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this issue contains...

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President's Message.....

Dear Readers

Greetings!

Such has been the pervasive influence of Covid-19 that a year after its onset, no discussion on economic, business or credit quality outlook can be de-linked from it. While the first wave of the pandemic dragged the Indian economy into its deepest contraction since Independence, the effects of the second ongoing Covid-19 wave are yet to be assessed. It is said that the resurgence of Covid-19 has dented the economic activity in the first half of the first quarter of FY 2021-22. Past two months have been challenging for all of us, the entire health system of the country has been jeopardised.

I want to highlight two important aspects that proved its importance during the pandemic and need to be embraced immediately. Firstly, Covid-19 pandemic has reinforced the need for organizations to establish a robust risk management framework and initiate a formal Enterprise Risk Management (ERM) program to assess their readiness on the 'risks that impact' their business. The ERM is a dynamic journey that needs regular review to access and prepare for the possible risks that can dis-balance the business.

Secondly, the outbreak of Covid-19 has made it imperative for companies to adapt to technological changes, changing business models, e-commerce and new growth avenues to reach the consumers. Investment in technology and its adoption will help in embracing the new normal at a faster pace.

It gives me immense pleasure to share with the readers that SME (USA) has approved RCP of NACRI as a Competent Person. It is a great achievement for the MEAI and would not have been possible without the hard work and perseverance of some of the MEAI members. I would like to heartily congratulate the members for this achievement.

MEAI has embraced the new normal very well by adopting technological solutions and continuing its journey of imparting knowledge to mining and other professionals through a series of knowledge sharing webinars on varied topics. In this series, the Belgaum Chapter of MEAI, in association with Geological Society India, Regional Centre and G.S.S. College of Belagavi has organised a virtual lecture on Hydrology of Hard rock Region.

MEAI members have also participated in a webinar on "Modalities of Price Indexing in India" organised by Metalogic PMS and contributed with their suggestions in building the National Mineral Index. I would like to congratulate the Ahmedabad and Hyderabad Chapters for electing a new executive body for the term 2021-2023.

During the month, MEAI also consulted its members internally and submitted its suggestions and recommendations on Draft 'Mineral Auction Second Amendment Rules 2021' to the Ministry of Mines as a part of stakeholder comments.

In conclusions, I would like to caution the readers to take all precautions against the Covid-19 pandemic and insist that they get inoculated as per their turn. Following the Covid-19 appropriate behaviour is the need of the hour.

Stay safe, stay healthy.

With best wishes,

Sanjay Kumar Pattnaik
President

Mining Engineers' Association of India

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EDITOR'S DESK

Dr. P.V. Rao
Editor, MEJ

For the members of our Association, the MEAI, and the supporting organisations viz. Geological Society, FIMI and ASSOCHAM, the August 1, 2019 became an extraordinary day to celebrate as the CRIRSCO (Committee for Mineral Reserves International Reporting Standards), an international body of repute, recognised it as the Professional Organisation (PO) in India, the National Committee for Reporting Mineral Resources and Reserves in India (NACRI) as the National Reporting Organisation for reporting Mineral Resources and Reserves in India (NRO), and the NACRI developed Indian Mineral Industry Code (IMIC) as the National Code for India.

The focus of the PDP has been to clarify the trainees on every aspect of the IMIC, illustrated with examples.

The MEAI in its mission to train the mineral industry professionals and enable them register as Competent Persons (CP) for smooth implementation of the IMIC in India, has launched the virtual mandatory 40-hour IMIC Professional Development Program (PDP) on January 4, 2021. The NACRI sponsored PDP spread over a 4 weeks period, with 3 days in a week (Monday, Wednesday and Friday) from 5pm to 8pm. Dr A. Srikant, one of the founding members of the NACRI and an eminent mineral industry professional with over four decades of industry and teaching experience in India and abroad, volunteered to coordinate and rollout the virtual PDP on IMIC. The NACRI Managing Committee formed a 10-member Professional Development Core team from amongst the NACRI members to conceptualise a detailed training schedule for the prospective CPs on all intricate aspects of IMIC, MEAI and NACRI, and the mineral industry best practices. The delegates to the NACRI held PDP was a paid program and had to pay a fee of Rs 10000, which included applicable 18% GST. The faculty from the NACRI were magnanimous enough to offer their free services voluntarily.

The focus of the PDP has been to clarify the trainees on every aspect of the IMIC, illustrated with examples. Key topics covered in the PDP included Scope of the IMIC and Code of Ethics, Competence and Responsibility, Reporting of Exploration Targets, Exploration Results, Mineral Resources and Mineral Reserves, Accuracy of estimates, Checklist of Assessment and Reporting Criteria, Technical Studies - Scoping, PFS and FS, Estimating Capital Costs and Operating Costs, Reasonable Prospects for Eventual Economic Extraction (RPEEE), Community and Sustainability issues, Permitting and Legal issues, Discussion on UNFC and IMIC, Best Practices in Report Layout and Content, Exploration, Mineral Resource estimation, Quality Control, and Technical Studies - Drilling, Sampling, Storage, Geotechnical Engineering and Mine Design. High professional standards were adopted in conducting the PDP by ensuring minimum attendance, weekly online evaluation of each participant, as the participants needed to secure the minimum qualifying marks (50%) to gain eligibility for CP registration. 23 candidates attended the first PDP, and the NACRI issued formal certificates of training to all successful candidates. Candidates from mining and consulting companies such as Dalmia Cements, DataCode, Deccan Gold mines, DMT, GeoVale, HZL, Ramagad Minerals, SRK, and Tata Steel attended the first PDP.

Considering the overwhelming success accomplished from the first PDP held in January 2021, the NACRI rolled out the second PDP on IMIC on 5-30 April 2021. In all, 21 participants attended the second PDP from leading mining companies viz. NMDC Ltd, JSW Ltd, HGM Ltd, and ERM Group of Companies. It is heartening to note that in both the PDPs, a few self-employed professionals also participated. The timelines of the next PDP on IMIC shall be announced by the NACRI shortly.

For the MEAI HQs to register a CP, it is obligatory for the RCP to be a mineral industry professional, a Life Member of MEAI, and present proof of a minimum of ten years professional experience. In addition to the above, the incumbent must present to MEAI HQs proof of successfully attending the mandatory 40-hour IMIC PDP organised by the NACRI and payment of annual CP registration fee of Rs 5000 (plus applicable 18% GST). I am happy to inform the readers that some candidates who successfully attended the first or second PDP on IMIC have already registered as CPs.

Dr Abani Samal, another founding member and the Managing Committee Member of the NACRI has successfully steered our application with the SME (Society for Mining, Metallurgy & Exploration), USA for reciprocity and consequently the SME has recognised the MEAI as its overseas RPO from India and its RCP as a Competent Person under the SME Guide on May 13, 2021. The efforts to attain similar reciprocity with other member countries of the CRIRSCO are in progress.

. - Editor

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NEWS FROM THE MINING WORLD

➤ From digging to electric fields: new technique to extract metals from hard rock ore

An international group of scientists has developed a new mining technique that uses electric fields, instead of digging, to extract metals from hard rock ore.

In a paper published in the journal Science Advances, the researchers say the methodology consists of installing electrodes within a given ore body and applying electric currents that could induce the transport of electrically charged metals such as copper through rocks by a process called electromigration.

The technique is called electrokinetic in situ leaching (EK-ISL) and it has been previously applied for metal recovery from fly ash, wastewater sludge, soils, and mine tailings materials but not for the recovery of metals from intact hard rock bodies.

EK-ISL combines two existing technologies: in situ leaching, which comprises the application of a lixiviant to selectively dissolve target metals from their ore without excavating its host matrix, and electrokinetics, which comprises the application of a targeted electric field to control and accelerate the transport of the lixiviant or dissolved target metals within the subsurface.

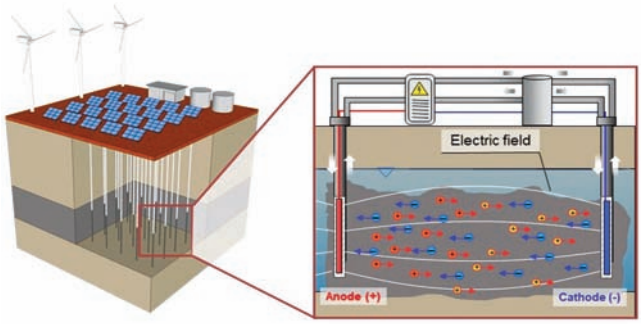


Illustration of metal extraction from a subsurface ore body via EK-ISL. (Courtesy of the University of Western Australia).

"The metals are extracted within the ore body, instead of the traditional means of having to dig them out and milling huge amounts of material," Henning Prommer, coauthor of the study and a professor at the University of Western Australia, said in a media statement. "Traditional methods of excavating ore material result in a large amount of solid waste brought to the Earth's surface which needs to be disposed of, whereas this new method dramatically decreases wastage."

According to Prommer, global estimates place solid waste from mining at 100 gigatonnes per year, which is significantly larger than any other form of waste generated by humans.

In addition to the environmental consequences of such disposal, Prommer and his colleagues pointed out that the current mining paradigm can be considered unsustainable because, for example, in the past decade there has been a major decline in the discovery of shallow copper ore deposits while the average ore cutoff grade has also decreased by approximately 25%.

"Many Cu deposits currently deemed 'Tier 1,' such as the Pebble East giant copper-gold deposit in Alaska (USA) and the deeper ore zones at the Escondida porphyry Cu deposit in Chile, are buried by hundreds of meters of overburden. Under these circumstances, conventional Cu mining becomes increasingly challenging because of the necessity to remove, process, and store large quantities of waste rock," the experts wrote.

In addition to this, their data show that the economic viability of processing such diminishing grade material by relying on the non-stop improvement in the efficiency of mining technologies and the economy of scale means using more energy, water, and land per unit mass of extracted copper.

"Similar considerations also apply for many other commodities," the researchers adduce. "Consequently, the current mining paradigm can be considered inherently unsustainable, and there is a recognized need for the development of new approaches for more sustainable exploitation of known but currently unviable metal deposits."

The EK-ISL technique, which proved to be thermodynamically viable to leach Cu at ambient temperature and pressure using relatively environmentally benign lixiviants such as ferric chloride, was tested in laboratory experiments and through computer modelling.

After successfully extracting copper from an intact sulfidic porphyry Cu ore drill core sample, the group is confident the idea will also work in the field, not only for copper but also for a wide range of other metals.

"This is really exciting because we can use intermittent power sources such as solar and wind to extract minerals," Prommer said.

Valentina Ruiz Leotaud | May 16, 2021

➤ **Anglo American CEO: "45% of the world's economic activity is driven by the mining sector"**

Tasked with talking about the role of mining in society as part of the opening plenary at this year's virtual CIM convention, Anglo American (LSE: AAL) chief executive Mark Cutifani didn't mince words.

With a world population of 7.6 billion that's growing toward 9 billion, "the simple fact is that the world cannot survive without mining and our contribution to literally every aspect of modern life," Cutifani said.

Cutifani noted that other critical sectors, including energy, food production, construction, transportation, renewables infrastructure and communications all rely on mining. "In fact, 45% of the world's economic activity is driven by the mining sector," he said, counting both direct commodities sales and mining's support of other industries (including the productivity improvements that come with mechanized farming, for example).

Not only that, but compared to agriculture's footprint – which takes up 50% of the world's habitable land – mining only takes up 0.04%.

That is "literally the smallest footprint relative to our economic contribution than any other industry." However, there remains a gulf between the public perception of mining and the reality of mining. "Even with all the contributions we make, people tend to see us an industry that takes more than it gives," he said noting that the mining industry bears some responsibility for that. "One of the things we don't do well as industry is talk about what we do."

Life-of-community plans

The role of mining and mining companies' relationships with local communities is also changing, in step with advances in technology and the increasing focus on sustainability. For example, as part of its sustainability goals – which revolve around supporting a healthy environment and thriving communities and being a trusted corporate leader – Anglo has committed to support the creation of five jobs offsite for every one onsite.

"When we talk about life-of-mine plans, we're also now starting to focus on life-of-community plans and how we can create 100 years future for those communities based on the infrastructure that we can bring as part of our mine development," Cutifani said. The company's microfinancing programs in South Africa and South America have supported the creation of 137,000 jobs, he noted. And the development of a reverse osmosis water purification facility in South Africa has opened up new opportunities for agriculture and for locals to enter new industries that rely on clean water.

"We understand the impact of technology and future of work will have. . . so we understand that we have to be a catalyst in those local communities for new jobs." As the focus on sustainability and climate change increase, those pressures are already starting to reshape mining. "Ten years ago, we used to define ourselves as a mining company, and for most, that created an image of a company digging holes," Cutifani said. "In 2018, we redefined our own conversation about ourselves and took the way our customers were describing us – and that is as a metals and minerals company."

Looking another 10 to 20 years into the future, Anglo (which currently mines everything from iron ore to precious and base metals to diamonds and more) sees itself becoming a "materials solutions company." That vision incorporates an understanding of how the company will support the circular economy (including more recycling) and efforts against climate change, and the need to adjust its portfolio to the needs of society. The goal, Cutifani said, is to understand where the world is going and become a catalyst to get there quicker.

"We need to help people understand what we do and how critical we are – we need to be a partner in society in creating a new future," he said. "We are the key to decarbonization and creating a long-term sustainable planet." Cutifani also urged miners "to take the time to understand our role in society and make sure we're creating the future, we're not becoming a victim of the future." His remarks came during a panel, which was moderated by Jerrod Downey, president of Crownsmen Partners, and included Jody Kuzenko, president and CEO of Torex Gold Resources (TSX: TXG), David Cataford, president and CEO of Champion Iron (TSX: CIA; ASX; CIA), and Denise Johnson, group president of Caterpillar.

