID reader captures the data from the tag fixed in the tipper, the tipper details like validity of Insurance, Permit and Tax is displayed in the monitor

FINGER PRINT READER

- Drivers are asked to place their fingerprints on the fingerprint reader. If the driver has pre registered his fingerprint with us then a slip at the In-Gate is automatically generated.

TRUCK DISPATCH PROCESS

IN GATE SLIP

- Once the Fingerprint is matched with our database 2 copies of Ingate slip is automatically generated. The Ingate slip contains the Name of the driver, License number, Vehicle registration number and Entry time. The driver collects the slip and moves on to the loading point.

LOADING POINT

- At the loading point our supervisor collects one copy of the slip & allows the tipper for loading.

WEIGH BRIDGE

- After the tipper is loaded it proceeds to the Weigh Bridge and the driver gives the 2nd copy of the Ingate slip to the operator at the Weigh Bridge. The weigh bridge operator generates the TP sheet from the I3MS software & gives it to the driver.

QR CODE SCANNER

- Once the Transit pass is generated at the weighbridge the QR code printed on the pass is scanned and all the data present in the Transit pass is captured in our software.

OUT GATE

- After receiving the Transit Pass the tipper proceeds to the Out gate. One more RFID reader is fixed at the Out gate. As the tipper goes the RFID reader captures the data from the RFID tag fitted in the Tipper.

VEHICLE EXISTS

- Vehicle Exits

Study of Load on Supports in Blasting Gallery Panels in Underground Coal Mines – Case Studies

Dr. Singam Jayanthu*, S Jayadarshana**

ABSTRACT

This paper presents an overview of support systems used in typical blasting gallery panels at GDK 8, GDK 10, And 21 Incline of SCCL. In general, the capacity of the hydraulic supports used in underground coal mines for the development and depillaring workings is about 40 to 50 tons. Vibrating wire type sensors have been predominantly used for the measurement of load on these supports. Maximum load observed on the supports is about 50% of the capacity of the maximum support indicating adequacy of the support system in the respective underground mines with adequate safety factor. Recent innovations and the need of wireless sensor networks for continuous online monitoring for load cells is also emphasized for better understanding of behavior of supports. The experimental set up available for testing and calibration of load cell in Mining Engineering department of NIT-Rourkela will be utilized for conducting the tests , and also for future developments of WSN system for real-time monitoring of load on supports for better safety of workings.

INTRODUCTION

Underground excavation of minerals causes disturbance in earth surface. Therefore mine strata needs to be supported by means of artificial support systems. These support systems are of two types; active and passive. Active support system consists of props, chocks, roof bolts etc whereas Passive support systems include mesh, straps, shotcrete, and steel sets etc. The active supports i.e. props, chock, roof bolt need continuous monitoring as these are of certain capacity. If the pressure coming upon the roof supports exceeds its capacity, it can cause failure of roof supports and this can lead to disturbance of roof which may also lead to roof fall. To avoid these accidents, condition of the roof supports should be monitored time to time with reference to the variation of load on the support at different stages of extraction of mineral. For this purpose, load monitoring of roof support systems is necessary. There are different types of props, such as hydraulic, friction, and wooden. According to load measurement arrangements, props are also classified as Open circuit and Close circuit Props. The images of various support systems used in Blasting gallery panel at SCCL mines are shown in Fig 1. Open circuit props are monitored using load measuring gauges. These are known as load cells. In earlier days there was no technology to monitor load on supports. It was done manually by observing visible changes such as crack on wooden props, subsidence of roof etc. It was an unhealthy practice as it could not predict the failure of the support system within a safe time period. Thus, there was a need for monitoring of load coming upon the support. This is why load cells were introduced into underground mine support system. There are different types of load cells, such as hydraulic, mechanical, strain gauge, vibrating wire type.

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OPERATION OF LOAD CELL

Vibrating wire load cells are very useful and give an important data when they are used in compressive load applications. These are available in three gauge wire or six gauge wire construction to eliminate positioning effect or tilt effect. The average of three or six independent gauge data provides very accurate load measurement. The three or six gauge wires are positioned at 120^0 spaced vertically on the periphery of a cylindrical stainless steel element of load cell. When a compressive load acts on the load cell, the gauge wire get compressed and tension in wire is reduced and at the same time the length of gauge wire. This changes the natural frequency of the wire. Vibrating wire readout model SME 2460-S provides a low voltage pulse signal to a magnetic coil near gauge wire, which in turn, makes wire to vibrate at its natural frequency. The readout selects the frequency corresponding to peak voltage produced in the coil being the resonant frequency. Readout unit indicates the signal in terms of frequency, time period, or load direct in units such as tons.

Fig 1: Support system in blasting gallery panel of a typical underground coal mine[Jayanthu, 2012]

Vibrating-wire transducers are used in many instruments, including load cells, deformation gauges, surface and embedment strain gauges, earth pressure cells, pressure sensors for piezometers, and liquid level settlement gauges[15]. The working principle of Vibrating wire load cells is well known. A highly tensioned wire is fixed between two flanges inside the hollow casing across the length. A coil is positioned almost near the middle of the wire. When this coil is energised by using some external source, the magnetic field generated plucks the wire and lets it vibrate in its resonant frequency reflective of the external force. These vibrations cause voltage fluctuations in the coil that corresponds to the vibrations. When stress or pressure comes upon the load cell, the tension on the wire changes as the two flanges are physically moved towards each other and this in turn causes small decrease in the effective length and tension of the wire. Thus the vibration frequency of the wire also changes. A vibrating wire type load cell is shown in Fig 2.

A read out unit is used to extract readings from the load cell. It provides a low voltage pulse signal to the magnetic coil which in turn causes the wire to vibrate at its natural frequency. The read out unit selects the frequency corresponding to peak voltage generated in coil being the resonant frequency. If continuous read out is needed then two coil vibrating wire transducers are used. One coil electronically plucks the wire and senses the vibration caused voltage fluctuations. This frequency is calculated. The second coil vibrates the wire at the same frequency. As frequency changes, so does the plucking frequency of the second coil.

The vibrating wire theory thus can be expressed as follows:

$$\square = \frac{\Delta\square}{\square} = \frac{4\square^2\square}{\square}\left(\square^2 - \square_0^2\right)$$

Where,
f= resonant frequency of wire vibration
ÄL= change in length of vibrating wire
L= initial length of vibrating wire
E= Young's modulus of the steel wire
ñ= volumetric weight of wire

Fig 2: Vibrating wire type load cell under calibration at Ground Control laboratory of NIT-Rourkela (Jayanthu, 2014)

There are three coils placed inside the load cell 120° apart. The reason behind this is when load comes upon the upper platen; it is not uniform throughout the surface. Thus reading should be taken from various parts of the surface and then averaged o get the accurate reading. For this study, the load cell has four different colour wires (red, yellow, green and black) coming out of it for measurement purpose. Red, yellow and green wires represent the positive end of the wires inside and the black one is the negative end. While taking readings every coil is connected to the read out unit one by one i.e. red-black, yellow-black and green black. Then the readings are noted down. If it comes in frequency or time period then it is multiplied by a constant named gauge factor to obtain the load reading and finally these three readings are averaged to obtain the final reading. Now-a-days, there are read out units available which gives load reading instead of frequency or time period. Fig 3 shows the readings being taken from a load cell installed on a hydraulic prop.

The read out unit used these days are microprocessor based. These are programmed to display the reading in frequency or time period or directly in engineering unit like Ton or kg/cm^2. It has a double line alphanumeric LCD, internal real time clock and battery backed 64 KB memory. It has two different ports for charging and interfacing with the sensor. Its weight is 1.5 kg approx. the readout unit sends a low voltage pulse signal to the magnetic coil which in turns makes the wire to vibrate at its natural frequency. The readout unit selects the frequency corresponding to peak voltage generated in coil being the resonant frequency.

LOAD ON SUPPORTS – CASE STUDIES IN BG PANELS Incline-SCCL

Thickness of Queen Seam is about 9.5 m with an average gradient of 1 in 12 towards S 39W with F grade of coal. Coal face mechanization in the panel consists of jumbo drills and remote controlled Load Haul Dumpers (LHD) loading on to chain conveyors in the levels. Geo-mining details of the panel are summarized below:

Depth of cover (minimum)	-	176 m
Depth of cover (maximum)	-	196 m
Thickness of seam	-	9.5 m
Width of the development gallery	-	4.2 m
Height of the development gallery	-	3.0 m
Length of the panel	-	960 m
Width of the panel	-	870 m

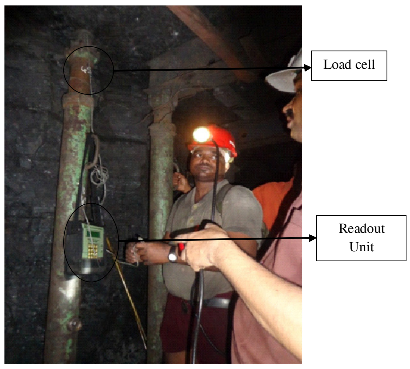

Fig 3: Reading of Load cell installed on hydraulic prop in a typical Underground coal mine (Jayanthu, 2014)

BG 3E panel was started on 23/02/2012 and was sealed during the month of April 2013. Earlier 30 pillars were extracted but later another 3 pillars were permitted for extraction (Fig 4). The total area of the panel was 30,107m^2 with 32m*29m size of panel. The support system in the district consists of I-section MS cross girders of 200 x 200 mm, set on 40 ton hydraulic props at each end. In each row there are two props and a girder, with a row spacing of 1.0 m (Fig. 1). Additional supports including chocks and props are being provided wherever required. W straps are used with 2.4m long roof bolts, Resin capsules arealso used for providing better support to the roof.

Hydraulic props of 40 T capacity were set at about 6 to 10 T in majority of the supports in the panel. Summary of observations of load on Hydraulic props are presented in Table 1. At station 67AL-(D1) the cumulative load has reached up to 10.15 T when it was nearly 10 m from the goaf edge, it was installed on 12th March 12 at about 20 m from the goaf edge. Maximum daily variation observed was 4.21T on 18th March 12 when it was 15 m from the goaf edge. Goaf sounds were heard when the cumulative load reached up to 10.15 Tons. Maximum daily variation of load observed at station 66AL- (F2) was 5.48 T when it was about 4 m from the goaf edge. At Load cell in 66AL-(F2), sounds were observed when the cumulative load reached up to 10.24 followed by stone fall on 25th April 12.Up to the end of August 2012, cumulative load reached up to 27.53 at station 65AL-(H4) when it was 3m from the goaf edge after which it was removed.On October 28 2012 after a natural fall on 21st October goaf sounds were heard when the cumulative load was 14.92 T, the maximum day load observation was also recorded on that day which was 4.33T at 13m GED. Up to the end of February 2013 maximum day load was observed to be 4.77 T with a cumulative load of 21.48 when it was 4m from the goaf.

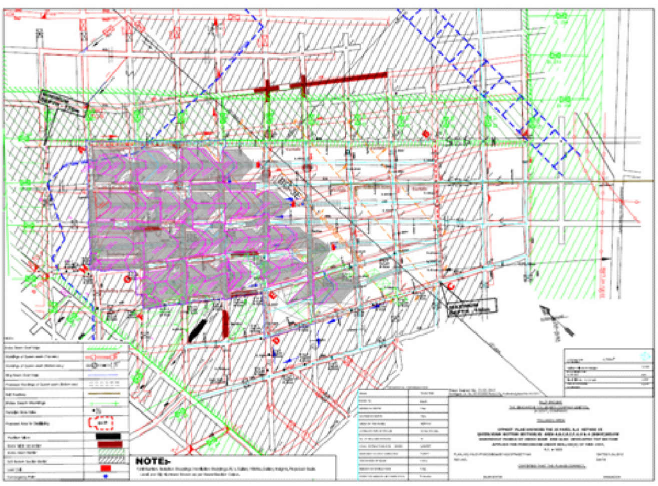

Fig 4: Blasting gallery panel in Queen Seam at 21 Incline-SCCL

Table-1: Summary of observations of load on hydraulic props— 21 Incline-SCCL

Location	Date of Installation with GED	Final Cum load (Tons)
67AL-(D1)	12-03-2012 at 20m GED	7.92 T, GED 2m on 03-04-12
67AL-(D2)	04-04-2012 at 29m GED	5.7 T, GED 5m on 13-05-12
67AL-(D3)	14-05-2012 at 28m GED	4.97 at 2m GED on 21-06-12
65AL-(H3)	14-05-2012 at 26m GED	6.69 T, GED 1m on 15-07-12
65AL-(H4)	26-07-2012 at 27m GED	26.33 T, GED 3m on 27-08-12
64AL-(J4)	22-08-2012 at 34m GED	13.02 T, GED 3m on 25-09-12
65AL-(H7)	12-09-2012 at 22m GED	7.04 T, GED 4m on 01-10-12
65AL-(H9)	01-10-2012 at 34m GED	23.4 T, GED 4m on 13-10-12
64AL-(J9)	03-12-2012 at 24m GED	4.1 T, GED 2m on 34-12-12
67AL-(D11)	30-12-2012 at 16m GED	35.51 T, GED 2m on 23-01-13
64AL-(J11)	19-01-2013 at 23m GED	21.48 T, GED 4m on 14-02-13
65L-(I2)	25-02-2013 at 16m GED	2.62 T, GED 3m on 06-03-13

GDK 8 Incline-SCCL

Godavarikhani No.8 Incline, existing in the southern extension of – South Godavari Mining Lease. It falls in RamagundamTaluq of Karimnagar District of Andhra Pradesh State. It lies between Latitude: 18 –50 and Longitude: 79^0 –28' & 79^0-35'.The 5.60 Sq.K.m of the leasehold is a strip of 68.48 Sq.KM leased area of South Godavari Coal Field, belonging to Singareni Collieries Company Limited. The Mine is approximately 20 KM from Ramagundam Railway station, 10 km from Central screening plant & Railway siding of GDK.No.1incline. It is 60 KM from Karimnagar and about 220 KM from Hyderabad by Road. South side GDK 10 & 10 A Inclines. North side Identified for OCP 2 Mine extension Block, Dip side part of OCP 2 & part of OCM 1-Extension Phase-II. The Gondwana series slightly dipping in North-Easterly consists here in the property the Barker and Talchirformation. The production was started on 1974 with the life time about 38 years and extractable reserves of 36 MT. The average daily production was consistently more than 1400 t, with good production records. Till now 24 B G panels were successfully. The gradient of mine is 1 in 8. The grade of coal is 'D' grade. Total number of seams encountered the area are seven namely – 1A,1,2,3B,3A,3 and 4seams, of which No.1,2,3 and 4 seams are considered to be workable. The strata within the boundaries are gently anticlerical in structure.

The support system in the district consists of I-section MS cross girders of 200 x 200 mm, set on 40 ton hydraulic props at each end . In each row there are two props and a girder, with a row spacing of 1.0 m. Additional supports including chocks and props are being provided wherever required. The split galleries are supported with 1.8 m long roof bolts with 1m spacing and row is 1.2m apart. Advance supports are installed up to 40m in all the rooms. Junctions are supported by two sets of skin to skin MS girders of 150mm x 150mm and supported by two No. of 40T hydraulic props on each side. In addition to the above cable bolting was done at 1.5m interval in grid pattern anchored up to a length of 1.0 m above the coal seam into sand stone roof. Corners and Sides supporting is being done with 1.5 m length bolts with 1m grid pattern whenever required. Fig 5 shows variation of about 22.8 ton load on hydraulic support in a typical working place of Blasting gallery panel at GDK-8 incline –SCCL.

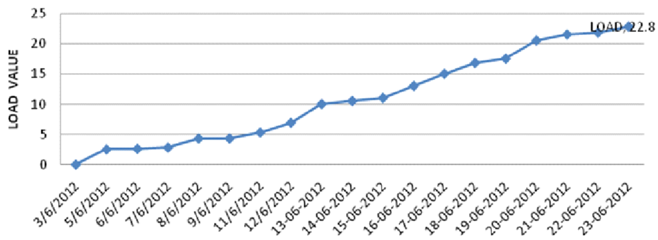

Fig 5: Variation of load on support in a Blasting gallery panel at GDK-8 Incline-SCCL

GDK-10 Incline-SCCL

About 30 nos of BG panels were extracted in GDK-10 incline producing about 7 Million tons of coal. Some of the particulars about the mine GDK-10 Incline are presented in Table 2. First Blasting Gallery method of extraction was introduced in SCCL in 1989 at GDK No.10 Incline and being worked successfully. Although, first BG in India was introduced in East Katras Colliery of Jharia Coal Fields, BCCL and Chora Colliery of Raniganj Coal Fields, ECL in 1987, the workings were abandoned in East Katras Colliery due to Strata Control Problem, and were discontinued in Chora Colliery due to premature Spontaneous heating problem. GDK-10 Incline mine falls in Godavari Valley Coal Fields of Singareni Collieries Company Limited and is situated in Andhra Pradesh. It was opened on 25-11-1976 with three workable seams viz., 3A Seam, 3 Seam and 4 Seam. The parting between No. 3A Seam and No.3 Seam is 40m and between No.3 Seam and No.4 Seam is 4.5 m to 5.5 m.

Table 2: Particular about the mine GDK-10 Incline

Extractable Reserve in the mines	13 Million Tons.
Area Of Lease Hold	40 Ha
Gassiness	I Degree
Grade Of Coal	D
Men On Roll	1342
Annual Target(10-11)	7,30,000T
Introduction of BG Tech.	1989
Total no. Of panels extracted	30
Production From BG Panels	70 Lakh Tons

The coal measure formations observed in borehole # 637 within GDK 10 Incline area indicated that the thickness of III seam is about 11 m with an average gradient of 1 in 7 towards N 23½° E. The strata overlying the coal seam are composed of coarse to medium grained sandstone with carbonaceous shale bands. Cavability studies of roof of III seam at GDK 10 incline and the underground observations in the previous panels (NIRM, 1999), indicated a Maximum cavability index of the roof of about 2915 in the overlying rock mass in the BG panel-I of Block-C. First major fall conditions are anticipated at about 50 to 60 m clear span in the goaf without presence of any ribs. Induced caving of immediate roof up to 8 m (i.e., bed with cavability index of 1616) allows the overlying roof with low cavability index to fall on its own at about 21 m clear span in the goaf. It will also give cushioning effect during first major fall with no perceptible dynamic loading. As per the records submitted by the management, the maximum area of extraction at the time of major fall was about 6,800 m^2. Minimum and Maximum period of extraction of a panel is about 5 months to 1 year 4 months. Minimum and maximum depth covers of the BG panels worked so far are in the range of 11 to 199 in Block A and Block B. Many of the above panels were sealed off/closed prematurely due to occurrence of fire. Minimum and maximum width/length of the panels was about 125 m and 250 m. Main fall area was in the range of 1282 to 6800 $m^{2.}$ Depth of Panels varied from 111 to 166 m in this block.In the above Block B, many of the above panels were sealed off/closed prematurely due to occurrence of fire/spontaneous heating. Minimum and maximum width/length of the panels was about 75 m and 180 m. Main fall area was in the range of 2885 to 6092$m^{2.}$ Percentage of extraction varied from 50 to 90 in the above block. In the Panel no 2D of the above block out of total reserve of 2,50,000 tons, 2,22,812 tons with percentage of extraction of 89, which may be considered as efficiently worked panel in the above block. Table 3, and 4 presents information about BG Panels of 3 Seam Block-C atGDK.N0.10inc, and details of working BG Panel No.3Aof No.3 Seam, Block-C, respectively.

Table 3: Information about BG Panels of 3 Seam Block-C atGDK.N0.10inc

Panel No.	Dimensions and Area m2	Panel Started on	Panel Sealed on	Period of extraction	Total Reserves (Tons)	Extracted Coal (Tons)	% of Coal Extraction	Area Extracted (m2)
1A	150 X 175 (26,250)	08-03-2000	22-12-2000	08M 14D	3,24,000	1,31,288	41	13,354
1B	150 X 160 (24,000)	12-02-2001	16-07-2001	05M 04D	2,26,575	80,242	35	7,345
2A	103 X 154 (15,862)	09-12-2001	29-06-2002	06M 20D	2,10,125	184,680	88	15,862
2B	113.5 x 150 (17,025)	29-07-2002	18-01-2003	06M 20D	2,30,850	1,43,542	62	12,987
2C	123 x 150 (18,450)	10-03-2003	30-09-2003	06M 20D	2,35,000	1,87,694	80	17,478
2D	125 x 150 (18,750)	06-02-2004	25-07-2004	05M 19D	2,27,772	1,41,634	62	11,704
2E	150 x 128.5 (19,275)	06-07-2005	08-02-2006	07M 02D	2,50,000	2,22,812	89	19,030
2F	121 x 150 (18,150)	16-02-2006	27-08-2006	06M 11D	2,36,000	1,77,000	73	15,537
1C-1	12387	11-10-2006	26-05-2007	06M17D		1,65,384		12,450
1C-2	13095	08-05-2007	02-11-2007	06M08D	5,94,484	1,79,889	84	12,042
1C-3	9816	05-07-2008	12-05-2008	06M29D		1,47,630		8,740
1D	120 X 150 (18892)	01-12-2008	21-07-2009	07M21D	3,05,156	2,30,464	76	18,800
1E	150X79 (11049)	17-07-2009	05-10-2010	012M22D	1,98,214	1,67,994	84	22,080

Minimum and maximum width/length of the panels was about 103 m and 150 m in the above Block C. Total area extracted in the BG panels of above block are in the range of 7345 to 22080 m^2. Percentage of coal extraction in the panels are in the range of 35 to 89. In the Panel no 2E of the above block , out of total reserve of 2,50,000 tons, 2,22,812 tons. The percentage of extraction was 89%, which may be considered as efficiently worked panel in the above block. Panel size in these workings is 150 x

128.5 m, and worked during 06-07-2005 to 08-02-2006 for a period of 7 months 2 days. Thickness of #3 seam is about 11 m with an average gradient of 1 in 5.5. The strata overlying the coal seam are composed of white sandstone with carbonaceous clay bands. Coal face mechanization in the panel consists of jumbo drills and remote controlled Load Haul Dumpers (LHD) loading on to chain conveyors in the levels.

Table 4: Details of working BG Panel No.3Aof No.3 Seam, Block-C

Incubation period	9 months
Overlying Seam	1 Seam goaf by 10A Longwall
Underlying Seam	4Seam virgin
Thickness of seam	11 m
Width of the development gallery	4.2 m
Height of the development gallery	3.0 m
Size of the Panel	150m x 120m
Area of the Panel	16000 m^2
No. of Pillars	6
No. of Rooms	9
Depth	
Average size of pillars	60 X 50
Gradient of the seam	1 in 5.5
Boundary	
North	3 seam virgin.
East	3 seam virgin.
West	3 seam 2A panel sealed off
South	3 seam bottom section B&P
Total Coal in the Panel	283000 T

The support system in the district consists of I-section MS cross girders of 200 x 200 mm, set on 40 ton hydraulic props at each end (Fig 1). In each row there are two props and a girder, with a row spacing of 1.0 m. Additional supports including chocks and props are being provided wherever required. The split galleries are supported with 1.8 m long roof bolts with 1m spacing and row is 1.2m apart.Advance supports are installed up to 40m in all the rooms. Junctions are supported by two sets of skin to skin MS girders of 150mm x 150mm and supported by two No. of 40T hydraulic props on each side. In addition to the above cable bolting was done at 1.5m interval in grid pattern anchored upto a length of 1.0 m above the coal seam into sand stone roof. Corners and Sides supporting is being done with 1.5 m length bolts with 1m grid pattern whenever required.

Observations of load on Hydraulic props by the end of August, 2011 is presented in Table 5. Hydraulic props of 40 Tons capacity are set at about 6 to 8 T in majority of the supports in the panel. At station L3-66AL the cumulative load has reached up to 6 T when it was nearly 8 m from the goaf edge, it was installed with a setting load of 5.35 T at about 19 m from the goaf edge. Maximum daily variation observed was 1 T on 24-08-11 when it was 13 m from the goaf edge. Load cell at station L4-66BL the maximum variation of loadwas recorded about 6 Tons.When it was nearly 13 m from the goaf edge. Maximum daily variation observed was 2.3 T on 29-08-11 when it was 15 m. At station L5-67BL about 4.5 Tons variation of load was recorded when it was nearly 3 m from the goaf edge, it was installed with a setting load of 9.8 T at about 18 m from the goaf edge. Maximum daily variation observed was 1 T on 02-08-11 when it was 15 m from the goaf edge of Max. load was observed when station was within 10 meters from goaf. Table 6 presents summary of observations of load on hydraulic props in 66AL (LOAD CELL- 3)

Table 5: Load Observation Up To The End Of The Month Of August-11

SL. No	Location	Cum load (Tons)	Max. change in	Stone fall details
1.	70L	2.957	1.107	Natural fall occurred on 10-08-11.
2.	68BL	2.457	0.870	Natural fall occurred on 03-08-11, 10-08-11 and on 30-08-11.
3.	68AL	2.190	0.907	Natural fall occurred on 10-08-11.
4.	68L	0.300	0.127	Natural fall occurred on 18-07-11 and on 29-07-11.
5	67BL	4.584	1.000	Natural fall occurred on 01-08-11, 03-08-11 and on 27-08-11.
6	67AL	3.947	0.783	Natural fall occurred on 01-08-11, 03-08-11 and on 27-08-11.
7	67L	4.120	1.237	Natural fall occurred on 12-08-11 and on 30-08-11.
8	66BL	6.147	1.560	Natural fall occurred on 17-08-11 and on 30-08-11.
9	66AL	6.057	1.033	No fall

Table 6: Summary of observations of load on hydraulic props in 66AL (LOAD CELL- 3)

DATE	GED m	GREEN Sensor	YELLOW Sensor	RED Sensor	AVG LOAD	DAILY VAR. LOAD	CUM LOAD
12-08-2011	19	13.12	4.81	-2.18	5.250	-	0
13-08-2011	19	13.40	4.98	-2.20	5.393	0.143	0.143
14-08-2011	19	13.89	4.62	-1.53	5.660	0.267	0.410
16-08-2011	19	13.95	4.68	-1.51	5.707	0.047	0.457
17-08-2011	19	14.08	4.79	-1.52	5.783	0.077	0.533
18-08-2011	19	14.25	4.95	-1.50	5.900	0.117	0.650
19-08-2011	17	15.92	3.61	0.78	6.770	0.870	1.520
20-08-2011	17	16.28	4.15	1.58	7.337	0.567	2.087
21-08-2011	17	16.16	4.44	2.19	7.597	0.260	2.347
22-08-2011	15	17.05	3.71	2.63	7.797	0.200	2.547
23-08-2011	15	17.47	4.10	3.88	8.483	0.687	3.233
24-08-2011	13	17.35	5.32	5.88	9.517	1.033	4.267
25-08-2011	11	15.85	7.19	6.93	9.990	0.473	4.740
26-08-2011	11	15.21	9.03	6.55	10.263	0.273	5.013
27-08-2011	10	15.87	9.64	5.72	10.410	0.147	5.160
28-08-2011	10	12.50	10.43	5.59	9.507	-0.903	4.257
29-08-2011	8	11.63	9.73	9.81	10.390	0.883	5.140
30-08-2011	8	11.66	9.78	10.98	10.807	0.417	5.557
31-08-2011	8	11.21	9.99	12.72		0.500	6.057

CONCLUSION

Following are the salient findings and conclusions on the basis of observation of load on supports during extraction of pillars by BG method in some of the panels at SCCL mines:

1. Vibrating wire type load cells are preferred as compared to strain gauge, hydraulic, mechanical types for monitoring load on the supports in underground coal mines. Maximum load on support in depillaring workings at 21 incline, GDK 8 incline etc of SCCL reached upto 30 Tons without any adverse strata or support conditions.
2. Maximum load on support and convergence of workings upto the end of August 2011 in BG panel #3A are 14 Tons, and 32 mm, respectively at GDK 10 incline. Maximum rate of convergence and load on support recorded was about 4mm/day, and 2 Tons/day, respectively in typical BG panel. In 67 Level maximum bed separation of about 10 mm was observed within 0.5 to 2.5 m horizon in the overlying roof. Goaf falls were regular with induced caving up to 1.5 m in Sandstone roof conducted for seven times till the end of August, 2011, and natural falls occurred with adequate filling.
3. Overview of performance of previous BG panels at GDK 10, and cavability of roof indicated that in near future, BG panels may be planned with panel sizes of about 120x120 m, so that the major fall with adequate span may occur at an area of about 8000 m^2. This size of panel may minimize the chances of premature sealing/closure of panels reducing chances of fires/spontaneous heating in subsequent BG panels besides goaf treatment with inert gas.
4. In general, readings of load on supports in BG method are taken manually once in every one or two days. Carrying the readout unit which is of approx 1.5 kg to every load cell and taking reading out of it is a tough job taking lot of time as well as requires a skilled person who can operate the readout unit. If the load cells can be digitized, monitoring of the load can be much easier , and continuous load monitoring is also possible. Thus digitization of vibrating wire type load cell for mine support systems is required in view of the requirement of online real time monitoring of load on supports for improved safety of underground workings. The experimental set up available for testing and calibration of load cell in Mining Engineering department of NIT-Rourkela will be utilized for conducting the tests , and also for future developments of WSN system for real-time monitoring of load on supports for better safety of workings.

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mrCloud: Cloud SDI Model for Mineral Resources Information Infrastructure in India

Rabindra Kumar Barik, Meenakshi Kandpal*, Arun B. Samaddar***

ABSTRACT

Spatial Data Infrastructure (SDI) is an important concept for sharing spatial data across the web. With cumulative techniques of spatial technology and cloud computing, SDI has the greater potential and has been emerged as a tool for processing, analysis and transmission of spatial data. The cloud computing is a paradigm where analysis is done at the top of the cloud computing environment from the edge of the client. This paper proposed and developed a cloud computing based SDI framework for mining analytics from spatial big data for mineral resources management in India. We built a prototype i.e. *mrCloud* framework which assimilate the entire mineral resources information and related locations in India. *mrCloud* framework can assist/help common people to get enough information for their further studies and research on mineral resources in India. QGIS is used for mineral resources geospatial database creation and visualization. With the integration of QGIS Cloud Plug-in, the mineral resources geospatial database uploaded in cloud server for analysis in cloud computing infrastructure.

Keywords—Cloud computing, SDI, mineral resources, overlay analysis

INTRODUCTION

Spatial Data Infrastructure (SDI) has facilitated by sharing and exchanging of spatial data holding by various stake-holders. It has initiated to create an environment which enables a wide variety of users to retrieve, access and disseminate spatial and related non-spatial data in secure way[1]. SDI has the capability for storage and decision making of spatial data, bringing data and maps to a common scale as per the user needs, querying, superimposing and analyzing the data and designing/ presenting final reports/ maps to the administrators and planners [2]. The utility of SDI for planning of environmental monitoring, natural resource management, health care, land use planning and urban planning, watershed management, marine or coastal managements [3][1], land information and decision making have become widely popular and are being used in different areas for a wide range of applications. SDI has became an emerging area in which it has the ability to integrate and analyze heterogeneous thematic layers along with their attribute information to create and visualize alternative planning scenarios for planners and decision makers. The user friendliness of SDI is a feature that has made SDI a preferred platform for planning in global, regional, national and local level coupled with various analyses and modeling functionalities. SDI integrates common spatial database operations such as query formation, statistical computations and overlay analysis with unique visualization and geographical functionalities[3][4]. These characteristics distinguish SDI from other spatial decision support systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes and designing strategies. By integrating SDI with cloud computing technology, it has been merged to perform a value added services that give rise to spatial cloud computing [9] [13] [18]. Spatial data have rich information about temporal as well as spatial distributions [14]. In traditional setup, we send the data to the cloud server where these are going for further processing and analysis.

The common components for the SDI Model, it has been divided into five vital components. All these five components are shown in Fig. 1. These five components are basically static and dynamic in nature. Accessing networks, policy and standards are coming under the dynamic components where as data and people are said to be static [10-12].

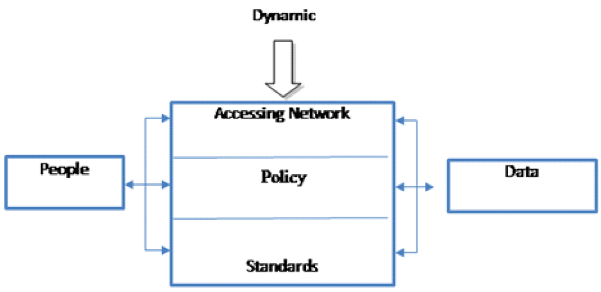

Figure 1. Five components of SDI Model, as data and people are static components, whereas, access network, policy and standards are dynamic components [13].

SDI Model is used in several applications including, but not limited to, resource management, healthcare, environmental monitoring and even urban planning. In addition, SDI has been integrated with database operations with overlay operations [2][11][13]. SDI has also served a significant role in water resource management, river basin management, mineral resources as well as coastal supervision inside which it has the unprecedented

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possibility to collect, distribute and evaluate all the hydrological figures, river basin related figures, coastal data and mineral figures (related to geospatial data) in a universal stand. For development of SDI model, it was integrated with cloud computing technology which added numerous services that gave rise to cloud SDI model [13]. Basic concept for the cloud SDI setup, it manages to send the geospatial data to cloud server for analysis and processing [14].

There are several open source software, plug-in and libraries are available meant for the prototype growth of cloud SDI model [12][10][2][3]. For enlargement of cloud SDI model, geospatial database formation is required. After designing of the database, geospatial web services are designed to validate the cloud model [3]. Thus, for designing and implementing of web services and database creations, it uses several open source GIS software [4][13][24].

So by adding cloud computing and SDI concepts, it provides best usage and perceive mineral resources information infrastructure network in a better way. The main purpose of this information network is to provide awareness among the people for proper management of mineral resources information in India. This has made the development and implementation of cloud SDI model a necessity.

Related works

Cloud computing provides an enormous amount of calculable possessions plus storage designed for the execution of different geospatial analysis. The cloud representation provides a changeover starting from desktop to quantifiable with numerous web servers. Cloud computing, along with other web processing architectures, have delivered a vast atmosphere on internet to distribute assets [6][13]. By integration of cloud with SDI, it delivers the Cloud SDI Model [5][7][8][13].

Likewise, Cloud SDI Model deploys multi-tenant design by allowing further clients to share resources devoid of troubling each other. This incorporated hosted provision methods are helping with application advancement and maintenance by installing patches for a better user experience. Several Open Source projects, with the aim of contributing to the society, are currently running on Cloud Computing platforms with different specifications and standards. Skygone Cloud platform and OpenGeo suite are operating in Amazon EC2 whereas QGIS is deployed and employed in the cloud for various Geospatial Web Services [17][18]. From these several reviewing of the research works, it summarizes that Cloud SDI Model can be implemented on mobile and thin client environment.

OBJECTIVE OF THE PRESENT STUDY

In the present paper, it has proposed the advance architecture of spatial cloud computing in mineral resources management sector. The mineral resources related spatial data has been processed at the edge. The present paper made the following contributions to mineral resources management:

- *mrCloud* framework is proposed for analysis and transmission of spatial data in mineral resources management sector
- Spatial data analysis scheme and overlay analysis in thin clients environment was performed using *mrCloud* Framework.
- It has performed a case study by doing overlay analysis of mineral resources management in India.

PROJECTED STRUCTURE FRAMEWORK OF MRCLOUD

The skeleton of *mrCloud* is separated into two main vital parts. The first and the most significant part is the cloud part in which mineral resources geospatial database is uploaded among the assistance of QGIS cloud plug-in [18]. Open Street and Google map that are basically data providers are used with the urbanized database for additional processing and investigation. For invocation of Web Feature Services, cloud server managed by QGIS Cloud supplier. QGIS Cloud supplier has been answerable for the organization of cloud layer. The second part i.e. client part is the part which has been categorized into three users for using the developed model. Fig. 2 has revealed the projected system architecture of the *mrCloud*.

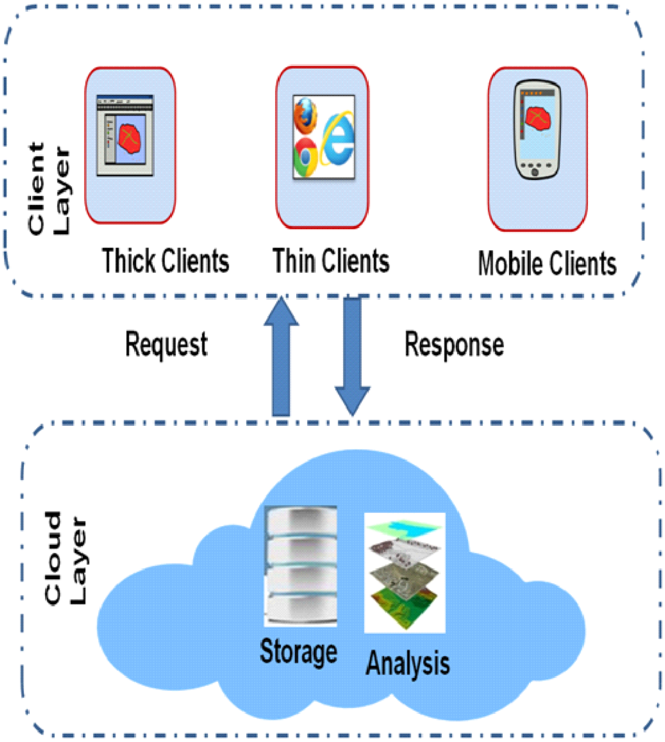

Figure 2. System architecture of mrCloud which has client and cloud layer. In client layers, it is categorized into thick , thick and mobile clients. In cloud layer, the geospatial data are stored and used for further analysis.

METHODOLOGY ADOPTED

In the commencing of geospatial catalogue, the chief accent is real-world advancement to broaden plus discover the essential of the cloud SDI model [20-21]. For the development of *mrCloud*, the multitasking and multiuser is united based on iterative model. Fig. 3 represents the entirely iterative model process for enlargement of *mrCloud*. In this model, it has gone through 3 iterative phases. In iterative phase 1, it dedicated for the geospatial database creations for mineral resources information in India. In iterative phase 2, it designed and developed the geospatial web services in cloud environment for over lay analysis in thick clients. For complete model development, it has completed in phase 3.

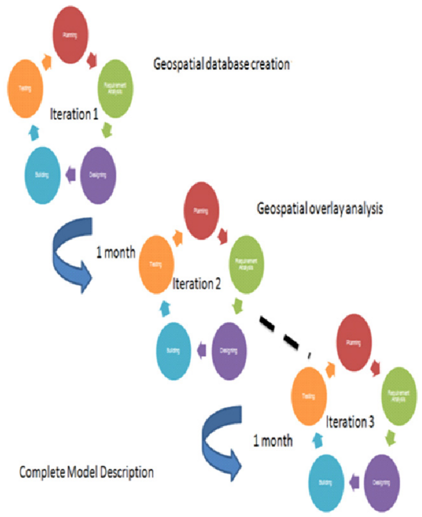

Figure 3. Iterative Model approaches for development of mrCloud

RESULTS AND DISCUSSIONS

The established cloud SDI Model for geospatial database formulation is intermittent and continual in nature, and each application upgrades strategically ladder wise during various appraisal and numerous testing of a built components. In built components, QGIS software is use to lay down the geospatial database creation used for mineral resources in India. In the present study, it uses Quantum GIS Ver. 2.14.10 for integrated geospatial data visualisation of mineral resources in India. At this point worldwide coordinate scheme WGS-84 with EPSG:4326 coordinate reference system are chosen in the visualisation of geospatial database. In Fig. 4, it has revealed the visualisation of mineral resources in India through QGIS thick client framework.

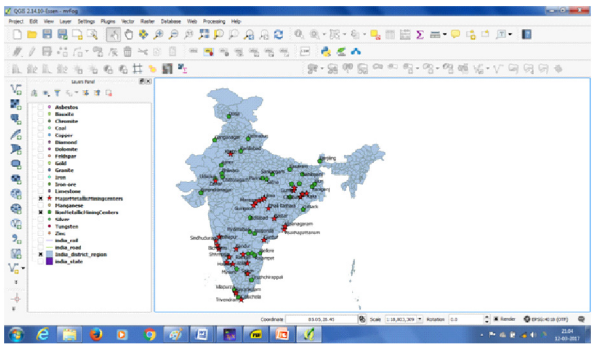

Figure.4. Overlay operation on thick client environment in Quantum GIS Environment.

CONCLUSIONS

The primary objective of this paper is to developed and validated *mrCloud*, which uses cloud computing gateway in Cloud SDI framework. The development of *mrCloud* augments the overall efficiency of processing of geospatial data, which in turn is beneficial to the decision makers/ end users in mineral sector. In order to analyze, the developed m*rCloud* framework, we have considered geospatial database of mineral resources in India as a case study. In future, it has planned to add more intelligence services in the developed framework particularly at cloud layer.

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Hazards of Battery – Don't Ignore

Dr.B.N.Sahoo

INTRODUCTION

In the recent past, we have come across the news of erratic battery blast incidents,be it in mobile phone, laptops, locomotive or Industrial batteries. As our interdependence on energy storage system increases so does the associated hazards with them. Batteries have the potential to be dangerous if they are not carefully designed or abused.

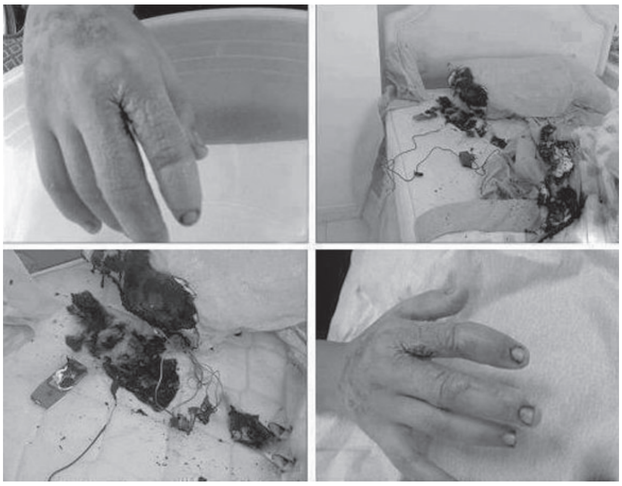

Figure 1 Mobile Phone Battery blast

An array of battery are available in the commercial market, and the range of products continue to increase. It is important to know the battery technology used by a storage system, and the technology associated chemical hazards. Depending on the battery technology, therewill be different risks when exposed to different externalities, e.g. overcharging batteries, puncturing of battery case, high ambient temperature. The resultant chemical reaction can cause severe property damage, loss of limb or life.

Figure 2 Laptop battery blast

The hazards associated with use of batteries is often not realised or neglected. The general notion that the batteries are small entities and can not create any harm is often proved wrong. It has led to series of catastrophic accidents.

In this paper an attempt has been made to bring awareness about the unforeseen hazards associated with battery use and certain precautionary measures. The accidents from battery burst can be avoided by following these simple procedures.

Hazards associated with batteries

In general there are four main hazards associated with batteries:

- Battery acid: The electrolyte in a battery is corrosive and can burn skin or eyes, creat holes in clothing, or even etch a concrete floor.
- Flammable gases: Batteries emit hydrogen gas, which is flammable. It ignites easily and can cause a fire or explosion if allowed to accumulate in a small area.
- Electrical shock: Many of us are aware of this danger because we may have seen sparks fly when jumper cables are attached to a car battery.
- Weight: Batteries, like those used in forklifts, are heavy and require proper material handling equipment to lift them safely.

