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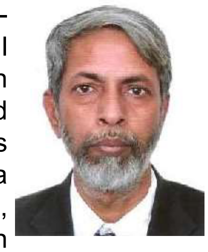
Regd. Office : IMEJournal, Laxmisagarpatna, Bhubaneswar 751 006
E-mail : indianminingjournal61@hotmail.com Mobile: +919861008387

Prof.(Dr.) S. Jayanthu

Persons in the News



Shri Amarendu Prakash Director-in-Charge (Bokaro Steel Plant), Steel Authority of India Limited (SAIL), has been appointed as Chairman, SAIL for a period of five years from the date of his assumption of charge. Shri Prakash a B.Tech in Metallurgy from BIT Sindri, (Ranchi University), he is an accomplished technocrat and possesses over 28 years of experience, comprising 24 years in Plant Operations at BSL and 4 years at Chairman's office in SAIL. Shri Prakash began his career at SAIL in year 1991 with posting in Rolling Mills. During the long stint of 20 years in BSL, he mastered the art of steel rolling and finishing. Shri Prakash, played a crucial role in timely completion of upgradation of Hot Strip Mill (HSM) in 1997 and 2007, implementation of ERP and six sigma certification in the HSM and was the driving force behind setting-up of technology hub to serve as a think-tank for research in hot rolling, coordinating patenting and copyright activities. Under his able leadership, patent on technical design of Reheating Furnaces was successfully filed.

As a key member of the Production and Sales Planning team, he was instrumental in strategizing the overall production and manufacturing of quality products mix for maximization of revenue. He pioneered the business analytics division for a product mix optimization, identify investment needs and proactive analysis of business information to customize production as per market trends. A widely travelled technocrat across the globe to countries like Germany, France, Italy,South Korea, which among others, has done an immense value addition to his vast knowledge and experience in the field of Steel Manufacturing Technology. During his short stint in Chairman's office, he orchestrated the formulation & development of key strategies at the apex level and their effective implementation. He had been involved in driving business transformation and financial turnaround of SAIL which resulted in bringing back the Company from a streak of 3 years of losses starting from FY 16 into profit in FY19. He led the team in Management Business Simulations Competition and won the National Championship, besides winning the Asian Championship to participate in the Global Management Contest representing India. In the year 1999, he was conferred upon by SAIL the prestigious "JAWAHAR AWARD" for best young manager for his leadership qualities.

Shri Akshay Shrikant Bapat appointed as Director (Technical) of MCL. As Director (Technical) of MCL, Bapat will be a member of the Board of Directors and will report to Chairman and Managing Director (CMD). He will be responsible for operation of mines and also of field activities, technical functions and safety of mines. Shri Bapat, before taking over the charge as the Director (Technical/Project &Planning), MCL, was posted in Coal India Limited HQ, Kolkata as Executive Director(Environment). He has worked in various capacities in Coal India subsidiaries WCL and SECL and has over 36 years of rich experience in Coal Mining, Planning and matters pertaining to Environment & Forest. Shri Bapat is resident of Pune, Maharashtra and has done Bachelor of Engineering(Mining) from Nagpur University in the year 1987. He holds First Class Mine Manager's Certificate of Competency under the Mines Act from Directorate General of Mines Safety, Dhanbad.

Shri Palle Buchi Reddy appointed as Director (Personnel) of Western Coalfields Limited (WCL). As Director (Personnel) of WCL, Shri Reddy will be a member of the Board of Directors of WCL and will report to Chairman and Managing Director of WCL. He will be overall in-charge of coordinating and implementing personnel and industrial relations policies, management functions, administrative control etc.

Shri N Senthil Kumar appointed as Director (Pipelines) of Indian Oil Corporation Limited (IOCL). Shri Senthil Kumar is an Engineering Graduate in Electronics & Communication Engineering from the Government College of Technology, Coimbatore. He joined Indian Oil as Senior Operations Manager in April 2004 and subsequently rose to the the current position. As Director (Pipelines) of Indian Oil, Senthil will be a member of the Board of Directors and will report to the Chairman. He will be in charge of the Pipelines Division to achieve transportation of crude oil and petroleum products in line with the corporation's plans and objectives. He will also be responsible for revamping of existing pipelines besides taking up of new pipelines projects.

