Future of Bulk Production from Underground Coal Mine in India

— Bijay Kishore*

Abstract

The proportion of coal production from underground mine in India is around 8% only which is very less compared to leading coal producing countries in the world. It shows that our major focus, dominance and reliance have been on opencast mining in meeting coal/energy demand of the country. However, 70% of the country's coal reserve are amenable to be worked by underground methods. Lesser cost of production, high productivity, less hazard, easier mining by opencast method, less geo-mining difficulties, more mechanization, etc. have caused more thrust to open cast mining over UG mining.

But time has come now to shift our priority from open cast mining to UG mining because of the reasons like environmental issues, depletion of shallower deposit, growing demand etc. Most of the underground coal mines in our country is conventional mine having less productivity. Hence to maintain the productivity and to fulfil the demand, mechanisation with introduction of mass production technologies in underground mines on urgent basis as planning, execution and adaptation is the need of the hour.

Earlier attempts to develop mechanised underground mine were not very successful due to improper planning, lack of advanced geo-technical studies and R&D facilities, issues related to spares and maintenance, technical lapses, high cost due to absence of indigenous equipment supplier etc. This has further discouraged us to develop towards mechanisation in underground mining.

For sustainability it is necessary to bring home the world-wide technological developments in underground mining. The challenges in underground mechanisation could be met if our planning is guided by a realistic approach considering all important issues like suitable, productive and safe methods, increased machine utilisation, inventory management, health and safety standards, improved work culture and discipline, skill development, state of the art R&D facilities etc.

A new development in this regard is deployment of Continuous Miner with Active Fill Technology (CMAFT). This is an innovative method of underground mining which can eliminate all the problems associated with opencast mining and provide adequate safety, nearly 100% extraction and provide many other advantages and yet be cost effective with lesser gestation period.

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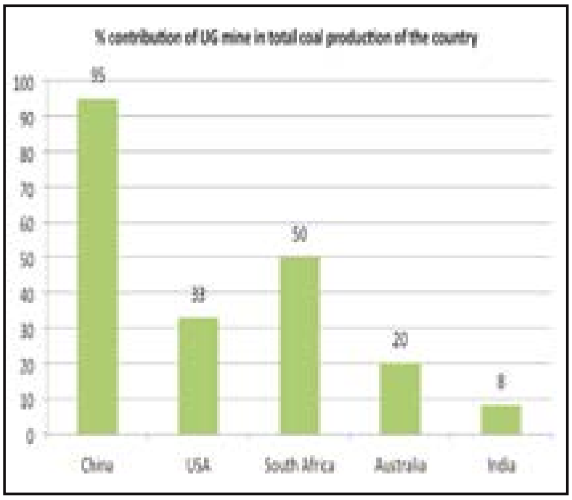
Introduction

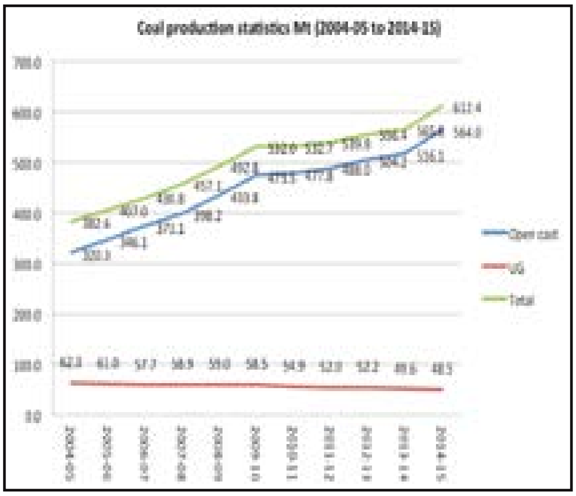
Coal fulfills around 30% of global primary energy needs, generates over 40% of the world electricity and used in production of 70% of the world's steel.

Around 60% of this world coal production comes from underground mines and the remaining 40% from open cast mines. However, the proportion of coal production from underground coal mines varies widely in various countries. China accounts for about 95% of its production from underground mines, while corresponding figures for USA and India stands at about 33% & 8%, respectively. In South Africa, production from underground mines is about 50% while in Australia, it is 20%.

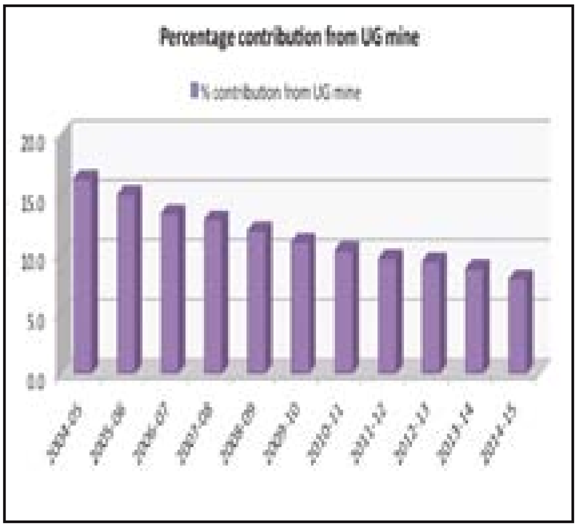


The above statistics indicates that leading coal producers have significant contribution from underground mines.

But the Indian Statistics is different.



It shows a gradual but consistent decline of coal production from underground mines.



The percentage contribution of production from underground mining has fallen from 16% to 8% during the above 11 year period. It shows that our major focus, dominance and reliance have been on opencast mining in meeting coal/energy demand of the country. However 70% of the country's coal reserve are amenable to be worked by underground methods.

The major reasons for the above trend are:

- Better Economics by open cast mining
- Less Hazards
- High productivity
  - ➢ OMS achieved in Opencast mine is around 11-12 whereas average OMS of underground conventional mine is around 0.75-1.25
- More Mechanisation
  - ➢ Earlier stripping ratio of 3:1 was considered optimum beyond that it was not economic
  - ➢ But now due to the deployment of huge size HEMMs, even a ratio of 8:1 is considered to be viable
- Easier mining method by open cast
- Less impact of geo-mining adversities
- Higher percentage of extraction (Almost 100%)
- In India not much mechanisation could be developed in underground mines and conventional underground mines have higher cost of production and less productivity.
- Some attempts of mechanisation in underground mine was tried but was not successful due to various reasons.
- Large-scale deployment of mechanisation at the underground mines is capital intensive.
- Undue over dependable on overseas equipment supplier leading to cost implications.

Due to above reasons, the development of underground mining technology in India has been put in backstage. And most of the underground mine in India is conventional. If we compare ourselves with other major coal producing countries like China, USA and Australia, we are far behind. Advanced countries like Australia are already conceiving to produce about 15 million tonnes per annum from one longwall face. In India, the pace of development of underground mechanization had been very slow mostly because of improper equipment selection, non-availability of spares and equipment itself and so many other factors.

But time has come now to shift our attention towards underground mining.

Need to develop underground mine mechanisation in India

- Most of the underground mine in India is conventional and the resulting shortfall in production due to exhaustion/closure of open cast mine cannot be made up by conventional underground mining. Hence to maintain the productivity and fulfil the demand, mechanisation with introduction of mass production technologies in underground mines on urgent basis as planning, execution and adaptation is the need of the hour.

- Limited shallow depth reserves amenable to opencast mining are likely to be exhausted in foreseeable future (may be after 20-25 years) and the production from opencast coal mines may reach a plateau.
- Damaging environment, land, flora and fauna is another burning issue due to open cast mining and calls for an alternate option.
- Opencast mine disrupts the natural equilibrium of the surroundings. The surrounding habitat is disturbed on account of air pollution dust and noise.
- As gestation period is generally more in case of underground projects, hence we have to start our planning well in advance.
- Apart from sustaining production from the existing mines, developing new projects has become necessary to reduce the gap between the demand and supply
- At present, multiple clearances are required from the government for commencement of new opencast projects like site clearances for mining lease, forestry clearance and environment clearance. This process would be much simpler in case of UG mining as the forest land and environment clearances in respect of underground mines are relatively uncomplicated.

Journey of Mechanised underground mine development in India

Most of the underground coal mines in India are conventional Bord & Pillar with manual loading or SDL/LHD loading. For mechanised mass production through UG, prevailing technologies adopted till now in Indian mines are:

(i) Powered Support Longwall Technology

(ii) Continuous Miner Technology (Bord/Room & Pillar);

Longwall Technology

First endeavour for mechanisation was in 1978, which was the deployment of Power Support Longwall (PSLW) technology in Moonidih, BCCL. After that, further attempts to deploy Longwall were made in several mines in BCCL, ECL, WCL, & SECL. The technology could not achieve its desired level of success. The collapse/damage of powered supports in SECL (Churcha West) & ECL (Kottadih), in the year 1990 and 1997, respectively, has set in sense of apprehension about its applicability and success in Indian coal mines.

Major reasons for not achieving adequate success of longwall mining in India are:

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Major reasons for not achieving adequate success of longwall mining in India are:

(a) No policy for introduction of mass production technology: Even after Nationalisation there was not any firm policy of Government for Mass Production Technology. Hence no private/Govt. Company have come forward to manufacture equipments for mass production.

(b) Standardisation of longwall equipment: There was no standardisation of longwall equipment in India. Longwall equipments procured in India were having different specifications. As a result no indigenous manufacturers were motivated to manufacture small demand of Longwall spare parts. As the numbers of operating faces were less, suppliers were not able to provide either manufacturing facility or spare depot in India. Further Longwall equipments imported from abroad was not suitable for Indian hard coal.

(c) Mismatching place of application: The study revealed that Longwall faces were introduced in extremely critical condition (viz. difficult geo-mining condition, steep & thin seams, Degree III gassiness, very high ambient temperature) and failed. These has caused misapprehension that the Technology is not suitable for Indian mining condition, in general.

(d) Inadequate Face dimension: Inadequate face width and length caused frequent shifting of equipments and increase in non-productive work and time.

(e) Lack of infrastructure facility: Longwall equipment deployed in already running mines having insufficient infrastructure facilities to match the desired level of production.

(f) Lack of advanced geo-technical studies and R&D facilities: In most of the cases insufficient geological information and geotechnical knowledge due to inadequate bore hole density (exploration) led to wrong planning including wrong selection of powered roof support, orientation of panels with respect to lateral stress direction. Weak geological information, wrong interpretation of faults, thinning of seams, intrusion and variation of strength of immediate roof, poor knowledge of hydro-geology caused continuous water percolation in the strata which led to strata control problems in many incidents. The glaring example in this regard is failure of powered support at Churcha(SECL) and Khottadih(ECL). In both the cases the supports collapsed and failed to withstand the load exerted by super incumbent strata during periodic weighing due to underrated supports. These two incidents gave severe negative impacts to the programme of large scale introduction of longwall technology in other Indian mines.

(g) Technical lapses: Technical lapses viz. Deployment of unmatching Road headers like AM 50s and Dosco, lack of manriding facilities, conventional face transfer system etc. led failure of Longwall technology in India.

(h) Uncertainty of Caving: Immediate roof being hard shale or massive sand stone there has been encountered the problems of caving uncertainty in some of the Indian longwall faces.

Further, Chinese PSLW sets were procured for 3 mines in SECL, which operated with a fair degree of success in early years. Later, production dropped significantly due to poor equipment maintenance and other unrelated problems.

Successful Introduction of High Capacity Longwall at Adriyala, SCCL will pave the way for introduction of such high end Longwall Technology at other mines and help in overcoming the earlier impediments and boosting confidence in underground mining technology to facilitate more such technological achievements across the country in the coming years.

Continuous Miner Technology

The first fully mechanised Bord and pillar system using continuous miner technology started its operation in 2002 at Chirimiri, Anjun hill mine at SECL. Since beginning the system has achieved over 40000 tons/month during development and 50000 Tons/month during depillaring. After that continuous miner were deployed with success in many other mines of India. Today mechanised depillaring operations using continuous miner technology have been considered to be a success in India. Its success has paved way for its wide application in underground mines. In our country the present status of projects with application of Continuous Miner technology is briefly enumerated as under:

❐ In operation

- Jhanjra, ECL – Joy Continuous Miner
- Sarpi, SECL – Joy Continuous Miner
- Tandsi, WCL - Joy Continuous Miner
- Kumberkhani, WCL- Sandvik LCCM
- NCPH, Chirimiri, SECL- Joy Continuous Miner
- Sheetaldhara-Kurja, SECL- Bucyrus Continuous Miner
- Pinoura, SECL- Bucyrus Continuous Miner
- Rani Atari- Sandvik LCCM

❐ Proposed

- Jhanjhra, ECL- MOU has been signed

- Tilaboni, ECL - Under tendering
- Kottadih, ECL- Under tendering
- Block-II, BCCL- LOA has been issued
- Lohapatti, BCCL- Bids under scrutiny
- Saoner-I,WCL- Under re-tendering
- Churcha, SECL- LOA has been issued for two sets

In both the systems (Long wall and Continuous Miner), the technology has developed manifold worldwide in terms of:

- Size & capacity of equipment,
- Customization : variety of equipment to cater to different needs,
- Sophistication and automation
- Ever growing actual production and productivity levels
- Features of enhanced safety and hazard management system with the technology, etc

Mass production technology in our country are still to achieve the desired level of production and productivity in line with the world-wide development in underground mining. Continuous efforts are required to bring home the world-wide technological developments in underground mining. The challenges in underground mechanisation for the increased production and productivity with safety could be met if our planning is guided by a realistic approach considering all important issues like suitable, productive and safe methods, increased machine utilisation, inventory management, reduction in cost due to accidents through improved health and safety standards, improved work culture and discipline through efficient management. Adequate training of workforce for skill development for underground mechanisation would be an essential input. The application of Research & Development for scientific exploitation is also another requirement to meet the challenges of increased mechanisation aimed for higher productivity with profitability. Policy guidelines may also be drawn for replicating the Chinese model of developing suitable technologies for higher percentage of extraction under our geo-mining conditions.