The wider theme of the plenary session was "resilient and thriving," with the discussion touching on diversity and inclusion in mining, sustainability and ESG, and the impact of covid-19 on the industry.

Alisha Hiyate - the Canadian Mining Journal | 3/3/2021

➤ **New bull chart for $30,000 copper price: porphyries nearly mined out**

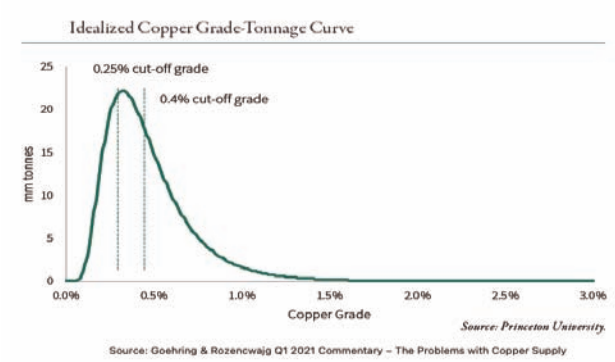
Predictions for copper at double or triple today's level is a fairly recent phenomenon – and bears still outnumber bulls as to what's next for the bellwether metal.

Wall Street natural resource investment house Goehring & Rozencwajg Associates confirmed their place in the superbull camp this week, predicting a copper price north of $30,000:

"The previous copper bull market took place between 2001 and 2011 and saw prices rise seven-fold: from $0.60 to $4.62 per pound. The fundamentals today are even more bullish.

"We would not be surprised to see copper prices again advance a minimum of seven-fold before this bull market is over. Using $1.95 as our starting point, we expect copper prices to potentially peak near $15 per pound by the latter part of this decade." The rosy demand side for copper has been well documented and Goehring & Rozencwajg focuses on supply, specifically depletion in their latest commentary. Depletion, surprisingly, is not discussed that often in the industry and according to the authors is little understood, despite its fundamental importance for long-term supply trends.

Low and declining grades, uninspiring green and brownfield discoveries (with a few exceptions) and thin, slow project pipelines have become rules of thumb in the copper mining industry. To those issues, the report adds copper miners' habit of high-grading (mining your best quality ore first) and growing your reserves with a simple ploy – lowering cut-off grades when prices rise.



Source: Goehring & Rozencwajg Q1 2021 Commentary – The Problems with Copper Supply

Even with prices well above $10,000 a tonne, these paper reserves cannot keep growing, according to Goehring & Rozencwajg, specifically at porphyry deposits which produce 80% of the world's copper. The authors have calculated an industry average cut-off grade of 0.25%, down from 0.4% in the mid-2000s when the firm first started tracking producers' reserve calculations at 115 mines across the globe responsible for four-fifths of total output.

"The copper industry's ability to increase its reserve base by lowering its cut-off grade is nearing an end, regardless of how high copper prices go. It is a complicated but very important subject based on how copper porphyry deposits are geologically formed. "Lowering the cut-off grade clearly cannot go on indefinitely; unlike interest rates there is a firm low at zero. More important, the log-normal shape of the grade-tonnage plot means that most of the reserves have likely already been added.

"Most reserves are located on the right side of the mean where the grade-tonnage curve has a long tail. On the left hand side of the mean, the log-normal distribution shows that the grade-tonnage curve has a very short tail with far few reserves."

Frik Els | May 14, 2021

➤ **2nd tranche of commercial coal mines auction gets tremendous response: Govt**

The Centre on Tuesday said the second tranche of commercial coal mines' auction has received tremendous response which is reflected in around 50 mine specific tender documents being purchased by bidders till date. Moreover, many other prospective bidders are in the process of registration and purchase of tender documents from the auction portal, the coal ministry said in a statement.

"The response to this auction tranche, till now, has been tremendous," it said. The bid submission date has been extended to enable interested parties travel to mine locations for inspection once the lockdown curbs are removed in states, it added. In March, India launched the second tranche of auction for commercial coal mining, offering 67 mines for sale.

Coal Minister Pralhad Joshi launched the auction process in a programme held in New Delhi.

This is the highest number of mines on offer in a particular tranche after commencement of the auction regime in 2014. "This is the second tranche of auction of coal mines for sale of coal which paves way for liberalisation of Indian coal sector enhancing efficiency, competition and private sector participation leading to development of a vibrant coal market, boosting economic growth and employment generation," the statement said.

Out of the total 67 mines offered by the ministry, 23 are under Coal Mines (Special Provisions) Act and 44 under Mines and Minerals (Development and Regulation) Act. The blocks on offer are a mix of mines with small and large reserves, coking and non-coking mines and fully and partially explored blocks spread across six states - Chhattisgarh, Jharkhand, Odisha, Madhya Pradesh, Maharashtra and Andhra Pradesh.

PTI | May 18, 2021

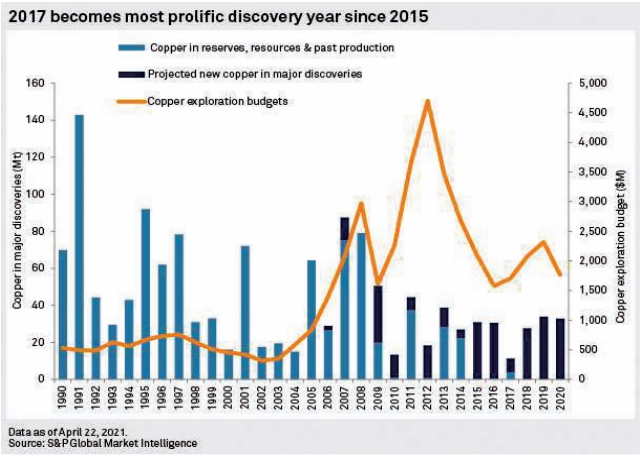
➤ Copper cupboard remains bare as discoveries dwindle — S&P study

The copper industry's continued investment in mostly brownfields exploration opportunities, combined with generally longer timeframes from discovery hole to reserve statement contribute to the continued low rates of major discoveries that can move market fundamentals, an analysis by S&P Global Market Intelligence found.

An analysis of significant copper discoveries between 1990 and 2020 shows that of the 229 deposits discovered in the period, only three were found in the past three years.

While Latin America was the top location for discoveries over the past ten years, the 26.3 Mt of copper found is significantly lower than any other decade since 1990. While this is up from only one identified for the period in S&P's 2020 analysis, the 4.6 million tonnes in the three deposits are well below the total discovered in most years and pales compared to the 1.12 billion lb. copper found over the 20 years.

While Latin America was the top location for discoveries in the past ten years, the 26.3 million tonnes of copper found is significantly lower than the prior decade, S&P reports.



Source: S&P Global Market Intelligence

Although the amount of copper in major discoveries has increased by 46 million tonnes since 2020, much of the increase is at older discoveries made in the 1990s, which have increased by 26.7 million tonnes year over year as a direct result of companies shifting more of their exploration budgets towards known deposits and existing mines, S&P's Corporate Exploration Strategies study found.

While the total amount of copper in major discoveries increased by 46 million tonnes year-over-year in 2021, the bulk of the change was resource growth at existing discoveries. Less than six million tonnes came from newly added discoveries, and of that, only 3.9 million tonnes was in recent years, according to S&P data.

"While it is a testament to the quality of the deposits discovered in the 1990s that new copper continues to be added to their endowment, the lacklustre performance of recent years is concerning," said commodity analyst Luke Nickels during a 'State of the Market: Mining Q1 2021' webinar.

Latin America, which accounts for about 40% of global copper output, is the primary location for copper exploration, attracting more than one-third of copper budgets over the past two decades. This significant effort, mainly focused on Chile and Peru, has resulted in over half of the global discovered copper since 1990.

Chile and Peru alone account for 82% of the 604.6 million tonnes discovered in Latin America and 44% of the global total found since 1990. While Latin America was the top location for discoveries in the past ten years, the 26.3 million tonnes of copper found is significantly lower than any other decade since 1990. Conversely, the discovery rate in Africa and Europe has increased dramatically in the past ten years, together accounting for half of the copper discovered since 2011.

According to S&P, this is mainly due to Ivanhoe Mines' (TSX: IVN) 2014 discovery of the 18.9 million tonne Kakula deposit in the Democratic Republic of Congo and Freeport-McMoRan's (NYSE: FCX) 2011 discovery of the 23.3 million tonne Timok deposit in Serbia.

So acute is the shortage of new substantial discoveries, S&P says the medium-term development pipeline is at risk. Even if projects with a low probability of advancing through to production come online, copper demand is expected to substantially exceed mined output by 2028, with refined supply deficits expected to start in 2021.

S&P cautions that of the 229 major discoveries included in this analysis, 146 are not in production, including 114 yet to complete feasibility studies. Just 11 have finalised construction plans and begun development.

"This is insufficient not only to meet demand increases but to offset production decreases at existing operations. Significant investment of time and money will be required of the industry within the next several

years to ensure that the projects in the pipeline meet this medium-term supply pinch," says Nickels.

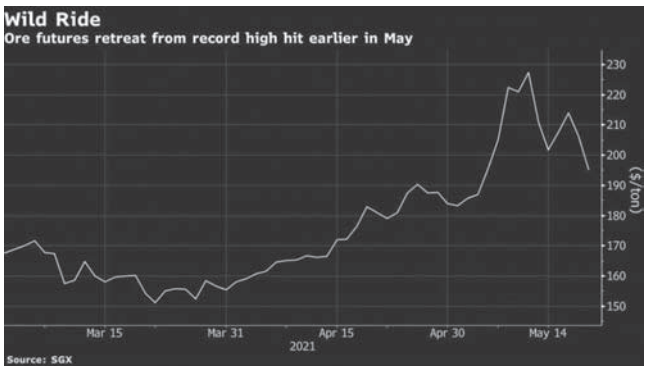
MINING.COM Staff Writer | May 20, 2021

➤ Giant new iron ore mine may aid China's push to cool prices

BHP's start up of production at the South Flank project may help temporarily cool a hot market. (Image of the Western Australia Iron Ore complex, which hosts South Flank. Courtesy of BHP).

BHP Group's start-up of production at its $3.6 billion South Flank project in Australia — combined with existing operations at the site — will create the world's biggest iron ore hub. It may also help temporarily cool a hot market.

Iron ore futures are trading below $200 a ton after China's cabinet called for tougher oversight of commodity markets and protection for consumers from soaring prices. While South Flank was a replacement mine, the announcement of a big mine coming on stream can add short-term to negative market talk, according to Peter O'Connor, mining analyst at Shaw & Partners Ltd.



Commodities have tumbled as international markets are gripped by inflation fears and the authorities in Beijing continue to try to jawbone and manage prices lower. China's cabinet expressed concerns Wednesday about the surge in prices for a second week in a row, calling for more effort to curb "unreasonable" gains and prevent any impact on consumer prices. The meeting, chaired by Premier Li Keqiang, also called for a crackdown on speculation and hoarding.

Against this backdrop, where steel margins were getting compressed in China and Li was trying to talk commodities down, "it weighs on that narrative as opposed to really weighing on the market," O'Connor said. "But when you get these sort of extremes — that subjective narrative can be a key driver."

South Flank has been built to replace the depleting Yandi mine — and together with the existing Mining Area C — will form a hub with annual production of 145 million tons a year. South Flank's higher quality product will also lift the average iron ore grade across BHP's Pilbara operations. In the short-term, there was potential for a squeeze higher in BHP's ore exports as South Flank and Yandi operated in tandem, although the overall physical impact on the market was likely to be small, said O'Connor.

The start of production of 80 million tons a year at South Flank, matching Yandi, comes at a time when top exporters Australia and Brazil have been challenged in meeting strong demand from Chinese steel mills. Pilbara shipments were down 6% in April compared to the year-ago period, while Brazil's exports were flat, according to Bloomberg Intelligence. BHP's current guidance is for annual production at the upper end of its range of 276-286 million tons.

Bloomberg News | May 20, 2021

➤ Research reveals formation of ultra high-grade gold

The high-grade Fosterville mine in Victoria. Image: Kirkland Lake Gold

The secret behind the formation of bonanza gold deposits has been revealed by two researchers from Canada's McGill University. Professor Anthony Williams-Jones of the Department of Earth and Planetary Sciences and PhD student Duncan McLeish recognised the implausible nature of "ultra high-grade"

(Continued on Page 32)

GEOTECHNICAL STUDY TO EVALUATE PIT SLOPE DESIGN OF A LIMESTONE OPENCAST MINE - A CASE STUDY

Dr J. C. Jhanwar[1]*, Dr. C. P. Verma[2]*, Mr. A. G. Sangode[3]*, Mr. S. Kumbhakar[4]*

Abstract

This paper deals with a geotechnical study conducted at a mechanised limestone opencast mine attached to a cement plant in India. The study consists of comprehensive field investigations and detailed slope stability analysis to evaluate pit slope design, which can enable optimum mineral extraction while maintaining pit slope stability. The slope mass at this mine mainly consists of dolomite and limestone overlain by up to 40 m thick soil cover in some slope sections. The Rock Quality Designation across different rocks varies from 76 to 90, which signify very good rock quality. The Uni-axial compressive strength of limestone and dolomitic limestone varies in the ranges of 51 - 78 MPa and 81 - 112 MPa respectively, which signify Strong to Very Strong rocks. The limestone & dolomitic limestone are classified as good to very good rock mass based on Rock Mass Rating classification approach. Detailed stability analysis is carried out to evaluate optimum pit slope designs for different slope sections at this mine for an ultimate pit depth of 140 m. The recommended slope designs include overall pit slope angle, overall slope angles for rock slope and soil slope, bench width, bench height, ramp width and inter-ramp slope angle. Sensitivity analysis is carried out to study the relative influence of the change in cohesion and angle of internal friction on the factor of safety. Further, different remedial and control measures are suggested for implementation during the execution of recommended slope design for optimum mineral extraction along with pit slope stability.