Charging of batteries

Recharging should be done only in a location specifically designed for that purpose. The following features are needed:

- Adequate ventilation to disperse fumes given off during charging
- "No Smoking" area
- Elimination of open flames, sparks, welding, and electric arcs
- Fire protection equipment, such as fire extinguishers nearby
- Equipment and materials for absorbing spilled electrolyte
- Emergency shower and eyewash stations in case of an electrolyte splash

Figure 3 Car Battery Blast

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Safety procedures for charging & using the batteries safely:

- Be sure the proper charger is being used for the particular kind of battery.
- Check the vent caps are in place to prevent overflow and spilling of electrolyte.
- Shut off the charger when connecting or disconnecting the battery.
- After charging, allow the battery to cool down—it prolongs battery life.
- Never overcharge a battery—that's another way to prolong battery life.
- Bleeder valves should be checked regularly for choking.
- When charging deep discharged batteries, the current and charge level should be checked every hour.
- Battery charging procedure to be displayed near the battery charging area.
- Any kind of loose connection of the battery charging clamp must be avoided.
- To switch off the main source before removing the charging clamp of the battery
- To remove the positive terminal before removing the negative terminal.
- There should be open aeration near the battery charging bench/area.
- No metal pieces should be kept near the battery charging area.
- The battery charging device should be properly earthed and must be of recommended brand (with ISI certification)
- The plug and socket etc. should be checked for crack and loose connection to avoid generation as well as spreading of spark.
- Rubber matting on the charging bench to be done

To protect themselves when working with batteries, workers need to use the proper personal protective equipment (PPE).

- Wear hand gloves and safety googles/face shield before approaching the battery for any check or handling.
- Not to tamper with the terminals of the battery.
- Training on battery handling/ charging procedures to be imparted to maintenance personnel.

CONCLUSION

Every life, limb or equipment is important. Cases of loss of eye sight, burn injuries due to battery burst leave irreplaceable damage, scars for the whole life to repent. A small precaution, if taken in time can save us from this life long agony.

Let us be careful about batteries and save precious lives, limb or equipment.

Dr. B. N.Sahoo is basically a mining engineer having Post Graduate Diploma in Industrial Safety Engineering. He has Graduate, Master and Doctoral Degrees in Environmental Engineering. Dr. Sahoo has a number of publications in National and International journals to his credit. Dr. Sahoo is presently working as General Manager(Safety and Environment) in Oil India Limited.

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pictures help the organization to take action accordingly to prevent accidents.

Fig.8: E-Surveillance of railway siding with the CCTV cameras

INSTALLATION & COMMISSIONING OF OITDS

Operator Independent Truck Despatch System(OITDS) have been implemented successfully in 3 OCPs viz. Bharatpur OCP, Lingaraj OCP and Balram OCP.

DEPLOYMENT OF MECHANICAL SWEEPER

To reduce generation of airborne dust in the transport road, mechanical sweeper is deployed to clean the dust lying on the floor of the road.

Fig. 9: Mechanical Sweeper deployed at Lingraj OCP, Talcher

WAY FORWARDS

MANPOWER POOL

Initiative will be taken very soon to generate pool of vocationally trained manpower of local villages apart from industrial training. The trained drivers/operators can be hired by the contractors at the time of need.

SILO LOADING FOR ROAD SALE DESPATCH

MCL is thinking to startSILO loading of Road Sale trucks. This willrestrict the movement of trucks unnecessarily to load and unload due to under loading and overloading respectively thereby eliminating crowding of trucks to avoid accidents.

SAFETY App

Action has already been initiated to use SAFETY App in MCL.It will facilitate one to share safety aspects, to give suggestions for improvement of safety or to give the root cause of the incident/accident from anywhere.

DIGITAL DIARY OF STATUTORY PERSONS

Efforts have been made to write statutory diary/report online.

BIOMETRIC ATTENDANCE

Aadhaar based attendance monitoring with the help of National Informatics Centre(NIC) is being done in MCL HQ &area offices. Work is in progress to startAadhaar based attendance in all the units/projects within a couple of months.

USE OF UAV & SPACE TECHNOLOGY

Use of Drones or Unmanned Arial Vehicles(UAVs) can be introduced for various applications in mines.Trial has been done at Samaleswari OCP with students from IIT, Kharagpur.Guidelines for use of UAV from designated authority is awaited.However, satellite data is also being used for mine surveillance, mine plantation and land reclamation.

Fig.10: Trial of Drone at Samaleswari OCP by with IIT, Kharagpur

CONCLUSION

Since long, the technological initiative has been started for the sake of an Effective and Safe Management. But toachieve “Zero Harm Potential”, there is need of continual improvement in the TECHNOLOGY as an Initiative with Innovations for state of the art of Safety Management Approach.Therefore, there must be of all-out effort from all levels to promote R&D activities to have advanced technology to meet the forth coming challenges to ensure safety.

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Big Data Analytics as An Important Value Driver for Mining Industry

Suryanshu Choudhury

ABSTRACT

Today's digital transformation has dwarfed the past transformations among all the industry sectors. However mining industry is nowhere exception to this transformation journey. Big data analytics as part of this digital transformation allow the mining operations to reach new levels of performance from mine to market, across the whole mining value chain.These are increasingly recognized in the mining industry as value drivers. With the rise of concern on Big Data, the mining industry is undergoing a digital transformationin an effort to break through its traditional image and of course, improve its performance through innovation. This paper is based upon the application of big data analytics specific to mining industry as an important value driver. Due to the diversified operations involved in mining industry starting from the exploration to the actual mine operation a huge quantum of data is generated. These data need to be captured and analysed systematically for the system improvement.

Key Words: Big Data analytics, Digital Transformation, Mining.

INTRODUCTION

Traditionally, Mining organizations are willing to implement new technologies only if it can fetch some financial benefits. Organizations naturally put more emphasis on quantitative benefits as a clear measure of money generated or saved in comparison with the investment made, qualitative benefits are largely underestimated. However, companies had to face several challenges in the previous years which can be rooted to inefficiency in their operational processes. Commodity prices dropped to record lows, but the slow industry could not keep up with the pace of its rapidly changing market, and their expenditures did not decrease the same way either. Easily accessible mines are depleting, and safety concerns are also inthe centre of attention. Mining companies have to react to these events; they have to alter their businesses to face the new challenges through the digital transformation.

Digital transformationis about leveraging technology in order to improve existingprocesses and maintain profitability amid increasingly challenging market conditions.Big Data analytics as part of the digital transformation deals with the large volume of data related to mining operation on a close to real-time basis.In mining industry data analytics are used to monitor operational details of excavators, drills, dump trucks, undergroundshafts and mills, enabling mine managers to make real-time decisionsthat keep operations at optimal capacity.

Next generation mining capitalises on advancements in technology, such as integrated operation centres, integrated decision making using analytics and supporting performance management frameworks, provide an ability to identify improvement opportunities throughout the supply chain. Specialised software and bespoke applications can track the location and quality of materials and equipment performance.The most recent commodity boom resulted in high utilisation rates of equipment. Based on average lifecycles, it is estimated that one-third of the world's mining haul trucks need replacing. The most sophisticated mining organisations are already using analytics to aid planning, anticipate maintenance needs and prioritise their capital with more precision.

The mining sector must learn from other industries that have pioneered business-services models that integrate stand-alone services into multi-towered service organisations – resulting in end-to-end support. These models can be adapted for mine planning and customer order management, pricing and risk management.Integrated information systems will give leaders a stronger handle on the costs of mine management from site to site and among product groupings, which can identify room for improved practices, supplier rationalisation and scope for cost savings.Developing a strategy for next generation mining requires both an understanding of the challenges facing the industry, and a willingness to adopt an agile, integrated business model.Mining industry requires innovation to increase their bottom line, to be moreeffective in the exploitation.

BIG DATA

Big data has many definitions of which the most extensive one was written byFrank J. Ohlhorst: "Big Data defines a situation in which data sets have grown tosuch enormous sizes that conventional information technologies can no longereffectively handle either the size of the data set or the scale and growth of thedata set. In other words, the data set has grown so large that it is difficult tomanage and even harder to garner value out of it" (Ohlhorst, 2012).

Big Data Analytics is going to spur the next wave of

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efficiency gains in mining industryby enabling faster and better-informed decisionsat all levels. In a competitive market, every effort to improvemargins using operational intelligence isnecessary. That is why analytics is expected toplay a significant role in driving better assetutilization, boost productivity and addressmaterial flow delays. To achieve this goal,various types of sensors are embeddedacross the mining operations. These sensorsgenerate vast amounts of geoscientific,asset condition and operational data in real time.This data can be analyzed using parallelprocessing and faster distribution of intelligenceto stakeholders.It is possible to do this because modern Big Dataplatforms can assimilate vast amounts ofheterogeneous, real-time inputs from multiplesources. These, in turn, extract real-timepredictive and prescriptive analytics to driveoperational excellence.

CHARACTERISTICS OF BIG DATA

Big Dataencourages the analysts to take the complexity and diversity of the world intoconsideration when they examine the data sets instead of endeavouring to reachpunctual and perfectly accurate results from analyses made in an artificial andcontrolled environment.

Big data is messy with varied qualities and complex distribution. However,this imperfection is the property that reflects the real world the most, so it has tobe incorporated in the analyses. The theory of messiness is closely related to the important attribute of big data,namely correlation which is basically the statistical connection between two values. If one of thevalues changes, the chances are high that the other one will change too.

DIMENSIONS OF BIG DATA

There are four dimensions (4Vs) of big data: volume, velocity, variety and veracity (Ohlhorst).

Volume

Volume Refers to the vast amounts of data generated every second. If we take all the data generated in the world between the beginning of time and 2008, the same amount of data will soon be generated every minute in today's technological transformation. This makes most data sets too large to store and analyze using traditional database technology. New big data tools use distributed systems so that we can store and analyze data across databases that are dotted around anywhere in the world. It is observed that by 2020, we will have 50 times the amount of data as that we had in 2011. The sheer volume of the data is enormous and a very large contributor to the ever expanding digital universe is the Internet of Things with sensors all over the world in all devices creating data every second.

Velocity

Velocity Refers to the speed at which new data is generated and the speed at which data moves around. Technology allows us now to analyse the data while it is being generated (sometimes referred to as in-memory analytics), without ever putting it into databases.

The Velocity is the speed at which the data is created, stored, analysed and visualized. In the past, when batch processing was common practice, it was normal to receive an update from the database every night or even every week. Computers and servers require substantial time to process the data and update the databases. In the big data era, data is created in real-time or near real-time. With the availability of Internet connected devices, wireless or wired, machines and devices can pass-on their data the moment it is created.

Variety

Variety Refers to the different types of data we can now use. In the past we only focused on structured data that neatly fitted into tables or relational databases, such as financial data. In fact, 80% of the world's data is unstructured (text, images, video, voice, etc.) With big data technology we can now analyze and bring together data of different types such as messages, social media conversations, photos, sensor data, video or voice recordings.

In the past, all data that was created was structured data, it neatly fitted in columns and rows but those days are over. Nowadays, 90% of the data that is generated by an organization is unstructured data. These days data generated in many different formats: structured data, semi-structured data, unstructured data and even complex structured data. The wide variety of data requires a different approach as well as different techniques to store all raw data.

Veracity

Big Data Veracity refers to the biases, noise and abnormality in data. It is generally observed that most the cases the data which is being stored and analysed are not meaningful to the specific concern areas. Whenthere are millions of records, it is unavoidable that some of them are not relevantor not correct and would alter the big picture, which could lead to falseconclusions. Some examples are inaccurate sensor measurements or the lack ofcredentials in social media. One of the greatest challenges of big data analysis isto clean the data, remove uncertainty about its veracity

Big data is messy because it is formulated from the real world, and reflects itsmessiness. However, data can be generated in many forms, some of it in a morestructured way, than the others. Data is structured when it "has a predictableand regularly occurring format of data" (Inmon&Linstedt, 2015). Structured data is normally built on a deliberate structure; it is welldefinedand predictable. It is stored in relational databases in records, attributes,and indexes. Therefore, it is easier to analyze, run different queries on them,even if they contain millions of individual items (Inmon&Linstedt, 2015). Structured data is notnecessarily generated by people, in many cases; it is a result of machine logs,sensor data.On the other hand, unstructured data is more natural, typically text-heavy data. Itis "unpredictable and has no structure that is recognizable to a computer"(Inmon&Linstedt, 2015). It does not follow a pre-defined data structure orhierarchy that results in slower querying and data analysis. Examples ofunstructured data are books, electronic documents, recently social data, or the internet itself with its millions of web pages. However, pictures, audio, and videofiles represent data that is hard to process and organize, and they also belong tothis category.

BIG DATA ANALYTICS IN MINING

Big data analytics is increasingly gaining popularity in mining and many other industries. Due to developments in the economy and the mining industry over the past couple of years, the key focus has shifted back to reducing the cost of mining operations and improving efficiency. With every phase of a mining company' s value chain producing large amounts of data on a daily basis, big data plays a crucial role in achieving better decision making processes backed with business analytics and predictive analytics. However, in order to achieve these, mining companies need to identify how to manage the diverse range of the data at hand, which data to collect and how to prioritize it. They also need to create interfaces to make big data analytics possible to improve day-to-day operations. Big data can be used effectively to monitor mining activity in real time and thus help companies achieve competitive advantage. The use of big data basically large pools of data that can be brought together and analysed to discern patterns and make better decisions which will become the basis of competition and growth for individual corporations, enhancing productivity and creating significant value for the world economy by reducing waste and increasing the quality of products and services.

Data sources in the Mining industry may be classified as direct and indirect measurements. Direct measurement sources are those taken by instruments such as conventional geodetic surveys and GPS. Indirect sources refer to systems that collect data as a by-product of processes or operations such as Fleet Management Systems (FMS), supervisory control and data acquisition (SCADA) and blast hole drills data etc.

EXPLORATION

There is enough scope of applicability and utilisation of the Big data during Exploration. Mining area exploration can be enhanced by drones and data analytics. As it was mentioned,new mines are usually located in distant, remote locations, so it is a complicated andexpensive process to send out geologist professionals so they can take samples especiallywhen only a small portion of the attempts result in positive outcome. With the rise of usage of drones and high-resolution cameras, explorers can have an overview of the landscape fromabove, and they can process these recordings to generate a 3D blueprint of the area. This waythey can discover near surface mineralized structures under the soil, based on anomalydetection. After the initial findings they still have to take ground samples, but the pre-evaluationprocess dramatically increases the chances of locating rich mining fields. With these advancement companiescan save considerable time and cost while locating new mines, compared to traditional methods.

HEAVY EARTH MOVING MACHINERIES PERFORMANCE ANALYSIS

During the mining operation, heavy earth moving machines generate huge quantum of data like fuel consumption, cycle time, operation time, idle time, speed of operation, payload, engine rpm etc. on real time basis. There are many ways of capturing these data source like manual data capturing and automatic data capturing through some sensors by adopting some sort of systems like Fleet management systems and some other systems (Fig-1). Systematic and periodicanalysis of these data can very well depict actual performance details of themachineries. As these data sets are captured on real time basis, over the period of time for months and years the size of the data is a prime concern for the users. In this regard, for the purpose of storing, transferring and analysing purposes, cloud based approach adopted for the ease of accessibility.

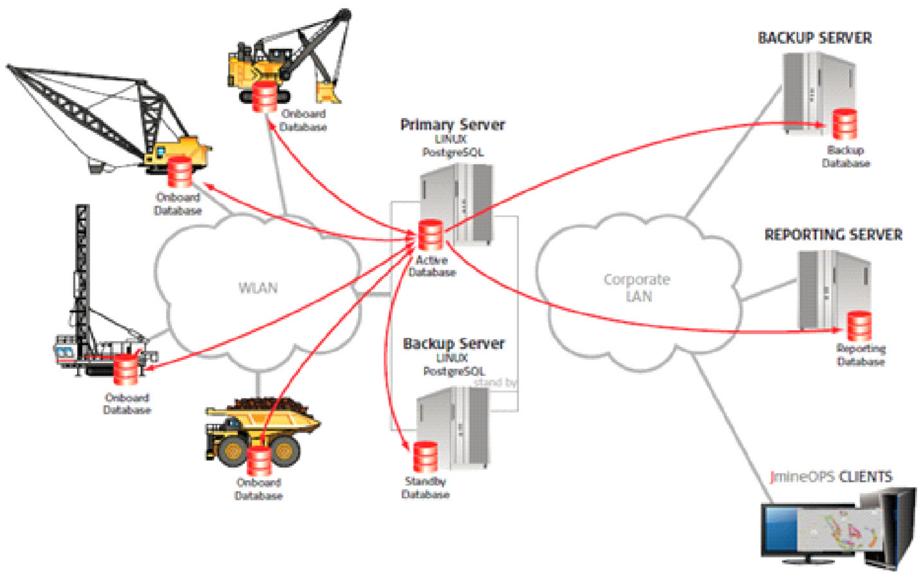

Figure-1: Data capturing through Fleet management system

Managing equipment is one of the most important aspects on a mine-site. Any down time, repairs, or poor logistical planning can have a huge impact on the efficiency and thus the profitability of a mine. Big data can shed light on equipment management to help miningoperators drive total efficiency. Furthermore, data such as tire pressure, scheduled repairs, faults and driver information (routes on site, speed, proper use) can all be captured,analyzed and mitigatory actions can be taken for the deviations.

SLOPE STABILITY MONITORING RADAR

Slope monitoring forms an integral part of slope management in Open Pit mines. Slope stability monitoring radar system developed on radar technology which is now used at most of the mines. This provides information for detecting potential unstable ground, assessing the performance of slope design which involves identifying any slope instability and/or failure mechanisms that develop. If the failure mechanisms are understood and the slopes are properly monitored, the risk of slope movement and the subsequent consequences can be considerably reduced. This allows for optimal mining conditions that are safe for mine personnel as well as working equipment. The radar sends lots of information to the server on real time basis which need to be critically analysed and interpreted.

The principle behind the software is to establish a grid of measurement points and to re-measure the grid periodically to look for differences in the position of the grid nodes (Fig-2). This system was designed to provide simple-to-use, reliable solutions with flexibility and performance to function in a wide range of monitoring applications.

SiteMonitors can be used to measure and monitor, deformation, long term trend of rock behaviour,stability of slopes and structures.

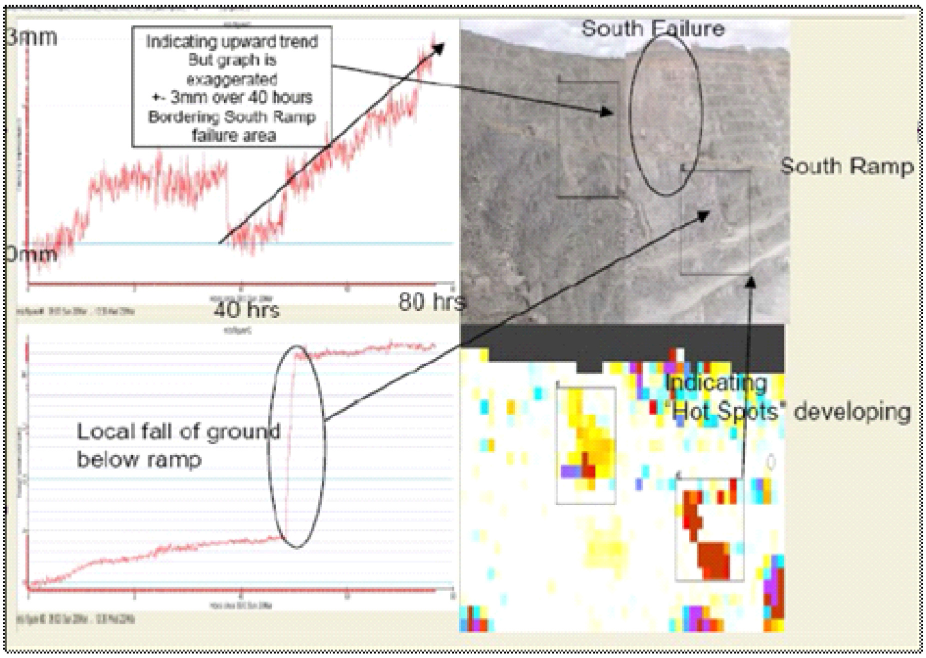

Figure-2: Output of Slope stability monitoring Radar.

IMPLEMENTATION OF BIG DATA ANALYTICS

When rolling out the use of big data its important that you consider the potential teething problems and stumbling blocks that could occur early on, such as legacy systems, IP and privacy aspects as well as storage and security challenges. Mining corporations also need to ensure that employees are fully equipped with the tools required to manage the volume, variety, velocity and value of data from across the business. Big data bring with it a wide variety of advantages, including the ability to utilize data to operate mines proactively rather than analyzing data and results from the past. However, in order to do this effectively the people on the ground need to be given a solid understanding about how to best define rules around how data gets procured, stored, maintained and used to achieve the best business outcomes.

The Mining industry can derive several critical business benefits from Big Data Analytics.

- Improve the operation of the equipment and machines.
- Ensuring continuous flow of material from ore extraction point to the processing plant.
- Reducing non-productive time between unit operations such as unscheduled maintenance, delays, wastage and waiting time.
- Helping management make informed decisions on the "as-is" production process, covering the value chain from extraction to delivery at plants and beyond
- Providing on the fly assay results and interpretation analysis to field geoscientists to take informed decisions

CONCLUSION

With the present competitive market, all the mining companies are forced to optimize their operations in order to reduce their cost of production for long term survival. Also due to the level of uncertainties and risks associated with the natural phenomena, mining industry has been witnessing several challenges since its inception.Big data analytics plays as an important value driver for the industry. This paper described briefly about the concepts,source and utility of the big data through which the industries can be benefited.Big data has the capacity to facilitating faster and more responsive business decisions based on business analytics and predictive analytics. Mining firms can use this information to predict market demand and optimize supply. Big data cannot only be used to control current operations, but also leverage to improve operations in the future. Mine site managers can get an understanding of the most productive site days and look into the conditions surrounding them. These conditions can then be replicated for greater productivity and efficiency in the future.Big data can help site managers collect more accurate and detailed performance information on everything from product inventories to sick days and therefore expose variability and boost performance. In fact, many leading companies are using their ability to collect and analyse big data to conduct controlled experiments to make better management decisions.

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  - National Aluminium Company (NALCO), Damanjodi, Orissa.
  - Essel Mining & Industries Ltd., Joda, Orissa
  - Orissa Mining Corporation, Bhubaneswar and Barbil, Orissa
  - Ultratech Cements at various locations.
  - Damodar Mangalji & Co Ltd.
  - Lafarge Cement (Arashmeta & Sonadih)

Raw Materials For Steel Plants in India ,Current Status, Quality Control, Quality Assurance ,Demands in Light of Emerging Technologies

GS Khuntia*

INTRODUCTION

The principal raw materials used in steel making are iron ore, coal, limestone and dolomite, while the other raw materials used in small quantities are manganese ore, kyanite, quartzite, bauxite etc. Raw materials constitute 40-45% of the total input cost in steel making and, therefore, any progress made in controlling the cost of raw materials fed to steel works as well as their specific consumption per tonne of hot metal produced, shall substantially affect the economy in steel making.

For improving the productivity in steel plants, the metallurgical process has demanded stringent quality of raw materials, improvement of processing and beneficiation techniques in the mines and adoption of new technologies like ore-bedding blending and screening facilities both at the mine and the steel plants.

Silica and alumina are the main gangue materials on Indian iron ore, limestone, dolomite and metallurgical coal and these constitute slag as much as 500 kg. per tonne of hot metal produced (now about 350 Kgs) . For producing steel at the lowest production cost, the consumption rate per tonne of hot metal production in respect of various raw materials should be aimed their lowest, in addition to producing lowest slag volume.

CONSUMPTION OF RAW MATERILALS

For production of one tonne of hot metal in the Blast Furnace, the following quantities of raw materials are consumed on an average, though the fingers vary from steel plant to steel plant in India and Table 1 indicates a comparison with Japanese steel mills.

Table 1

Raw materials	Qty per tonne of hot metal (KG)	Today Consumption Norm	Japanse steel mill consumption rate (kg)
Iron ore	1600-1700	1700	1600
BF Limestone	400	250	
SMS Limestone	150	110	200
BF Dolomite	120	100	Serpentine consumed
SMS Dolomite	60	50	
Coke	860	900 kg of Coking Coal	400

The Present consumption of raw materials as well as the projected consumption by the end of 15th h Plan (2025-30) as per NSP-2017 is as under The Projection of Steel Production as approved by PM is as under by 2031

-Crude Steel-300 MTPA (103 MT now)

-Iron ore-4 50 MTPA (160 MT now)

-Coking Coal—180 MT (Low ash-9%)

-Inverstment-10 Lakh Crores INR

-Time Period-15 years

Milestone years-2030

Since the iron content in magnetite deposit is low, around 35-40%, and it requires elaborate processing operation for enriching to a level of 64-65%, the cost of production of iron ore with 64-65% Fe is substantially higher compared to haematite deposit, where the operations are much simpler and merely by size reduction and washing it is possible to produce iron ore lump and fines for supply to steel works.

The five principal distribution zones of iron ore are as under:

Table 3

Zone	State
A	Bihar, Odisha
B	Bailadila, Rowghat and Dalli Rajhara of M.P. and Surajgarh of Maharashtra
C	Bellary & Hospet in Karnataka
D	Goa and Redi areas
E	Kudremukh, Bababudhan in Karnataka

Quality

Apart from large reserves, India has very high quality iron ore averaging 62-63% Fe. Though the ore from Bailadila is about 66% Fe, one of the best in the world. The quality of iron ore consumed in Indian Steel Plants is as under: (1970-2000)

Table 4

Steel Plant	Fe%	Today Quality	SiO2%	Al2O3%
DSP	60-62	62.5	2.5-3.5	5.5-6
IISCO	60-62	62.5	2.5	4-6
TISCO	63-65	64	SiO2+ Al2O3%	6%max.
RSP	60-62	62.5	2.5-3	4-4.5
BSP	62-64	63	3-3.5	3.25-3.75
BSL	62-64	63	1.4-3	4-5.5

* Former Executive Director (Operation), SAIL/ Director, NMDC/ Mining Advisor to ESSAR STEEL & JINDAL STEEL /Currently Director,IIMCS & Director,OMC Ltd / Chairman,MGMI-BBSR/VP-SGAT

Linkages

Most of the steel plants have captive mines in iron ore, limestone and dolomite sector, while cooking coal is purchased from Coal India Ltd. The raw materials linkage to various steel plants is furnished in Table 5 in next page.

These mines are linked to steel plants based on available information in the past on the prospecting of various iron ore and limestone / dolomite deposits. With the increased exploration efforts and information available now, a re-thinking will be necessary to rationalize the present linkages of the captive mines to the steel plants taking into consideration the proximity of such deposits from the steel plants and various other techno-economic considerations.

Steel Production

The projected hot metal capacity and expected production by the end of 7th Plan and estimated capacity by 2000 A.D. have been indicated in Table 2.

TABLE 5. Raw Material Linkage – Source to Steel Plants

Steel Plant	Iron Ore	Limestone		Dolomite	
		BF	SMS	BF	SMS
RSP	Baesua, Kalta	Purnapani	Satna	Birmitrapur	Baraduar
BSP	Dalli-Rajhara	Nandini	Nandini	Harri	Harri
BSL	Kiriburu Meghahatuburu	Bhavanathpur	Kuteswar	Tulsidamar	Bhutan
DSP	Bolani Barajamda	Birmitrapur Purnapani	Satna	Birmitrapur	Bhutan
IISCO	Gua, Manoharpur	Birmitrapur	Satna	Birmitrapur	Baraduar
TISCO	Noamundi, Joda	Birmitrapur	Satna	Gomordih	Gomordih
VSP	Bailadila	Jaggayyapeta	Badanpur	Machkot Kotmir	Karepalli

EXPLORATION & QUALITY CONTROL -

EXPLORATION AND FINDINGS

Exploration was conducted in SAIL IRON ORE MINES – Kiriburu /Meghataburu /Barsuan /Kalta /Bolani Mines /Dalli & Rajhara in Bhilai Steel plant for iron ore deposits for assessment of probable geological reserve, mineable reserve and grade. Exploration programme consisted of the following items.

i) Geological mapping (1.2,000)
ii) Core drilling
iii) Sampling of cores at an interval of 1 m
iv) Chemical analysis of samples

GEOLOGICAL MAPPING:

GSI/IBM did Exploration of Barsuan /Kalta for RSP , Rajhara & Dalli Mines for BSP . Kiriburu /Meghatuburu-5 MTPY Mechanised Mines , also Bolani Ores (DSP Captive Mine) were transferred to Bokaro Steel Plant on May/1977 & DSP by Restructuring of Steel Industry Bills passed in Parliament . I shall narrate about NMDC system in IRON ORE MINES

The Deposits were-North Block & Central Block in Singhbhum/Bihar) / South Block (Odisha) /Meghatuburu (singhbhum)-Separate Mine Planned-5 MTPY

By 1977, May month, Kiriburu (KRB) & Meghatuburu mines (MRB) were transferred to SAIL, Bokaro steel plant by virtue of "restructuring Bill of steel Industry passed parliament". As per that , KRB, MRB mines were truncated from NMDC & attached to Bokaro steel plant of SAIL. As a resulting this bill of parliament, me & about 160 Executives & about 2500 workmen were transferred from NMDC to Bokaro steel plant, SAIL on transfer term with our seniority & service conditions. Later on KRB & MRB mines were integrated to Bokaro steel plant, SAIL, became a past & parcel of Bokaro steel plant. Various HODS i.e. personal, finance, MM, IED, maintenance, mines operations of Bokaro started looking after various depts. Of KRB & MRB.

Regarding Exploration /Mines Planning/Quality control .Total Mining area , were covered by geological mapping in 1:2,000 scale , the surface exposures of the laterites, shale, BHJ and iron ores have been delineated in the map. The contour plan of the deposits have been prepared on the basis of survey in 1:2,000 scale and contour interval is 1 m.

CORE DRILLING:

(a) Explorary Drilling -Core drilling was undertaken at the interval of 200 m to 400 m basing on topographic condition and density of forest. Borehole points in each deposit is shown on the geological map. A total Explorary Drilling was done at a rate of 25 M/Million Tonne of RESERVE . Some Trenches /Adits were driven also/Samples taken /Analysed for the constituents Fe%. SiO_2%, Al_2O_3 %, TiO_2 %, S%, and P%. & FEASIBILTY REPORT PREPARED

(b) Detailed Drilling for Mine Planning –Done in grid Pattern of 100mX100m upto 100 m depth , A total of >10000m Drilling was done at a rate of 100-120 m/Million Tonne of RESERVE . Some Trenches /Adits >200m , Drifts .200m were driven to prove ore body continuity also/ Samples taken /Analysed for ORE CONTINUITY , Large no of TRIAL MINING EXCAVATIONS were done , Samples analysed in NML, Jamsedpur (Float & sink / Ore characterstics analysed / different ORE DRESSING TESTS done to decide FLOW SHEET OF PROCESSING PLANT (Crushing -3/4 stages / screening / Scrubbing /Classifier /Dewatering screens ,the constituents— Fe%. SiO_2%, Al_2O_3%, TiO_2%, S%, and P%. & DETAILED PROJECT REPORT PREPARED,RESERVE, Ore Types, Slice plans@ 12 meters computed –Each Bench/Slice shows -Reserve Benchwise say 10 MT ,Ore Types-Massive Hematite / Poreous Laminated / Lateritic / Blue dust / Reserve computed Bench wise for each ORE TYPE computed with OB Volume

(c) Resource Estimation / Cut-off grade / Strike width / Width of Bench / Weighted average and average grade / Tonnage factor / Core recovery % / Thickness of Ore Body / Strike influence or strike length / Dip length or width influence etc Computed

Iron Ore Feed-Product Mix

Iron ore feed in the Blast Furnace constitutes lump and ore fines which are agglomerated in the form of sinter or pellets. The earlier steel plants were designed for iron ore lump feed, while the recent plants like BSL/BSP/RSP/DSP/VSP are designed for utilization of agglomerated fines in the shape of sinter with improvement in steel technology. It has been broadly estimated that for every 1% increased use of sinter, it raises the output by 3.5% and coke consumption is reduced by 3%. This has resulted in progressive increase in the use of sinter in the Blast Furnace burden today to achieve high productivity and cost efficiency. In Japanese Steel mills, which are known for their high efficiency and low cost of operation, the average feed constitutes about 80-90% of agglomerated fine, which comes to about 70-80% sinter and direct lump ore consumption ranger from 20 to 25% only.

The proportion of lump and sinter used as well as sintering facilities in Indian steel plants is given in Table 6.

TABLE 6

Plant	Lump%	Sinter%	Annual installed capacity (MT)
IISCO	100	0	-
DSP	70	30	1.52
TISCO	60	50	0.80
BSP	60	40	3.37
RSP	60	40	1.20
BSL	30	70	4.10
VSP	20	80	-

Although there are three pellet plants i.e. Noamundi Mine of TISCO, Chowghule & Co. at Pale, Goa, Mandavi, Goa and one pellet plant of 3 MT annual capacity at an estimate cost of Rs. 107 crores is approaching completion at Mangalore for utilizing Kudremukh iron ore fines for agglomeration, pellet making in India is not finding popularity due to high costs and non-availability of inputs like furnace oil and electricity.

Ore Preparation

In present day Blast Furnace practice, ore preparation plays a vital role in productivity of Blast Furnaces requiring intensive beneficiation and materials handling process for achieving the following advantages:

- Increasing iron content
- Removal of gangue / undersize material
- Meeting close size requirement
- Homogeneity in chemical composition
- Agglomeration of fines for improved economics in iron ore mine working.

Quality

For 1% increase in Fe, there is 1.25 - 2.5% decrease in coke consumption, 25-30 kg reduction in flux consumption per tonne of hot metal. In Japanese practice, the Al_2O_3 in the iron ore feed is restricted at 1.8% (max) and critical values are stipulated for S.P, Alkalis etc. In Soviet practice, by suitable raw material preparation it is possible to restrict feed with Fe variation 0.15%, SiO_2 & Al_2o_3 variation 0.33% resulting in saving coke consumption rate by about 4%. Iron ore consumption per tonne of hot metal average to 1700kg, both in form of lump and fines.

Size

The size of the lump and fines in integrated steel plants in India at present is 10–40/50 mm and 100 mesh – 10 mm, while in the Japanese plants it is 8-30 mm (3% reduction in coke consumption is achieved). The present trend world over is to have a ratio of top size : bottom size lump ore = 3:1 (preferably 8.25 mm). Bhilai, Bokaro and Rourkela Steel Plants have decided to reduce the iron ore lump size to 8-30 mm.

Sinter Feed

For achieving maximum productivity and minimum cost in steel products, in Japanese practice the sinter charge in Blast Furnace varies from 70-100 % with – 100 mesh iron ore fine 40% tolerance, whereas in Indian plants such tolerance is less than 10%. This has resulted in restriction in use of high grade iron ore fines “Blue Dust” known to be very rich in Fe% but with 200 mesh size. Experiments in TISCO plant could establish the use of blue dust upto 30% in sinter and similar

- results have been achieved in experiments conducted by Research & Development Centre, Ranchi for utilizing 200 mesh microfines to about 20% with or without addition of lime in sinter making in case of Barsua Iron Mine of Rourkela Steel Plants.

Undersize Tolerance

For achieving reaction and gas permeability 5 mm tolerance in lump ore is targeted at 1% and at 3% in sinter feed in Japanese steel mille, while such tolerances are much higher in Indian Steel Plants.

Reduction / Degradation Index

The index in Japanese steel mill is as under :

RDI	Lump	Sinter
At – 5 mm	90% max	40% max

Similarly decrepitating ore is not used in Blast Furnace and in case of lump ore, decrepitating index (5 mm at 3%) is insisted on in Japanese plants.

Ore Preparation with Washing & Wet Screening

For achieving the desired proportion of lump and fine and improvement in quality and for supplying close range calibrated size products, most of the mechanized iron ore mines attached to steel plants have introduced multi stage crushing screening and a few with washing facilities. The grade of the ore washed in some of the plants is furnished at TABLE 7.

TABLE 7

Mine	Product	Quality			Size
		Fe%	SiO_2%	Al_2O_3%	

In order to cater to the need of lumps at 8-30 mm, it will be necessary to introduce tertiary crushing screening facilities with wet process in most of the captive mines attached to steel plants very shortly.

Blending of Ore

Three or four benches are operated at a time for feeding ROM ore in the quarry to the crushing screening plant for achieving the above objective. In order to supply uniform quality ore most of the mines have provided or are planning to provide the following facilities:

- Rigid quality control in mine operation by operating 3-4 benches at a time.
- Adequate provision of blending and stockpile with facilities for stacking and reclaiming before dispatch at mine head.
- Adequate provision of stockpile with modern blending arrangement in the steel plant in the form of stacker and reclaimer.

The desired level of quality control is achieved through:

- Adequate core drilling to realize the desired level of accuracy in ore reserve estimation and computerized ore body modeling with mine production planning.
- Implementation of such production scheduling through effective dumper dispatch programme from individual mine bench and adequate sampling and monitoring arrangement.
- Adequate stockpiling facilities by provision of stacker / reclaimer for providing ore with uniform chemical and physical characteristics, provision of ore bedding and blending facilities in the steel plants with stacker / reclaimer and provision of block rake system of 4500/ 7500 tonnes utilization of micro fines / Blue Dust.

The Blue Dust constitutes 6-10% of the total reserves of iron ore and is very rich in Fe content, but conforms mostly to 100-200 mesh size. By washing process most of the blue dust will be lost to tailings disposal system and therefore dry circuits have been provided in some of the mechanized iron ore mines like Barsua / Dalli / Kiriburu Meghahatuburu. For achieving maximum economics in the ore production and for conservation of mineral resources it is desirable that such products re utilized in sinter making by addition of lime in the sintering process.

LIMESTONE

The consumption of limestone both of BF and SMS grade as at present and future is as under

1984-85	5.00MT
1989-90	8.00 MT
2000-AD	16.00MT

The reserves are 6300MT for Blast Furnace grade and 1000 MT for SMS grade.

Table 8 indicates the captive mines, existing capacity, the reserve of ore and fluxes and quality of ore and fluxes supplied.

Linkages

Most of the steel plants except TISCO/IISCO/DSP, which receive their suppliers of BF grade limestone from Birmitrapur, have their own capacity mines and linkage has already been furnished in Table 8. Similarly, BSL / RSP/ BSP have their own captive mines for supply of SMS grade limestone but they are self-sufficient to about 60-70%. Expansion programme, through introduction of mechanized mining and crushing-screening facilities, is being planned for Kuteswar (1.5 MT finished product per annum) and ILQ, Santa (7 lakh tonnes per annum) and Nandini Manual Mine / Shahpura Limestone Mine (2.5 lakh tonnes per annum).

Since good quality of SMS grade limestone cannot be achieved by mechanization in quarry as it will result in dilution of the feed to the crushing-screening plant, it is planned to introduce 50-300 mm boulder to be produced in the quarry manually and feed the same by mechanized transport to crushing-screening plant to achieve a close range product with undersize/oversize limited to 10%. However, in the area of limestone, both BF and SMS grades, though the present size is 25-75mm except BSL (30-60mm), most of the steel plants are planning to introduce 10-50mm size limestone. The balance quantity of SMS grade limestone is purchased from sources at Katni/Jukehi/ Santa/Rewa area from M.P.

Constraints

Inadequate SMS Grade Reserve

Except Kuteswar deposit the reserve of SMS grade limestone in the country is quite limited Systematic exploration is required in under mentioned areas where SMS limestone with SiO2 less than 1% has been reported.

a) Himalayan occurrences in Dehra Dun and Tehri districts of Uttar Pradesh, Himachan Pradesh and Meghalaya.
b) West Rajasthan

Quality – High Silica in SMS Limestone

SMS lime stone supply from M.P. is characterized by high silica of about 3% compared to standard practice of 1% silica in SMS limestone used in Japanese mills. It is, therefore, necessary to identify and develop sizable supply of this SMS grade limestone.

Small Manual Quarries

As the SMS grade limestone requirement is not very large, manually operated quarries are developed as captive sources s well as in the non-captive sources. Due to engagement of labour on contractual basis in non-captive sources, the supplies are very often disrupted due to industrial relation problems.

Wastage of Fines

The undersize i.e. – 25mm fraction that will be generated in the process of crushing screening, will constitute as much as 30% and therefore will pose a problem in the economics of mine working unless it finds a suitable market in neighbouring cement industries.

Similarly BF grade limestone I often associated with SMS grade limestone and therefore dispatch of this BF grade limestone should also improve for economic working of such SMS deposit.

Recommended Steps

a) Development of one or two large capacity (1.5 – 2 MT product per annum) mines in M.P. by mechanized means for ensuring supply in quality and quantit

b) Identification of superior grade i.e. low silica deposits in Himalayan Belt for supplying to different steel plants for blending with the existing supply of SMS grade limestone.

c) Studies to be undertaken for improvement in quality of SMS grade limestone from M.P. through proper processing.

DOLOMITE

Consumption

The consumption of dolomite is about 2MT per annum in the Steel Plants both in the process of steel making and for refractory purposes. The norm of consumption of dolomite varies from plant to plant with 50-200 kg of BF grade and 40-60 kg of SMS grade dolomite per tonne of hot metal produced.

Reserves

Reserve of BF grade and SMS grade dolomite is about 1426 MT (updated to 1976) distributed in three zones in the country as shown below.

	Zone	Total Reerve (MT)
A.	Bihar & Odisha	581.25
B.	Central India & A.P.	525.01
C.	Karnataka, Tamil Nadu & A.P.	202.87
	Total	**1309.13**

SMS grade dolomite is produced and supplied from captive mines of Steel Plants at Baraduar (RSP), Hirri (BSP), and Tulsidamar in a limited quantity (BSL), while BF grade dolomite is supplied to the steel works from non-captive sources at Birmitrapur and other captive sources like Tulsidamar (BSL) and Gomardih (TISCO).

Quality

The desired specification of dolomite for consuming industries in India is as under:

Industry / Gr.	CaO+ MgO%	MgO%	SiO_2%	A.I%
	(Min)	(Min)	(Max)	
Blast Furnace / Sinter / Pellets	48	18	4	8
Steel Melting Shop	50	20	2	4
Refractory making	52	22	1	2

A number of areas of refractoris has been identified by a Technological Planning Committee and RDCIS, Ranchi, SAIL, has taken up a few works in the areas of refractory for development of tar bonded dolomite bricks and high alumina refractories which will increase the life of convertor lining considerably and reduce the shut down period. Except for BSP, other Steel Plants meet their shortfall in production of SMS grade dolomite in their captive mines from Baraduar area where in addition to RSP mine, another 2 – 3 private mines are in operation as well as from Bilaspur area.