Roadmap to Success

(1) Exploration and detailed geo-technical studies: Complete and detailed study of an entire coal block is required to be done before implementing the new projects. Learning from previous mistakes should be utilised for future planning.

(2) Utilise the learning from leading countries: Both China and India introduced Longwall almost at same time. But today China has not only gone far ahead from India in terms of the technology but also it has become world leader in Coal production. China has made tailor made equipment suitable to their geo-mining conditions. For this they first developed required skills for their manpower. They have given adequate importance to applied R&D for product design and quality improvement.

(3) Selection of technology/equipments suitable to geo-mining conditions: By conducting detailed studies, numerical modelling, and preparation of data related to specific geo-mining condition of the mine choice of technology (viz. Continuous Miner, Longwall etc.) should be selected and equipment should be designed.

(4) Indigenous Manufacturing of the equipments at lower cost: Indigenous manufactures to be encouraged to develop their technical expertise to produce equipments which are suitable to Indian geo-mining conditions at lesser cost. Further spare and maintenance issues will be resolved by this. Proper economic instrument like tax holding etc. may be thought of.

(5) Development of more number of mechanised faces: Technical expertise will come only if more number of mechanised faces are developed. If there are more number of mechanised faces, equipment manufacturers will be encouraged to establish service depot in India due to increased sale volume.

Continuous Miner with Active Fill Technology (CMAFT): A new development

A new technology yet to be adopted in Indian mines is “Continuous Mining with Active Fill Technology (CMAFT)”. This involves cutting coal by continuous miner and hauling it by Mobile Flexible Conveyors (MFC) from the face then through trunk conveyor up to the surface. This technology has been innovated by Shri B P Singh, Director of Mines Safety, DGMS.

The voids so created are continuously filled with Active Fill Matrix (AFM) which is high density paste fill that quickly sets and provides 1.5 to 5 MPa support to the excavation. AFM is a high concentration paste prepared from coal ash (Bottom and Fly Ashes) or crushed & sized over burden rock from opencast mines mixed with quick setting binder, plasticizer, stabilizer, expansive chemicals and water. The paste fill gains quick strength within two to three hours with ultimate strength of 30 to 50 MPa so that the miner can cut another slice without leaving any rib or block of mineral, which are normally left for support. As no coal is left in the form of ribs or pillars, the dangers of fires, explosions, inundation and strata failure are eliminated in coal mines. Fig 1 shows multiple entry cutting, loading and transportation by continuous miner and Mobile Flexible Conveyor.

Active Fill Matrix

Active Fill Matrix (AFM) is a mixture of cemetitious material and chemicals mixed in required proportions in a matrix vessel and pumped in to the mined out voids in the form of paste having 80% solid and 20% liquid. Expanding chemical doped in the AFM during the process of setting expands and provides required positive supports in the roof and sides of the excavation before getting transformed from paste to solid. The required level of positive support and setting time of the AFM are controlled by changing proportions of the mixing constituents. Fly Ash, Bottom Ash, Stone Crusher's Waste, Grits, Sand, Dolomite Powder or many other solid wastes may be used as fillers in the AFM.

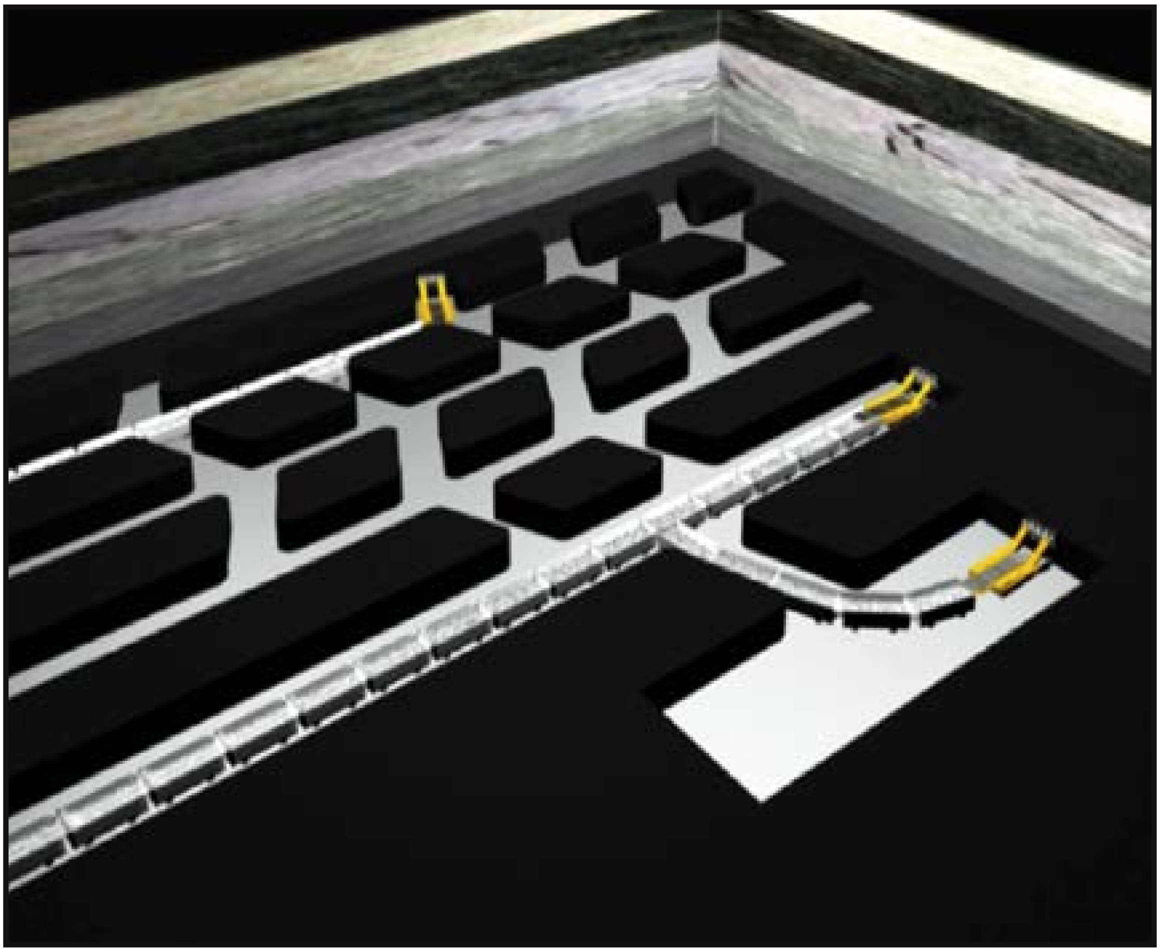

Fig. : 1

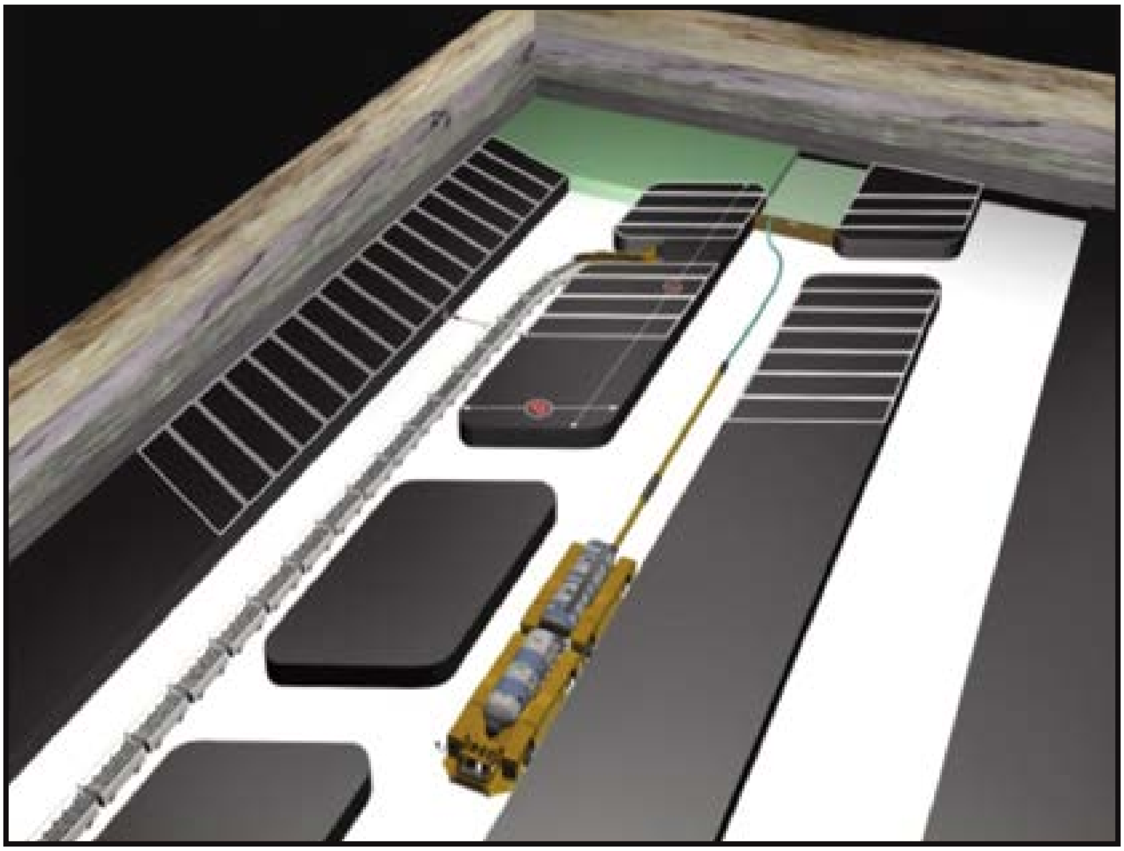

Fig. : 2

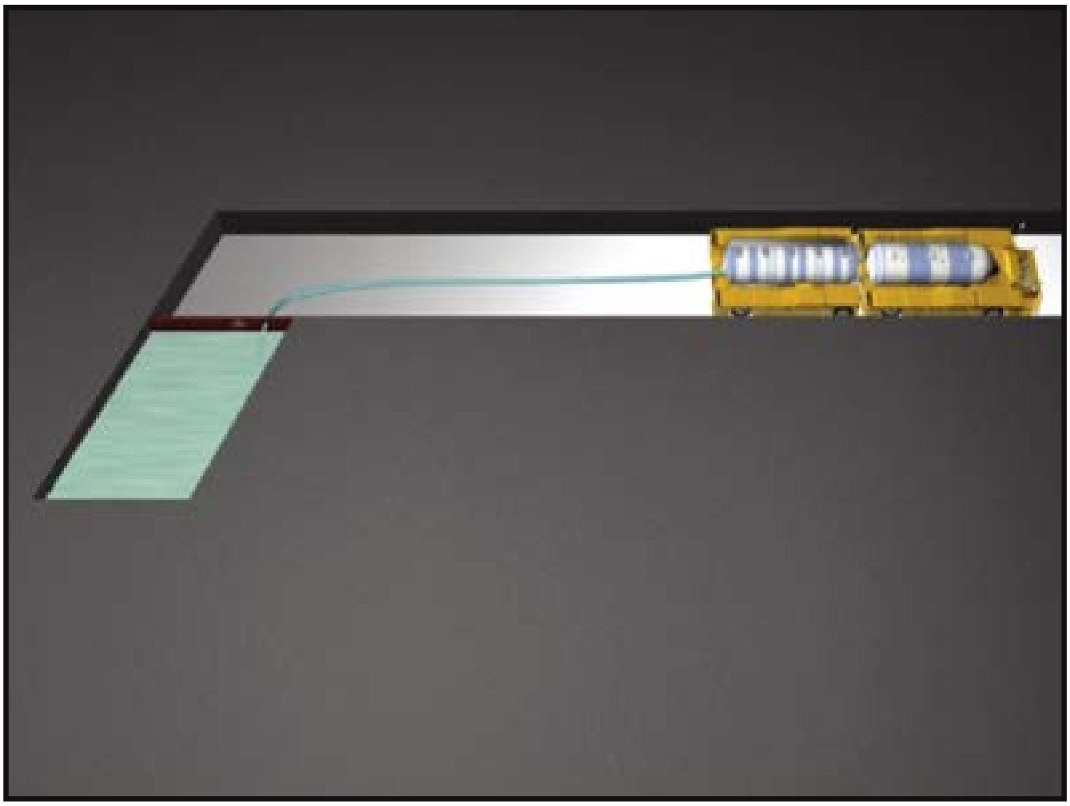

Fig. : 3

Fig. 3 shows AFM being pumped to a slice.

