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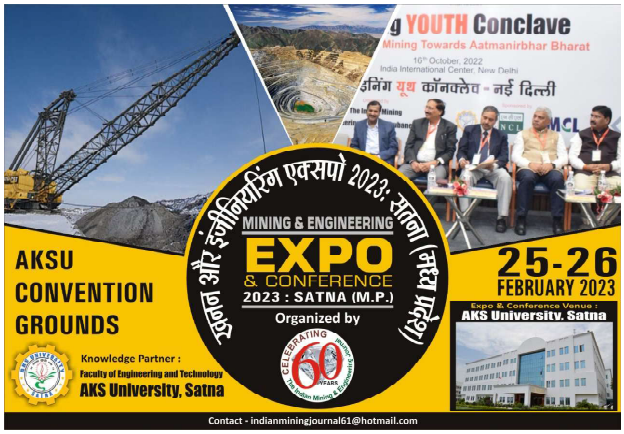

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Persons in the News

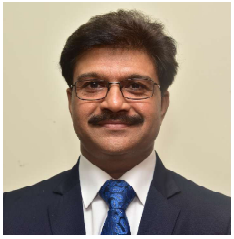
Shri Satya Narain Kapri presently General Manager, South Eastern Coalfields Ltd. (SECL), has been appointed to the post od Director (Technical), South Eastern Coalfields Ltd. Shri Kapri is a Btech (Mining) Graduate from ISM Dhanbad in the year of 1987 and joined SECL in August 87 at Hasdeo Area. He worked as Jet (Mining), Asst Manager, Colliery Manager, Sub-Area Manager, General Manager (opr), and Area General Manager and General Manager (Production) at Hasdeo Area, Baikunthpur Area, Bhatgaon Area, Johilla Area, and SECl HQ respectively. Apart from this he also worked at ECL as an agent at Kenda sodepur Area and AM (PC&D)at Rajmahal Area.

Shri Nilendu Kumar Singh presently General Manager, South Eastern Coalfields Limited (SECL), has been appointed as Director (Technical), Eastern Coalfields Limited. Shri Singh a graduate in Technology (Mining) in the year 1989 from Indian Institute of Technology (Indian School of Mines), Dhanbad. Thereafter he obtained a First Class Mines Manager Certificate of Competency in the year 1994. He started his career in Coal India Limited in the year 1989 from Central Coalfields Limited and has a long and varied experience of over 33 years having worked in various subsidiaries of Coal India Limited. He was working in CCL for 22 years, during which he was posted in Piparwar, Ashoka, Urimari and Kalyani projects of CCL. Prior to joining ECL, He was working at South Eastern Coalfields Limited, where he worked as Mines Manager to Regional General Manager in SECL's Gevra, Deepika, Korba and Raigad regions.He has vast experience in operating modern mining techniques. He also visited Australia in the year 1997 to gain experience in advanced mining techniques. Apart from his official work, he also has a special interest in sports and painting. He has represented at the All India University level in Volleyball. He is a lover of nature and a man of noble values. He relates to people and his leadership qualities inspire his subordinates to work with confidence and enthusiasm.

Shri Shivam Srivastava presently Chief General Manager, NTPC Limited, has been selected for the post of Director (Fuel), NTPC Limited. As Director (Fuel) of NTPC, Srivastava will be responsible for ensuring fuel availability, affordability, and security for generating stations. He will be responsible for the development and operation of captive coal mines including associated field activities, other technical functions related to mines and the safety of mines. Further, he will also be responsible for fuel supply agreements with gas suppliers and coal suppliers including Coal India Ltd. and Subsidiaries, SCCL and others and ensuring timely and quality coal supply at power stations as per power generation requirements and maintaining adequate stock level.

Shri Vishwanath Suresh presently Executive Director, Steel Authority of India Ltd (SAIL), has been selected for the post of Director (Commercial), NMDC Limited. Shri Suresh is an MBA (Marketing) from the National Institute of Technology (NIT), Rourkela. He has been associated with SAIL for more than three decades.

Ajit Kumar Saxena has been appointed as the Chairman-cum-Managing Director of MOIL. Saxena will assume the charge of the post till the date of his superannuation i.e. 31st of December 2025 or until further orders, whichever is earlier. Saxena has 36 years of experience in steel sector with wide experience in technical, operational and project management areas. Prior to this assignment, Shri Saxena held the position of Director (Operations) at RINL-Vishakhapatnam Steel Plant. He started his career as a management trainee (Technical) in Steel Authority of India Ltd (SAIL) in 1986 and thereafter, held various positions during his long tenure in SAIL such as Chief General Manager, Mills, IISCO, Burnpur and General Manager, Bhilai Steel Plant, etc. Shri Saxena holds B.Tech degree from Institute of Technology, Banaras Hindu University in Metallurgy and has also acquired an MBA. MOIL is one of the largest manganese ore producers of the country. The company's consolidated net profit declined 7.4% to Rs. 51.38 crore despite of 4.5% rise in net sales to Rs. 267.70 crore in Q2 FY23 over Q2 FY22.



Shri Amit Garg has been appointed as Director (Marketing) of Hindustan Petroleum Corporation Limited (HPCL) effective December 27, 2022. Prior to joining HPCL as Director (Marketing), Shri Garg was Executive Director (Aviation) in Bharat Petroleum Corporation Limited (BPCL). Shri Garg is a Post Graduate in Electronics & Management. Shri Garg is a senior leader in Oil & Gas space having rich and varied experience of over 35 years across the entire value chain in the Industry including sourcing, storage, logistics and sales across various functions in BPCL. He also served as a full time Director with Indraprastha Gas Ltd. the largest CGD in the country and as a Nominee Director with Maharashtra Natural Gas Limited, a Joint Venture of BPCL & GAIL (India) Limited.

Shri G Krishnakumar presently Executive Director (Other Units), Bharat Petroleum Corporation Ltd, has been selected for the post of Chairman & Managing Director (CMD), Bharat Petroleum Corporation Ltd. Shri Krishnakumar an Electrical and Electronics Engineering Graduate from the National Institute of Technology, Tiruchirapalli and a post-graduate in finance management from the Jamnalal Bajaj Institute of Management Studies, Krishnakumar joined BPCL as a management trainee in April 1987. Shri Krishnakumar was a Senior Manager (Loyalty Programmes), Deputy General Manager (Learning and Development), Chief General Manager (Marketing), Lubricants, Chief General Manager, HRD, Executive Director, HRD and Executive Director, Lubricants.

Shri Rajiv Gupta presently Executive Director (ED), Engineers India Limited (EIL), has been appointed to the post of Director (Projects), EIL.

Shri Jitendra Malik presently General Manager, Bharat Coking Coal Ltd. (BCCL), has been appointed as Director (Technical), Northern Coalfields Ltd. (NCL) for a period with effect from the date of his assumption of charge of the post till the date of his superannuation i.e. 31.05.2025.

Indian Mining Industry News

COAL NEWS

COAL INDIA TO MEET 700 MT PRODUCTION TARGET OF FY23, SAYS CHAIRMAN

Coal India Chairman Pramod Agrawal exuded confidence that the PSU will achieve the production target of 700 million tonnes for the current financial year. Coal India (CIL) accounts for over 80 per cent of the domestic coal output. "I am confident Coal India will achieve the 700 million tonne coal production target this financial year," the chairman was quoted as saying in a statement. Addressing virtually a team of CIL-arm MCL, Agrawal congratulated company officials for registering a growth of 15.9 per cent over the targeted production of coal, which is almost 19 million tonne. Stating that the demand for power will increase in coming days, Agrawal said, “There will be increased demand for coal from Coal India, and MCL, which is successfully supplying about 435000 tonne of coal daily to the power sector, will have to increase its contribution.”

QUALITY OF DOMESTIC COAL INCREASED CONSIDERABLY: GOVERNMENT

The government said the quality of domestic coal has increased considerably as the grade conformity of fossil fuel has improved to 69 per cent in the current fiscal. The government and the coal companies, including Coal India, have taken several steps to achieve the objective of supplying quality coal to all consumers. In a statement, the coal ministry said, "The grade conformity (of coal) has jumped to 69 per cent in 2022-23 (till November 2022) as against 51 per cent in 2017-18." These companies have taken steps like periodic re-gradation of coal mines, introduction of improved mining technology and installation of auto analyzers, among others to improve the quality of Indian coal. An app called "UTTAM" -- Unlocking Transparency by Third Party Assessment of Mined Coal -- was also introduced in 2018 for coal quality monitoring. It has been helping consumers to view the third-party validation of coal supply. Many consumers are taking advantage of this app in planning their coal usage, the statement added.

COAL MINISTRY IDENTIFIES 4 COKING COAL BLOCKS FOR AUCTION TO PRIVATE SECTOR

The Coal Ministry has identified four coking coal mines to be offered in subsequent rounds of auction for the private sector to further increase domestic raw coking coal supply, an official release said. The Central Mine Planning and Design Institute (CMPDI) also will finalise Geological Report (GR) for four to six new coking coal blocks in the coming months, he ministry said in a release. "In order to further step up coking coal production, the Ministry of Coal has identified four coking coal blocks and the Central Mine Planning and Design Institute (CMPDI) also will finalize Geological Report (GR) for 4 to 6 new coking coal blocks in the coming months," it stated. These blocks may be offered in subsequent rounds of auction for private sector to further increase domestic raw coking coal supply.

Coking coal is a key input in steel making and the country remains dependent on imports to meet 85 per cent of its coking coal needs. With these measures, domestic raw coking coal output may touch 140 million tonnes (MT) by 2030, the ministry said. Coal India Ltd (CIL) has planned to increase raw coking coal output up to 26 MT from existing mines and identified nine new mines with peak rate capacity (PRC) of about 22 MT by FY'25. Also, CIL has offered eight discontinued coking coal mines, out of the total 30, on an innovative model of revenue sharing to the private sector with a PRC of two MT. CIL accounts for over 80 per cent of domestic coal output.

COAL CONSUMERS BODY SEEKS RESUMPTION OF RAKE-BASED SUPPLIES TO NON-POWER SECTOR

The Coal Consumers Association of India (CCAI) has made a plea to the government to resume rake-based supplies to the non-power sector in a bid to maintain cost competitiveness and sustain operations. Despite Coal India's production and despatches improving considerably this year, the supply of dry fuel to the non-power sector continues to languish below optimal levels amidst spiralling costs. This situation has led to the non-power sector relying on road-based supplies, in turn leading to soaring costs for its constituent industries. Converting rail quantities to road offtake often attracts higher premiums than those already paid to Coal India Ltd (CIL) for rake-based supplies, CCAI said.

"Converting rail quantity to road offtake may often lead to a higher premium for coal which may be more than the premium paid to CIL for supply via rail mode. This is invariably adding the additional burden of cost on the NRS (non-regulated sector) consumers on top of the higher transportation cost of coal via road," CCAI said in a letter

this month to the Coal ministry. As CIL's production and overall despatch have growth exponentially and are on an upward trend while the country's peak demand has comparatively reduced in recent weeks due to the fall in temperature, the government's intervention is requested so that the number of rake supplied to the NRS consumers may be increased at the earliest possible, the letter said.

"Also in mode agnostic single window auction, the price of coal is going to be the same for both rail mode and road mode. Linkage auction is also a type of e-auction of coal and CIL subsidiaries are supplying a much less number of rakes than the allotted quantity by rail to NRS. Considering the plight of industries and their CPP units, in line with the modalities of mode-agnostic single-window auction, rail-to-road conversion may be considered without change in premium so that the consumers do not have to bear the additional expenditure without any fault on their part," it said.

MINING NEWS

MORE INITIATIVES ON ANVIL TO BOOST STEEL SECTOR IN 2023

With increasing steel production in the country, the focus in 2023 will be on boosting raw material supplies and producing more special grade steel, according to Union minister Faggan Singh Kulaste.India produced 113.43 million tonne of crude steel in January-November 2022, which is 10 per cent higher compared to the year-ago period. The government aims to double the country's annual crude steel making capacity to 300 MT from 150 MT at present. In an interview to PTI, Kulaste, the Minister of State for Steel, said more initiatives for the sector will be taken in 2023. Last year, the government introduced the Production Linked Incentive (PLI) scheme for specialty steel to enhance the production of the high-end alloy.Special grade steel is used in various sectors, including power, shipping, railways and auto. The demand for this steel is being met through imports."Our focus will also be on taking measures to support industry besides finding new markets as the production of steel continues to grow in the country," he said.

Ensuring the raw material security for steel production will be a key focus area for the government as the country is mostly dependent on import of raw materials like coking coal. While other minerals are available in sufficient amounts, Kulaste said India is dependent on imports for coking coal. The country imported 57 MT of coking coal in FY22 to produce 120 MT crude steel. New reserves of coking coal are being identified. The country has around 34 billion tonne of coking coal, of which about 18 billion tonne have already been proven, the minister said."The development of technology for mining and washing can make the country self-reliant besides ushering in huge employment opportunities and accelerating the process of development of urban, semi-urban and rural areas," Kulaste said.

In 2022, the government took various measures to support the steel industry by removing the export duty on steel items and extending export benefits under the Remission of Duties and Taxes on Exported Products (RoDTEP) scheme to products of iron and steel for a specified period. These measures will help the domestic steel industry increase its share in the global markets, Kulaste said. Indian Steel Association (ISA) Secretary General Alok Sahay said exports of steel, which fell around 55 per cent in April-October 2022 compared to the year-ago period, is expected to resume at a slower pace initially. "Imposition of export duty on the steel sector led to a number of consequences for the sector and the country... India lost out on the opportunity to sell surplus quantities and thus the country faced adverse balance of trade," Sahay said. While there is duty relief, surge in imports at predatory prices is a challenge, he noted.

He also said rising imports have become a concern for the domestic steel industry. In April-October 2022, the finished steel imports stood at 3.151 MT, up 14.5 per cent over the same period last year. The y-o-y increase in October was around 78 per cent. "In the prevailing global slowdown, India has become a dumping destination for various global exporters viz. dumping action is visible for HR coils for Japan and Brazil. Countries like Japan and even Vietnam are keen to export HR coils USD 575-580/ per tonne," Sahay said. Tata Steel's CEO and MD T V Narendran termed 2022 "a tumultuous year for the steel industry".

Globally, the industry started well on the back of a strong post-Covid recovery and the infrastructure investments that many governments across the world had announced to support this recovery. However, the conflict in Ukraine made worse the inflationary pressures being felt due to supply chain bottlenecks in the post Covid world. Gas prices shot up as did coal prices which led to steel prices shooting up, he noted. "Amid all this, India continues to stand out for its economic recovery and infrastructure investment-led growth. This makes us optimistic about the future despite a challenging year. We expect 2023 to be a better year than 2022 for the steel industry globally," Narendran said. Sesahgiri Rao, Joint MD and Group CFO of JSW Steel, said the year saw elevated volatility in both raw material and steel prices with a steep decline in global demand. In 2023, steel demand is expected to grow 8 per

cent, Bimlendra Jha, Managing Director of Jindal Steel and Power Ltd (JSPL), said.

SAIL said the domestic steel consumption has huge potential for growth. The recent removal of export duties also augurs well for the domestic steel industry to play aggressively in the global market, Steel Authority of India Limited (SAIL) said in a statement.This year has been largely a year of mixed sentiments and performances for the domestic steel industry. The impact of the Russia-Ukraine war was felt across the global steel industry. On one hand, the global steel prices fell which pulled down domestic prices also and on the other hand, there was a steep price rise of input materials especially, coking coal. Dilip Oommen, CEO of AM/NS India, said the "knock-on effects of these constraints have been felt in the second half of the year as many companies are under pressure with squeezed margins. In October, India became a net importer from being a net exporter earlier." Atul Bhatt, CMD of RINL, said significant progress has been made towards the targets as envisioned in the National Steel Policy 2017. Steel companies are planning to enhance their capacities to meet the increased demand. While CPSEs are planning to add around 18 MT, private companies are likely to add around 95 MT and SSI (Secondary Steel Industry) around 33 MT capacity by 2030, he said.

SAT SETS ASIDE SEBI'S ORDER TO IMPOSE PENALTY ON BHUSHAN STEEL FOR DISCLOSURE LAPSES

The Securities Appellate Tribunal (SAT) has set aside a Sebi's order to impose a Rs 2 lakh penalty on Bhushan Steel Ltd, now known as Tata Steel BSL Ltd, for disclosure lapses. Bankruptcy proceedings were initiated against the debt-laden Bhushan Steel Ltd in July 2017. After completing the corporate insolvency resolution process (CIRP), Bhushan Steel was taken over by Tata Steel Ltd in 2018. "The impugned order dated 14 February 2022, cannot be sustained and is quashed. However, it would be open to the respondent Sebi to issue a show cause notice for the alleged violation against the entity," SAT said in an order passed on December 20. The ruling comes after an appeal was filed against the Sebi order, levying a Rs 2 lakh fine on Bhushan Steel for not making the requisite disclosure under LODR (Listing Obligations and Disclosure Requirements) rules. It noted that the appellant was found guilty of non-disclosure of the number of investor complaints filed with the stock exchanges on a quarterly basis -- March 2016, September 2018 and December 2018.

Under the rules, a listed entity shall file with the recognised stock exchange(s) on a quarterly basis, within twenty-one days from the end of each quarter, a statement giving the number of investor complaints pending at the beginning of the quarter, those received during the quarter, disposed of during the quarter and those remaining unresolved at the end of the quarter. However, SAT in its order noted that "the company had gone into July 2017 under the Insolvency Bankruptcy Code (IBC) and in view of the decision of this tribunal, no penalty can be levied on the new management which came into the picture on May 18, 2018. "The violation, if any, committed for the quarter ended March 2016, was of the previous management which cannot be imposed upon the new management." It further noted that the non-disclosure for the quarter ended September 2018 and December 2018 is concerned, no charge has been levied against the appellant in the show cause notice and consequently, no penalty can be imposed for this violation, the tribunal said.