Utilisation Planning

While Baraduar, Hirri and Bilaspur area are meeting the major requirement of SMS and refractory grade dolomite, the reserve being limited, additional exploration is necessary in Bhutan / Jayanti and Dehra-Dun area, known to have huge reserve of low silica superior grade dolomite. Mining operations in Dehra-Dun both for low silica limestone and dolomite is suspended due to environmental problems. But some steel plants (BSL,RSP, TISCO) are getting low silica dolomite from Bhutan/Jayanti. The grade of low silica dolomite lump as compared to that supplied from Hirri/ Baraduar is as under:

	CaO%	MgO%	SiO_2%	R_2O_3%	A.I%
Hirri / Baraduar	**29-30**	**20-21**	**2.25**	**1.5**	3-3.5
Jayanti / Bhutam	**30**	**21**	**1.0**	**1.0**	2

Detailed exploration is necessary in the deposits as Jayanti/ Bhutan. Although there are indication that these deposits are quite expensive and have vast potential, SAIL, with WBMDC is jointly developing infrastructure facilities for developing mines at Jayanti. Visakhapatnam and Vijaynagar Steel Plants are planning to obtain dolomite from Khamam and Bagalkot area respectively.

Constraints

Small Manual Quarries

As the requirement of dolomite is comparatively small, captive mines of lower capacity are attached to Steel Plants and the shortfall in supply is met from non-captive sources having very small capacity mines with contact labour

-With the prohibition of contract labour engagement in mining operation, this is causing serious problems in the operation of such small manual quarries in the private sector and even in public sector.

Therefore, a comprehensive programme for development of dolomite mines with adequate high capacity of production with the concept of boulder mining (50-30 mm size) and mechanized crushing and screening facilities will go a long way in orting out the above problems for regular and consistent supply, both in quantity and quality in steel works.

Undersize

A lot of undersize (-40/- 25 mm) to the tune of 20-25% us currently not having a market, thrown as waste and affecting economy in dolomite production. Therefore, alternative utilization of undersized dolomite in sinter making and in other industries may improve dolomite mining economy.

Recommended Steps

Through opening a large capacity mechanized mine to solve the above constraints: It may be better to have 2 – 3 mines having higher capacity of more than one million tones product per annum, opened at Hirri / Baraduar / Tulsidamar area with boulder mining for feeding dolomite boulder of specified quality for crushing and screening.

By this, it will be possible to supply good quality as well as quantity of both BF grade and SMS grade dolomite from Tulsidamar / Hirri / Baraduar to steel works.

STRATEGIES FOR FUTURE DEVELOPMENT

Problems in Quality of Flux

Sizing

Sizing of flux material is a major problem and steel plants even with sintering fcilities are hesitant to purchase fines from the mines because of fear of contamination and high percentage of insolubles. It is necessary to carry out systematic study to overcome this problem so that both lump and fines can be produced in respect of limestone as well as dolomite, both of BF and SMS grade, so that flux material can be produced and supplied to steel works economically. Solution to this lies in boulder

-mining as well as crushing and screening facilities and utilization of lump as well as fines.

High Acid Insolubles

High acid insolubles in fluxes are causing serious problems. Blending in a limited way in steel works is a short term solution while long term solution calls for detailed exploration and development of low silica limestone as well as dolomite – Dehra Dun, Mussoorie, IP for lime stone and Jayanti / Bhutan, Khamam for dolomite so that such fluxe of superior grade received from distant places can be blended with existing supplies from the captive mines for effective blending and enrichment.

Costs

Preparation of ore and fluxes to meet the stringent physical and chemical parameters at the steel works, requires installation of sophisticated facilities at the mines, employment of highly skilled personnel and other inputs. Although quite a lot of work has already been done in this area, it is very important that much more inputs are required to be fed in the captive mines of the steel plant for better preparation of raw materials with reasonable increase in additional cost for achieving greater benefits that flow out of the use of better prepared raw materials. In respect of raw materials that will be fed from non-captive sources, a system of consultation, inspection, element of prices related to specific improvement etc. and increase in the cost within a reasonable limit can be introduced.

Organisation

Modern Blast Furnace technology practices demand better prepared are and fluxes so that efficiency and productivity of Blast Furnace is determined more on what is done on raw materials outside the Blast Furnace than what is done on the raw materials inside the Blast Furnace. This calls for highly competent management to ensure consistency in chemical and physical specification of the ore and flux as well as good measure of flexibility to meet the changing needs and to give opportunity for blending of ore and fluxed received from other sources when necessary.

SAIL has already created an organization RMD, for expansion of mines , controlling guiding operation for carrying out innovation, allocation of resources for operating

TABLE 8

Steel Plant	Captive Mine	Existing Capacity (Finished Product) (MT)	Reserve (MT)	Quality	
				Chemical	Physical (Size)
Bokaro Steel Plant	Kiriburu Iron	4.25		Lump: Fe-63%	10-40mm
	Ore Mine		340		
	Meghahatuburu	4.30	120	Lump: Fe-61.6%	10-40mm
	Iron ore Mine			Fines:Fe-62% SiO_2-3% Al_2O_3-5-5.5%	+100mesh-10mm
	Bhavnathpur	1.45	100	CaO-42%	25-80mm
	Limestone Mine (BF)				
	Kuteswar	0.40	93	CaO-50%	30-60mm
	Limestone Mine (BF)			TI-5% (max)	
	Tulsidamar	0.60	20	MgO-21-16%	25-80mm
	Dolomite Mine			CaO-31-32% SiO_2-1.2-4%	
Rourkela Steel plant	Barsua Iron Mine	2.01	139	Lump: Fe-61% Al_2O_3-4% SiO_2-2.5%	10-50mm
				Fines: Fe-60% Al_2O_3-4.5% SiO_2-3%	+65 mesh-10mm
	Kalta Iron Mine	2.0	102	Lump: Fe-63%	10-50mm
	Purnapani Limestone& Dolomite Quarry (BF)	0.62	30	TI-11+-1% CaO-44%	25-50mm (+50mm 10% max)
	Ispat Limestone Quarry, Satna (SMS)	0.3		TI-5.5% (max) CaO-50%	40-80mm
	Ispat Dolomite Quarry, Baraduar (SMS)	0.24	65	TI-5% (max) MgO-20%	40-80mm

TABLE 5 Ore Processing Scheme of Some Major Iron Ore Mines.

Sl. No	Mine	Dry screening process	Washing process: Wet screening/ classification	Washing process: scrubbing/ Wet screening/ classification	Washing & gravity separation process/jigging	Magnetic separation process (spirals)
1.	Barsua	*			*	
2.	Bolani			*		
3	Bailadila – XIV		*			
4.	Bailadila – V		*			
5.	Daitari		*			
6.	Donimalai		*			
7.	Dalli	*		*		
8.	Gua	*				
9.	Kiriburu			*		
10.	Kudremukh					*
11.	Meghahatuburu	*	*			
12.	Noamundi	*		*		
13.	Rajhara	*				

TABLE 6 Size Requirement of Fluxes in Steel Industry

Name of the plant	Size of flux (mm)	Source	Immediate size of lump (mm)
BSL	25-80	Bhavnathpur (BF limestone)	25-50
	30-60	Kuteswar (SMS limestone)	25-50
	25-80	Tulsidamar (BF limestone)	25-50
RSP	25-50 (+60mm-10% max)	PLDQ: Purnapani (BF limestone)	20-40
	40-80	ILO-Santa	25-50
	40-80	IDQ-Baraduar (SMS dolomite/Purchase source)	20-40
BSP	10-50	Nandini Limestone Mines (BF limestone)	20-40
	50-100	Nandini Manual Mine (OH/RMP Grade limestone)	20-40
	50-100	Hirri Dolomite (SMS dolomite)	20-40
DSP	25-75	Purnapani/Birmitrapur (BF limestone)	25-50

Wet High Intensity Magnetic Separation

Tests done at laboratory and pilot plant scale have shown that iron ore slimes from Barsua mine containing 70% of the material below-200 mesh (74 micron) and an iron value of 48% could be upgraded to 63-65% Fe with decrease in alumina to 3.2% from an initial value of 14% in the feed. It is planned to install two machines of 120 tph capacity at BIM to treat the tailings of the ore washing plant. The recovered iron value has been found to be eminently suitable for assimilation in the charge mix if sintering plant of Rourkela Steel Plant.

ELEMINATION OF RAW LIMESTONE FROM BF BURDEN

Charging raw limestone in the burden adversely affects the thermal requirement of the process. Theoretical calculations show that approximately 0.33% kg of coke can be saved from every kg of raw limestone when removed from the burden.

Use of Superfines in Sintering

Already brought-out earlier

Use of Metallurgical Wastes

Use of SMS convertor slag for sinter making could save consumption if limestone to a great extent.

Modification Necessary in Existing Crushing and Screening Facilities in Limestone and Dolomite Mines

In view of lowering the sizes of fluxes from present level of 25-80mm / 30-60mm to 20-40mm / 25-50mm for achieving higher productively, modernization measures are necessary to be introduced in existing crushing and screening facilities in limestone and dolomite mines by introduction of tertiary crushing and screening with close circuit recirculation arrangement. Besides, wherever manual sizing is d one, this

BENEFICIATION OF INDIAN IRON ORES-AN R&D PERSPECTIVE

In the present scenario, Indian iron ores, on account of selective mining does not require elaborate treatment/ processing to upgrade the quality of lumps and fines especially with respect to iron content but the alumina content is not significantly lowered. One of the most important aspects in the beneficiation of Indian iron ores is their complex nature from the stand point of elimination of alumina. The aluminous minerals generally occur as adhering to the coarse pieces, as cavity fillings and as lateritic material.

IBM developed a number of flow sheets on various kinds of iron are and based on gained expertise evolved flow sheets for total beneficiation for Indian iron are. The aforesaid flow sheet may provide a user-friendly guidelines that can be used successfully with minor modification in almost all types of iron are deposit in India.

Only processed iron ores are used in iron industry. Iron ore processing in the country is restricted to meet the physical standards, as it is inherently medium/high-grade. Therefore, all the Integrated Steel Plants (ISPs) deploy multi-stage crushing, washing and sizing of r.o.m. ore to produce lumps (-30+10 mm) and sinter-feed size (-10+0.15 mm) material. While, non-captive sector supplying lumps to coal-based DRI plants, resorts to multi stage crushing and screening to meet the size requirement. This practice generates large amount of fines (-10/-6 mm) and slimes (-100 mesh/0.15 mm) which get unused at the mine site. Characteristically, Indian iron ores are fragile in nature and mining & processing combined, generated substantial amount of fines. The proportion of lumps & fines in general is around 2: 3.(40:60)

- These stacked fines (minus 10/6 mm screen undersize), slimes and the category of available low-grade resources falling in between threshold value and saleable grade on account of selective mining during last six decades constitute the potential source for producing usable grade iron concentrate after beneficiation. This will not only utilise existing discard material for recovery of valuable but also conserve limited high-grade lumpy hematite reserves in the country.

- Extensive R&D work was indeed carried out at various laboratories in India and at IBM Ore Dressing Laboratory in particular on low-grade/sub-grade iron ore, iron ore fines (-10 mm) and classifier/tailing pond slimes (-100 mesh). The flow sheet developed on almost all types of ore reflects the possibility of producing concentrate suitable for sinter & pellet making (Chapter 3.7). By and large these flow sheets may offer a road map for likely process route of beneficiation. By taking advantage of the same, the existing operators must look towards beneficiation as a means to overcome the crisis of supply of high-grade ore and this is the need of the hour. The capital cost of 250 tph beneficiation plant works out to be around Rs 100 crores. The cost of beneficiation in respect of fine for sinter feed will be around Rs 200/- per tonne whereas for pellet feed it would be in the range of Rs 250/- to 350/- per tonne.
- The mining industry is currently run in fragmented lease holds and operated by captive & non-captive units producing iron ore in the ratio of 25:75. Since, creation of a beneficiation facility is capital intensive, it may not be possible for small to medium sized entrepreneurs in the non-captive sector to invest in such venture. However, a large number of small mines located nearby can form consortium to have their beneficiation facility erected. A concept of custom mill for beneficiation needs to be introduced, whereby the fines from small mines in the vicinity of the facility could be received, blended, processed in a centralised processing unit and the concentrate thus produced could be pelletised or sold to appropriate market. Such consortium would need to work on certain defined objectives: (t) consistent supply of raw material for which they must sign an MoD amongst themselves (ii) seek Government's intervention for land, power, fuel (coal) & water requirement so that they be made available at the subsidised rate; and seek relief by way of import duty waive-off on imported technology and equipment for setting up such beneficiation facilities as a measure to incentivise these small players so that they venture into such highly capital intensive project.
- Primary function of incorporating agglomerates in the blast furnace burden is to utilise the fines generated during various stages of mining and processing. Blast furnace being a counter current gas reactor, these fines cannot be directly used as they hamper the gas flow. The present facility in the country for processing & utilisation of beneficiated fines through agglomeration is highly inadequate particularly in the non-captive sector. This has led to large amount of fines (around 70-75% of the total fines production) getting exported.
- The National Steel Policy suggests encouragement of sintering and pelletisation so as to utilise these iron ore fines which make up about 90% of the present exports.
- Agglomeration of iron ore fines basically involves two main methods-sintering and pelletisation.
- 30. Sintering is the agglomeration technique of iron ore fines in the size range of-I 0+0.15 mm to produce clusters by incipient fusion at high temperature.
- Sinters are porous and brittle and that is why sintering process of agglomeration is restricted to Integrated Steel Plants (ISP) using blast furnace route & mini blast furnace of non-captive sector only. The entire ISP has their own sintering plants (except IISCO) to cater to its own needs and consume the entire generated fines (classifier underflow of iron washing plant) for sinter making. The non-captive producers deploying mini blast furnace for hot metal production use limited amount of fines for sintering after beneficiation. Nevertheless huge quantities of fines are left unused at present at various mine sites even after their export.
- The total installed sintering capacity in the country is 39 million tonnes. However, the production is 31 million tonnes (2009-10).
- **The pelletisation is the other mode of agglomeration applicable for fines below 325 mesh size.**
- Pellets are hard and compact and therefore they can be transported over a long distance as they can withstand the rigors of handling, i.e. repeated loading, unloading, etc. Pellets are viable and therefore can be produced and sold everywhere. Pellets, therefore, will playa very important role in iron making in both blast furnace as well as coal based DRI units.
- In India, pellets are selectively used in gas based DRI units whereas the ISPs based on certain assumptions consider them unviable. This facade however appears to be fading away now. Many ISPs have moved proposals to incorporate some portion of pellets in the blast furnace burden to replace the calibrated lumps because of their superior chemistry, quality & strength in addition to enhancement of productivity. Therefore, pelletisation in all likelihood would come up in a big way in India.
- **The installed capacity of pelletisation plant in the country is 28.8 million tonnes, however, production is meagre 11.5 million tonnes only.**
- At present, practically none of the ISPs has pelletisation facility. The present level of pellet making facility in non-captive sector however is too little and needs augmentation of its capacities besides initiating creation of new facilities both in captive and non-captive sectors. ISPs can commence beneficiation followed by pelletisation in immediate future as it has readily available huge stocks of slimes impounded in its tailing ponds. This will not only recover the loss of valuables

from slimes but also help in controlling environmental degradation on account of its perpetual stacking.

Of late leading players in the Mining & Steel Industry have realised the importance of pellet making and have begun to incorporate pelletisation facilities which are as follows:

Owner	Source of Raw material	Pellet Plant Capacity (million tones)	For use in
SAIL	Gua mine fines	4.0	ISP
SAIL	Taldih & Kalta	2.0	ISP
TATA Steel	Noamundi mines	6.0	ISP
Jindal Steel & Power Ltd.	Barbil and from various other mines	10.0	DRI
ESSAR	Orissa fines	10.0	DRI
KIOCL	Bellary and Donimalai Fines	0.5 (4.0)	DRI
NMDC	Bailadila Bacheli Slimes	2.0	DRI
NMDC	Donimalai Slimes	1.2	DRI

CONSLUSION

Many of the recent advances in iron making can be directly attributed to improvements in ore preparation as well as fluxes in uniform power sizes. To obtain maximum efficiency in Blast Furnace, it is considered essential to charge material having constant physicochemical and physico-mechanical properties. Recent development in raw materials preparation for iron making can be summarized as follows:

- Beneficiation of the ore to improve its chemistry;
- Reduction in variability through bedding – blending practices;
- All materials screened before charging in Blast Furnace (fines, 5mm below 5%);
- Increase in sinter ratio as much as possible (60-100%);
- Increase in basicity of sinter and pellets to be charged in Blast Furnace;
- Increase in strength of sinter, control of reduction, degradation index (RDI below 40%);
- Increase in reducibility of sinter pellet and sized ore;
- Utilisation of Blue Dust to as much as 40% in sinter fines for production of sinter with suitable coke distribution maintaining a high bed;
- Utilisation of rich ultra-fines recovered from iron ore slimes will also improve the economics of iron ore mining which is so vital to steel makers.

SAIL RMD MINES EXPANSION PLAN

The growth plan of SAIL is linked with the development of new iron ore mines at Chiria and Taldih, alongside the modernisation and expansion of all the existing operating mines.

The post expansion capacity of RMD mines at Kiriburu, Meghahatuburu, Bolani, Gua, Kalta, and Barsua/Taldih is going to be 5.50, 6.50, 10.00, 10.00, 2.50, and 3.00 MTPA respectively. There is a plan to develop Chiria in phases. In first phase the mine will be developed for 7 MTPA and finally up to 15 MTPA.

G S Khuntia

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- n Currently Director of "Odisha Mining Corporation Ltd of Odisha Govt. from 2008,June by Odisha govt. notifications & India International Mining Consultancy & Services, Bhubaneswar &Former Member of Board Sub-committee of Visakhapatnam Steel Plant of RINL (GOI) for handling & transit losses as outside Expert (from 3/2012-2013 in rank of Independent Director on Board) ,VP of MDC on SHE (state govt sponsored NGO promoting PG in Safety Engg, Odisha Govt. recognized (4 semester course,2 in NIT Rourkela & 2 in MDC, Bhubaneswar approved by UGC)Recipient of a number of Awards of NATIONAL and international Repute.A widely travelled man on different assignments making most of the situation wherever he worked.

Health Issues Related to Indian Asbestos Mining - A Review

Prof Dr G Kumar *

ABSTRACT

Asbestos refers to a group of six types of naturally occurring minerals. Asbestos minerals are made up of fine, durable fibers and are resistant to heat, fire and many chemicals. Once called the "miracle mineral" for such properties, asbestos was used in a slew of everyday products, from building materials to fireproof protective gear. It is now widely known that exposure to asbestos can cause mesothelioma, a fatal cancer that affects the lining of the lungs, as well as other cancers and lung-related illnesses.At present in India more than thirty mines are in operation. It produces 2800 tones of asbestos per month (mainly chrysotile and tremolite) and in recent years substantial quantity (-70%) is imported from Canada. The quality of asbestos produced in India is very poor. The mining and milling and other related processes expose the people to cancer and related diseases. Women are more affected by their exposure in processing unit compared to male who are generally working in mines. Direct and indirect employment in asbestos related industry and mine is around 100,000 workers. Latency period (length of the time between exposure and the onset of diseases) in India is estimated to be 20–37 yr. The causes for lung and breathing problem are mainly due to obsolete technology and direct contact with the asbestos products without proper precaution, because in India asbestos are sold without statutory warning. This paper reviews health effects (such as fibrosis, sequelae, bronchogenic cancer, and malignant mesothelioma) on the Indian mine workers caused due to asbestos mining related activities with respect to their present day condition.

Key words: Mesothelioma, Chyrsotile, Tremolite, Fibrosis, Sequelae, Bronchogenic

INTRODUCTION

Asbestos refers to a group of six types of naturally occurring minerals. Asbestos minerals are made up of fine, durable fibers and are resistant to heat, fire and many chemicals. All six types of asbestos minerals have common characteristics. All forms of the mineral are odorless and tasteless. When asbestos is present in a material or product, it cannot be detected by a visual examination and must be tested in a laboratory. In addition to the properties shared by all asbestos minerals, each of the six types has its own distinct features. The types are separated into categories based on the physical appearance of individual asbestos fibers. Asbestos minerals are divided into two categories: Serpentine asbestos and amphibole asbestos.

SERPENTINE ASBESTOS

Serpentine asbestos refers to asbestos made up of long, curly fibers. This category only includes one mineral, called chrysotile, also known as white asbestos. It was the most commercially used form of asbestos. Its flexible nature easily allowed it to be used in products and combined with other elements. Prior to widespread knowledge of pleural mesothelioma and its connection to asbestos, the mineral was hailed for its fireproof and heat-resistant qualities. It was used throughout the world, finding its way into products that still pose a hazard today.

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AMPHIBOLE ASBESTOS

Amphibole asbestos includes the other five asbestos minerals: Amosite, crocidolite (also called blue asbestos), tremolite, actinolite and anthophyllite. These minerals are composed of brittle, rod- or needle-shaped fibers. Because of these properties, amphibole fibers are more hazardous than chrysotile when inhaled or ingested. However, the same characteristics usually make it a bad candidate for use in commercial products. Exposure to amphibole asbestos is mostly limited to exposure to naturally occurring deposits. Asbestos fibers can be molded or worn into fabrics, non-flammable and a good heat insulator. Asbestos is strong and resistant to heated chemicals. They are used in India as fireproof products such as safety clothing for fire fighters and insulation such as hot water piping. In India asbestos is widely used as floor tiles, ceiling tiles, roof materials. The asbestos industry in India is spread over in numerous states; out of this nearly 60% are in operation at present. At present, chrysotile account for over 90% of the World production1). Asbestos is obtainable by underground and open cast mining in India, out of which the most common method is open-pit mining. Only about 6% of the mined ore contain usable fibers. The fibers are separated from the ore by crushing, air suction, and vibrating screen, and in simplified manual processes are sorted into different length or grades.

PROPERTIES

The physical properties of asbestos are its capability to be readily separated into fine filaments of high tensile strength and enough flexibility along with high degree of incombustibility. In India, the coarser and brittle fiber variety has a very limited use for the manufacture of asbestos sheet and asbestos cement. The long fiber grades are of fine silky chrysotile variety of high tensile strength. Asbestos of medium grade variety, i.e. short fibroid materials are compounded with various synthetic resins for the manufacture of molded articles. Asbestos of low-grade short variety are used for millboards, paper, boiler coverings and mattress fillings. The length of the fiber as well as the chemical composition of the ore determines the kind of product that can be made from the asbestos. The longest fibers have been used in fabrics, commonly with cotton or rayon and the shortest ones (called as milled asbestos) for molded goods, such as pipes of gaskets. Asbestos are also used in the construction material, textiles, missile, jet parts, asphalt paints and in friction products such as brake linings. The chemical composition of Asbestos in India varies as follows:

SiO_2 40.09%, Al_2O_3 1.27%, Fe_2O_3 + FeO 2.53%, MgO 41.41%, and H_2O 14.06%4).

OCCURRENCE IN INDIA

In India, asbestos occurs in the states of Andra Pradesh, Rajastan, Bihar, Karnataka, Tamilnadu and Manipur (Fig.1). Most of the Indian asbestos deposits belong to the tremolite-actinolite variety. It occurs in tremolite-actinolite schists, amphibolites and metamorphosed basic and ultra basic rocks. Bihar and Rajastan were mainly enriched with tremolite followed by small amount of chrysotile. In Andrapradesh and Tamilnadu the amphibole variety is more abundant than the chrysotile variety. In Jharkhand, chrysotile asbestos occurs in Singhbhum districts associated with serpentinised dunites and peridodites and is usually between 3.1 to 6.2 mm long. Chrysotile asbestos fibers are short between 9.4 to 15.75 mm in length. Lakshmana mines in Cuddapah district in Andrapradesh chrysotile fibers are between 0.076 to 0.152 mm in length.

Fig. 1. Occurrence of Asbestos in India

Resources

As per the UNFC system, the total resources of asbestos in the country as on 1.4.2010 are placed at 22.17 million tonnes. Of these, 2.5 million tonnes are reserves and 19.6 million tonnes are remaining resources. Out of the total resources, Rajasthan accounts for 13.6 million tonnes (61%) and Karnataka 8.28 million tonnes (37%). The remaining two percent resources are estimated in Jharkhand, Andhra Pradesh, Odisha and Uttarakhand. The production of asbestos at 387 tonnes in 2012-13 increased by about 40% as compared to that in the previous year. Exports of asbestos remains only 78 tonnes in 2012-13 as compared to 1,296 tonnes in the previous year. Exports were mainly to Angola and Nepal. Exports of asbestos-cement products were 56,406 tonnes in 2012-13 as compared to 41,304 tonnes in the preceding year. Exports of asbestos cement products were mainly to UAE (31%), Saudi Arabia (18%), Nepal (17%), and Qatar (9%). Imports of asbestos were 460,449 tonnes in 2012-13 against 378,122 tonnes in the previous year. The imports comprised chrysotile asbestos 458,571 tonnes and asbestos (others)1,309 tonnes. Imports of asbestos were mainly from Russia (58%), Kazakhstan (23%), Brazil (13%) and China (4%). A total of 12,649 tonnes asbestos-cement products were also imported in 2012-13 as against 6,641 tonnes in the previous year. Imports were mainly from Thailand (72%). Besides above Asbestos Fibre of 458,571 tonnes was also imported during the year 2012-13. Import of Asbestos Fibre was mainly from Russia(58%)

ASBESTOS UTILITY AND HEALTH EFFECTS

The asbestos demand has decreased in the industrialized world, where it is growing in the developing countries. The amount of asbestos used by the Asian countries was almost doubled between 1970 and 19958). Canada is marketing their deadly asbestos largely to countries like Thailand, Korea and India, where the powerful heat resistance and binding properties of asbestos are valued in the production of low cost building materials, as well as automobile brake linings and textiles. So the epidemic of illness and death that has plagued the West in the past will more likely to be repeating in Asia soon. Asbestos causes cancer of the lung, lung lining and abdomen and can take 20 yrs or so to manifest (latent period). The detailed study in Australia1) shows that the lung cancer and mesothelioma in asbestos mine workers are revealed after 37 years during the observation period from 1945–2000. It is expected that the affected people number will go to a maximum during 2010 in Australia.Various malignant diseases of the lungs, pleural and gastrointestinal system are linked to the asbestos exposure as per the latest edition of Harrison principles of internal medicine. Which incidentally does not mention any difference among the various types regarding potential harmful effects of asbestos namely chrysotile, crocidolite, amosite, etc., [1,2]. For example Britain has allowed maximum concentration of chrysotile as 0.5 fibers/ml (f/ml) and for crocidolite and amosite as 0.2 f/ml [3]. India prescribe <2 f/ ml for all asbestos [4]. Release of asbestos fiber by corroded and weathered asbestos-cement products is already a concern - this may expose millions in our country to unexpected and unknown hazards. It is proved beyond any serious doubt that asbestos cannot be used safely in any developing countries.All forms of asbestos cause asbestosis, a progressive fiberotic disease of the lungs. All can cause lung cancer and malignant mesothelioma. EPA has proved asbestos to human carcinogens on cancer of WHO standard. Canadian asbestos is free from amphibole but still associated with mesotheliomas [5]. The strict occupational exposure risk limits of the world for chrysotile asbestos (0.1 f/ml) are estimated to be associated with lifetime risk of 5/1000 for lung cancer and 2/1000 for asbestosis [6]). Still the developed countries can technically achieve this limit but the residual risks still are too high to be acceptable. In new developing industrial nations like India the exposure are much higher and the potential for epidemics of asbestos diseases is greatly increased.

SCENARIO IN INDIA

The Asbestos mines in different parts of India are shown in Fig. 1. The average production of month of reference Jan 96 – 99 and yearly average and average 05 yearly for one decade is shown in Figs. 2 and 3. Figure 2 shows that the production has reached a maximum of about 2800 tones per month in 1990–1995 and it reduces to 1800 tones per month, due the large-scale import from Canada. But the short-term variation from Jan 96 to Jan.99 the fluctuation is too much (Fig.2). In general the decreasing trend of production is evident [7]. Figure 3 shows the reduction in the yearly production of asbestos in India.

In India, asbestos production at present is about 2000 tones per month from their own mines in Andrapradesh, Rajastan and Jharkhand. Several states in India have many asbestos industries. Out of which 60% are in operation now. India imports asbestos worth Rs 40–50 crores annually, without mentioning it as a hazardous product). In India raw material asbestos is received from Canada without any warning and India sends back the finished product to them along with the warning hazardous product. In India workers slice open the bags of Canadian asbestos with knives, then shaking the bags into troughs and mixing it with cement to make piping). Here the unprotected workers are completely covered in asbestos dust, where precautions are absolutely not in place.

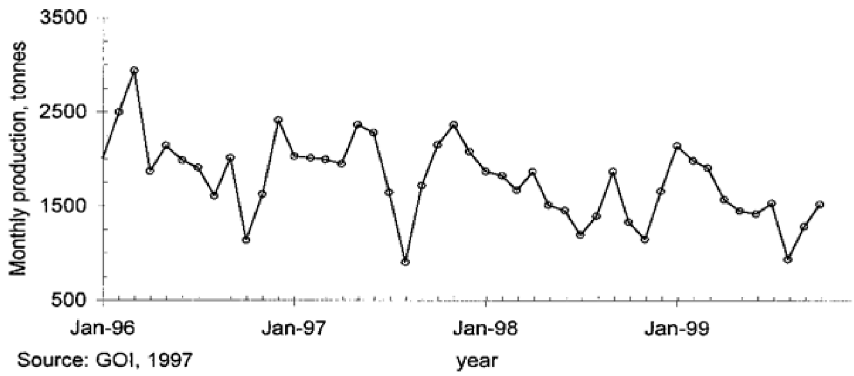
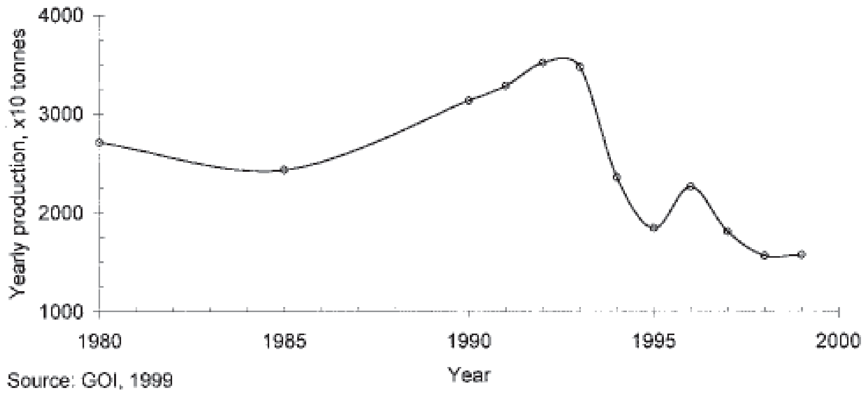


Fig. 2. Production of asbestos in India Reference Months Jan (96 – 99).

Fig. 3. Average 5 Yearly asbestos production in India.

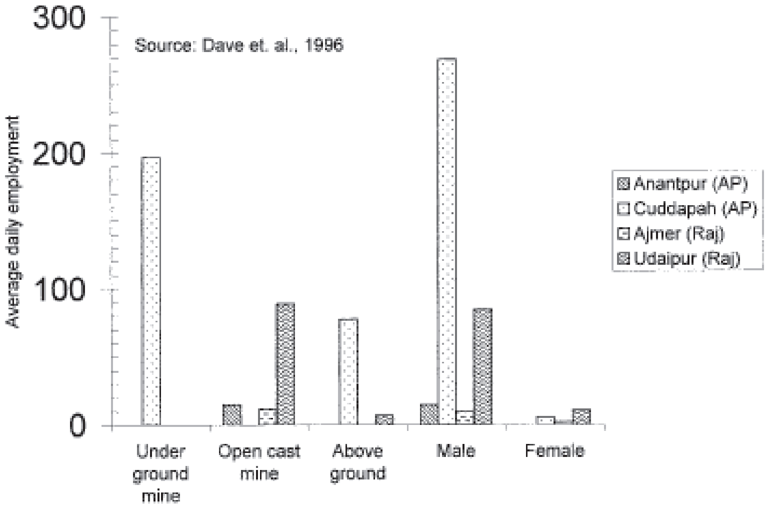


WORKERS OCCUPATION

At present in India more than 30 mines are in operation in AP and Rajastan. Mainly serpentine (chrysotile 42%) variety is mined in AP and amphibole (tremolite 58%) variety in Rajastan. The amphibole variety is technically of poor grade here. The main causes of environmental degradation in asbestos mining here is due to the change in the rise in the asbestos fiber level (<2 f/ml, by government of India in model rule 123-A under section 112 of the factories act as amended in 1987) in and around the mining area and milling units and their impact to health status of the workers. So lot of studies were carried out here to infer the effects of working environment on respiratory system in the workers and to find out the interdependency of various health parameters [5, 9]). Thus this study tries syntheses the data available from these working environments and correlates them to have an understanding of the impact of asbestos mining and related activities to human health in India.

Figure 4 shows that more workers (mainly males) are engaged in underground mining and open cast mining regions of India. Females are hardly one percent working in mines; they are all working in the milling and processing units. Hence females are expected more to inhalation of fibers compared to males. For example in the Pullivendala asbestos and the associated mine milling units in Andrapradesh the levels of fibers varied over time and in different processing stages and methods [8,9].

Fig. 4. Statistics of workers employed in asbestos mines in India.



HEALTH EFFECTS

Impairing of lung functions in workers in both directly and indirectly exposed groups of both the sexes. It was observed that the restrictive pattern was more common (70%) as compared to the obstructive pattern (18%) while a mixed pattern is around 12%. Here as compared to the miners the prevalence of lung function impairment was more common in millers and in workers in the indirect exposure group. In female workers of the indirect exposure group and milling units, the prevalence of restrictive impairment was nearly two to two-and -half times more common than their male counterparts. Similarly radiological changes were more common in workers in the milling units than mining units. Amongst radiological changes in direct as well as indirect exposure, parenchymal changes were more common than pleural one. Pulmonary tuberculosis were detected in six workers all of them were male workers. In milling units and in the indirect exposure group the prevalence of parenchymal changes was more common in females. Fig. 5 indicates the pulmonary function impairment in different operation groups [4, 10].

It is observed that the males are employed mainly in the underground mines due to prohibition of employment of females. The female was largely employed in milling units and indirect exposure processing units. So the males are exposed to very low levels and females are exposed to higher levels than the TLV accepted by the government of India in model rule 123-a under section 112 of the factories act 1948 as amended in 1987, which is also applicable to chrysotile mine and milling environment. The levels of fibers are very high due to use of obsolete technology, inadequacy complaisance to mines and safety act and low content of asbestos fiber in parent rock. May be the low yield gives a poor economic returns to mine owners and hence the less investment in environmental control aspects here. The higher significant difference in fiber levels between mining and milling units kept male work force healthier than their female counterpart in India. Primary pleural Mesotheliomas is also reported from numerous observations in some patients of this area who are not exposed at any time to asbestos, but have this problem due to pollution and other sources [11].

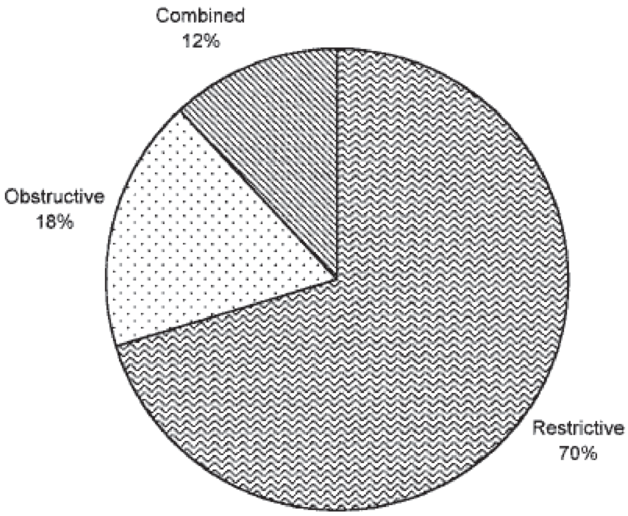


Fig. 5. Pie diagram showing the pulmonary function impairment in different operation groups (Dave et al., 1996).

Effusions

Effusions occur when fluids accumulate in the lungs. These events can be acute with complete resolution, or can be chronic and result in significant accumulations of fluid with associated fever and pain. If severe, effusions can result in rounded ateclatasis, where the lung is left without air. Effusions occur frequently when mesothelioma sets in, but can also result from benign fibrosis, plaques and nonspecific fibrous thickening. Effusions are therefore symptoms of asbestos exposure that can result in death. Amphibole fibres have been associated with effusions more so than chrysolite fibers, likely because amphibole fibers are more irritative and long-lasting in the lungs.

Autoimmunity

Autoimmune diseases such as rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis have been found at increased rates in populations exposed to asbestos. Asbestos is believed to bring about systemic autoimmunity by suppressing the body's natural killer cells, and has been thought to increase the incidence of lung cancer by suppressing pulmonary parenchymal cells. A study exposed mice to serpentine chrysolite asbestos and amphibole crocidolite asbestos to compare the effects of these two types of asbestos on autoimmunity.The results from this experiment determined that crocidolite asbestos had a slightly more toxic impact than chrysotile on the immune function of pulmonary parenchymal cells. This finding confirms the more damaging health effects overall of amphibole asbestos in comparison to serpentine asbestos.

Irritation

Upon inhalation, asbestos causes significant irritation to the lungs and bronchioles. The resulting irritation causes the lungs to try to digest the asbestos. However, because of its chemical and physical stability, the asbestos cannot be digested and instead becomes encased in scar tissue. Growing masses of scar tissue result in benign fibrosis, effusions and plaques in the lung cavity . Since crysolite fibers are thin-walled sheets of silicates, they have a half-life of of 0.3–11 days, whereas the double-chained chemistry of amphibole fibers have a much longer half life that extends from 500 days to infinity. It is therefore clear that amphibole fibers have a much more irritative effect on the lungs than crysolite fibers and are therefore much more likely to lead to asbestosis, effusions and plaques through irritation.

ASBESTOS HAZARDS IN INDIA

The following points highlights certain asbestos hazards of concern in India:

- In India asbestos are sold without statutory warning symbol in the market and are not pelletized and in majority cases the workers do not wear the protection gear. Hence, annual turn over of the industry is around Rs 800 crores).
- Direct and indirect employment in asbestos mine is around 100,000 workers. Hence the people affected by asbestosis will shoot up to a double fold soon.
- Latency period in India is estimated to be 20–37 yrs.
- Between 1945–2000, Asbestos production on an average was 1800 metric tones per month, since then there has been decline in the Asbestos Mining.
- Occupation hazards in India occur due to Repair/ maintenance, shop building, asbestos by product, cement use, railway, mining, insulating materials, obsolete technology, inadequacy complaisance to mines and safety act and low content of asbestos fiber in parent rock.
- In India the clinical effects observed are fibrosis, sequelae, Bronchogenic cancer, malignant mesothelima (by blue asbestos) and other cancer risk). Acute mesothelioma is associated with exposure to asbestos). In the third world countries use of asbestos has been increasing at an annual rate of about 7%). The grave health hazards of asbestos are entirely preventable. Now suitable safer substitutes are available. Asbestos can be substituted by Fibrous glass, animal skins etc.). Finished products of Asbestos do not pose any health risk. When it is damaged or broken during processing the asbestos fibers became air borne

and can be inhaled. It also releases fibers when it crumbles and struck in lungs. After exposure to 20 yrs or so of latent period (length of the time between exposure and the onset of diseases) the cancer started to show up). Though lower fiber level has been found in all the mine sites, the health degradation among people is more due their exposure to processing units. So a further suitable strict control measure has to be adapted for importing asbestos and processing them in the milling units. Enormous studies shows the extensive epidemiological and toxicological studies which have confirmed the respiratory morbidity due to asbestos exposure which is related to dose and duration of exposure, the processes of work and type of Fiber [12]. So it is the right time for the developing countries to keep this menace under control before it boomerang.

USING ASBESTOS VS. BANNING ASBESTOS

If the experiences of a number of highly industrialized countries over the last 10 years show that it is now technically possible to abandon asbestos completely, any attempt, even a partial one, to find substitutes for this dangerous substance presents many obstacles to any country wishing to enter upon this path. What are the constraints, what is at stake and what are the costs?

If a country is to abandon asbestos, it will need to find solutions for all three of these interconnected problems:

• it must try to reduce, and later eliminate, this serious risk in order to protect current and future generations;

• it must care for the victims of asbestos-related diseases, which may result from exposure a very long time before [13];

• it must introduce the risk-reduction measures needed to deal with the exposure which will inevitably result from the presence of asbestos in buildings, industrial or domestic machinery, vehicles or other products [14,15].

All countries have to face this global menace, and no country can pretend to ignore it. Every State has a responsibility to face up to the health disaster on its territory resulting from the past and present use of this dangerous substance; every State has a moral obligation to dispose of its own asbestos and take responsibility for the consequences. Some activities which carry a serious risk of exposure to asbestos (e.g. decommissioning of old ships) tend to take place in countries where labour costs are lowest. Such activities represent an important economic issue for these countries. Although health protection regulations are displayed at the decommissioning sites, the health conditions there seem to be appalling and the regulations governing waste disposal are non-existent. How can the world be made aware of this serious problem of risk transfer and deal with it in a sustainable manner?

Although it is the duty of the most highly industrialized countries to inform others of the existence of risk, the way in which each country will see the problem will be highly dependent on its own history, geographical situation and level of social, industrial, economic and cultural development. The process of consideration within each country will certainly be influenced both by the priority accorded to this risk compared with other issues which are also considered priorities and by a set of criteria connected with the country's networks, trade, main industries and domestic stocks of asbestos and its substitutes.

• How do these various parameters affect policy choices about the protection of workers' health?

• What importance should be accorded to the national industrial base for asbestos processing in the country, the availability and local cost of some of the raw materials to make asbestos substitutes and the economic and social cost of the industrial conversion required to move over to substitutes?

• Can an industrial producer and exporter of asbestos speak clearly to its clients about information, risk evaluation and assistance?

• What are the last remaining barriers preventing the complete abandonment of this highly dangerous substance?

• How can we share the collective knowledge about the protection of people's health from the serious risks of exposure to asbestos?

CONCLUSIONS

Asbestos use is not fully banned in the most of the developed countries., but it is strictly regulated by the Environmental Protection Agency (EPA) and other government entities. Asbestos can only be used in products that have historically contained the mineral. In other words, no “new uses” are permitted. Additionally, these products can be made with asbestos only if there is no adequate substitute. This has led to a steep decrease in nationwide use. In 1973, domestic consumption of asbestos was 803,000 metric tons. Consumption in 2005 was a fraction of that, totaling only 2,400 metric tons. The small amount that is still used annually goes into products that require fireproof and heat resistant qualities. Products which may still be made with asbestos include protective clothing, pipe insulation, brake linings and similar materials. Thus in the case of Asbestos uses, we should always remember “ Handle with Care”.

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Coal India's dismal performance year 2017-2018.

J P Panda *

INTRODUCTION

Failure to achieve the target for two consecutive years 2016-17 and 2017-18, in a row shows that how the coal Ministry and Coal India is crumbling. The Public sector Maharatna company is being systematically allowed to collapse, similar to Air India so that private sector takes over again. Indeed the signs are imminent as the cabinet in the name of competition has permitted commercial Mining.If commercial mining is being allowed on the basis of per tonne tariif why did not the government do the same thing to the captive blocks ? They could have earned huge money from per tonne cess and the catastrophe of deallocation avoided, the captive industries would have grown and we would not have lost employment to Indian workers and there would have been less NPA of banks. Our Import coal bill would have come down sharply.Coal India production subsidiary wise in the year 2017-18.From the above table it is clear that there was a shortfall of 32.63 Mt from the target which is nearly 5.44%. If in terms of Power generation shortfall due to 32.63 Mt it will be approximately 7000 MW. The growth is even less than last years which was 2.9%. Let us compare the the past performance of Coal India in the year 2016-17.The salient features are against a target of 598.61 Mt coal India has achieved only 554.13 Mt and the shortfall 43.48 Mt shortfall against target is 7,26% and the growth over 2015-16 production (538.75 Mt) is hardly 2.9%.If someone analyses why CIL is failing to achieve target year after year, the resons are :

Non Governance by NDA Government :

The non appointment of CMDs of subsidiary companies and Coal India in time has cost this nation very dearly. Most of the subsidiaries and Coal India has remained headless from time to time. Even today CIL is being managed by an acting Chairman. Hardly any minister is functioning at the centre as every one is in election mode, be it UP, North East or Karnataka, none have time for governance. Almost all ministers are busy 24X7 denigrating Sonia, Rahul &UPA and none have time for governance.