The strength of fill may be made to vary between 10 to 70 Mpa. There is huge advantage of this technology:

- Almost 100% extraction of coal: elimination of ribs, fenders barriers etc.
- Roof and side is fully secured and there is no risk of fatality on account of the roof fall which is major hazard in underground mining.
- Very thin and very thick seam can be mined with ease without difficulty.
- Amenable to work at very low to very high depth.
- Since there is no subsidence on surface coal below river, streams, villages, railway, highway, forest etc. may be mined.
- No need to use explosives, hence associated problems with explosives will be eliminated.
- No risk of spontaneous heating of loose coal left after extraction as in case of conventional method of mining.
- No impact on ground water table.
- Ease for receiving statutory clearance on forest and environment.
- Coal locked in standing pillars may also be mined out easily.
- This is a green mining Technology.
- And many more advantages

The Pictorial Representation of Active Fill Technology is as below :

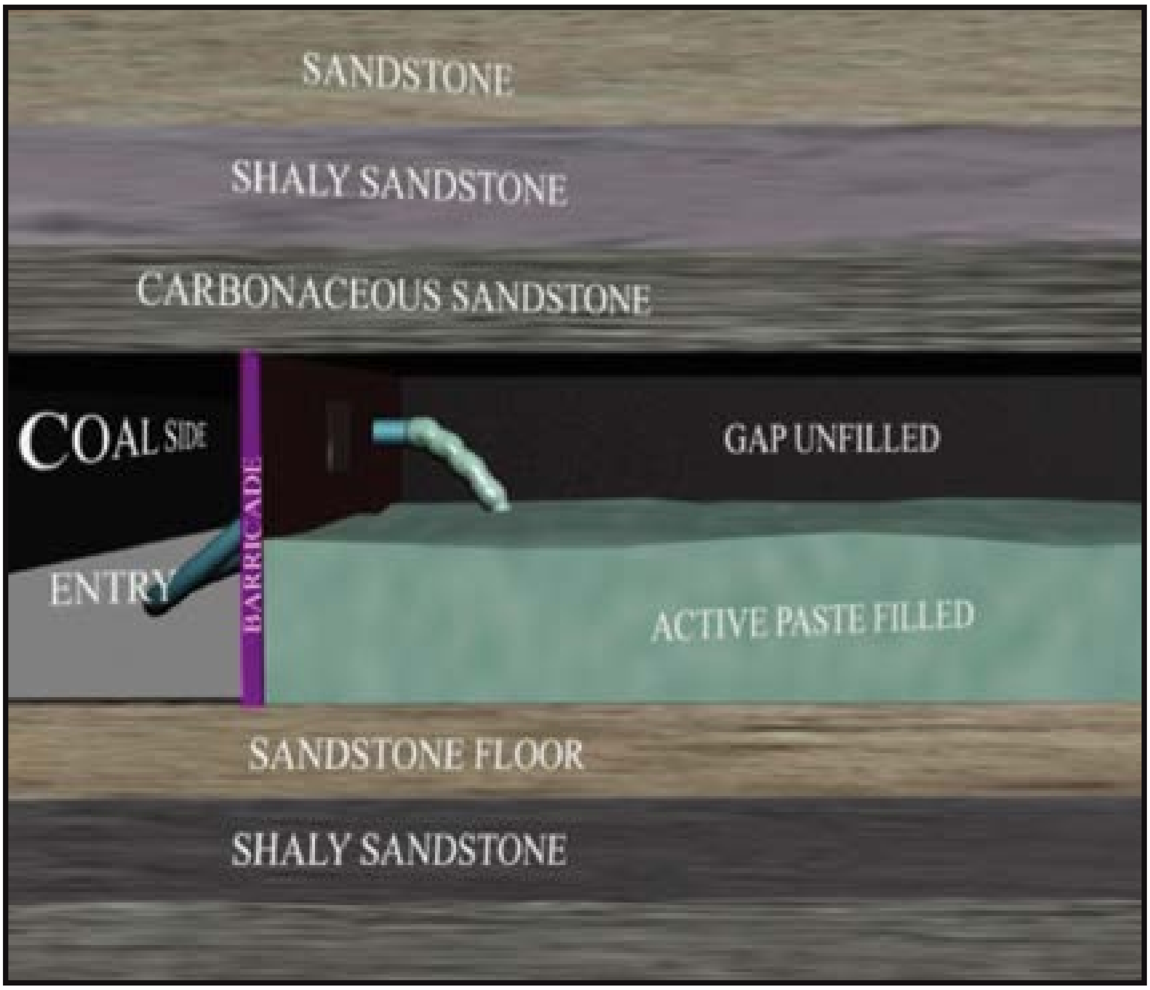

Fig. : 4 : Filling of slice by AFM

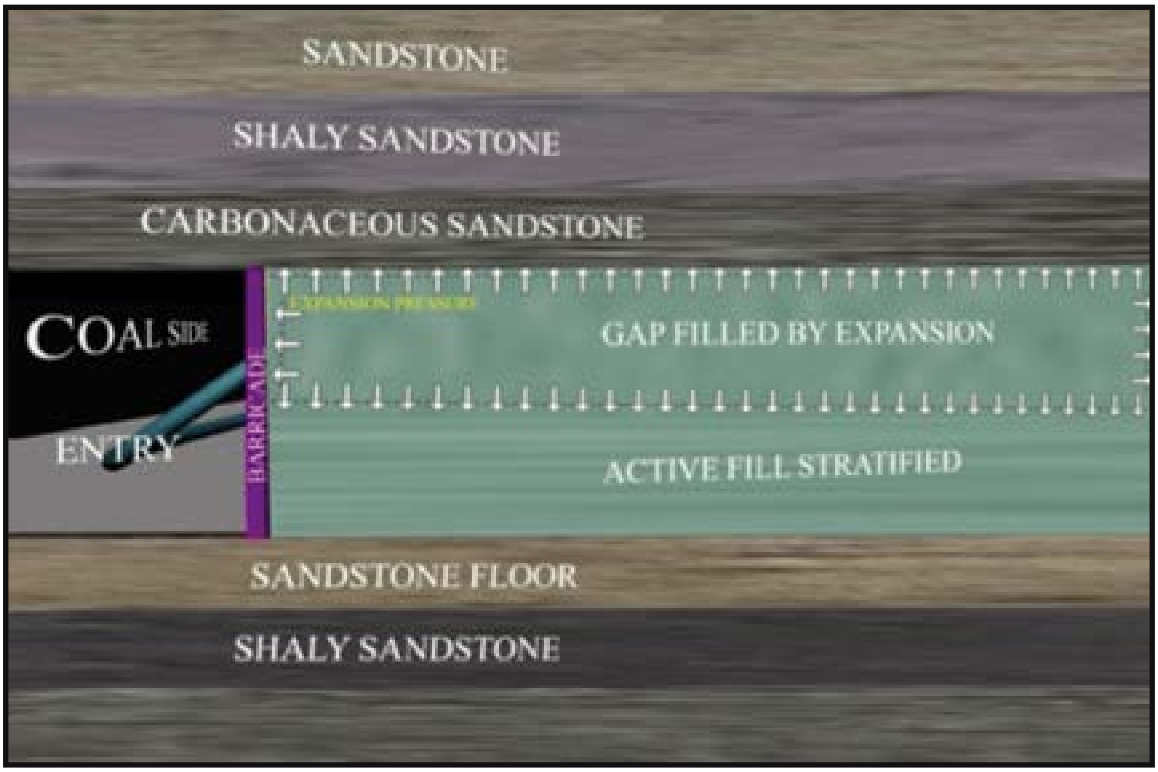

Fig. : 5 : Paste in the Slice under Expansion and Setting Solid Simultaneously

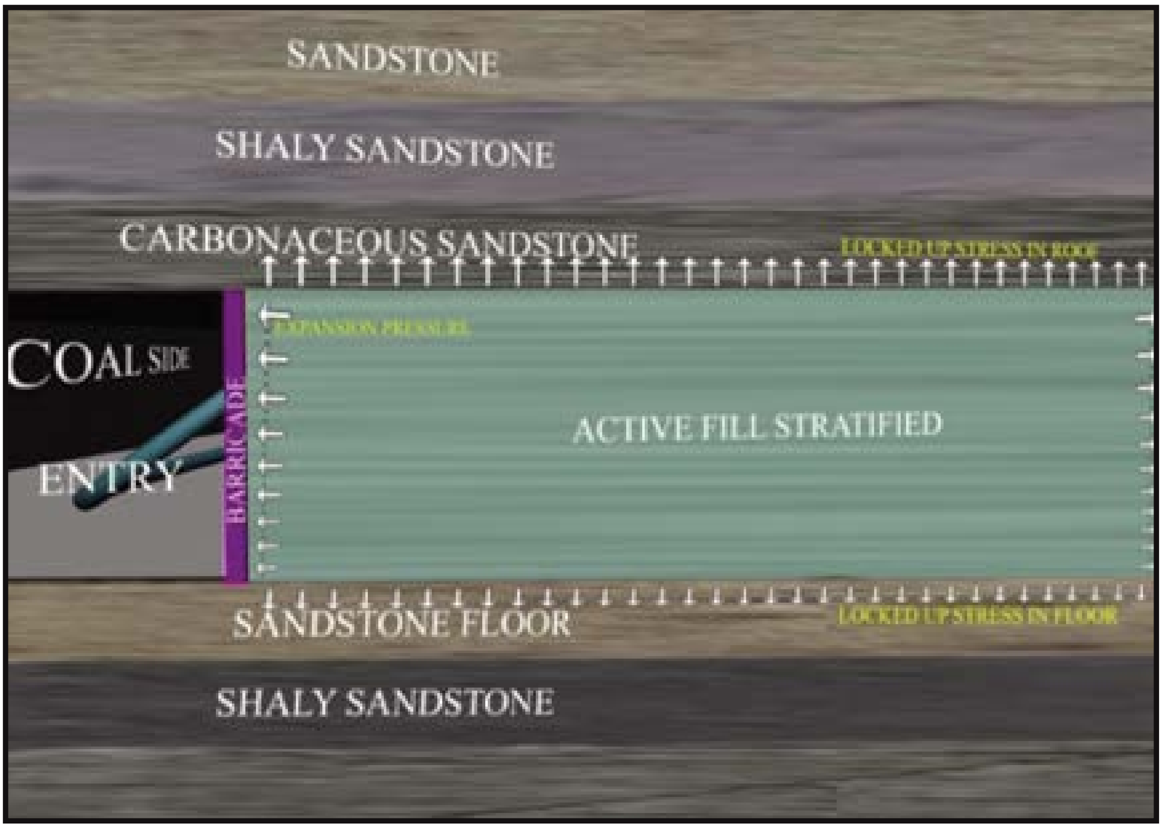

Fig. : 6 : AFM solidified and stresses locked up

The productivity and efficiency of this technology is such that it can compete with productivity of any surface/opencast mines and underground mines using longwall technology at lesser investment.

The description of this technology is based on my interaction with Shri B P singh, Director, Mines safety, DGMS.

Conclusion

The open cast mines are besieged with a number of environmental implications like land degradation, impact on flora & fauna, pollution of air and noise etc. Shallower deposits coal will last for only another 20-25 years. This calls for urgent development of underground mechanised coal mine for mass production in India. Adequate efforts in this line are required. Adequate thrust on R&D and skill development is prerequisite for this. Number of mechanised faces are to be planned so that indigenous manufactures are encouraged to produce equipment which are economic and services & spares issues which were bottleneck earlier will be resolved. To begin with, suitable measures from State agencies would be required. Different modules like Mine developer cum Operator (MDO), Technology provider cum Operator (TPO) etc. can be worked out with foreign participation. Deployment of CMAFT is one of the suitable options in this direction. CMAFT can become a substitute to open cast mining where R&R issues can be handled easily. India imports about 90% of its requirement of coking coal, in spite of availability of Coking coal reserves in our Jharia Coal field. Jharia coalfield has problems of coal fires and subsidence. Moreover high population density in mining area further complicates the issue. Mining the deep seated unmined seams with CMAFT can be a possible solution.

References

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(3) Underground Coal mining in India- Technological option and challenges ahead by MD Suresh Kumar

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Pit and Waste Dump Slope Monitoring in Coal Mines – An Overview

— Sanjiv Kumar*

Introduction

Dump slope and pit slope monitoring have become necessaryin large opencast mines of Coal India Limitedbecause of handling of large volume of materials (Coal & OB) in a short span of time. The land acquisition is a big bottleneck in expansion of any mine resulting into high OB dumps (external as well as internal) and the height of dumps have grown up to 90 m and more. After introduction of large capacity machines and large scale outsourcing , mining at higher stripping ratio and mining of deep coal seams became economical resulting into higher pit slope of the mines. Therefore, for the safety of men and machines deployed in those mines, it is necessary to monitor the pit slope as well as dump slope.