Key Words: Opencast Limestone mine; Rock mass; Stability analysis; Pit slope design.

INTRODUCTION

The mine is situated in the state of Rajasthan (India) at a distance of 03 km from the National Highway connecting Jaipur and Delhi. This is a mechanized opencast mine, which produces limestone of an order of 5.0 MT/year at a stripping ratio of 1:0.7 (Limestone:Waste) for supply to the attached cement plant. The elevation of mining lease (ML) area ranges from 365 m to 455 m above MSL with a general ground level at 365 above MSL. The current and proposed ultimate pit depth of this mine are at 75 m and 140 m respectively. The bench height and minimum bench width each are maintained at 10 m with an existing overall slope angle in the range of 20 - 40 degree. The mine management wants to achieve optimum extraction of limestone while maintaining pit slope stability through the execution of a scientific pit slope design. In view of this, a geotechnical study is carried out at this mine to evaluate optimum pit slope designs suited to different slope sections. The mining lease area consists of few isolated relict hills, mostly composed of cement grade limestone within almost flat alluvial land. A typical view of the limestone mine is shown in Figure 1. A surface cum geological plan of the mine workings is shown in Figure 2. The general slope of the ground within the Core Zone is towards South West except Northern portion of the lease area. The depth to water table ranges from 30 m to 35 m below the land surface in alluvium and from 35 m to 40 m below the land surface in limestone.

GEOLOGY

General strike direction of the formations of this area is NE-SW with a variable dip. The limestone occurs as isolated outcrops separated from each other by soil and talus overburden. Intrusions of Granite/Pegmatite/Quartz veins and Amphibolite/Ultrabasic rocks are seen at places. The limestone deposit belongs to Ajabgarh Group of Delhi Super Group of Precambrian age. The limestone is light to dark grey in colour, massive, medium to coarse grained and crystalline in nature. Colour banding is seen at some places. Two separate parallel bands of limestone are noticed in the area, which are separated by dolomite bands. The geological succession of the litho units of this region are shown in Table 1. The limestone is seen intruded at places by pegmatite, quartz veins calc-argillaceous formation and amphibolites. At places, development of Actinolite and hornblende is seen in association with other silicate rocks. Genetically, the limestone is high grade but due to structural deformations

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Figure - 1: Typical view of the limestone mine

and intrusions a wide variation of calcium, magnesium and silica is expected. The width of individual limestone bands varies widely from 250 m to 800 m due to various phases of structural disturbances. The limestone bands are inclined with general dip varying from 40°~60° towards east (Ref. 2 & 7).

Table - 1: The stratigraphic succession of litho-units in the area

Delhi Super Group (Pre Cambrian)	**Ajabgarh Group** Upper phyllite, Limestone, Biotite Limestone, and Calc-Gneiss, Calschit, Phyllites, Biotite, Schist, Calciphyres and Hornfels	**Intrusions** Granites, Pegmatites, Ultrabasic, Quartz Veins and Amphibolite
	Alwar Group: Quartzites, Arkos Grits and Conglomerates ----------UNCONFORMITY---------- **Railo Group** Garnetiferrous Biotite Schists, Limestone, Dolomitic Limestone, Local Basalt grit.	Aplogranites, Epidiorites and Hornblende-Schists, Ultrabasic
Aravalli Super Group	Impure Limestone, Quartzites, Phyllite, Biotite-Schists, Composite Gneiss Quartzite, Grits and Local Soda- Syentites, Conglomerates. Local Amygdaloids and Tuffs	

ASSESSMENT OF INTACT ROCK AND ROCK MASS

The quality of intact rocks and rock mass of this mine are assessed through the determination of rock quality designation (RQD), uni-axial compressive strength and rock mass rating (RMR) (Bieniawski, 1989).

Rock Quality Designation (RQD)

The RQD (Deere,1989) was estimated from the rock core logs of 03 numbers of bore holes drilled at different locations in the mine area. The bore-hole wise RQD across different rocks in this mine has varied from 67.31 to 89.18 and the rock wise RQD across different bore holes has varied from 76.06 to 90.52. Based on RQD, the rock quality of limestone and dolomitic limestone at this mine are categorized as "Very *Good".*

Compressive Strength of In-tact Rocks

The rock samples for laboratory testing were selected from rock cores obtained from bore hole drilling at different locations in the mine. Some of the rock core samples. The uni-axial compressive strength of limestone and dolomitic limestone varies in the ranges of 51.16 - 78.81 MPa and 81.65 - 112.75 MPa respectively. The limestone and dolomitic limestone at this mine are accordingly classified as strong rocks and as strong to very strong rocks respectively (Ref. 2 & 6).

Rock Mass Rating (RMR)

The RMR classification approach as proposed by Bieniawski, 1989 is considered in this study to assess the rock mass quality. The RMR at different locations in the mine

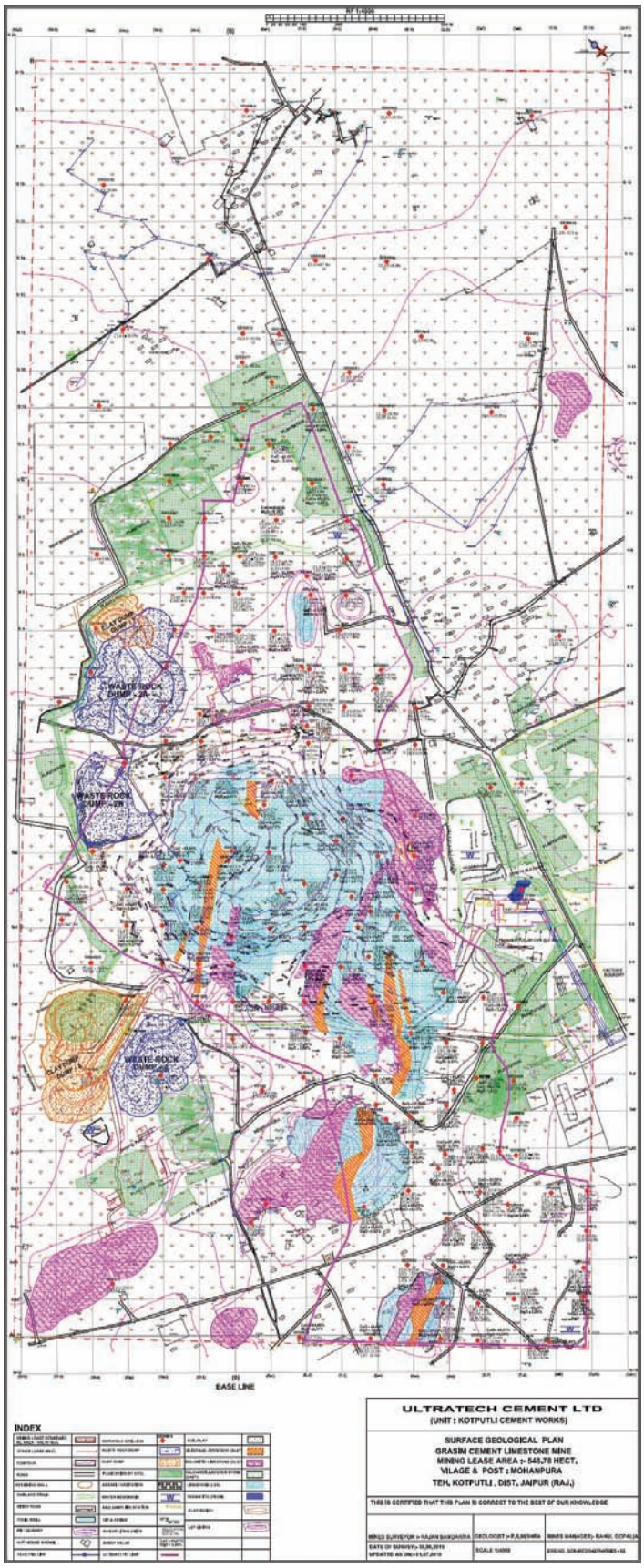


Figure - 2: A surface cum geological plan of the limestone mine

is estimated by assessing different parameters and their ratings at respective locations in the benches (Table 2). The basic RMR in respect of limestone & dolomitic limestone varies from 62 to 78 and 68 to 82 respectively. Based on RMR, these rock masses are classified as Good to Very Good rock mass.

STRUCTURAL MAPPING

General Detail

The structural mapping of exposed rock masses at different locations on various benches of this limestone mine is carried out. The rock mass is found to be sparsely to closely jointed. There are 2-3 joint sets, which include a bedding joint and a semi vertical joint and random joints. The joints are very closely to widely spaced. The joint spacing mostly varies widely over a range of 04 - 200 cm. The joints are rough and undulating and are tight to slightly open at places with either no fillings or with filling of weathered/crushed material. The joints have low to medium persistence in the range of 1 - 8 m. The typical views of rock masses on different benches are shown in Figure 3 (a & b). Analysis of the structural geology data is carried out using stereographic projections to identify discontinuity sets, and to examine their influence on slope stability.

In this analysis, the friction angle is considered at 35^0, whereas bench slope angles are considered as per the actual field measurements. Stereographic projections/great circles of joints and slopes with respect to two different locations are shown in Figure 4. The orientation of these joints vis-à-vis the slope orientation indicate formation of small wedges and likelihood of planar instability conditions on bench scales at some locations. However, the joint conditions are not likely to support any significant wedge and planar instabilities even on bench scale. At some places, the orientations of joints are found favourable from the slope stability point of view. However, in view of the existing structural exposures and rock mass characteristics, any significant structurally controlled slope instability seems unlikely at this mine.

PIT SLOPE STABILITY

Stability Analysis

Stability analysis for pit slopes at this mine is conducted through Bishop Simplified and Morganstern-Price methods using the Slope Stability Analysis Softwares, GALENA (v 6.1) and Geo-Studio 2007 (v. SLOPE 7.23) respectively. These softwares work on limit equilibrium method of analysis to determine the factor of safety (FOS). The stability analysis has been performed considering non-circular and circular failure surfaces. The unit weight, cohesion and friction angle of slope forming rock masses are considered in the ranges of 26 - 28 KN/m^3, 200 - 250 KPa and 30^0 - 35^0 respectively. The unit weight, cohesion and friction angle in respect of soil are considered in the ranges of 15 - 18 KN/m^3, 20 - 30 KPa and 15^0 - 20^0 respectively. The stability analyses are conducted

Location	UCS, MPa (Rating)	RQD, % (Rating)	Spacing of discontinuities, cm (Rating)	Condition of discontinuities (Rating)	Ground water (Rating)	Rock Mass Rating (RMR)
Bench: 2, Hill 2, DLST	67 - 126 (7 - 12)	70 - 86 (17)	2 - 139 (10 - 13)	Rough, undulating, hard filling in open joints (20 - 25)	Dry (15)	74 - 82
Bench: 3, 4, 5 & 6, Hill-2, DLST	67 - 126 (7 - 12)	70 - 86 (17)	50 - 200 (6 - 15)	Smooth, plain, closed/open joints, no filling in open joints (18 - 20)	Dry (15)	68 - 79
Bench No. 7, 8 & 9 Hill-2, LST	36 - 65 (4 - 7)	65 - 89 (11-17)	30 - 75 (9 - 11)	Smooth/Rough, wavy, 1 - 5 mm open joints, no filling in open joints (20 - 24)	Dry (15)	62 - 74
Bench No. 4 & 5 Hill-1, DLST	67 - 126 (7 - 12)	70 - 86 (17)	10 – 100 (10 - 13)	Rough, wavy, Closed /1 - 3, 3 - 6 mm open joints, no filling (20 - 25)	Dry (15)	74 - 82
Bench: 8 & 9 Hill-1, LST	67 - 126 (7-12)	70 - 86 (17)	50 - 400 (6 - 15)	Rough, 2 - 10 mm open, no filling (18 - 20)	Dry (15)	68 - 79
Alkali Side, LST	36 - 65 (4-7)	65 - 89 (11 - 17)	20 - 200 (9 - 11)	Smooth/Rough, wavy, closed & 1 - 7 mm open joints, no filling (20 - 24)	Dry (15)	62 - 74
Bench: 7, Dhaula side, LST	36 - 65 (4 - 7)	65 - 89 (11-17)	10 - 120 (6 - 15)	Rough, Closed /3 - 7 mm open joints, no filling (18 - 20)	Dry (15)	62 - 74
Bench: 6, Dhaula side, LST	36 - 65 (4-7)	65 - 89 (11-17)	10 - 75 (6 - 15)	Rough, wavy, closed /1 - 10 mm, open joints, no filling (18 - 20)	Dry (15)	67 - 78
Bench: 5, Dhaula side, DLST	67 - 126 (7-12)	70 - 86 (17)	20 - 200 (10 - 13)	Rough, closed 2 - 15 mm open joints, no filling (20 - 25)	Dry (15)	74 - 82