Indeed what has happened to Promise of 1 billion tonne production by 2020.It is sad that even after 4 years in power and promising by 2020, 1 Billon tonne coal production the NDA Government coal Ministry/ Coal India is still near half the mark i.e nearly 550 Mt. The time left is hardly two years and a massive jump of 450 Mt which means increasing the production by 80% is impossible to achieve , This brings into yet another Jumla by NDA government.

The acute power shortage shall leave this country in perpetual darkness and what an audacity of telling people that all the india shall be electrified by 2019 when there will be minimum thermal power generation. The Niti Ayog says that in coming 25 years thermal power will be still the dominant power provider with nearly 60% of the total generation. The renewable will ultimately contribute to about 40% power. Meanwhile the country is being led to bankruptcy with more and more import of thermal coal, huge unemployment due to stagnancy in coal and thermal power generation.

In terms of power generation loss what it means if CIL does not reach target in consecutive two years in a row

Continuous production shortfall of nearly 80 Mt of CIL against target in the last two years means that in terms electricity generation nearly 16000 MW power could not be produced .Or we have to import as much thermal coal of equivalent GCV to sustain our power houses to produce the same amount of electricity. In either case what a colossal loss to the nation ?The chartered accountant Minister Piyush Goyal must explain to the nation how much we have lost and how much more we will be losing ?.

Why repeated failure on consecutive years :

Obviously this government cannot blame the UPA for this. Are we deliberately and systematically killing Coal India so that privatization takes place ?

Coal India subsidiaries and their performance

If we go through the performance of different subsidiaries it will be evident that only 2 subsidiaries namely NCL and NECL achieved their production target.

The biggest shortfall is from SECL & MCL. Both of these might be contributing to nearly 25 Mt shortfall and other subsidiaries nearly 10 Mt

The only silver lining is NCL which exceeded target and achieved 105% The reasons for shortfall are many e.g

Environment and forestry clearance could not be obtained in time

Frequent disruption by villagers over employment and R & R problem , especially in the Talcher Coalfield.

Infrastructure development for coal evacuation lagging behind.

There is absolute lethargy in the ministry as most ministers are on election mode all the time

Can anyone in Coal Ministry explain why the growth of coal production only 1% in spite of engaging a large number of Hired machinery contractors and MDOs. Why the departmental production has gone down badly. Why the Availability & Utilization of HEMM of CIL so bad

HEMM	Availability	Utilization
Dragline	78%	67%
Shovel	72%	45%
Dumper	66%	35%
Surface miner	85%	58%

It is obvious that coal India has failed on both fronts by departmental HEMM, like Production.Overburden removal It is sad that the coal ministry is hardly functioning. Can

* Ex CGM MCL,CIL

any one in the ministry explain why it has failed in the

LAND AQUISTION FRONT

The land value has been increased to nearly 4 times under land acquisition act and yet land availabilty is a major problem. The explanation could be non cooperation Non NDA ministries of BJD and TMC ruled State governments of Odisha and Bengal, but the problem is equally bad in the NDA ruled states like Jharkhand, Chattisgarh and Madhyapradesh.

Infrastructural development front for evacuation of coal : the rail ministry is also headed by Mr Piyush goel and yet The Tori-Shivpur (Kathotia) rail link for North Karanpura – Auranga coalfields of CCL that started in the year 1990 is still under construction and is delayed due to Forest Clearance issues,. The Jharsuguda Barpalli track supposed to be complted by 2016 June is yet to be completed. Rail tracks in three corridors of Mand-Raigarh, Talcher & Korba coalfields of SECL is progressing extremely slowly. These infrastructure projects are laguishing for more than 20 years. The BJP Govt came to power on the slogan of Good governance, Is this Good governance ? The government which talks about Bullet trains does not act fast on small patches of Railway track for coal Evacuation in Ib valley, North Karanpura, Talcher rail corridor & Mand Raigarh rail corridor causing huge loss of production and huge loss of revenue to Railways and India

R & R front as there are frequent stoppage of work by landlosers The govt which speaks about 100 smart cities cannot make a single smart township for rehabilitation of land losers which results in frequent law and order situation and work stoppages (Talcher Coalfield is a burning example) have taken place. It seems that CIL is expecting Miracle will happen and villages who part their land without prper rehabilitation

It may be remembered that thousands of crores of District development fund and CSR fund available with State governments and Coal India are not being used at all to produce some Smart Townships in non coal bearing areas to rehabilitate the land losers. The district development fund which should have been utilized for buiding infrastructure and smart townships has not yet been touched

Employment generation front : This government talks of skill development of landlosers but shockingly the land losers whose main demand is employment are not being trained in the number of central workshops under it. The author had suggested converting hundreds of vocational training centres of coal India into skill development centres in previous articles published in this paper. Yet there is hardly any initiative.

Has the Development of Coal India has gone Crazy As some one in Gujrat has pointed during Gujrat elections that development has gone crazy , now it seems the development of Coal India has indeed gone CRAZY. How else the CIL coal production in this country which aspires for 8-9% GDP growth remains almost stagnant for two consecutive years. The failure to achieve 1 Billion Tonne by 2020, with poor justification of utilizing solar energy etc and rationalizing repeated failures in the coal front, the government is leading this country to power famine, poor industrial growth.The time is indeed running out. The government is rudderless. And the Good governance is a big question mark.

CSR front : It did not use the massive CSR work done by it to better B 2 C and C 2 B (business to community and community to business relations) .All the CSR efforts done by Coal India are laudable but unfortunately it has not concentrated on the key result areas (KRA) like employment generation which would have resulted in better B 2 C and C 2 B (business to community and community to business benefits). In spite of large scale expenditure on CSR on grant to schools, construction of medical college etc the landlosers and villagers have a grouse against the company because for them the main problem is their rehabilitation and employment

Innovation

Coal India must invest money on Articulated dump traucks so that rainy season production does not go down sharply

Construct concrete haulroads by prefabricted concrete slabs manufactured in special manufacturing units.USE GPS technology like OITDS (operator Independent truck dispatch system) for Monitoring all operations.Use drones for surveying and monitoring.Construct prefabricated smart townships to rehabilitate land losers.Use continuous miner for high underground production.Sink new shafts with high speed shaft boring machines.Use surface miners for OB removal.Use pipe conveyors and silos for rapid loading.Use slurry transport technology to make available washed coal at affordable transport cost.If Coal India has to survive, it has to undertake all the above measures in the near future.

CONCLUSION :

The non governance is so glaring that Coal India might indeed be sold out within shorter time than expected. Or is it being deliberately sabotaged to bring in private ownership like what was done as in case of Air India.The ministry might give lame excuses like that India is going for Solar and other renewable energy in the future, But Niti Ayog has said that India will have 40% renewable and 60% thermal energy in the coming 30 years.Hence coal has to be produced at an accelerated rate and non performance of Coal India will be suicidal for the development of this country.Increased increased coal production will generate huge employment opportunities, We need not Import thermal coal by spending taxpayers money and create employment in Indonesia, Australia and South Africa in stead of India.Non performance of Coal India and too much reliance on renewable will result in poor growth of GDP and the biggest sufferes will be the poor and middle class in this country.The present policy is definitely not conducive to growth and it needs immediate course correction

Laboratory And Field Investigations On Condition Monitoring of Wire Ropes And Winding Equipment In Mines

Dr. Singam Jayanthu*, S Jayadarshana**

ABSTRACT

This paper presents the details about Non-destructive testing methods for evaluation of condition of winding equipment used in mining industry. Available statutory provisions related to safety of the winding equipment such as Drum shaft, Brake Tie rods, pins etc., are presented. Non-destructive testing (NDT) on various components of the winding and other mining machinery related to coal and metal mining sectors has been conducted by various organizations. Procedures followed for Ultrasonic and Magnetic Particle testing are also discussed. Case study related to a typical mine winding equipment of underground mine is presented along with the salient findings of the NDT tests. This paper also illustrates the details about calibration of defects; wear and broken wires by electromagnetic method in a wire rope used for hoisting of men and material in mines, aerial rope ways, lifts etc. Electromagnetic method of testing the wire ropes consists of powerful magnets to magnetize the wire rope, and sensors to detect the defects in the wire ropes. A typical instrument used in the investigation consists of the inner coil to detect the local defects like corrosion, pitting, broken wire, wear and nicks. In the present study a method was adopted to simulate the magnitude of the defect signals of wear and broken wear by creating artificially in the laboratory, which can be used for analyzing the actual signals recorded during in-situ testing on wire ropes.

INTRODUCTION

Testing of materials or components without impairing its functional properties is termed as Non Destructive testing. Any manufacturer of components conduct non-destructive tests to check for the quality of the material before dispatching to the customers fro their immediate use. For this purpose, destructive tests cannot be applied due to obvious reasons. Standard tests conducted by manufacturers include; Proof load tests, UFD (Ultrasonic Flaw detection), MPT (Magnetic Particle Tests). However, Proof Load tests cannot be conducted for the mining machinery parts without dismantling the individual parts after its commissioning at the site. Therefore, NDT (Non-Destructive tests such as Ultrasonic and Magnetic particle tests) are required to assess the condition of such mining machinery parts, which is also mandatory as per the DGMS guidelines (DGMS, 2001). At present, manufacturer tests report and customers tests report are only available before commissioning or put to use. Unfortunately, third party testing by any research or academic institutions and associated documentation is not being practiced. This practice would have improved the reliability of evaluation of condition of equipment later while in operation. This unique document would have served the purpose of reference for comparison with the results of subsequent tests for evaluation of condition of respective components. These tests are being widely used for ascertaining and monitoring periodically the health of vital components of winders and suspension gear parts. Safety and efficiency of the winding installations have always been the concern of all the people of the mining community.

It is necessary in this context that all the winding installations and components should be of good quality with high reliability. As most of the winders in our country are old, they need periodic monitoring of the conditions of winding installations. The problem is more critical due to the large number of old engines. In order to ensure the reliability of the winding installations and to prevent failure of the winding equipments and components during service which may result in loss of life and property, it Is all the more important to have a planed periodical testing of the components. The important mining machinery components of winding system are chains, D-shackle, Distribution plate, Chase blocks, Pins, winding engine shafts, brake tie rods etc. In this regard, to ensure the safety of winding operations, statutory provisions are made in Indian mining law (DGMS, 1988).Need for NDT tests were always felt by the owners of the winding equipment to evaluate the condition of the components in the interest of the safety, and productivity. Ultrasonic Flaw Detection Tests and Magnetic Particle Test in various winding installations (NIRM, 2004, 2005a, 2005b) is presented in this paper along with electromagnetic tests conceited on wire ropes using rope-defectograph.

TESTING METHODS

Ultrasonic and Magnetic particle method of non-destructive testing have been widely used. Principle of testing and procedure followed for such tests are illustrated by many investigators (Krautkrammer and Krautkrammer, 1983), and presented in many standards (IS-3703,1998; IS-7743, 1998; IS-4904,1997; IS-9565,1998; IS-8791, 1992). Salient points related to the ultrasonic and magnetic particle tests conducted by NIRM, and results of such tests in typical winder components are presented below:

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Ultrasonic Method

Ultrasonic testing is the most widely practiced non-destructive testing of studying the condition of the mining machinery components to get a comprehensive picture of defects which are both inherent and service defects (Table 1). In this inspection technique high frequency sound waves are sent into the object under test, the sound waves travel through the material. During their path of travel they suffer loss of energy and are reflected at interfaces. The receiver probe picks up the reflected waves and an analysis of this signal is done to locate flaws in the object under inspection. Sound waves follow the loss of optics in their propagation (Anon, 1997). Further the velocity of propagation of sound in various metals has been very accurately measured. The time taken by the sound pulse to travel through the material is the direct measure of the length of path traveled by it. Ultrasonic inspection both through transmission and pulse echo techniques are used. Pulse echo technique is the most widely used technique in ultrasonic testing (Fig. 1). Ultrasonic can detect cracks, laminations, shrinkage, cavities, flakes, pores and other discontinuities like intrusions etc in plates, pipes, welds, castings, forgings etc. in service defects, such as fatigue cracks, creep cracks, hydrogen embrittlement, stress corrosion etc. as well as thickness determination can e carried out using the ultrasonic pulse echo technique. In the ultrasonic testing conducted by NIRM (NIRM, 2004, 2005a , 2005b, 2005c), ultrasonic equipment of type-MODSONIC GALILEO -100 was deployed. 100% back wall reflection method with manual mode of operation was adopted with a couplant - SAE 20 oil and low melting grease. IIW block - V1 and Miniature block V2 were used, and 100% FSH echo was observed on the CRT screen of Ultrasonic Detector equipment. Normal beam probe of , 1, 2, 2.4 MHz frequency, 12.5, 19 , and 25 mm dia hard face type was used. Frequency, size and angle of the angle probe that was used for the experiments were 1, 2.2 MHz, 37X17mm, 45, 60, and 70 degrees respectively.

Table 1: Ultrasonic testing details

1.	Type of equipment used	MODSONIC GALILEO-100
2.	Method of testing	'A' Scan, 100% back wall reflection method
3.	Mode of operation	Manual
4.	Couplant used	SAE 20 oil and low melting grease
5.	Calibration block	IIW block – V_1 & Miniature block – V_2
	Probe details	(i) Normal beam probe Frequency : 1, 2, and 2.4 MHz Size : 12.5, 19 and 25mm dia Type : Hard face (ii) Angle beam probe Frequency : 1 and 2.2 MHz **Size : 37 x 17 mm** Angle : 45°, 60°, and 70°

Magnetic Particle method

Electromagnetic crack detector of Yoke Model was used with longitudinal method of magnetism. Method of inspection was fluorescent technique examined under ultraviolet black lamp. Magnetic particle testing is a sensitive method of locating surface and subsurface defects in ferromagnetic components. When these components are magnetized, magnetic discontinuities that lie in a direction approximately perpendicular to the field direction result in the formation of a strong leakage field (Anon, 1994). In the present testing, Yoke was used to magnetize the testing specimen (Fig 2 and 3).

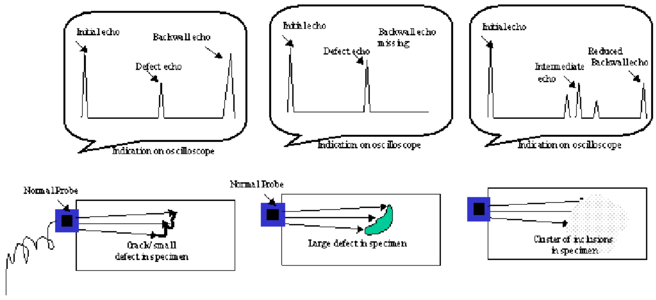

Fig 1 : Principle of ultrasonic testing-Pulse echo method

This leakage field is present at and above the surface of the magnetized components and its presence can be visibly detected by the utilization of finely divided magnetic particle. Application of dry particles or wet particles in a liquid carrier, over the surface of the components, result in a collection of magnetic particles at a discontinuity. The magnetic-bridge so formed indicates the location, size and shape of the discontinuity. Magnetization may be induced in a component by using permanent magnets, electromagnets or by passing high currents through or around the component (Table 2).

Fig 2: Longitudinal Magnetization with yoke for magnetic particle testing

The direction of a magnetic field in an electromagnetic circuit is controlled by the direction of current flow and the magnetic lines of force are always at right angle to the direction of the current flow in a conductor.

Table 2: Magnetic Particle Testing Details

Type of equipment used	Electromagnetic crack detector Yoke model
Method of magnetism	Longitudinal
Current used	HWDC
Method of inspection	Fluorescent technique, examined under Ultraviolet black lamp

TESTING OF WINDER VITAL COMPONENTS

Prior to the testing, the suspension gear parts were cleaned with solvent (Diesel) and then dried with compressed air. Indian Standards were followed while conducting the non-destructive tests (IS-3703,1998; IS-7743, 1998; IS-4904,1997; IS-9565,1998; IS-8791, 1992). These components were physically examined whether they are free from pitting, corrosion, wear and deformation in the body. All the components were tested under loaded condition.

- All the components were scanned along the longitudinal and transverse direction using normal beam probes.
- Angle beam probe (45°) was also used for scanning along the transverse direction.

A) **Suspension Gear Parts:** All components were magnetized by Yoke type Electromagnetic crack detector and viewed with Ultraviolet lamp. All the suspension gear parts such as rope cappel with pin, Egg-link, D-Shackle with pin, Safety Hook, Top D-Shackle, Distribution Plate, Bottom D-Shackle, Bridle Chains & Cage D-Shackle with pins are all free from surface and sub-surface defects. All the load carrying pins were tested with normal beam probe longitudinally does not reveal any internal flaws.

B) **Drum shaft:** The shaft was divided into number of zones. Testing was carried out with both normal and angle beam probes in loaded condition (Fig 4).

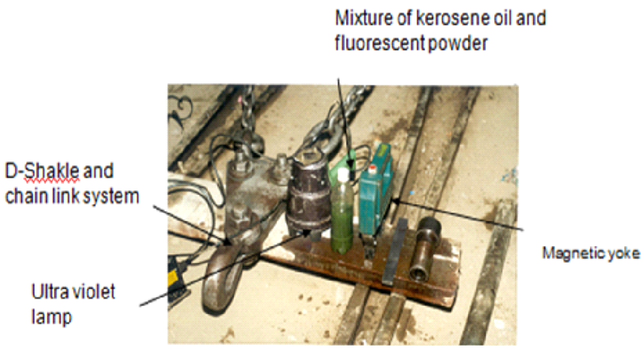

Fig 3: Magnetic particle testing of components of suspension gear parts

The shaft was rotated 180° to test all the points the drum shaft was scanned with normal probe radially and axially. The entire length of the shaft was also scanned longitudinally from one end. Then the shaft was scanned with 45° angle beam probe. The drum shaft does not reveal any internal flaws.

Fig 4: Ultrasonic testing of typical drum shaft with normal probe

C) **Sheave Wheel Shafts:** The end covers and top bearing covers were removed and the accessible portions were tested with normal and angle beam probes. The shafts were also scanned longitudinally with normal beam probes. Careful scanning in the accessible portions of the shafts did not reveal any internal flaws.

D) **Load Carrying Pins (East & West):** All the Load carrying pins were scanned from both the ends longitudinally with normal beam probe. The pins did not reveal any internal flaws.

E) **Vertical Brake Tie Rod:** The entire tie rods were scanned with both normal and angle beam probes. Tie rods do not reveal any internal flaws (Fig 5).

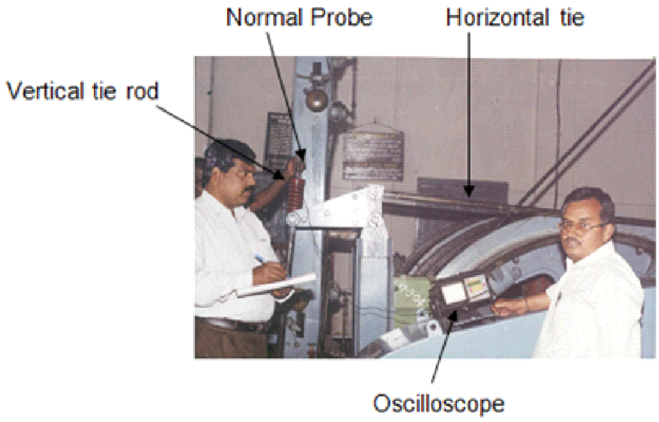

Fig 5: Ultrasonic testing of typical vertical brake tie rod

F) **Horizontal Brake Tie Rod:** The entire Brake Tie Rods were scanned with normal and angle beam probes. The threaded portions of the tie rods were also tested longitudinally from one end with normal beam probe. The tie rods are free from internal flaws.

On the whole, the above tests of suspension gear parts and winder components by ultrasonic and magnetic particle tests indicated no defects. In rare circumstances, when defects such as inclusions, cracks were noticed, it was immediately replaced by defect free components.

G) **Winding ropes:** Electromagnetic method of testing the wire rope is the most widely practiced non-destructive method of studying the condition of wire rope under in-situ conditions. In this method, wire rope is magnetized using powerful magnets [1,2]. The magnetic lines of forces travel along the axis of wire rope. If there is a discontinuity, the magnetic lines of forces deviate from their path and there will be a leakage field to the air. Using suitable sensors, leakage fields are detected, recorded and analyzed to identify the type of discontinuity. Fig. 1 shows the schematic layout of the equipment used in electromagnetic testing. faults, which includes broken wire, wear,corrosion, pitting, and inter strand nicking.

Inductive coils are used to detect these defects. This is detected by the inner coil of the equipment.

• LMA Sensors: LMA means loss of metallic area. Hall sensors are used to measure this parameter. This is detected by the outer coil (Hall sensor) of the equipment.

Defects in Wire Ropes: In order to analyze the defects in a wire rope by the electro-magnetic method, there should be a prior knowledge of the possible defects. The defects (Fig 6) usually present in a rope which was put into many years of service are Wear ,Nicks ,Corrosion ,Pitting ,Broken wire.All these defects appear as local faults (LF). The loss of cross sectional area due to these defects appears as LMA. Inner coil detects the LF defects and Hall sensor detects LMA.

The signals detected by the inner and outer coils are in the range of milli-volts. LMA signals are easy to analyse, as the shift in voltage from the base line is easily correlated with the loss in area calibrated using calibration rod before recording the test data. The difficulty arises in analyzing the inner coil signals, which detects the signals from wear, corrosion, pitting, nicks and broken wire. It is very difficult to distinguish the LF signals if they are of the same magnitude. A prior knowledge of the type of defects present in the rope helps in characterization of the various defects.Apart from the defect signals, inner coil also records signals due to the construction of rope, called as lay noise. These signals are usually measured from the non-defective portions of the rope, which may be about 75- 100 mV depending on the construction of the wire rope and its usage.

Defect Patterns: Inner coil voltage variation is an indication of the presence of defects. Few of the typical defect patterns recorded are illustrated here. If the wire rope is free from defects, the variation of inner coil voltage is small, and is uniform throughout the length of the wire rope. This pattern arises due to the construction of wire rope, termed as lay noise. A typical pattern of a lay noise is shown in the Fig. 7. The Y-axis represents the magnitude of the inner coil voltage and X-axis, the linear dimension of the rope.Fig. 8 & 9 shows a gradual increase in inner coil voltage, which arises due to the presence of defects possibly due to wear, nick and few broken wires. Defects due to broken wires are shown in Fig. 10. In general, it Is not possible to distinguish the signals due to nick and broken wires.

Calibration:In atypical defect pattern shown in Fig. 6, possible defects were only wear and the broken wires. Form these patterns; it is not possible to distinguish the wear and broken wires and also the number of broken wires. In order to estimate the signal level due to wear and broken wires, calibration tests were carried out in the laboratory by creating artificial defects.

Calibration for wear:Wires with different percentage of wear were artificially prepared by grinding the wire surface. The equipment consisting of magnetic head and the sensors was kept in the vertical position and the wires were allowed to fall freely in between the powerful magnet, and the inner coil voltage was recorded.

Calibration of broken wire:To estimate the signal due to broken wire, cross sectional area of the individual wires was considered. Wire rope with various numbers of broken wires was artificially created and was allowed to fall freely in between the powerful magnet, and the inner coil voltage was recorded. These calibration results as cross sectional area vs. the inner coil voltage are presented in Fig 5.

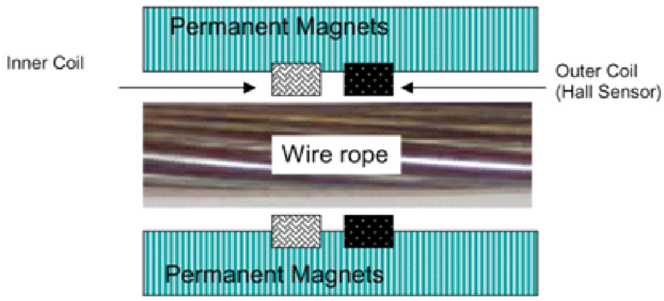

Fig. 6: Schematic layout of equipment used in electromagnetic testing

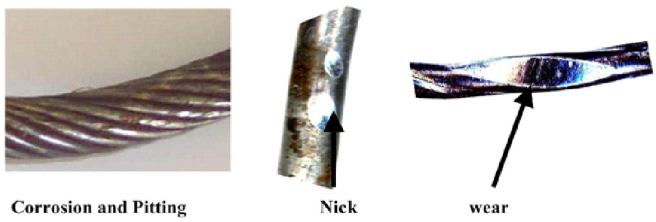

Fig. 7: A typical rope sample with defects

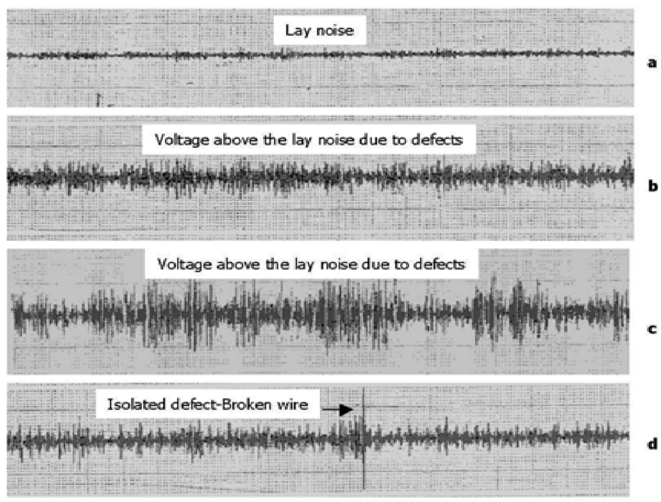

Fig. 8: Defect pattern in a typical wire rope

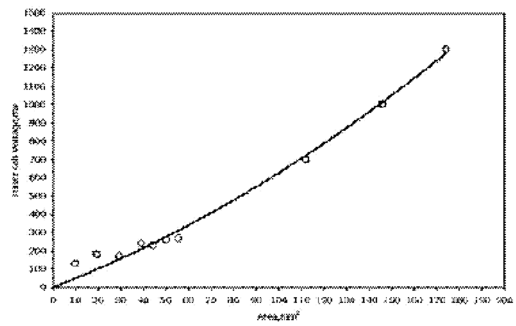

Fig. 9: Calibration curve of wear Vs inner coil voltage

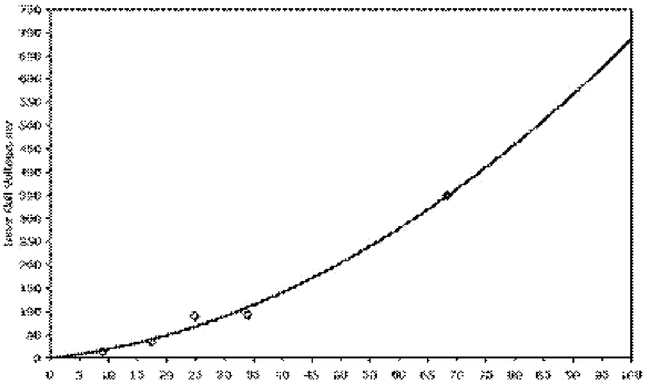

Fig. 10: Calibration curve of area of broken wires Vs inner coil voltage

Based on the recorded inner coil voltage, the percentage wears and the area of the broken wires is estimated from these calibration curves. From the area, the number of broken wires was estimated based on the construction of the rope. It is assumed that when the wear of wire reaches 50% of its original diameter, the wire breaks. From this graph it is inferred, that any inner coil voltage less than 200 mV is treated as wear. It should be noted, that the inner coil signal up to 30% of wear could not be distinguished as it merges with the lay noise. Fig. 10 shows the calibration curve of inner coil voltage due to broken wires vs area of the wires. It is inferred that approximately one broken wire of diameter 3.26mm (for a typical construction of a wire rope) produces a signal of 40.88 mV, which is merged with the lay noise. Approximate voltage output from different number of wires is presented in Table 3 for a typical rope. Fig. 11 demonstrates a Rope defectograph commissioned in a typical underground mine for NDT test on winding rope.

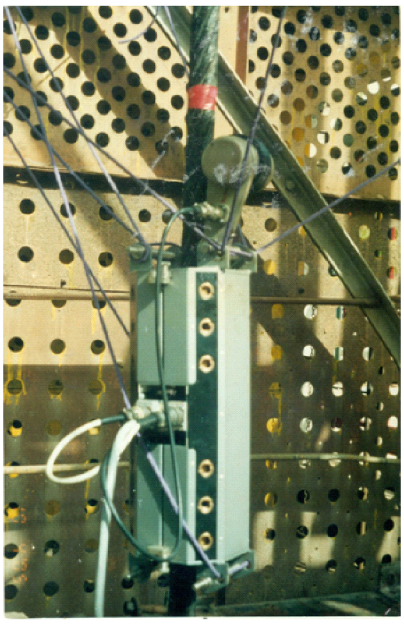

Fig. 11: Rope defectograph commissioned in a typical underground mine for NDT test on winding rope

Table 3: Approximate Voltage Output from Different Number of Wires

Inner coil voltage (mV)	No. of Broken wires
40.88 1	1
122.64 3	3
204.4	5
327.04	8
367.92 9	9

From the Table.3, it is clear that if 3 wires are broken, the signal voltage merges with the lay noise (about 100 mV), and signal voltage due to wear (Fig 4). Therefore, it is not possible to distinguish lay noise, wear and broken wire in case of signal levels of about 120 mV. To consider a signal due to broken wire, the voltage should exceed 200 mV. It may be noted that the voltage exceeding 200 mV corresponds to a breakage of 5 wires. This calibration curve helps in calculating the number of wires, considering the construction of the wire rope.

CONCLUSIONS

In case of any new equipment, non-destructive testing of its components is required before they are put to use. For this purpose, Ultrasonic and Magnetic particle tests are most widely used, in addition to proof load tests by manufacturers and customers. Based on non-destructive evaluation of various mining machinery components, it is recommended that a document of such tests by other than the manufacturer/mining industry (i.e by any research/ academic organisation recognized by DGMS) would be useful for better evaluation of condition of the equipment later in working condition.

Major/vital components such as drum shaft and brake tie rods need to be tested in loaded condition for better evaluation of safety of the equipment. In view of absence of such clause in the existing mining law, it is also suggested to modify the testing procedures, accordingly. Magnitude of the defect signals were simulated with rope-defectograph by creating artificial defects in the laboratory, which can be used for analyzing the actual signals recorded during in-situ testing on wire ropes. Calibration methodology was based on fundamental principles, keeping the objective of quantifying the LF results, which helps to study the condition of the wire rope. The calibration curves and typical signal patterns of lay noise, various defects in a wire rope are illustrated. The major problem in analyzing the defects is owing to the presence of the noise caused by the construction of the wire rope, which interferes with the signals due to the defects. The difficulty arises in distinguishing the inner coil signals from wear and broken wire. Additional studies are required for standardizing the method of calibration for wide application to various industrial purposes.

ACKNOWLEDGEMENTS

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Intelligent Fuelling Management Solutions For Mining Firms

Hemant S Dahale*, Krishna Prasad. G**

INTRODUCTION

Fuel expenses accounts for a major share of the daily operational expenses of mining companies. All the mining firms get the fuel from Oil marketing companies and they pay for it. To be competitive keeping a proper check on the consumption of the fuel is critical for any mining firm. In India mining firms have manual system on which they are relying for the management of the Fuelling under various departments like, stores, maintenance, purchase etc. With the mining operations happening at such a complex terrain with insufficient manpower in many cases, keeping a proper record on accurate fuel consumption is quite challenging. This paper addresses to the operational losses which could be happening due to the inefficiency of the existing system for fuel delivery & consumption management in detail. It also explains in detail the various technologies/solutions that can be implemented for managing the fuel consumption. These solutions are already being used in leading mining firms in India & world wide. Being designed to work in mining areas, these solutions are quite robust and would give the desired results. This also includes the Return of Investment (ROI) for such a solution and also includes advanced solutions like Just in Time filling, where a mining vehicle/equipment is filled only when it needs fuel. Also it covers high speed filling technologies for saving the fuelling time and there by optimising operational efficiency. The authors of this report have over 20 years of experience in the oil and gas industry working with various industrial segments and the latest technologies available in the market for fuel management.

BACKGROUND

The fuel management system forms an integral part of the management process in a mining industry and hence is one of the most critical areas. It deals with the management of commercial, operational and administrative functions pertaining to estimating fuel requirements, selection of fuel suppliers, fuel quality check, transportation and fuel handling, payment for fuel received, consumption and calculation of fuel efficiency.

The results are then used for cost benefit analysis to suggest further improvement. At various levels, management information reports need to be extracted to communicate the required information across various levels of management. The core processes of fuel management involve a huge amount of paper work and manual labour, which makes it tedious, time-consuming and prone to human errors. Moreover, the time taken at each stage as well as the transparency of the relevant information has a direct bearing on the economics and efficient operation of the mines.

Both system performance and information transparency can be enhanced by the introduction of Information Technology in managing this area. This paper reports on the development of RFID based Fuel Management System, Software based on a specific architecture, which aims at systematic functioning of the Core Business Processes of Fuel Management of a typical Mining company in the Indian scenario.

This report brings light to the pitfalls in the current fuel management systems being followed in mines and also it discuss in details the various technical solutions available in the market and being used internationally in the mining industry.

CYCLE OF FUEL CONSUMPTION IN MINES

The mining firm orders fuel to the respective oil depot

- The fuel (diesel) reaches the tank from the Oil Depot in Tankers
- There are 2 ways in which this would be dispensed out

a. Through stand along dispensers for filling equipments/ vehicles reaching the refuelling site

b. Through pump and flow meter arrangement to aMobile Tanker for filling stationary equipments in mines.

EXISTING SYSTEMS IN MINES

In many of the mines the system is manual

- A dip stick is used for measuring the level of fuel inside the underground tank and it is converted to volume using strapping table.
- Required quantity of fuel is ordered from the oil depot when is level is below a certain limit
- The dispensing of fuel is measured using dispensers or flow meters and recorded manually
- At the end of the day the entire fuel consumption is tallied against the supply for the day.

Where lies the problem?

Let's use a terminology called operational Losses.

Operational Loss is the accounted fuel losses in the mine.

For eg: - If a mine purchase daily 10000 litres of diesel has 100 vehicles So, suppose 10 KL was ordered when the fuel level was 500 mm and the new level is 1500mm.

At the end of the day you see that, the level of fuel is again say 500 mm.

So, as per this there shall be clear record of how these 10000 Litres was consumed in the day. But, with the manual readings being taken, it is virtually

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impossible to keep a proper record of Fuelling accurate data. If you add all the quantity of fuel dispensed to various vehicles, it would be less than 10 KL.

The difference is the operational loss. From our experience there are several mines which are running with 5-7 % operational loss. Optimising the operational losses is needed for profitable operation.

So for a mining firm with 10 KL daily consumption and an operational loss of 5%, say Rs 40 is the cost of diesel

The operating loss/day = 10000*40*0.05 = Rs. 20,000

Monthly Loss = 20,000*40 = Rs. 8,00,000

Annual loss = 8,00,000*12 = Rs. 96,00,000 (Ninety Six Lakhs)

The possible reasons for these losses, from our experience are

1. Intentional and Unintentional Human discrepancies
2. Error in measurement
3. Unavailability of accurate records, readings for verification

In many mines, this loss is not even accounted as there would not be any measuring equipments as such. But at a times when the margins are getting squeezed due to international competition, managing these loses is critical. Also, the accurate consumption details of various vehicles would also give clear indications of the maintenance needs of the vehicle too.

SOLUTION- BASIC PRINCIPLE

If we study in detail the possible reasons for the operational losses, it happen due to the following these reasons

a. Intentional and Unintentional Human discrepancies
b. Error in measurement
c. Unavailability of accurate records, readings for verification

So, the solutions are based on the following 3 principles

1. Authorisation of Fuelling by Identification
2. Accurate Measurement of fuel dispensed.
3. Recording of data which are readily available for processing.

AUTHORISATION OF FUELLING BY IDENTIFICATION

For avoiding the error of Intentional or Unintentional Human error, this principle would help. The solution would identify the vehicle to be filled or being filled automatically with out the need of a human interface.

We could program the identity of the vehicles to be filled in the software and the hardware would identify the vehicle and seek authorization before starting the filling.

Accurate Measurement of Fuel Dispensed

The error in measurement happens due to the in accurate measuring instruments.

With our solutions there are accurate measuring instruments available which would record the accurate amount of filling against the vehicle id.

Recording of data which are readily available for processing

This principle will address to the issue of unavailability of accurate records for processing. The system would record the filling details of each vehicle against their id and will send the same to back end software which would prepare the necessary reports.

In the following pages, we shall explain in detail the various components of the solution.

ATG FOR TANK AUTOMATION

ATG is (Automatic Tank Gauging Systems) is a gauge which could be inserted in tanks and which could

provide accurate details of the level, volume and density of fuel inside the tank on a real-time basis. It would

be connected to a Back office Software through a console. The console would provide power supply to the

ATG and would also facilitate the data transfer.

The advantage of the system is

- Just in time ordering with advances features like “pop up alarm” once the level goes downsource for best supply chain management
- Precise, Fast and reliable measurement of the fuel inside the tank avoiding human errors
- Safety aspect. No need to put a dip every time.
- Real time level of Diesel, level of water, Temperature inside the fuel tank.
- Better Diesel Stock management.
- Static leak detection of the tank

In short the mine owner can be tension free about Underground Fuel Tank Management.

REPORTS

- The back office could give various reports including the variation in level and volume over time.
- The graphical display of level and volume at any point of time

The Back office software is customisable to have the reports which the mining firms require.

MANAGING MULTIPLE SITE TANKS WITH ATG

If there are more than one mine being operated by a firm and if the ordering of fuel is centralised from a location, there is a possibility to get the fuel level and volume in all the tanks in a computer at the centralised location.

SOLUTIONS FOR MONITORING THE FUEL BEING DISPENSED THROUGH STAND ALONE DISPENSERS

Automation of Fuel Dispensing through Pumps

- OPT Terminals could be connected to standalone dispensers
- Every Transaction through the Dispenser would happen when authorised by OPT only
- The Authorisation shall be done with the driver Proximity cards or with the RFID tags fitted on the fuel inlet of the vehicle / Equipment.

- There is a possibility to prefix a limit for each vehicle and thus manage the inventory cost for fuel.
- For rented fleets, there is even possibility for fixing limits based on the Kilometres being run and even modules are available which could help to raise invoices to Contractors.
- The fuelled data is stored in the memory of the terminal for further processing
- All the filling data would be available in the prescribed report format for further processing, when data's polled through wired or wirelessly from the terminal & further which could be shared either through mail or ERP.
- In short the complete filling process could be monitored remotely & quite effectively.

BENEFITS OF THE SOLUTION

- Complete control over the fuelling of the rented trucks fleet
- Total Transparency in fuelling operation.
- Minimal Chance of intentional or Unintentional human error in filling and in turn savings in fuel.
- Precise Data available at the click of a mouse.
- Effective data for MIS.
- Complete fuel transaction through the dispensers is recorded and hence could optimise fuel expenses reducing lose.
- The solution helps the management to have accountability of the actual filling process as decided by the management
- The system could work 24*7 and is tamper proof.

RENTED TRUCK FILLING MANAGEMENT

Certain Mines have an arrangement with rented truck owners that, the fuel for there operation would be supplied by the mine based on the number of trips made by them during the last day and the cost of fuel is deducted from the fortnight or monthly payment.

Find below the system which would help to manage them. Say for a mine there are 200 rented trucks and they ply in 4 different routes and depending on the distance covered in each routes fuel allowance is fixed for each trip

- Each truck shall be fitted with an active RFID tag.
- Fuelling limit can be fixed depending on the usage of the particular vehicle.
- Now the OPT knows how much fuel to be given to each truck.
- So when the truck reaches the fuel station, the truck id is captured automatically from the RFID device and the dispenser would only dispense the fuel allotted for it for the day.
- The data would be saved in the OPT and could be downloaded to the Back office software for further processing.
- There would be also modules in the software which would help to raise an invoice to the truck owners deducting the amount of fuel taken by them

Thus the entire process could be managed at ease and the management would have better control over the entire process.

In short all the stake holders are happy

- Happy mine owner
- Happy workers
- Happy truck Owner

SOLUTIONS FOR MONITORING THE FUEL CONSUMPTION THROUGH A MOBILE TANKER (BOWSER)

The following is the cycle in which the filling through a mobile tanker is happening now The possible loopholes for loosing fuel are the following

1. The only record which is available for analysis is the manual record.
2. As the fuel consumption of mining vehicles are very high, there is always a chance for some mischief happening which would result in loses to the firm.

So, the following steps needs be managed

1. Filling of the Bowser
2. Filling of the vehicles. Making sure that the reports are accurate
3. No unauthorised filling is happening
4. Making the reports available for analysis with vehicle wise reports.

I) For the filling of the Bowser- a flow meter would be an ideal device. It could give you the accurate reading of the amount of fuel being dispensed in to the Bowser. Else if it is being filled from Stand alone dispensers the solution offering would record this filling too.

II) . For the point 2,3 and 4 the following solution combined with the Back office Software's would do

ROI (RETURN ON INVESTMENT) OF A TYPICAL SOLUTION

Consider a solution for a fleet of 200 vehicles owned or rented with an average filling of 15 KL with cost of a litre Rs.30. And take the cost of the complete solution as Rs. 20 lakhs and with additional maintenance cost The average saving from the solution would be 2 %.

Here find an ROI Calculation

AVERAGE DAILY CONSUMPTION	=	15000 LITRES
AVERAGE COST/LITRE	=	RS. 40
AVERAGE DAILY FUEL COST	=	15000*40=RS. 6,00,000
AVERAGE ANNUAL SALES CONSIDERING 300 WORKING DAYS	=	RS. 6,00,000*300
	=	18,00,00,000
AVERAGE SAVING CONSIDERING 2 % SAVING	=	RS. 18,00,00,000*.02
	=	RS.36,00,000
APPROXIMATE PROJECT COST	=	RS. 20,00,000
ROI IN MONTHS	=	40,00.000/36,00,000*12
	=	**13.3 MONTHS**

HIGH SPEED FILLING USING BOWSER

The usual filling speeds which is being used for filling mining vehicles/equipments ranges from 60-80 LPM due to various constraints like the

a. The capacity of the pumps
b. The nozzle which is being used
c. The constraints in the inlet of the fuel tank of the mining vehicles

For filling of mining vehicles a filling speed of 200LPM would be optimum considering various factors like

1. The capacity of a Bowser used in India is usually 9KL of which approx 7KL is only filled at a time for the easiness of moving in the mine
2. The average filling at a time varies from 300 - 400 litres if the filling is happening in 2 shifts. So,with a filling speed of 200 LPM the filling could be done in 2 minutes or less

   The following are the hardware's needed for a high speed filling arrangement

1. High speed Pump
2. A Strainer
3. Flow meter with all the hi speed filling arrangements connected
4. Specialized Hose which is connecting to the mining vehicles with specialised coupling type nozzle arrangement.
5. Modification in the mining vehicles tank fuel inlet arrangement to connect the hose with coupling arrangement.