Factors affecting the Dump stability

There are several factors which affect the stability of dump slope :

- Dump configuration
- Foundation conditions
- Dump material properties
- Dumping method
- Dumping rate
- Topography
- Dump drainage &
- Seismic and dynamic stability

There are four basic types of slope failures :

1. Plane failure
2. Wedge failure
3. Toppling failure
4. Rotational / circular failure

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and the factors affecting slope failures are :

- Geological discontinuities like fault , slip planes etc
- Presence / effect of water
- Geo technical properties of material like Compressive strength , cohesion etc.
- Mining methods
- Geometry of slope
- Erosion
- Vegetation
- Seismic effect

In earlier days, slope monitoring was carried out with the help of :

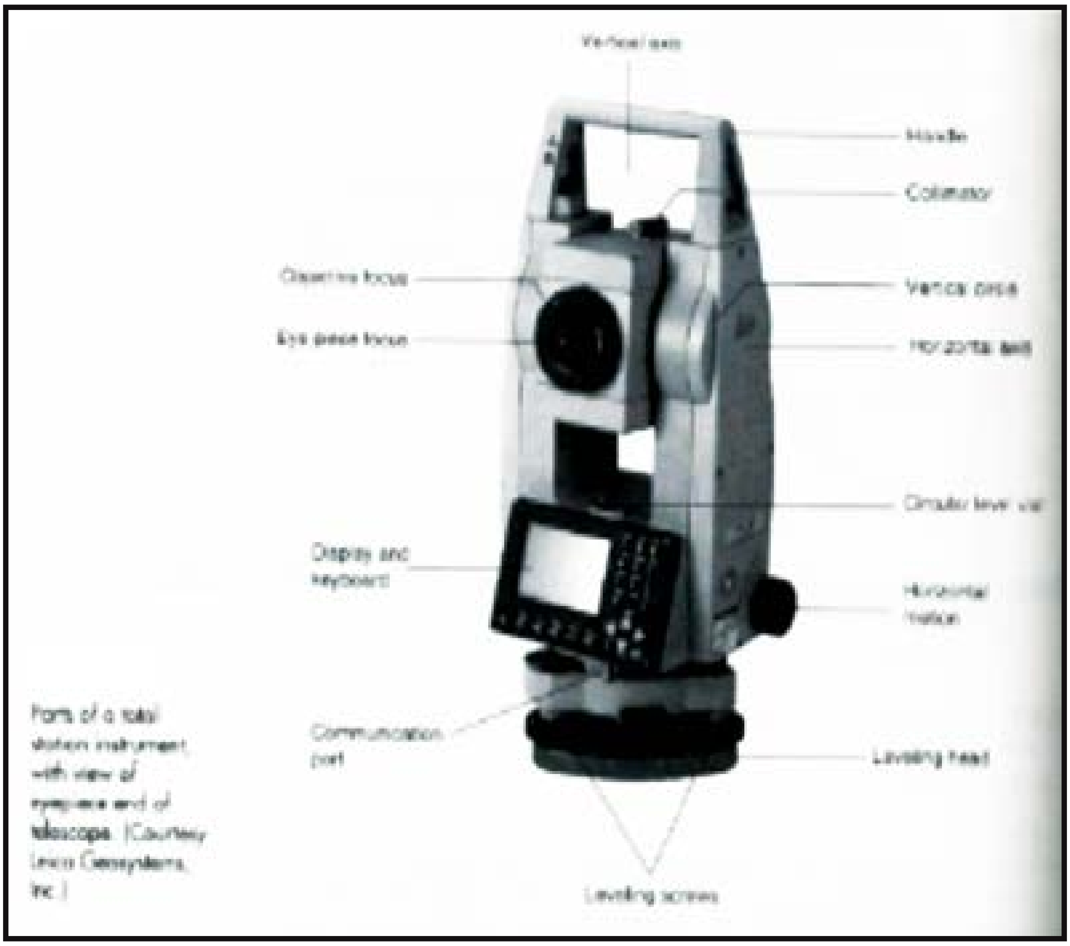
- Bore hole extensometer
- Tel -Tel
- Inclinometer
- Peizometer

But now a days, slope monitoring is being carried with the help of:

- ETS (Electronic Total Station)
- LiDAR (Light Detection And Ranging)
- TLS (Terrestrial laser Scanner) and
- RADAR

Electronic Total Station (ETS)

The **advantages** of the **Total Station** electronic surveying system are that it computes the horizontal distance measured, average of multiple angles measured and average of the sloping distance. As an electronic device, it is able to store all data collected in the field for later use.



Different Parts of Total Station

It consists of an EDM, Theodolite, Microprocessor combined into one. It also has a memory card to store the data. It also consists of battery socket which houses the battery. A fully charged battery works for about 3 to 5 hours continuously.

Accuracy of a Total Station

Accuracy depending upon the instrument and varies from instrument to instrument

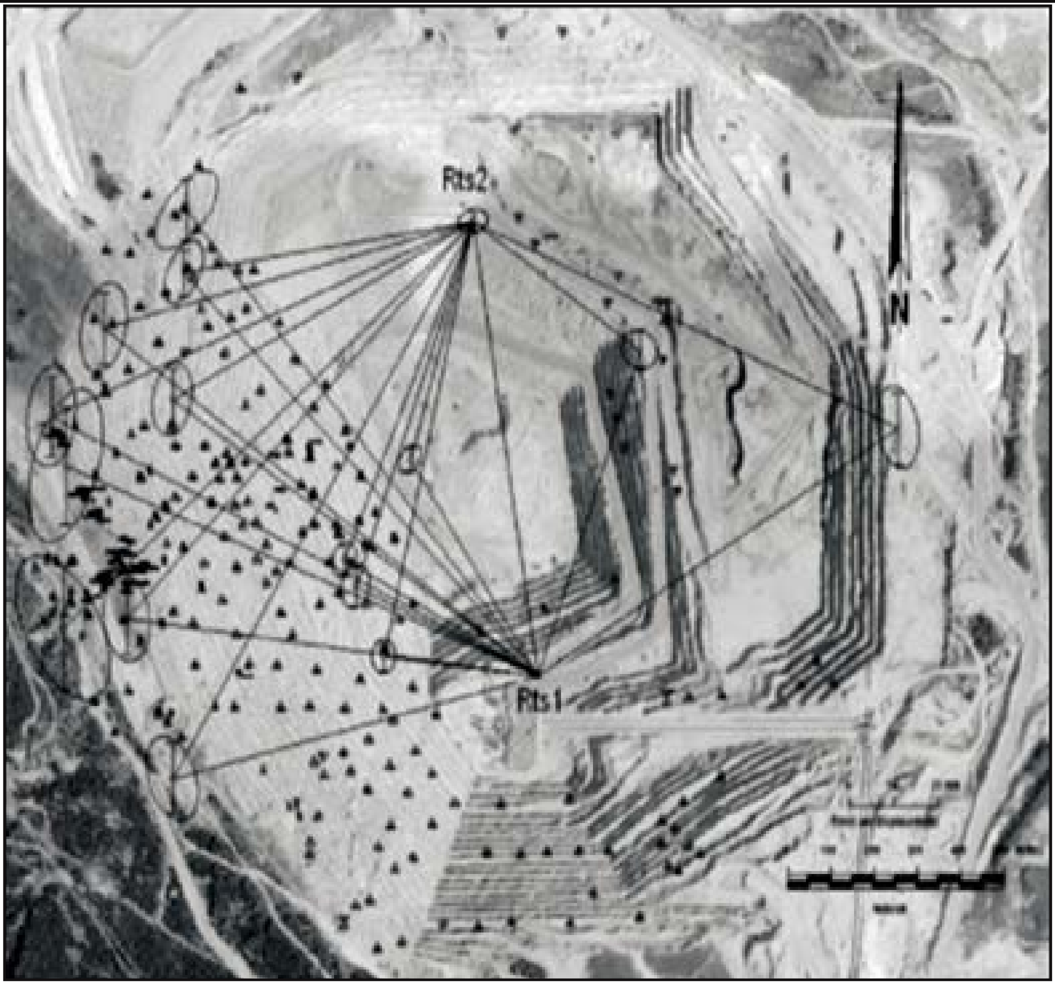
- The angular accuracy varies from1″ to 20″.
- Distance accuracy depends upon two factors.
  - (a) Instrumental error which ranges from +/– 10mm to +/– 2mm.
  - (b) Error due to the length of measurement. It can be from +/– 10mm to +/– 2mm per kilometre.

But, there are limitations of ETS for slope monitoring like

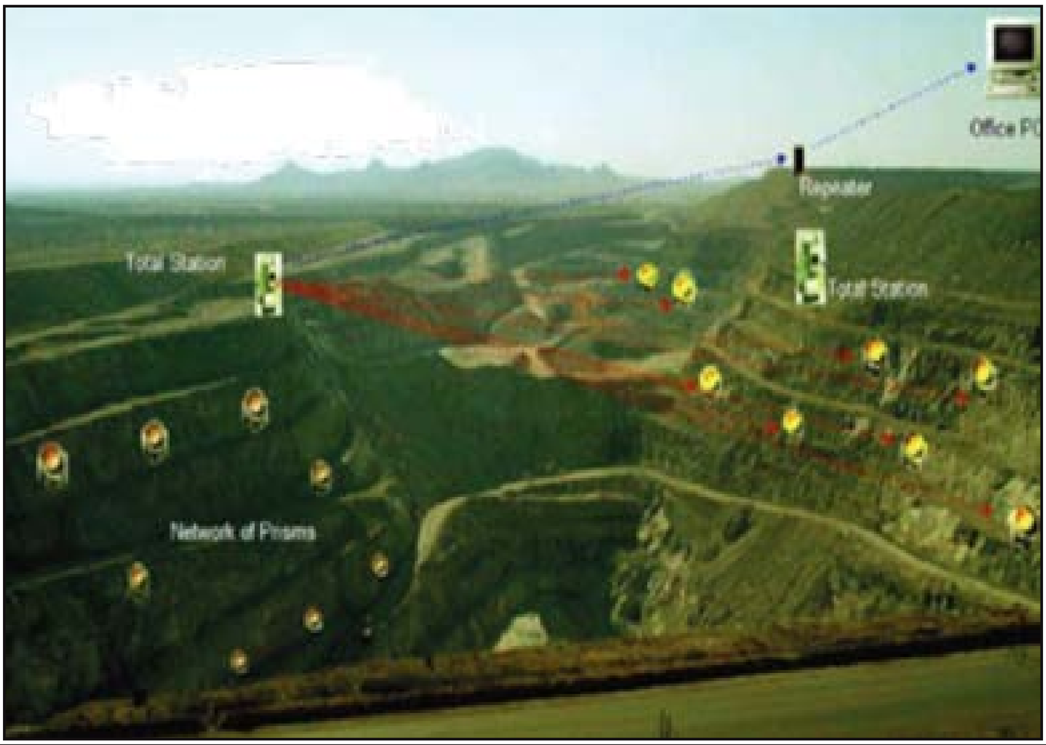
- The ETS can record only intermittent slope data depending on no. and position of reflector or other surface.

Automated Robotic Total Station (RTS) Networks consists of

- a number of robotic total stations placed in special shelters, the number being dictated by range, atmospheric conditions, visibility, design of the optics, power of laser and resolution of charge coupled device camera.
- A number of prisms are installed on the slope at regular spacing for measuring movements at the monitoring points. The total stations can also be linked to satellite based positioning systems that provide absolute control.
- Customized software's provide a total integration using wireless communication network to measure movements of slopes in X, Y and Z directions



Rts2
N
Rts1



Office PC
Repeater
Total Station
Total Station
Network of Prisms

TLS (Terrestrial Laser Scanner)

Terrestrial laser scanning (TLS) is a ground-based, active imaging method that rapidly acquires accurate, dense 3D point clouds of object surfaces by laser range finding

Non-Reflective Light Detection And Ranging (LiDAR) Scanning

- LiDAR is an optical remote sensing technology which can measure the distance and local position of a target.
- LiDAR technology comprises terrestrial laser scanning (TLS) and airborne scanning.
- This active self-contained measurement technology utilizes a beam of laser lights, targeted towards the area of monitoring which returns the pictorial / digital representation of the critical area of the slope and their relative movements using the travel time of the reflected radiations.
- Recent LiDAR scanners can be mounted in both the static and mobile surveying platforms which can provide digital elevation models (DEM) in rapid time and the survey of mine slope can be made up to 15 times faster than the conventional survey .

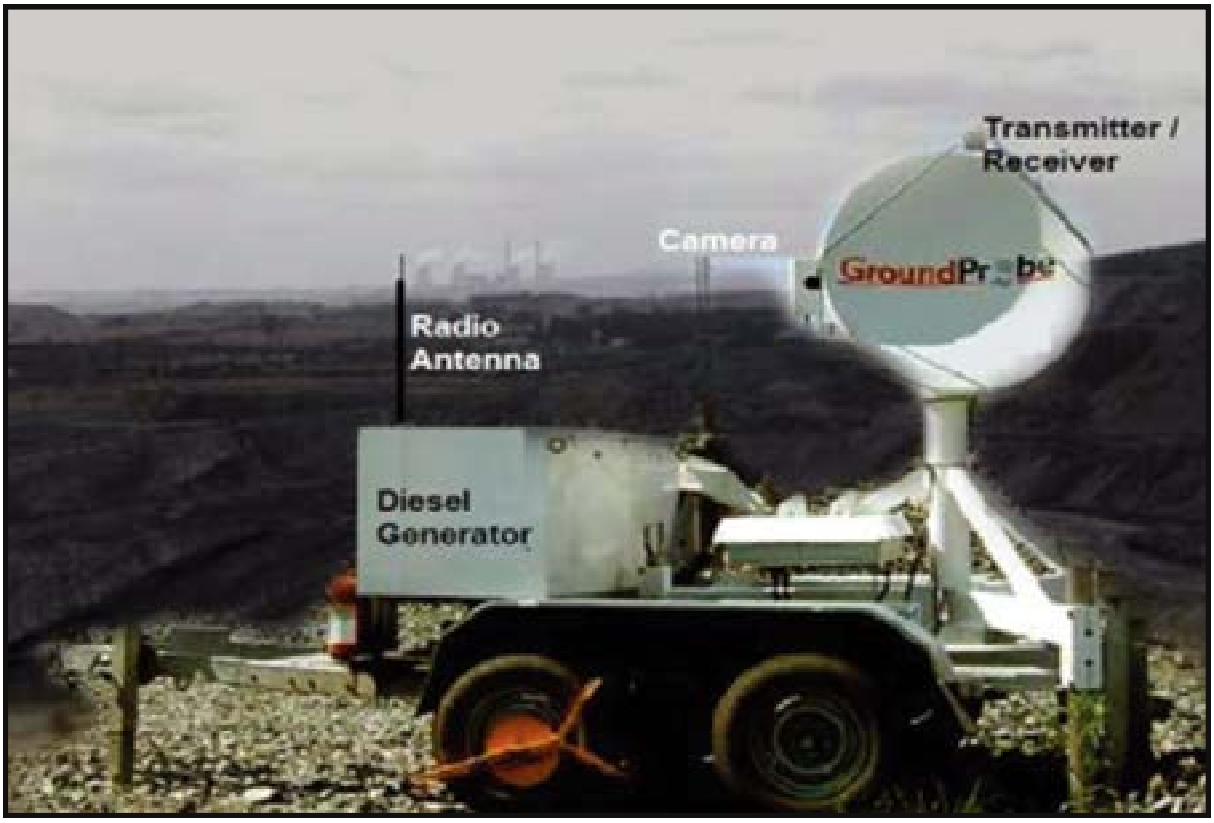
Radio Detection And Ranging (RADAR)