SHYAM METALICS TO INVEST RS 7,500 CRORE IN 4-5 YEARS, FORAYS INTO STAINLESS STEEL BUSINESS

Shyam Metalics and Energy Ltd on Tuesday said it has forayed into the stainless steel business by acquiring Mittal Corp Ltd in an NCLT-led resolution process. The company will invest about Rs 7,500 crore over the next 4-5 years to scale up its metal business, Shyam Metalics vice-chairman and managing director Brij Bhusan Agarwal said. "Mittal Corp's acquisition cost is about Rs 450 crore, and we outbid Jindal Stainless, the competitor for the sick asset put under the NCLT resolution process. The acquisition will enable us to foray into stainless steel and special products, such as defence materials," he said. To meet market regulator SEBI's norm, the promoters need to dilute their current holding of 88 per cent in Shyam Metalics by at least 13 per cent within the next 18 months, Agarwal said.

The process of dilution will depend on the market situation but is likely to begin in the next 6-9 months. The company said that stake dilution will be from a combination of a fresh equity issue and an offer for sale which will fuel the company's integrated capacity from 8.8 million tonnes to 14.4 million tonnes by 2025. The saleable steel capacity of the company will go up to 3.6 million tonnes from 2.1 million tonnes by 2025, a senior company official said. "In the last two years, we have invested Rs 2,400 crore in the company. We had announced a capex roadmap of Rs 3,950 crore but now we have revised the investment horizon for the next 4-5 years to a total of Rs 10,000 crore to meet organic and inorganic growth plans," he said.

The total revenue will touch Rs 25,000 crore by 2025 from about Rs 10,300 crore in FY'22 fueled by expansion and new businesses, Agarwal said. The Kolkata-based steel

company said that out of the fresh proposed investment of Rs 7,500 crore, about Rs 5,000 crore will be channelised into its main West Bengal-based plant at Jamuria near Asansol. The company also has a plant in Odisha and was contemplating a beneficiation plant there to reduce cost and raw material security. The company in 2021 took over an aluminium foil plant in Giridih. It took over sick steel maker Ramsarup Industries in an NCLT-led resolution.

CEMENT COMPANIES LIKELY TO FOCUS ON VOLUME GROWTH NEXT FISCAL AMID HIGHER COMPETITION AND VOLATILE INPUT COSTS

Top rung cement companies are likely to focus on increasing volumes of cement sales rather than pricing in FY24, a pre-election year. There are a few factors which may compel companies to focus on this strategy. First, companies have engaged in organic and inorganic expansion to gain market share. According to estimates, the sector reported an incremental capacity of 33 MT in FY23 so far, which is likely to increase competitive pressure. Second, the capacity addition amid fluctuating prices of raw material such as pet coke and coal due to geo-political conflicts provide little room for companies to increase prices.

Growth Grind

Capacity Guidance and Estimated Demand & Supply

Company	FY23E	FY24E	FY25E
UltraTech	131	134	149
ACC+Ambuja	69	74	80
Dalmia Bharat	40	49	57
Shree Cement	46	53	56
Industry Total Capacity	586	620	661
Supply Growth YoY (%)	6	6	7
Industry Demand	390	425	450
Demand growth YoY (%)	10	9	6
Capacity Utilisations (%)	67	68	68
Incremental Supply	32	35	41
Incremental Demand	35	35	25

Figures in MT SOURCE: **Companies, Jefferies**

Another reason is historically, demand for construction increases in a pre-election year as the government increases spending on urban, rural, and low cost housing, and infrastructure. These segments generate 80-90% of the cement demand. Analysts estimate demand to grow at a compounded annual growth rate of 8-9% between FY22 and FY25. Large cement manufacturers such as Ultratech Cement, Ambuja Cements, Dalmia Bharat and Shree Cement are likely to record higher revenue growth given timely expansion, strong balance sheet and stable cashflow from operations. Their earnings per share (EPS) is expected to increase by 25-58% while revenue may grow by 15-25% year-on-year for FY24.

JK CEMENT BUYS CONTROLLING STAKE IN ACRO PAINTS FOR RS 153 CRORE

JK Cement has acquired controlling stake in Acro Paints through a wholly owned subsidiary for Rs. 153 crore, according to a press statement from the company. The acquisition has been carried out through JK Paints and Coatings which is the vehicle for the company's expansion in the paints business. Acro Paints is a leading manufacturer in northern India of architectural and high-performance paints and coatings. This acquisition is a step towards fast-tracking JK Cement's entry into the paints business, expanding its product offerings and potentially foraying into new markets, as per the press statement. "We are excited about this acquisition as we believe it will create adjacencies that will act as a key driver of our growth. We are pleased with continued association of Acro's promoters - Mr. Charanjeet Gaind and Mr. Ashok Gaind for the next one year which will provide an opportunity for us to gain from their rich experience", said Raghavpat Singhania, JK Cement's Managing Director. Charanjeet Gaind and Ashok Gaind will continue to remain on the board of Acro Paints Ltd. and will contribute towards a shared vision of the two companies, according to the company release.

JK Cement is the leading manufacturer of wall putty in India and this segment has a significant overlap with the paint industry. The pan India distribution network of JK Cement comprises of 1,00,000 dealers, 75,000 influencers & 1,500 distributors. JK Cement's chief executive officer Madhavkrishna Singhania identified the acquisition as a step forward in a broader plan that will entail expansion across new areas for the cement maker. "We have a focused launch plan to gradually deepen our presence in our strong markets over the next few years, and have identified specific geographic, product, and channel niches where we will dominate. We will leverage the strengths of both our brands as we expand our presence in the paint industry. We believe Acro is synergistic with our portfolio and will help us comprehensively address the fastest-growing paint and putty segment", said Madhavkrishna Singhania. Situated in Bhiwadi, Alwar District, in Delhi-NCR region, Acro Paints has two manufacturing facilities with a post-expansion capacity of 60,000 kilolitres in decorative and textured paints and 6,700 kilolitres in construction chemicals. The ongoing capacity expansion is expected to be completed by Q2 FY24.

PURBANCHAL CEMENT LINES UP RS 200CR FOR EXPANSION, BENGAL IN ROADMAP

Assam-based Purvanchal Cement has earmarked Rs 200 crore for acquisition and expansion over the next few years, including foraying into markets outside the northeastern region like West Bengal, a senior official said. The Maithon Group company has at present a 0.5-million tonne capacity plant near Guwahati. "We are evaluating between brownfield expansion and acquisition preferably with mine rights in the northern part of Assam," Purbanchal Cement MD Vedant Agarwal said."We have earmarked Rs 200 crore over the next two-three years to fund our expansion. Initially, we are aiming at ramping up our installed capacity to 1 million tonnes," he told PTI. Agarwal said the company is also looking at opportunities beyond the northeast. "There are plans to set up a grinding unit in West Bengal to tap the eastern market demand," he said.

The West Bengal government has been wooing manufacturing industries for investment, banking on robust coal deposits, officials said. In recent times, however, cement makers have been hit by high commodity prices and supply hurdles. "As a result of coal shortage, the industry is experiencing severe cost pressure, which has led to price volatility. However, things seem to be improving, albeit slowly," Agarwal said.

ESSAR GROUP PLANS $4.9 BLN PETROCHEMICAL COMPLEX IN ODISHA

India's Essar Group plans to set up a 400 billion rupee ($4.92 billion) petrochemical complex in the eastern state of Odisha in a tie-up with a global player. The oil to petrochemical complex will have an annual capacity of 7.5 million tonnes, it said. It did not name its partner in the project. The group also plans to set up a 14 million tonne a year export-oriented pelletizing complex in Odisha, at an investment of 120 billion rupees and with a 250-kilometer slurry pipeline, it said.

NTPC POWER GENERATION RISES NEARLY 12% TO 295 BILLION UNITS IN APR-DEC 2022

NTPC's power generation grew 11.6 per cent year-on-year to 295.4 billion units (BU) in April-December this fiscal. This assumes significance as NTPC supplies one-fourth of the electricity in the country. NTPC recorded a generation of 295.4 BU during April-December 2022, registering a growth of 11.6 per cent compared to the same period the previous year, a company statement said.On a standalone basis, NTPC generated 254.6 BU during April-December 2022, a 16.1 per cent year-on-year rise. Its coal-based thermal power plants registered a PLF (plant load factor or capacity utilisation) of 73.7 per cent for 9 months in FY23 (April-December 2022) compared to 68.5 per cent in the year-ago period. NTPC's captive coal production remained at 14.6 MMT in the said period, with 51 per cent year-on-year growth. NTPC group's installed capacity is 7,0824 MW. Recently, the company has crossed 3 GW of renewable capacity.

CIL'S COAL SUPPLY TO POWER SECTOR UP 11 PC AT 433 MT

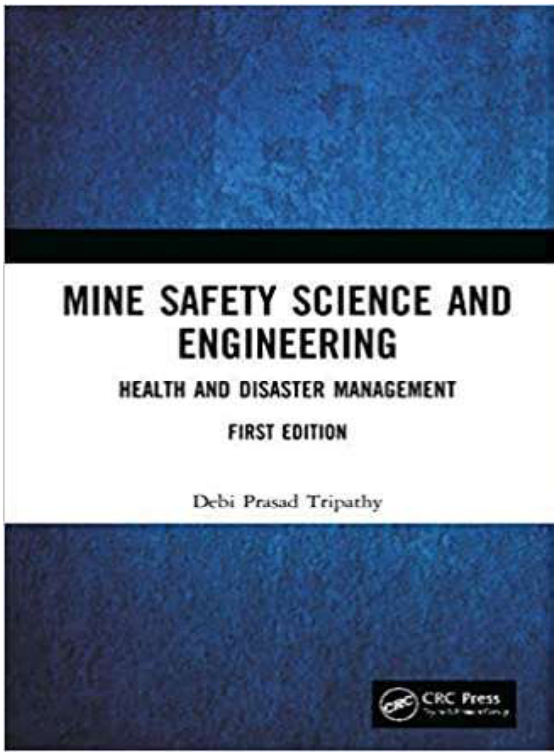
CIL's coal supply to the power sector rose 11 per cent to 432.7 million tonne in the April-December period of current financial year. In the year-ago period, the supply was 390.2 MT. The supply to the non-power sector last month was 10.5 MT due to increased output. Coal India Ltd's output in April-December 2022-23 increased to 479 MT from 413.6 MT in the year-ago period. "To outdo the annual output target of 700 MT, CIL has to produce 221 MT in Q4 FY23 against 209 MT for comparable quarter last fiscal. Our production pace is already up and expected to rise higher. Another point in our favour is large quantities of over burden removal. We feel positive about scaling over the output target," the company said in a statement.

The PSU excavated 1,154 million cubic metres (MCuM) of over burden removal (OBR) till December against 968.6 MCuM in the corresponding period last year. The PSU supplied close to 508 MT of coal to all consuming segments in April- December, registering a growth of 5.4 per cent as compared to the year-ago period. CIL accounts for over 80 per cent of the domestic coal output.

NMDC LIFTS FINES' PRICE BY RS. 500/TONNE, IRON ORE LUMP BY RS.200

NMDC has increased the price of iron ore lump by Rs.200 a tonne and that of fines by Rs.500 for the same quantity with effect from January 1. The new price is Rs. 4,300 for lump ore and Rs.3,410 for fines, India's largest iron ore producer said in a filing with the stock exchange. During the previous revision on November 30 it had increased prices by Rs.300 each respectively, per tonne. As iron ore is a key raw material in steel production, any change in its price is a reflection on the demand for the end products. In another filing, the public sector enterprise said December ore output dipped to 3.61 million tonne (MT) from 3.95 MT a year earlier.

Book News



MINE SAFETY SCIENCE & ENGINEERING HEALTH & DISASTER MANAGEMENT

By-

Prof D.P.Tripathy, Prof of Mining , NIT(Rourkela)

1st Edition 2019, Hard Cover Rs. 9795/-.

Published by CRC Press, UK. 404 pages.

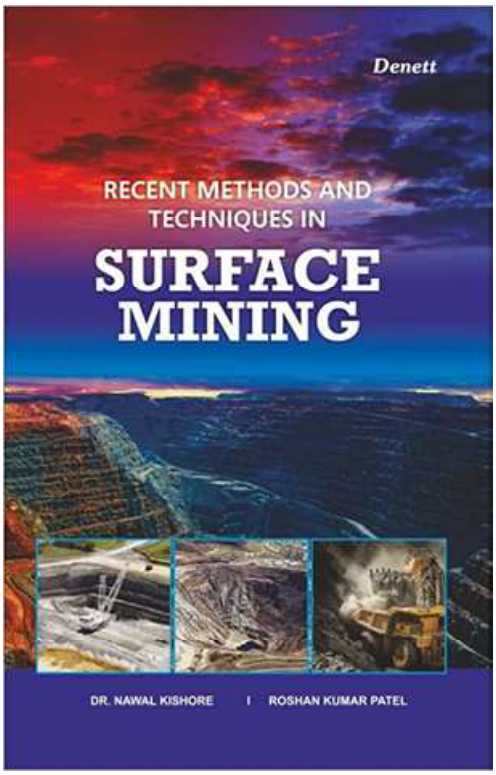
ISBN-10 :1138061492, ISBN-13 : 978-1138061491

Prof D.P.Tripathy had undertaken several scientific studies related to mine safety, dust, sound, illumination and other aspects which are considered important for any mine to make their work place safe. His several years of experience is evident from a list of Thesis he had guided and contain very useful and practical solutions. This book has incorporated all his research, teaching, field visit and literature survey on Mines Safety. This publication authored by him is one among the books on: Noise Pollution, Dictionary of Environmental Science, Dictionary of Quotations, Dictionary of Earth Science and Environmental Pollution Research. His areas of teaching and research interests are: Mine Environment and Safety Engineering, Environmental Management (Air & Noise), Mine Management, Mine Planning, and Computer Applications in Mining Industry.

In Mining operations, Mines Act 1952, has been the base for the entire country to enact several Rules and Regulations (including new technologies and ideas through Technical Circulars) safe working conditions, safety and health of workmen working in mines. Apart from listing in details the various Acts and Rules and their important provisions etc, the book contained safety standards, policies, guidelines and new set of regulations like Safety Management Plan. The innovative and practical methods for ensuring safe mining operations are also discussed in this book including technological advancements in the field. This book will prove useful as reference for engineering and safety professionals working in the mining industry, regulators, researchers, and students in the field of mining engineering.

In view of the very high unaffordable cost of the foreign publication, it is suggested that Dr Tripathy will bring out an Indian Edition with latest features in place in India after 2019.

The IME Journal editorial team compliment Prof Tripathy for this publication.



RECENT METHODS AND TECHNIQUES IN SURFACE MINING

By-

Dr. Nawal Kishore and Roshan Kumar Patel

Edition : 2022, Paperback, Rs.200/-, Published Denett, Nagpur, 228 pages

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A Combined Metrics Framework Based on Lean and CMMi's Measurement & Analysis Practices for Mining Industry

Praveen K Harkawat*

ABSTRACT

In today's competitive business environment, even small improvements in productivity and efficiency can have a huge impact on company's profitability. Whether it is through reduced lead times, reduced waste, minimized downtime or improved quality, operation managers are looking for any advantage at every product / process's stage. Lean management is a long-term operational discipline that methodically seeks to enhance efficiency and quality by identifying and eliminating wastage of resources. The concept is being used in varied industries and helped by improved productivity, safety & better management. Lean in being used by few mining companies also. However, there are many challenges in lean implementation in mining, which can be addressed by using lean combined with other improvement frameworks. One of the key challenges is effective monitoring & tracking of lean programs. One possible solution could be, CMMI's processes used by IT / Technology companies across the globe and have helped in improving quality, delivery & customer satisfaction. CMMI's Metrics related processes / practices are being used extensively by the organizations for better monitoring & control of key measures. This paper explores the possibility of usage of CMMI's metrics practices with lean implementation in mining for monitoring & tracking of status of lean improvement initiatives across the mining organization.

Key words: Lean, Mining, CMMI, Metrics

INTRODUCTION

India is among the top 10 global producers of many minerals. It has enormous potential in the mining industry. The country produces more than 87 minerals including fuel minerals, metallic minerals, non-metallic minerals, atomic minerals and minor minerals. [1]. Mining sector has a major role in nation's development and economy. Indian mining industry is characterized by limited adoption of standard quality frameworks and relatively lower maturity from the perspective of systematic planning, sustainability and business processes. The industry which is facing challenges such as fluctuating demand, cyclical pricing, and reduction in the profitability; operating an effective & efficient business is very crucial for the future business sustainability.

In the current competitive & volatile environment, the sector should explore growth opportunities through innovation, advanced technology & process improvement frameworks for better productivity & safety and sustainability. Indian mining industry is very capital intensive and require attention towards reduction of wastage of key assets which can be better managed through lean framework. Lean has helped many organizations immensely in improving the utilization of machines & manpower and other assets. CMMI is another process framework used by IT / Technology companies across the globe and have helped in improving quality, delivery & customer satisfaction. CMMI's Metrics related processes / practices are being used extensively by the organizations for better monitoring & control of key measures. A combined lean & CMMI measurement framework could be of great help to mining industry.

The available data reveal the limited utilization of Lean & other frameworks and that there is a lack of coherent and conceptual models to guide the implementation of new systems in this industry. It demands innovative systems and frameworks. So, there is a need for promotion of lean and other frameworks which would help to achieve better results in sustainable mining operations. The paper suggests the usage of CMMI's metrics practices with lean implementation in mining for monitoring & tracking of lean improvement initiatives / programs across the organization.

CHALLENGES OF MINING INDUSTRY IN 2023

Gone are the days when miners could simply explore for minerals. Looking ahead, successful miners will be those

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that also mine for innovation. Mining for innovation means organizations must develop new products and processes internally to maximize financial and talent resources. They must also consider acquiring new resources & systems from outside their organization if that gives them a more sustainable path forward. Both types of 'innovation mining' will at the same time require new processes and protocols to manage the business in the coming years. [2]

In 2023, growing expectations around sustainability, climate change and license to operate, as well as a more uncertain geopolitical environment, will top the agenda for mining and metals leaders. Global disruption will also put new pressure on costs, productivity and workforce, prompting companies to explore opportunities to reimagine business models and accelerate innovation. The question is, how can mining and metals companies navigate immediate challenges, such as rising costs and supply chain disruption, while progressing their transformation into purpose-led, low-carbon, digitally enabled organizations? As we head toward 2023, the mining and metals sector is responding with more fundamental shifts to business and operating models. New business models offer opportunities for miners to reposition for a changing future, with many companies considering the benefits of strategies to rationalize, grow and transform. [3]

One very important and suitable tool for transformation in mining companies can be Lean along with selected processes of CMMI. Lean has been implemented by mining and allied industries and given good benefits to the organization. It can help mining companies also to ensure sustainable operations. CMMI is being implemented by many IT organizations across the world. The combination of Lean & CMMI's Measurement Processes, an an integrated & structured monitoring framework can be attempted for mining industries.