Benefit

- Filling time of a 800 Litre tank could be reduced from 10-12 minutes to 4 minutes and with a fleet of 70 vehicles substantial saving in fuelling time
- Increased productivity.
- More profit.
- Happy Stake Holders.

CONCLUSION

The various technical solutions briefed in the report are being used internationally and helping leading mining firms have substantial fuel saving in its operation. With fuel expenses accounting for a large share of the daily operating expenses, managing it is quite critical for being competitive.

At a time when the world is getting smaller and smaller, technology should reach the right people and help them make there life easy, more profitable business and contribute for the growth of the Nation.

(NB: Photo diagrams can be referred during presentations)

Rock Fragmentation Analysis of South Kaliapani Region using Kuz-Ram Model-A Case Study

P. Sahu*, A. Parida, S. R. Mallick*****

ABSTRACT

Evaluation of fragmentation size is very important as far as Mine Economy is concerned. Rock fragmentation prediction has been carried out by various researchers for optimising the blast design parameter using various softwares and mathematical models. Kuz-Ram model is one of them. The paper mainly focus on prediction of mean fragmentation size by Kuz-Ram model and comparing with actual size obtained from image processing software, Wipfrag by considering various factor such as spacing to burden ratio, powder factor and rock factor etc. The prediction based on Kuz-Ram model shows better result compared to actual size. For further confirmation of the result, a statistical analysis based on MVRA is done and the prediction shows higher coefficient of determination (R^2=0.994) for Kuz-Ram model.

INTRODUCTION

Mining is extraction of valuable minerals exist beneath the earth surface through excavation. Excavation method can be done in two ways, either by direct penetration or by drilling and blasting. Drilling and blasting method consume huge amount of explosive. The main objective of blasting is optimum fragmentation. When explosive detonates, hole pressure may exceed 20,000-1, 00,000 times than the atmospheric pressure. This also generates stress waves that travel with a velocity of 5000 m/s. The loading front of the stress wave is compressive. The shock wave travels outward as a compression wave in all directions from the borehole, moving at or near detonation velocity. The rock surrounding the borehole is crushed as the force of the wave exceeds the compressive strength of the rock. The force of the wave overcomes the elastic limit of the rock, causing it to bend outward and crack. Radial cracks are radiate out from the borehole. Rock fragmentation depends upon two groups of variables: rock mass properties which cannot be controlled and drill-and-blast design parameters that can be controlled and optimized.

The fractured rock mass has certain inertia which the gas pressure must initially overcome to start rock movement, creating fragmentation. So rock fragmentation depends upon rock factor, powder factor and energy factor as stated by Kuz–Ram, 1980. Rock factor is the ratio of compressive strength to tensile strength of rock mass (Hino, 1959). Jimeno *et al.*, 1995 observed that blasting operations are determined by a number of parameters, which can either controllable or uncontrollable. They classified the controllable parameters into three groups as A- Geometric: diameter, charge length, burden, spacing etc., B- Physico-chemical or pertaining to explosives: types of explosives, strength, energy, priming systems, etc. and C- Time: delay timing and initiation sequence, where uncontrollable factors include geology of the deposit, rock properties, presence of water, joints, etc. Jethro Michael Adebola *et al.*, 2016 predicted fragmentation size using Kuz-Ram model by considering blast design parameters. The fragmentation size was reduced from 113 cm to 105 cm by optimising the blast design parameter.

Current study explains Kuz-Ram model is best suitable for prediction of mean fragmentation size, comparing with actual size by considering various factor such as burden to spacing ratio, powder factor and rock factor etc.

2. SITE DESCRIPTION AND DATA COLLECTION

The chromite bearing Sukinda Ultramafic belt is one of the largest chromite deposits of India (Srinrvasachari, 1979, Chakraborty and Chakraborty, 1984, Sahu and Venkateswaran, 1989). The Mine where rock blast study is carried out falls in South Kaliapani region belongs to Sukinda Ultramafic belt (Figure 1). The blast design parameters such as spacing, Burden, hole depth, stemming, charge amount per hole was collected from blast site (Table 1).

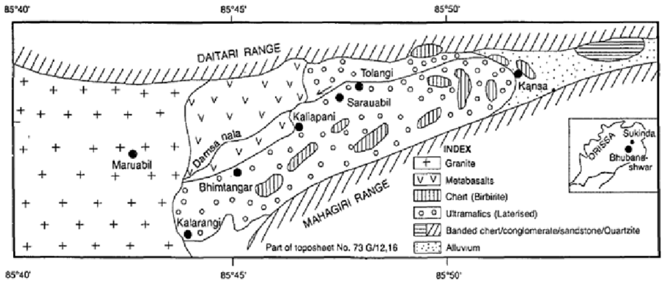

Figure 1: Location of Kaliapani Mine in the Sukinda Ultramafic Belt, Jajpur District, Orissa (Sahoo, 1995)

RESULT AND DISCUSSION

In hard rock mining, blasting is the most productive excavation technique applied to fragment in-situ rock to the required size for efficient loading and crushing. In order to blast the in-situ rock to the desired fragment size, blast design parameters such as bench height, hole diameter, spacing, burden, hole length, bottom charge, specific charge and rock factor are considered for Kuz-Ram Model. The model explains the mean fragmentation size as the function of rock factor and energy factor. The rock factor is the ratio of compressive strength to tensile strength (Hino,

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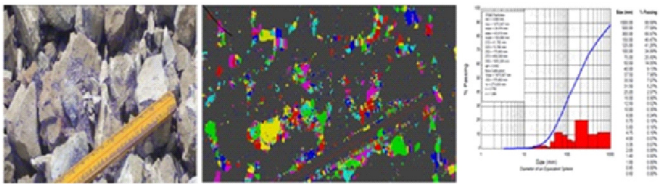
1959). The energy factor is the product of powder factor and Relative weight strength of explosive. The actual mean fragmentation size (X_{50}) is obtained through image processing software (WipFrag) and is compared with Kuz-Ram model (Figure 2).



3.1 Kuz-Ram Model

It is the most widely used rock fragmentation model, based on Kuznetsov equation (Eq-1) relates the mean fragment size to the quantity of explosive needed to blast for a given volume of rock.

$$X_{50} = A \times \frac{Q^{\frac{1}{6}}}{K^{0.8}} \times \left(\frac{115}{RWS}\right)^{\frac{19}{20}} \quad \text{...............Eq-1}$$

Where,

A=Rock Factor,

Q=Charge Weight (kg)

K= Powder Factor

RWS=Relative Weight Strength of Explosive

Table -1: Blast Design Parameters and Mean Fragmentation Size of South Kaliapani Region

Blast Site	S (m)	B (m)	Dia. (mm)	Depth (m)	No of Holes	C/H	PF	RF	X_{50} (m) Kuz-Ram	X_{50} (m) WipFrag
BS-1	3	4		6.6	120	37.5	0.47	8.7	0.32	0.24
BS-2	3.5	4		7.6	100	50	0.46	7.5	0.29	0.13
BS-3	3	3.5		5.5	135	25	0.43	9	0.34	0.18
BS-4	4	4.5		7.5	125	50	0.37	11.8	0.56	0.28
BS-5	2.5	3		5.5	85	18.75	0.45	10.8	0.37	0.19
BS-6	3.5	4	150	6.6	155	43.75	0.47	8	0.30	0.32
BS-7	4	4.5		6.5	110	50	0.42	6.9	0.29	0.38
BS-8	3.2	3.8		7	70	37.5	0.44	8.4	0.33	0.26
BS-9	4	4.5		7.5	90	56.25	0.41	11.9	0.53	0.42
BS-10	3.5	4.2		7.2	95	56.25	0.53	11.13	0.40	0.38

(S=spacing, B=Burden, C/H=Charge/Hole, PF=Powder Factor, RF=Rock Factor, X_{50}=Mean Fragmentation Size)

3.2 Powder Factor

Powder factor is the ratio between the amount of broken rock and total weight of explosive consumed. It is an important parameter in blast design and has a vital role on the resultant fragmentation. Higher powder factor causes crushed rock and lower powder factor results oversized rock. The relation shows with increase in powder factor, the mean fragmentation size decreases for both Kuz-Ram model and WipFrag software. The relation holds good for Kuz-Ram model comparatively than WipFrag software (Figure 3).

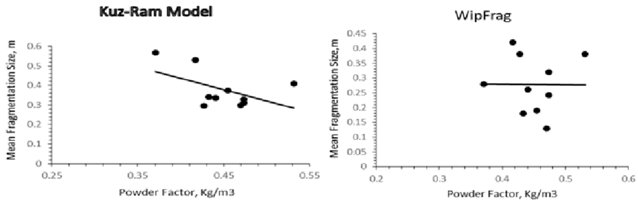


Figure 3: Relationship between Mean Fragmentation size and Powder Factor

3.3 Spacing to Burden Ratio

Spacing and burden are important parameters and possess immediate impacts on rock fragmentation in blast design. Excessive burden creates resistance to penetrate the explosion gases into the fracture and displace rock. Small burden allows the gases to escape and push the blasted rock in an uncontrolled manner with high speed.

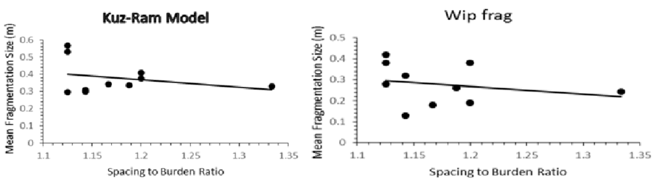


Figure 4: Relationship between Mean Fragmentation size and Spacing to Burden Ratio

Small spacing causes excessive crushing between the holes and superficial crater breakage. Excessive spacing results in inadequate fracturing between the blast holes which creates irregular faces with toe problems. So the relation between Mean fragmentation size and spacing to burden ratio is developed for both Kuz- Ram Model and wipfrag software. The result hold good for both.

3.4 Rock Factor

The rock factor plays vital role for crushing and scattering of rock. The crushing and scattering of rock occurs for both compressive wave and tensile wave. The rock factor is the ratio of compressive strength (CS) to tensile strength (TS) of rock mass. So the relation between mean fragmentation size and rock factor is developed for both Kuz- Ram Model and WipFrag software. The graph shows better trend in case of kuz-Ram model compared to WipFrag software.

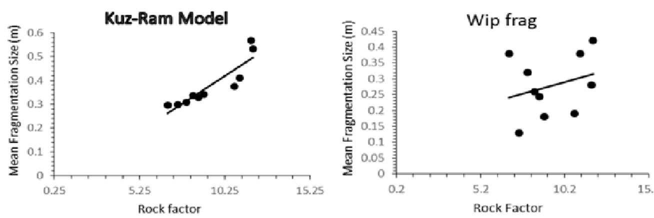


Figure 5: Relationship between Mean Fragmentation size and Rock Factor

3.5 Comparison between WipFrag and Kuz-Ram Model

The bar diagram shows mean fragmentation size obtained from Kuz-Ram model match the mesh size (25-60 cm). Serial no 1, 2, 3 and 5 shows mean fragmentation size by WipFrag is less than mesh size.

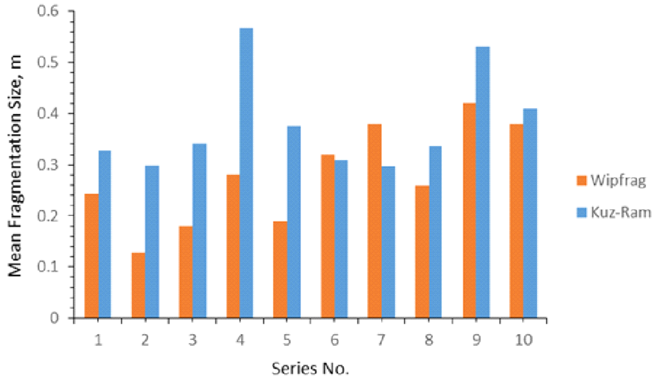


Figure 6: Comparison between Mean Fragmentation Size using WipFrag and Kuz-Ram Model

3.6 Comparison between Kuz-Ram model and Image Processing software by Statistical Approach (MVRA)

The practical application of multivariate statistics to a particular problem may involve several types of univariate and multivariate analyses in order to understand the relationships between variables and their relevance to the problem being studied. So this approach is considered for both kuz-Ram model and image analysis software (WipFrag) to correlate between mean fragmentation size and rock factor, powder factor and charge per hole (Tab 2).

Table 2: Regression Statistics using Kuz-Ram Model and WipFrag

Summary Output	Kuz-Ram	WipFrag
Regression Statistics		
Multiple R	0.997	0.68009697
R Square	0.994	0.462531889
Adjusted R Square	0.991	0.193797834
Standard Error	0.0087	0.0866
Observations	10	10

The relationships developed by WipFrag shown less correlation of determination (R Square) and high standard error compared to Kuz-Ram model. So Kuz-Ram model is best suitable for optimisation of blast design parameter. A new equation based on Kuz-Ram model is developed using multivariate regression analysis (Eq-2).

$$X_{50} = 0.27 + (0.04 \times \text{Rock Factor}) + (0.002 \times \text{Charge per Hole}) - (0.83 \times \text{Powder Factor})$$

CONCLUSIONS

The mean fragmentation size is predicted using Kuz-Ram model by considering rock factor, powder factor and relative weight strength of explosive.The predicted fragmentation size is compared with actual fragmentation size (WipFrag) based on the result of spacing to burden ratio, powder factor, rock factor and mesh size (25-60 cm).For further confirmation of the result, a statistical analysis based on MVRA is done and the prediction shows higher coefficient of determination (R^2=0.994) in case of Kuz-Ram model.The comparison result found to be best for Kuz-Ram model.

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Selective Flocculation of Gua Iron Ore Tailings using Starch and Polyacrylamide as Flocculant

Lenin Mohapatra*, Barun Harichandan and A. K. Dash*****

INTRODUCTION

High demand and depletion of steel in India is increasing day by day. So to meet the demand of steel, the use of low grade iron ore is needed.As India is the fifth largest producer of iron ore, huge amount of slimes or fines are generated during mining process leading to environmental problems.As huge quantities of slimes are generated annually and are being accumulated over the years with reasonably high iron content.So it can be considered as a national resource rather than a waste.As Indian iron ore has high alumina content, it decreases the blast furnace productivity.Highly viscous alumina slag requires larger quantity of flux and slag volume resulting in an increase in coke consumption and decrease in blast furnace productivity [1].If these iron ore are beneficiated and pelletized , it would increase BF and sinter plant productivity.From the literature it is observed that many conventional beneficiationtechnique like gravity separation, magnetic separation, flotation are employed to beneficiate low grade fines but these techniques remain ineffective to upgrade fines because of presence of larger quantity of clays and fines.Hence there is a need for exploring technique such as flocculation and selective flocculation process.This technique is not only help to recover valuable minerals but also address the environmental problem. Selective flocculation is defined as the selective agglomeration of desired mineral in the form of floc using natural or synthetic flocculant and unwanted mineral remain suspended in the supernatant fluid.

It can be observed from the earlier research work that many attempts have been made by different investigator on selective flocculation of different material such as bauxite,coal, phosphate,chromite,magnetite etc. [2, 3, 4, 5, and 6]. The success on such technique relies heavily on chemistry of the process.From the literature it is observed that compared to other flocculant starch has high affinity towards hematite [7, 8].Hence there is a need to study the application of selective flocculation process for particular mineral/tailing.Therefore in this paper an attempt has been made to study the selective flocculation of typical iron ore tailing employing starch and polyacrylamide as the flocculant has been envisaged.

MATERIALS AND METHOD USED

Materials used

The iron ore slimes were collected from Gua iron ore mines(Jharkhand) of SAIL.Chemical analysis of feed iron ore (in wt. %) was,Fe = 48.19%, SiO_2 = 11.96% and Al_2O_3 = 7.30%

It is observed that silica is the major impurity present in the sample. The percentage of other impurities is comparatively small. For Flocculation study the received sample was crushed in a laboratory jaw crusher followed by ball mill to reduce the particle size and then the sample was ground in a laboratory ball mill with required weight of the ball and then it was screened below 75 micron (200#) size.All the flocculation experiment carried out at 75 micron size. Table 1 shows the size analysis of Gua slimes by using wet sieving method in the laboratory.

Table 1:Size analysis of Gua slimes by using wet sieving method in the laboratory

Size, µm	Weight, g	Wt. %	Cum. Wt.% Retained	Cum. Wt.% Passing
-6500 +5000	0.0	0.0	0.0	100.0
-5000 +2380	1453	27.942	27.94	72.06
-2380 +1190	897	17.25	45.19	54.81
-1190 +595	738	14.192	59.38	40.62
-595 +368	256	4.923	64.31	35.69
-368 +200	456	8.769	73.08	26.92
-200 +150	355	6.826	79.90	20.10
-150 to 0	1045	20.098	100.0	0.00

Method

The settling test was carried out in a batch 500ml graduated cylinder with stoppers.Slurry was made with iron ore sample of -75 micron size with tap water according to required pulp density.Amount of iron ore fines and tap water to be used are calculated according to pulp density required.The cylinder was graduated by pasting a graph paper on its outer wall for noting the height decrement of interface in terms of cm.required dose of flocculant was added to it from stock solution.For conditioning the slurry it was stirred for one minute and tumbled 5 times for dispersion of particles.The settling rate of particle was measured by noting down the movement of suspension/water interface as a function of time till there is no further downward movement of particle indicating the end of settling.The effect of various flocculantdosages on different pulp density at different pH were studied and compared by plotting graph.

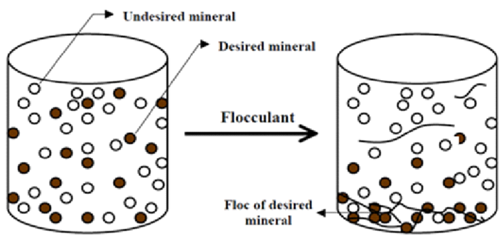

Figure1: Formation of floc by the desired mineral after the addition of flocculant

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RESULT AND DISCUSSION

In this section different operate parameters like pH, flocculantdose,feed grade and solid concentration on the performance of selective flocculation process is explained. The performance was judged by grade and recovery of process at different experiment conditions.

EFFECT OF PH ON SETTLING RATE

Initially settling characteristics of sample was carried out and effect of pH on settling rate of slimes without addition of flocculant is determined. The result of the study carried out is represented in figure 2.From the figure it is observed that increase in pH increases the settlingrate and maximum settling rate of 0.381 cm/s is obtained at pH 11 using a pulp density of 2% by weight.Hence it may be observed that at higher pH all the particles including gangue particles settle down resulting in a complete settling of particles. Therefore to achieve the selectivity of valuable minerals all the experiments were carried out at pH of 9. Therefore after the completion of above tests selective flocculation studies are carried out using different dosage of Polyacrylamide (PAM) and starch as flocculant.

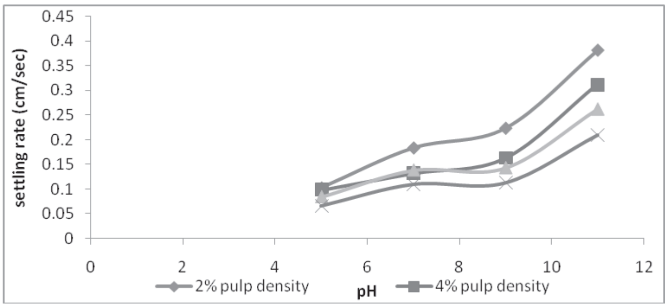

Figure 2:Effect of pH on settling rate at different pulp density

Effect of flocculant dose on settling rate and grade

Graph of height of interface against time at pH 9 in case of starch and PAM are shown in the figure 3 & 4 at 4% PD. From the figure it was observed that with increase in flocculantdosesettling rate increases which may be attributed to the adsorption of amide and hydroxyl group in the particle and make bridges with them [9]. The unit of flocculant dose is mg/g.

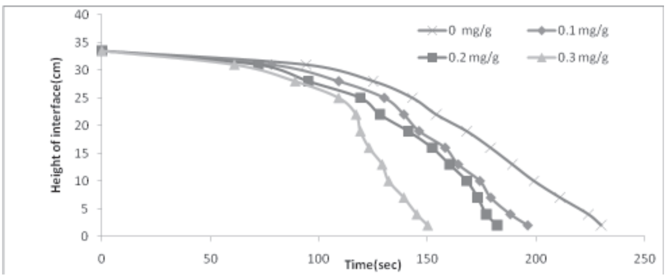

Figure 3: Effect of flocculant dose of starch on settling rate at 4% PD and pH 9

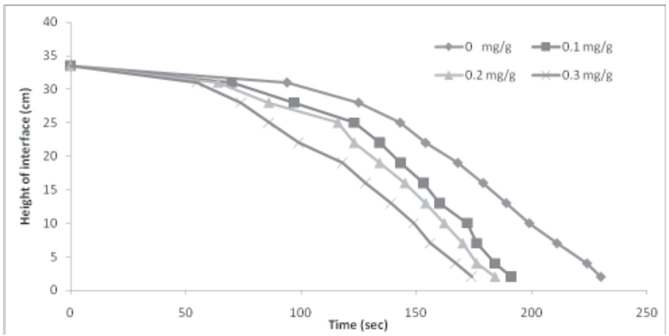

Figure 4: Effect of flocculant dose of PAM on settling rate at 4% PD and pH 9

The variations of grade and recovery with the change of flocculant dose are depicted in figure 5 and 6 for both the flocculant and starch respectively.From the figure it may be seen that with increase in flocculant dose of starch , grade of iron increase to a maximum value of 65.34% with a recovery of 92.31% using 0.4 mg/g dosage of starch.However it is observed that beyond 0.4 mg/g, there is a moderate decrease in grade of concentrate which may be caused by the entrapment of gangue particle in the matrix of iron mineral floc and agglomeration of gangue particle with iron mineral decreases the grade.Similarly the results obtained for PAM shows same results as in case of PAM.From the results it may be seen that a maximum grade of 63.44% with a recovery of 86.84% can be obtained using 0.3mg/g dosage of PAM.From both the results it is concluded that comparing starch and PAM, starch shows higher grade of iron than PAM used in the studies.

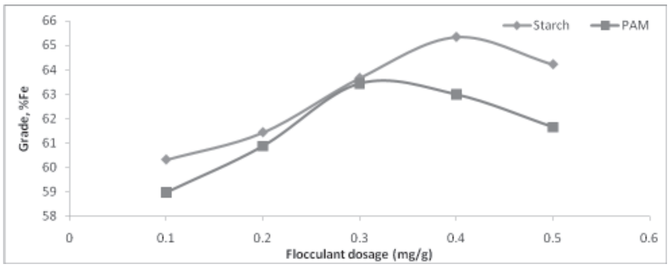

Figure 5: Effect of flocculant dose on grade for both PAM and starch

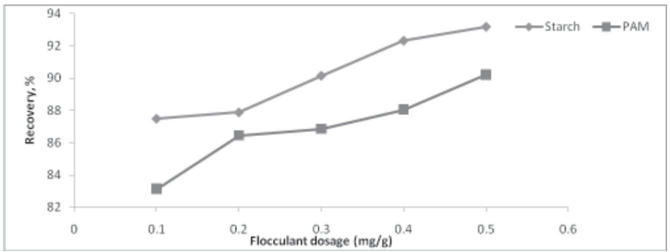

Figure 6: Effect of flocculant dose on recovery for both PAM and starch

EFFECT OF PULP DENSITY

The effect of pulp density (PD) on settling rate is shown in figure 7 & 8 at 0.2mg/g flocculant dose forboth starch and PAM flocculant. From the figure it is observed that with increase in pulpdensity, initial settling rate decreases due to the buoyancy force as well as lesser ease of liquidtrickling through particles [9].

The variation of grade of concentrate with change of pulp density is shown in figure 9.From the figureit is observed that with the increase in pulp density, grade of concentrate decreases. As the solid concentration increases, floc formation increases due to the increase of collision between particles. So with increase in more floc formation, entrapment of gangue particle increases which leads to the decrease in grade of concentrate.

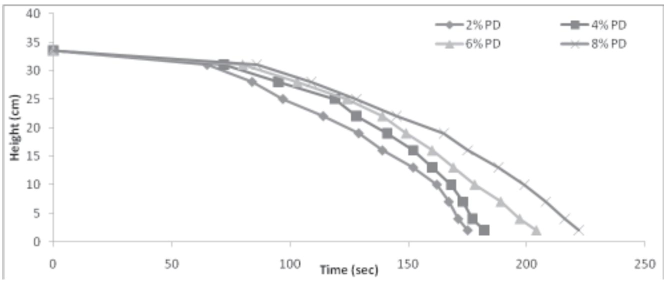

Figure 7: Effect of pulp density on settling rate at 0.2 mg/g FD of Starch

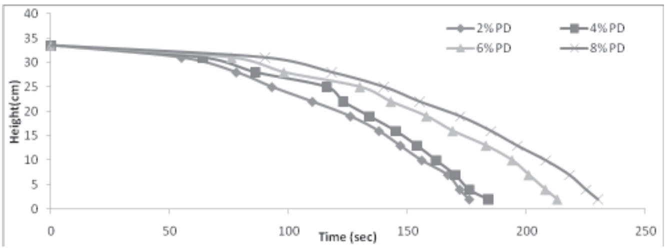

Figure 8: Effect of pulp density on settling rate at 0.2 mg/g FD of PAM

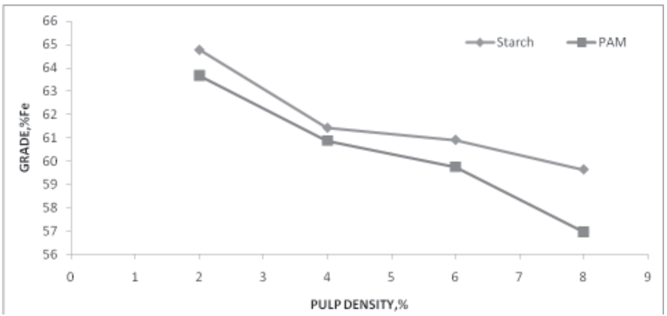

Figure 9: Effect of pulp density on grade of concentrate at pH 9, FD 0.2mg/g

CONCLUSION

To meet the demand of steel, use of low grade iron ore increasing day by day.To beneficiate the low grade iron ore, selective flocculation process is applied.In this paper characterization study indicates that the sample contains 48% Fe with 11.96% SiO_2& 7.30% Al_2O_3. The present investigation has shown that the settling rate increases with increase in flocculant dose.With increase in PD, the settling rate decreases for both the flocculant.The initial flocculation experiment indicates a maximum concentration of 65.34% Fe with a recovery of 92.31%is achieved by using starch as flocculant.However using PAM, maximum grade of 63.44% achieved with a recovery of 86.84% .So comparing both Starch and PAM, results are better in case of starch than in case of PAM at same flocculant dose.

ACKNOWLEDGEMENTS

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Process Mapping: A Tool for Project Monitoring & Scheduling for the Development of Green Field Mining Project

Dr. Kshirod C. Brahma*, Arvind Singh Chauhan**

WHAT IS PROCESS MAPPING

A process map is a planning and management tool that visually describes the flow of work. Process maps show a series of events that produce an end result.. It shows who and what is involved in a process and can be used in any business or organization and can reveal areas where a process should be improved.

PURPOSE OF PROCESS MAPPING

The purpose of process mapping is for organizations and businesses to improve efficiency reduce duplicity and redundancies. Process maps provide insight into a process, help teams brainstorm ideas for process improvement, increase communication and provide process documentation. Process mapping will identify bottlenecks, repetition and delays. They help to define process boundaries, process ownership, process responsibilities and effectiveness measures or process metrics.

UNDERSTANDING PROCESSES

One of the purposes of process mapping is to gain better understanding of a process. The flowchart below is a good example of using process mapping to understand and improve a process. In this chart, the process is making pasta. Even though this is a very simplified process map example, many parts of business use similar diagrams to understand processes and improve process efficiency, such as operations, finance, supply chain, sales, marketing and accounting.

BENEFITS OF PROCESS MAPPING

Process mapping spotlights waste, streamlines work processes and brings in understanding. Process mapping allows you to visually communicate the important details of a process rather than writing extensive directions.

Flowcharts and process maps are used to:

- Increase understanding of a process
- Analyze how a process could be improved
- Show others how a process is done
- Improve communication between individuals engaged in the same process
- Provide process documentation
- Plan projects

Process maps can save time and simplify projects because they

- Create and speed up the project design
- Provide effective visual communication of ideas, information and data
- Help with problem solving and decision making
- Identify problems and possible solutions
- Can be built quickly and economically
- Show processes broken down into steps and use symbols that are easy to follow
- Show detailed connections and sequences
- Show an entire process from the beginning to the end

Process maps helps to understand the important characteristics of a process, allowing you to produce helpful data to use in problem solving. Process maps let you strategically ask important questions that help you improve any process.

BOTTOM OF FORM

Types of process mapping

Process mapping is about communicating the process to others. One can build stronger understanding with process maps. The most common process map types include:

- **Activity Process Map**: represents value added and non-value added activities in a process
- **Detailed Process Map**: provides a much more detailed look at each step in the process
- **Document Map**: documents are the inputs and outputs in a process
- **High-Level Process Map**: high-level representation of a process involving interactions between Supplier, Input, Process, Output, Customer (SIPOC)
- **Rendered Process Map**: represents current state and/ or future state processes to show areas for process improvement
- **Swimlane (or Cross-functional) Map**: separates out the sub-process responsibilities in the process
- **Value-Added Chain Diagram**: unconnected boxes that represent a very simplified version of a process for quick understanding
- **Value Stream Map**: a lean-management technique that analyzes and improves processes needed to make a product or provide a service to a customer.
- **Work Flow Diagram**: a work process shown in “flow” format; doesn’t utilize Unified Modeling Language (UML) symbols.

PROCESS MAPPING SYMBOLS

Key elements of process mapping include actions, activity steps, decision points, functions, inputs/outputs, people involved, process measurements and time required. Basic

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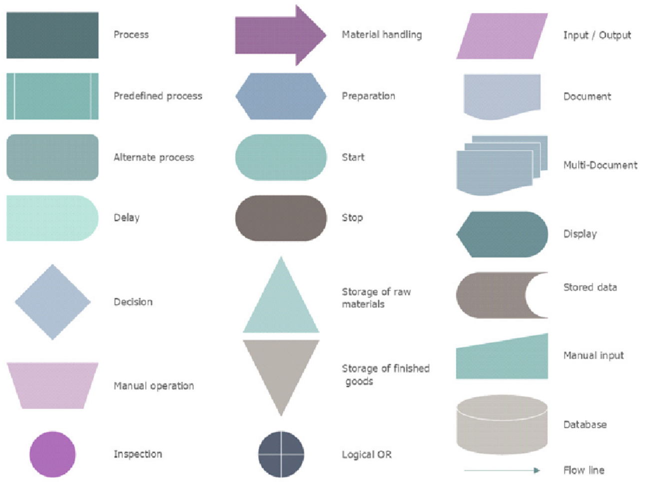
symbols are used in a process map to describe key process elements. Each process element is represented by a specific symbol such as an arrow, circle, diamond, box, oval or rectangle. These symbols come from the **Unified Modeling Language** or **UML**, which is an international standard for drawing process maps.



BUSINESS PROCESS MAPPING

In business, a process is a group of interrelated tasks that happen as a result of an event. These tasks produce a desired result for the customer. Process mapping can be used in many areas of business: business process improvement, business process redesign, reengineering, training, quality improvement, simulation, information technology, work measurement, documentation, process analysis, operational process design, process integration, acquisitions, mergers and selling business operations. Business process mapping can also be helpful for complying with manufacturing and service industry regulations, such as the common **ISO 9000 (International Organization for Standardization)** or **ISO 9001**.

How To Create A Process Map

Process mapping has become streamlined because of software that provides a better understanding of processes. Process maps can be created in common programs like Microsoft Word, PowerPoint or Excel, but there are other programs more customized to creating a process map. Process mapping is about communicating process to others so that one can achieve his/her management objectives. Knowing how to map a process will help one build stronger communication and understanding in his/her organization.

Step 1: Identify the problem

Step 2: Brainstorm activities involved

Step 3: Figure out boundaries

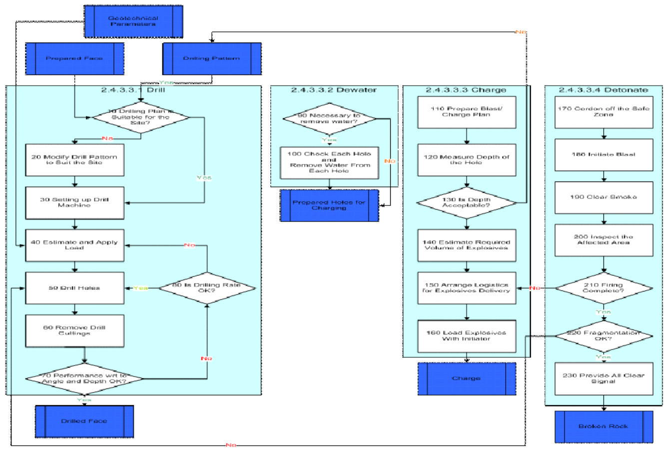
Step 4: Determine and sequence the steps

Step 5: Draw basic flowchart symbols

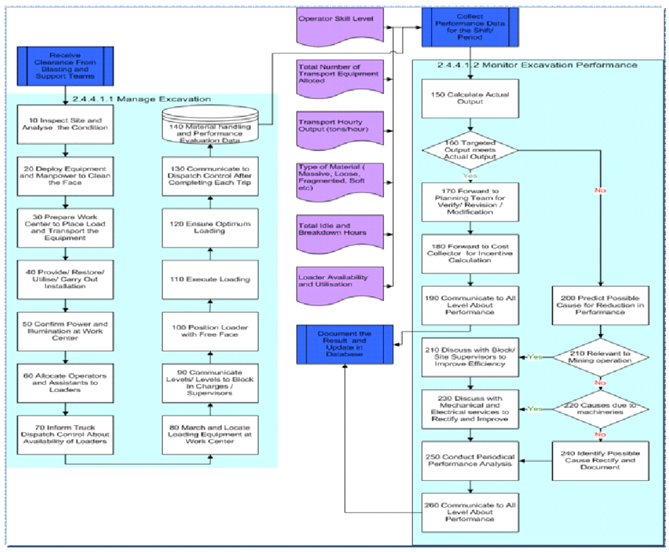
Step 6: Finalize the process flowchart

Process maps provide valuable insights into how a businesses or an organization can improve processes. When important information is presented visually, it increases understanding and collaboration for any project.

Break Mineral Bearing Rock - Process Flow

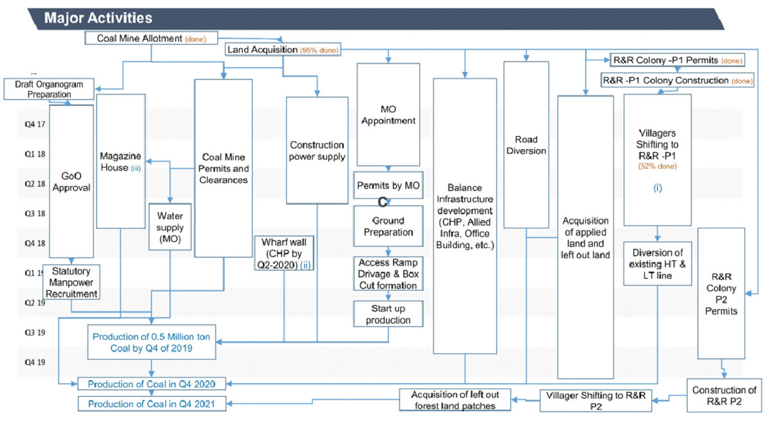


Load/ Cut Mineral - Process Flow



Case Study:

A process map prepared for an open cast coalmine, under development. In this project, Coal block has been allocated, most of the land has been acquired, major

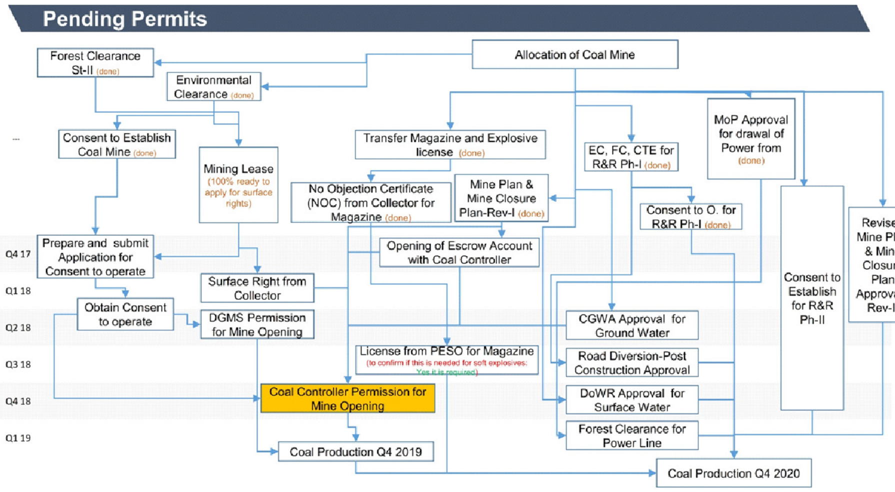


permits and licences have been obtained and it is planned to produce the coal from mine by Q4 2019.

In this process map, it can be observed that Coal Mine Allocation has been done, Land acquisition is completed by about 95%, and Construction of R&R Colony has been completed. It also shows the stage of various activities like construction of Magazine House is going on and is expected to complete by Q3 of 2018. It also shows various activities required to be completed before start of 0.5 Million Ton of coal by Q4 of 2019.

Activities like Balance Infrastructure (CHP and allied infrastructure), road diversion, acquisition of left out forest patches are not required for coal production in Q4 19 but are required coal production in Q4 2020. Similarly other activities like Construction of R&R Colony Phase 2, shifting of villagers to R&R Colony Phase -2 and acquisition of left out forest patches are required for production of coal in Q42021.

In the above process map, it can be observed that the permits like Forest Clearance, Environment Clearance, Mining Lease, Consent to Establish etc. have been obtained and the permits like Consent to Operate, DGMS permission, Surface Right etc. are still pending and are required for the start of Coal Production on Q4 2019. Licences like Approval of Revised Mining Plan & Mine Closure Plan (Revision-II), Consent to Establish R&R-Phase -2 are not required for coal production in Q4 2019 but required for the coal production in Q4 2020.



CONCLUSION

Senior management of the organisation can know about the building blocks of the project, their status and the bottlenecks.

Process Mapping is very versatile and powerful tool which can be used in various stages and to achieve the various management objectives ranging from process improvement to project monitoring and scheduling.

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Managing Sustainability in Open Cast Mining Operations through Geotechnical Planning and Design: A Need of the Era

Sanjay Kumar Singh* , Deepak Pandaya**

ABSTRACT

The mining industry is a fundamental industry involved in the development of modern society, but is also uncertainties associated with mining operation due to working against nature creations. The potentially hazardous nature of open cast mining requires the application of sound geotechnical engineering practice to mine design and general operating procedures, to allow safe and economic mining of any commodity within any rock mass. The main objectives for managing sustainability in open cast mining operations through geotechnical planning and design is 3'S. i. e. as follow:-

SAFE STABLE SUSTAINABLE

The intent of this paper is to provide pattern of good geotechnical engineering practice and to assist mining operators in achieving sustainability with implication of this guidelines. This guideline seeks to encourage the application of current geotechnical knowledge, methodology, instrumentation, and management techniques and hardware to the practical solution of geotechnical engineering issues in open cast mining. It is recognized that open cast mining experience and professional judgement are important aspects of geotechnical engineering that are not easily quantified, but can contribute significantly to the formulation of various acceptable and equally viable solutions to a particular mining problem. Management at each mining operation should recognize, identify and address the geotechnical issues that are unique to each particular mine, using current geotechnical knowledge, methodology, software and hardware appropriate to the situation.

It is appreciated that all the geotechnical considerations discussed in this paper do not apply to all mines. Conversely, this standard may not cover all the issues that need to be addressed at all mines. However, sound management requires that the techniques appropriate to a given set of conditions be selected and applied.

INTRODUCTION

The key role of "Enduring Value " is to translate the principles of sustainable development into practices that ensure that mining industry operates in a manner which is attuned to the expectations of the community, and which seeks to maximize the long-term benefits to society that can be achieved through the effective management of national natural resources. Figure-1 shows Sustainable mining operational area and sustainability in mining operational terms as being too:

- Implement and maintain ethical business practices and sound systems of corporate governance.
- Integrate sustainable development considerations within the corporate decision making process.
- Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities.
- Implement risk management strategies based on valid data and sound science.
- Seek continual improvement of our health and safety performance.
- Seek continual improvement of our environmental performance.

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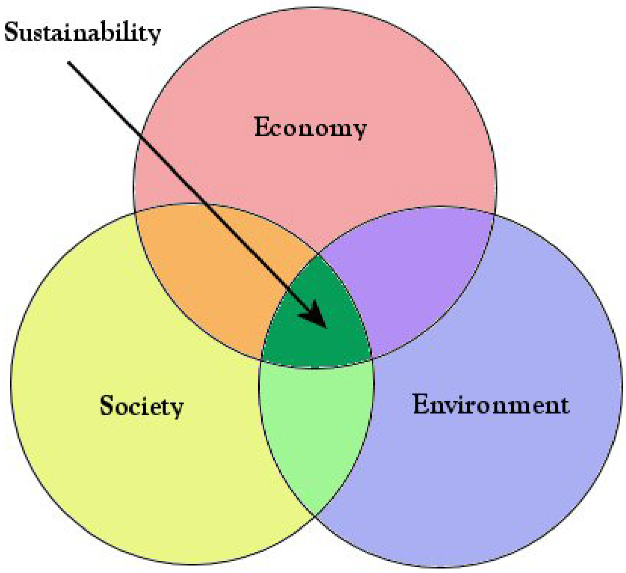


Figure-1: Managing Sustainability in Mining Operations

Keeping in view of above thoughts, further explanation is provided by the classification for geotechnical aspects for sustainability in open cast mining operations is essential issues in now a days. Study of environment involves understanding of two major set of conditions:

I. Physical conditions and

II. Social and cultural conditions.

- Physical conditions constitute mostly the abiotic attributes of the environment such as the earth material, minerals, soils, water, landforms, air that together affect growth and development of man.
- The social and cultural conditions include environmental parameters such as the ethics, economics, aesthetics, etc. which affect the behaviour of individuals or a community.
- Environmental geological appraisals of a terrain recognize the potential hazards and resource utilization pattern.
- Further specific details on the various geo-factor considerations and analyses of their environmental impacts are analyzed.

Four general sustainable management goals required for restorative of areas disturbed by mining including:-

- Safe to humans and wildlife.
- Non-polluting.
- Stable.
- Able to sustain an agreed post-mining land use.

GEOTECHNICAL IMPORTANCE IN SUSTAINABLE MINING

The set of sustainable mining conditions should be bridge between mining operations and those who are influenced. Sustainable mining is technically using the best available mining technology (BAMT) for mineral/coal production. In different conditions and in different location the best available technology would be different. The definition of best available technology depends on several conditions and is changing between mining locations and time periods. Sustainable development is one of a range of ideas about how humans should best interact with each other and the biosphere.