Table 2 - Details of Rock Mass Rating at different locations

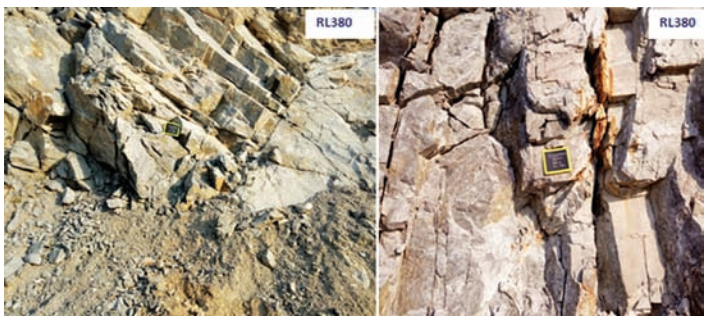


***Figure - 3a**: A view of dolomite rock mass on the 2nd bench of side hill no.2*

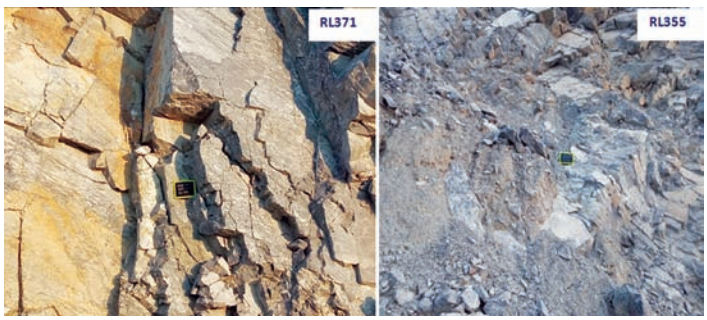


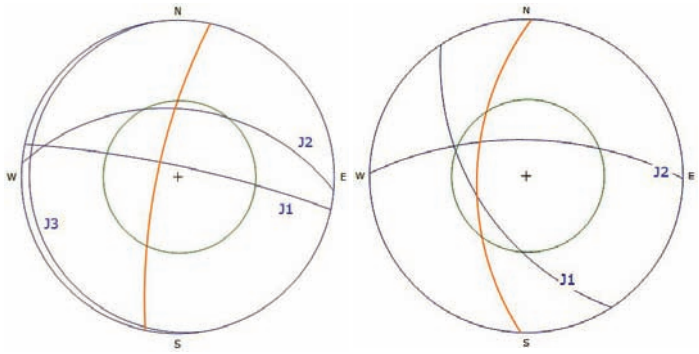
***Figure - 3b**: A view of dolomite rock mass on the 3rd & 4th bench of side hill no.2*

considering fully drained conditions and also considering a phreatic surface due to ground water. The ultimate pit depths/overall slope heights of 140 m is considered in the stability analysis. Typical outputs of stability analysis of pit slopes considering only rock strata and both soil and rock strata are shown in Figures 5, 6 and 7.

Pit Slope Design

The pit slope design is formulated for a safety factor of 1.2 - 1.3. Based on stability analysis, the overall slope angles for ultimate slope heights of 140 m for complete rock slope and rock slope overlain by soil strata of 18-20 m and 40 m thickness are suggested at a maximum of 56 degree, 52.5 degree and 46.5 degree respectively. The inter-ramp slope angle is suggested at 59^0. The bench width and ramp width in rock slope are suggested at a minimum of 4.5 m & 10 m respectively. The bench heights in rock slope and soil slope are suggested at 10 m and 5 - 6 m respectively. The bench width is soil strata is suggested in the range of 6-7 m.

During normal operations, it is however suggested that the higher bench width be maintained as per the operational requirements. With the progressive deepening and lateral expansion of pit workings, geotechnical characteristics of



Location: Dolomite, Bench No. 02,
Hill No: 2,RL - 380

Slope- 750/2820
J1 - 820/120
J2 - 430/50
J3 - 30/2610

Location: Dolomite, Bench No. 02,
Hill No: 2, RL-382

Slope - 550/2720
J1 - 530/2370
J2 - 640/10

Figure - 4: Stereographic projections of bench slopes vis-à-vis joint planes

rock masses and other relevant geotechnical parameters may change and new structural features may get exposed and therefore scientific review of rock mass vis-à-vis slope design/stability is suggested at different stages of mining. Based on progressive reviews, the slope design may need to be revised, if required as the pit deepens and expands.

Sensitivity Analysis

Sensitivity analysis is carried out to study the influence of cohesion and angle of internal friction on the factor of safety and identify which of these two parameters is more significant with respect to the stability of pit slope. There are three litho-units of different thicknesses in the pit slope of 140 m height and three different slope sections are considered in this analysis as mentioned below: (i) Soil: Not present, Dolomitic Limestone: 40 m, Limestone: 100 m (ii) Soil: 20 m, Dolomitic Limestone: 40 m, Limestone: 80 m (iii) Soil: 40 m, Dolomitic Limestone: 40 m, Limestone: 60 m. Based on the analysis, it is observed that factor of safety of overall slope is more sensitive to the angle of internal friction than

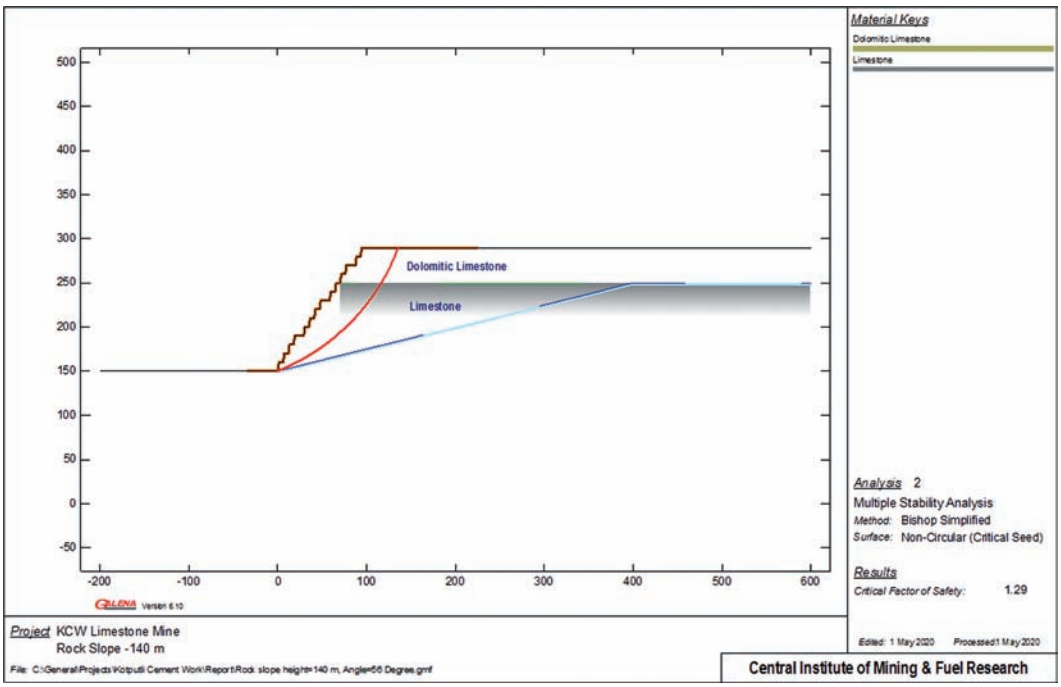


Figure - 5: Stability ananlysis of an overall pit slope of 140 m height with only rock strata

cohesion of limestone and this is applicable to all the three slope sections as indicated in Figures 8 and 9.

CONCLUSIONS AND RECOMMENDATIONS

1. The RQD across different rocks varies from 76 to 90, which signify very good rock quality. The Uni-axial compressive strength of Limestone and Dolomitic limestone varies in the ranges of 51 - 78 MPa & 81 - 112 MPa respectively, which signify Strong to Very Strong rocks. Based on RMR in the range of 62 - 82, the rock masses are classified as Good to Very Good. In view of the existing structural exposures and rock mass characteristics, any large scale structurally controlled slope instability is unlikely at this mine.
2. An overall slope angle of 56^0 is suggested for an ultimate pit depths of 140 m. The overall slope angle for rock slope overlain by 18-20 m and 40 m soil with an overall slope height of 140 m are suggested at 52.5^0 and 46.5^0 respectively. The inter-ramp slope angle and ramp width are suggested at 59^0 and 10 m respectively.

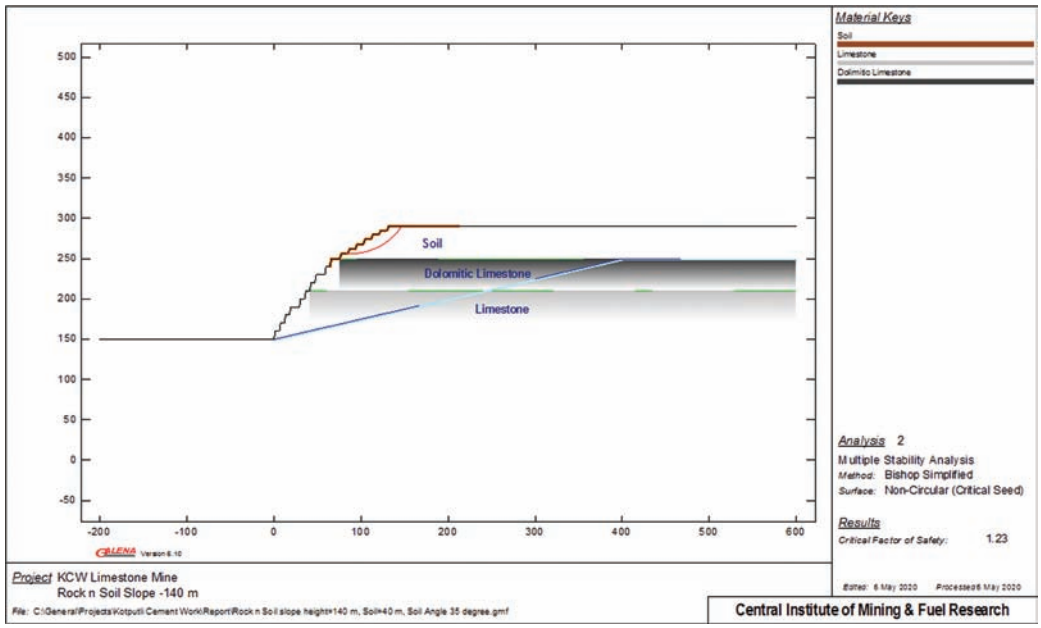


Figure - 6: Stability ananlysis of an overall pit slope of 140 m height with soil (40 m) rock (100 m)

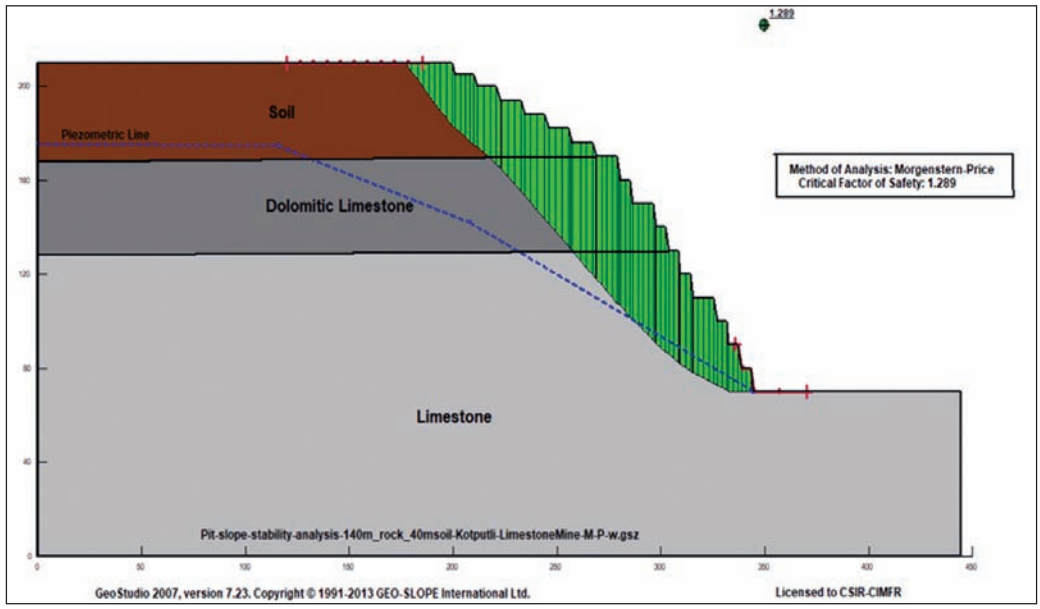


Figure - 7: Stability ananlysis of an overall pit slope of 140 m height with soil (40 m) rock (100 m)

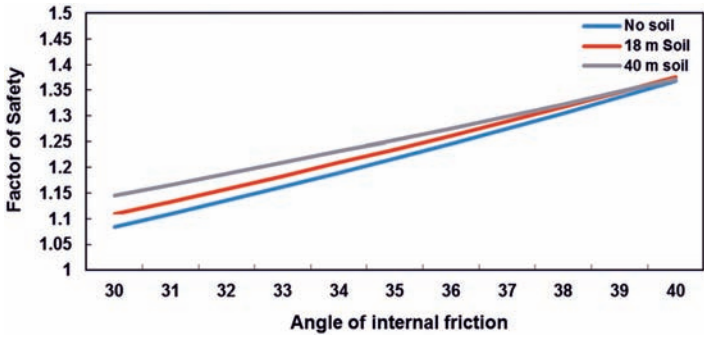


Figure - 8: Effect of angle of internal friction of limestone on stability

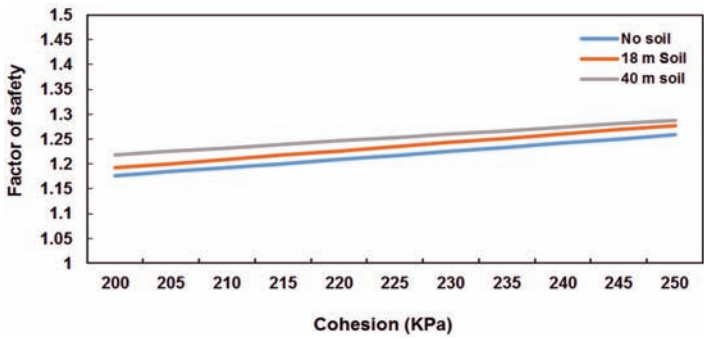


Figure - 9: Effect of cohesion of limestone on stability

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HUMAN FACTORS ANALYSIS OF ACCIDENTS IN INDIAN COAL MINE USING HFACS AND ARTIFICIAL NEURAL NETWORKS

Dr. Suresh Chandra Suman[1], Pritam Kumar Sinha[2]*

Abstract

Worldwide it has been proved that human errors play a critical role in industrial accidents and disasters. Historically, mining has been viewed as an inherently high-risk industry. There is very little research available on human errors involved in Indian coal mining accidents. Few research papers indicate that human errors are responsible for the mishaps in the Indian coal sector, but there is no indication of the type of human errors and suitable interventions. Therefore, it is particularly important to identify and analyse the human factors that cause coal mine accidents.