LEAN, CMMI AND ITS USAGE IN MINING INDUSTRY

In the current competitive global economic environment in which business is operating in, key resources and the way they are managed are becoming increasingly important. Lean thinking aims to remove wastes from work processes. The goal of lean management is to develop processes that reduce waste to create a productive and sustainable working environment for employees and customers. Lean is all about eliminating wasteful or redundant activities, improving workflow and drawing more value from what companies do. Because of its success in manufacturing, lean has spread over the years to many other core engineering sectors including Mining, Oil & Gas, Construction, Heavy Engineering etc. [4]

Usage and implementation of lean in the mining industry started few years ago. Over the years, it has provided some benefits to the mining industry through cost reduction, productivity & quality improvement, and better safety. Mining and metal industries have been using lean framework based on business context, needs, internal and external environment. It's helping companies in achieving some benefits, but more can be done by working towards further improvements to meet ever changing needs of the organizations and businesses. There are many challenges in lean implementation in mining industry, which need to be addressed for benefit of the industry. Implementing lean in mines is more challenging than in most manufacturing plants due to the inability to control certain elements in contrast to controlled plants where the steps to execute methods such as 5S and visual workplace to improve cleanliness and organization are more straightforward. Nevertheless, operational excellence is possible, though it requires strategies for effective implementation and sustainability of lean initiatives. [4]

One of the ways to improve lean implementation could be, adding best practices of other frameworks like CMMI, which has combination of best of the processes used in IT companies.

CMMI AND MEASUREMENT ANALYSIS (MA) PROCESS AREA

In 1986, Software Engineering Institute (SEI) of Carnegie Mellon University developed the first maturity framework across a multitude of domains. Capability and Maturity Model (CMM) is the earliest maturity model to guide the software development. CMM Published in 1993 to become later the Capability Maturity Model Integration (CMMI). The CMM was specifically developed to provide an orderly, disciplined framework within which to address software management and engineering process issue. CMM become later the Capability Maturity Model Integration (CMMI), which provides a way to display and assess the organization methods and activities across accepted criteria.

CMMI Performance Solutions is a proven, outcome-based performance improvement model providing faster, better, and cheaper results. CMMI is the globally accepted standard that improves and enhances organizational capability and performance. CMMI provides a prioritized pathway to build and implement new capabilities that deliver consistently measurable results and outcomes. For 25+ years, high-performing organizations have achieved clear, sustainable business results with ISACA®'s Capability Maturity Model Integration (CMMI®) model. Originally created for the U.S. Department of Defense to assess the quality and capability of their software contractors, the CMMI model has expanded beyond software engineering to help organizations around the world, in any industry, understand their current level of capability and performance and offer a guide to optimize business results. The model is used by companies in 106 countries. CMMI Performance Solutions helps organizations quickly understand their current level of capability and performance in the context of their own business objectives and compared to similar organizations. CMMI's performance improvement model has helped thousands of globally recognized companies—including many Fortune 500 organizations. [5]

CMMI's Measurement and Analysis (MA), can help mining organizations to develop and sustain a measurement capability used to support management information needs. It involves the following activities:

- Specifying objectives of lean measurement and analysis so that they are aligned with identified information needs and project, organizational, or business objectives
- Specifying lean measures, analysis techniques, and mechanisms for data collection, data storage, reporting, and feedback
- Implementing the analysis techniques and mechanisms for data collection, data reporting, and feedback
- Providing objective results that can be used in making informed decisions and taking appropriate corrective action

CMMI's Measurement and Analysis (MA), with some customization can be used along with lean program management.

FRAMEWORK COMBINING MEASUREMENT ANALYSIS (MA) PROCESS AREA / PROCESSES AND LEAN PRACTICES FOR BETTER MONITORING & TRACKING

Lean metrics are the measures that can be used to control and monitor the processes such that continuous quality can be facilitated by identifying the opportunities for improvements and changes. Before we make an effort to reduce or mitigate waste and move towards lean management, it is imperative that we should know how to measure them. Many organizations would have tried different methods to monitor & track key metrics for reporting to the management. Despite best of the efforts by the lean implementation team, many times desired results could not be achieved. So, it will be prudent to try an innovative measurement framework which can give clear visibility to the management about the progress of lean in the organization.

Also, lean implementation or at least the first few years of implementation is a top management driven process. It is controlled and guided by management, therefore, during this phase it is compulsory to ensure the uniformity and the cohesiveness of this deployment throughout all the organization through a structured measurement program. The management-driven metrics program can be defined using CMMI's MA PA which is proven and resulted into a consistent result for many organizations.

A systematic lean metrics program enhances the prospects for improvement by pinpointing and actually measuring the magnitude of waste, cost saved, productivity and key variables triggering customer dissatisfaction.

Following table shows CMMI's Measurement & Analysis (MA) Process Area's (PA) Practices (as defined in CMMI-Dev V1.3 Model) and proposed Lean Measurement Practices which can be used to design a Metrics Program to monitor and track Lean implementation in the organization –

Table 1: Mapping of CMMI MA PA and Proposed Lean Metrics Practices

CMMI Measurement & Analysis (MA) PA's Practices and Processes	**Proposed Lean Measurement (LM) Practices & Processes**
MA.SP 1.1 Establish Measurement Objectives	L-MnA1.1: Establish Lean Metrics Objectives
Establish and maintain measurement objectives derived from identified information needs and objectives.	Establish and maintain lean measurement objectives derived from identified information needs and objectives of the organization & management implementing lean program
MA.SP 1.2 Specify Measures	L-MnA1.2: Decide Lean Metrics to be Tracked
Specify measures to address measurement objectives.	Specify lean metrics to address organizational measurement objectives
MA.SP 1.3 Specify Data Collection and Storage Procedures	L-MnA1.3: Define Lean Data Gathering & Storing Mechanism
Specify how measurement data are obtained and stored.	Specify how lean measurement data are acquired and put in storage.
MA.SP 1.4 Specify Analysis Procedures	L-MnA1.4: Define Lean Metrics Analysis Procedure
Specify how measurement data are analyzed and communicated.	Specify how lean measurement data are analyzed, reported and communicated
MA.SP 2.1 Obtain Measurement Data	L-MnA2.1: Get the required Lean Metrics Data
Obtain specified measurement data.	Get specified lean metrics data.
MA.SP 2.2 Analyze Measurement Data	L-MnA2.2: Conduct Lean Metrics Analysis
Analyze and interpret measurement data.	Analyze and infer the lean metrics data.
MA.SP 2.3 Store Data and Results	L-MnA2.3: Store up Lean Data, Results and Findings
Manage and store measurement data, measurement specifications, and analysis results.	Manage and store lean measurement data, specifications, findings and analysis results
MA.SP 2.4 Communicate Results	L-MnA2.4: Share Metrics Analysis Results
Communicate results of measurement and analysis activities to all relevant stakeholders.	Communicate results of Lean Metrics and analysis activities to all relevant stakeholders

The proposed framework can be converted to a dashboard for management review. Mining companies can use this proposed framework with more customizations as per organizational needs and ensure more rigours monitoring of lean initiatives.

The complexity of most mining operations—along with their sheer scale, safety-critical focus, geographic isolation, and environmental impact and other challenges can be tackled by the new proposed framework. This combined framework can have positive business impact and result into benefits. Companies that excel at implementing such best practices throughout the organization will in a better position in monitoring & tracking of lean initiatives. It will allow companies to make more accurate decisions, improve health and safety, boost efficiency, and ensure sustainable operations.

CONCLUSION

Lean can be implemented in more structured way in mining by combining the available best practices & lesson learned from other industries. A structured implementation of Lean & CMMI PA in mining can provide a clear direction for applications in various key operations specifically in operations. If implemented with proper planning & with key selected CMMI processes, It will help in reduction of wastage of key resources and improve the productivity,

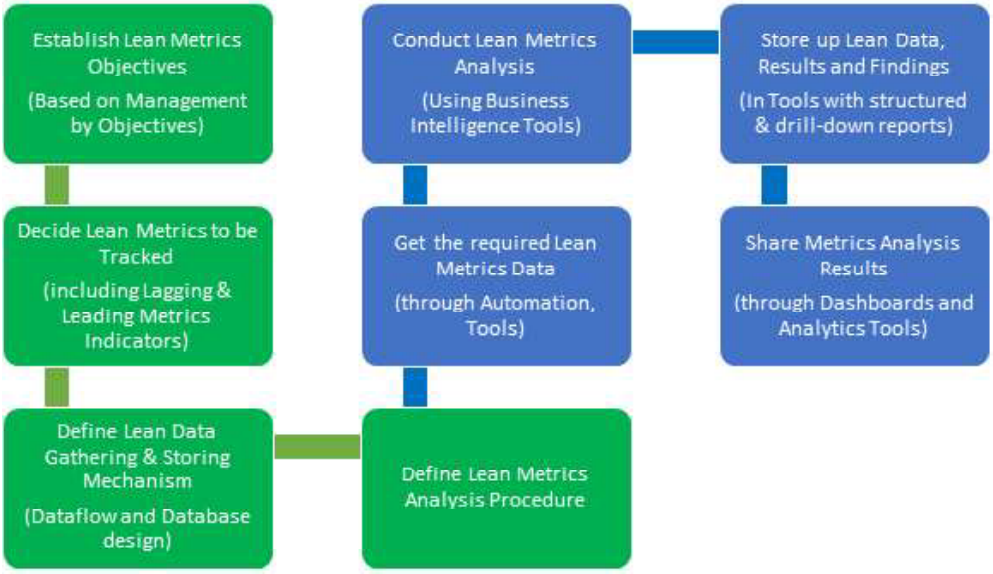

Figure 1: CMMI's M&A-based Measurement Framework for Lean Management based on the mapping of CMMI M&A practices with lean practices

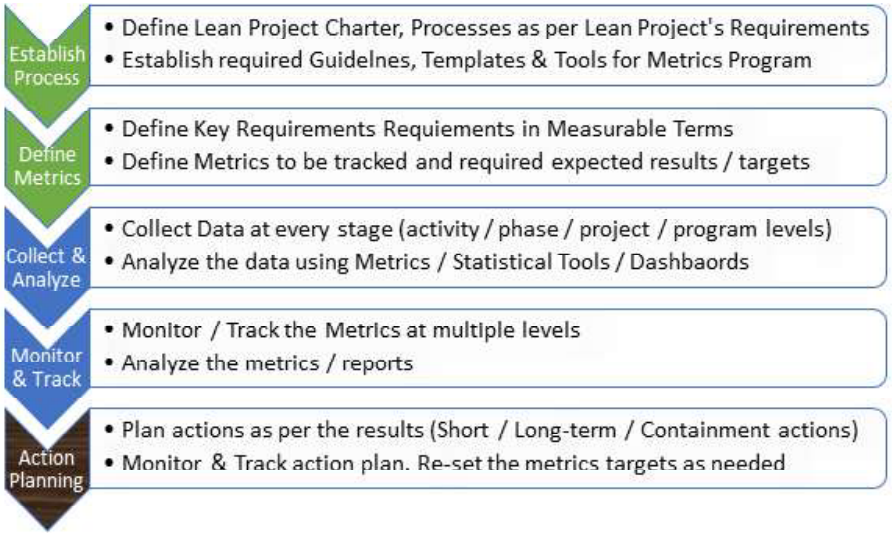

Figure 2: CMMI's M&A-based Measurement Framework – Workflow / Stages of Metrics Program for Monitoring & Tracking Purpose

safety, machine's availability and will result into more sustainable mining.

Implementation & Validation of this framework, followed by any adjustments would greatly benefit both further research and its practice in the mining sector. In future the framework can be enhanced by adding more best practices of other improvement frameworks like BSC, CMMI (Monitoring & Tracking Processes), six sigma, value engineering etc.

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Pollution and Protection of Holy River "THE GANGA" in Recent Times – A Review

Dr. Manabendra Nath*

INTRODUCTION

Water is the source of life and is one of the most abundant natural resources throughout the world so its management and utilization is a serious global concern. In India the river Ganga is considered the most pious and holiest river. The Ganga river originates from Gangotri glacier at Gomukh and travels a distance of about 2525 km before it ends in Bay of Bengal in Eastern part of India. The Ganga water also known as 'blue gold'. The northern India is heavily depends on water of the river of Ganga and thereby it is being over exploited because of rising India's population and its economy. According to puranas, i.e. mythology

The great sages said :
"The holy Ganga descended from the heavenly planets to deliver all the vast ocean of material existence. Ganga devi emanated from the lotus feet of Lord Hari and so everyone happily glorifies her. The water of the Ganga is enjoyed by the demigods who reside on the peak of Mount Sumeru. By bathing in her water, all one's sinful reactions are vanquished. By pleasing Ganga-devi, one can easily gain release from the bondage of material existence."
"O Mother Bhagirathi! You give happiness to everyone. The significance of your holy waters is sung in the Vedas. I am ignorant and am not capable to comprehend your importance. O Devi! you are full of mercy. Please protect me."

The Ganga flows directly from the lotus feet of Lord Krishna and that's why it is the most pious river in the earth particularly in the land of India. As per mythology the Ganga was brought down to the earth by Bhagirath. The legendary is like this – the father of mankind Manu and then his son Maharaj Iksvaku and like in the generation king Sagar appeared. Once for the satisfaction of God and by the direction of Sage Orba, kind Sagar performed horse sacrifice. When the sacrifice was going on Devaraj Indra stole the horse. Then king Sagar sent his 60 thousand son to search the horse. After a long search they saw the horse below the sea in the Ashram of Kapil Muni and thought that Kapil Muni had stolen the horse and thereby they were very angry to kill him but when Kapil Muni opened his eyes they became reduced to ashes. After a long time when Sagar's sons were not coming king sent his grandson Anghuman. After reaching in the Ashram of Kapil Muni, Angshuman saw the horse and offer his prayer to Muni. Kapil Muni told him to take away the horse. But for the penance of his father and grandfather Angshuman asked Muni what he had to do. Then Muni told that by the touch of river Ganga they would be liberated. As such Angshuman mediated but failed and in the generation his son Dilip also failed and lastlyDilip's son Bhagirath succeeded to bring the Ganga in this earth through the hole of Karansamadura. The Ganga then asked Bhagirath who would stop her violent flow. Bhagirath prayed to Shiva to take the flow of water. Lord Shiva agreed and in this way Ganga Devi from Dhurbalokavia Chandraloka via Swarga Loka and then Lord Shiva took the flow of water on his head. Then from the head of Shiva through Meru Parbat and ultimately via Himalaya it reached India and flows through East-South direction and finally after reaching the Kapil Muni Ashram Ganga liberated all the forefathers of Bhagirath. Then Ganga merges to the Bay of Bengal. Before merging to the Bay of Bengal Ganga reached Nabadeep Dham of West Bengal where all waters of Ganga were drunken by Sage Jahnu and after the request of Bhagirath the sage cleared Ganga Devi through his right ear that's why another name of Ganga is Jahnabi.

The different names of Ganga as per scripture :

1	Bishnupadi	As it touches the feet of Lord Krishna
2	Mandakini	As it flows slowly
3	Bhagarati	As it brought by Bagirath
4	Patit Pabani	As it liberates all the sinful souls
5	Janhabi	As it flows through the right ear of Sage Jahnu.

In the Mahabharata we find that the mother of parental grandfather Bishma was Ganga Devi. The Ganga Devi was also the life of king Santanu. The colour of Ganga Devi is white and she wears white dress. She has four hands. She carries Lotus and Nectar on her hand.

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From time immemorial the Ganga believed to be sacred river to the Indians particularly the Hindus. The river Ganga have many pilgrim towns or places of worship and historical cities on their banks such as Kedarnath, Badrinath, Rishikesh, Haridwar, Kanpur, Allahabad, Varanasi, Patna, Kolkata, Nabadeep etc. Since time immemorial its water has been favor for its purity and self-clearing capacity. The rivers support livelihoods of millions in the basin and their drinking water needs. However, construction of dams and barrages storing and diverting the flows, coupled with various indisciplined anthropogenic activities have depleted and polluted its flows, have destroyed its environment and ecology, so much so that it is now listed as *one of the ten most endangered rivers of the world*. Further, climate change and global warming forbade unspecified catastrophic impacts on the river regime.

PHYSIOGRAPHY AND GEOLOGY OF GANGA BASIN

The Indian subcontinent is divided into three major physiographic subdivions, the Himalaya, Indo-Gangetic Plain and Peninsular India. The Indo-Gangetic Plain is the extensive alluvial plan of the Ganga, Indus and Brahmaputra rivers and tributaries and separates the Himalayan ranges from Peninsular India.

Formed in response to the Himalayan orogeny, the Indo-Gangetic Plains form the largest alluvial tract in the world. From west to east, it may be divided into four zones namely, Punjab-Rajasthan Alluvial Plains, Gangetic Plain, Bengal Plain and Brahmaputra Plain. Located between 77^0 – 8^0 E Longitudes and 24^0 – 30^0N latitudes, the Gangetic Plain occupies the central position in the Indo-Gangetic Forelnad Basin System. Depending upon the geographical position and geomorphology, the Ganga Plain is further subdivided into western Gangetic Plain located in the state of Bihar. In the western sector, the Yamuna river acts as the axial river upto Allahabad, where it meets Ganga and from there in the eastern part, the Ganga is the axial river and the entire river coming from Himalaya meet at right angles to it.