Shri P Kannan appointed as Director (Operations) of Chennai Petroleum Corporation Limited (CPCL).

Shri Polavarapu Mallikharjuna Prasad appointed as Chairman and Managing Director of Coal India (CIL). A Mining Engineer from Osmania university. Shri Prasad took over as the CCL CMD on September 1, 2020, and has more than three decades of experience in the mining sector. He is credited for the diversion of Nallah at Hingula opencast area to unlock coal reserve of 26 million tonnes (MT) in FY15 and the commencement of a new railway siding at the Talcher Coalfields. Shri Prasad also took over as the CMD of Bharat Coking Coal (BCCL) in August 2019. Both CCL and BCCL are subsidiaries of CIL.

Shri Amitava Mukherjee Director (Finance) of NMDC Limited. Who is also holding the additional charge of NMDC Limited's Chairman & Managing Director (CMD) post, has been given tenure extension on CMD role. Thus, he will be holding the additional charge as CMD of NMDC Limited for a further period of three months with effect from June 1, 2023 to August 31, 2023. Shri Mukherjee belongs to the 1995 Batch of Indian Railway Accounts Service (IRAS). Shri Mukherjee is a Cost Accountant and holds master's degree in commerce. He spearheaded implementation of ERP (S4/ HANA) and has been driving other digitalisation initiatives like, mine transportation and surveillance system, fleet management system. Under his stewardship, the demerger of NMDC Steel Ltd from NMDC Ltd was completed in time bound manner and shares of NSL were listed in stock exchange on February 20. Project Management, digital initiatives, and policy formulation are his forte.

Prior to joining NMDC, he was General Manager (Finance) in Rail Vikas Nigam Limited (RVNL). During his service in IRAS from 19967 -2016, he held key position in the Eastern Railways. Before joining IRAS, he worked in Indian Oil Corporation Limited (IOCL) from 1994-1997. He has received "FE CEO of the Year Award" from Financial Express for the year 2022 in the Large Manufacturing Industry Category. Also, CII has recognised him as Leading CFO of the year 2022 under the sectorial category of Industrial Manufacturing. He received the National Award for outstanding services during the year 2006 during his tenure in Indian Railways. He is on the Board of nine subsidiaries/ associate/joint venture Companies of NMDC. He also holds the position of Chairman in BRPL.

COAL NEWS

COAL STOCK GROWS 44 PER CENT TO OVER 110 MT: COAL MINISTRY

The overall coal stock in the country increased 44 per cent year-on-year to 110.58 million tonne (MT) on June 13, according to the Ministry of Coal. In a statement, the ministry said the higher coal stock position indicates the commitment to maintaining an ample supply of the dry fuel -- a key ingredient required for electricity generation. "The overall coal stock position at mines, TPPs (thermal power plants) and transit as on June 13, 2023, reached 110.58 MT, indicating a substantial increase of 44.22 per cent as compared to the stock of 76.67 MT on the same day last year," it said. The ministry is focused on ensuring the energy security of the nation. It is actively working towards enhancing coal production and supply-efficient transportation of coal to all the stakeholders.

The coal stock at pitheads of Coal India Limited (CIL) as on June 13 stood at 59.73 MT, indicating a growth rate of 25.77 per cent compared to 47.49 MT last year. This upward trend highlights effective stock management strategies and operational efficiency. The coal dispatch to the power sector was 164.84 MT on June 13, registering a notable growth rate of 5.11 per cent compared to 156.83 MT a year ago. The coal stock at TPPs (DCB) as on June 13, 2023, is 34.55 MT as compared to last year to date which was 22.57 MT, indicating a significant growth of about 53.1 per cent. Overall, cumulative coal production for FY 2023-24 has witnessed remarkable growth, with a production of 182.06 MT as on June 13, 2023, representing an impressive growth rate of 8.26 per cent compared to the previous year's production of 168.17 MT. "Furthermore, the overall coal dispatch has seen a substantial increase, reaching 196.87 MT on June 13, 2023, for FY 2023-24. This represents a commendable growth rate of 7.71 per cent compared to the previous year's dispatch of 182.78 MT.