There are various types of RADAR available for specific use like :

1. Real Aperture Radar (RAR)
2. Synthetic Aperture Radar (SAR) in the form of Interferometry Synthetic Aperture Radar (InSAR) or Ground based Interferometry Synthetic Aperture Radar (GBInSAR) and
3. Ground Penetrating Radar (GPR)

Real Aperture Radar (RAR)

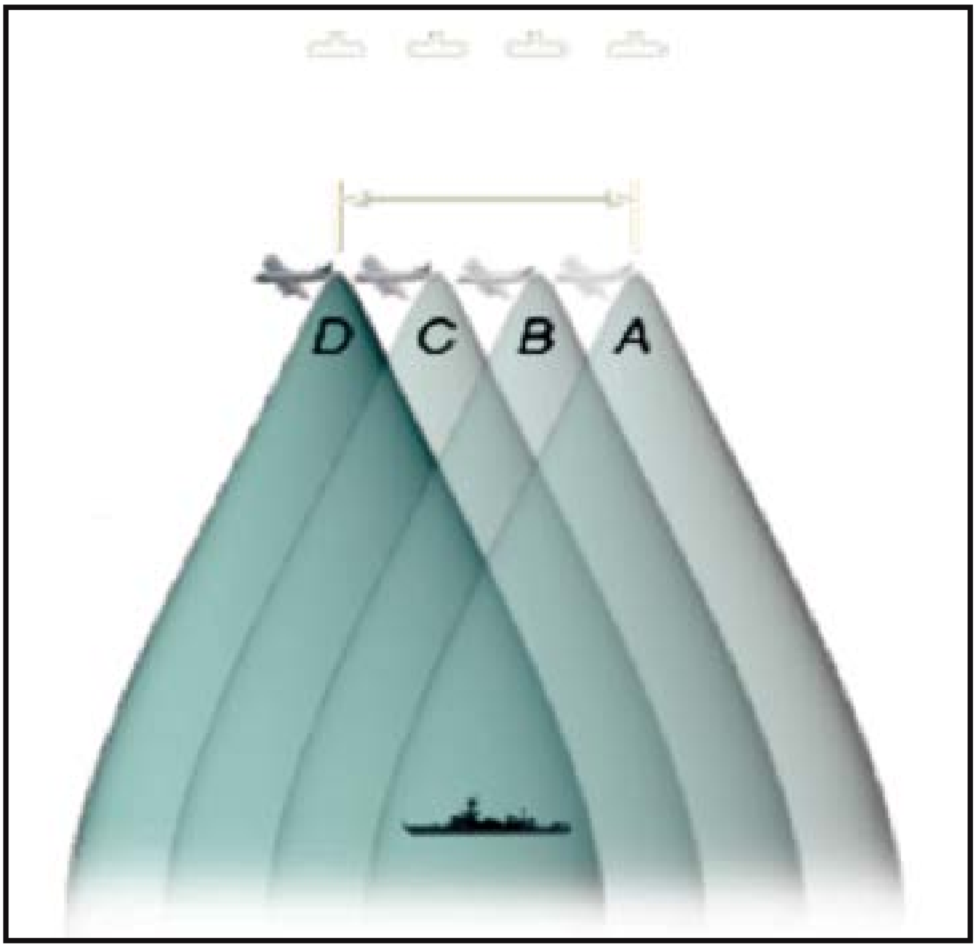
The real aperture radar (RAR) consists of radar and a scanning antenna, which is mounted on a tripod controlled by motors and gears for both horizontal and vertical movement .When the radar is fixed in any location, using differential interferometry the system can detect deformation of the strata round the clock. Once installed, it takes photographs and scans the area under observation. The resolution and range of images are dependent on size of the antenna.



Synthethic Aperture Radar (SAR)

It can either be InSAR or GBInSAR depending upon its location and operation.

Interferometric synthetic aperture radar (InSAR) is a radar technique that uses two or more synthetic aperture radar (SAR) images to generate maps of surface deformation or digital elevation, using differences in the phase of the waves returning to the satelliteor aircraft. The technique can potentially measure millimetre-scale changes in deformation over spans of days to years. It has applications for geophysical monitoring of natural hazards, for example earthquakes, volcanoes and landslides, and in structural engineering, in particular monitoring of subsidence and structural stability.



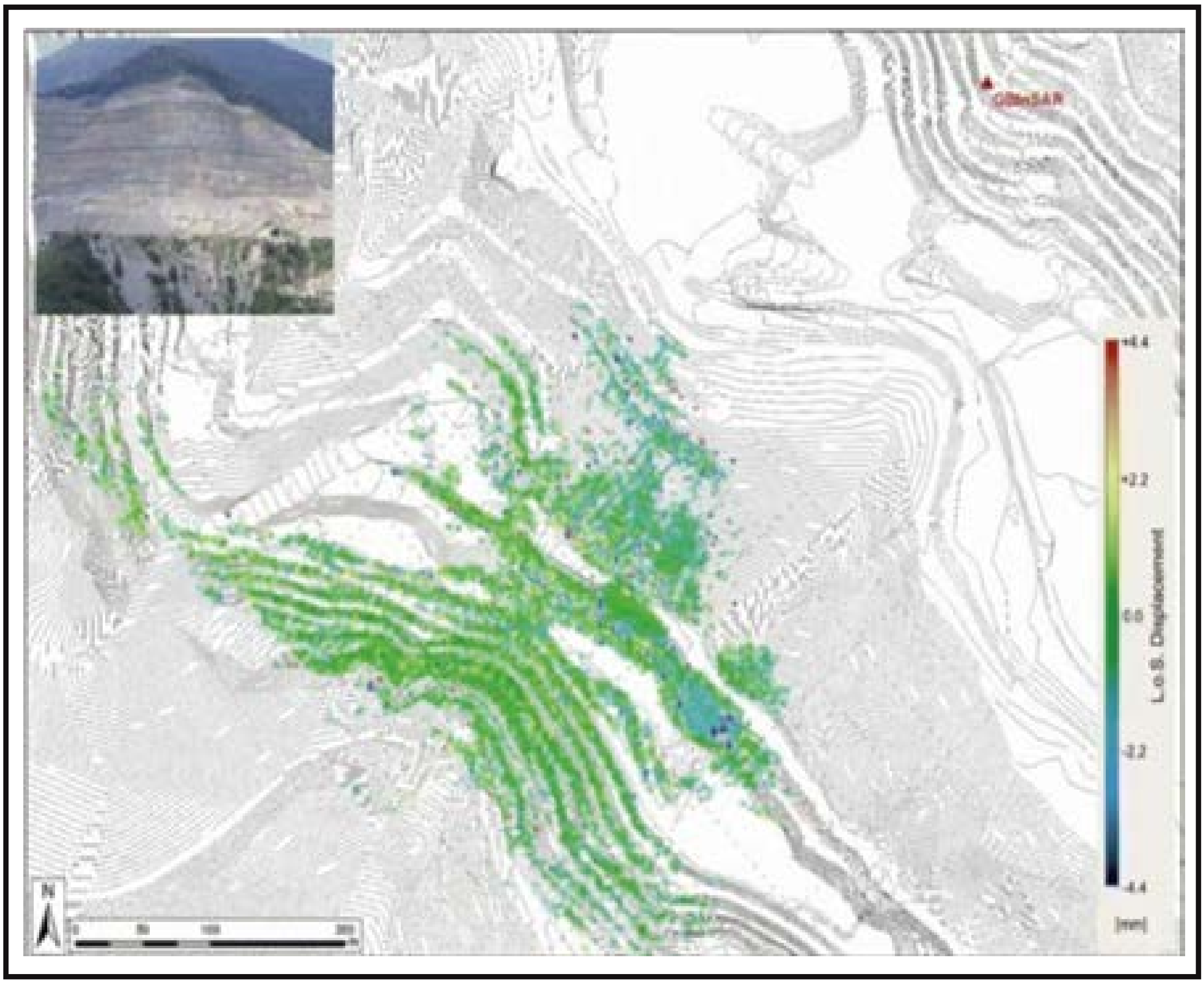
Satellite based SAR can capture data of a particular area only when it passes over that area. Therefore, depending upon the type, location of Satellite, data can be captured at a fixed interval ranging from every 8 days to 35 days and interferrograph can be prepared at such interval only. Some of the satellite and their duration cycle are tabled below :

Satellite SAR	Owned By	Duration (Days)
ERS 1 & 2	Europe	35
ENVISAT	Europe	35
RADARSAT 1 & 2	CANADA	24
COSMO SKYMED	Italy	8
TERRASAR - X	Germany	11
SENTINEL-1	US	12

Ground Based Interferometric synthetic aperture radar (GBInSAR)

Ground-based SAR Interferometry (GBInSAR) is a remote sensing technique for the displacement monitoring of slopeThis technique is based on the same operational principles of the Satellite SAR Interferometry, but the Synthetic Aperture of the Radar (SAR) is obtained by an antenna moving on a rail instead of a satellite moving around an orbit. SAR technique allows 2D radar image of the investigated scenario to be achieved, with a high range resolution (along the instrumental line of sight) and cross-range resolution (along the scan direction). Two antennas respectively emit and receive microwave signals and, by calculating the phase difference between two measurements taken in two different times, it is possible to compute the displacement of all the pixels of the SAR image. The accuracy in the displacement measurement is of the same order of magnitude as the EM wavelength and depends also on the specific local and atmospheric conditions.

GBInSAR is used internationally as a leading-edge tool for near-real-time monitoring of surface slope movements in landslides and open pit mines. The success of the technology relies mainly on its ability to measure slope movements rapidly with sub-milimetric accuracy over wide areas and in almost any weather conditions. In recent years, GBInSAR has experienced significant improvements, due to the development of more advanced radar techniques in terms of both data processing and sensor performance. These improvements have led to widespread diffusion of the technology for early warning monitoring of slopes in mining applications.



L.o.s. Displacement Map of a Quarry Rock Face in NW Italy recorded from 28 June to 7 July, 2011. The Box shows a picture of the Site.

Real Aperture RADAR (RAR) or Synthetic Aperture Radar (SAR) have got limitations that it can take images of Solid ground and the radio waves can't penetrate into sub surface area or in area covered under water. For sub surface uses specific type of RADAR is used that is called as Ground penetrating Radar (GPR).

Ground Penetrating RADAR (GPR)

GPR uses high-frequency (usually polarized) radio waves, usually in the range 10 MHz to 2.6 GHz. A GPR transmitter emits electromagnetic energy into the ground. When the energy encounters a buried object or a boundary between materials having different permittivity, it may be reflected or refracted or scattered back to the surface. A receiving antenna can then record the variations in the return signal.

Conclusion

Monitoring of active waste dumps or pit slopes are not possible. Only those old dumps or pit slopes which are more than 60 m high needed to be monitored for possible failure. The Total Station can be installed at strategic location for measurement of displacement but it is rather difficult to predict any slope failure. Therefore, the first requirement is to capture data of various dump by means of satellite based InSAR at periodic interval of 8, 12 or 24 days depending upon the Remote sensing satellite like SENTINEL, COSMO, RADARSAT. These agencies can be hired to capture and provide data in respect of all the mines of aCompany and based on the result / analysis, if there is any displacement of dump slope / pit slopes, Company can go for installation of Ground Baser InSAR (GBInSAR) for a particular mine. GBInSAR captures data on 24X 7 basis throughout the year in any weather from a point as far as 4 Km away from the actual site with a sub millimetric accuracy. Based on the data , displacement with time can be drawn and actual time of failure of any slope can be predicted on the basis of Inverse Velocity graph with respect to time.

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Nurturing Socio-Economic Development through Mining Engineering Education

— B.S. Choudhary*

Abstract

The mineral resoureces are gift of nature and cannot be grown through agricultural processes, or created artificially in a laboratory or factory. Mineral resources and its safe development are considered as an important essential components to contemporary societies and economies of a nation. Sustainable development requires integrated systems of governance. Most countries still lack the framework for turning minerals investment into sustainable development: Voluntary codes and guidelines, stakeholder processes, and other systems for promoting better practice in areas where government is unable to exercise an effective role as regulator are gaining favour as an expedient to address these problems. Lenders and other financial institutions can play a pivotal role in driving the best practice.

Significant developments in future mining systems, technology and best practices are emerging that are driven by issues relating to human resources, competitiveness, environmental and social responsibility, within the dynamics of globalization. It is proposed that the definition of the role and attributes of the mining engineer in the mine life cycle needs to be viewed more holistically in the face of increasingly more diverse and complex responsibilities. These developments are motivating the need to consider a fresh approach to mining education and training at all levels for industry.