The Ganga plain extends from Aravalli-Delhi-ridge in the west to the Rajmahal hills in the east; Himalayan foothills (Siwalik Hills) in the north to the Bundelkhan-Vindhyan Plato – Hazaribag Plateau in the south, occupying the area of about 250,000 km^2. The length of Ganga Plain is about 1000 km; the width is variable, ranging between 450-200 km being wider in the western part and narrower in the eastern part. The southern margin of Ganga plain is irregular, and shows at many places outcrops of rocks protruding out of the alluvium. The northern margin of the Ganga Plain is marked by the exposure of Siwalik rocks, the contact is often made marked by a thrust.

The Ganga basin, an important constituent of the Himalayan foreland, formed as a consequence of the India-Asia collusion around 55 million years ago resulting in the formation of the Himalaya. This provided a large continental mass which together with large rainfall in the catchment area and long term erosion generated/enlarged the river valleys of the Ganga. It is established that the Ganga once has flowed longitudinally behind the Himalaya. Southern thrusting and massive frontal erosion of the Himalaya caused progressive truncation of the longitudinal courses of this river.

Geologically, the Ganga is a very interesting system as the process controlling valley formation and filling in this large river basin are extremely variable in space.

So, the Ganga, one of the 20 largest rivers of the world, originates from the Gangotri glacier in the snow capped Himalayas of Uttarkhand and after flowing through several states debouch into the Bay of Bengal. Raising in the Gangotri glacier the Ganga follows a long course of 2525 kms. through the states of Uttarkhand, Uttar Pradesh, Himachal Pradesh, Madhya Pradesh, Rajasthan, Haryana, Punjab, Bihar, Jharkhand, Chattisgarh and West Bengal (Fig.) before joining the Bay of Bengal. Out of 2525 kms. 600 km are reported to be most polluted. Joined by the mighty tributaries like Yamuna, Son, Betwa, Ghaggan, Gandak, Kosi, Gomti etc. it has a catchment of 861,404 sq.kms.

The Place Gangotri is famous because Mother Ganga is descended on earth at Gangotri.

Further, Gangetic alluvial basin occupies the crustal downwarp formed between the rising Himalayas and the Vindhyas in the Peninsulas shield. The Ganga with its tributaries from one of the largest alluvial plain in the world, densely populated with intense agricultural activities, being the food basket of the country.

CAUSES OF POLLUTION IN GANGA RIVER

The river Ganga has now become extremely polluted because of the rapid industrialization and urbanization. The water being mainly used for drinking purpose and irrigation in agriculture. Due to its over exploitation and discharge of toxic industrial influents in holy river Ganga has started losing its efficiency.
The main causes of pollution mainly manmade are stated below –

- Human waste
- Industrial waste / pollution
- Religious events
- Construction of dam
- Animal bathing
- Washing of cloths
- Cremation of dead bodies
- Runoff from agricultural practices
- Bio-medical waste disposal
- Deforestation in the watershed and the origin of the river.

The affect are being observed mainly on the human beings who are the user, biolife and marine life.

MAJOR POLLUTING INDUSTRIES

The major Ganga Water Polluting Industries include Chemical, Pulp and Paper Board, Textiles, Pharmaceuticals, Cement, Electrical and Electronic equipment, glass and ceramics, leather tanning, food processing and petroleum refining.

MITIGATION

In order to mitigate the problem Govt. launched several action plan from time to time. Amongst them the Ganga action plan or GAP I was first launched by the Govt. in 1986 in order to curb the pollution problem on the river Ganga. It was implemented in Class-I town (25 nos.) in the states of U.P., Bihar and West Bengal & GAP II was further extended in two more cities like Jharkhand and Uttarkhand along with previous 3 cities. The two phase issue was declared complete in the year 2000. Thereafter National River Ganga Basin Authority (NRDBA) was established by the Central Govt. in 2009 under the Environmental Protection Act, 1986. It declared Ganga as the 'National River of India'. Under this the Prime Minister and Chief Minister of all states included through which Ganga flows.

The Supreme Court of India has been working on the closure and relocation of many of the industries plants like Tulsi along the Ganges & in 2010 Govt. declared the stretch of river between Gaumukh & Uttarkashi as '**Eco sensitive Zone'.**

CONCLUSIONS

Ganga is the holy river not only in respect of spiritual purpose but also for the general activities of the human beings. The water quality of Ganga has to be maintained. Though different projects were taken from 1986 to till date under the Modi government but unless the people are cautious we cannot save Ganga from pollution and ultimately we will become the victim. More public awareness has to be created among the mass people in order to save the mother Ganga from pollution. During different religious activities particularly in the Kumbha Mela, Sahi Snan, Makar Sankranti Snan, the throwing of different items into the water has to be restricted not only by the government but also by the NGOs of the nearby localities. More so mining of sand, quarrying of stones, burning of human beings near the Ganga, disposal of chemicals in the river Ganga and construction of dams over the river are to be looked for seriously now.

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Significance of Measuring Stress Underground in Roof, Floor and in the Pillars and Development in Stress Measuring Techniques

Radhe Krishna* Victor Chisala** Daniel Mabeti***

ABSTRACT

This paper describes the need to measure stress underground in roof, floor and in the pillars in underground mines because of the uncertainty of the stress employed by mining.The pillars used in the mines are mostly for three purposes namely, support pillars, protective pillars and as control pillars. Rock stresse measured to prediction and above all, to get an idea of any over stressing caused by excavations, several techniques are available for this purpose: which method should be chosen so that it can provide adequate accuracy and to meet the requirements of available time and facilities. Different views of this matter are discussed. Measuring techniques, support, protective and control pillars

Key words' Hydraulic fracturing, acoustic emission, Destressing, Vertical and horizontal stress, , yielding pillars.

INTRODUCTION

Below the earth's surface as the depth increases, it is expected that the principal stress σ_z which is egh, where e is the density of the overlying rock. It is reported that the stresses become hydrostatic i.e. $\sigma_1 = \sigma_y = \sigma_z$

In flat strata, it is observed that horizontal strata may counter and lateral expansion i.e. $\sigma_x = \sigma_{z_y} = {}^{\varphi}/_{1-\varphi}$

where φ is the Poisson's ratio and φ = (1-φ)is approximately $^1/_3$ because if this uncertainty and also because of the necessity of measuring stresses imposed by mining excavations, the need to measure stresses in underground in roof floor and in the pillars become important.Forces and stresses are invisible but can be observed in terms of recognisable effects. Newton defined forces as the product of body mass and its acceleration. After a century, stress was introduced as the intensity of force that is the ration of force per unit. Mathematically, it can be defined as

Sn = $^{\Delta F}/_{\Delta A}$ $(\Delta A \rightarrow 0)$

Where ΔA = An experimental area at the point P.

ΔF = The resultant force acting on the area ΔA

Sn = stress at point P across the planes where the normal is n … there is an infinite number of stresses in existence at the point P, the start of stress is related to some particular planes passing through it on which the stress is resolved into normal and shear components

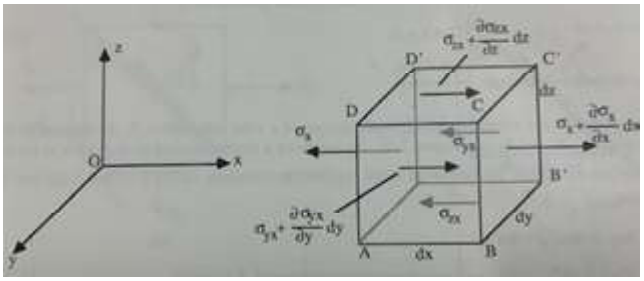

Figure 1

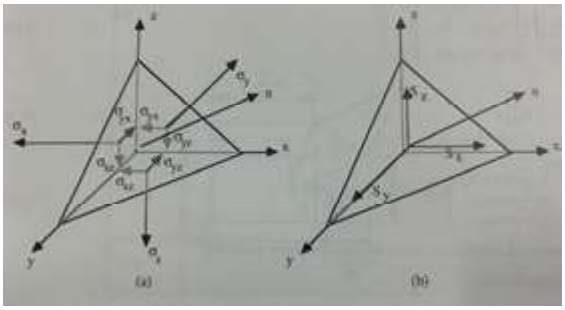

Figure2

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Figure 1 Stress components in x-direction and Figure 2 Forces acting on an infinitesimal tetrahedral on (a) stress at a point and (b) components of resultant stress vector Figure 3 Stress in three-dimension

Measurement of magnitude of stress and their directions is fairly common in mining. Although these measurements tend to be expensive still, it warrants for safety purposes. For example, when choosing, the orientation for a cavern, one hopes to avoid cracking the long dimension perpendicular to the greatest principal stress. If the initial stresses are very high, the shape will have to be selected largely to minimise the stress concentrations. Knowledge of rock stress also help in layout of complex underground works, underground power, ventilation tunnels and other openings. Sometimes, initial stresses are so high that engineering activities can trigger rock failure. Whenever the major stresses in the region of an excavation is more than about 25% of the unconfined compressive strength not cracking.

NEED TO MEASURE INITIAL STATE OF STRESS

It is often possible to estimate the magnitude of the stresses and their directions but one can never be certain of its accuracy.

However, the knowledge of the state of stress is always warranted the case when choosing the orientation of the cavern, it is important to avoid aligning the long dimension perpendicular to the greatest principle stress. If the initial stresses are very high, the shape will have to be selected to minimise stress concentrations. Knowledge of rock stresses also helps in the layout of complex underground works. Knowledge of the initial state of stress help evaluate the potential hazard of triggering an earthquake. The state of stress can be considered a basic rock attribute whose magnitude and direction affect the overall rock strength, permeability, deformability and the important rock mass characteristics.

The other purposes of measuring stress in roofs and floors in mines are used to know:

(1) Mine induced stress distribution
(2) Severe stress concentration zone
(3) To understand mechanism of roadway deformation
(4) Knowing rock falls in advance. Stability control of retaining wall, pillar design in coal mines and possibility of rapid mining.

These are the brief compendium and will never be irrelevant to know the initial state of stress when dealing with rocks in situ.

STRESSED ROCK BEHAVIOUR

In mountainous regions, the in-situ stress may approach close to the rock strength and may release violent release of stored energy. It is therefore pertinent to determine the magnitude and direction of the initial stresses and the work site.

It is generally possible to estimate the magnitude and the directions of the stresses, but it cannot be guaranteed on their correctness without backup measurements. There are various ways in which in which stresses act in nature and in engineering works.

The most obvious evidence of ground stress is an earthquake which is caused by shear displacement along a fault plane during which they gradually accumulate energy (strain energy) in the surrounding rocks. This stored energy depends on the size of the rock and released suddenly and catastrophically.

Rock falls and rockbursts that also cause problems in engineering works are initiated by the sudden and violent release of energy in much the same manner as earthquakes and its magnitude may reach up to 5.5 on Richter scale and explosive bursting near the surface causing buckling and heaving in quarries floors where ground water pressure is high. Another mode of release is in the form of gradual squeezing, although it is not …and hazardous, this can cause very serious and extensive damage to mine openings and its linings.

The vertical stress component is usually quiet close to that produced from the weight of overburden. However, the horizontal stresses are so different from those predicted by gravitational theory which is still not fully understood and an area of active geomechanics research…which engineers and scientists do not yet fully understand the …in which stresses are affected by such plane slip during the deposition and denudation of rocks. Naturally, different processes and stresses may apply three land of rocks i.e. igneous, sedimentary and metamorphic.

CHOICE OF STRESS MEASURING TECHNIQUES

Apart from practical rock stress measurements, techniques are mainly due to calibration of the equipment and the assumptions made in the physical properties of rock (i.e. rock is homogeneous, isotropic and electric).

Some researchers have avoided the calibration problems by adopting indirect compensation techniques. Measurement of relative stress is a much simpler way which provides much more useful information. While it is important from a scientific point of view, the measurements must be precise. Nevertheless, in choosing the most appropriate techniques of measurements for a given field situation and the interpretation of results it is important that the engineers must be guided by theoretical concepts.

The best known and most used techniques are hydraulic fracturing the flat Jack method and overcoming. Each of these methods have advantages and disadvantages. In each case, stress is inferred but in actual case displacements are measured. Results so obtained are usually considered satisfactory.

There are some methods under developments which are likely to be more usual than others. These are (i) sonic velocity methods (ii) stress relaxation method (differential strain care analysis (DSCA) and (iii) based on acoustic emission method known as *Kaiser Effect*.

The *Kaiser Effect is* a sudden increase in the rate of acoustic emission that appears to occur when the applied stress has reached a level greater than any previously experienced by the rock specimen

STRESS ON PILLARS, FLOOR AND ROOF

Pillars are mainly stressed due to the overlying strata on it and should be large enough not to be highly stressed. Research findings have shown that if the pillar has a width and height ratio (W/H) of 10:1. It should remain stable. However, the load it can accept will depend on the strength of the floor and roof material.

The standard approach to the calculation of pillars stress is from tributary area theory. For horizontal seams:

Pillar stress = $\sigma_v/1-e$ where, σ_v is vertical stress field and e is the extraction ratio.

For inclined pillars stress = $\sigma_v \frac{\text{COS2 } \alpha + \sigma h \text{Sin2 } \alpha}{1-e}$

Where $\propto$ = angle of dip in degrees and J_h = horizontal field stress.

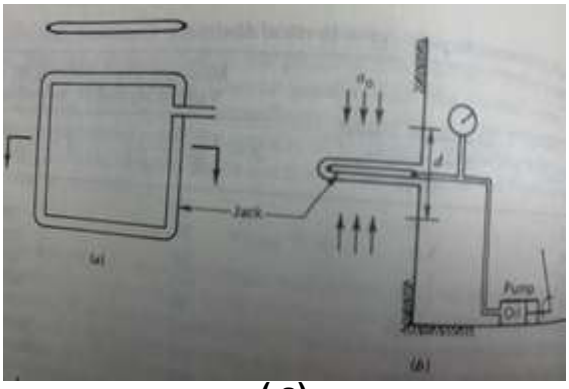
The head for reliable estimates of the prevailing state of stress has resulted in development of stress measurements devices and procedures. Methods developed till now have postulated two principles in the measurement methodology. Most common procedures are based on determination of strains in the wall of that borehole induced by over coring part of the hole containing rock measurement device.

The second type of procedure represented by flapjack measurement and hydraulic fracturing determines a circumferential normal stress component at a particular location in the wall of a borehole. The circumferential stress at each measurement location may be released directly to the state of stress and the measurement site and the measurement location may be related directly to the state of stress at the measurement site. If sufficient boundary stress determinations are made in the hole periphery, the value of the stress can be determined directly.

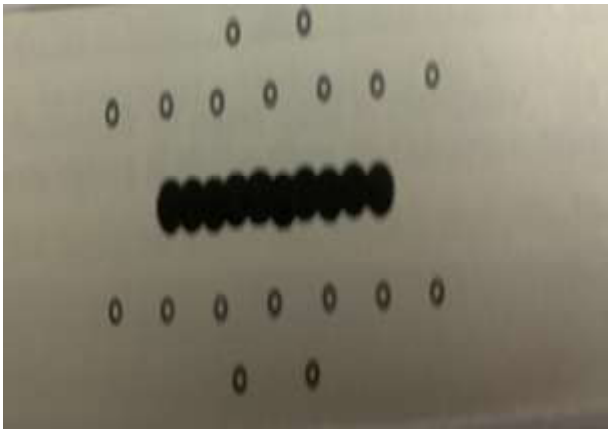
Where it is possible for mining personnel to reach the site of measurement, it is very convenient to measure directly the state of stress in the excavation wall. The flat Jack method is an attractive procedure for determining the boundary stresses in an opening. This method must satisfy three prerequisites for successful in-situ determination using flat Jack. These are:

(i) Undisturbed surface
(ii) Site of instrumentation should behave elastically so that the displacements are recoverable and
(iii) Closed from solutions should exist in relation to boundary stress.

In opening with circular cross-section is the best shape for insertion of flapjack. Its installation is shown in . The flat jack is grouted in the slot and the Jack is pressurised to restore original distance do whose value is very close to normal stress. The stress in allotment pillars should be calculated from tributary theory and the local carried by the yielding pillars should be ignored.



(a)



(b)

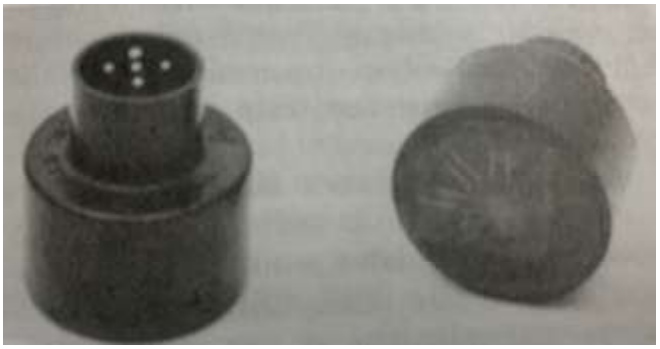
Figure 2 Flat- Jack method for measuring nsitu stress (a) Fla- jack and (b) Arrangement of slots and measuring points for determination of Insitu stress by flat jack, respectively

Flat Jack methods are inexpensive and are suitable for measuring stresses in roof, floors and walls of the excavation.

DEVELOMENT OF STRESS MEASURING TECHNOLOGY

The most current technique of stress measuring in use for deep level is hydraulic – fracturing. At great depth drill hole closure or serious spalling, the conventional method of stress measurement become inoperative. It is therefore, suggested to use any of the following methods;

i. Sonic velocity methods,
ii. Wellbore breakouts methods
iii. Differential strain curve analysis (DSCA)
iv. Acoustic method (Kaiser Effect)



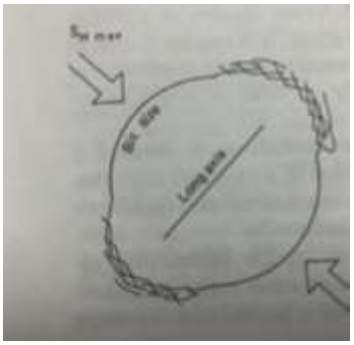


Figure 3 South African "doorstopper 'gauge' 'Figure 6 Wellbore breakout

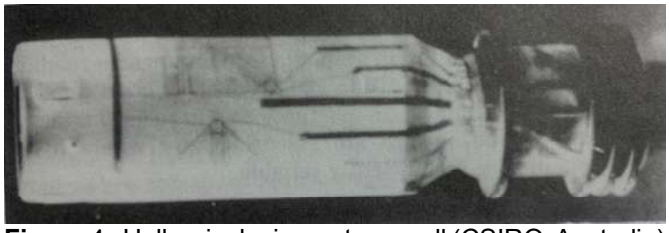


Figure 4 : Hollow inclusion s stress cell (CSIRO, Australia)

CSIR/CSIRO OVERCOMING METHODS

They allow stress to be resolved in three dimensions rather than a single plane perpendicular to the hole. These techniques are are most popular and give reliable results. This method is easier and less expensive.