Mining was, is, and will also in the future be a fundamental industry involved in the development of human society. There is no doubt that mining had and will always have a negative environmental impact, as it is a destructive activity. There is also no doubt that humanity cannot progress without mining operations. Environmental impacts will continue to increase because the ratio of waste/element produced by mining operations is, and will increase in the future, as high-grade minerals/coal become rarer and as low-grade minerals/coal are exploited. There is little to question about the value of mining to society, but questions remain about how to best proceed to exploit our resources.

Sustainability of a system is its ability to survive and retain its functionality over time. For a mining system to be sustainable, it should be efficient, reliable, resilient, and adaptive. Efficiency requires that the resource use, cost and environmental impacts of the mining engineering system are minimal.

Reliability ensures that the system is sufficiently far away from its predictable failure states. A resilient system has the ability to return to its original functioning state within an acceptable period of time when subjected to unpredictable disruptions. An adaptive system is responsive to gradual and natural changes within itself and in its environment, and is flexible to modifications and alterations required to cope with such changes. Together, these characteristics help in deciding whether a mining system is capable of surviving in a complex and evolving socio-economic environment without losing its own character and function, and without violating the limits of the carrying capacity of the natural systems. Thus, the objective of sustainable mining is to ensure the integration of mining system into the natural and man-made environment without compromising the functionality of either the mining system or that of the ecosystem and society, and this harmony between the natural and created environments must be maintained at the local, regional and global scales. Therefore, in the mining engineering domain, sustainability can be looked upon as a dynamic equilibrium between four E's - engineering design, economy, environment and equity (social), as described in Figure-2.

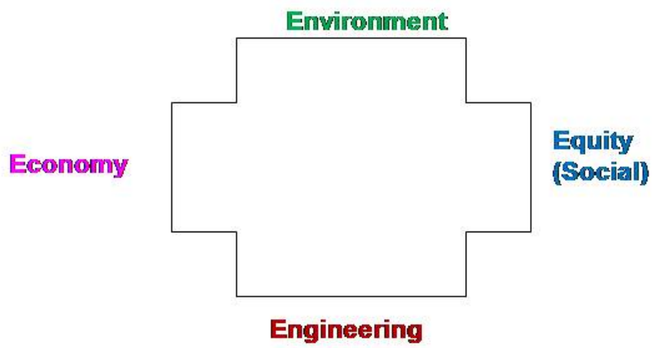


Figure-2: The four E's of sustainability in mining operations.

In view of the four E's approach of sustainable engineering, the sustainability objectives that may be incorporated in geotechnical projects are: (i) involving all the stakeholders at the planning stage of the project so that a consensus is reached on the sustainability goals of the project (such as reduction in pollution, use of environment friendly alternative materials, etc.), (ii) reliable and resilient design and construction that involves minimal financial burden and inconvenience to all the stakeholders, (iii) minimal use of resources and energy in planning, design, construction and maintenance of geotechnical facilities, (iv) use of materials and methods that cause minimal negative impact on the ecology and environment, and (v) as much reuse of existing geotechnical facilities as possible to minimize waste. This approach aims at reaching a dynamic equilibrium between engineering integrity, economic efficiency, environmental effectiveness, and social acceptability and equity. In an endeavor to incorporate sustainability in geotechnical design, three new trends have been identified: (i) geo-structures are now designed for performance rather than for ease of construction, (ii) designs are now more responsive to site specific requirements, and (iii) the designs consider soil structure interaction rather than just analysis of structural or foundation parts.

Mining Geotechnical practitioners are well aware of the importance of slope design in opencast mine. The role of sustainability has received less attention than might be the case for civil geotechnical applications due to the relatively short lifespan of mining related operation in open pits and dumps. However, significant risks associated with inadequate operation management are still present and should be considered during geotechnical slope design work. Mining operations may also have limited awareness of requirements to trained engineer and managing sustainability; especially in the period of mine working and stability of ground after relinquish of lease area.

GEOTECHNICAL BEST PRACTICES IN OPEN CAST MINING

Geotechnical engineering, as an important field of civil as well as mining engineering, has an important role in supporting sustainability in operation and thus sustainable development. This is because geotechnical assignments have potential to interfere in many social, environmental and economic aspects of mining operation by the use of large amounts of natural resources, vast amounts of energy and fuel, and by the involvement in landform changes that potentially persist for centuries. Moreover, geotechnical engineering has huge potential to enhance the sustainability of projects due to its early position in the mining process, where impacts can be reduced and greatest gains can be made.

Because geotechnical engineering works are at the start of the mine development, geotechnical assignments have the possibility to influence the decision-making process at early stages of mine planning and design, setting the sustainability values for the whole mine life cycle, adding value and reducing adverse impacts. No any mine can be sustainable without profitability of mining business. Ability to surface mine depends on the value of the minerals/coal being high enough to offset the cost of overburden removal. Stripping Ratio determines relative amounts of each to be moved (figure-3).

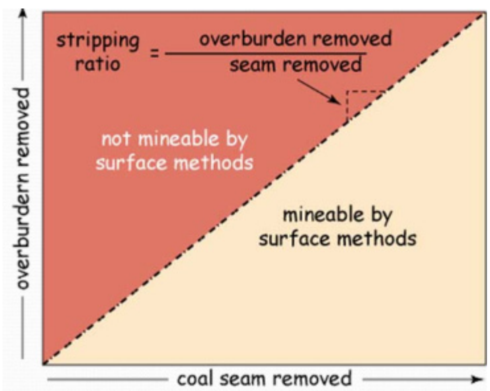


Figure-3: Economic of Opencast Mining and determination of Stripping Ratio

The feasibility of opencast mining operations on coal reserve/ seam property is determined by two main economic factors.

I. Overburden to Coal Stripping Ratio

II. Quality of Coal/minerals

Breakeven Stripping Ratio: The point beyond which the mineral/ coal cannot be economically extracted out is called the break even stripping ratio. Factors which play a great role in the stripping ratio calculation are: - Cost of stripping - Extracting cost of mineral/coal - Percentage of rejects - Cleaning cost of coal or ore dressing cost - Sale value of clean coal/dressed ore - Reclamation cost - Cost of transportation - Overhead and sale of ore/coal Before going for any surface mining operation an economic comparison is necessary between the underground mining cost per ton of ore production and surface mining and reclamation cost per ore production and a stripping ratio is to be calculated.

Break even stripping ratio = (mining cost per ton of minerals by u/g method – open cast mining cost & reclamation cost per ton of minerals) / (cost per cubic meter of over burden by the open pit method) The break even stripping ratio is generally much higher than the ordinary stripping ratio and can be increased if the price of mineral is increased or if the technology of mining is improved. The factors like degree and types of operation, economy, reclamation etc. effects the break even stripping ratio. So ultimately selection of mining methods and equipments, production requirement, various sub systems, geometry and geotechnical aspects of the deposits, capital operating and overhead expenses, gross cost, environmental and social consideration etc. play a role for deciding stripping ratio.

Considering above point *for* opencast mine planning due concern of economic and ecological parameters. Economic rationality is planning of open cast mine ***stripping ratio*** is well calculated by overburden to coal stripping ratio and quality of coal. Geo-technical significance of opencast mining operations mainly depends upon three factors such as **Slope Stability, Mining Method/Environment**, and **Equipments deployment** for **Safe, Stable and Sustainable.**

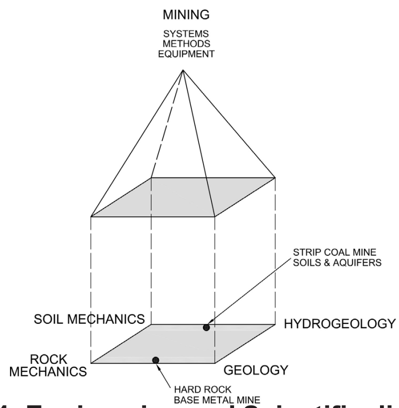


Figure- 4: Engineering and Scientific disciplines required for open pit slope design

Open cast mines call for the excavation of the earth surface to reach the underlying minerals of economic utility. The excavation process requires cut slopes to be formed on an earlier plain earth surface. Stability of the cut slopes is crucial for the safe and economical mining operations. The slope stability is governed by the local geological and geo-technical characteristics of the slope forming mass and the prevailing ground water conditions (figure-4). The design of the open pit mine slopes is a deciding factor for efficient exploitation of underground minerals as well as for the safety of the mine and the mineworkers which control the economics of the operations. The ever increasing pit depths and production requirements from opencast mines subject the design engineers and planners to work under the constraints of two conflicting requirements of stability and production. Economics could be improved by steepening the slope thereby reducing the amount of waste excavation on the other side, excessive steepening of slope could result in failure leading to loss of life and damage to property. This scenario poses a big question as to how to achieve an optimum design – a compromise between a slope that is flat enough to be safe and steep enough to be economically acceptable. The consequences of a slope failure could be quite serious in terms of safety and economics and are governed by the location and extent of failure. Hence, the design of the steepest slope with desired stability asks for a detailed and reliable geotechnical investigation. The factors, which mainly influence the stability of a typical opencast slope, are the shear strength parameters of slope forming material, the presence and characteristics of structural discontinuities in the slope mass and the ground water conditions (Singh and Monjezi, 2000). There have been quite a number of researchers who have proposed the characterization of the rock mass distinguishing them on the basis of strength but there always persists a certain degree of uncertainty while acquiring the field data for designing a slope leading to erroneous rock mass characterization.

PLANNING FOR SUSTAINABILITY

The strategy involve that geotechnical issues be systematically considered during the whole life of a mining operation, from its beginnings in the pre-feasibility study stage, through the operation of the mine, to the final closure and abandonment of the mine. The design of open pit excavations will endeavour to prevent hazardous and unexpected failures of the rock mass during the operating life of the open pit.

The importance of a systematic approach to mine planning and design using soundly based geotechnical engineering methods cannot be over-emphasized. Open pit mines can represent a complex engineering system with many sub-systems that need to function in an integrated manner for the mine to operate safely and economically. **Mine planning and design** has, as its goal, an integrated mine systems design whereby a mineral is extracted and prepared at a desired market specification at a minimum unit cost within the accepted/applicable social and legal constraints. The words "planning" and "design" are sometimes used interchangeably; however, they are more correctly seen as separate but complementary aspects of the engineering method.

Geotechnical Planning and Design for Open Cast Mining Operations

Figure- 5: Managing Sustainability in Open Cast Mining Operations through Geotechnical Planning and Design

Mine planning, deals with the correct selection and coordinated operation of all the sub-systems, eg. Mine production capacity, workforce numbers, equipment selection, budgeting, scheduling and rehabilitation. **Mine design** is the appropriate engineering design of all the sub-systems in the overall mine structure, e.g. production and near-wall blasting, loading and haulage platforms, electric power, water control (eg. pumping, depressurization), dust control, ground support and reinforcement, and excavation geometry.

It is strongly recommended that a formal mine planning and design system be established early in the life of a mine. Such a system might involve the regular informed discussion, as often as required, of a range of planning and design issues in the current operational areas and the new areas of the mine. The "mine planning and design meeting" should be an interdisciplinary meeting requiring the involvement, as necessary, of a range of expertise including: survey, geology, mining engineering, drilling and blasting, geotechnical engineering, rehabilitation, workforce supervision and management (figure-5).

It is often useful, as part of this planning and design system, to adopt a formal mining approval process for the development and/or mining of currently producing or undeveloped mining blocks. This formal mining approval process would include the production of plans, cross-sections and longitudinal projections of the mining block(s), as appropriate, plus a written description of the proposed mining work to be done and the mining issues that need to be addressed. A draft mining plan and the associated notes for the ore block(s) in question should be issued, in a timely manner, for discussion at the next mine planning and design meeting. Following discussion and resolution of the issues, final approved mining plan(s) and notes can be issued.

It has been found that notes from past mine planning meetings can form a valuable summary as to why certain mining decisions have been made and thereby assist with decision making in the present and future.

Formal mine plan approval should include the signatures of the people responsible for each relevant component of the plan - e.g. survey, geology, drilling and blasting, geotechnical, planning and design aspects plus the Colliery Manager and the Agent/Sub Area Manager – as appropriate.

GEOTECHNICAL DESIGN CONSIDERATIONS

It is recognized that during the geotechnical design stage there is usually limited detail of the overall rock mass available, and that it is necessary to make a number of assumptions/simplifications to arrive at a balanced mine design.

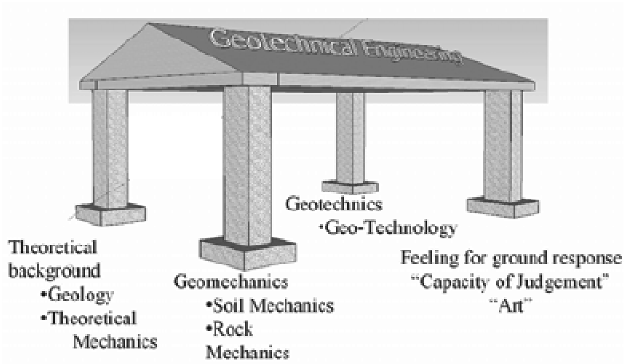


Figure- 6: Four columns of Geotechnical Engineering

Geotechnical data for design can be obtained from a number of sources including: available reports, natural outcrops, existing surface and underground excavations, chip and diamond drilling (for determining rock mass strength, structure, and hydro geological data), geophysical interpretations, seismic records, pump tests, field tests, trial pits, and experience. It would be a report of the obvious to say that the quality and usefulness of these sources of data is widely deviation. However, qualitative information is better than none and, if nothing else, such data can be used to identify the areas requiring more detailed investigation and analysis. Once the potential for economic mining has been identified it is considered sound practice to geotechnically log some diamond cored boreholes as soon as the core becomes available. Re-logging core for geotechnical purposes, after it has been stored or split for assay determination, is necessarily inefficient (double handling) and may give unreliable data on discontinuity characteristics. The reliability of data from re-logging of core initially drilled for exploration purposes, particularly core that has not been adequately stored or oriented, is limited.

Obviously, the number of geotechnical holes required for a particular project will depend on the level of available geological/geotechnical information at the site and the size and mine life of the project. For instance, it is possible that very few, and potentially no geotechnically logged drill holes could be required for mine excavations in close proximity to existing pits (that have similar geological conditions and can be accessed to define the relevant geotechnical design parameters).

The information gained from geotechnical investigations notably provides valuable information for mine design, but also assists with the development of a mineral resource estimate, and ultimately an ore reserve estimate. Particularly in marginal deposits, the geotechnical mine design limitations may define whether the resource can be classified as a reserve and therefore whether or not it should be mined.

Once there is considered to be adequate geotechnical design information, a **ground control management plan** should be formulated (figure-6). The plan should define the most appropriate excavation geometry (and ground reinforcement and support - where required), excavation methods, monitoring strategies (eg. monitoring of ground movements, mapping of geological structure, and recording general ground performance), and emergency action procedures.

The size of the mining operation will obviously be a major factor in determining the amount of effort and resources that are required to develop and implement the ground control management plan. It will be necessary to apply considerable mining experience and judgement when establishing the ground control management plan at a mine for the first time. With experience, it will be possible to successively refine the plan over time to address the ground control issues identified as being important to the continued safe operation of a mine.

The issues that would need to be considered include:

- depth and operating life of mining projects;
- potential for changes in expected ground conditions in the wall rock mass (eg. Rock strength, earthquake events, rock stress, rock type etc.);
- production rate;
- size, shape and orientation of the excavations;
- the location of major working benches and transportation routes;
- potential for surface water and groundwater problems;
- the equipment to be used, excavation methods, and handling of ore and waste;
- the presence of nearby surface features (for example public roads, railways, pipelines, natural drainage channels or public buildings);
- the potential for the general public to inadvertently gain access to the mine void during and after mining; and
- time dependent characteristics of the rock mass

(particularly after abandonment).

It follows that early identification of relevant geotechnical issues at a site will greatly assist with the development of a well-balanced ground control management plan.

OPERATIONAL GEOTECHNICAL CONSIDERATIONS

Misra and Basu (2011, 2012) already developed a multi-criteria based sustainability assessment framework for pile foundation projects. Authors also advocating, the framework considers same line of view for a mine life-cycle of the mining operations, and combines resource consumption, environmental impact and socioeconomic benefits of a beginning project over its entire life span to develop a sustainability index (Figure-7). The use of resources is taken into account based on the embodied energy of the materials used, the impact of the process emissions is assessed using environmental impact assessment and the socioeconomic impact of the project is assessed through a cost benefit analysis. Three indicators are derived from the three aspects and are combined through weights to calculate the sustainability index (SI) for the different alternatives available for the project (Figure 3).

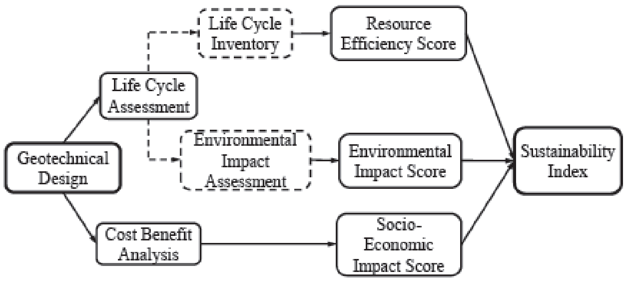


Figure- 7: Multi-criteria based sustainability assessment framework.

During operation of the pit, the (newly developed) ground control management plan is used to improve the geotechnical database, and to assess the suitability of the current mine design and the general stability of the mine. This on-going assessment is required because of the relative paucity of data that is usually available when the mine design (and ground control management plan) is first formulated. An example of the on-going review of geotechnical databases is mapping of geological/ geotechnical features (e.g. the orientation, spacing and length of planes of weakness) as mine faces/walls are exposed.

Pit wall mapping data is necessary to determine the sizes, shape and orientations and modes of failure of potentially unstable blocks of rock - particularly in a hard rock environment. Once the full scope of each relevant rock failure parameter has been derived, it is then possible to establish more appropriate mine design strategies to control the hazards that may result from rock failure. A well-managed ground control management plan should include regular discussions of all ground control issues with relevant mine personnel both during mine inspections and in more formal planning meetings. In particular, changes in the geological structure and general rock mass appearance and the detection of incipient rock mass failures should be noted during the development of a mine. This will allow for early recognition of instability issues so that a review and modification (if necessary) of extraction techniques, mine design, ground support and reinforcement, and monitoring practices can be completed before any problems become difficult or expensive to control. It is not uncommon, throughout the operating life of an open pit, that alterations will be made to the general mine plan (eg. blast design optimization to minimise blast damage, and wall cut-backs); therefore, when designing mines, a certain amount of flexibility is required.

KEY FACTORS FOR PIT SLOPE DESIGN

Considering the importance of risks, the slope design in open pit mines must be based on a well-controlled methodology, especially since experience shows that each rock mass characterized by its geological structures is unique, and therefore there are no standard recipes that achieve the right solution with certitude. This methodology can be broken down into several phases: 1) characterization of the rock mass through the acquisition and analysis of geological and geo-mechanical data, 2) identification of potential mechanisms of deformation and failure, and their modeling; 3) the slope design and the definition of methods of reinforcement and monitoring. The stability of pit slopes in rock is typically controlled by the following key geotechnical and mining factors:

- **Lithology and Alteration –** The rock types intersected by the final pit walls and level of alteration are key factors that impact eventual stability of the pit. Geological domains are created by grouping rock masses with similar geo-mechanical characteristics.
- **Structural Geology –** The orientation and strength of major, continuous geological features such as faults, shear planes, weak bedding planes, structural fabric, and/or persistent planar joints will strongly influence the overall stability of the pit walls.
- **Rock Mass Structure –** The orientation, strength, and persistence of smaller scale structural features such as joints will control the stability of individual benches and may ultimately restrict the inter-ramp slope angles.
- **Rock Mass Strength –** Rock mass strengths are typically estimated via intact rock strength and rock mass classification schemes such as the rock mass rating (RMR) system. Lower rock mass quality typically results in flatter overall slope angles.
- **Groundwater Conditions –** High groundwater pressures and water pressure in tension cracks will reduce rock mass shear strength and may adversely impact slope stability. Depressurization programs can reduce water pressure behind the pit walls and allow steeper pit slopes to be developed.

- **Blasting Practices –** Production blasting can cause considerable damage to interim and final pit walls. This increased disturbance is typically accounted for with a reduction in the effective strength of the rock mass. Controlled blasting programs near the final wall can be implemented to reduce blasting induced disturbances and allow steeper slopes. Scaling of blast induced fracturing is essential.
- **Stress Conditions –** Mining induces stress changes due to lateral unloading within the vicinity of the pit. Stress release can lead to effective reductions in the quality of the rock mass and increases in slope displacements. Localized stress decrease can reduce confinement and result in an increased incidence of raveling type failures in the walls. Modifying the mining arrangement and sequence can sometimes manage these stress changes to enhance the integrity of the final pit walls.

METHODOLOGY FOR PIT SLOPE STABILITY ASSESSMENT

A series of design sectors were defined to group areas of the proposed mine with similar mine geometry, geology and rock mass characteristics in order to complete the slope stability analyses. A number of different types of stability analyses were undertaken to determine appropriate slope angles for a given open pit slope. Slope stability analyses undertaken in this study included the following types:

- **Kinematic Stability Analyses –** Stereographic analyses were conducted on the discontinuity orientation data to identify the kinematically possible failure modes. Appropriate bench face angles and/or inter-ramp slope angles are assigned in such a way as to reduce the potential for discontinuities to form unstable wedges or planes. Typically, it is not cost effective to eliminate all potentially unstable blocks and a certain percentage of bench face failure and/or multiple bench instabilities are acceptable. Most of the smaller unstable features will be removed during mining by scaling the bench faces.
- **Rock Mass Stability Analyses –** Limit equilibrium analyses of the rock slopes were performed to compute the overall factors of safety against large-scale, multiple-bench failures through the rock mass. Maximum inter-ramp slope heights and overall slope angles were defined based on the results of the rock mass stability analyses.

MINE SLOPE DESIGN AND ACCEPTANCE CRITERIA

The recommended pit slope configurations were developed based on analysis results and using data interpreted from the geological model, rock mass characteristics, and inferred groundwater conditions. All these data may be limited or variably distributed and/or of uncertain quality. The target level of confidence for this preliminary pit slope study is typically around 40% to 60%. A general guidance to pit slope design acceptance criteria is summarized below (after Read and Stacey, 2009) and suggested FOS targets for open pit design at the New Prosperity Open Pit are highlighted in **Bold**.

Table- 1: Mine Slope Design and Acceptance Criteria

Slope Scale	Consequences of Failure	Acceptance Criteria		
		FOS (min) (Static)	FOS (min) (Dynamic)	POF (max) P[FOS≤1]
Bench	Low to High	1.1	N/A	25% - 50%
Inter-ramp	Low	1.15 - 1.2	1.0	25%
	Medium	**1.2**	**1.0**	**20%**
	High	1.2 – 1.3	1.1	10%
Overall	Low	1.2 – 1.3	1.0	15% - 20%
	Medium	**1.3**	**1.05**	**5% - 10%**
	High	1.3 – 1.5	1.1	≤5%

It is noted that there are few recorded instances in which earthquakes have been shown to produce significant instability in hard rock open pits. In most cases, earthquakes have produced small shallow slides and rock falls in rock slopes, but none on a scale sufficient enough to disrupt mining operations (Read and Stacey, 2009). As such, slope stability under seismic (earthquake) conditions was not evaluated in this study.

MINE DEVELOPMENT, ECONOMICS AND SLOPE DESIGN ACCURACY

Mine Development Stages: The application of soundly based geotechnical engineering methods to the mine planning and design process can result in significant improvements to mine safety, productivity and economic efficiency and should be included as an integral part of each mining projects may go through a number of stages:

1. Evaluation,
2. Planning,
3. Design,
4. Construction,
5. Commissioning and
6. Operating.

Within this broad development framework, technical and financial assessments are undertaken at a number of stages. Mining studies tend to occur in Stages 1 to 3. Open cut slope design studies tend to occur in Stages 1 to 3 and 6. Although once the mine is operational, revision of mine plans and financial reassessments usually continue throughout the mine life. In practice most mining projects usually undergo a two or three stage study program.

Mine Stages, Study Accuracy and Pit Slope Angles: Table-2 sets out the various project stages, together with the approximate levels of accuracy usually accepted in the industry. However, what do the mining costs presented in Table-2 mean in geotechnical and hydro-geological terms? On the groundwater side a very major dewatering program for a large scale mine may comprise some 13% of the total mining cost. Consequently, at the Design stage a large error in this aspect, of say 30%, would only result in a 4% change in the total cost. This alone would be within the normal range of accuracy for this level of study. However with inadequate groundwater control, the real impact on costs may be on the overall viability of the mining system or equipment. This would ultimately be reflected in reduced productivity, delays and increased costs.

On the geotechnical side the impact of inaccuracies in the geotechnical design parameters is easier to quantify because it is usually understood in terms of a change in slope angle which can be related directly to waste tonnages and stripping ratios. For example, a 5° decrease in overall slope angle for an intermediate size open cut truck and shovel mine would result in about a 20% increase in costs. The order of accuracy required in slope angles at each stage of a mining study is presented in Table-1. These numbers are approximate and individual project specific constraints such as style of mine development, coal seam and pit geometry, depth and scale, will modify these numbers; nevertheless they provide a good approximate guide.

Table- 2: Approximate Levels of Accuracy in Mining Studies (After Sullivan 1994 and 2006)

TYPES OF STUDIES		GENERALLY ACCEPTED ACCURACY OF COST ESTIMATES (+ or - %)	APPROXIMATE ORDER OF ACCURACY REQUIRED IN OVERALL SLOPE ANGLE (degrees)
Mine Study	Equivalent Terms or Secondary Stages		
Preliminary	Exploration Review Order of Magnitude	50 40	± 10 to 15
Pre-feasibility	Conceptual	25	± 5 to 10
Feasibility		15	± 3 to 5
Design	Detailed Mine Planning	5 to 10	± 1 to 3

In geotechnical engineering the overall slope design targets required in order for open cut designs to match the overall mine study accuracies are:

- Bankable Feasibility Level - ±1° to 5° and
- Full Design Level - ±1° to 3°.

These are very tight tolerances and based on the author's experience considerably less than the accuracies achieved in practice. As the geological and geotechnical complexity increases the overall risk also increases. The impacts as they relate to mine development, design and slope management include:

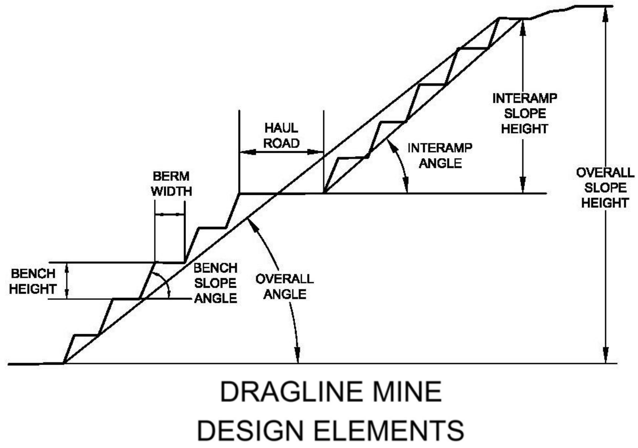
- increased reliance on a good geological model,
- increased levels of specific geotechnical investigations required,
- increased difficulty in achieving representative sampling and
- increased reliance on a good slope management program.

THE MINING METHOD/ENVIRONMENT

The principle elements of two open cut mines are illustrated in Figures 8a) and b). In a deep open cut mine, Figure 8a) the three design elements are:

1. Firstly the bench and berm geometry, which is the basic building block of the slope;
2. Secondly the inter-ramp slope (height and angle) and
3. Thirdly the overall slope (height and angle).

For any one slope and any one mine, one and or all of these elements could be the critical design element, requiring analysis and design. In some mines consideration of all three is essential and they may form competing design elements.



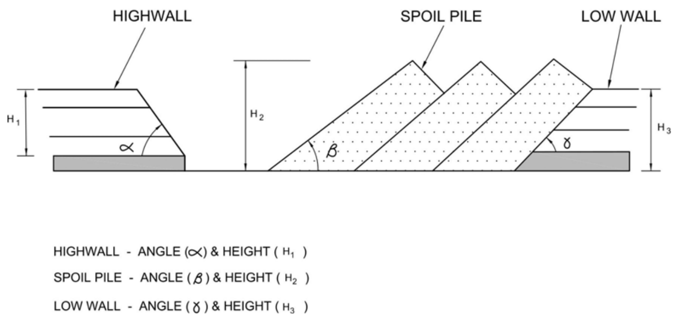


Figure- 8: Slope design elements for a) Deep open cut mine and b) Shallow surface mine

In a shallow dragline mine, Figure 8b) the three design elements are:

1. High wall, which is equivalent to the bench in an open cut mine;
2. Low wall, which is a "one off" design element and
3. Spoil pile.

The potential impact of those elements on the two main areas of risk, safety and economics, are set out in slope design.

Table- 3: Deep Open Cast Mine Slope Design Elements and Risk Areas

Slope Design Element	Component	Main Controlling or Influencing Factor			Risk Area	
		Geotechnical Issues	Mining System	Environmental Factors	Safety	Economics
Bench Geometry	Angle	*	*	•	*	
	Height	*	*	•	*	•
	Berm Width	*	*	•	*	•
Inter-Ramp	Angle	*	•		1	
	Height	*			1	
Overall	Angle	*	•		1	
	Height	*				

* Principal factor or main concern

• Minor factor or concern

Notes-1: Assumes a sound Pit Slope Management Procedure is in place.

The bench geometry is a function of both geotechnical conditions and mining systems, although in certain geotechnical conditions environmental factors will play a role.

LIMIT TO SUSTAINABLE PLANNING

The optimum slope design should be balance between safety and economy. It is certainly to be expected that variations in different geotechnical parameters will occur as the pit deepens and that confirmation of the input parameters must be undertaken during different stages of mining. Furthermore, as a consequence of additional available data the modifications to the slope design may be required as the pit is deepened and approaches its ulti-mate profile.

The mapping of weak zones, faults and bedding planes should be a regular process by the departmental geologist. The generated data will be used as an input parameter to reana-lyze the stability to get the realistic picture of the stability of mine slopes in different geo-mining condition. It will help to detect any unfavorable conditions at different stages of mining at the earliest possible.

A fresh sampling and testing of the exposed litho units should be done to verify any change in the slope mass characteristic.

The updated strength properties will be used to determine the stability condition of the slopes being mined during that very period. It will help to accommodate the changes in strength properties by suitably modifying the slope design. It will help to apply the remedial measures well in advance to a critical slope for avoiding the failure. It, in turn, will help in preventing any loss to men and machineries.

The continuous mining, blasting and ground water condition disturb the **stress condition** in the field which tries to come in to equilibrium by stress redistribution which may result in to movement of the slope any time. It is advisable to continue slope monitoring to detect the **onset of failure** so that early and effective stabilization measures can be taken at the earliest. If the instability is unavoidable then it can be brought down in a predictable manner.

The mine should have an effective garland drain, all around, to collect run-off rain water before it reaches the mine slopes. The drains should be steeply graded to promote rapid water move-ment and minimise the chances of ponding. It is essential that these drains should be kept clear of silt and debris. The benches should have toe drains. These drains should be again interconnected to drain out the rainwater into the mine sump.

Creation of high slopes and undercutting at lower ore benches should be avoided during the closure of the mine in monsoon. The undercutting and creation of high slopes are done under the apprehension that the slope will definitely fail in the monsoon so it is better to take out the maximum ore even by sacrificing the safety. This philosophy is not correct and invariably invites the failure which otherwise can be avoided/ minimized/ controlled by systematic mining.

As shown above it has to be accepted that ground behavior cannot be established and forecasted with 100 % accuracy. Therefore, the best is that ground models are associated with a sustainability index. The sustainability index should be determined based on reliability factors for data, interpretation, and model interpretation parameters. At present such sustainability indexes are not satisfying, in particular, because the reliability of model interpretation parameters cannot or only partially be established. Without a proper indication of sustainability of opencast mining operations through geotechnical planning and design is **3'S.** i. e. **safe, stable, sustainable** planning will be incomplete.

CONCLUSIONS

Sustainable mine planning of opencast mining projects is a complex, multi-objective optimization problem that requires an integrated approach with the incorporation of technical, environmental, economic, social or other issues.

In the optimization process of a surface mine development and scheduling problem sustainability parameters should be incorporated in all stages of the mining project, throughout the whole mine life cycle, from the first exploratory stages to the post mining period.

In this paper, the critical role of sustainability parameters on the systematic mine planning of opencast mining projects was described by dividing the mine planning model into interrelated sub-models, with a discussion of some critical issues concerning the development of opencast mine.

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Innovative Application of Noise Control Through Active Noise Cancellation Technique in Mines – An Appraisal

Dr. Singam. Jayanthu

ABSTRACT

This paper presents details of innovative application of noise control through active noise cancellation technique having scope of wide application in mines. A critical analysis of the exposure of miners to high sound pressure level Noise (>90 dBA) is carried out. The Noise Exposure Index of different machine operators is also observed. And a theoretical solution in the form of a specially designed headphone incorporating Active Noise Cancellation and Band Pass Filter is established. The Noise level was found to be above the permissible limits in GDK 10A incline and GDK 10 incline for most of the machinery. At face the noise was within permissible limit of 90dBA only at a distance of 20 m in Tirap mine. The machine producing least noise level among those observed was Mine Riding Car in GDK10A incline and the noise level produced was 74 dBA at 20 m. This very high noise level was hazardous for the miners exposed to them as well as it hampered the speech communication inside the mine. A solution to it using conventional headphones has failed because of its inefficiency in allowing desirable sounds of person to person communication and the sound of the alarm of the 'Roof Fall'. This Paper illustrates a design of special headphone incorporating the techniques of ANC and Band Pass Filters for use in mechanized mines which allows all the desirable sound to pass through but filters out the undesired machine noise. The headphone would facilitate efficient speech communication inside the mines.

INTRODUCTION

Provision of suitable work environment for the workers is essential for achieving higher production and productivity in both surface and underground mines. Noisy working conditions have negative effects on the workers' morale and adversely affect their safety, health and performance. It is brought to the knowledge of all concerned that Noise is emerging as an important and challenging health hazards for mine workers. With increasing mechanization of mining operations and use of heavy machinery the noise level in mines have increased over the years. Surveys conducted by various institutions have shown that noise levels in majority of the mining operations are higher than the recommended limit of 90 dBA. Repeated or prolonged exposure to excessive noise levels leads to hearing impairment.Potential sources of noise emissions include compressors, drilling machines, crushers, and other mechanical equipment used at a mine. Increasing the distance between the noise source and the listener is often a practical method of noise control. Where such noise control measures are not possible, personal hearing protection devices, such as approved ear plugs or ear muffs, should be worn by every person exposed to noise levels exceeding 90 dBA. [1,14]

The results obtained after investigation indicated that the sound pressure levels of various machineries were higher than the acceptable limits i.e. >90dBA. In the mines under study, most of the mine workers were exposed to SPL (sound pressure level) beyond 90dBA due to machinery noise. Therefore, control measures should be adopted in mines for machinery as well as hearing protection aids should be supplied to the workers in order to protect the mine workers from NIHL (Noise induced hearing loss). In order to assess the status of noise levels in mines, systematic noise surveys are needed to be conducted using appropriate statutory guidelines so that effective control measures can be taken up in mines. Keeping this in view, this paper elaborates the technical details of the level of exposure of the mine workers to noise. A proposed solution to this hazardous aspect, using the technique of Active Noise Cancellation and Sound Filtration has also been made in this paper. This paper also introduces the fraternity to a headphone for mining workers and mining engineers, which is devised using ANC and Sound Filtration.

NOISE LEVEL STANDARDS

Some times because of noisy ambience inside the mines, the primitive indications of a roof fall in the form of bursting sound is neglected by the mine workers unintentionally which proves to be fatal in some cases and highly dangerous the other times.[2] These types of accidents are not directly because of exposure to noise but indirectly a dangerous consequence of noise. Because of noisy surroundings around the machine operators, it becomes very filthy task for mining engineers to instruct them while on work. The only option left with the engineers remains to instruct them to switch off the equipment first. This regular 'switching off' and 'switching on' of the equipment accounts for a heavy loss to the company in terms of energy consumption.

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Table 1: Protective Measures against different Sound Pressure levels as per Indian Standards

Sound Pressure Level (dB)	Protective measures
< 85	Very little risk to unprotected ears
90-115	Danger of hearing impairment and deafness
115-130	Worker shall not be allowed to enter without ear protection
130-140	Person protective equipment is must
>140	No worker shall be allowed to enter

In an occupational health survey conducted in an below ground metal mine more than 80% of workers showed evidence of Noise Induced Hearing Loss of 27.7% and 13.1% had severe and profound hearing impairment. Noise Induced Hearing Loss was observed among all categories of mine workers but the prevalence was highest among workers engaged in drilling operations.[3]

The occurrence and severity of NIHL was related to the degree of exposure to noise and years of service in the mine. More exposed a mine worker is to the noise, more are his chances of NIHL. Apart from this, various other consequences of lesser potential are caused, but are potentially strong to cause a fatal accident in the mine. Some of them are listed in the following sections.

After detailed study of the level of exposure of mine workers to noise and the sound pressure levels of the machine noise, it has been found that most of the mining equipment were observed to be generating the noises exceeding the danger limit set by DGMS. Frequency spectrum analysis revealed low frequency dominant noise situations for almost all-mining equipment.

FIELD OBSERVATIONS

Field Observations on Sound Pressure Level were carried out in three mines viz. GDK 10 Incline, GDK10A incline of SCCL and Tirap O/C mine of NEC during different periods

Machinery Noise

In the all the mines under study, the SPLmax and the Leq were above the permissible limits set by the Indian Standards. The reasons for the same being, either not so proper wear and tear of the machines or the manufacturing defects from the manufacturer. The miners thus had to work in a very noisy environment. The prolonged exposure to which may cause hearing impairment or temporary hearing shift. The machinery should be regularly oiled and greased to have proper wear and tear. This was also not taken proper care in most of the mines. . The Noise level was found be above the permissible limits in GDK 10A incline and GDK 10 incline for most of the machinery. At face the noise was within permissible limit of 90dBA only at a distance of 20 m in Tirap mine. The machine producing least noise level among those observed was Mine Riding Car in GDK10A incine and the noise level produced was 74 dBA at 20 m. This very high noise level was hazardous for the miners exposed to them as well as it hampered the speech communication inside the mine.

Also in most of the cases, the machineries having been imported from outside India, lacked proper supervision. In the inadequacy of which, untrained guidance caused machine to work in improper way and thus generating a lot of Noise.

Noise Exposure Index

The noise exposure index (NEI) is defined as the ratio of actual exposure time at a certain noise level, to the permitted exposure time, that is:

NEI = C/T, Where, C = actual time (measured in mine) T = permitted exposure time

If the noise level should change during the course of an employee's work shift, an NEI must be Calculated for each different noise level. The total or accumulated NEI for that shift is then the sum of all the individual NEI's,

i.e, NEI = C1/T1 + C2/T2 + ...

Where C1 = actual exposure time for noise level No. 1.

C2 = actual exposure time for noise level No. 2.

T1 = permitted exposure time for noise level No. 1.

T2 = permitted exposure time for noise level No. 2.

A worker is considered out of compliance if his daily total NEI exceeds unity. In practical terms, this means that his actual exposure time has exceeded the permitted exposure times

DESIGN OF HEADPHONE

Two technologies influx are to be used for designing the headphone. The first one is the band pass filter and the second one is ANC (Active Noise Cancellation). Active Noise Cancellation (ANC) is a method for reducing undesired noise. ANC is achieved by introducing a canceling "antinoise" wave through secondary sources. These secondary sources are interconnected through an electronic system using a specific signal processing algorithm for the particular cancellation scheme. My proposed method is to build a Noise-cancelling headphone by means of active noise control and a band pass filter to be used by miners inside the mines. Band pass filter will filter out the noise having frequency lying outside the human audible frequency range. And then the noise, will be cancelled out by ANC technology. Essentially, this involves using a microphone, placed near the ear, and electronic circuitry which generates an "antinoise" sound wave with the opposite polarity of the sound wave arriving at the microphone. This results in destructive interference, which cancels out the noise within the enclosed volume of the headphone. This thesis demonstrates the approaches that I take on tackling the noise cancellation effects, along with results comparison.[4]

Noise Cancellation makes use of the notion of destructive interference. When two sinusoidal waves superimpose, the resulting waveform depends on the frequency amplitude and relative phase of the two waves. If the original wave and the inverse of the original wave encounter at a junction at the same time, total cancellation occur. Directions where noises interact and superimpose. Most importantly, ANC can block selectively.

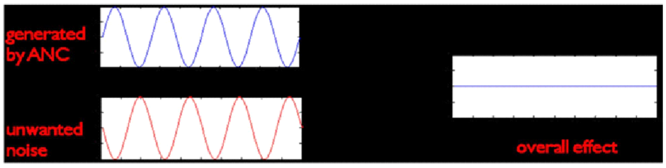

Fig.1: Signal Cancellation of two waves 180⁰ out of phase[5]

ANC is developing rapidly because it permits improvements in noise control, often with potential benefits in size, weight, volume, and cost. Blocking low frequency has the priority since most mine noises are below 1 KHz, for example excavator noise or noise from the compressor. This mainly led us to focus our project on low frequency noise cancellation.

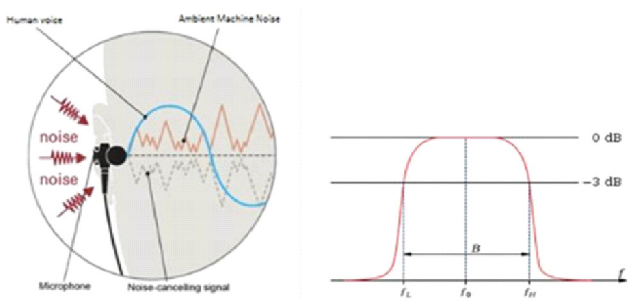

Fig.2: Active Noise Cancellation Technology and the Band pass fiter (Romero and Lopez)

Since the characteristics of the acoustic noise source and the mine environment are time varying, the frequency content, amplitude, phase, and sound velocity of the undesired noise are non-stationary. An ANC system must therefore be adaptive in order to cope with these variations. Adaptive filters adjust their coefficients to minimize an error signal and can be realized as (transversal) finite impulse response (FIR), (recursive) infinite impulse response (IIR), lattice, and transform-domain filters. The most common form of adaptive filter is the transversal filter using the least mean-square (LMS) algorithm. Figure 12 shows a framework of adaptive filter. Basically, there is an adjustable filter with input X and output Y. My goal is to minimize the difference between 'd' and 'Y', where 'd' is the desired signal. Once the difference is computed, the adaptive algorithm will adjust the filter coefficients with the difference.

There are many adaptive algorithms available in literature, the most popular ones being LMS (least mean-square) and RLS (Recursive least squares) algorithms. In the interest of computational time, I used the LMS.[6]

One of the main constraints in the choice of an adaptive algorithm is its computational complexity. For the application of ANC, it is desired to choose an algorithm which is computationally very fast. Taking this into consideration, LMS algorithm became an obvious choice over RLS. The update equation for the LMS algorithm is given by w(n+1) = w(n) +ì*e(n)*w(n) where ì is the step size, e(n) is the error at time n and w(n) is the filter coefficients at time instant n.