SECL IN EXPANSION MODE; TO MAKE GEVRA WORLD'S LARGEST COAL MINE: CMD PREM MISHRA

South Eastern Coalfields Limited (SECL) is aiming to scale up the capacity of its Gevra mine to 70 MTPA to make it the world's largest coal producing site by the end of ongoing fiscal, company's CMD Prem Sagar Mishra said. Located at Korba, about 193 kilometer from Raipur, the capital of Chhattisgarh, SECL's Gevra mine is the world's fourth largest coal mine at present, the official told PTI in an interview at Bilaspur. While two of the largest coal mines are in the US, one is in Indonesia, Mishra said adding "we are in expansion mode of our Gevra mine to 70 million tonne per annum (MTPA) to make it the world's single largest coal producing site." In financial year 2022-23, the mine produced 52.5 MT of coal which was above its target for the year, the Chairman-cum-Managing Director said. When asked about the timeline for achieving the 70 MTPA target, the CMD replied "we aim to achieve it by the end of the current fiscal year. We are waiting for the environmental clearances which we expect to attain by the mid of this financial year." The company has applied for environment clearances for around 20 MT excavation capacity. Sharing details of the Gevra mine, Mishra said it is an open cast mine spread over an area of 27 square kilometer. The mine has been excavated up to a depth of about 600 metres. Around 1.5 lakh tonne of coal is mined from the block on a daily basis.

SECL is also building a railway corridor connecting Gevra to Pendra Road and is in the process of installing two silos and a 20 million tonne per year coal handling plant in Gevra mine region for faster loading and transportation of coal from the block. The plan is to transport the coal to the silos through conveyor belts and load it on the rakes through the silos. This process will reduce the loading time significantly and improve supplies of coal. Based in Bilaspur, SECL with 67 blocks, is among the top three coal producing subsidiaries of Coal India Ltd (CIL), under Ministry of Coal. In FY23, CIL's output was 703.21 MT, out of which SECL's contribution was 167 MT.

PLAN FOR ONE OF WORLD'S BIGGEST COAL MINES CHALLENGED IN INDIA

Coal India Ltd. is holding talks with residents opposed to a mine expansion that would create one of the world's largest operations producing the fuel. Protests against plans for the Gevra site in the eastern province of Chhattisgarh threaten to complicate the company's ability to win approvals to expand annual capacity to 70 million tons. Output at that volume would see the site become the single biggest global source of the fossil fuel, according to Coal India. Rising power demand has pushed India to prioritize energy security and boost output of coal, which continues to account for about 70% of electricity generation. Residents of the area close to Gevra have raised concerns over air pollution, the impact on ground water levels and compensation for acquired land, said Deepak Sahu, joint secretary for Korba district — where the mine is located —

at Chhattisgarh Kisan Sabha, a farmers' union in the state.

Coal India and its subsidiaries have faced challenges in ramping up other operations, including in Chhattisgarh, and a public hearing was held this week at the Gevra site. "The company has taken considerable measures to address the issue of pollution associated with the mining process," and studies have shown there's no impact on ground water levels in the Korba district, a spokesman at South Eastern Coalfields Ltd., the unit that operates Gevra, said by phone. The Coal India unit gave 700 jobs in lieu of land last year, the most in a decade, and has increased financial compensation for land, he said.

COAL MINISTRY ISSUES VESTING ORDERS FOR 22 MINES

The Ministry of Coal issued vesting orders for 22 auctioned coal blocks, which are expected to attract a capital investment of Rs 7,929 crore. The mines are also expected to generate annual revenue of Rs 9,831 crore and generate around 71,467 direct and indirect job opportunities. Additional Coal Secretary M Nagaraju, who is the Nominated Authority of the Ministry of Coal, issued vesting orders for 22 coal mines to successful bidders of coal blocks under commercial coal mine auction in the national capital, it said. Out of the 22 coal mines, 11 mines are under the Coal Mines (Special Provisions) Act, 2015, and the rest comes under Mines & Minerals (Development and Regulation) Act, 1957. A total of 16 coal mines are fully explored mines while six mines are partially explored ones, the ministry added.