KAISER EFFECT (ACOUSTIC EMISSION) METHOD

When a rock is under stressed, it emits sub There is a sudden increase audible noiseless (known as Kaiser Effect) which increases with the increases in stress. There is a sudden increase in the rate of acoustic emission which occur when the applied The technique measurement mint of stress becomes greater than the previous stress

experienced by the said rock mass is quite similar to the DSCA. This method is promising, precise and reliable.

CONCLUDING REMARKS

The analysis of stress and strain is fundamental for all work of stress and strain field problem which needs knowledge of theory of elasticity for their solutions. Stress and displacements, in the vicinity of energy release rate, strain, energy density and the determination of stress intensity factors etc. need a supporting background of solid mechanics. Research has shown that stress measurement only serves as a useful data for estimating the state of stress in a pillar or rock, but until to date, it has reached to a state of prediction of collapse of rock or pillar.

Rocks under stress behave in different ways such as earthquakes, rock falls and rockbursts. Squeeze and stress are transmitted from place to place in the rock mass through solid material and across joints, from block to block. Rocks differ from most other engineering materials as they contain fractures of one type or another, which renders their structure discontinuous. It is important to understand the making of rock (rock material and rock mass). Rock material is a hand specimen in a piece drill core …in the lab. Rock mass is the total in-situ containing bedding planes, faults, joints, folds and other structural fractures.

Rock masses are (i) discontinuous (ii) heterogeneous (iii) anisotropic (engineering properties). There are eighteen stress components in a cube. However, only six are independent for the cube in equilibrium.

The three principle stresses are generally not equal. Conventionally, they are termed minor, intermediate, and minor principal stresses according to their magnitudes. The stress state that can be found in the filed in the laboratory testing are: uniaxial stress, biaxial stress, axisymmetric triaxial stress and hedonistic stress. In choosing the most appropriate method of measurement for a given field situation and in the interpretation of the results obtained, it is important that the engineer is guided by theoretical concepts to experience …and intuition. The researchers have summarised principles in relation to the stress – strain characteristics of the rock concerned.

The most ideal stress meter…should be one of very high rigidity, which could be inserted in such a way that absolutely no deformation of the rock occurs around the hole into which it is going.

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Slope Monitoring of Vindhyan Limestone and Bijawar Phosphorite Deposit

Sardar Singh Bagri* B. K. Mishra*

ABSTRACT

Slope stability analysis is an integral aspect of every opencast mining operation for the duration of the project. In the Indian mining context, slope design guidelines for various types of mining techniques have yet to be formulated, and there is an increasing need to devise solutions to ensure safety while boosting output. The Geology and Geotechnical parameters play a vital role in Pit Slope Design. The Study emphasizes the importance of a geology and geotechnical aspects in order to address the slope design in Vindhyan Limestone and Phosphorite mine whose stability is largely controlled by geological structures. The study area is free from major structural disturbance like fault, fold and joints and the area is tectonically stable. The intact rocks of Limestone and Phosphorite are categorized as strong rock based on the Uni-axial compressive strength. Stable benches have been created maintaining the ultimate pit geometry.

Key word: Slope, Limestone, Phosphorite, Flac, N-Value.

INTRODUCTION

When mineral resources are mined from the surface and below, the operation is referred to as open pit mining. Because of the pit's downward inclination, slopes occur during the operation. Even in very hard and strong rock, it is not always possible to maintain vertical slopes that are stable enough or pit walls that are high enough. As a result, pit slopes must be slanted at an angle. The angle of this inclination must be adequate to prevent rock collapse. This angle is thus determined by the local geological component at every mine and serves as an upper constraint on the total slope angle. Slope stability is the one of the greatest problem which any open cast mine encounters. Scale of this problem is divided into. Gross stability problem: It refers to the overall problem of stability of major parts of slope due to large shear failure and it generally occurs in deeply weathered rock. b. Local stability problem: It refers to problem which is much lower in scale and it generally doesn't affect more than a couple of benches at one time. It mainly occurs due to shear plane joints or slope erosion due to surface drainage. Slope Geometry, Geology and geological structure, Ground water, Lithology, Dynamic forces, Method of mining and equipment used, Angle of internal friction, Cohesion is the main factors affecting the slope stability (Khan 2016, Suman 2015, Kumar 2013).

A complete sequence of the rock belonging to Vindhyan super group is exposed in Maihar Bhadanpur-Dhanwahi (Kuteshwar) area.

Table 1.0 Regional Geological sequence of the area

Group	Formation	Member
Upper Vindhyan Group	Bhander formation	Upper Bhander sandstone & Sirbu shale
		Lower Bhander sandstone
		Bhander sandstone
		Ganurgarh shale
	Rewa formation	Rewa sandstone
		Rewa shale
	Kaimur formation	Upper Kaimur quartzite
		Kaimur shale
		Lower quartzite
----------Unconformity----------		
Lower Vindhyan group/ Semri group	Rohtash formation	Rohtash limestone
	Khenjua formation	Glauconitic beds (sandstone)
		Fawn limestone
		Olive shale
	Porcellanites formation	Porcellanites
	Basal formation	Kajrahat limestone
		Basal conglomerate & quartzite

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The Hirapur-Mardeora proterozoic phosphorite deposits in Madhya Pradesh's Sagar and Chhatarpur districts (Lat. 24°19'N and 24°23'N and Long. 79°9'E and 79°14'E) are part of the Bijawar group of rocks' gangau ferruginous and phosphatic formations. (Mathur and Mani, 1978, Banerjee et al., 1982).

Table 2.0 : Regional Geological sequence of the area (Khan et al 2012)

Lower Vindhayan system		Semri group (Late/Upper Precambrian) .....Unconformity.....	
		II	
	Bijawar group	Gangue	Quartz-breccia phosphorites Ironstone-phosphorites
	(Early to middle Precambrian)	Ferruginous and phosphatic formations	Shale-phosphorites, at places weathered/ leached formed secondary phosphorites
Cuddapah system		I	
		Non-phosphatic formations .....Unconformity.....	
	Archean -	Bundelkhand complex	

MINING METHOD

The two mines where slope study was studied for varying factor of safety, adopts shovel – dumper combination engaging hydraulic excavator loading into tipping trucks. The average bench height is 4 to 6m and drilling and blasting is used to fragment the strata. In case of the limestone mine the average RQD is around 60 percent & for phosphorite is about 80 to 90 percent.

METHODOLOGY

Rock samples from different benches were collected and tested for using them in FLAC software. The factor of safety values were over 1.0 and the resultant slope angle was accordingly determined.

⟹ (Refer to DGMS Tech Circulars for FOS etc)

RESULT AND DISCUSSION

Parametric studies were performed via numerical models of Phosporite deposits (FLAC/Slope) to investigate the variation of the angle of internal friction (30°- 35° at an interval of 4°) and Cohesion (0.01-0.05kgcm^2 at an interval of 0.04kgcm^2) on FOS. Also, Pit slope angle was varied from 30° to 55° at an interval of 5°. (Figure-1)

Parametric studies were performed via numerical models of Limestone deposits (FLAC/Slope) to investigate the variation of the angle of internal friction (30°- 40° at an interval of 8°) and Cohesion (0.02-0.10kgcm^2 at an interval of 0.06kgcm^2) on FOS. Also, Pit slope angle was varied from 30° to 55° at an interval of 5°. (Figure-2)

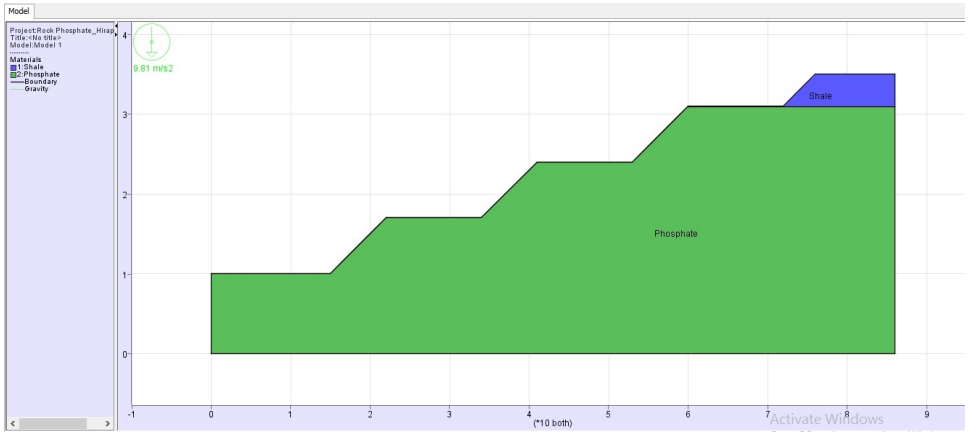

Figure 1 A: Mine bench model of Phosphorite deposit

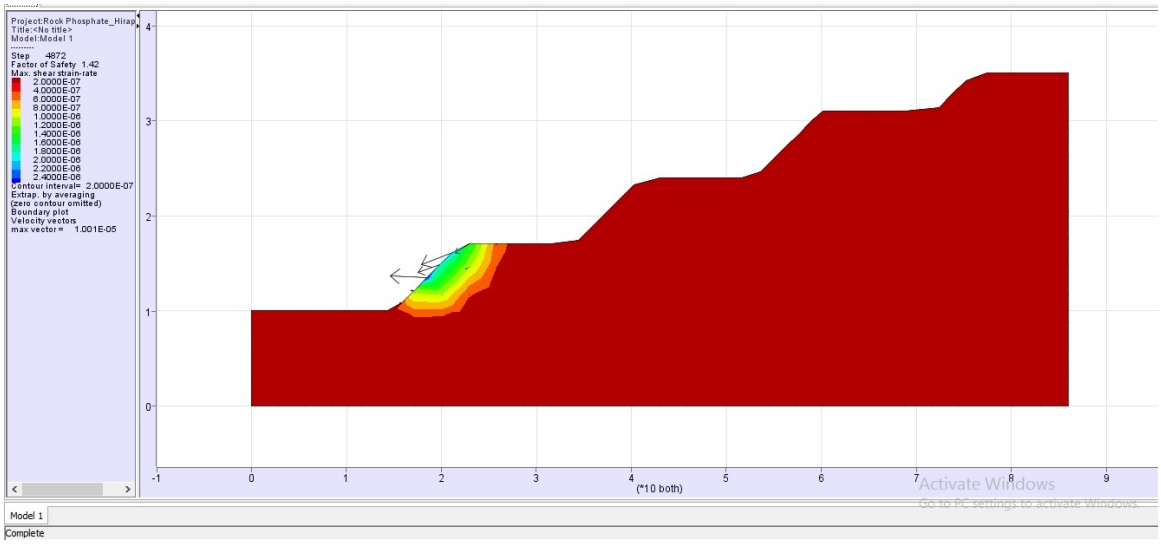

Figure 1 B: FOS 1.42 of Phosphorite deposit

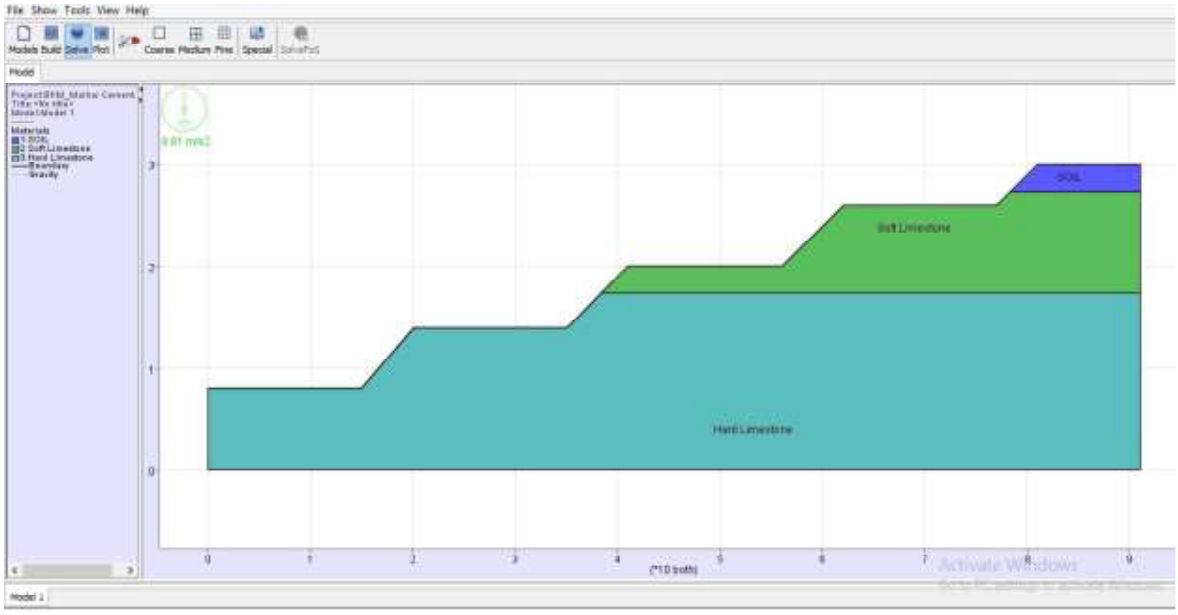

Figure 2 A: Mine bench model of Limestone deposit

SN	Slope angle	FOS using Flac
1	40 (Limestone)	1.34
2	45 (Limestone)	1.2
3	45 (Phosphorite)	1.41
4	40 (Phosphorite)	1.31

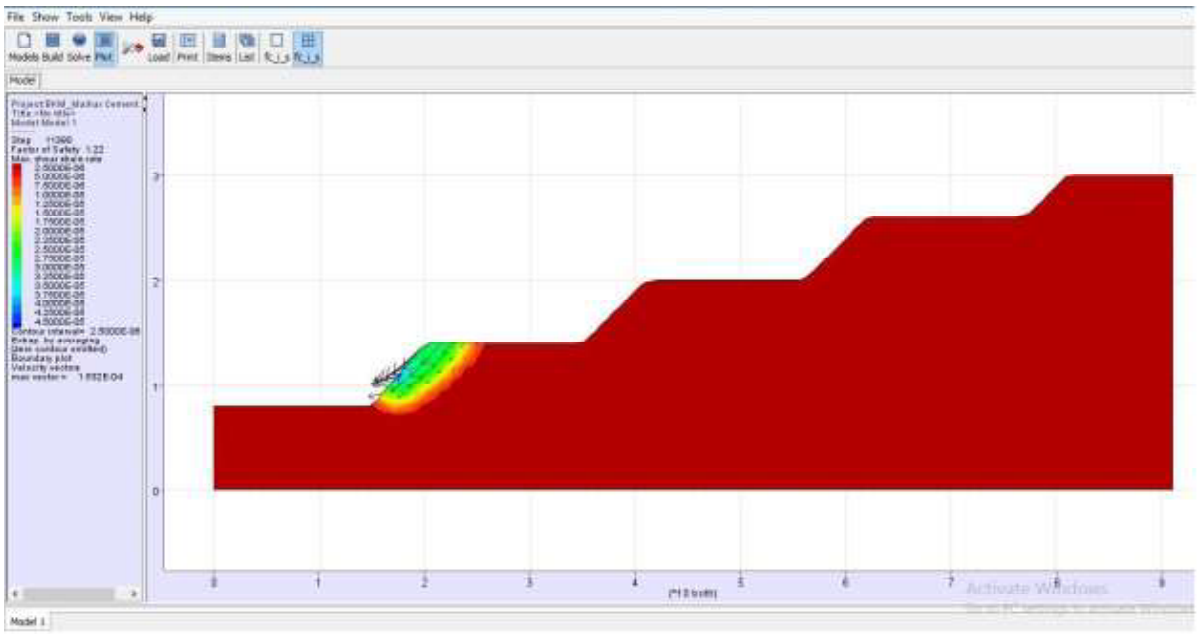

Figure 2 B: Limestone deposit

From the analysis it can be seen that FOS varies accordingly as we change different parameters such as slope angle, angle of internal friction, cohesion and more stable in Phosphorite deposit. Factor of safety is a calculation of resisting force divided by driving force. So if any change in resisting force occur due to any activity FOS increases or decreases as the case may be.
Opencast mining is a low-cost mining process that allows for great automation and enormous output quantities. Mining depths in open pits have progressively grown during the previous decade, raising the possibility of large-scale stability issues. It is critical to identify the many forms of slope collapse and implement cost-effective solutions to avoid, eliminate, and limit risk."

Only cohesion and friction angle have been taken into account for the parametric experiments. Even though not all of the benches may be the same height, this study may still be applied to certain bench angles. For the sake of this analysis, it is assumed that the effects of the water table and geological disturbances are negligible. Other characteristics, such as the impact of geological disturbances, water table, and blasting, can be measured in addition to cohesiveness and friction angle. Other numerical models, such UDEC and Galena, can be utilised for slope stability analysis in order to contrast the sensitivity and usefulness of the various programmes.

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Selection and Application of Overburden as Stowing Materials Replacing Sand in Underground Metal Mine

Deependra Pantawane*

ABSTRACT

India is facing scarcity of river sand, the traditional stowing material. Apart from availability, there have been legislations which prohibits use of sand in both as a stowing material as well as in civil construction. To meet the demand for stowing material, alternate materials like overburden material, fly ash and a mixture of bottom ash with sand has been a subject of several field trials and experiments. With the easy availability of overburden material, mines have taken up field trials to use them optimally without compromising on safety etc. By using overburden material as stowing material, mines will also have better management of dumps to safely store the material.