In an effort to further reduce the accident rates, the human factors associated with incidents/accidents need to be addressed. The purpose of this study is ANN modelling based on the HFACS model to predict the major-threatening factors involved in Indian coal mine accident/incident.

In this paper, HFACS model and use of artificial neural network was done to predict the influence of various human errors involved in Indian coal mine accident/incident. The result shows that the Unsafe /Inappropriate Acts and the Preconditions for Unsafe Acts are the highest weight among all factors and the relevant coal mining companies can start from these two aspects to prevent coal mine accidents and enhance the safety of coal mining companies. By highlighting the human causal factors in a systematic way, this study has provided mine safety professionals necessary information to reduce mine accidents/incidents further. The identification of errors will help the industry to take corrective action for reducing the toll and it will be a good tool for inquiry officers, inspectors and academicians.

Keywords: *Human Factors Analysis and Classification System(HFACS), Artificial Neural Network (ANN), Incident, Coal Mine, Safety, Risk Rating*

1. Introduction

The mining industry is well known worldwide for its high-risk and dangerous working environment. As a result, the mining industry continues to be accompanied with a high level of accidents, injuries, and diseases. However, in all forms of industry, no matter what risks employees face, employee safety is an important aspect of organizational operations.

It is found that Indian mines have considerably higher accident and fatality rates compared to those in USA and South Africa, respectively. Therefore, the safety of Indian coal mines is a very important issue. However, there has been no significant statistical analysis of the safety records of Indian coal mines.[1] The main cause of Indian coal mining accidents/incidents is human factors. Therefore, it is particularly important to use the Human Factors Analysis and Classification System (HFACS) to classify and analyze the factors that lead to coal mine accidents and to identify the main causes. Accurate and objective assessment and analysis of accidents requires a combination of qualitative and quantitative methods. HFACS is a qualitative analysis method and the analysis results obtained are not objective enough and require a quantitative analysis method to support it. Therefore, the quantitative analysis of the causes of accidents in this paper uses the Artificial Neural Network as an approach. The first step in reducing human error related incidents and accidents is to identify the types of error and organizational problems that ultimately lead to adverse events. The primary goal in this study is to identify the causal and contributing factors for mining incidents and accidents.[2-4]

In this study, the data of 98 coal mine accidents/incidents were collected and classified as per HFACS model and associated risk matrix were developed for each accidents/incidents. The Artificial Neural Network based on HFACS model is used to predict the influence of various input parameters. Despite its simplicity, the model achieved state-of-the-art performance on the test set. The use of a suitable model as a predictive tool would improve the safety in coal mining. Together, these analyses will provide valuable

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information, such as trends in system deficiencies helping the mining industry to mitigate risk by identifying the most important areas of human error.[5]

2. Accidents/Incidents

The different types of injury have been discussed below in Indian mining context:

2.1. Minor Injury: It means any injury other than a serious bodily injury which involves or in probability will involve, the enforced ansence of the injures persons from work for a period of twenty four hours or more.

2.2. Reportable Injury: It means any injury other than a serious bodily injury which involves or in probability will involve, the enforced ansence of the injures persons from work for a period of seventy two hours or more.

2.3. Seriously Body Injury: It means any injury which involves; or in probability will involve the permanent loss of any part or section of a body or the use of any part. or section of a body or the permanent loss of or injury to the sight or hearing or any permanent physical incapacity or the fracture of any bone or one or more joints or bones of any phalanges of hand or foot.

2.4. Fatal: Those accidents in which at least one death is involved is termed as fatal.

2.5. Disaster: Those accidents in which atleast 10 death is involved is termed as Disaster.

2.6. Dangerous Occurrences: Cases in which neither any life is lost nor any person is seriously injured but could have been happened so, had the persons been present at the spot of accident, are covered under the category Dangerous Occurrences.

3. HFACS Model

The Human Factors Analysis and Classification System (HFACS) was developed by Dr. Scott Shappell and Dr. Douglas Wiegmann for use in the US Navy. During the development process, efforts were made to ensure that the framework can be used not only as a data analysis tool, but also as a structure for accident investigation. The HFACS model is based on the cheese model proposed by Reason and it is a four-level framework that addresses Unsafe /Inappropriate Acts, Preconditions for Unsafe Acts, Unsafe Leadership and Organizational Influence Factors. The Unsafe /Inappropriate acts refers to the actions that occur immediately before an incident/accident and directly caused the adverse event. It is further divided into three error categories (skill-based, decision, and perceptual) and two violation categories (habitual and ocasional). The preconditions for unsafe acts level describes the environmental and psychological conditions that lead to an unsafe act. These conditions include the physical and technological environments, communication, fitness for duty, physical and mental limitations, adverse mental states, and adverse physiological states. Unsafe leadership deals with the actions and decisions of the frontline management. Subcategories in this level include inadequate supervision, planned inappropriate operations, failure to correct known problems, and supervisory violation. Organizational influences deal with the factors that go unnoticed during the formal inquiry. Organizational influences revolve around three subjects; resource management, organizational climate and organizational process.

Although HFACS model was developed for use within military aviation, it has been proven effective in civil aviation (Wiegmann and Shappell, 2001b, a; Wiegmann et al., 2005; Shappell et al., 2007), aviation maintenance (HFACS-ME: Krulak, 2004), air traffic control (HFACS-ATC: Broach and Dollar, 2002), railroads (HFACS-RR: Reinach and Viale, 2006), medicine (ElBardissi et al., 2007), and remotely piloted aircrafts (Tvaryanas et al., 2006).[6-11]

The HFACS model was originally established for the investigation and analysis of aviation safety accidents. After continuous development and research, HFACS has undergone tremendous changes and has been widely used in medical, railway, coal and other fields. HFACS analyzes the causes of accidents in terms of man, machines, environment and management. Although HFACS has been widely used in the field of coal, its own limitations still exist. The HFACS Coal Mine Safety Incident Human Model is shown in Fig. 1

The above table shows the description of each index of the HFACS model. This elaborates the four levels of influencing factors of the model in order to accurately identify the level of each factor and provide a basis for analyzing the cause of the accident.

4. Data Collection

The study on the role of human errors in the coal mining industry requires evaluation of a good number of accidents/ incidents. The research is done with inquiry records of past 98 accidents/incidents occurred in coal mines of a major coal producing company in central India. The accident/incident data spanning from 2009 to 2015 was referred for analysis with a total of 112 case histories. Among these, 14 cases were found to be partially documented and were discarded; the remaining 98 cases were finally considered. The data combined both underground and open-cast mines.

4.1. Input

Based on the analysis of 98 case histories, human errors based on HFACS (such as Unsafe /Inappropriate Acts, Preconditions for Unsafe Acts, Unsafe Leadership and Organizational Influence factors) were classified and conidered as input parameters for the ANN model.

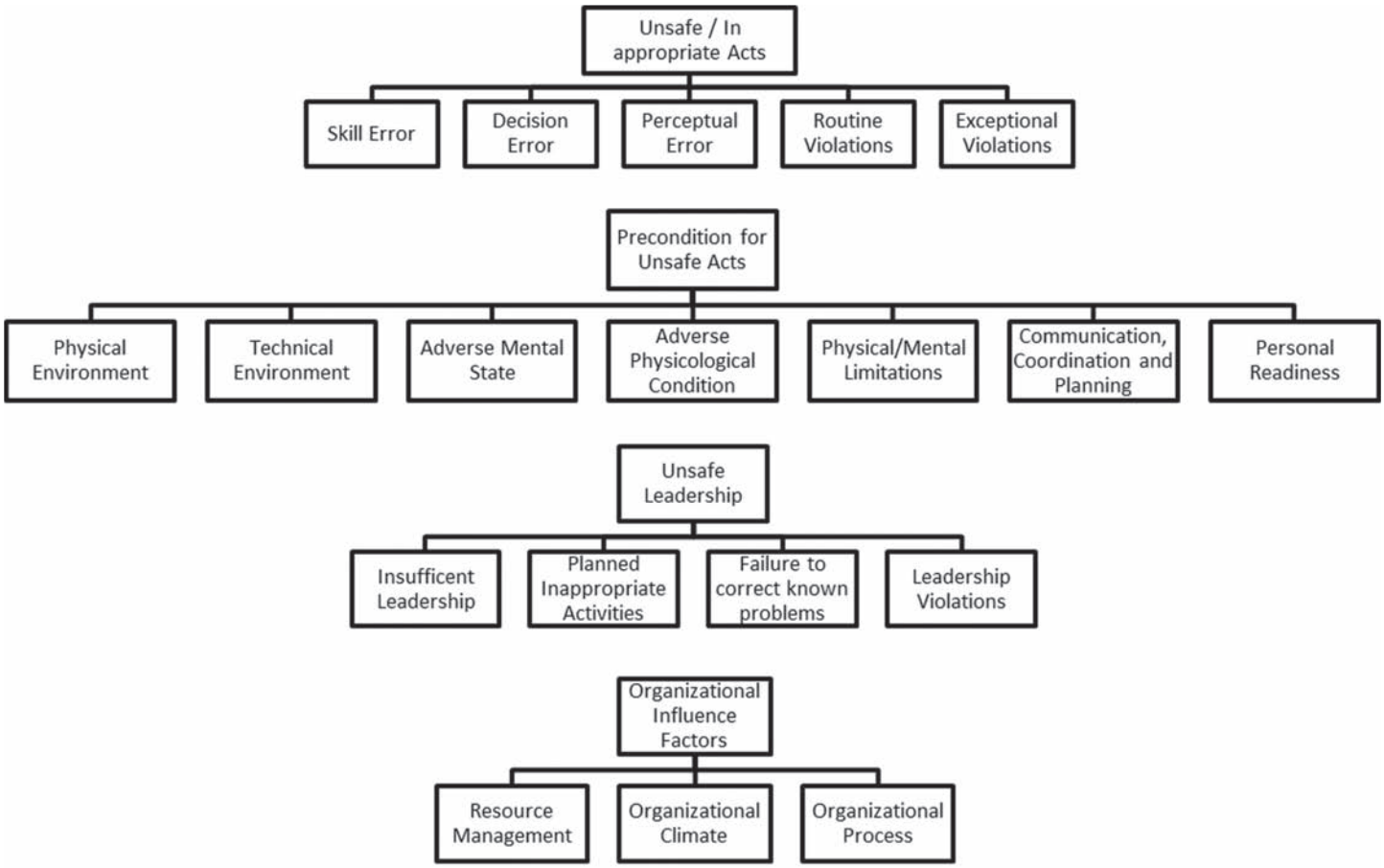

Fig. 1. HFACS Model

4.2. Output

Based on the analysis of 98 case histories, a risk matrix was developed according to the relevant risk of each accident/ incident. Associated risk matrix was developed based on the type of injury, numbers of casuality/fatality, and absence hours from mine duty for each accident/incident.

Formulation of Risk Matrix

For minor incident, the associated risk was calculated as the number of minor incident (MI) multiplied by the number 1. Similarly, for reportable injury, associated risk was calculated as the number of reportable injury (RI) multiplied by the number 3. Similarly, for the serious body injury associated risk was calculated as number of serious injury (SI) multiplied by the number 5. For accidents leading to fatalities the associated risk was considered as number of Fatal (FI) multiplied by the number 10. Any accident may result in Fatal, Serious injury, Reportable injury, Minor incident or combination of these. Therefore, associated risk matrix was developed for all 98 cases as described below:

Risk Rating = (FI x 10+ SI x 5+RI x 3+MI x 1)

Where,

FI = No. of Fatal

SI = No. of serious injury

RI = No. of reportable injury

MI = No. of minor incident

5. Artificial neural networks

An artificial neural network is a network of multiple artificial neurons. It basically consists of an input layer, an output layer and a number of hidden layers. A three-layered neural network has the representational power to represent any function. But the number of hidden layers and the number of neurons in a hidden layer is decided on the basis of accuracy of the output. As the neural networks become deeper, it is tough to train such networks due to the phenomenon known as gradient diffusion; moreover, the training time increases significantly. Shallow networks take lesser time to be trained, but are sometimes not able to represent the complex functions.