MATLAB SIMULATION

LMS algorithm uses the estimates of the gradient vector from the available data. LMS incorporates an iterative procedure that makes successive corrections to the weight vector in the direction of the negative of the gradient vector which eventually leads to the minimum mean square error. Compared to other algorithms LMS algorithm is relatively simple; it does not require correlation function calculation nor does it require matrix inversions.

$$w(n+1) = w(n) + \frac{1}{2\mu}[-\nabla(E\{e(n)\}]$$

Where, w(n) → coeficient of the adaptive filter, ì is the step-size parameter and controls the convergence characterteristics of the LMS algorithm; e (n) is the mean square error between the output and the reference signal

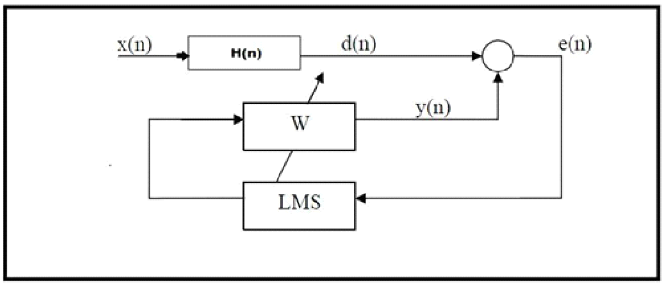

Fig.3. Frame work of adaptive filter incorporated in the headphone [10]

The error is given by:

$$e^2(n) = [d^*(n) - w^h x(n)]^2$$

The basic LMS algorithm fails to perform well in the ANC framework. This is due to the assumption made that the output of the filter y(n) is the signal perceived at the error microphone, which is not the case in practice. The presence of the A/D, D/A converters and anti-aliasing filter

in the path from the output of the filter to the signal received at the error microphone cause significant change in the signal y(n). This demands the need to incorporate the effect of this secondary path function S(z) in the algorithm. One solution is to place an identical filter in the reference signal path to the weight update of the LMS algorithm, which realizes the so-called filtered-X LMS (FXLMS) algorithm. The FXLMS algorithm has been observed to be the most effective approach among all other solutions. Also this algorithm appears to be very tolerant to errors made in the estimation of S(z) thereby allowing offline estimation of S(z) as the most apt choice. Besides, the use of FIR filters to design W(z) makes this system very stable. But the downside is the use of high order filters that will make the algorithm run slow, and also the convergence rate of this algorithm depends on the accuracy of the estimation of S(z). The major disadvantage of this algorithm is the presence of acoustic feedback. The coupling of the acoustic wave from the canceling loudspeaker to the reference microphone will cause this acoustic feedback problem, resulting in a corrupted reference signal x(n). This can potentially lead to delayed convergence and possible non-convergence of the algorithm.[11]

In this paper, the counter noise using different Active Noise Cancellation techniques. Adaptive Filters have been used to implement ANC Techniques. A noisy environment may contain noise varying linearly or non-linearly. Depending upon various constraints like noise or non-linear noise, efficiency, budget, environment of the noise there can be different algorithms to update the filter coefficients. Various methods like LMS Algorithm, FxLMS algorithm, Particle Swarm Optimization (PSO) Technique have been used to show the reduction of noise actively. The linearly varying noise is filtered using LMS Algorithm or FxLMS while if we want the filter to vary its coefficient non-linearly PSO Technique has been used.[12][13]. The theoretical solution to workable ANC headset for both artificial and real world noise. More specifically, our ANC headset can deal with noise frequency ranging from 100 to 800 Hz. Furthermore, we have implemented and compared four variations of adaptive algorithms, namely FxLMS, FuLMS, Feedback ANC and Hybrid ANC.

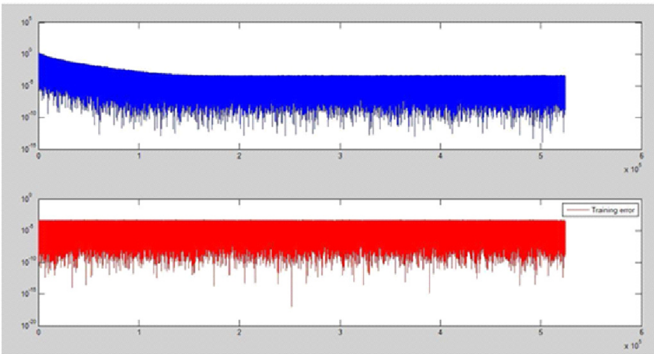

Fig.4. Resultant signal obtained after the test algorithm has been applied

CONCLUSION

Out of the three mines studied, at the face, only in the Tirap o/c Mine, NEC the machinery was producing Noise within the permissible limit of 90 dBA i.e 87 dBA and that was at distance of 20 meters from the face. The Maximum Sound Pressure Level Observed was 118 dBA by Drillcon Rock Breaker in GDK 10A incline, SCCL. And the minimum Sound Pressure Level observed within a distance of 20 m from the machinery was 74 dBA by Man riding car in GDK 10A incline SCCL. The Noise Exposure Index (NEI) was all within the safe limits (<1) in West Virginia u/g coal mine USA except for the stoper (NEI = 17.10), where the worker works in rotation. The Theoretical Programming was developed using MATLAB and the result was found to be effective in Noise Reduction for Efficient Speech Communication.

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b. France would no longer use Coal to produce electricity after **2022** and that

c. Up to **€4 billion** will be invested in boosting energy efficiency.

Sustainability Across the Mining Life Cycle

In order to manage the mining and mineral projects in an environmentally and socially responsible manner, a range of initiatives and protocols that cover all stages of the mining process, from initial exploration to mine rehabilitation and closure, has been developed.

These initiatives are further supported and enhanced by the Leading Practice Sustainable Development Program in Mining.

The program established best-practice procedures that encompass all stages of the mining process and the key issues which affect sustainable mining.

Sustainable Mining

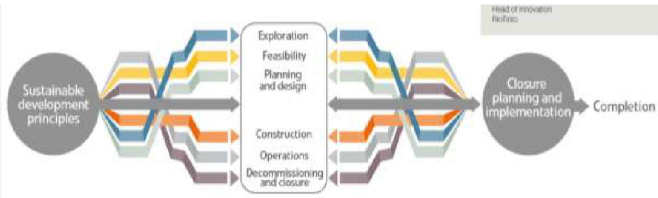

Fig.1 - Phases of a Mining Project Which Need to be Considered in Evaluating Mining Sustainability

Various phases of a Mining Project Which Need to be Considered in Evaluating Mining Sustainability:

- Exploration
- Feasibility
- Planning & Design
- Construction
- Operations
- De-commissioning and Closure

Environmental Management

Baseline data collection, including surface and groundwater quality and quantity, soil types, fauna and vegetation types and meteorological data

Waste rock characterisation and preliminary assessment, including testing of sulphide ore bodies

Feasibility planning to support the mine evaluation process, including economic, environmental and social impact assessment

Developing Robust Environmental Management Systems and community engagement initiatives suitable for use throughout the mine life cycle

Risk Management Techniques to manage and mitigate environmental impact during the operations phase

Best-practice Rehabilitation planning and implementation

Biodiversity management to minimise long-term impacts from operations

Monitoring and measuring the performance of closure and rehabilitation activities

Sound Emission Regulation

Social Impact Assessment

- Community engagement planning and communication
- Mine closure planning
- Managing Community engagement and communication activities during the construction phase
- Managing Risk and Mitigation impact
- Planning and developing effective monitoring framework
- Water management, eliminating Acid Mine Drainage

Water Management

- Water supply – identification and quantification
- Impacts of water diversion on local water resources/ users
- Water supply, storage and treatment
- Waste water treatment and disposal
- Site Storm water management
- Acid rock drainage management

Mineral Administration in India

Why the mineral rich states in India are the most backward and underdeveloped states !?

The Western part of India is relatively prosperous; thanks to stable state governments since independence.

The Eastern half on the other hand has had a hard time dealing with changing conditions over the past seven decades

In context of mineral rich states of the menace of naxalism has severely hampered progress.

Being resource rich does not guarantee development of a state or country. We have multiple examples in the world which proves this i.e. Venezuela, Iraq etc. and also we can have some examples where a country is not so resource rich still it's a developed country like Japan.

Again, we have countries which are resource rich and developed i.e. The USA, Canada.

Implementation of Environmental Laws in India

The Honourable Supreme Court of India had once commented on the governance by referring to the ineffective implementation of Environmental laws in the following words: "If the mere enactment of laws relating to the protection of environment was to ensure a clean and pollution free environment, then India would, perhaps be the least polluted country in the world. But this is not so.

How can mining be Environmentally Sustainable

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.

Few examples of new technologies that are environmental friendly:

1. RopeCon Conveyor System

The system is developed for transporting material in and over difficult terrain: it can traverse obstacles such as rivers, buildings, gorges, or roads without any problem whatsoever and can easily overcome steep conveying sections of up to 70°.

It has transported 10 million tons of bauxite in two years from its Mount Oliphant mine location to the rail station.

It generats 1200 kw/hr of braking energy

Fig.2 - RopeCon Conveyor System

Fig.3 - RopeCon Conveyor System

Fig.4 - RopeCon Conveyor System in an Opencast Mine

Salient Features of RopeCon Conveyor System

- Generates 1200 kw/hr of braking energy
- Cost saving in the mine: $ 1.5 Million
- Conveying Capacity: 25,000 T/hr
- Rope Span: Up to 1 Km
- Can handle lump sizes of up to 1,000 mm
- Can overcome differences in elevation of up to 1,200 m
- Land use & disturbance are minimized
- Conveyor distance: up to 20 km in one section
- Cost saving compared to truck: 60%
- **Construction:**

  Side Walls: Corrugated belts and integrated wheel sets on fixed track ropes which are guided over tower structures
- **Power Generation:**

  The system is powered by two AC induction motors. When the conveying system is loaded with Ore and begins making its way down the mountain, the drives begin using a continuous braking (regeneration) mode which produces the electrical power.

2. Pipe Conveyors

The Pipe Conveyor is an enclosed curve type transportation system for all kinds of bulk materials. At the loading and discharging points, the conveyor system is identical with open troughed conveyors. The difference starts after the loading point, where the belt is formed into its typical tubular shape by special idler arrangements over a certain distance and finally is led through idler panels with hexagonal cut outs and offset idler arrangement. At the discharging point, the belt opens automatically after the final idler panel and transfers the material to its next destination.

Due to its tubular shape, the conveyor is able to manage horizontal and vertical curves as well as high inclinations. The enclosed transportation system not only protects the conveyed material against external influences such as climatic conditions, it also avoids material loss and spillage and thus, protects the environment.

Pipe Conveyors: Design

- Belt has to have sufficient stiffness
- Belt edge stiffness is reduced to ensure seal at the overlap
- Hot materials can be handled with use of suitable belts

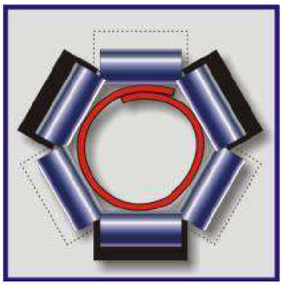

Fig.5 -Pipe Conveyor Design

Fig.6 – Pipe Conveyor

Fig.7 – Pipe Conveyor - Typical Structure

Fig.8 – A Pipe Conveyor Negotiating 300 M Radius And 90º Turn

Advantages of pipe conveyors

- Environmentally acceptable
- Environmental protection against dust
- Un affected by wind & rains; needs no covers
- Ability to negotiate vertical & horizontal curves
- Ability to negotiate steep angles of inclination
- No side drift since the belt is totally contained
- Reduction of **Green house gases**, emitted from trucks
- Prevention of spillages
- Prevention of theft/pilferage
- Flexibility in the path of conveyor
- Reduction in noise pollution
- Reduction in traffic congestion
- Spillage free transportation
- Reduced structural costs by elimination of walkways

3. Virtual Reality

The School of Mining Engineering at the University of New South Wales has constructed a virtual reality simulator called the AVIE.

Within the safe confines of a 3D simulation, potential hazards can be safely experienced, evacuation procedures tested, and feasibility studies consolidated.

Fig.9 – Advanced Visualisation and Interaction Environment (**AVIE**)

A range of modules has been developed by industry professionals to simulate various mine environments – from open-cut to underground, from hard rock to coal.

The scope for industry training results in a cost-effective, low risk, high-impact learning experience.

The AVIE is also being used to simulate the environmental and social impacts of a proposed mining operation, allowing the government and the community to visualise potential impacts before mining starts.

4. Improvements in Blasting by Split Charge with Air Deck Using BOSTECH Gas Bgs:

The technique, known as "Split Charge" in Explosive Column has been applied in presplit and also production blasting in open-pit mines. Numerous practical applications have demonstrated that for air-deck blasting to be effective, the optimum length of the air gap has to be determined for good results.

Melnikov and Marchenko (1971) proposed the air-deck theory of how one or more air gaps used in the explosive column called Air deck can improve fragmentation.

Fig.10-Gas Bag before Inflation

Fig.11 – Inflated Bag

Advantages of Gas Bags

- Reduction in Blast Induced Ground Vibrations
- Reduction in Noise (dB)

- Reduction in Explosive Consumption (15% - 20%)
- Improved fragmentation
- Ensures proper distribution and utilization of Explosive Energy in the blasthole.
- Can be used for Controlled Blasting where Charge per Hole is severely restricted.
- Can seal off water at the bottom of the hole, enabling use of ANFO.

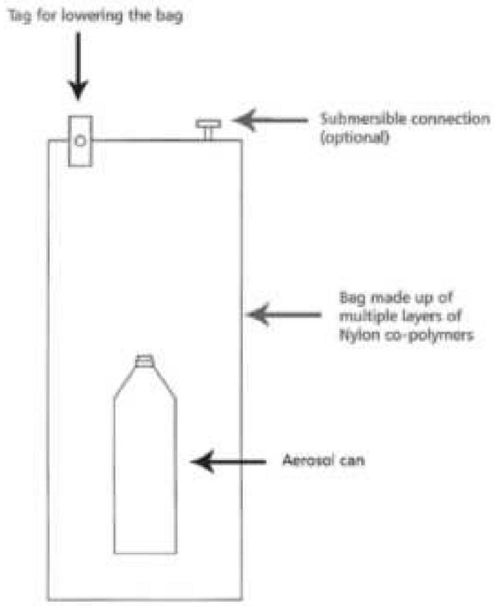

Fig.12 - Gas Bags (Cross Section)

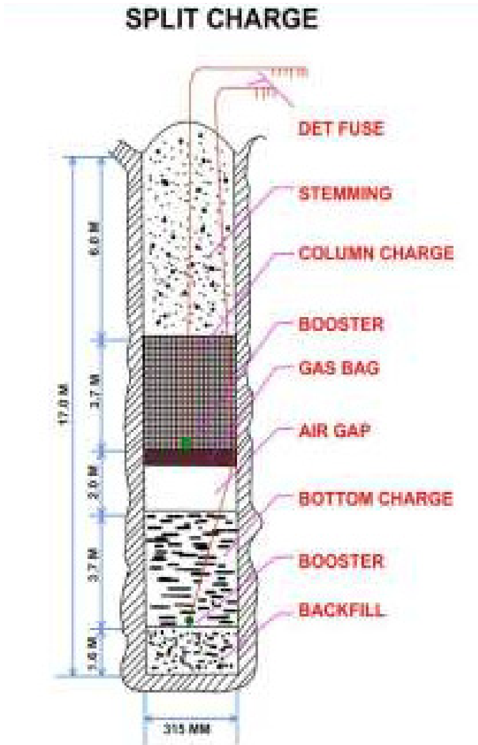

Fig.13 - Split Charge in Explosive Column

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Benchmarking of HSE Performance Parameters and its Measurement in Oil India Limited

Ajaya Kumar Acharya*

INTRODUCTION

Due to the very nature of the Oil & Gas in handling, storage and transportation involved in Exploration & Production (Upstream) sector, exposure to various Hazards cannot be ruled out. Such Hazards bring a situation of risk and uncertainty in the Oil & Gas business. The impact of the unfortunate events/incidents has shaken many Oil & Gas company in the past. Hence, this calls for a coordinated and continual effort for reduction of the potential losses to maximize the profits through a sound and effective functioning of HSE Management system. The system also ensures protection of the most valuable resources of an organization i.e. People, Equipment and Environment. The scope of HSE is not limited to an individual at work place safety only; it extends to each family, dependents and the society at large.

Therefore, the need of the hour is to make HSE performance an integral part of business performance for which, an integrated approach is required for interlinking of all types of Professionalisms with HSE matters. HSE standards need to change according to the changed business scenario, Personal values, behavior & mind set of individuals. Carrying capacity of HSE plan should be widened based on Scientific model. Traditional way of thinking on safety management has gone and it is necessary to review and relook the efficacy of the existing system by measuring HSE performance parameters with benchmarking and establishing a SMART goal with a view to achieve the target.

PREAMBLE

OIL INDIA LIMITED, aNavaratna PSU companyis engaged in E&P Activities. OIL started its journey in 1959 and became a PSU in 1982. It was awarded 'Navratna' status in 2010. It is engaged in the business of exploration, development and production of crude oil and natural gas, transportation of crude oil and production of LPG. It was adjudged as one of the five best major PSUs and one of three best energy sector PSUs in the country in CRISIL-India Today survey in 2015. Dedicated workforce of approximately 7750 people & 8 Board of Directors including three independent directors).

OIL pays utmost importance to Health, Safety & Environment (HSE) with a goal to achieve sustainable development and improvement of HSE standards through proper management of HSE risks. OIL is committed to continuously review & improve HSE initiatives to prevent accidents, minimize environmental impact, prevent environmental pollution and reduce health and safety risks.

* **Chief General Manager (HSE)/ OIL India Ltd/**

HSE policy to this effect was adopted by the company on 22nd October, 1984. This policy has been subsequently revised /modified and approved by Board in its 344th meeting held on 17th November, 2003; policy has been widely circulated to all concerned to develop awareness amongst all sections. The Board of Directors have also approved an Environment Policy on 25th April, 2012, Safety Policy on 21st March 2014 and Occupational Health Policy on 12.02.2016.

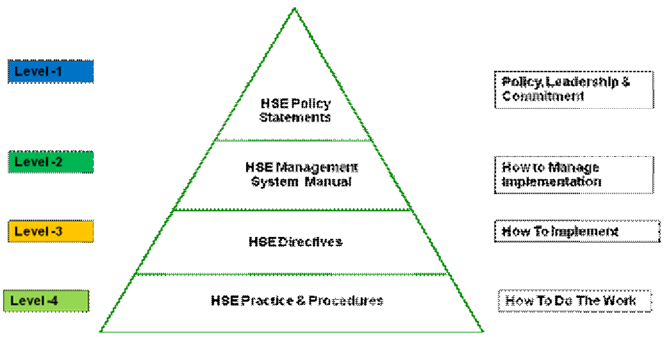
Also, to provide the framework and structure to meet the highest level of HSE expectations, a HSE —MS manual along with a guide has been prepared and adopted for all the operational areas of OIL. OIL's commitment to HSE performance is also reflected through one of its vision statements that "OIL is fully committed to Health, Safety & Environment.

HSE- MS Framework

The HSE management system framework provides a broad based set of expectations based on Rules and regulations, national and international standards and guidelines. The framework helps the managers Focus on critical HSE needs, forecast and allocate resource, set direction for HSE activities, and consistently deliver improved HSE performance.

HSE management System

HSE management System in OIL is a four tiered hierarchy of arrangements:



LIMITATIONS IN CURRENT PRACTICE IN OIL.

OIL started taking initiatives to demonstrate proactive HSE performances considering present limitations in the current practices. However, the outcome was not achieved up to a desired level. The accidents and incidents were occurring in erratically in OIL fields and were disturbing to OILs Management. One of the reasons maybe non measurement of HSE proactive performance parameters which usually received less Board level attention than other business priorities. Because of the difficulty in measuring effectiveness in responding to prevention of accident and protection of Oil's property it was felt by OIL to make an attempt at all to measure HSE performance without merely assessing the 'safety output' (e.g. injury rates) leaving many other indicators such as measures of 'safety climate' or various aspects of the safety management processes.

In the traditional way safety performance in OIL was expressed as given below:

- Numbers of accidental injuries per year;
- Rates of accidents per 100,000 employed;
- Frequency of accidents per million person hours;
- Days lost due to injury per year;
- Severity rate (ratio of major to minor outcomes);
- Estimated accident costs.
- the use of 'output' key performance indicators such as lost time injury rates tend to dominate to the exclusion of other such indicators

LOST TIME INJURY RATE

In many organisations, the length of time since their last 'lost time' or 'medically treated' work related injury is given special significance as the principal indicator of success or failure in health and safety management. While many argue that every accident can be prevented, in reality, especially in very large organisations, some level of error leading to harm is probably inevitable.

The obvious limitation of a single focus on lost time injury rates is that it shifts attention of away from other unplanned events with the potential to cause injury, including 'near misses' and 'unsafe acts and conditions'. Furthermore, the exclusive use of lost time injury rates can be an extremely limited because it reveals nothing about whether the underlying management processes are appropriate or adequate. The real causes of prevention failure are invariably deeply rooted in the ineffective management of operations, which includes failure to control behaviour and change attitudes.

The use of lost time injury rates as a single performance measure, is that, this ignores issues such as work related ill health and unsafe conditions such as the unacceptable exposures to health hazards. Health damage is generally a bigger issue than accidental injury but health performance indicators are harder to identify and quantify.

PARADIGM SHIFT FROM TRADITIONAL CONCEPT OF MEASURING HSE PERFORMANCE.

Many organisations emphasize auditing should not just check on the effective elimination or control of risks by specific preventive measures but should assess the completeness and operation of key elements in the health and safety management system. This means gathering evidence from documents, from observation and from interviews to assess the adequacy and implementation of elements such as policy, organisation, planning and implementation, monitoring and review - and ensuring that, in practice, they operate as a system which 'locks on' to potential problems and deals with them before harm occurs.

Measuring in this way enables the duty holder and other players to assess the strengths and weaknesses in existing management arrangements, including gaps between 'theory espoused' and 'theory practised' and to assess differences in management performance between (and within) undertakings and over time.

In business 'what gets measured gets managed'. However, in the field of HSE, it is far from clear whether 'key players' share a clear view of performance and its measurement.

BENCHMARKING CONCEPT AND ITS APPLICATION IN HSE MANAGEMENT.

Health, Safety and Environmental Protection Benchmarkingis a planned process by which an organisation compares itshealth, safety and environmental processes and performancewith others to learn how to:

- Reduce the incidence of injury and ill-health;
- Improve environmental protection and sustainabilitymeasures;
- Improve compliance with regulations;
- Reduce HSE-related costs;
- Enhance Company reputation.

Benchmarking is thought to have been conceived by mediaeval cobblers who marked a bench to ensure their customers received a consistent size of shoe. Later, UK Ordnance Survey created a national series of vertical datum reference points called benchmarks that are (for those without GPS!) still in use today.

The general industry understanding is that Benchmarking is a continuous, systematic process for evaluating the products, services, and work processes of organisations that are recognised as representing best practices, for the purpose of organisational improvement. Benchmarking is now applied to a wide variety of business systems and processes and is used in a qualitative (subjective) sense and, increasingly, in a quantitative way by the use of Performance Indicators. Benchmarking is particularly useful as an improvement tool for business processes, and is now advocated as an HSE best practice.

WHAT IS BENCHMARKING PRACTICES

The search for HSE best practices in global scenario is relentless. As soon as oneorganisation is seen as best in class, then others will seekto at least match, but preferably exceed, their performance.

Best Practiceis a technique, method, process or activity that is generallyaccepted as being more effective at delivering aparticular outcome than any other, when applied to a particularcondition or circumstance.

The idea is that withproper processes, checks, and testing, a desired outcomecan be delivered with fewer problems and unforeseen complications.Best Practice can also be the most efficient (leasteffort) and effective (best result) way of accomplishing atask, based on repeatable procedures that have proventhemselves over time for a significant number of people.*Best Practice is not perfect practice and will evolve tobecome better as improvements are developed.*

Benchmarking is a structured process that allows us tolearn from others. It focuses on change (for the better!) notjust on analysis, and is generated externally from theprocess users. It attempts to answer such questions as:

. *Why We need a change?*

. *What are we going to change?*

. *When are we going to change?*

. *What will we be the effect of the change?*

For continual improvement in HSE standards & performance of Oil India Limited as per OIL's Vision, OIL has taken an initiative with a project on "Benchmarking of HSE Parameters in OIL's Installations and also Assurance of QHSE Certification" at Company level. The project is being executed by M/s. DNV GL based on the 8th edition of ISRS (International Sustainability Rating System) with a prime focus on sustainable development & operation rather than only safety. To achieve the long term goal of zero accidents and incidents, it is important that QHSE performances are measured based on critical parameters benchmarked to international standards & practices. The ISRS benchmarked tool used by M/s. DNV GL shall act as an indicator on the performance & implementation status in OIL with focus on a single & integrated management system. As one of the well-known management guru has said 'What gets measured, gets done"

Since E&P industry is hazardous in nature, OIL's operations are susceptible to various risk. The risk that are not identified cannot be managed and controlled. The ISRS tool works on the philosophy of proactive risk identification & management including improvement in stakeholder confidence, avoidance of business disruptions and also to meet the regulatory requirements.

OIL'S INITIATIVE ON BENCHMARKING OF HSE PERFORMANCE

PARAMETERS

The present systems at OIL requires a cultural change by systematic approach like ISRS / benchmarking tool. This along with a behaviour based safety system will enable OIL's personnel to foster safer behaviours at work place for a safe & sustainable QHSE performance.

Therefore, for benchmarking of HSE parameters & QHSE Certification in OIL, 10 Nos. installation as model were selected as mentioned below:

1. Drilling Installation - 2 Nos.
2. Workover Installation - 1 No.
3. Production Oil Installation - 2 No.
4. Production Gas Installation - 2 Nos.
5. Pipeline Installation - 1 No.
6. Engineering Installation - 2 Nos.

To benchmark the above selected installations in a customised way, the following steps were followed:

Phase I :Gap Analysis / Pre-Assessment and Cultural Assessment

For gap analysis, there are 15 processes in ISRS and these are interlinked with each other. The 15 processes are –

- Leadership commitment to QHSE
- Managing Assets
- Contractor Management
- Project Management
- Emergency Preparedness
- Compliances Assurance
- Work Planning & Control
- Human Resources
- Training & Competence
- Communication & Promotions
- Risk Management (Risk Evaluation, Risk Control & Risk Monitoring)
- Accident / Incident Reporting and Investigation
- Management of Business Risk etc.

To ensure effective risk management, the above mentioned 15 processes have been grouped into 5 process families as given below :

- Leadership / Planning and Administration / Results & Review
- Risk Evaluation / Risk Control / Risk Monitoring
- Human Resources / Training & Competence / Communications &

Promotion

- Emergency Preparedness / Learning from Events
- Compliance Assurance / Project Management / Asset Management / Contractor Management & Purchasing

Cultural assessment was also carried out in all the selected installations.

For implementation of benchmarking of HSE parameters in the above mentioned installations, QHSE Co-ordinators & Process Champions were also appointed.

Phase II: Trainings

- Overview of Modern Safety Management System Training
- Overview of Behaviour Based Safety Management System Training
- Customised Process Safety Management Training
- International Benchmarking and Certification Training

The above mentioned trainings were organised to develop internal resources for effective implementation of benchmarking of HSE parameters in the selected model installations and further implementation of the same in remaining installations of OIL in the future.

Phase III:

- Facilitation / handholding with all the relevant process champions to finalise action plans for implementation of benchmarking parameters
- QHSE Guidance Manual Preparation/ Review of OIL's Loss Control Manual / HSE Management System

Phase IV :

- Finalizing of benchmarking parameters based on Gap Analysis findings (70 parameters have been selected in OIL)
- Appointment of Behaviour Based Safety Implementation Committee
- Implementation of Behaviour Observation Program
- Internal Assessment on benchmarking Parameters by OIL before the final assessment by DNV GL(regarding the Progress & Review of Process Based Safety / Behaviour Based Safety for Implementation)

Phase V :

- Final Baseline Assessment and Certification after 3 months of International Benchmarking and Certification training
- Awarding QHSE Benchmarking Certification.

Phase VI :

- Surveillance Assessment.

CONCLUSION

In practical application, Benchmarking is a performance measurement tool used in conjunction with other improvement initiatives to measure comparative operating performance and identify and implement Industry Best Practices. Classification of Benchmarking falls into two main areas, what is being compared and against whom is the comparison being made. Benchmarking is an important business improvement tool. Almost any process or activity of an organisation is a candidate for benchmarking and there are several different categories of what can be compared.

Benchmarking demands an external comparison but that does not mean we have to operate outside our own organisation. Internal Benchmarking is the comparison against the best within the same organisation It could be comparison between Departments or units, within the same company or organisation.

Benchmarking is a method for improving a business process by first analysing our own process, then finding the reasons for better performance among other comparable processes and, finally, on the basis of the insight gained, redesigning our process. OIL has taken initiatives for benchmarking of HSE parameters in the selected installations and subsequently, the remaining installations of OIL will be benchmarked with internal resources as per international standards & practices.

Sri Ajaya Kumar Acharya obtained degree in Electrical Engineering in the year 1983 and Diploma in Industrial Pollution & Control in 1998.He is a certified ISRS (International Safety Rating System) Auditor and NDT (Non-Destructive Testing) Level-II Inspector. He joined OIL INDIA LTD(OIL) in the year 1983 and worked in various capacities till today in the oil field areas particularly E & P Activities. He is having a vast experience in tackling field problems and HSE related issues. To his credit, 33 nos. of technical papers are published & presented by him in various national and international forums.

At present, he is working as Chief General Manager (HSE) and HOD in OIL INDIA LTD dealing with all policy matters on HSE and Fire Service as domain expert. He is a pioneer in formulation of SOPs. CDMP, Loss control / SMS manual and near miss Management system besides many other policy documents including implementation of the same in OIL.

Mineral Levies on Mining of Major Minerals under the MM(D&R) Act, 1957 and its Rules in India–Issues & Concerns

Vijay Singh*

ABSTRACT

January 12, 2015 is a historical day for the mining industry qua mining lease holders &/or mine owners, since the Union Government carried out major amendments in the MM(D&R) Act, 1957 and thereafter repealed the much simpler "The Mineral Concession Rules, 1960 & The Mineral Conservation and Development Rules, 1988" amongst others and promulgated new rules to be in line with the massive amendments carried out in the MM(D&R) Act, 1957. In the course of amendments the current dispensation has altered the way the Mining Leases are sanctioned, governed & administered and has also brought in new levies on major minerals viz., contributions to DMF & NMET, transfer charges, etc. Provisions such as provisional assessments on payment of royalty on removal of minerals; interests @ 24% p.a. on delay in payments of royalties among others have been brought in. If one were to get into the details of the amended provisions of the mineral laws, one can make out that the polity have sprinkled provisions of direct tax (income tax) and indirect taxes (other than income tax) in the amended MM(D&R) Act, 1957 and its rules. If you read on, you would notice that amendments have made administration and levy & collection of royalty, contributions to DMF & NMET, transfer charges, payment of GST, Tax Collection of Source by the DMG have become cumbersome to the statutory authorities and to lessees as well. In addendum the new laws have paved the way for needless, unwarranted and unending litigations at the Hon'ble High Courts and the Hon'ble Supreme Court of India.

INTRODUCTION

In India (including Jammu & Kashmir), all major mineral Mining Leases (MLs) viz., Iron-ore, Manganese, Limestone, Bauxite, etc. are sanctioned, governed, administered etc. by the Central Government and the State Governments under the provisions of:

a) The Mines and Minerals (Development and Regulation) Act, 1957 (MM(D&R) Act, 1957);
b) The Minerals (Other than Atomic and Hydro Carbons Energy Minerals) Concession Rules, 2016;
c) The Mineral (Auction) Rules, 2015;
d) The Mineral Conservation and Development Rules, 2017;
e) The Minerals (Transfer of Mining Lease Granted Otherwise than through Auction for Captive Purpose) Rules, 2016; &
f) Other allied rules.

The Constitution of India, under Entry 54, List I of the Seventh Schedule, empowers the Union Government to regulate mines and mineral development, as declared by the Parliament by law to be expedient in the public interest, and the Union Government has under section 2 of the MM(D&R) Act, 1957 has made an express declaration as to the expediency of Union Control of Mines and Mineral development as provided under the said MM(D&R) Act, 1957.

The Hon'ble Supreme Court of India in **M/s. The Sandur Manganese & Iron-ores Ltd. vs. State of Karnataka (CIVIL APPEAL NO. 7944 OF 2010)** has held as under:

"By virtue of Section 2, the State Legislature is denuded of its legislative powers to make any law w.r.t. regulation of mines and mineral development to the extent provided in the MM(D&R) Act, 1957. Thus there is no question of the State having any power to frame a policy de hors the MM(D&R) Act and Rules."

Hence in the light of above, it is only the Union Government that can formulate, amend, provide for any levies on major minerals through the provisions of the MM(D&R) Act, 1957 and its rules.

Never-the-less, as per the federal structure of Republic of India, land is always a state subject and unless otherwise specified, the levies on major minerals are levied and collected by the State Governments in its territorial jurisdictions as per the law framed by the Central Government.

TYPES OF MINERAL LEVIES

The following are the various types of mineral levies on mining of major minerals under various statutes:

Sl. No.	Charge / levy on extraction of major minerals	Reference in the applicable statute
(1)	Royalty	Section 9 read with Second Schedule of the MM(D&R) Act, 1957.
(2)	Contribution to District Mineral Foundation (DMF)	Section 9B of the MM(D&R) Act, 1957 read with Rules 2 & 3 of 'The Mines and Minerals (Contribution to District Mineral Foundation) Rules, 2015'.
(3)	Contribution to National Mineral Exploration Trust (NMET)	Section 9C of the MM(D&R) Act, 1957.
(4)	Transfer Charges	Rule 6 read with Schedule IV of 'The Minerals (Transfer of Mining Lease Granted Otherwise than through Auction for Captive Purpose) Rules, 2016'.
(5)	Other local levies imposed by the State Governments	As per the applicable statutes

I. ROYALTY

The term royalty has not been defined in the MM(D&R)

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Act, 1957 and neither in any of the allied rules,hence one has to rely on the general dictionary meaning of royalty.

As per Webster's dictionary the meaning of the word "royalty" is as hereunder:

"A compensation or portion of proceeds paid to the owner of a right, as an oil right or a patent, for use of it".

Royalty ought to be paid in respect of any mineral removed or consumed by the lessee&/or owner, or by his agent, manager, employee, contractor or sub-lessee from the lease area or otherwise, except in case of coal consumed by workman engaged in a colliery, provided that such consumption by the workman does not exceed one-third of a tonne per month (Section 9 of MMDR Act, 1957).

Royalty on extraction of all major minerals are paid at the rates specified in the Second Schedule to the MM(D&R) Act, 1957 either on ad-valorem basis orotherwise. The royalty is computed on ad-valorem basis at a fixed percentage of "Average Sale Price" as decided and published by the Indian Bureau of Mines (IBM), Govt. of India on a monthly basis for a particular mineral and for a particular state. For example:

(a) On Iron-ore (CLO, lumps, fines and concentrates all grades) – royalty is computed and paid @ 15% of average sale price on ad-valorem basis.

(b) On Lime stone (LD grade – less than 1.50% silica content) – royalty is paid at a fixed rate of Rs. 90 per tonne. On Lime stone (others) – royalty is paid at a fixed rate of Rs. 80 per tonne.

Royalty shall not be enhanced in respect of any mineral more than once during any period of three years (proviso to section 9(3) of the MM(D&R) Act, 1957).

ISSUES & CONCERNS

A. IS ROYALTY A TAX?

The answer to the above is **YES & NO**.

- The Hon'ble Supreme Court of India(**7 Judge Bench)** has held that **ROYALTY IS TAX** in **M/s. India Cements Ltd. vs. State of Tamilnadu** reported in **(1990) 1 SCC 12.**
- In another case the Hon'ble Supreme Court of India(**5 Judge Bench)** has decided that **ROYALTY IS NOT A TAX**in **State of West Bengal vs. M/s. Kesoram Industries Ltd.** reported in**(2004) 10 SCC 201.**
- **Final decision whether royalty is tax or not? Referred to a 9 Judge Bench of Hon'ble Supreme Court in Mineral Area Development Authority vs. SAIL & Others.** Reported in **(2011) 4 SCC 450.**

Hence the matter is seized before the Hon'ble Supreme Court of India and final decision is awaited.

In case the Hon'ble Supreme Court of India decides that royalty is a tax then the service tax imposed by the Central Government on the payment of royalty @ 15% (including cess) w.e.f. 01-04-2016 to 30-06-2017 and GST (Goods and Services Tax) @ 18% w.e.f. 01-07-2017 may not survive, since there cannot be payment of tax on tax.

The Hon'ble High Court of judicature for Rajasthan at Jodhpur in D.B. Civil Writ Petition No. 14578/2016 (Udaipur Chambers of Commerce and Industry & others vs. Union of India & Others) in its judgement dated 24-10-2017 has upheld the levy of Service tax on payment of royalty.

The Hon'ble Supreme Court in SLP(C) No. 37326/2017, in its order dated 11-01-2018 has ordered for stay in collecting service tax from the petitioners, emanating from the order passed by the Hon'ble High Court of judicature for Rajasthan at Jodhpur,until further orders by the Hon'ble Supreme Court.

It would be in the best interest of lessees/owners, if payment of GST on royalty is paid under protest, so as to claim refund of the same if the decision of the Hon'ble Supreme Court on royalty (supra) is rendered in favour of lessees/owners.

B. SHOULD ROYALTY BE PAID ON MINERALS EXTRACTED FROM PRIVATE LANDS i.e. NON-GOVERNMENT LANDS?

The Hon'ble Supreme Court of India in a judgement in **CIVIL APPEAL NOS.4540-4548 OF 2000 dated 13.07.2013** in the case of **Threesiamma Jacob & Ors Vs. DMG Kerala & Ors.** has held that in case of private lands, not only the surface rights even the sub-surface rights, including minerals beneath, belong to the land owner. In this scenario, then a question came before the Hon'ble Court as to why royalty has to be paid on the minerals extracted from the private land, since the land and neither the minerals lying underneath belong to the Government. The Hon'ble Court has referred this issue along with a batch of other similar petitions to a different bench, and the matter is yet to be heard and decided by the Hon'ble Supreme Court on payment of royalty from minerals extracted from private lands not owned by State Government.

C. VALUE ON WHICH ROYALTY IS TO BE COMPUTED AND PAID IN CASE OF PAYMENTS MADE ON AD-VALOREM BASIS AND OTHER CONNECTED MATTERS?

Where-ever royalty has to be paid on ad-valorem basis, then the base value to be considered for the purpose of computation of royalty as per Second Schedule to the MM(D&R) Act, 1957 is the "**AVERAGE SALE PRICE (ASP)**" as published by the Indian Bureau of Mines (IBM) for a month and for that mineral and for a particular state. It is very clear that royalty has to be discharged to the State Government or Dept. of Mines and Geology (DMG) of the respective states where the mineral is excavated on the basis of ASP, irrespective of the actual selling price of the lessees/owners in the market.

Illustration:

Mineral considered	– Iron-ore Fines of grade 63.50% Fe.
Location	– ML in Odisha
Date of supply / sale	– 01.03.2018

Particulars	Scenario I	Scenario II
Actual selling price of iron-ore fines per tonne	Rs. 2,000	Rs. 2,500
ASP as published by IBM for iron-ore fines per tonne*	Rs. 1,435	Rs. 1,435
Royalty @ 15% ad-valorem on ASP	Rs. 215	Rs. 215
GST (CGST + SGST) @ 5% on supply / sale of iron-ore	Rs. 100	Rs. 125

**ASP published by IBM and put up on the website for December, 2017.*

As seen above royalty has to be paid on ASP declared by IBM irrespective of the actual sale value. However GST has to be paid on the actual selling price of goods i.e. iron-ore fines sold from the lease area, when royalty is not shown on the face of tax invoice.

As per Rule 39 (Payment of royalty) of the Minerals (Other than Atomic and Hydro Carbons Energy Minerals) Concession Rules, 2016 (**here-in-after referred to as MCR, 2016**):

i. Royalty to be paid when the minerals are removed out of the ML area, whether for sale or otherwise.

ii. Royalty to be paid on minerals whether processed or un-processed?

iii. Royalty has to be paid whether the mineral is sold or not.

Also as per Rule 43 of MCR, 2016 i.e. Publication of Average Sale Price (ASP) – IBM ought to publish average sale price (ASP) within 45 days from the due date of filing of monthly returns as specified under MCDR, 2017.

Due date of filing monthly Returns (10th day of the following month for the previous month)

+

45 days (10 + 45 days = 55 days)

For minerals excavated in March2018, IBM to publish the ASP byMay 25, 2018

This essentially means that at the time of removal of minerals from the mining lease area for sale or otherwise, the correct ASP for that mineral for that state is not available for the lessee/owner to defray the royalty, contributions to DMF& NMET, payment of GST on royalty, etc.

The lessee to consider the latest available IBM declared ASP for the mineral in the state, pay the royalty, contributions to DMF& NMET, etc. collect the Mineral Despatch Permits (MDPs) from the DMG and remove the mineral from the mining area.

Therefore, the Central Government i.e. Ministry of Mines, New Delhi has introduced a concept of **Provisional Assessment and Adjustment** in **Rule 40** of the Minerals (Other than Atomic and Hydro Carbons Energy Minerals) Concession Rules, 2016, contributing to the already existing chaos.

In addendum, Rule 49 talks about payment of simple interest @ 24% p.a. on expiry of the 60th day from the date fixed by the Government.

As per Rule 40 (Provisional Assessment and Adjustment) of MCR, 2016 the royalty, contributions to DMF & NMET, paid at the time of removal of the minerals from the mining area is always provisional and the lessee has to re-compute the royalty, contributions to DMF & NMET, once the IBM publishes the ASP for the specified mineral for the specified month and state and pay the difference or adjust the difference for the subsequent period removals.

In continuation of illustration on removal of Iron-ore on 01-03-2018 from an ML area in Odihsa, the IBM publishes the Average Selling Price Iron-ore Fines for Odisha, under Rule 43 (Publication of ASP) of MCR, 2016 on or before 25-05-2018, let'ssay:

i. at Rs. 1,800 per tonne; or

ii. at Rs. 1,200 per tonne

then the royalty, contributions to DMF & NMET, GST on royalty shall have to be revised and made good as follows:

ASP as published by IBM at **Rs. 1,800** per tonne of iron-ore in Odisha

Particulars	Scenario I	Scenario II
Actual selling price of iron-ore fines per tonne at the time of removal on 01-03-2018	Rs. 2,000	Rs. 2,500
ASP as published by IBM for iron-ore fines per tonne on or before 25-05-2018 under rule 43 of MCR, 2017 for the month of March, 2018	Rs. 1,800	Rs. 1,800
Actual Royalty to be defrayed on ASP published by IBM on or before 25-05-2018for the month of March, 2018 @ 15% ad-valorem	Rs. 270	Rs. 270
Less: Royalty already paid at the time of removal of Iron-ore on 01-03-2018 from the ML area	(Rs. 215)	(Rs. 215)
Difference in royalty to be paid to the DMG within 60 days from the date of removal to escape payment of interest under rule 49 of MCR, 2016	Rs. 55	Rs. 55
GSTon royalty @ 18% to be paid on the difference amount	Rs. 10	Rs. 10

(1) ASP as published by IBM at **Rs. 1,200** per tonne of iron-ore in Odisha

Particulars	Scenario I	Scenario II
Actual selling price of iron-ore fines per tonne at the time of removal on 01-03-2018	Rs. 2,000	Rs. 2,500
ASP as published by IBM for iron-ore fines per tonne on or before 25-05-2018 under rule 43 of MCR, 2017 for the month of March, 2018	Rs. 1,200	Rs. 1,200
Actual Royalty to be defrayed on ASP published by IBM on or before 25-05-2018for the month of March, 2018 @ 15% ad-valorem	Rs. 180	Rs. 180
Less: Royalty already paid at the time of removal of Iron-ore on 01-03-2018 from the ML area	(Rs. 215)	(Rs. 215)
Difference in royalty to be paid to / (received from) the DMG within 60 days from the date of removal to escape payment of interest under rule 49 of MCR, 2016	(Rs. 35)	(Rs. 35)
GSTon royalty @ 18% to be paid / (refunded) on the difference amount	(Rs. 6)	(Rs. 6)

The above exercise shall have to be done for contributions to DMF & NMET as well, since contributions to DMF & NMET are directly linked to payment of royalty.