INTRODUCTION

Cut-and-fill method of stoping is widely adopted due its numerous advantages like safety of the work place, higher recovery of the ore, effective strata control, and working in greater depths. During opencast mining, the overlying soil is removed and the fragmented rock is heaped in the form of overburden dumps (Ghosh, 2002). Open cast mines all over the globe and also in India, face serious problems of handling and disposal of the overburden produced as large storage area is required.

On the other side underground mining currently accounts for a bigger share of world coal production than opencast. Underground mining that accounts for about 15–20% of total coal production in India produces huge mine voids simultaneously (Sivakugan et al., 2004). Mine voids created during the underground mining should be stowed with suitable backfill material to avoid collapse of the overlying strata. Thus to provide ground supports to minimize the land subsidence problems and mine safety aspects, backfilling is the valuable part of mining. Hence attempts are being made to utilize the overburden rather than to dump it.

River sand is widely used, as a stowing material due to its easy availability and operational safety concern and the most important is its geotechnical properties. On the other hand, its overexploitation may cause negative impact to the riverine ecosystem as well as the productivity of nearby land mass. Thus, an alternative of river sand for backfilling is required. Backfilling with mine overburden or waste rock material may provide an alternative for river sand.

- Utilisation of these nearby mine overburden dumps as backfilling material in underground mine voids might be a good alternative of river sand.
- Backfilling with mine refuse and waste rock also includes the elimination of the environmental, health, safety and social problems associated with surface disposal.
- From last few decades, India is facing scarcity of river sand, the traditional stowing material owing to mining legislations and its heavy demand in infrastructure development.
- The existing mine overburden dumps might be a good alternative for sand and provide a sustainable mining practice.
- Geotechnical and physico-chemical characterization is required to evaluate the suitability of OB dump material to be used as an alternative.
- The properties such as specific gravity, particle size distribution, porosity, permeability have to be determined. Sand being the traditional stowing material, all the properties the overburden material(OB) are to be compared in accordance to riverbed and processed overburden(POB).

SELECTION OF BACKFILLING MATERIAL

Selection of any alternative material to be used for backfilling should be examined for its short- and long-term mechanical properties and expected behaviour following its use and placement in voids. Stated below are some of the approaches to select such filling materials -

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Global production of land won minerals including waste and overburden

Year	Production net weight, 1.000 tons	% Increase since 1975	Materials moved gross weight 1000 tons	% Increase since 1975
2000	20,933070	47.7	62,265038	48.2
1998	20,610531	45.4	60,015452	42.9
1995	19,735291	39.3	57,548678	36.8
1988	18,607294	31.1	56,864321	35.4
1985	16,942603	19.5	52028252	23.9
1980	16,196957	11.4	47407590	12.8
1975	14,172463		4200725	

Source: Sustainable mining practices a global perspective, Rajaram et al. (2005)

(a) Assessment of the suitability of waste material composite as backfilling materials
(b) Assessment of the rock as a geological/technical barrier after backfill installation
(c) Assessment of the geotechnical properties of backfill.

TECHNIQUES ADOPTED IN MINE FILLING

The various techniques of mine back filling include - Mechanical backfill, Pneumatic backfill, Paste backfill, Hydraulic backfill (hydraulic stowing) and a combintion of pnuematic and haydraulic backfill.

IMPORTANCE OF PHYSICO-CHEMICAL ANALYSIS

- Physicochemical properties of OB material have their own importance in different manners such as reaction takes place owing to the presence of different elements in the OB and simultaneous combustion of OB.
- Presence of nitrogen (N), phosphorus (P), sulphur (S), etc., causes different chemical reactions to the environment.
- Presence of various elements in OB material may lead to different types of chemical changes with available water sources and result to AMD or may cause some of the atmospheric pollution by simultaneous combustion.

PHYSICAL AND GEOTECHNICAL PROPERTIES OF OB

- A number of geotechnical and physical properties are there to be tested to check the suitability of any material for backfilling in underground mine voids.
- Karafakis et al. (1996) found that slake durability, plasticity, particle size analysis and triaxial compression test are some of the key tests that must be performed for backfilling material.

GRAIN SIZE ANALYSIS

- There is a significant importance of grain size over geotechnical assessment of filling material. Backfilling material, which contains well-graded particles, should offer more resistance to displacement and settlement than one with uniformly graded particles.
- The fractions above 20 mm are considered to be oversized and leads to pipe blockage and flow difficulties. Also the presence of finer particles causes permeability and settlement problems. Thus the material to be used for stowing has to be studied for its particle size distribution. Wet sieve analysis is conducted for estimating the fines percentage for each sample and dry sieve analysis is conducted for estimation of gradation properties
- Maximum grain size of a grain used in filling should be less than 1/5th of the pipe bore to limit the critical velocity of flow in pipe (Prashant et al. 2010).

- It has been observed that the presence of fine grained sediments within coarse particle slurries results in a reduction of power required for pumping the slurry to disposal. The required pump pressure to transport slurries in pipelines and inject them into voids.

Some other properties need to be checked are -

- **Atterberg limit testing**:- to check the consistency of material used as backfill. It is measured by Casagard apparatus. Gravel and clean sand is considered as non cohesive, shall be used as backfill.
- **Slake durability** : material may experience cyclic change of wetting and drying during flowing and placement, which can degrade the particle and may alter the material properties.
- **Compaction**: to determine moisture content of the waste, which will achieve maximum dry density for the material that has been compacted.
- **Permeability**: this is the ability to allow the liquid to pass through its pores.

CASE STUDY

Non-availability of river sand, is causing immense problem for this underground Manganese mine in Nagpur district. This mine which is adopting stowing or filling in Cut and Fill stopes by sand is facing availability of sand. To ensure uninterrupted mining in Cut and Fill method of stoping, several attempts have been made to use alternate material in place of sand. Overburden from an adjoining mine was considered for use as a stowing material replacing sand.

A number of field trials were undertaken and tests were carried out to ascertain the physical and geotechnical properties suiting the conditions and to find the right mix for the hydraulic transportation of the stowing material.

GEOLOGICAL AND PHYSICAL PROPERTIES OF THE OVERBURDEN MATERIAL

Over burden material of the area consists of mica schist of meta-sedimentary rock formation containing sand particle and dolomite band intrusion. Most of the Overburden material having the characteristics of plastic type paste formation and sudden fragmentation rock particle connection with water. Overburden material is erodible with respect to water, air and temperature.

METHOD OF WORKING IN THE MINE

This underground mine adopts Horizontal cut and fill method of stoping with post filling by hydraulic sand stowing. A stope drive not more than 2.4 m wide and 1.8 m high is made in the orebody between the two winzes leaving a block of ore 5m thick (called sill pillar) in ore. In the stope an ore pass and a man way at an interval of 30m.

The haulage drive of size 3.4 m x 2.1 m has been developed in footwall rock and is placed 20 m away from ore body and cross cuts of size 2.4 m x 2.1 m are driven from haulage road to intersect the ore body from foot wall to hang wall. The cross cuts are placed at an interval of every 30 m. Moreover, the raise/winzes is placed at 60 m interval.

SUPPORT SYSTEM

Rock bolt support system of 1.5 m long at 2 m spacing in haulage road, cross cut, ore drive and stope back in square pattern is being adopted. A 5 m thick crown pillar is being designed with a safe conservative estimate with Factor of Safety (FOS) of 1.5. Multi-Point Bore Hole Extensometer (MPBX) has been installed to monitor the strata. Detailed geotechnical studies had helped in designing the support and also maximum volume of unfilled area at any point of time is decided. At present the maximum stable unfilled volume at any point of the stopping operation is estimated to be 840 m^3 for the mine under study.

APPLICATION OF OVERBURDEN IN MINE IN BACKFILLING

Huge quantity of overburden material is generated in the adjoining opencast workings. Use of these OB materials for backfilling/stowing may found to be useful for mining industries to recycle the material and reduce the environmental impact, thus saving of the land used for dump creation. In view of these, technical investigation was carried out into the feasibility of developing a strong alternative filling material in place of sand i.e. overburden material for stowing purpose. To replace the sand as fill material, OB material was used for experimental purpose by hydraulic transportation. Initially some pills/pellets of overburden material with various compositions was developed. In these pallets, polymer and binder have been

used and trials were conducted. During the trials it was observed that only the following product mix as presented in Table 1, resulted in partial success for hydraulic transportation in underground, and Figure 1 shows the photograph of the product mix which was found suitable for hydraulic stowing operation :

Table 1 : Presents the Product mix which were subjected to Hydraulic transportation to Underground stopes

Mix No	Fine OB (<2 mm)	Course OB (2 to 10mm)	Sand	Clayey soil	Gypsum based Putty	Water Content
4	45%	45 %	NIL	NIL	10 %	9%

Figure 1 : Photograph showing the most suitable product mix for hydraulic stowing operation

Figure 2: shows the photograph of the fill material which was used finally

Table 2: presents the constituent of the stowing material which was used in the final trials

Mix No	Fine OB (< 2 mm)	Course OB (2 to 10 mm)	Sand	Clayey soil	Gypsum based Putty	Water Content
4	45%	45%	NIL	NIL	10%	9%

OBSERVATIONS

The developed product mixes after heat treatment is suitable for underground hydraulic stowing purpose in underground mines. Some product mixes are rejected due to its non-compatibility and properties are not matching with sand. It is also concluded as the increase in temperature will cause the change in bond of the mix it will change the hardness also. It may kindly be noted that the developed product mix is prepared only for use of fill material in underground mines for hydraulic transportation.

FIELD TRIALS AFTER TREATMENT OF MATERIAL

Final field trial on experimental basis was conducted at the mine for a minimum quantity of around 30 m^3 of the material to confirm the physical properties of the OB material as fill material. This material was transported to underground by hydraulic transportation. Table 2, presents the constituent of the stowing material which was used in the final trials. Figure 2, shows the photograph of the fill material which was used finally.

RESULTS AND CONCLUSION

The result of the stowing in mine stopes was quite encouraging. After the introduction of alternative fill material of OB in place of sand for hydraulic transportation to fill the voids in the stope, the floor of OB stowed material is more compact and non-expansion in nature. It will improve the face productivity by basket loading manually in comparison with sand floor and modern mobile underground equipment's could be used for drilling in stope and loading, transportation of ROM in the stope by side discharge loaders or load, haul and dump machines. With the rock mechanics instrumentation program of Multi Point Bore Hole Extensometer (MPBX) and strain bars and continuous monitoring may reduce the thickness of barrier pillar from 5 m to 4 m in coming years. This will help to conserve the manganese ore locked in underground. Also water bleeding through barricades was seen to be on a decreasing trend.

Overburden which is available in abundance in the nearby areas will be an effective material to backfill the voids. Several researchers have demonstrated its efficacy in stowing, and as a replacement material to river sand for stowing in underground mines and backfilling in opencast mines. Policy framework and national strategy can make it possible to utilize maximum overburden dump waste in gainful manner. It would mitigate environmental threat; provide sustainable mining and cleaner environment.

ACKNOWLEDGEMENT

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Internet Of Things - A Boon To Mining Industry for Attaining Sustainable Development

Pragya Shrivastava*

INTRODUCTION

Every Mining organisation generate huge information required right from exploration stage till marketing of the final product. Data from the multiple sources of origin involve selection, collection, storage, transmission, editing and evaluation of data through intervention of digital techniques vis-a-vis computation. At a time the IT arena is subjected to rapid expansion and development, IoT (internet of things) has been a blessing for computation of data of varied nature. When we talk of 'sustainable development' data analyses/management and computation also play a vital role in deleiniation of economic values of coal/ore deposits, study of environmental data recorded on continuous basis, online data from loading-transport-processing(beneficiation)-usage system.

The internet of things (IoT) is a computing concept that describes the idea of everyday physical objects being connected to the internet and being able to identify themselves to other devices. The IoT is significant because an object that can represent itself digitally becomes something greater than the object by itself. No longer does the object relate just to its user, but it is now connected to surrounding objects and database data. When many objects act in unison, they are known as having "ambient intelligence." . In the context of the mining industry, this technology involves connecting equipment, fleets, and people based on *radio frequency identification device* (RFID) and sensor technologies. The Internet of Things is all about the combination of data from many different sources and being able to gain insights and interactions as a result of bringing those things together

The Internet of Things (IoT) will prove key for mining companies to become more competitive, increase their market share, and realise inefficiencies and cost savings, a report has found. According to the latest research from Inmarsat, the Internet of Things (IoT) will play a critical role in helping mining businesses to increase the level of automation and improve production efficiency, enabling them to compete with rivals operating in lower cost markets.

Joe Carr, Director of Mining at Inmarsat, commented on the findings: "It is no surprise to see that mining businesses are looking to IoT to help them gain a competitive advantage. Mining businesses across the world are under constant pressure to produce the same product at a lower price than their rivals. At the same time, it is becoming harder to find high quality deposits in lower sovereign risk countries. This pressure is amplified in developed economies, such as Canada and Australia, where labour costs are much higher than in emerging markets, leaving operators in these territories at a significant competitive disadvantage. These businesses must drive down operating costs and improve productivity to remain competitive, and the most effective way to do this is the adoption of IoT and automation.

WHAT CAN IOT DO ?
PREDICTIVE MAINTENANCE

Sensors embedded in mining equipment can monitor equipment health and trigger alerts to predict failures before they occur, giving the ability to react at the right time. Proactive maintenance also means that spare parts can be ordered well in advance, avoiding express shipping costs when a breakdown occurs. By moving beyond reactive or time-based maintenance, miners can ensure higher asset uptime, and increased productivity by delivering more ore from the existing infrastructure.

IMPROVED SAFETY OF PEOPLE AND EQUIPMENT

Miners are highly focused on employee safety, as operations often take place in extreme environments and far-flung locations. IoT in the mining industry can play a significant role in addressing potential health risks and safety concerns such as the collapse of unstable shafts or injuries resulting from the operation of mining trucks. By enabling autonomous operations without the need for human intervention, operators can remotely monitor equipment, and use real-time data from equipment sensors as well as geological and other data to anticipate and react to potential safety threats.

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ANALYTICS AND INTELLIGENCE

The increasing use of IoT in mining will churn out large volumes of data related to production processes, operational environment, safety and other aspects of operations. Analyzing this data can provide useful insights on process variability and deviations from expected operating conditions in real time, allowing miners to take actions that drive higher process efficiencies and combat safety threats. Advanced analytics can turn vast data sets into insight about the probability of future events and help mining companies predict upcoming trends.

COST SAVINGS

As explained earlier, IoT enables miners to move from reactive to proactive maintenance, which translates into reduced asset downtime and consequently, reduced cost of operations. Additionally, autonomous machine operation improve productivity and reduce costs by eliminating manual monitoring. By tracking devices in real time, supervisors can ensure that the right machine is available at the right time and place, preventing production delays and associated costs.

BETTER DECISION-MAKING

IoT enabled equipment provide real-time updates that not only makes possible a real-time response to issues, but also facilitates sophisticated decision-making at the central operating center that can take actions to optimize operations across the whole supply chain. This capability can be deployed to maintain high equipment utilization and ensure consistency with operating plans.

IOT DEVELOPMENT IN MINING

• SYMBOTICWARE

Symboticware was founded in 2008 and is based out of Sudbury, Ontario, operating in the technology epicentre of underground mining. They develop innovative technologies that are enabling today's industrial Internet of Things. Their technologies deliver the right data, at the right time, to the right people to drive the right business outcomes. Symboticware's core product is the SymBot®, a monitoring and data solution that delivers standardized information-based technology that enhances the productivity, safety and efficiency of mobile and fixed assets. Their solutions leverage the customer's existing infrastructure and data reporting and visualization systems. Using open, standards-based solutions allows their customers to leverage their current investments and knowledge, while facilitating interoperability and ease of integration. On the technology front, pervasive communication and connectivity can still present challenges. They recognized early that underground mines and related areas do not have pervasive communication, which results in data gaps, manual data entry and subsequent inaccuracies in the data. Mines weren't getting real-time data—they were getting chunky data that was not trusted for decision support. They are giving accurate data by using algorithm design to support IOT.

• BESTECH

BESTECH is a multi-disciplinary engineering firm servicing the mining industry with offices in Sudbury and Timmins, Ontario. They also offer innovative solutions that enable mining operations to increase efficiency, reduce energy costs and improve worker safety. Their most revolutionary product, the NRG1-ECO, is a mine-wide ventilation control system that can save millions of dollars in annual energy costs. It adjusts a mine's ventilation system and reduces energy consumption by responding to the activity of mine personnel and vehicles, and the data from environmental sensors. Ventilation is an important and complex system within underground mines and is also the largest energy consumer in a mine. Today, mines ventilate at 100% capacity, which means that all fans are operating 24/7. However, with our technology, a mining operation has the ability to analyze the underground environment and fine-tune the ventilation system to provide air when and where it is needed. In essence, it can turn the fans on to deliver the correct amount of required ventilation only to the zones of the mine where people and equipment are present. As mining companies dig deeper into the ground, the product is a useful tool when considering infrastructure development costs.

With respect to the NRG1-ECO, the system has the capability to save 30% to 40% of existing current energy consumption by controlling the fans. As such, a mine site is able to reduce costs in the range of $2 to $4 million. We believe the system will have an impact on productivity in the mine as well. In the underground mine working environment, it is difficult to determine where people and equipment are located. Yet, with the use of radio frequency technology that is integrated in the NRG1-ECO, mining operations are able to quickly locate their employees and equipment. The other aspect of this technology consists of monitoring the air quality underground, which enhances

health and safety for miners as environmental hazards can be detected before they cause any harm.

- **ROWEBOTS**

What they really do is they provide technology to allow people to connect sensors to the internet. That's really what they do: they provide one-stop shopping. It could be hardware, software or an application. Their main product is something called the Unison operating system. And it looks like Linux except it runs on very tiny computers. In mining, for example, they could actually be putting specialized sensors on mining vehicles. With specialized sensors, they can monitor different things and actually transmit data either over a satellite network, depending on where the vehicles are, or over a cellular network, so that somebody can actually track the vehicles. The data can help us to figure out what the productivity is and when the vehicles need service. They have a remote field service offering so we can update the sensors live in the field without sending a technician there. They also have all of the high-level protocols to organize about 500 trucks on a network and be able to track them all and have them registered and managed through a central system.