1.0 Introduction

The world of mining has changed dramatically in the past 10 years with the economic development of India and China; record commodity prices; stability in some resource-rich countries (e.g. South East Asia); instability in others (e.g. Africa); greater recognition of the need for community engagement; and so on. Thus it is timely to analyse and attempt to describe what skill sets a mining engineer needs to thrive in this dramatically changing environment.

The industry has expressed a greater commitment to new technology and practices as part of the quest towards improved health and safety, competitiveness, sustainable development and corporate social responsibility. Mining engineers who are strongly grounded in enabling technologies and systems engineering, as well as in change management and innovation, will be key prerequisites to success in technology transfer and process transformation for the next generation mine. New mining systems technology, as well as process adaptation for best practices, in the hands of a next generation of innovative mining engineers offers the solution to addressing the new interactive issues that are emerging.

Mining engineering curricula in India generally evolved by focusing on the academic requirements associated with a mine manager's statutory certificate of competency. It is no longer adequate to just educate mining engineers in how to design and operate mines safely. There remains a necessity for a strong focus on these skills, but this potentially risks the exclusion of other knowledge and skill sets which are becoming increasingly relevant. The expectations of the capabilities of the future mining engineer, on the part of both industry and society, are shifting in response to the need to accommodate the dynamics of technology advances as well as changing real world issues and the paradigm of sustainable mining.

The mining sector worldwide is experiencing unprecedented changes in multiple spheres which largely include socio-economic conditions, modernization, demand supply pattern, high volatility of metal prices and rising exploration costs. Mining industry is one of the core indicators of Indian economy. Since independence, there has been a pronounced growth in the mineral production both in term of quantity and value. India produces as many as 87 minerals, which includes 4 fuels, 10 metallic, 47 non-metallic, 3 atomic and 23 minor minerals (including building and other materials). This sector has a huge potential with respect to mineral reserves exploration and production.

The total value of mineral production (excluding atomic minerals and also excluding value for February and March in respect of 31 minerals notified as minor minerals w.e.f. 10.02.2015) at 2, 80, 332 crore during 2014-15 increased marginally by 1% as compared to the previous year due to increase in the production of coal, lignite, lead concentrate, zinc concentrate, laterite, limestone, magnesite and ochre. The increase

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in value of mineral is also due to increase in average prices of important minerals like bauxite, sillimanite and wollastonite. Out of the total value of mineral production, the fuel minerals contributed the major share of about 1, 93,372 crore or 69%. The rest was accrued by metallic minerals `38,597 crore or about (14%), non-metallic minerals `7,323 crore or about (3%) and minor minerals 41,040 crore or about (15%) (Indian Mineral Year book, IBM, 2017).

2.0 Challenges Faced by the Minerals Sector

Viability of the Minerals Industry : The minerals industry cannot contribute to sustainable development if companies cannot survive and succeed. This requires a safe, healthy, educated, and committed work force; access to capital; a social licence to operate; the ability to attract and maintain good managerial talent; and the opportunity for a return on investment.

The Control, Use, and Management of Land : Mineral development is one of a number of industrial activities which are often characterised by competing land uses. There is frequently a lack of planning or other frameworks to balance and manage possible uses. As a result, there are often problems and disagreement around issues such as compensation, resettlement, land claims of indigenous peoples, and protected areas.

Minerals and Economic Development : Minerals have the potential to contribute to poverty alleviation and broader economic development at the national level. Countries have realized this with mixed success. For this to be achieved, appropriate frameworks for the creation and management of mineral wealth must be in place. Additional challenges include corruption and determining the balance between local and national benefits.

Local Communities and Mines : Minerals development can also bring benefits at the local level. Recent trends towards, for example, smaller work forces and outsourcing affect communities adversely. The social upheaval and inequitable distribution of benefits and costs within communities can also create social tension. Ensuring that improved health and education or economic activity will endure after mines close requires a level of planning that has too often not been achieved.

Mining, Minerals, and the Environment : Mining activities have a significant environmental impact. Managing these impacts more effectively requires dealing with unresolved issues of handling immense quantities of waste, developing ways of internalizing the costs of acid drainage, improving both impact assessment and environmental management systems, and doing effective planning for mine closure.

An Integrated Approach of Using Minerals : The use of minerals is essential for modern living. Yet current patterns of use face a growing number of challenges, ranging from concerns about efficiency and waste minimization to the risks associated with the use of certain minerals. Companies at different stages in the minerals chain can benefit from learning to work together exploring further recycling, re-use, and re-manufacture of products and developing integrated programmes of product stewardship and supply chain assurance.

Access to Information : Access to information is key to build greater trust and cooperation. The quality of information and its use, production, flow, accessibility, and credibility affect the interaction of all in the sector. Effective public participation in decision-making requires information to be publicly available in an accessible manner.

Artisanal and Small-Scale Mining : Many millions of people make their living through artisanal and small-scale mining (ASM). It often provides an important, and sometimes the only, source of income. This part of the sector is characterized by low incomes, unsafe working conditions, serious environmental impacts, exposure to hazardous materials such as mercury vapours, and conflict with larger companies and governments.

Sector Governance : Roles, Responsibilities, and Instruments for Change: Sustainable development requires new integrated systems of governance. Most countries still lack the framework for turning minerals investment into sustainable development: which need to be developed. Voluntary codes and guidelines, stakeholder processes, and other systems for promoting better practice in areas where government is unable to exercise an effective role as regulator are gaining favour as an expedient to address these problems. Lenders and other financial institutions can play a pivotal role in driving better practices.

The dominant challenges currently faced by the mining industry are increasingly related to sustainability issues: ecological as well as socio-economic matters in mining operations and neighbouring communities. However, there are no standards or models to be followed in integrating sustainability principles into mining education and research. The other engineering disciplines and Indian Professional Engineering Associations are also facing similar challenges. The socio-political environment and the obvious struggle for a social license to operate have created close to insurmountable barriers to mine development in many parts of the world. Nonetheless, the industry and educational institutions have been slow in reacting and adapting to recent trends. The academic arena must take leadership in creating the kind of professionals, services and research that will help the industry adapt. It is paramount, nonetheless, that the industry supports the academic initiatives from the very outset. Professors, researchers and students need the assistance from mining practitioners and communities in identifying research priorities, specific challenges and avenues for exchange and continuous learning (Figure 1).

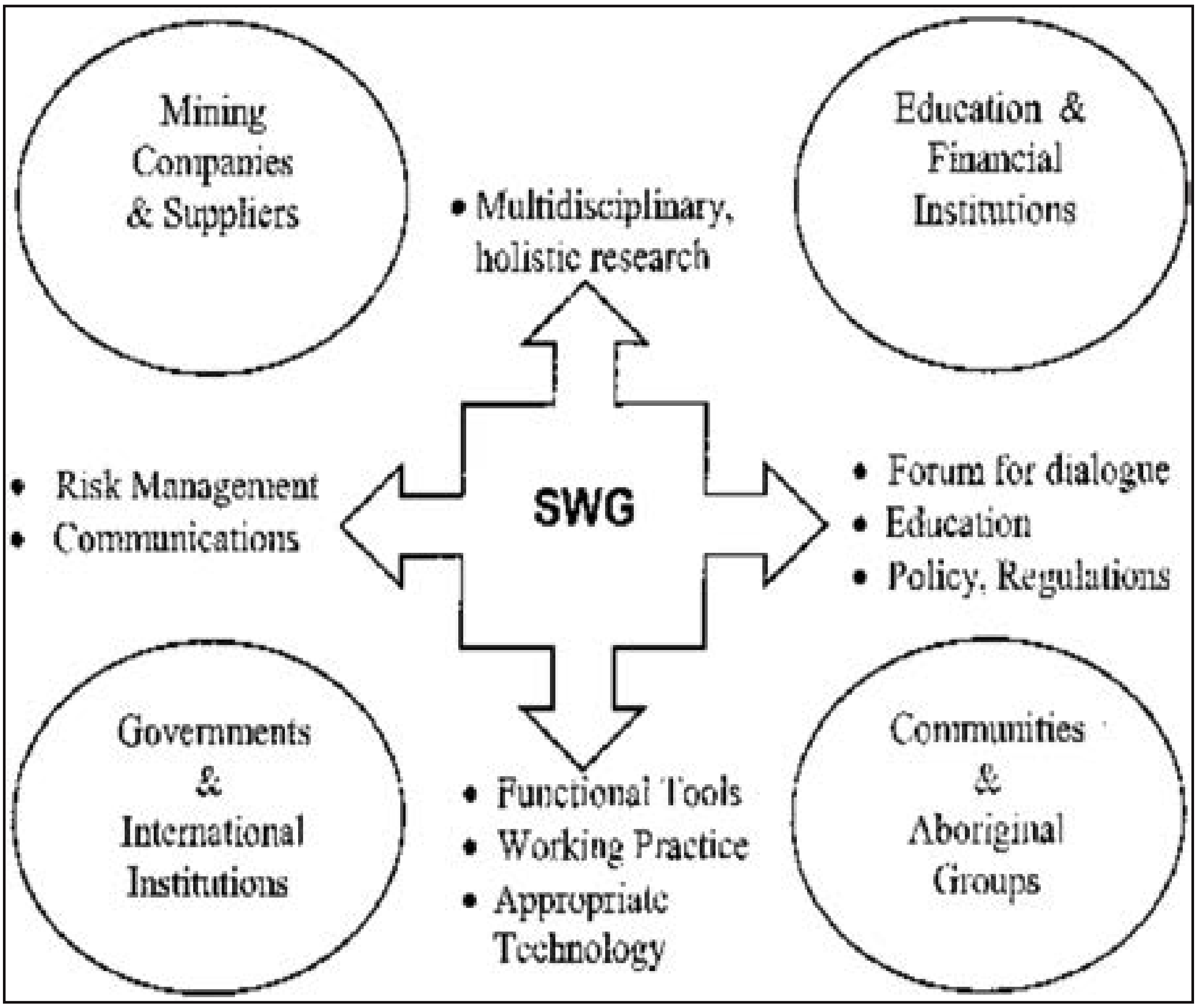

Figure 1: Sustainability Working Group: scope of educational and research activities

3.0 Sustainable Development Principles

The basic sustainable development principles discussed by various agencies can be briefly said as;

i. Economic Sphere

- Maximize human well-being.
- Ensure efficient use of all resources, natural and otherwise, by maximizing rents.
- Seek to identify and internalize environmental and social costs.
- Maintain and enhance the conditions for viable enterprise.

ii. Social Sphere

- Ensure a fair distribution of the costs and benefits of development for all those alive today.
- Respect and reinforce the fundamental rights of human beings, including civil and political liberties, cultural autonomy, social and economic freedoms, and personal security.
- Seek to sustain improvements over time; ensure that depletion of natural resources will not deprive future generations through replacement with other forms of capital.

iii. Environmental Sphere

- Promote responsible stewardship of natural resources and the environment, including remediation of past damage.
- Minimize waste and environmental damage along the whole of the supply chain.
- Exercise prudence where impacts are unknown or uncertain.
- Operate within ecological limits and protect critical natural capital.

iv. Governance Sphere

- Support representative democracy, including participatory decision-making.
- Encourage free enterprise within a system of clear and fair rules and incentives.
- Avoid excessive concentration of power through appropriate checks and balances.
- Ensure transparency through providing all stakeholders with access to relevant and accurate information.
- Ensure accountability for decisions and actions, which are based on comprehensive and reliable analysis.
- Encourage cooperation in order to build trust and shared goals and values.
- Ensure that decisions are made at the appropriate level, adhering to the principle of subsidiarity where possible.

4.0 Forthcoming Statutory Provisions

The proposed Mines and Minerals (Development and Regulation) Bill, 2011 incorporates schemes for socio-economic activities for enabling and facilitating self-employment opportunities, management and maintenance of local infrastructure for socio-economic purposes in areas affected by mining related operations {Section 56(3) b}. In addition, it incorporates sustainable development through modern technology, pollution control measures, scientific exploration and conservation. The bill also postulates the development of National sustainable Development Framework {Section 46(4)} to incorporate guidelines enabling formulation of project level practices for sustainable mining, and specifically includes systemic measures needed to increase sustainability of mining operations through minimal adverse impact on quality of life of the local communities; Protecting interest of affected persons including host population; Creating new opportunities for socio-economic development including those for sustainable livelihood; Mineral conservation both in terms of mining technologies or practices and mineral beneficiation.

This is an additional statutory challenge to the industry which can be addressed only if the human resources serving the industry are well equipped with suitable knowledge base and attitude.

5.0 Mining Engineering-A Holistic View of

A more holistic view of mining engineering, based upon a strong framework of more diverse systems for mine design and planning needs to be promoted. It is important to anchor the core systems of mining, mineral processing and geology in the context of mining engineering. The core systems traditionally bring together the interaction between the mineral resources, mining and processing systems. Other engineering and applied science contributions support the technologies and practices that account for equipment, power, water etc. Also, it is becoming increasingly important to recognize the interdependence that exists between environmental and social factors that now need to be related to traditional technical and economic factors in mine design, planning and management (Figure 3). It appears to be sensible that this more holistic framework could be rooted in a paradigm of sustainable mineral resources development. The need to account for social licence, environmental and social impact assessment, regulatory and permitting constraints, risk assessment and management in mine design and planning is becoming paramount. Also, the concept of the mine life cycle needs to be reflected in that framework, encompassing exploration, development, construction, production, rehabilitation/reclamation and closure. In this context, the mining engineer needs to become even more an integrator of diverse skill sets and best practices, and a coordinator of an increasingly interdisciplinary team. The management of projects and people based upon strong leadership and social intelligence are fundamental to success in this role.