The multi-layered neural network shown in the Fig5 has one input layer denoted as X or A(1). There are two hidden layers denoted as A(2) and A(3), and an output layer denoted as A(4) which must be equal to actual output Y. The corresponding weights between layers is denoted as W(1), W(2), W(3). Term Z is used for the product of neuron values

	Human Factors		Description
Unsafe /Inappropriate Acts	Errors	Skill based error	It occurs mainly with little or no conscious thought or lack of certain level of knowledge, experience and skills.
		Decision based errors	It is also termed as 'honest mistakes'. It is due to improper choices, poorly executed procedures, misinterpretation or misuse of relevant information.
		Perceptual errors	It is the result of degraded sensory input, when a decision is made based on faulty information.
	Violations	Routine Violations	These are usually habitual and are often permitted by a system of supervision and management that allows such departures from the rules.
		Exceptional Violations	These may be defined as isolated departures from rules, regulation and set guidelines and are not condoned by management or authority
Preconditions for Unsafe Acts	Environmental Factors	Physical environment	The physical environment deals with the operational environment (tools, machinery, housekeeping, ergonomics etc.) and ambient environment (temperature, humidity, visibility etc.).
		Technological environment	The technological environment refers to equipment design and the interaction between the operator and the apparatus.
	Condition of Employee	Adverse Mental State	The mental conditions that have an adverse impact on the performance of the face workers contribute to unsafe acts.
		Adverse Physiological Condition	Adverse physiological state deals with physiological and medical conditions that have bearing upon safety performance.
		Physical/Mental limitations	This category deals with the situation when the demand of the job exceeds the capability of an individual.
	Personal Factors	Communication, Coordination and Planning	Poor communication and coordination between workmen and supervisors, supervisors and management, management and contractor can lead to confusion and misunderstanding in the execution of work and can create conditions for unsafe acts
		Personal Readiness	Work training, eating conditions, schedules, etc.
Unsafe Leadership	Insufficient Leadership		Inadequate management of human and material resources
	Planned Inappropriate Activities		Sometimes, the production measure or to make up the production loss or for some installations or commissioning of equipment with squeezed timeline expose the people at an unacceptable level of risk.
	Leadership Violations		Leadership violations are those instances when people in leadership positions wilfully disregard the established rules and regulations.
	Failed to correct known problems		The category refers to the situations/instances when the deficiency among the individual, training, equipment or other safety-related issues are known to the leadership, yet are permitted to keep on unabated.
Organizational Influence Factors	Resource Management		It refers to the corporate decisions encompassing the provision and continuance of organizational assets. The human and material resources required for production.
	Organizational Climate		It is the situational based consistencies in the organization's treatment of individuals
	Organization Process		It refers to corporate decisions that affect day-to-day activities of the organization and can include the enforcement of SOPs, rules, regulations, the supply of safety materials & PPEs, availability of fit for purpose equipment, risk management, safety program and oversights between the workforce and the administration.

Fig. 2. Table 1. HFACS index and index content overview

	Parameters	Min	Max	Mean
Input Parameters	Unsafe /Inappropriate Acts	0	4	1.80
	Preconditions for Unsafe Acts	0	4	1.05
	Unsafe Leadership	0	4	1.00
	Organizational Influence Factors	0	2	0.43
Output Parameters	Associated Risk*	2	65	10.74
No. of Samples	98			

Fig. 3. *Data specification*

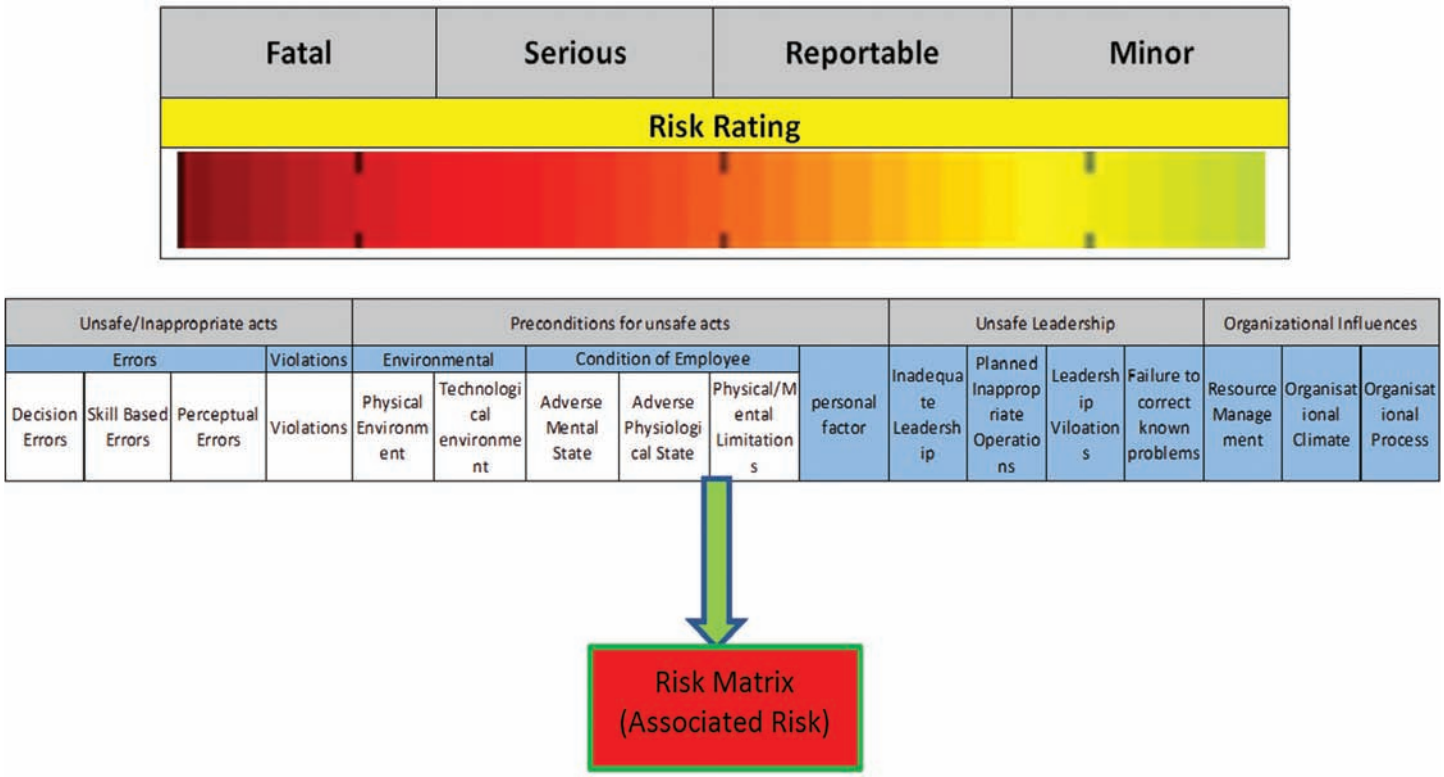

Fig. 4. Formation of Risk Matrix

with the corresponding weights and f (z) is the activation function.[18-20]

6. Modelling using ANN

Multilayered neural networks have been trained to predict output based on various input parameters such as Unsafe /Inappropriate Acts, Preconditions for Unsafe Acts, Unsafe Leadership and Organizational Influence Factors. The mean squared error (MSE) cost function and the error backpropagation method have been used to train the network. The LBFGS algorithm has been used for the optimization of the cost function using the gradients at different layers. The ANN model produced the result with high degree of accuracy with MSE (final test) equal to 0.6354 and R as high as 0.9968 so that it could be readily used.

7. Sensitivity Analysis

Sensitivity analysis was done to find the relative importance of the various input parameters of ANN model. The sensitivity analysis was performed in three steps:

1) The mean values of each input attribute were calculated;
2) The output for these mean inputs was computed; and
3) One input attribute at a time was varied to its maximum and minimum values, and the output was computed for each case

It can be seen from the sensitivity analysis that Unsafe / Inappropriate Acts and the Preconditions for Unsafe Acts play the most important role in the model (Fig.8.)

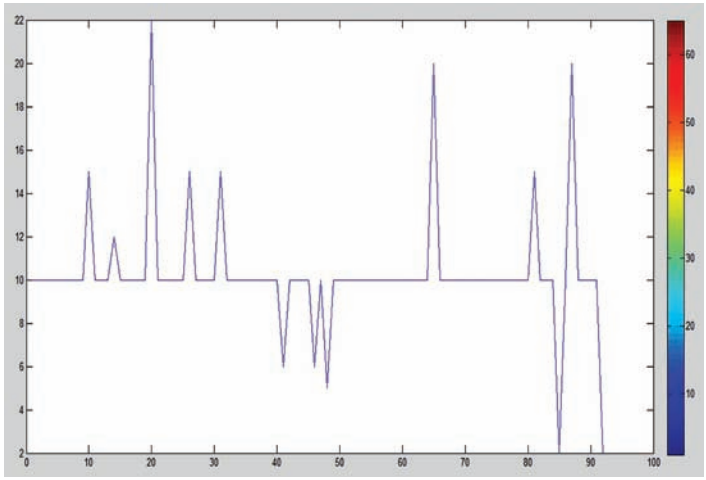

Fig. 5. Output Data Specification

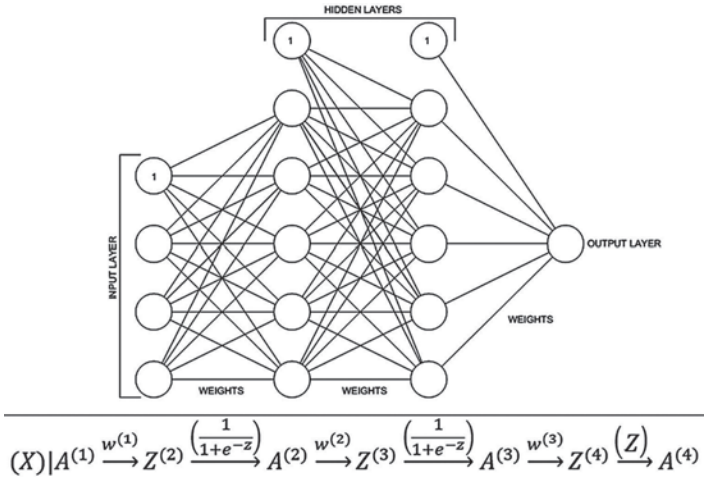

Fig. 6. Multilayered neural network

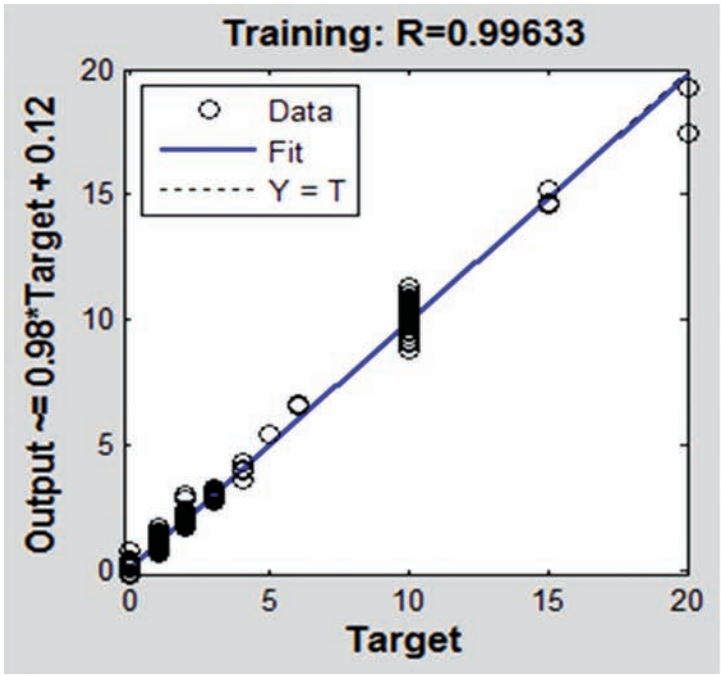

Fig. 7.1. Actual target versus predicted output for train set

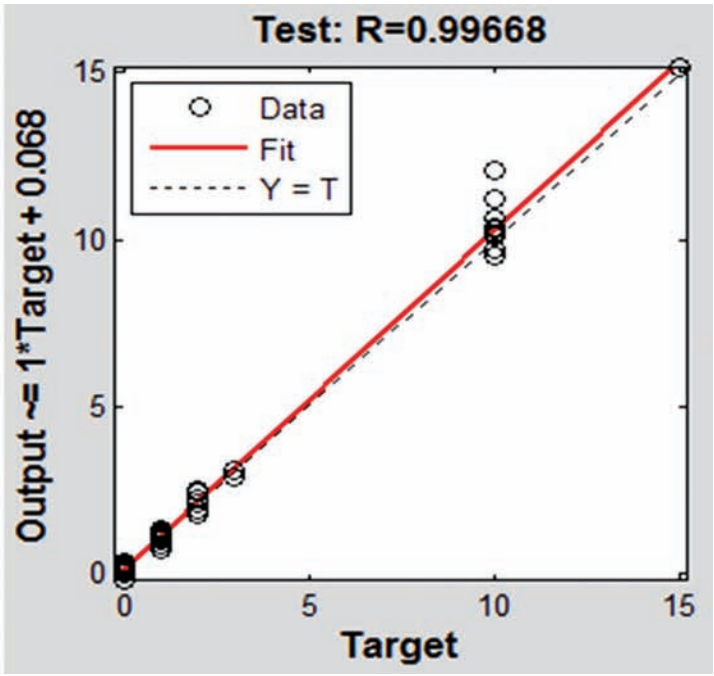

Fig. 7.2. Actual target versus predicted output for test set

Fig. 7. Actual target versus predicted output for train and test set

Fig.8 presents plot of the outputs from the sensitivity analysis for each input variable. The top of the each box represents the maximum average output of input attribute and the bottom of the box represents the minimum average output of input attribute. By looking at the boxes in Figure 8, from the averages it appears that the Unsafe /Inappropriate Acts and Preconditions for Unsafe Acts, appear to have the largest influence on the network's output. Furthermore, it appears that the Unsafe Leadership and Organizational Influence Factors have the smallest influence on the networks output.