- **QWANTECH**

Qwantech incorporated in 2009. One of their main products is a key performance indicator (KPI) system that uses real-time data from the frontline. They take a company's existing KPIs and provide a way to track, organize and display them. Generally, a consultant will work with a company to help it discover what KPIs should be of most concern, and from that point, we implement the tools that help them put those KPIs into place within the organization. One of the pain points they've found is that organizations are often not using one unified set of databases or systems. They have quite a few departments or sites that are using different sets of software to collect data. A lot of organizations with large systems have trouble engaging users or data at a departmental level, and conversely, a lot of departments collect good information that remains in a silo. It is difficult for a company to implement these KPIs on a day-to-day real-time basis when such fragmentation exists

- **GEOMECHANICA**

They're developing a computer simulation software, which is very advanced both in terms of physics and in terms of the computational engine. In the software, you specify input parameters related to the Earth such as rock properties, and then you can predict how the rock will deform, and if it's going to fracture, how it will fracture, and various mechanical properties about the rocks. The software makes predicting the rock behaviour a lot easier and a lot more accurate, and fast. It gives you the results very quickly—within a few hours. The solution takes advantage of Big Data. The platform is very flexible. It can be utilized with a variety of datasets and computation models. Let's say it's database applications: you could use their library and do fast computations on the GPU. You could use a desktop PC with one or two GPUs in it, or you could have many parallel processors, or you could have a big giant infrastructure with many processors.

In terms of mining, the biggest application will be structural and stability analysis. For example, when you go into a cave, you can extract material from the ore body. Their application can tell you what will happen if something goes wrong, unlike other tools that only tell you if the structure is going to be stable. Then there is tunnelling. We can again study the stability of tunnels and also the change the ground that surrounds an excavation. We can analyze the excavation damage zones and consequently optimize the amount or type of rock support needed.

CONCLUSION

A connected mining operation with integrated data (from exploration till marketing of the products) is arguably a scenario toward which every mining company should strive in the next five to ten years for sustainable development. "[Integrated data] is going to drive the future of mining. Is [the operation] efficient? Is there some technology that can make it better towards achieving sustainable development goals with higher percentage of recovery, minimal damage to the eco-system, less carbon footprint, higher safety and no social impact etc ? How many tons of ore did you produce, at what cost, quality etc? What's the metallurgy? How do you get the ore/coal to the surface faster? These are the kinds of issues that are important. I believe in mining intelligence and data. It may take five, ten, fifteen years or more, but the IoT will arrive at Indian mining sites. These mines will be connected, optimized, efficient, and far more sustainable than in the past. The opportunity is knocking. For technology adoption in mining to succeed, it generally has to improve the bottom line or meet a mandated requirement. Mining operations have already been tweaked with the pre-IoT technology, so any new process must show a significant improvement above the status quo.

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Role of Trans-Disciplinary Research in Turnaround of Mining Industry vis-a-vis ICT Applications for Improvement of Safety

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ABSTRACT

This paper presents overview of a few innovations be the author as scientist of CSIR-CIMFR, NIRM-Ministry of Mines, and Professor of NIT Rourkela through various industry oriented trans-disciplinary research activates over 35 years to improve safety in mines. Various innovative attempts made including application of Information and Communications Technologies (ICT) through more than 110 industry/Ministry sponsored projects for development of new concepts, designs and implementation in the field of opencast and underground mines in India. Mining evolves the cycle of stages which is started from exploration continuing through production and ends with closure of the mine. In every stage of mining process, we face lots of risk, hazards to environment and mankind. So minimizing the riskiness of the job and hazards technological innovations are coming forward in the mining industry.

Renewal of the innovations is driven by the growth of the demands of the minerals with respect to communities and the environment. Adopting the technological innovations like geophysical methods for exploration of minerals, global positioning system, geographical information system, 3-D models using software etc makes the mining process more productive and reliable. So technological innovations shape the future. Attempts made on development and experimental trials of innovative systems for the first time in India for online-real-time slope stability monitoring with TDR, WSN, IoT, LoRa, Cloud/Fog computing etc for opencast mines is also presented with emphasize on urgent need of Trans-Disciplinary Translational industry oriented Research and Academics (TTIORA) for improving safety in mines, including fatigue monitoring.

Keywords: Mine Safety, WSN, TDR, IoT, LoRa, Cloud/Fog computing, Transdisciplinary research

INTRODUCTION

Mining is considered as the backbone of the economy and also an old industry. So as an old industry does not mean to adopt traditional methods. In general, we observe the mining industry is less technologically advanced in comparison to other industries like biotechnology, communication etc. But the reality is different. Mining has the scope of innovation which brings the better efficiency, safety and environmental and social integration in any adverse situation. Innovations in mining are difficult and challengeable because we mined the non-renewable resources which are present beneath the surface where unknown and unreceptive conditions get in the way of exploration and extraction. Technological innovations in mining industry provide the smarter exploration of the minerals, more efficient mining, safer working conditions and more environmentally responsible industry. The smarter exploration methods help in identifying the minerals, chemical and physical properties of minerals in the field and detecting the depth of the mineral deposit and modeling the mineral deposits. Mining methods based on the data which is more suitable for the extraction of mineral. The technological innovations improve the underground communication system and also provide the sophisticated mineral transport system and emergency response. It also minimizes the impact on the environment.

Innovation represents the changes in ongoing process for mining industry that draws the areas of knowledge. Innovation does not limit itself in the field of technology it can be based on social and environmental aspects. From the mining point of view social and environmental aspects are playing the vital role. So technological advancements consider these factors while renewing the technology. Attempts have been made by the author since 1990's about field oriented research and in line with NEP2020, also on Transdisciplinary Translational Industry Oriented Research and Academics (TTIORA) as scientist and Professor above three decades. Some of the recently developed systems through projects related to TTIORA are presented below besides critical review and emphasis on urgent need of TTIORA for sustainable development

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of mining industries.

Adopting a huge fleet of machinery, with massive capacities of shovels and dumpers became quite common in the Mining Industry. Despite the technologies and methods, the human element plays an important role in maintaining the whole system safely and efficiently. manner. As most of the mining accidents are caused due to the operator's negligence / Heavy earthmoving machinery, there is a need to monitor the operator's efficiency, and alertness while operating the machinery. Drowsiness or sleepiness, and the accompanying physical and mental state of employees is one of the major factors contributing to accidents in the mining industry worldwide. This paper presents some of the technologies (Artificial Intelligence and Machine learning) used to monitor and assess the fatigue levels of the work personnel working in various capacities as vehicle drivers, hauler/conveyor operators, pump operators, or any moving machinery operators etc both in underground as well as surface mining conditions in the Mining Industry. Although AI/ML algorithms can assist fatigue monitoring, true reasons can only be understood by using studies using technology like biomarkers.

Slope stability is one of the major geological concerns in open-cast mines. The mining area slopes needs to be regularly monitored to detect occurrence of any slope failure prior to any catastrophe. An early warning system solves this purpose preventing loss of significant mass of human lives as well as property. This is a critical scrutiny which renders various techniques and methodologies regarding Slope monitoring of open-cast mine. Wireless sensor network has been standing out as a productive competent tool for monitoring the tangible environmental structures by sensing the differences, processing this raw data and finally communicating the result to the web from where it can be referred for researches and predicting mechanisms. Internet of Things comes into picture for communicating the sensed and processed data from the sensors to the application where it can be further analyzed. In recent scenario power issue is of great concern associated with deploying a real-time monitoring system. This review depicts how WSN can be adopted and preferred to any other technologies used in slope monitoring due to its advantages it brings. Moreover, collaborative operation of WSN with IoT results in a more systematic, robust, energy-efficient, cost-effective real-time monitoring approach.

TELE MONITORING FOR MINE SAFETY

Automatic monitoring system is one of the main means to ensure the safety of underground engineering construction. At present, the study of construction safety of underground engineering mainly adopts the traditional manual monitoring methods whose data collection process are cumbersome and time- consuming. (Fig 1). The typical underground engineering monitoring system is composed of four parts: data acquisition, data transmission, data analysis and processing, and security state early warning. The typical underground engineering monitoring system is composed of four parts: data acquisition, data transmission, data analysis and processing, and security state early warning (Fig 2). The data acquisition terminal mainly uses sensors and cameras. Data transmission adopts wired and wireless modes; data analysis and processing adopt a variety of intelligent algorithms and early warning system forecasts security status based on the processing results.

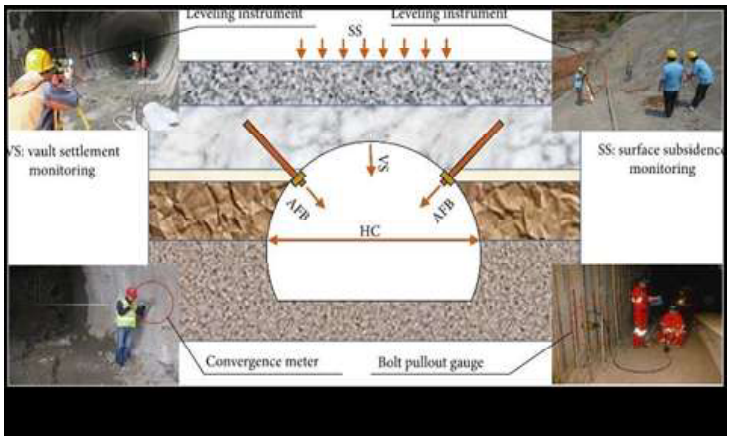

Fig 1: Traditional monitoring data acquisition (11)

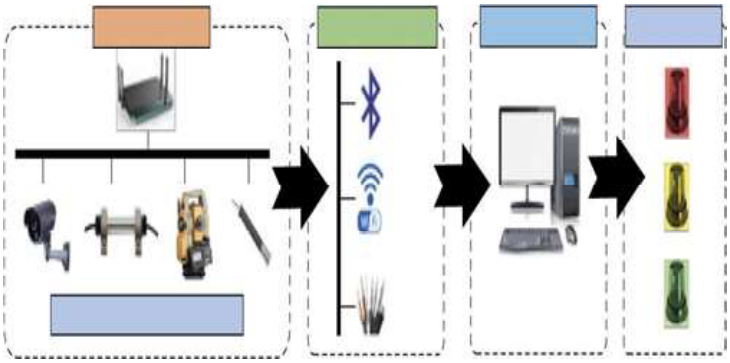

Fig 2: Architecture of the monitoring system (11)

WIRELESS SENSOR NETWORK BASED MONITORING SYSTEM FOR MINE SAFETY

Wireless Sensor Networks (WSNs) are a new kind of ad hoc network, which consist of hundreds to thousands of WSN Nodes that communicate with each other, and can monitor areas from small to huge (9). WSNs have emerged as a powerful technology. In recent years, with the rapid development of mobile communication, micro-electro-mechanical-systems (MEMS) and high- speed electronic devices, sensors with characteristics of low power consumption, programmability, multi-parameter sensing or multi-sensor modules and low power consuming wireless communication infrastructure have provided practical wireless solution to real-life problems in variety of domains. With outstanding advantages of ease of configuration, flexibility to shrink or expand the monitoring range, strong fault-tolerance and mobility, WSNs can play an important role in monitoring and analyzing dynamic, hostile and unfamiliar environments. Conceptual structure of a typical WSN is shown in Fig-3.

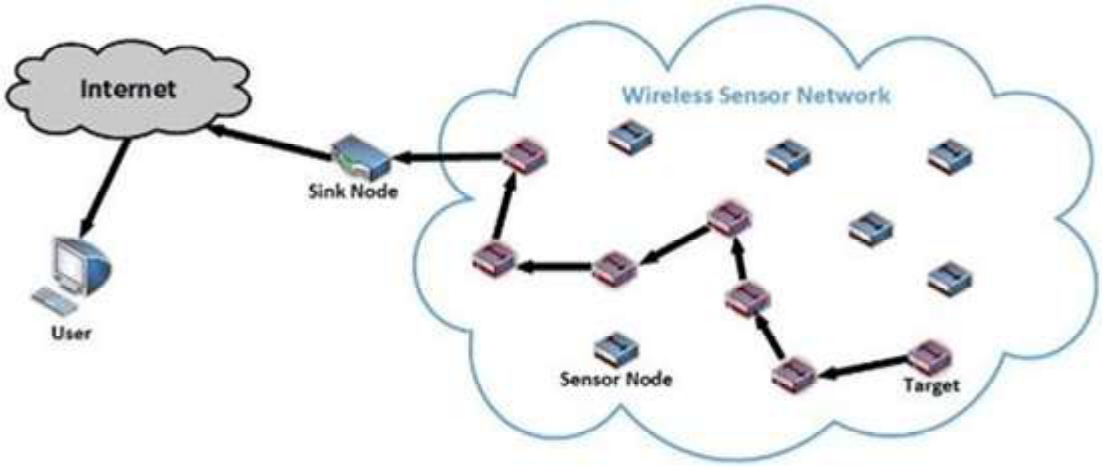

Fig 3: Conceptual Structure of a Wireless Sensor Networks (WSN)

FATIGUE MONITORING FOR IMPROVING SAFETY

Fatigue is a complex state characterized by a lack of alertness and reduced mental and physical performance, often accompanied by drowsiness (1999 U.S. DOT Operational Definition). Fatigue is increasingly recognized as a problem affecting the workforce. Research shows 13% of workplace injuries (National Safety Council) can be attributed to fatigue, a dangerous byproduct of a society that operates 24 hours a day.

The majority of the accidents occurred due to Heavy Earth Moving Machinery, in which the human element is the main contributing factor. Round the clock working operations, monotonous and repetitive duties are directly influencing the worker fatigue levels. Fatigue is a serious symptom that is prevalent across a variety of occupations and industries (World Health Organization, 1990). The U.S. Centers for Disease Control and Prevention, (CDC, 2015) estimates that one in three adults does not get enough sleep, labeling fatigue as a public health problem. Quantifying and analyzing the fatigue levels for each operation is essential for safely doing work.Symptoms of “extreme tiredness” and “reduced functional capacity” are two of the main factors to be assessed for each worker. Fatigue can manifest physically, mentally, and/or emotionally. Monitoring operator fatigue and distraction are the key factors in minimizing the incidents at the workplace. Mining environment associated fatigue is commonly due to operating machinery during night time, improper lighting at the workplace, poor design of lighting systems, bad temperature settings at the workplace, noise, and highly repetitive tasks resulting in boredom.

A study published in the American Journal of Health Promotion stated employees that “almost always” felt tired during the day missed an average of 2.7 times more days of work and had 4.4 times more productivity loss than those who reported “almost never” feeling tired. Fatigue of any kind poses a workplace hazard, as well as reduced

productivity. According to the National Safety Council, the challenge costs employers $1,200 to $3,100 per employee annually, due to absenteeism, health care, and other related costs.

SMART TECHNOLOGIES FOR FATIGUE MONITORING

Artificial Intelligence (AI) is the ability of computers and robots to sense, reason, and perform tasks that are usually done by humans. Machine Learning (ML) is a subset of AI that are algorithms that improve over time through exposure to more data. Deep Learning (DL) is a subset of Machine Learning that uses artificial neural networks, algorithms inspired by the human brain, learn from massive amounts of data. Natural Language Processing (NLP) is a branch of AI that helps computers understand, interpret, and manipulate human language. Advances in AI and ML have brought us many applications that were previously unimaginable.

Machine Learning has brought recommender engines that suggest the products we may be interested in buying, a movie we may want to watch, or a news article that we may want to read. Advances in Natural Language Processing have made it possible to translate between two languages in real-time enabling communication between two remote teams and pushing productivity higher. Deep Learning advances brought us autonomous and self-driving cars, identify a specific type of cancer, and even dancing robots[2].

Artificial Intelligence and Machine Learning are prime technologies that could help the mining industry, due to the remote mine sites, the hazardous nature of the work, and the high costs of labor and transport. Indeed, AI & ML have found uses in mineral exploration, smart sorting of minerals and ores, demand forecasting, autonomous machinery, etc. Applications of AI & ML are relatively new in mining, and the full potential of these advances need to be realized. Artificial Intelligence, especially computer vision and deep learning techniques, just started to appear in the realm of driver safety monitoring and fatigue management systems. For example, Dotnetix.ai's Nexus employs an in-cabin camera and sensors suite monitoring distracted driving conditions, and streaming data to the control center. Hexagon mining uses a combination of visual analytics, collision avoidance system, and body clock models.

As explained in the introduction sections <insert section number here> fatigue is a result of many factors: work schedule, nutrition, sleep, personal habits, circadian cycles, long and monotonous work, tiredness, medical and psychological causes. To truly monitor the drivers and the operators for any fatigue, a holistic view of all the causes of fatigue needs to be adopted. However, a holistic view requires the ability to merge and understand data from personnel's medical, social, behavioral, and physical records. Doing this manually is an impossible task. In addition, the data is typically in silos, and most likely in a non-automatable format. Moreover, a real-time monitoring system is needed to alert the driver of any possibilities of incidents and accidents. Artificial Intelligence has excelled at places where human capabilities have met their limits, especially when it comes to consuming streams of data and analyzing for actionable insights. We now present a couple of approaches to monitoring fatigue, and driver safety using AI. Figure 4 shows A typical driver safety monitoring system. Figure 5 represents the Road Monitoring using Deep Learning.