I. Infusion of Other Disciplines into Mining Engineering

Interdisciplinary collaboration can leverage synergies between university researchers and teachers that can enhance the capacity of relatively insular and small mining schools. The last one and half decade has seen a movement in mining education and research towards more interdisciplinary collaboration to focus more diverse expertise on issues such as environmental stewardship, and sustainable development. History, however, shows us some notable contributions from outside the mining discipline, for example, in mine ventilation, explosives and blasting.

A core group of professors and postgraduate students interacted to coalesce into what came to be called the Sustainability Working Group (SWG). This grew into a group of researchers, government and industry practitioners who shared a dedication to informal collaboration in a flexible learning mode. Members originating from diverse disciplines were needed to support credibility and the required range in capacity. This model built a legacy of capacity to relate all aspects of mining engineering to sustainability.

The aim for the mining school through SWG is to develop the capacity to integrate sustainability principles widely into our teaching, in parallel with a world class program of research. The model required that we infuse students from other relevant disciplines as well as mining engineering to add the diversity to fuel the growth of the initiative. We work to develop the commitment of academics from other disciplines at ISM and other Universities to join the student supervisory teams and to fill critical gaps. In addition to high quality research, many postgraduates from these non-engineering points of origin have been very successful in gaining excellent employment opportunities in mining and consulting companies, academia and government.

II. Mining Engineering Education-Introspection and Innovation

The new enforcement has emerged as the strongest key challenge to the present Mining Engineering Education dealing mostly technical rigors while the social awareness of managers regarding the human behaviour is still untouched. Mining engineering involves design, planning and management of operations for the development, production and eventual reclamation of earth resources extraction projects. This requires a very diverse set of skills. The mining engineer has traditionally been viewed as the "Jack of all trades and master of none". Indian Mining engineers have traditionally been highly regarded for strengths in both mining and mineral processing. Our current view of mining is that these strengths must be integrated with competency in environment and social sciences. This has implications for the future modification of the mining curriculum. The curriculum should incorporate leadership role, fostering responsible mining practices and enabling technologies. The objective would facilitate innovative mining and mineral processing methods to address the technical challenges as well as key social and environmental issues encountered by the mining sector. Hence there is a requirement for deliberate holistic strategy for the integration of social, political and economic issues. This modification should be ongoing in congruence to the social and environmental needs.

Nevertheless, collaboration and cross discipline partnership is essentially called for at the current level of requirement. Although at the practical level this can be challenging, often for pragmatic reasons, such as conceptual and methodological differences between disciplines yet the traditional 'silo' effect of inadequate integration needs to be offset.

III. University-Industry Relations

This paper has addressed the skill set required of future mining engineers. It needs to be remembered that the universities and mining schools therein are where mining engineers develop those skills. Without motivated and talented academics teaching these skills they will not be transferred to the mining engineer of the future mine. The outcomes of Back from the Brink bear repeating:

"Research is not severable from issues surrounding education…. Research has a significant role in:

- Promoting higher quality undergraduate education
- Developing the international standing of universities
- Establishing academic "nurseries"
- Transferring up to date technology to undergraduates."

Furthermore, it stated that universities must reward behaviour "aimed at placing a priority on the development of teaching excellence in tertiary education."

In India, mining academics have struggled to obtain research funding from government and especially in the case of non-coal projects, from industry. Mining engineers generally are attracted to a career in academia if they can pursue their research interests. Furthermore, universities are increasingly promoting staff predominantly on the basis of research performance. Without funding, the research will not be carried out, promotions will not happen and the talented staff will either leave the profession or not be attracted to it in the first place. Industry and government need to support research capacity in the mining schools. Undoubtedly, it is sensible for a mining company to seek the best world class research capacity on campus to undertake a research task to address its R&D priorities. This capacity may well be located outside the mining school on that campus. There is a host of excellent research, however, that can be very successful in more applied areas that would be extremely supportive to a mining school. Industry has a role to play in fostering research in and around mines that generate the highly qualified people that will be the next generation of employees or academics. It also should consider investing directly in mining schools in order to ensure optimum graduate recruitment: high quality graduates that are aligned with industry needs.

IV. Modifications in Curriculum

Fusion of new subjects in the existing curriculum to cater the requirements of the industry. The subject Environmental studies, Engineering EthicsDisaster Management, Environmental Aspects of Mining Industriesshould be included in the mining engineering discipline both in undergraduate and post graduate courses. These subjects will help the students to improve the mining setting such asEnvironmental Aspects of Mining Industries subject can help the students to understand the issues like air pollution, water pollution, biodiversity, land reclamation, socio-economic, environmental impact assessment, environmental management plan, forest clearance, environmental clearance-procedure and guidelines and other related issues.

6.0 Conclusion

Mining is a very distinctive profession that will undoubtedly be transformed in the coming decades. An important task will be to reshape mining education to align with the changing needs that primarily appear to be driven by the dynamics of technological advances and sustainable development. It will also be critical to reinvigorate the human and physical resources that serve the educational process within mining schools. This is a collaborative task for academics, alumni, industry and government together. Also, there is no reason why educational collaboration cannot involve global schools to the benefit of all.

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Mine Fires

— S. K. Bhagat*

- Occur whenever and wherever combustible Materials are present in mine workings .
- To break out a Mine fire three conditions must be fulfilled.
  1. Combustible material
  2. Sufficient oxygen
  3. Open Fire
- To break out of fire due to spontaneous heating of coal two conditions must be fulfilled.
  1. Oxygen
  2. Heat

TYPES OF MINE FIRE

a. **Incipient Fires or Fire due to Sp. Combustion** — Seam fires which originate in abandon and discontinued working, goaf of seam, fractured pillar, Geological disturbance.

b. **Open Fire —** Originates in open mine working such as shaft, roadways, coal face etc.

Surface Precaution against fire

- All surface structure and support within horizontal distance of 10m from all entrance to a mine shall be of fire-proof material.
- Within 15 m of any entrance to a mine :
  - i. Shale or other carbonaceous material shall not be heaped or dumped.
  - ii. Dead leaves or dry vegetation shall not be accumulated.
  - iii. Combustible material other than materials required for use within 24 hrs shall not be stored.
  - iv. Inflammable material shall not be stored.
  - v. No persons shall light a fire or permit a fire to be lighted.

UNDERGROUND PRECAUTION AGAINST FIRE

- No timber or other combustible material shall be used for construction of, or in connection with,
- any shaft lining
- room housing,
- any machinery belowground
- Wood cuttings shall not be left belowground but shall be regularly removed to the surface.
- In 1st degree gassy seam flame or electric welding may be used if permitted by manager.
- In 2nd and 3rd degree gassy seam prior permission of RI is needed.
- All unused workings connected to surface through a walk able entrance, which is not permanently closed, shall be inspected by competent person once in every 30 days for signs of illicit distillation of liquor.
- Brattice cloth, ventilation ducting, conveyor belting and hydraulic fluids used belowground shall be of fire resistant type.

SPONTANEOUS HEATING

- Spontaneous heating of coal occurs due to **auto oxidation** of coal at ordinary atmospheric temperature.
- It is an exothermic reaction.
- The existence of a **weak leakage air current** is an important condition for spontaneous heating.
- Such condition exists in **goaf** of coal seam being worked by bord and pillar method with **caving** and in the vicinity of **geological disturb zone**.

** Chief Manager (Env.), IICM*

- However spontaneous heating may also found in stowing district if goaf if not properly stowed.
- Spontaneous heating of coal occurs due to **auto oxidation** of coal at ordinary atmospheric temperature.
- It is an exothermic reaction.
- The existence of a **weak leakage air current** is an important condition for spontaneous heating.
- Such condition exists in **goaf** of coal seam being worked by bord and pillar method with **caving** and in the vicinity of **geological disturb zone**.

Incubation period

Is the period between the on set of first oxidation and the time point when one can detect fire by the senses.

That is the period between first roof fall in a depillaring district and the appearance of first sign of heating.

It depends on

a. Seam thickness

b. Nature of immediate roof

c. Method of working

d. Method of roof control

e. Regularity and continuity of working

f. Liability of coal to spontaneous heating.

CROSSING POINT / TEMPERATURE

The temperature at which the temperature of the powder bed of coal, with oxygen and air passing through it, at pre-determined rate, crosses the temperature of the furnace or bath in which the sample is heated at a constant or an increasing temperature.

- ➢ The coal sample shall be collected by channel method
- ➢ The quantity of coal required: 3 kg
- ➢ placed under water
- ➢ Outer surface shall be scraped off before testing
- ➢ Sample prepared shall be used within 24 hrs

IGNITION POINT / TEMPERATURE

Ignition temperature is the minimum temperature at which the coal ignites without additional external source of heat on account of the exothermic reaction with oxygen.

SPONTANEOUS HEATING

Statutory Provisions

- Seams shall be worked in panel system.
- Size of panel – Extraction shall be completed within incubation period
- Each panel have independent ventilation system
- No extraction of pillar shall be commenced until Isolation stopping have been provided in all entrances to the district / panel except entrances required for the purpose of
- Ventilation
- Haulage roadway
- CO formed \ O_2 ratio shall be determined once in every 30days
- CO measured in return airways once in every 7days
-

STATUTORY PROVISION REGARDING DEALING OF FIRE

- Owner, Agent or Manager shall forthwith inform RI and send notice in form IVA within 24hrs to RI, CI, and DM or in case of fatal or serious accident, also to the Coal Mines Labour Welfare Committee.
- While dealing fire

  a. A competent person shall be present throughout on spot

  b. Adequate precaution shall be taken to prevent danger from Noxious Gases, Inflammable Gases, flame, steam, explosion of water gas, falling into potholes that may occur in the fire area.

c. There shall be kept available at or near all places belowground

i. Adequate no. of self rescuer & at least two smoke helmet.

ii. CO detector.

- FSL or approved means of CO_2 or O_2 deficiency Owner, Agent or Manager shall forthwith inform RI and send notice in form IVA within 24hrs to RI, CI, and DM

FIRE FIGHTING ORGANISATION

- **Fire station —** Fire station with suitable supply of fire fighting equipments shall be established and kept maintained at convenient points, both on surface and below ground.
- **Fire fighting Plan —** Shall show :

a. Water main taps

b. Fire station

c. Pumping station

d. Ventilation system

e. Escape routes etc

- Maintenance of Fire Extinguisher: every Fire extinguisher shall be examined by competent persons once at least in every month

REVERSAL OF VENTILATION IN CASE OF FIRE

Circumstances of Reversal of Main Fan :

- Fire is in the junction of the main intake splits
- In the down cast shafts
- Near pit bottom of down cast shaft
- After explosion.

ADDITIONAL PRECAUTIONS DURING SEALING OFF FIRE IN BELOWGROUND

- The stopping should be as far as possible from the site of the fire – To give longer time lag before the fire damp rises to explosive proportion
- Air sample should be taken at short interval.
- Every change in ventilation, specially throttling, should be done with care.
- Temporary stopping should be erected on the intake and the return airways.
- Before construction of stopping is commenced, an adequate stone dust barrier should be erected in the part of the roadway between the sheet of the fire and that of proposed stopping and this part should be thickly stone dusted.

DANGER FROM SEALED OFF AREA

There are two types of dangers from sealed off area

- Chances of CO poisoning.
- Chances of fire damp explosion.

Remedial measures

- Pressure balancing - Equalising pressure between inside and outside of fire stopping is called pressure balancing.
- Stoppage of leakage of air.

RE-OPENING OF SEALED OFF AREA

Factors considered

➢ Grahams Ratio should either indicate the value normal to the seam or nil

➢ Temperature in the area and of the surrounding strata shall come down to the relevant Geo thermal gradient

➢ Value of oxygen % come down to about 2% or below

➢ Rate of consumption of oxygen goes down to 0.007% per day or below

DANGERS APPREHENDED

- Fire may revive on re-admission of air
- Noxious gases may be in more %

- Chances of fire damp explosion
- Chances of roof fall

STATUTORY OBLIGATION & PRECAUTION TAKEN

- 14 days prior notice to DGMS
- Smoking and fire around down cast shaft shall be strictly prohibited
- Height of-fan evasee shall be increased
- Stone dust shall be stored in sufficient quantity
- Sand Bags shall be stored in sufficient quantity
- Establishment of Fresh Air Base.
- Sample analysis arrangement shall be established at the surface.
- Arrangement of Rescue team

STATUTORY REQUIREMENT REGARDING DETECTION OF SPONTANEOUS HEATING & FIRE

- Inspection of Top of all entrances to mine, all OC workings & any ground broken by extraction of coal by competent person, once in 7days, for presence of fire.
- Inspection of all unused workings connected to surface through a walk able entrance, which is not permanently closed, by competent person once in 30 days for signs of illicit distillation of liquor.
- Inspection for detection of CO % in return airway of every depillaring district and of every goaf not isolated, by a competent person once in every 7 days. (For early detection of spontaneous heating).
- The air in the return airway of every depillaring district and of every goaf not isolated shall be analysed by competent person once in every 30 days for determination of CO formed / O_2 absorbed ratio. (For early detection of spontaneous heating).
- Inspection of all depillaring district by competent person on every Idle day

- Inspection of Top of all entrances to mine, all OC workings & any ground broken by extraction of coal by competent person, once in 7days, for presence of fire.
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- Inspection of all depillaring district by competent person on every Idle day .