Simple matters have got complicated in the light of provisions under Rule 49 (Payment of interest) of MCR, 2016 concerning payment of interest after expiry of 60 days from the date of removal.

In the opinion of the author, and as per the interpretation of Rule 49 (Payment of interest) of MCR, 2016, if there is a delay beyond 60 days from the dateof removal of minerals from the mining area then the lessee &/or the owner ought to pay interest @ 24% p.a. till the difference amount of royalty, contributions to DMF & NMET is made good or adjusted.

The above provisions of MCR, 2016 has inherently inbuilt a mechanism wherein if the actual ASP published for a month within a period of 55 days is more than the ASP considered by the lessee &/or the owner at the time of removal of minerals for sale or otherwise, then the lessee has to mandatorily :-

a) Pay interest on delayed remittance of GST on royalty, since the due date for remittance of GST is 20th of the following month, for the previous month;
b) Lessee to rectifyhis/its monthly or quarterly GST returns in FormsGSTR-3B, GSTR-1, GSTR-2 & GSTR-3, depending on the month when the IBM actually publishes the ASP for the minerals removed from a lease area. In GST Laws there is no concept of filing revised returns, the registered person ought to rectify his / its returns subsequently along with payment of interest;
c) Lessees could face this issue on a recurrent and regular basis wherever the royalty has to be defrayed on ad-valorem basis when the prices are linked to the ASP published by IBM; &
d) Lessees are put to much greater hardship for no fault of theirs.

Probably it appears that Ministry of Mines, New Delhi has lost sight of erstwhile service tax and now GST aspects while framing the rules i.e. MCR, 2016, and neither have they actually taken practical aspects into consideration while framing the aforesaid rules.

The State Govt. or DMG collects tax at source (Tax Collection at Source – TCS) at the time of receipt of royalty @ 2% on the value of royalty under section 206C(1C) of the Income tax Act, 1961, from the lessees/owners.

In the light of above discussed provisions of Rule 40(Provisional Assessment and Adjustment) of MCR, 2016, it would lead to collection of taxes (Tax Collection at Source – TCS) on a provisional basis and the lessee has to revise &/or adjust the same subsequent to publication of ASP by the IBM within a period of 55 days.

Provisional collection of taxes in a very novel concept in the annals of direct taxes i.e. income taxes, and the same is enforced through a mineral law by the Ministry of Mines, Govt. of India, New Delhi.

Imagine the plight of the officers of DMG who enforce this and collect TCS every time the ASP declared by IBM is higher than that considered by the lessee at the time of removal of mineral from the mining area after obtaining Mineral Despatch Permits (MDPs).

This also would bring us to a question of payment of interest on the delay in collection and remittances of TCS amounts from the lessee??

Who is to pay the interest on delay in collection of TCS amounts and deposit into the credit of Income tax dept.? Will the Collector of tax i.e. DMG pay the interest, since the obligation is cast on the DMG of each state to collect TCS? There are no clear answers.

In addendum, as per the provisions of the Income tax Act, 1961 every deductor or collector of tax i.e. TDS deductor or TCS collector is mandatorily required to file quarterly returns and handover tax deduction or collection certificates to the deductee or collectee i.e. the lessee/owner. In case of provisional assessments how would the Directorates of Mines and Geology comply with filing of quarterly TDS or TCS returns and issue relevant tax deducted or tax collected certificates?

The issue of provisional assessment of royalty, contributions to DMF & NMET etc. and final assessment of the same is very cumbersome and the lessee would be put to great difficulty in keeping track and making good the shortfall and adjust the excess amount paid, if any.

Innocuously the Ministry of Mines, New Delhi has brought in in-congruency in provisions of MCR, 2016 vis-à-vis the Income tax Act, 1961, GST laws, etc. This anomaly has to be set right at the earliest.

I. DISTRICT MINERAL FOUNDATION:

Section 9B of the MM(D&R) Act, 1957 gives power to the State Governments to establish a trust as a non-profit body to be called as District Mineral Foundation and to make rules towards functioning of the same.

Section 9B was inserted in the MM(D&R) Act, 1957 w.e.f. 12-01-2015 through MM(D&R) Amendment Ordinance, 2015, dated 12-01-2015. However the Central Government notified "The Mines and Minerals (Contribution to District Mineral Foundation) Rules, 2015" vide Gazette notification no. G.S.R. 715(E), dated 17-09-2015, w.r.e.f. 12-01-2015.

The levy of contribution to DMF as prescribed in the aforesaid rules is as hereunder:

Particulars	ML or PL cum ML granted on or after 12-01-2015	ML or PL cum ML granted before 12-01-2015
Amount of contribution to be made to DMF by the lessee/owner	10% of Royalty	30% of Royalty

Despite making a provision in the MM(D&R) Act, 1957 towards levy of contribution to DMF w.e.f. 12-01-2015, the Central Govt. prescribed the rules for collection of contribution to DMF @ 10% or 30% of royalty only on 17-09-2015, after a delay of 8 months & 5 days.

Like rubbing salt on the wound, Rule 2 of The Mines and Minerals (Contribution to District Mineral Foundation) Rules, 2015 deems the same to be applicable with retrospective effect from 12-01-2015, putting the lessees/ owners across the country in a very piquant situation and exposing themselves to pay contributions for all removals of minerals for past period of over 8 months in one go (from 12-01-2015 to 16-09-2015).

The Hon'ble Delhi High Court, New Delhi,came to the rescue of lessees in W.P.(C) 12027/2015 & CM Nos.31892/ 2015-31894/2015 (M/s. Federation of Indian Mineral Industries & Others vs. Union of India & Another), wherein in its judgement dated 22-12-2015 directed the Governments not to use coercive measures towards collections of contribution to DMF for the retrospective period.

In all, The Mines and Minerals (Contribution to District Mineral Foundation) Rules, 2015 has 3 rules, even after an amendment carried out in the same vide G.S.R. 837(E), dated 31-08-2016, and which would fit in one A4 size page and the Central Govt. could have notified the same much earlier rather than waiting for a period of over 8 months, putting the lessees in a very difficult situation and opening a pandora's box for litigations.

WHEN WILL THE CONTRIBUTION TO DMF KICK IN?

a) On the date when the MM(D&R) Act, 1957 inserted section 9B in the statute w.e.f. 12-01-2015?

b) On the date The Mines and Minerals (Contribution to District Mineral Foundation) Rules, 2015 was notified vide Gazette notification no. G.S.R. 715(E), dated 17-09-2015?

c) On the date the District Mineral Foundations are set up by the State Governments? The state of Chattisgarh established DMF on 22-12-2015; the state of Madhya Pradesh established DMF on 28-07-2016; the state of Maharashtra established DMF on 01-09-2016; etc.

The issue reached the Hon'ble Supreme Court of India, New Delhi and the Hon'ble Court has in the Transferred Case (Civil) no. 43 of 2016 ruled that for the holder of a mining lease or a prospecting licence-cum-mining lease in case of minerals other than coal, lignite and sand for stowing, shall pay contributions to DMF w.e.f. 17-09-2015, when the rates were prescribed by the Central Government and in case of coal, lignite and sand for stowing, contributions to DMF are to be made w.e.f. 20-10-2015 in its order dated 13-10-2017.

Capping of contribution to DMF: As per sub-section (5) to section 9B of the MM(D&R) Act, 1957 the amount of contribution to DMF cannot exceed more than one-third of royalty to be paid.

I. NATIONAL MINERAL EXPLORATION TRUST (NMET)

Unlike DMF, NMET shall be established and controlled by the Central Government and the funds accrued to NMET shall be used for the purposes of regional and detailed exploration as may be prescribed.

The holder of mining lease or a prospecting licence-cum-mining lease shall pay contributions to NMET a sum equivalent to 2% of royalty.

The state Govt. is denuded of the powers to levy and collect contributions to NMET even on minor minerals, where the rule making powers are given to the concerned State Governments.

II. TRANSFER CHARGES

Transfer charges are levied under sub-rule (1) of Rule 6 of 'The Minerals (Transfer of Mining Lease Granted Otherwise than through Auction for Captive Purpose) Rules, 2016 w.e.f. 30-05-2016.

Transfer charges shall be paid by transferee who has got the mining lease transferred in his name under the provisions of the said rules.

Transfer charges shall be paid to the State Government @ 80% of royalty in addition to royalty, contributions to DMF& NMET, etc.

It can be seen that transfer charges are linked to payment of royalty and as discussed above all issues in relation to provisional assessments, payment of interest, etc. shall have to be endured even for payment of transfer charges.

In the opinion of the author, the transfer charges par-take the character of royalty and GST has to be paid @ 18% on transfer charges in addition to GST being paid on royalty under the reverse charge mechanism.

SUMMARY OF TOTAL MINERAL LEVIES

As per the extant provisions of mineral laws the total levies on extraction of major minerals in the revenue land (i.e. not forming part of any forest) owned by the State Govt. by taking iron-ore mining lease as an example is as here-under:

Particulars (as a percentage of Average Sales Price published by IBM)	Mining Lease Holder		Transferee in case of transfer of Captive mines
	Before 12-01-2015	On or after 12-01-2015**	
Royalty on ASP	**15%**	**15%**	**15%**
Contribution to DMF	30% of 15% = **4.50%**	10% of 15% = **1.50%**	30% of 15% = **4.50%**
Contribution to NMET	2% of 15% = **0.30%**	2% of 15% = **0.30%**	2% of 15% = **0.30%**
Transfer charges	--	--	80% of 15% = **12%**
GST on royalty & transfer charges under reverse charge mechanism u/s 9(3) of the CGST Act, 2017	18% of 15% = **2.70%**	18% of 15% = **2.70%**	18% of (15%+12%) = **4.86%**
Total*	**22.50%**	**19.50%**	**36.66%**

**GST on supply (i.e. sale) of mineral shall be extra.*

***w.e.f. 12-01-2015 all new major mineral Mining Leases shall be granted only by way of auction and the additional premium to be paid by the successful bidder is not considered here-in-above. Also additional levies viz., Forest Development Fees, etc. have not been considered in the table above, since these are levied and collected by the State Government &/or local authorities.*

CONCLUSION

In the light of above facts & issues brought to the fore, and the insurmountable litigations at various fora,the current dispensation should immediately step in and correct the anomalies as spelt out in this write-up and take measures to suitably amend the statutes to be in line with the provisions of the Income tax Act, 1961, Goods and Services Tax (GST) laws, etc. Rectifying the GST monthly returns in line with the provisional and final figures of taxes paid on royalty& transfer charges, contributions to DMF & NMET would be nothing less than a nightmare for lessees involved in mining operations in the country.

New Technology With Trans-disciplinary Research For Improved Safety in Mines Vis-à-Vis Ground Control Problems

Dr. Singam Jayanthu

ABSTRACT

Although efforts are being made in many coal mining areas to establish strata management cell as per recommendations of the 10th National Conference of Safety in Mines held at New Delhi 26-27th Nov, 2007, further modifications are required for its proper organization. This paper presents overview of ground control problems of mining and the need of action plan for application of trans-desciplinary research and meticulous investigations for improved safety, conservation and economy of the coal mining operations. This paper also presents field experimental trial of wireless system for online monitoring of sub-surface movements' in atypical opencast metal mine in India. Innovative real time monitoring of ground deformation was accomplished with Time Domain Reflectometry (TDR) to interrogate coaxial cables installed in three Holes. Based on this received information mine official could alert the persons who are working near to prone area. This study describes the integration of TDR directly with Arduino boards and XBee modules for real-time transmission of slope monitoring data as a part of Ministry of Mines, Government of India (GOI) sponsored project. The TDR system appears to be a reliable measuring system for estimation of the subsurface movements, and an experimental trial of system of Slope Stability Radar (SSR) for online surface movements combined with TDR may be more useful for complete understanding of the slope behaviour for improving safety in opencast mines. Action plan includes detailed geotechnical instrumentation and online monitoring of ground behaviour for underground and opencast workings to improve safety in mines and as a tool for forewarning the disasters. Many experimental trails on ground behaviour monitoring with innovative instrumentation and analysis through Industry and Ministry (Ministry of Coal/Ministry of mines-GOI) sponsored research projects were conducted by the author in various methods of underground extraction of mineral deposits in coal and metal mines. Author also emphasized that all the mining industries should take necessary steps to equip the ground management cell at corporate level, area level and mine level with requisite manpower. These steps through new technology with application of trans-disciplinary research will pay a long-way to warn the disasters due to ground movements in the mining Industry.

INTRODUCTION

The progress of the technology in many branches of engineering is quite rapid in recent years. However, in case of underground coal mining, the progress is not as expected. It remained a lot with traditional systems, and only a few attempts were made to adopt/absorb recent trends. Although it could be attributed partly to availability and adoptability of the modern mining machinery, but also mainly due to limitations of available strata control technology, be in underground (suitable designs of workings and support systems) or opencast mines (suitable design of pit slopes, and stabilization of high walls/ spoil dumps etc). Prospects of coal mining depends upon the quantity and quality wise demand, heat energy, ash content, caking index, economics of mining, market pricing structure for the available produce and scope of value addition by way of washing or processing of ROM (Singh, 2007).The factors are influenced by geographical distribution with quality wise abundance, depth wise availability, geomorphology of coal complexity of the deposits and amenability to economic mining options. More than 98% of our coal resources occur in 7 eastern states, with Jharkhand accounting for 29.1%, Orissa 24.3 %, Chhattisgarh 17.1%, and West Bengal 11.1 %. Madhya Pradesh 7.8%, Andhra Pradesh 6.9% and Maharashtra 3.6%.. The distribution of the coal resources are geographically imbalanced with just 2% of the global resource available in 8 eastern and central states of the country. A large part of the country has to transport coal from these remote areas or import from the favorable world market. The Australian and Chinese coal market is bubbling with activities and prepared to feed Indian market.

In olden days, due to lack of proper instruments, qualitative observations with limited possibility of quantification lead to some empirical relations/thumb rules. However, now-days, with improved technology of mining/instrumentation, numerical models - computer applications for analysis of data; investigators gained enhanced satisfaction through observational approaches. Acceptability of such studies by the field personnel may be improved by proper interpretation of the data so generated by experts in the strata monitoring. There is a need to be more innovative in application of the existing instrumentation with proper planning by experienced strata control engineers which may lead to possibility of modification in existing practices for better safety and economy of mining venture.

India has large resources of coal deposits for underground mining and lot of coal was blocked in existing underground

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mines. Safe extraction of these can be made possible by effective strata management. Accidents due to movement of strata in underground coal mines (Table 1) had been a major concern for the mining industry and it is largest contributing factor of underground coal mine accidents. Continuous efforts were being made by all concerned to reduce the hazard of strata movement. The analysis of the accidents due to strata movement for last 12 years (1997-2008) revealed that the roof fall and side fall accidents accounted for 59% of all below ground fatal accidents in coal mines. All types of strata were involved in roof and side fall accidents. Accidents due to fall of roof occurred in almost same proportion in bord & pillar development as well as depillaring districts.

Table 1: Cause wise Fatal Accidents in Coal Mines, due to Strata Movement.

Year	Fall of roof	Fall of sides	Total	Total below-ground accidents	Percentage of accidents due to strata movement
1997	38	12	50	94	53
1998	35	15	50	80	62
1999	33	11	44	74	59.5
2000	27	14	41	62	66
2001	30	9	39	67	58
2002	23	11	34	48	70
2003	18	5	23	46	50
2004	26	8	34	49	69
2005	18	7	25	49	51
2006	13	4	17	44	40
2007	13	4	17	25	68
2008	13	7	20	33	60
Total	287	107	394	671	59

The condition of strata and the stress environment around any working place is always dynamic in nature. No two working place are having identical strata condition. It is therefore essential to assess the roof condition of the working places at regular intervals by scientific methods. The analysis of the accidents, observations of the DGMS officers during the inspection of mines revealed that a system of monitoring of strata movement was not in vogue. Most of these accidents can be prevented by effective monitoring the strata movement and implementing SSR. Therefore, it is essential to further emphasis on the issue of strata control mechanism to reduce the accidents due to strata movement (fall of roof & sides). In every coal mining company, strata control cell shall be established at corporate and area levels within one year as per recommendations of the 10th National Conference of Safety in Mines held at New Delhi 26-27th Nov, 2007. However, till now strata control cell not establish in all the coal mining areas as required. This may be attributed partially due to lack of proper responsiveness among the officials of some coal mining Industries. Strata control cell in coal mines can assist mine managers, for formulation of Systematic Support Rules, monitoring strata control measures in a scientific way to ensure efficacy of support system and, for procurement/supply of quality supporting materials. This issue can be addressed by proper monitoring of strata and taking adequate control measures in time. Geotechnical instrumentation although has been extensively used in the coal mines, still there is no standard procedures for undertaking the investigation as well as type of instrumentation for monitoring of the strata behaviour. Keeping this in view, two short term courses were held at NIT-Rourkela on "Trends in strata control techniques and instrumentation for enhancing safety in coal mines" during July 28th—31st, 2008, and Nov 19th - 22nd , 2009.The Mining Engineering department of NIT-Rourkela also conducted Workshop/ Training programs in coalfield areas of M/s SCCL, SECL, WCL, MCL etc under the TEQIP sponsored by the World Bank through National Project Implementation Unit during Oct-Dec'08. Strata control technologies have undergone considerable change and it is pertinent that the field engineers must be trained in the state of the art instrumentation for effective implementation of the strata control measures in coal mines.

UNDERGROUND MINING-GROUND CONTROL PROBLEMS

Nearly 61% of the total reserve of coal is estimated within 300m depth cover, distributed in all coalfields from Godavari Valley to Upper Assam. The prime quality coking coal of Jharia is available mainly in upper coal horizons while the superior quality non-coking coal of Raniganj is available in lower coal horizons. The quality coal of central India to Maharashtra is also available mainly in seams within this depth range. As a result all the mines worked such seams extensively, primarily developing on pillars and depillaring with sand stowing. With the unfavorable economics of sand stowing and non availability of virgin patches for further development, most of the mines have been working-splitting or slicing the pillars, winning roof or floor coals manually or with SDL, conveyor combination.The resource position of coal shows nearly 37% within 300-700m depth cover and a small portion (7 %) below 600m depth cover. Quality coal below 300m depth cover in Raniganj, Jharia, East and West Bokaro, North and South Karanpura, Sohagpur, etc should be the main targets for underground mining. The coals of Godavari and Wardha Valleys may also be included in this category because of preferential pricing structure. The options world over for such deposits are pillar mining- pillar mining using continuous miner, longwall mining and sublevel or integral caving with special support system in case of complex thick seams.Best performance of pillar mining is reported from that of Churcha mine, the only unit to cross 1Mt annual production in the country. Flat 3m thick seams was worked with shuttle car and scraper loaders imported in 1960, used without design modification and even spare back up support. The experience valuable was not repeated in any other mine even though the identical equipments were introduced in a few other mines.The next generation pillar mining equipment – continuous miner loader and bolting assembly has entered in the mines after nearly 4 decades with very encouraging performance at Chirimiri and Tandsi mines The system has given 12-15t productivity and average production of 40000 t per month. Identical mines under suitable geo-mining condition should be identified and detailed geological exploration should be done for the deployment of such machines. From coal reserve and quality analysis and seam thickness and gradient,such sites appear to be in Rangundam, Sohagpur, E and W Bokaro, N and SKaranpura, Jharia and Raniganj coalfields where a large share of quality coal seams are still virgin. Isolated patches with quality coal seams in near flat seams beyond limiting stripping ratio in, M P and Chhattisgarh may also be explored for the introduction of continuous miners.

Longwall technology should be adopted with due consideration of coal seam parameters, panel geometry and coal quality in seams below 300m depth cover in Jharia, Raniganj, Godavari Valley, Sohagpur, E Bokaro and S Karanpura where bulk of coking and superior grade non coking coals within 300-600m and below 600m depth are estimated. The faces should be equipped with high capacity support with rapid yielding valves to sustain ground movement shocks frequently felt due to massive roof. High supports suitable for 3-5m seam thickness should be used in areas where 12 - 15km long panels could be formed, each of 2 to 3km length and face length of 250 to 300m. Gate road drivage technology using continuous miner, bolter and loader assembly should be perfected to maintain advance preparation of the panels so that the faces could get unhindered operation for its life.Mining of complex deposits often worked with sand stowing has failed to meet the production target, productivity and economics. The method of slicing with mass caving in vertical section like horizontal slicing inclined slicing or sublevel and integral caving used successfully in complex deposits of Yugoslavia, Romania, Soviet Union, Poland or France may have to be perfected for underground mining of thick seams. Power support for working over sand stowed floor while mining thick seams in slices is available in the world market, particularly in Hungary may prove to be suitable for working of thick seams under riverbeds in different coalfields. Methane drainage from the seams under mining should be done to ensure better working environment, safety of the workers and the workings.

The operating mines, with small patches declared to be virgin till date should not be selected for the deployment of longwall mining or continuous miners as invariably they lack vertical and horizontal transport facility and adequate number of panels for equipment life time.

Geological exploration to locate suitable panels for each set of equipment with seam thickness variation within the permissible limit, coal of quality and roof rock formation should be done in depth before introducing any such cost intensive technology with continuous miners in 300-400m depth cover and longwall technology below 400m depth cover. Necessary steps to ensure their success is summarized as follows

- Shaft sinking technology should be perfected to develop access to deeper seams
- Back up facility – vertical and horizontal transport, processing and dispatch system should be compatible to the mass production technology.
- Equipment supply and spare availability should be ensured for efficient full life performance
- Man power preparation including training and on face operational skill should be developed on priority
- Work culture should be improved in respect of devotion, commitment and adaptation of modern technology with efficiency
- Program should have support of the nation for continuity and financial back up
- So far as possible, the equipment should be imported lock stock and barrel to start with, followed by manufacture within the country.

The nation has to gear up for large underground production within next three to four decades; for 300 to 400Mt annual production. The involvement of industrial houses and those of leading global players should be encouraged for State of Art resource input and managerial support.

With the advent of modern coal mining techniques, it has become imperative to adopt roof bolting as a primary means of support in place of the traditional supports. About 2500 million tons of coal has been locked in pillars of which only about 1000 million tons is amenable to opencast mining, about 1500 million tons is to be extracted by underground mining. Strata control management is one of the major reasons for losing of pillars. Although technology has improved now-a-days with the introduction of Blasting Gallery method, Integrated Caving method and Hydraulic Mining, some of them are unsuccessful with the loss of trials at Churcha, Kottadih, etc., and many more due to lack of suitable strata control techniques. Salient features that lead to typical problems in underground coal mining include;

- Steeply dipping, faulted, folded, highly gassy beds under aquifers and protected land have remained virgin.
- Developed pillars under fires, surface features sterilized because of acute shortage of sand.
- Development has been in multi sections.
- Highly stressed zones have been created due to barriers/ stooks causing difficulty of undermining of the seams.

Hazardous roof conditions identified in some mines of other countries were positively correlated with mining activities beneath stream valleys (Mucho and Mark, 1994). Evidence of valley stress relief was found beneath several valleys in the form of bedding plane faults and low-angle thrust faults. At many places the ratio of horizontal to vertical stress was in the range of 2 to 3. This type of failure, previously believed to be only a shallow phenomenon, was also found at increased mining depths.

Horizontal stresses affect a number of US coal mines (Mucho, et al., 1995). To address the effects of the stress field and to control its potentially damaging effects, a number of control strategies have been developed, such as reorientation of the retreat direction, stress shadowing of the key openings, and altering the mining cut sequence. However, many of these techniques are direction dependent, and to be effective, they require precise determination of the major (maximum) principal horizontal stress direction. For these types of typical geomining condition associated with high horizontal stress, a system of roof truss was used successfully. Cable bolts were effectively utilized for strata control in thick seams and adverse roof conditions in Indian coal mines (Jayanthu and Gupta, 2001). Roof slotting is one tactic to stress shadow the adjacent workings (Frank et al., 1999). The studies by the National Institute for Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA) at Sargent Hollow Mine, in Wise County, VA, indicated that the weak floor strata was being subjected to, and damaged by, high horizontal stresses. After the 'advance and relieve mining method' was implemented, the overall mining conditions at the mine improved, and the roof control plan was approved for further use. Roof falls have been usually attributed to bad roof strata and high vertical stresses related to the overburden depth. However, for shallow depth conditions, roof falls in recent studies have been attributed to high horizontal stresses (Yajie and John, 1998). About 73 roof falls analysed in USA, 37 occurred in the entries with 52° angle with the major horizontal stress. Unfortunately majority of the locked up pillars in thick seams have strata control problems possibly due to high horizontal stresses, and need careful review of history of falls. Through the horizontal stress recognition features, some of the following control techniques can be effectively implemented;

- reorienting the drivage direction of the mine openings
- panel orientation and retreat direction
- stress shadowing through key openings
- altering mining cut sequences

In absence of the in-situ stress measurements in majority of coal fields, the following symptoms of a horizontal stress concentration exceeding strength of the surrounding rock were identified in different case studies.

- The roof problems occur under lighter than average depth cover, so vertical stress is evidently not a factor.
- The roof in the other gate of a longwall face may be in excellent shape, implying it is stress relieved.
- There may be a stress valley above the problem area.
- The problems show a recurring pattern with each crosscut becoming unstable when the face approaches an intersection.
- The roof is week, particularly a laminated shale.
- The panel may be the first in a set or lengthening of a panel has created a "stress shadow".

In the light of experience of past few years, the norm for designing of Systematic Support Rules in development roadways needs reexamination and modification. Life of the roadway should also be considered while designing the system. The galleries of a Bord and Pillar system may be self-supporting under a very strong roof or the immediate roof may be supported by props, roof bolts or roof stitching depending on the local conditions (Mathur, 1999). The weight of the main strata is borne by coal pillars. During pillar extraction, props, cogs, roof bolts have been conventionally used in splits, slices etc., with skin-to-skin chocks near goaf edges (Mobile Roof Supports in USA).Performance of the support systems have been extensively studied worldwide for understanding the strata mechanics. higher bond strengths and anchorage capacities with reduced annulus was indicated (Tadolini, 1998). Developments in support systems are related to material for bolts (cuttable bolts, tendon, resin, acconex, etc., for grouting, swellex, truss bolts), mobility of supports (mobile roof support), capacity of supports (high capacity shields, props) (Gupta and Prajapati, 1997; Khan and Hassani, 1993). Mobile supports have been successfully deployed for depillaring (Larry, 1998). Support capacities up to 800 tons are available and need introduction in Indian coalfields. It provides an upward active force on the immediate roof strata and results in normal cave line pushed back into goaf. This allows a wide stook to be mined while depillaring, thereby costly and relatively unproductive cycle of splitting of pillars and associated support can be minimised. In near future, the concept of man-less mining needs to be adapted to the maximum possible extent for improved safety, production, and productivity.

Continuous monitoring of strata behaviour in terms of convergence of openings in advance on either side of the extraction line, and stress levels over pillars, stooks in advance of the extraction and ribs in the goaf was required through remote monitoring instruments for understanding the strata mechanics at critical conditions of roof falls. Continuous monitoring of support pressures was attempted to investigate the rock mass response to mechanised pillar extraction (Follington IL and Huchinson, 1993). Integrated Seismic System (ISS) was introduced for an experimental trial at Rajendra mine, SECL, for prediction of strata movement during coal extraction by longwall mining. The system developed by South Africa works on the principle of monitoring microseismic activities through geophones. The concept of tele monitoring or online monitoring is yet to be established to improve the safety aspects in underground coal mining. The use of Borehole TV Camera for caveability studies is the need of the hour for detailed analysis of strata behaviour during mining.

INSTRUMENTATION IN UDNERGORUND MINES

Ground control instrumentation as show in Fig 1 surrounding the underground excavation was found to be useful to understand the ground behaviour and needs to be implemented meticulously with right type and number of instruments located at proper places as per the required geomining conditions. Many experimental trails on ground behaviour monitoring with innovative instrumentation and analysis through Industry and Ministry (Ministry of Coal/ Ministry of mines-GOI) sponsored research projects were conducted by the author in various methods of underground extraction of mineral deposits in coal and metal mines.

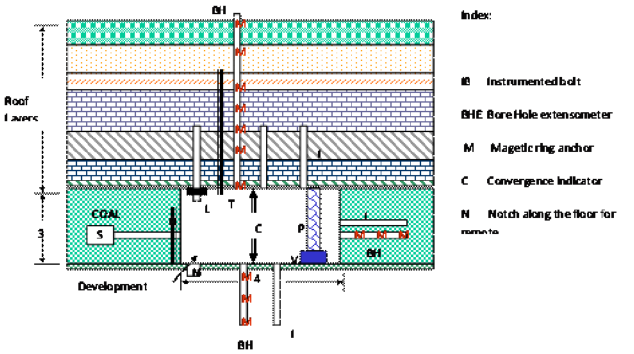

Fig 1: Typical instrumentation for strata monitoring around underground workings.

Extensometric Monitoring

Multi-point magnetic-ring extensometers will be used to monitor the bed separation up to 8 - 10 m in the roof at a few selected locations. A few Tell Tale instruments will also be installed for estimation of bed separation in the roof. Extensometers may also be installed in the floor, to determine the extent of floor heave. Similarly, the sides also will be monitored to assess the movements within the pillars. Based on the data recorded, the horizon of the weak planes along which bed separation or fracture is taking place, will be identified.

Strain in the Bolts

Instrumented bolts will be installed in the roof. These instruments will provide information about the strain or load developed along the length of the grouted bolt at different portions. These instruments will also be used in the sides of the pillars/floor to estimate the thrust

Load on Bolts

Anchor load cells will be installed along with the freshly installed bolts. These load cells will indicate the total load exerted by the strata along the bolt length.

Stress Changes

The change in stress with the extraction process will be monitored using stress gauges installed in the pillars. They will be installed at suitable depths inside the pillars, and they will be monitored as the drivages progress.

Roof-to-Floor Convergence

Convergence points would be installed at suitable locations for recording roof to floor movements at different stages of depillaring. The telescopic rod convergence meter measures the distance between two pegs, one in the roof and the other on the floor vertically below it. Remote convergence stations function on the principle of change of resistance due to convergence.

OPENCAST MINING - GROUND CONTROL PROBLEMS

The economic concerns and operational problems associated with unstable slopes state the need of suitable slope monitoring and management measures. Available Geotechnical sensors include vibrating wire piezometers, wire line extensometers, borehole extensometers, inclinometers; tilt meters etc. for sensing the changes in slope conditions, besides widely practiced total station monitoring. These geotechnical instruments are monitored by technicians in the field. Figure 2 shows the Slope Disaster at Rajmahal opencast mine, Eastern Coal Limited (ECL), India on 29-12-16 and Bingham Canyon Mine [2], southwest of Salt Lake City. The analysis of accident in open pit mine publicized that slope failure and dump failures have upward trends in the recent time[1]. Few examples of fatal accident involving slope and dump failure are mentioned in Table 2.

Fig.2 Slope Disaster at Rajmahal opencast mine, ECL, India on 29-12-16 and at Bingham Canyon Mine southwest of Salt Lake City, USA on 10-04-13.

Available electronic instrumentation includes vibrating wire piezometers, wire line extensometers; borehole extensometers, electrolytic bubble Inclinometers and tilt meters for sensing the changes in slope conditions, besides widely practiced total station monitoring. Technicians in the field can monitor these instruments. This research work is focused on the application of electronics and communication work deals with the elimination of manual slope monitoring in the industry with the help of Wireless Network Infrastructure replacing the need for physical cables.

Table.2. Few Examples of Fatal Accident involving Slope and Dump Failure

Sl. No	Date	Name of Mine	Incidence	Fatal
01	24.06.2000	Kawadi Open Cast (OC) Mine of M/s Western Coalfields Limited(WCL)	Slope failure of 31m high OB benches.	10
02	09.12.2006	Tollen Iron Ore Mine of M/s Kunda R Gharse in Goa	Failure of Slope 30m to 46m high Dump.	06
03	17.12.2008	Jayant OC Project of M/s Northern Coalfields Limited(NCL)	Failure of Dragline Dump.	05 persons 01 Shovel Buried
04	04.06.2009	Sasti OC Mine of WCL.	Dragline OB dumps of 73m height failed and slided down the pit.	02 Persons 02 Excavators Buried
05	25.02.2010	Hansa Minerals and exports Granite Mine.	Granite mass slided along an inclined joint plane and failed from height varying from 10m to 55m.	14 Persons
06	22.06.2014	Amlai Opencast Mine, South Eastern Coalfields Limited (SECL).	Dump failure due to sudden development of cracks in the embankment and Unstable Ground Conditions	2 Persons 1 Dumper 1 Dozer 1 Crane
07	29.12.2016	Rajmahal OCP of Eastern Coalfields Ltd(ECL)	Dump failure due to development of cracks and Unstable Ground Conditions	25 Persons 12 Tippers 6 excavators & 1 dozer

RECENT RESEARCH ON INSTRUMENTATION IN OPENCAST MINES

Geotechnical instruments for online monitoring is the need of the hour with the recent experiences of slope disasters in opencast mines. Cable based and Antenna based radar Systems are found to be useful and meticulous monitoring and interpretation of the data is highly solicited to give proper warning of the impending disasters due to slope failures. TDR can be called as cable-based radar and consists of two major components which are namely cable tester and coaxial cable. The cable tester works like a Transceiver. The TDR cable tester produces electric impulses which are sent down the coaxial cable. The coaxial cable is grouted into the ground (Figure 3). When these pulses approach a deformed portion of the coaxial cable, an electric pulse is reflected and sent back to the TDR Cable Tester. When the pulse runs across a change in cross-sectional cable geometry (e.g. due to a shear deformation), a portion of the signals is reflected back to the TDR device. The distance between the cable tester and deformity (x) can be accurately determined by the round-trip travel-time (T_R) and propagation velocity (Vp) of the cable.

$$x = V_p T_R / 2 \quad (1)$$

The TDR is used for finding the ground movement and it requires reading of the cable signature at regular time intervals. Ground movement such as slip along a failure zone, will deform the cable and result in a change in cable characteristic impedance and a reflection of energy. This change in the shape of cable can be used to determine the location of shear movement[3].

Software protocols and transmission algorithms using Arduino-Integrated Development Environment (IDE) Software were developed. RF module was utilized in Transparent Mode (AT) mode along with Arduino at transmitter and receiver side[4]. Data Communication was established between PC to PC wirelessly. Figure 4 shows the connection Diagram of the Integrated System. No packet loss was observed during the transmission. In the final communication model Arduino Uno board is replaced with Arduino Mega board and the RF module is replaced with advanced RF module. The upgraded Arduino Mega controller system succeeds to transmit the data wirelessly directly from the TDR to the system through RF module. Thus, it successfully removes the need for the PC from transmitter side of the RF transmission system. TDR data is transmitted wirelessly to the developed system with three coaxial cables connected to three different channels of Multiplexer (MUX). TDR generates three strings successively one for each of the channel of MUX continuously one after other. Each of the string contains 240 points representing the reflection coefficients along the length of the particular cable. As TDR works at a very high baud rate of 57600, so it generates the very large amount of data continuously[5,6].

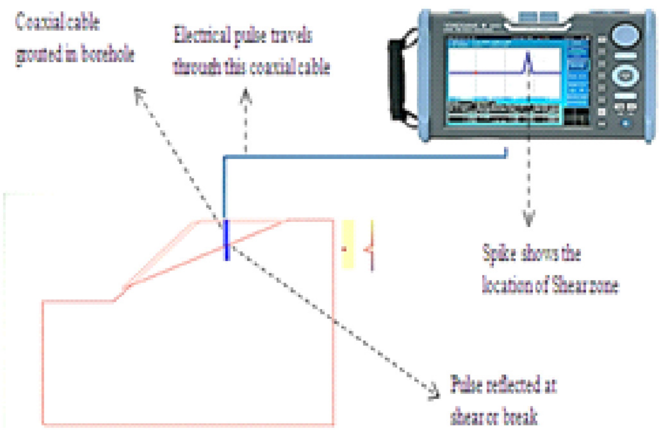

Fig.3. Functional Representation of TDR

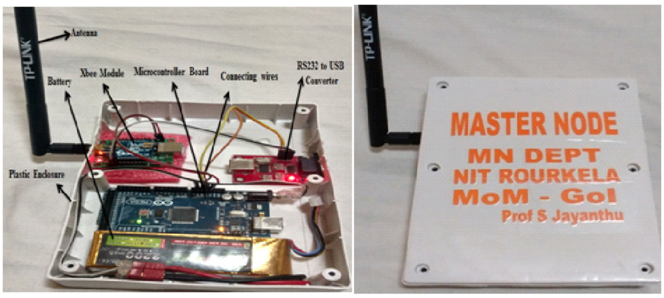

Fig.4. Integrated Master node for real-time monitoring

Though the Xbee PRO module is specified to provide the range of the 1 Mile (1.6 Km) by the manufacturer practically it fails to provide it due to various reasons. It includes the environmental condition, rough weather conditions, signal loss (attenuation) while transmission due to Earth Surface. One more serious problem with the RF wireless transmission is the line of sight issue. Same is concluded after the field trial carried out at the Dongri Buzurg Mine. The line of sight issue occurred while field trial as the distance between transmitter and the receiver side increases. The best way to overcome the line of sight issue is to install Router units between the two end devices wherever needed. Python is a flexible, simple coding programming language. Python is a very high-level, dynamic, object-oriented, general purpose programming language that uses interpreter and can be used in a vast domain of applications. This language can support different styles of programming including structural and object-oriented. Other styles can be used, too. Python is very flexible, because of its ability to use modular components that were designed in other programming languages. For example, you can write a program in C++ and import it to python as a module. Then add something else to it (for example design a GUI for it). It includes an internal standard library that is called "batteries inside" among Python lovers. It provides all facilities that are needed for programming from the basic operations to advanced functions. These third-party tools make everything possible in Python[7]. For example, by writing just 3 lines of codes you can create a web server. It can support COM, .Net, etc objects. Also, some alternatives and complements were created for python that make it easier to work with these objects in an integrated mode.

EXPERIMENTAL TRIAL AT OC MINE

The instrumentation was installed to provide a real time monitoring system and to provide quantitative information about ground movements. The locations and range requirements for installation of instrumentation were determined on the basis of various field visits and Geotechnical investigations and numerical modeling of selected mine. Automation was accomplished by connecting the Campbell Scientific TDR to a NIT Rourkela integrated RF module. TDR is controlled by a Campbell Scientific CR1000 datalogger.

As per the conditions of the mine site it is proposed to install Time Domain Reflectometry for real time monitoring of slopes.In the selected method, TDR along with three coaxial cables are installed for the primary monitoring (Figure.5). The depth of the hole is 11m and each coaxial cable is inserted in PVC pipe and grouted with cement. The PVC pipe is used for keeping the coaxial cable in dry condition and separate room was constructed for protecting the instrument.RG-6 type coaxial cable used for installation and three coaxial cables connected to TDR100 through SDM8X50 Multiplexer. This cable has been used in the field to monitor rock mass deformation with TDR. RG-6 coaxial cable having the 75 ohm characteristic impedance and the propagation velocity (VP) of this cable is 0.75. The Diameter of the cable RG-6 is 8.43mm and Operating temperature between the -40^{0}C to +80^{0}C[8]. TDR100 is connected to master node which is developed by scientific team of NIT Rourkela. The Generated real time data of TDR100 is directly sends to mine office through RF module (master node). Three Locations for the monitoring system were selected and coaxial cables were installed at those location. All the electronics were placed in a room which is specially constructed near to the cable locations and power is also available at that location. Measurements were taken weekly and three no of TDR monitoring cables that were grouted into drill holes to monitor precursor movement within the rock mass. The TDR measuring system, which was installed at the foot wall benches of DB Mine, MOIL and started operation in August 2017, is continuously working since August 2017, and has been conducting continuous measurements since August 2017. Figure.6 shows the Installed TDR instrument in Protecting Room at mine site. The Generated real time data of TDR100 is directly sent to mine office through RF module (master node).

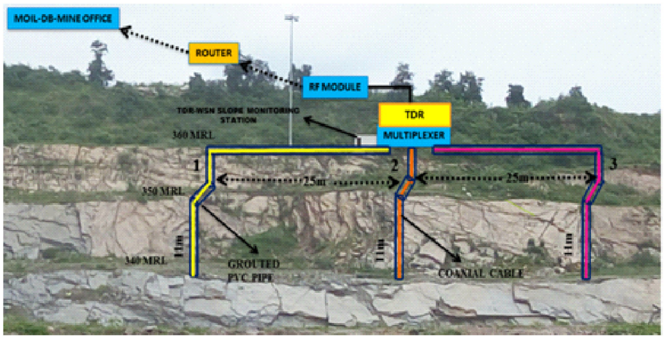

Fig.5.The method for the installation of the cables

Fig.6. Installed TDR instrument in Protecting Room at mine site

CONCLUSIONS

Many experimental trails on ground behaviour monitoring with innovative instrumentation and analysis through Industry and Ministry (Ministry of Coal/Ministry of mines-GOI) sponsored research projects were conducted by the author in various methods of underground extraction of mineral deposits in coal and metal mines. Geotechnical instruments for online monitoring is the need of the hour with the recent experiences of slope disasters in opencast mines. Cable based and Antenna based radar Systems are found to be useful and meticulous monitoring and interpretation of the data is highly solicited to give proper warning of the impending disasters due to slope failures. TDR along with developed RF module measurements proved to be reliable and cost effective for real time slope monitoring at the experimental site of a typical opencast metal mine in India. Conceptually, it would be possible to create an alarm system based on reflection coefficient (RC) values inferred from TDR measurements. The TDR system appears to be a reliable measuring system for estimation of the subsurface movements, and an experimental trial of system of Slope Stability Radar (SSR) for online surface movements combined with TDR may be more useful for complete understanding of the slope behaviour for improving safety in opencast mines. Geotechnical instrumentation although has been extensively used in mines, still there is no standard procedures for undertaking the investigation as well as type of instrumentation for monitoring of the ground behaviour and proper systems for warning of disasters with innovative applications of trans-disciplinary research. All the mining industries should take necessary steps to equip the ground management cell at corporate level, area level and mine level with requisite manpower. These steps through new technology with application of trans-disciplinary research will pay a long-way to warn the disasters due to ground movements in the mining Industry.

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