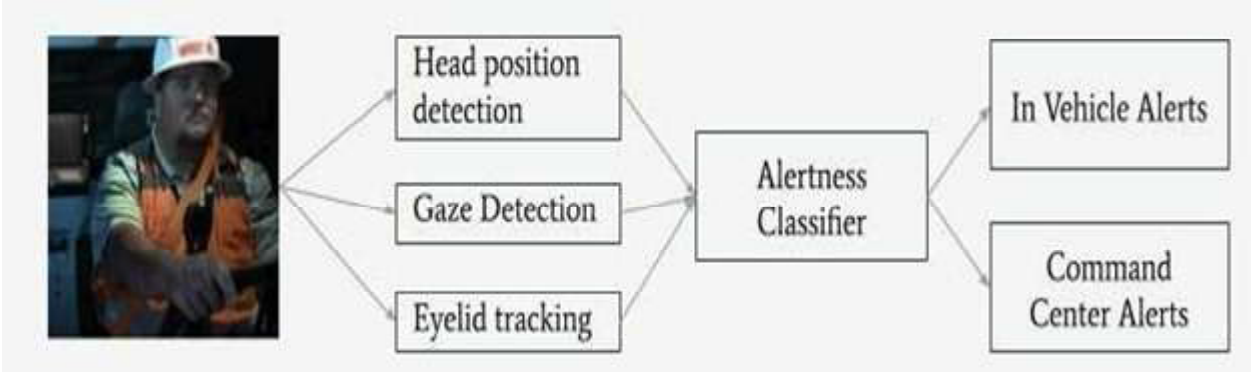

Figure 4: A typical driver safety monitoring system

Technology 1: In-cabin camera to monitor the driver's physical state.
Technology 2: Road monitoring system, with optimal location predictor
Technology 3: Ambient sensing technologies
Technology 4: Driver's physical measurements
Technology 5: Combine operator's medical records with the approaches above

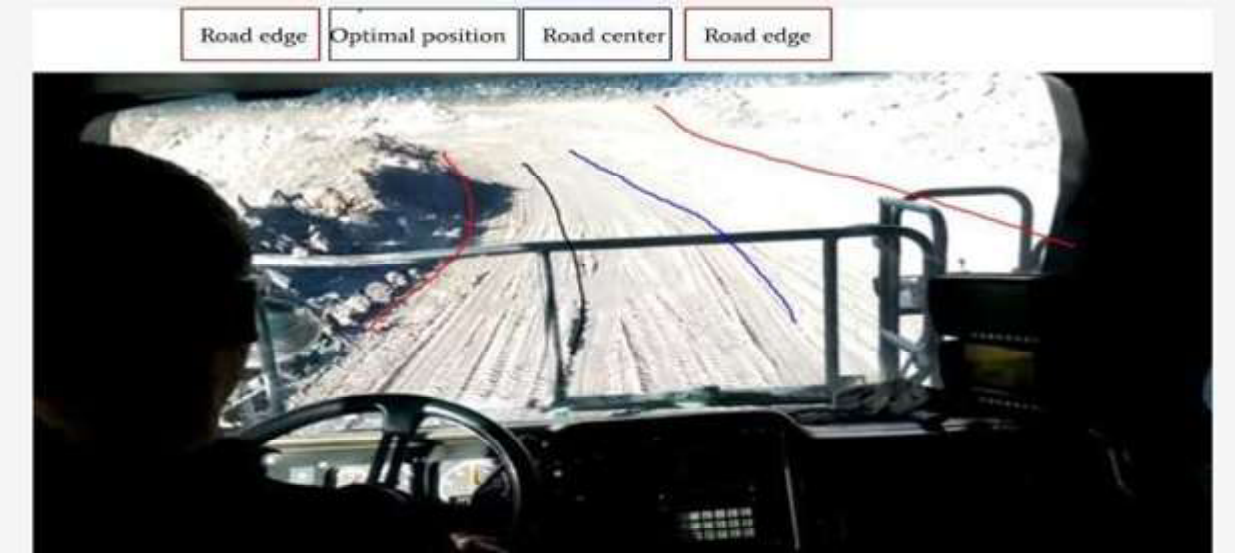

Figure 5: Represents the Road Monitoring using Deep Learning

No matter which approach is chosen, the data collected, and the incidents averted must be reviewed by the safety manager of the mining site, along with the operator(s) involved in the incident. To achieve this, videos and the data from the sensors are stored for later analysis and review. In addition, mine-wide analytics of the incidents, along with where and when they happened, and who were involved are extremely important to maintain the safety of the operations, and to make improvements on it.

BIOMARKERS FOR UNDERSTANDING UNDERLYING REASONS

The official National Institute of Health (NIH) definition of a biomarker is: "a characteristic that is objectively measured and evaluated as an indicator of normal biologic processes, pathogenic processes, or pharmacologic responses to a therapeutic intervention." (Biomarkers Definitions Working Group, 2001). Fatigue is a complex construct of symptoms that emerges from alteration and/or dysfunction in the nervous, endocrine, and immune systems. Identifying biomarkers of Chronic fatigue (CF) is an important part of this effort. Chronic fatigue (CF) in combination with a minimum of 4 of 8 symptoms and the absence of diseases that could explain these symptoms, constitute the case definition for chronic fatigue syndrome/myalgic encephalomyelitis (CFS/ME). Inflammation, immune system activation, autonomic dysfunction, impaired functioning in the hypothalamic- pituitary-adrenal axis, and neuroendocrine dysregulation have all been suggested as root causes of fatigue. Although AI/ML algorithms can assist fatigue monitoring, true reasons can only be understood by using studies using technology like biomarkers.

Fatigue monitoring is a necessary step in maintaining the safety of the mining operation, to safeguard the operators, and maintain high levels of efficiency. Mining operators can readily start to gain an advantage by deploying fatigue monitoring systems. Gaussian Solutions LLC has worked with clients to custom design solutions for their needs. With the advances in mobile processing, it is possible to quickly start deploying solutions using mobile phones. However, this solution is not robust. Dedicated cameras, and edge computing devices that are ruggedized to work in the mines are needed to achieve the reliability and availability needed in the mining industry. Good connectivity and real-time analytics are needed for the safety managers to monitor and take corrective actions when a driver's lack of attentiveness is detected. Mining operators should approach the problem with agility, and

be able to quickly deploy solutions, test, and improve on the deployments. A rapid development, deployment, test, monitor, and redo mantra should be adopted. All the data analyzed, and insights gained should be shared with the mining community to improve the overall state of the safety measures in a mine. Finding good analytics and machine learning partner will help a mining company progress faster and achieve greater results.

APPLICATION OF TDR-WSN-IOT FOR SLOPE MONITORING

Laboratory Experiment

A laboratory test was carried out on the TDR system to check the response of the TDR with the applied deformation. RG-6 type of co-axial cable is selected, and the reading is taken in the PC-TDR software. Laboratory set-up used to test the response of the TDR to applied deformation is shown in Figure 6, and 7. The response of TDR is then to be determined with deformation applied precisely mm by mm using the open cast model. RG-6 is used for the test with the specifications. RG-6 is used for the test with the specifications:

(I) Velocity of propagation (V_P) = 66% = 0.75
(II) Maximum Operating Frequency = 1 GHz
(III) Diameter(mm) = 6.5 mm
(IV) Operating temperature(C) = -40^0 to $+80^0$
(V) Characteristic Impedance(Ù) = 75

In the first test, RG-6 type of co-axial cable was deformed by model, and the TDR response was checked. This Open Cast (OC) mine model was designed using a Plexiglas and represents the open cast mine with three numbers of benches. The arrangement is done so that middle bench can move forward representing the bench movement. The model was having the arrangement of scale so that displacement can be measured. Table 1. Shows the reading of the reflection coefficients taken by TDR system when deformation applied by model. Same results are represented in graphical form in **Figure 8.**

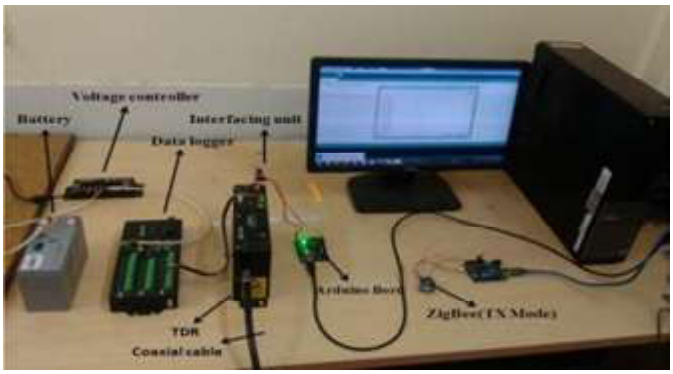

Figure 6 : Electronic instruments used for a laboratory experiment

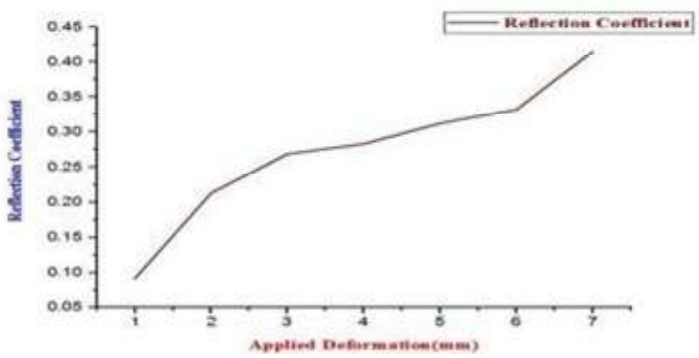

Fig. 8: Reflection Coefficient Vs. Applied Deformation

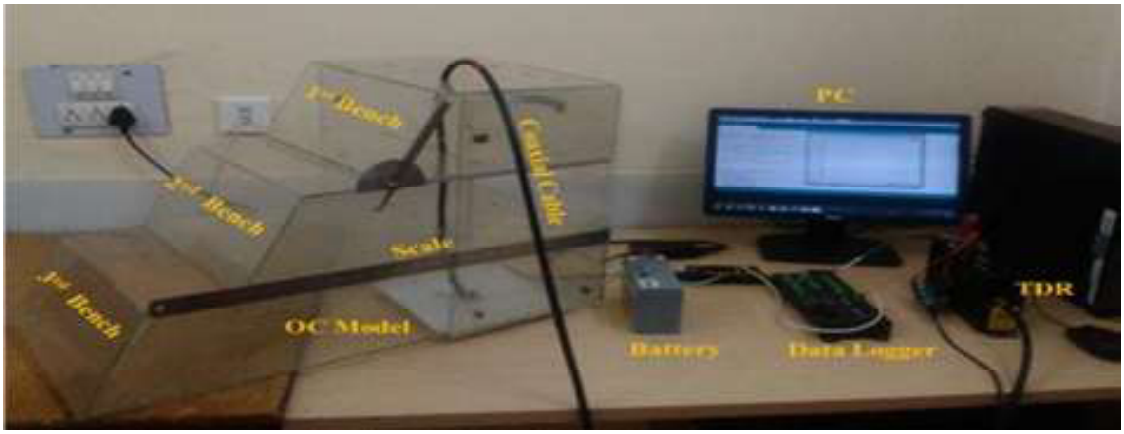

Figure 7: Set up used for the laboratory test

The reflection coefficient is a parameter that describes how much of an electromagnetic wave is reflected by an impedance discontinuity in the transmission medium. It is equal to the ratio of the amplitude of the reflected wave to the incident wave (Dowding *et al*., 1988; Kane *et al*., 2001; Lin, 2009). The impedance of the coaxial cables changes with the applied deformation, so a higher value of the reflection compared with other points of the cable. It can be concluded from the results of the above test that TDR senses the deformation occurring along the coaxial cable sensitively. It can be used successfully for the slope stability monitoring of the open cast mines. Changes in reflection coefficient caused by deformation of the cable are best modeled regarding changes in impedance and expressed as follows:

$$\text{Reflection Coefficient } (\rho) = (Z1 - Z0) / (Z1 + Z0) \quad (2)$$

Here, $Z1$ = characteristic impedance of the deformed section of cable and $Z0$ = characteristic impedance of the unreformed cable. Changes in ñ caused by deformation in the cable. The characteristic impedance increases due to the applied deformation so that reflection coefficient also increases.From the reflection theory, the applied deformation changes the shape of the cable results in the variation of impedance in the cable at a particular location (Kane, 1996; Kane *et al*., 2004). So some of the energy is reflected back from the shear zone, and after capturing the reflected wave, TDR analyses both signals and gives the output in the form reflection coefficient values. The change in capacitance and characteristic impedance at the location of cable deformation gives the change in the reflection coefficient also. A linear relationship between reflection coefficient and deformation was observed (Dowding *et al*., 1989; Dowding and Kevin, 2000). This result was considered encouraging because it suggests that, for a given type of cable, there is a direct, linear, and measurable relationship between the cable signal and shear deformation. In laboratory shear testing, the setup was simulated to know the intensity of slope movement. The TDR senses the slope movement of the coaxial cable injected into the slope. Two types of coaxial cables were employed here—RG-6 and RG-213. For RG-6 cable, the average highest magnitude of coaxial cable deformity by shear failure was 11 mm, equivalent to RC of 0.49 beyond which the cable breached as shoen in table 1. For RG-213, the average highest magnitude of coaxial cable deformity by shear failure was 14 mm, equivalent to RC of 0.050 beyond which the cable breached as shown in table 2. fter concluding the experimental results of laboratory testing, it was also observed that RG-6 cable is more responsive as compared to other coaxial cables used in this research work and it is cost-effective too. Due to this, RG-6 can be preferably used for installation in mine site for slope monitoring.

LORA TEST

The LoRa module used here for surveillance is from Pycom and its version is Lopy 1.0r. The antenna used at the transmitting and receiving end is 6 dBi with 900 MHz. Both the antennas were mounted at a height of 6 meters above the ground throughout the testing phase. The temperature during the testing was 29 °C whereas the humidity was 67%. The power consumption of these LoRa modules while data transmission was 14dBm. The experiment in Rourkela was performed within the distance range of 1 m to 2000 m in the case of SF-6. For SF-6, the average RSSI value ranges from -50 dBm to -130 dBm whereas the average SNR value ranges from 6 dB to -8 dB as shown in figure 9.

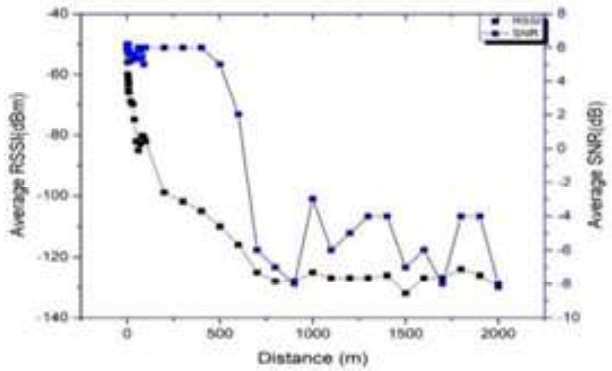

Figure 9: Average RSSI vs distance and average SNR vs distance with SF-6 in Rourkela

FIOTSM

The FIoTSM system. Initially, the prototype of the proposed system was tested with the open-cast mines model as shown in figure 10.The results of TDR behavior with the RG-6 coaxial cable under different test conditions strongly suggest that TDR can be used to determine the rate of ground movement of the slope failure along the TDR cable locations, provided calibration curves are obtained for each location. Testing of the coaxial cable with TDR and OC model indicated the reflection coefficient of 0.0916 - 0.415 vis-à-vis increase in the deformation

from 0mm-7mm. Testing of coaxial cable with TDR and press machine indicated the reflection coefficient of 0.135 – 0.89 vis-à-vis change in the diameter of the cable 0mm-4.4mm. These encouraging results were considered for implementing the above TDR system of slopemonitoring in the opencast mines in India as a part of Ministry of Mines, Government of India (GOI) sponsored the project. This result suggests that small shear Displacements and loads the TDR can be detected the signal reflections may be sufficient to quantify rock or soil movement. This graphic procedure allows visual determination of the cable deformation directly from the reflection amplitude. Rock/soil shear deformation can be effectively quantified when TDR reflections are sufficient amplitude to allow reliable quantification. Recommendations are given for continuing implementation by TDR for slope monitoring.

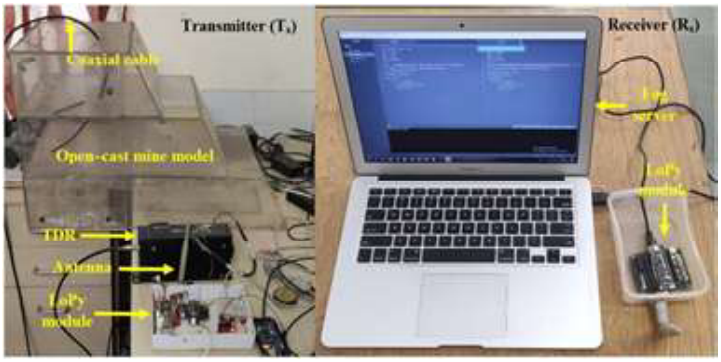

Figure 10: Prototype of the FIoTSM system

CONCLUSIONS

The mining industry should pay more attention to improve the productivity by upgrading the technology. Without changing technology, the allied industry has lagged behind the productivity to be achieved as per demand. Some of the recently developed systems through projects related to TTIORA emphasizes on urgent need of TTIORA for sustainable development of mining industries. Fatigue affects all of us, regardless of our skills, training, and knowledge. It influences your physical and mental abilities needed for even the simplest of tasks. As there is myriad of factors that can contribute to fatigue, there is no one single way to eliminate fatigue. A holistic approach to reduce fatigue that encompasses physical, mental, situational and ambient factors is necessary. Integration of multiple systems that exist today to monitor each of the factors is necessary. Machine Learning and data analytics have been proven effective to collect data from different sources and find actionable insights from them. Although AI/ML algorithms can assist fatigue monitoring, true reasons can only be understood by using studies using technology like biomarkers.

Applying such techniques to fatigue monitoring can benefit the operator, mining operations, and overall productivity. Emphasize is made for urgent implementation of transdisciplinary translational industry oriented research and academics with some of the technologies (Artificial Intelligence and Machine learning) used to monitor and assess the fatigue levels of the work personnel working in various capacities as vehicle drivers, hauler/conveyor operators, pump operators, or any moving machinery operators etc., both in underground as well as surface mining conditions in the Mining Industry. Benefits of Fatigue Monitoring results in increased operator productivity and reduction in incidents and accidents. The results of TDR behavior with the RG-6 coaxial cable under different test conditions strongly suggest that TDR can be used to determine the rate of ground movement of the slope failure along the TDR cable locations, provided calibration curves are obtained for each location. Recommendations are given for continuing implementation by TDR for slope monitoring, ans also TTIORA with various departments including DGMS, academic and research organizations in collaboration with the industry for improved safety.

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