- Inspection of all unused working, not sealed off, Isolation Stopping built around goaf out area and unused working, by competent person, once in every 7 days.
- The atmospheric condition behind Isolation stopping (Fire Stopping)(except explosion proof stopping) shall be ascertained by a competent person once in every 30 days in case of deg II & III gassy seam or fiery seam.
- Ascertain of temperature & humidity of the atmosphere outside the Fire Stopping and check it for leakage of fire and gas by a competent person once in every 7 days.

Fire extinguisher

a. **Soda acid type fire extinguisher :** not used for oil, electrical fires or flammable liquids

b. **Foam extinguisher :** Used for fighting fires involving combustible and flammable liquids but not recommended in electrical fires

c. **Dry chemical extinguisher :** used for flammable liquid fires , fires on diesel mining vehicles, Fires in electrical equipments

PRECAUTION WHEN A FIRE EXIST

- No person shall be deployed in any seam except with the permission of the CIM:

  a. Where a fire or spontaneous heating exist in an upper seam.

  b. Where the seam has a common ventilation with another seam on fire or spontaneous heating.

  c. Where the opening of the seam is within 60 m of any active fire on the surface or an overlying seam on fire.

  d. When the upper seam is on fire and the parting between upper and lower seam < 10 m of hard rock

  e. When there is fire on the surface which cannot be controlled immediately and the cover < 10 m of hard rock.

GRAHM'S RATIO

- Co formed / O_2 absorbed
- Normal value 0.5 to1%
- 1% - Development of heating
- 2% - serious heating
- 3% - Active Firemined

As per Reg GR measured in 30days

PILLAR FIRE

Causes

- Pressure difference of air between intake & Return airway on either side of pillar.
- Coal susceptible of heating.
- Geological disturbances.
- Undersize Pillars.
- Pressure drop across regulator
- Pressure drop between goaf and other workings.

Suggestion

In coal seam abound in natural prominent cleavage plane or geological disturbances Intake and return roadway shall be as far away (say at least 2 pillar length) from each other as practicable.

If not possible due to operational difficulty the pillar between intake and return roadway shall be of larger dimension than provided in the statute.

Precaution

- Keeping greater size of pillar
- Having 2 intake airways to reduce the pressure difference.
- Introducing boundary system of ventilation instead of central system of ventilation
- Preventing spalling and rubbing of pillar
- Keep sufficient water under pressure
- Intake & return roadway should be far away from each other(at least two pillar length)

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ISOLATION STOPPING

GASSINESS	Caving
1ST & 2ND degree If % of IG behind sealed off area is more than 2% then IS converted into explosion proof stopping	1M
3RD	Explosion proof 2 stopping each 1 m thick and 4.5 m apart with intervening space packed solid with incombustible material)

DEPTH OF LOCKING OF ISOLATION STOPPING

	Brick	RCC
Coal	1 m	0.5 m
Shale roof/floor	30 cm	30 cm
Sandstone roof/floor	15 cm	15 cm

ILLUMINATION STANDARD IN OPENCAST MINES

(DGMS Circular No. 06 of 2016)

Serial No.	Places to be illuminated	Minimum standards of illumination to be provided (in lux)
1	Work place of Heavy Machinery	15 H, 25 V (so as to cover depth and height through which the machine operates.)
2	Drilling operations	
	(i) Area where drilling rig works	25 V (so as to illuminate full height of the drilling rig)
	(ii) Area where drill,holes exists	15 H
3	Places where manual work is done	15 H, 25 V
4	Places where loading, unloading or transfer, loading of dumpers, trucks or train is carried on (including OB Dump and Coal Stack Yard)	15 H, 15 V
5	Operators cabins of machines or mechanisms	50 H at all places of operation
6	Haul roads for Trucks and Dumpers	10 H
7	Rail haulage track in the pit	10 H
8	Roadways and foot paths from bench to bench	10 H
9	Permanent paths for use of persons employed etc.	10 H
10	In-pit Crusher/Feeder Breaker	40 H
11	Hand Picking Points	50 H
12	Conveyers	
	(a) Transfer points and drive/tail end area	40 H
	(b) Along conveyor	20H
13	Coal Handing Plant	
	(a) Places of crushing, screening, segregation and loading/ unloading	40H
	(b) Operation points	50H
	(c) Other places (in general)	20H
14	Pumping Station	
15	(i) Electrical Sub-station	100 H, 50 V
	(ii) Other places of operation of electrical apparatus / equipment	20 H, 20 V
16	First Aid station	50 H
17	Rest shelter	30 H
18	Workshop	100 H, 50 V
19	Parking Yard	50 H
20	General working areas as determined by the Manager in writing	10 H at the level of surface to be illuminated

ILLUMINATION STANDARD IN UNDERGROUND MINES

(DGMS Circular No. 06 of 2016)

Serial No.	Places to be illuminated	Minimum standards of illumination to be provided (in lux)
1	At every shaft landing and shaft bottom or siding which is in regular	50H
2	Travelling roadway and Haulage road way, including Man-riding roadway and every incline in use 10 H, 10 V	10H,10V
3	Haulage Roadway (junctions) at which tubs are coupled or uncoupled	30H
4	At every places of loading and unloading	30H,20V
5	At every room and place containing any engine, motor or other apparatus in regular use	30H
6	Any working face and Goaf Edges of depillaring panels	20H,30V
7	Ladder way/Man way	15H
8	Pumping Station	30H
9	Area under filling /stowing	10H
10	Conveyors (i) Transfer points and drive/tail end area	40H
	(ii) Along conveyor	20H
11	Hand picking points	50H
12	Loco charging station	50H
13	Underground Garage/workshop	50H
14	(i) Electrical substation 100 H, 50V	100H,50V
	(ii) Other places of operation of electrical apparatus/ equipment	20H,20V
15	At every First -aid station	50H
16	Miners station/ Rest shelter	25H
17	Coal Handing Plant (i) Places of crushing, screening, segregation and loading/ unloading	40H
	(ii) Operation points	50H
	(iii) Other places (in general)	100H,50V
18	workshop at surface	10H
19	General working areas as determined by the Manager in writing	At the level of surface to be illuminated

Multiple Choice Questions (Dust)

— Bijay Kishore*

1. Dustiness in a mine

a. Increases illumination b. reduces efficiency

c. increases productivity d. none of the above.

2. Principal of dust monitoring instrument is

a. Sedimentation of dust b. Filtration of dust

c. coagulation of dust d. all of the above.

3. Two instruments which are used for dust survey are

a. MRE-NCB-113A-GDS b. CIP-10

c. NCE-5 d. a & b e. None of thease

4. Dust concentration can be reduce by

a. Prevention of generation b. Suppression of dust

c. Removal of dust d. all of the above.

5. Concentration of dust at any working place shall not be more than

a. 3 mg b. 4 mg c. 5 mg d. 6 mg

6. Dust respirator shall be thoroughly examine and tested at least once in every

a. month b. 2 months c. 3 months d. 6 months.

7. If concentration of dust is more than 75% of permissible limit then dust survey shall be carried out once at least in

a. 1 month b. 2 months c. 3 months d. 6 months

8 Dust plan shall be prepared on a scale

a. 1:1200 b. 1:2000 c. 1:2400 d. 1:600

9. If volatile matter of coal in a seam is <30 % then the incombustible dust in the mixture containing incombustible matter shall not be less than

a. 75% b. 80% c. 90% d. 70%

10. Heap of cement ,sand shall not be placed in the top of the down cast shaft within in a distance of

a. 50 m. b. 60 m. c. 70 m. d. 80 m.

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* *B.Tech (Mining Engg.), IIT (BHU), Sr. Faculty (IICM)*

11. Size of respairable dust is

a. 15 micron or less b. .20micron or less

c. 7 micron or less d. 3 micron or less

12. Sample of the zone treated with incombustible dust collected by

a. Strip sampling b. spot sampling

c. a& b both d. none of the above.

13. Sample of the zone treated with water is collected by

a. Strip sampling b. spot sampling

c. a & b both d. none of the above.

14. sample of dust collected shall be analysed within

a. 7 days b. 14 days c. 15 days d. 30 days

15. Minimum Qualification of dust in-charge shall be

a. Over man b. Mining Sirdar c. Under manager d. none of the above

16. % of Silica in incombustible dust shall not be more than

a. 5 b. 10 c. 3 d. 4

17. Dust in-charge can act as a sampling in-charge with average production of the mine is less than

a. 10,000 t b. 15,000t c. 5000 d. none of the above

18. Test of incombustible dust shall be carried out at least once in

a. 1 month b. 6 months c. 3 months d. 15 days

19. Every working face and floor and sides of every roadway shall be completely washed within a distance of

a. 60m b. 80 m c. 90m d. 100m

20. Representative dust shall not be collected after what duration of cleaning and treating of zone

a. 24 hrs. b. 48 hrs. c. 72 hrs. d. 8 hrs.

(Answer in next issue)

Multiple Choice Questions (Fire)

— Bijay Kishore*

1. **Spontaneous heating of coal is a process of**

   a. Slow oxidation b. fast oxidation

   c. formation of methane d. formation of O_2

2. **All Surface structure and support shall be of fire proof material if it is within following horizontal distance from all entrance to a mine**

   a. 20 m b. 15 m c. 10 m d. 5 m

3. **For the presence of fire, all open cast working and top of all entrance to a mine, shall be inspected by a competent person once at least in every .**

   a. 30 days b. 14 days c. 3 months d. 7days

4. **In degree 2 & 3 gassy mines flame or electric welding is done with prior permission of**

   a. Manager b. Regional Inspector

   c. Owner d. Chief Inspector of Mines

5. **For signs of illicit distillation of liquor all unused workings connected to surface through a walk able entrance which is not permanently closed shall be inspected by competent person at least in every**

   a. 15 days b. 7 days c. 30 days d. none of these

6. **Generally minimum period of incubation period is**

   a. 2 months b. 1 month c. 3 months d. 18 months

7. **Fire dam or an Isolation stopping shall be built in every entrances of a district / panel prior to the commencement of**

   a. Development b. Depillaring c. Both a & b d. none of these

8. **All unused workings which has not been sealed off shall be inspected by competent persons for fire risk once at least in every**

   a. 30 days b. 15 days c. 14 days d. 7 days

9. **Ideal day inspection shall be carried out by competent persons for**

   a. Development district b. Depillaring district

   c. Both in Development & Depillaring Districts d. None of these.

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10. Disused workings means working

a. examine by competent persons
b. Not examine by competent persons
c. Both a & b
d. none of these

11. For fighting electrical fire which type of fire extinguisher shall be used

a. Soda acid
b. Dry powder
c. Foam type
d. Both a and b

12. fire extinguisher shall be examined by competent persons once in every

a. 6 months
b. 3 months
c. 15 days
d. 1 month

13. Which of the followings is shown in the fire fighting Plan

a. Ventilation system
b. Pumping station
c. Water mains taps
d. all of these

14. In degree 2 & 3 gassy mine atmospheric condition behind sealed of area of old working or goaf shall ascertain once in every

a. 30 days
b. 15 days
c. 14 days
d. none of these

15. Fire stopping shall be inspected by competent persons once at least in every

a. 14 days
b. 30 days
c. 3 months
d. 7 days

16. Isolation stopping shall be inspected by competent persons once at least in every

a. 14 days
b. 30 days
c. 3 months
d. 7 days

17. Purpose of water seal is to

a. Drain water
b. Drain air or gas
c. Drain water without permitting any leakage of air or gas
d. None of these.

18. Ghrams ratio means

a. CO_2 formed/ O_2 absorbed
b. CO formed / O_2 absorbed
c. CO absorbed / O_2 formed
d. CO absorbed / CO_2 formed

19. During re-opening of sealed off area that has been sealed off due to fire there is a danger of

a. Chances of explosion in underground
b. Chances of explosion on the return pit
c. Chances of explosion in fan drift
d. All of them.

20. Dealing with pillar fire is best possible by

a. Heavy water spraying
b. stone dusting
c. short creating
d. None of the above

21. One of the main causes of pillar fire is

a. Geological disturbance inside the pillar only

b. Geological disturbance and inadequate ventilation

c. Crack inside the pillar and high pressure difference in between intake and return

d. Geological disturbance in the pillar, high quantity of air flow and high pressure difference

22. During re-opening of a sealed off area the process is done by:

a. Thinning and breaching of fire stopping, one in the intake side and the other in the return side

b. Direct breaching of one stopping

c. Direct breaching of two stoppings

d. none of thease

23. After breaching of two fire stoppings in the sealed off area following activities can be taken up:

a. Allow the person to enter the mine after breaching

b. Allow the person to enter the mine after 2 days

c. Allow the person to enter the mine after 3 days

d. none of the above

24. Inflammable materials shall not be stored within which distance from any entrance to a mine which is not effectively sealed off from the workings bellow ground

a. 5 m   b. 10 m   c. 15 m   d. 20 m

CMTM

COAL MINING TECHNOLOGY & MANAGEMENT

Vol. 21, No. 1 – June 2018

Special issue

for

First Class

Legislation Examination

Published by :

INDIAN INSTITUTE OF COAL MANAGEMENT
Kanke, Ranchi - 834006
Ph : 0651–2451030 – 33, 7112001 Fax : 0651–2451022
Visit us at : http://www.iicm.ac.in
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Published by

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Kanke, Ranchi-834006

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