8. Application to Indian Mining Industry

The safety in Indian coal mines is very important issue. However, there has been no significant statistical analysis of the safety record of Indian coal mines. In India, the main cause of accidents/incidents in coal mines is human factors. Therefore, it is especially important to use the classify and analyze the factors that cause coal mine accidents and to identify the main causes. The study is industry-driven and aimed for the industry implementation. Overall, this will help India's coal mining sector, to map the human errors involved in accidents and disasters.[5] These findings will provide useful information to recalibrate safety programme and policies for coal companies. Based on the outcome of the study, the coal mine organizations can start planning for safety from the most influencing features to least

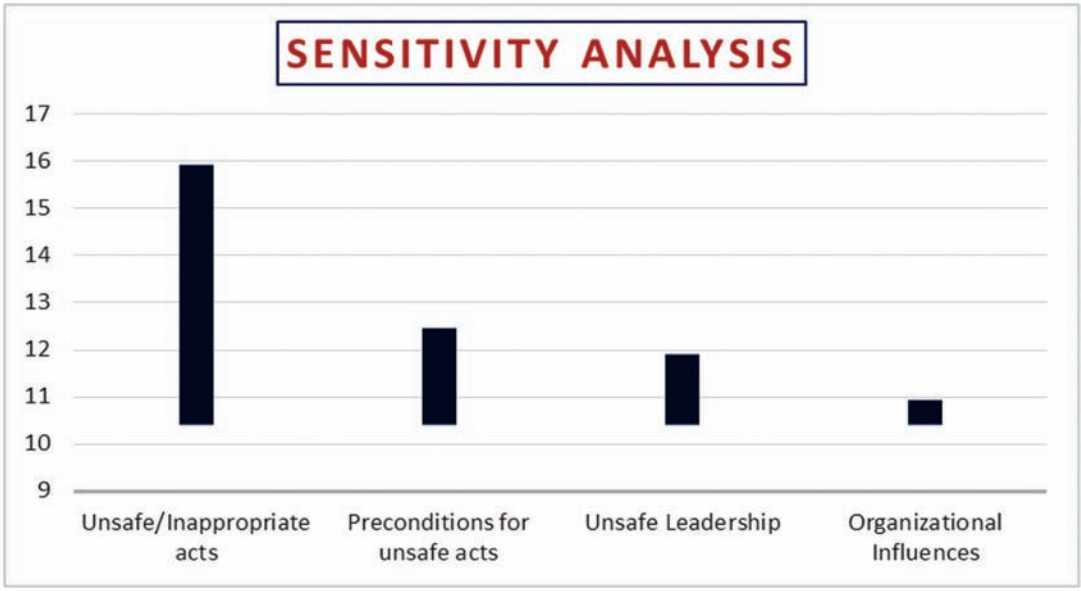

Fig. 8. Sensitivity analysis for created network

influencing features in order to prevent the occurrence of coal mine accidents. The Indian mining industry can also use this study for the budget allocation for safety planning. Using this study as a predictive tool will improve the safety of coal mining in India. Together, these analyses will provide valuable information, such as trends in system defects, and help the mining industry to mitigate risk by identifying the most significant areas of human error.

9. Conclusion

In this paper, a novel approach using ANN is developed to evaluate the importance of various type of human errors based on HFACS, such as Unsafe /Inappropriate Acts, Preconditions for Unsafe Acts, Unsafe Leadership and Organizational Influence Factors. The risk matrix is developed based on relevant risk of each accident/incident based on the type of injury, numbers of casuality/fatality and absence hours from mine duty for each accident/incident. The human errors based on HFACS such as Unsafe /Inappropriate Acts, Preconditions for Unsafe Acts, Unsafe Leadership and Organizational Influence Factors were classified and conidered as input parameters and the correspoinding risk was considered as output for the developed ANN model.

The multilayered neural networks have been trained to identify the most influencing parameters among the Unsafe /Inappropriate Acts, Preconditions for Unsafe Acts, Unsafe Leadership and Organizational Influence Factors. The ANN model produced the result with high degree of accuracy with MSE (final test) equal to 0.6584 and R as high as 0.9474 so that it could be readily used.

The Sensitivity analysis revealed that the Unsafe / Inappropriate Acts and the Preconditions for Unsafe Acts plays most important role among all factors and the relevant coal mining enterprises can start from these two aspects to prevent the occurrence of coal mine accidents and improve the safety of coal mining organization. The model can be fine-tuned further with more varied datasets to make it a general-purpose predictive tool in multi-parametric dependent phenomenon.

10. Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

[1] Mandal, A., & Sengupta, D. (2000). The analysis of fatal accidents in Indian coal mines. Calcutta statistical association bulletin, 50(1-2), 95-120.

[2] Hargrave, C. O., James, C. A., & Ralston, J. C. (2017). Infrastructure-based localisation of automated coal mining equipment. International Journal of Coal Science & Technology, 4(3), 252-261.

[3] Hargrave, C. O., Shuley, N. V., Ralston, J. C., & Hainsworth, D. W. (2007, September). Radar level sensor for longwall creep and retreat measurement. In 2007 IEEE Industry Applications Annual Meeting (pp. 2102-2109). IEEE.

[4] Singh, R. D. (2005). Principles and practices of modern coal mining. New Age International.

[5] SUMAN, S. C., & PATHAK, P. (2018). Anjan hill mine explosion: human failures resulting 14 fatalities. Bauxite Resources of Guizhou Province In China, 187.

[6] Shappell, S., Detwiler, C., Holcomb, K., Hackworth, C., Boquet, A., & Wiegmann, D. A. (2007). Human error and commercial aviation accidents: an analysis using the human factors analysis and classification system. Human factors, 49(2), 227-242.

[7] Krulak, D. C. (2004). Human factors in maintenance: impact on aircraft mishap frequency and severity. Aviation, space, and environmental medicine, 75(5), 429-432.

[8] Patterson, J. (2008, August). The development of an accident/ incident investigation system for the mining industry based on the human factors analysis and classification system (HFACS) framework. In Queensland Mining Industry Health & Safety Conference, Townsville, Australia.

[9] Reinach, S., & Viale, A. (2006). Application of a human error framework to conduct train accident/incident investigations. Accident Analysis & Prevention, 38(2), 396-406.

[10] ElBardissi, A. W., Wiegmann, D. A., Dearani, J. A., Daly, R. C., & Sundt III, T. M. (2007). Application of the human factors analysis and classification system methodology to the cardiovascular surgery operating room. The Annals of Thoracic Surgery, 83(4), 1412-1419.

[11] Tvaryanas, A. P., Thompson, W. T., & Constable, S. H. (2006). Human factors in remotely piloted aircraft operations: HFACS analysis of 221 mishaps over 10 years. Aviation, space, and environmental medicine, 77(7), 724-732.

[12] Reid, P. B., Dunn, M. T., Reid, D. C., & Ralston, J. C. (2010). Real-world automation: New capabilities for underground longwall mining. 2016-01-20]. http://www. lascautomation. org.

[13] Reid, D., Ralston, J., Dunn, M., & Hainsworth, D. (2015). Longwall shearer automation: From research to reality. In Machine vision and mechatronics in practice (pp. 49-57). Springer, Berlin, Heidelberg.

[14] Mitchell, G. W., Kininmonth, R. J., & Baafi, E. Y. (2009). Australasian coal mining practice.

[15] Feng, G. R., Wang, X. X., & Kang, L. X. (2008). A probe into "mining technique in the condition of floor failure" for coal seam above longwall goafs. Journal of Coal Science and Engineering (China), 14(1), 19-23.

[16] Wang, G. F., & Ren, H. W. (2012). New development of sets equipment technologies for coal mine long-wall face in China. Journal of Coal Science and Engineering (China), 18(1), 1-9.

[17] Zhiyan, Z. (2007). Dynamic analysis on stability of hydraulic powered support in deep inclined fully mechanized wall and prevention slips measures. Journal of China Coal Society, 32(7), 705-709.

[18] Murthy, V. M. S. R., Kumar, A., & Sinha, P. K. (2018). Prediction of throw in bench blasting using neural networks: an approach. Neural Computing and Applications, 29(1), 143-156.

[19] Mishra, D. P., Panigrahi, D. C., Kumar, P., Kumar, A., & Sinha, P. K. (2020). Assessment of relative impacts of various geo-mining factors on methane dispersion for safety in gassy underground coal mines: an artificial neural networks approach. Neural Computing and Applications, 1-10.

[20] Sarkar, B. C., Singh, R. K., Ray, D., Kumar, A., Sinha, P. K., & Sarkar, V. (2017, July). Iron ore grade modeling using geostatistics and artificial neural networks. In Iron Ore 2017 Conference Proceedings, Australian Institute of Mining and Metallurgy, Publication Series No 3 (pp. 431-437).

[21] Tu, H., Tu, S., Yuan, Y., Wang, F., & Bai, Q. (2015). Present situation of fully mechanized mining technology for steeply inclined coal seams in China. Arabian Journal of Geosciences, 8(7), 4485-4494.

[22] Rimmington, G. (2017). U.S. Patent Application No. 15/080,344.

[23] Kelly, M. S., Lever, P., Hainsworth, D. W., Gurgenci, H., & Dubois, R. (2001, June). Longwall Automation: Are We Ready for Success?. In Proceedings of the 3rd International Underground Coal Conference.

(Continued from Page 20)

The individual bench width for rock slope and soil slope are suggested at a minimum of 4.5 m and 6.0 - 7.0 m respectively. The bench height in respect of rock slope and soil slope are to be maintained at 10.0 m and 6.0 m respectively. It is expected that the recommended slope design and other measures will facilitate optimum extraction of limestone at this mine while maintaining pit slope stability.

3. In view of the rock mass being jointed, the slope faces in all benches be maintained in a very sound condition using good blasting practice and wherever loose rock blocks are observed in exposed benches, wire nets may be used to stabilize them.
4. Periodic geotechnical review of rock mass vis-à-vis slope design is suggested at different stages of mining to account for any change in the geotechnical characteristics of slope rock mass and other relevant parameters.
5. The slopes need to be regularly inspected for the development of any tension cracks and any other signs of instability. It is suggested that systematic slope monitoring be implemented once the pit reaches a depth of 100 m or earlier in case some potential signs of instability are observed. The slope monitoring data should be appropriately analysed to assess slope stability vis-à-vis mining.

ACKNOWLEDGEMENTS

The authors are thankful to The Director, CSIR-Central Institute of Mining and Fuel Research, Dhanbad (India) for his kind permission to publish this paper. Sincere thanks are due to the mine management for sponsoring the study reported in this paper and to all the colleagues at CIMFR, who were involved in this study. The views expressed in this paper are those of the authors and not necessarily of the institute they belong to.

REFERENCES

1. Bieniawski, Z. T. (1989), Engineering Rock Mass Classifications. John Wiley, 251p.
2. CSIR-CIMFR Final Report (2020), Geotechnical study for the advice on pit slope and waste dump stability at the Grasim cement limestone mine. Project No.: CNP/N/4906/ 2019-20, 68p.
3. Deere, D U (1989), Rock Quality Designation (RQD) after Twenty Years, US Army Corps of Engineers Contract Report GL-89-1, waterways Experiment Station, Vicksburg, MS. 67 pp.
4. Dips Software, Copyright 1989-2018 Rocscience Inc. (http://www.rocscience.com) GALENA (Version 6.1)
5. Slope Stability Analysis Software and User's Guide, Clover Technology. Australia.
6. International Society for Rock Mechanics (ISRM) (1981), Suggested methods for the quantitative description of discontinuities in rock masses. In E.T. Brown (ed.), Rock Characterization, Testing & Monitoring - ISRM Suggested Methods, pp. 3-52. Oxford: Pergamon Press.
7. Report on Geological Investigation of Kotputli limestone deposit, Vol. 1 (2002), Ercom Engineers Pvt. Ltd.

OBITUARY

Mr P.R. MERH

Some of the senior personalities in the Mining Industry are seen in the photograph. Front row: Mr. K. Narasimha Rao, Secretary, Tamilnadu Sub-Centre, Mr. A.S. Joshi, Divisional Manager, Tisco-Joda, Mr. A.J. Mathias, Treasurers-MEAI, Mr. M. Fasihuddin, Mr. K.K. Biran, Mr. P.R. Merh, E.D., SAIL-Raw Materials, Mr. V.S. Rao, G.M.(M&Q) Tisco, Mr. H.V. Sethuram, G.M. (Mines), Madras Cements Ltd., Mr. C.L.V.R. Anjaneyulu, Secretary, Hyderabad Sub-Centre of MEAI. Back Row: Mr. B. Mishra, Hony. Secretary, MEAI, Mr. M.P. Singh, Secretary, Dalli-Rajhara Sub Centre, MEAI, Dr. P.V. Rao, Sr. Analyst, Tisco Mines, Mr. Vaman Rao, Mining Engineer, Donimalai Project of NMDC and others.

Feel very sad to note that our MEAI former President Mr P.R. Merh (1982-1983) breathed his last on May 16, 2021 at Kolkata due to Cardiac arrest. He served as General Manager of Gua iron Ore Mines of Barbil Area and he was also Executive Director of RMD, SAIL. He was also examiner of Board of Mining Examinations of DGMS. He was a good friend of our Past President Mr V.S. Rao. He is survived by three daughters.

The members of MEAI express their heartfelt condolences to his family members and pray almighty to rest his soul in peace.

Mr Goverdhan Kuldeep

We, the members of Mining Engineers' Association, Rajasthan Chapter - Udaipur were shocked to learn about the untimely demise of our beloved member Mr Goverdhan Kuldeep, LM No. 2581, from Covid-19 on April 25, 2021. He was in the Department of Mines and Geology, Government of Rajasthan.

We have no words to express our sadness for a brilliant young Mining engineer. We all stand with his family members in this hour of tragedy.

The members of the Association extend their heartfelt condolences to his bereaved family and pray for his soul rest in peace.

Mr Anil Gupta

Feel sad to inform that Mr Anil Gupta (1972 batch ISM) and an active member of MEAI Delhi Chapter has passed away on April 25, 2021. Our deepest sympathies go out to his family during this difficult period. Our thoughts and prayers are with Mrs Gupta during this difficult time.

The members of the Association extend their Heart Felt condolences to his bereaved family and pray for his soul rest in peace.

Mr J.V. Bhatt

Mr J.V. Bhatt, Ex. Addl. Director, C.G.M., Gandhinagar and Life Member of MEAI, Ahmedabad Chapter left for heavenly abode on April 20, 2021.

Ahmedabad Chapter and the MEAI Members from across India are deeply saddened by the sudden demise of Late Shri J.V. Bhatt. Our heartfelt condolences on his sad demise.

Mr. Bhatt was born on January 1, 1941. He did M.Sc. Geology from M.G. Science College, Ahmedabad. He retired as Addl. Director from C.G.M., Gandhinagar, Gujarat. He had worked on Bauxite and made presentations on Bauxite of Gujarat at various forums. He lived very happily and led fulfilled life with family members including wife Smt. Jayaben J. Bhatt, his elder son Mr. Gaurang J. Bhatt and younger son Mr. Kalpesh J. Bhatt. Mr. Bhatt was very popular among the mining fraternity, friends and relatives.

The members of the Association express their heartfelt condolences to his bereaved family and pray for his soul rest in peace.

Mr D. K. Sahni

Mr D. K. Sahni, former CMD of MOIL & former Chairman of Nagpur Chapter passed away on April 30, 2021. May his departed soul rest in peace.

The members of the Association extend their heartfelt condolences to his bereaved family and pray for his soul rest in peace.

OBITUARY

Mr B.N. Mathur

Mr B.N. Mathur, Retired SME and Life member (LM 5251) of Rajasthan Chapter-Jaipur breathed his last due to cardiac arrest on May 10,2021 a 11.30pm at Jaipur. He is survived by his wife Mrs Sudha Mathur, Son & daughter-in-law Bhuvenesh-Kavita, daughter & son-in-law Shachi-Anuj and Richa-Shishir and five grandchildren.

The members of the Association pray for his soul rest in epace and extend hearfelt condolences to his bereaved family.

Mr C. R. Patel

(27.9.1952 – 30.4.2021)

Mr C. R. Patel, Ex. General Manager, GMDC and Life Member of MEAI, Ahmedabad Chapter left for heavenly abode on April 30, 2021 at Vizag. Ahmedabad Chapter and the MEAI Members across India are deeply saddened by the sudden demise of Mr C. R. Patel. Our heartfelt condolence on the sad demise.

Mr Patel was born on September 27, 1953. He did his B.E. in Mining Engineering from MBM Jodhpur, Rajasthan. After serving in various projects of GMDC, he retired as General Manager from GMDC, Gujarat.

He led a very happy and fulfilled life with family members including wife Smt. Shubhdraben Chelabhai Patel, his elder daughter Payalben Pinkal Patel, son Mr. Suvarnkumar Chelabhai Patel and younger son Mr. Nitinkumar Chelabhai Patel. Mr. Patel was very popular among the mining fraternity, friends and relatives.

The members of MEAI pray for his soul rest in peace.

Mr Nitin Sammanwar

Mr Nitin Sammanwar, Life member of Mumbai Chapter expired on April 24, 20-21 night after fighting with Covid-19 for 14 days in Thane. We pray the almighty for his departed soul rest in peace.

The members of the Association extend their Heart Felt condolences to his bereaved family and pray for his soul rest in peace.

Ms EMAM JYOTHI SPANDANA

Date of Birth: 16-08-1989

Schooling: SRI DURGA HIGH SCHOOL, LALAPET, HYDERABAD, TELANGANA

College: B.Com, VASUNDARA DEGREE COLLEGE, ECIL, HYDERABAD, TELANGANA

Father: Mr EMAM DURGAIAH, PAINTING CONTRACTOR

Mother: Mrs EMAM LAXMI, HOUSEWIFE

Brother: Mr EMAM ANIRVESH, INTERMEDIATE (DISCONTINUED)

Ms. Spandana Joined our MEAI HQs in the year 2012.

The office-bearers and staff members of the MEAI are saddened to learn about the demise of Ms.Spandana, Office Asst, MEAI, HQ, Hyderabad who succumbed to COVID-19 on 05-05-2021, at Gandhi Hospital, Hyderabad. Her loss is felt by many. May the memories of her wonderful personality and many contributions made by her will be remembered by all.

The office-bearers and staff Members of MEAI convey their heart-felt condolences to the bereaved family members and pray the almighty to give courage and strength to withstand her absence at this critical juncture.

May her soul rest in peace.

M. Narsaiah
Secretary General, MEAI, Hyderabad

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deposits, found in places such as Australia's Fosterville mine in Ballarat, Victoria, which has an average resource of 31 grams of gold per tonne.

In an industry where "high-grade" is considered around 5 grams per tonne, these deposits, sometimes with centimetres-thick gold veins, have posed a baffling question for miners and researchers alike – how do they occur? "As the concentration of gold in hot water is very low, very large volumes of fluid need to flow through the cracks in the Earth's crust to deposit mineable concentrations of gold," the team explained.

"This process would require millions of years to fill a single centimetre-wide crack with gold, whereas these cracks typically seal in days, months or years." "Using a powerful electron microscope to observe particles in thin slices of rock, we discovered that bonanza gold deposits form from a fluid much like milk." The researchers said gold colloids found in the hot water of the Earth's crust act like milk in the way they "flocculate" to form a jelly when their charge breaks down.

Once flocculated, the jelly-like gold becomes trapped between cracks in the rocks to form the ultra high-grade, highly valuable deposits which mining companies hope to discover. An understanding of this phenomenon had never been realised before, until Williams-Jones and McLeish made the discovery. "We produced the first evidence for gold-colloid formation and flocculation in nature, and the first images of small veins of gold-colloid particles and their flocculated aggregates at the nano-scale," they said.

"These images document the process by which the cracks are filled with gold and, scaled up through the integration of millions of these small veins, reveal how bonanza veins are formed." The discovery should benefit the entire mining industry as exploration levels remain strong in Australia.

"Now that we finally understand how bonanza deposits form, mineral exploration companies will be able to use the results of our work to better explore for bonanza deposits as well as gold deposits," the researchers said. A report from late-2020 showed that five of the 10 highest-grade gold deposits in the world were in Canada, providing the researchers with plenty of samples to choose from for their study.

Among that list was Australia's Costerfield gold mine in Victoria, which sat sixth with a grade of 12.6 grams per tonne. The Fosterville mine has the highest grade in the world with 42.4 grams per tonne at the time of the report.

Australian Mining | May 24, 2021

➤ China looks to control commodities for stability

In the wake of record-high copper, iron ore and steel prices, Chinese Premier Li Keqiang believes the country needs to manipulate its commodities to ensure China's economic stability.

A UBS research report suggested multiple possible avenues for China, all with potential pitfalls. Avenues include accelerating liquidity tightening, loosening production curtailments or introducing price ceilings. The negative effects of these suggestions were an impact on growth, environmental backlash and risk of effectiveness.

At a State Council executive meeting, Li said careful analysis had to be done. "We must carefully analyse the reasons behind this round of rapid increase in commodity prices and focus on the crux of the issue, to adopt measures in a targeted and holistic approach," Li said. Other ideas to increase supply in China's domestic market were to raise export tariffs for some iron and steel products, and temporarily removing or cutting taxes and tariffs for others. This was referenced in the UBS report which suggested removing exports would bulk up domestic supply chains.

"If China banned steel exports it would increase supply to the domestic market, pushing prices down and reducing inflationary pressures; this would impact steel spreads, result in a reduction in China's steel production, and in turn reduce iron ore demand and prices," the report stated. The report did not believe Chinese pressures would fundamentally impact international markets in the long-term, as China would look to regulate internally more than externally.

"Further restocking ex-China (all non-Chinese territories) may create near-term tightness in copper and aluminium, and keep steel markets tight, but we do not see structural shortages and believe prices will fall in 2022," the report stated. Li put it to the Chinese government to regulate the industry, as the market rides out this wave of volatility. "While the market continues to play a decisive role in resources allocation to ensure the supply of commodities and keep their prices stable, the government must better fulfil its responsibility," Li said.

Australian Mining | May 24, 2021

CONFERENCES, SEMINARS, WORKSHOPS ETC.

ABROAD

10-11 Jun 2021: **ICAME 2021- International Conference on Applied Mineralogy and Environment** in Copenhagen, Denmark. For more details, please visit: https://waset.org/applied-mineralogy-and-environment-conference-in-june-2021-in-copenhagen

15-16 Jun 2021: **International Conference on Mining Geology and Coal Exploration ICMGCE** in Toronto, Canada. Website URL: https://waset.org/mining-geology-and-coal-exploration-conference-in-june-2021-in-toronto; Contact URL: https://panel.waset.org/Support

23-25 Jun 2021: **MILL OPERATORS CONFERENCE 2021**. Online conference organized by AusIMM Brisbane, Australia

29-30 Jun 2021: **ICAG 2021 - International Conference on Advances in Geochronology** in Dubai, United Arab Emirates. For more details, please visit: https://waset.org/advances-in-geochronology-conference-in-june-2021-in-dubai

1-2 Jul 2021: **MINE WASTE AND TAILINGS CONFERENCE 2021**. Online conference organized by AusIMM Brisbane, Australia

26-27 Jul 2021: **OPEN PIT OPERATORS CONFERENCE 2021**. Online conference organized by AusIMM Perth, Australia

22-23 Jul 2021: **International Conference on Mining and Economic Geology ICMEG** in Berlin, Germany. Website URL: https://waset.org/mining-and-economic-geology-conference-in-july-2021-in-berlin; Contact URL: https://panel.waset.org/Support

22-23 Jul 2021: **International Conference on Geology, Mineral Exploration and Mining ICGMEM** in Rome, Italy. Website URL: https://waset.org/geology-mineral-exploration-and-mining-conference-in-july-2021-in-rome; Contact URL: https://panel.waset.org/Support

23-24 Aug 2021: **ICCGG 2021 - International Conference on Computational Geology and Geosciences** in Rome, Italy. For more details, please visit: https://waset.org/computational-geology-and-geosciences-conference-in-july-2021-in-rome

23-24 Aug 2021: **International Conference on Geology, Mineral Exploration and Mining ICGMEM** in Rome, Italy. Website URL: https://waset.org/geology-mineral-exploration-and-mining-conference-in-august-2021-in-rome; Contact URL: https://waset.org

12th Sep 2021: **International Conference on Geological and Environmental Sustainability (ICGES-21)** in Kuching, Sarawak, Canada. Contact Info: Phone: +91 8870915303; Email: info@scienceleagues.com

20-21 Sep 2021: **ICGG 2021 - International Conference on Geochronology and Geography** in Toronto, Canada. For more details, please visit: https://waset.org/geochronology-and-geography-conference-in-september-2021-in-toronto

28-29 Sep 2021: **NEW LEADERS CONFERENCE 2021**. Online conference organized by AusIMM Brisbane, Australia

6-7 Oct 2021: **ICEGGE 2021 - International Conference on Engineering Geology and Geomorphology Engineering** in Beijing, China. For more details, please visit: https://waset.org/engineering-geology-and-geomorphology-engineering-conference-in-october-2021-in-beijing

18-19 Oct 2021: **ICEG 2021 - International Conference on Earthquake Geology** in Rome, Italy. For more details, please visit: https://waset.org/earthquake-geology-conference-in-october-2021-in-rome

21-22 Oct 2021: **ICRSSGA 2021- International Conference on Remote Sensing Sensors for Geoscience Applications** in Athens, Greece. For more details, please visit: https://waset.org/remote-sensing-sensors-for-geoscience-applications-conference-in-october-2021-in-athens

8-10 Nov 2021: **IRON ORE CONFERENCE 2021**. Online conference organized by AusIMM Perth, Australia

8-9 Nov 2021: **ICEGGP 2021 - International Conference on Environmental Geology and Geological Problems** in Istanbul, Turkey. For more details, please visit: https://waset.org/environmental-geology-and-geological-problems-conference-in-november-2021-in-istanbul

2-3 Dec 2021: **ICRMGEA 2021 - International Conference on Rock Mechanics for Geotechnical Engineering Applications** in Tokyo, Japan. For more details, please visit: https://waset.org/rock-mechanics-for-geotechnical-engineering-applications-conference-in-december-2021-in-tokyo

6-7 Dec 2021: **ICCGM 2021 - International Conference on Computational Geosciences and Mathematical Modelling** in Kuala Lumpur, Malaysia. For more details, please visit: https://waset.org/computational-geosciences-and-mathematical-modelling-conference-in-december-2021-in-kuala-lumpur

6-8 Dec 2021: **INTERNATIONAL FUTURE MINING CONFERENCE 2021**. Online conference organized by AusIMM Perth, Australia

13-14 December 2021: **ICRGGACS 2021 - International Conference on Regional Geology, Geologic Analysis and Computer Simulations** in Cairo, Egypt. For more details, please visit: https://waset.org/regional-geology-geologic-analysis-and-computer-simulations-conference-in-december-2021-in-cairo

15-16, April 2022: **ICGGG 2022 - International Conference on Geochronology, Geology and Geophysics** in Cape Town, South Africa. For more details, please visit: https://waset.org/geochronology-geology-and-geophysics-conference-in-april-2022-in-cape-town

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