The cumulative peak rated capacity (PRC) of 22 coal mines is 53 million tonne per annum (MTPA) and has approximately 6,379.78 million tonnes (MT) of geological reserves. "These mines are expected to generate annual revenue of Rs 9,831 crore and will attract capital investment of Rs 7,929 crore. It will also provide employment to about 71,467 people both directly and indirectly," it said. With the vesting of these 22 coal mines, the coal ministry had issued vesting orders for a total of 73 coal mines under commercial auctions to date with a cumulative PRC of 149.304 MTPA. This will result in the generation of annual revenue of Rs 23,097.64 crore to the state governments and will generate employment opportunities for 2,01,847 people, both directly and indirectly, it said.

MINING NEWS

VEDANTA LTD PLANS TO INVEST USD 1.7 BILLION IN FY24 ON GROWTH PROJECTS

Vedanta Ltd plans to invest USD 1.7 billion in the current financial year to expand the capacities of its various business operations, its Chairman Anil Agarwal has said. It has already invested USD 1.2 billion in the form of growth capex in FY2023 to augment its assets and production. "We envisage committing another USD 1.7 billion in FY 2024 towards growth projects," Agarwal said. Sharing details of the company's projects, the chairman said Vedanta is already expanding its aluminium and zinc capacities. "Our oil and gas operations, which account for nearly one-quarter of India's production, is also diversifying its reserves and resources portfolio towards a vision of contributing 50 per cent to India's total Oil and Gas production," he said.

On the company's performance in the fiscal ended March 31, FY23, he said in the last year, Vedanta operated against a difficult and uncertain macro-environment, driven by prolonged geo-political conflict, subsequent energy crisis and aggressive monetary policies adopted by central banks. However, it delivered excellent operating performance and reported Rs 1,45,404 crore in revenue and Rs 35,241 crore in EBITDA. The company generated a healthy net-free cash flow of Rs 18,077 crore. "This all-round performance is a testament to our outstanding portfolio and accomplished leadership team. Vedanta is committed to growing responsibly by ensuring that the communities in which we operate, thrive and grow with us," Agarwal said.

The chairman further said 2022-23 has been an incredible year for India. The country outperformed and repositioned itself among the world's fastest-growing economies, even as most developed nations faced slower growth amidst high inflation. It posted an impressive 6.8 per cent GDP growth in FY2023 after delivering 9.1 per cent growth in the previous fiscal. India's improved outlook in many ways is attributable to the government's quest for self-reliance in manufacturing, minerals and resources. Its importance was accentuated in the aftermath of the pandemic and the Russia-Ukraine conflict, which saw heightened uncertainties and geopolitical tensions globally. "This trinity of manufacturing, infrastructure and energy along with a focus on digitalisation can continue to propel India's economic growth, unlock new business opportunities and create jobs. It is expected that India's GDP will double to USD 7.5 trillion during 2022-2031 with a substantial rise in the contribution from manufacturing," he said.

TATA STEEL, GERMANY'S SMS GROUP TO EXPLORE LOW CARBON STEEL MAKING TECHNOLOGY

Tata Steel has partnered with Germany's SMS group to explore development of low carbon steel making process. As part of the MoU, both companies shall undertake further technical discussions and initiate actions for conducting

Joint Industrial Demonstration of the EASyMelt technology developed by SMS group, Tata Steel said in a statement. "The demonstration will be executed at E Blast Furnace in Tata Steel's Jamshedpur plant with an objective to reduce CO2 emission by more than 50 per cent from blast furnace's baseline operation," it said. The EASyMelt (electric-assisted syngas smelter) technology is an iron-making solution that can be implemented in existing integrated steel plants to accelerate decarbonisation.

T V Narendran, CEO & MD, Tata Steel, said "We actively look for solutions to facilitate the transition to green steel production, and thus contribute to a sustainable future. Further, India being the second largest steel producer in the world also places a huge responsibility on large manufacturers like Tata Steel to lead the country's decarbonisation journey." Tata Steel intends to take this association ahead with a deeper collaboration to access better technologies and processes to reduce the carbon footprint in a meaningful and consistent way, he said. Tata Steel is prioritising decarbonisation and has set a goal of achieving net zero carbon emissions by 2045.

JINDAL STAINLESS ROPES IN DASSAULT SYSTEMES TO MANAGE PRODUCTION, OPERATIONAL FUNCTIONS

Jindal Stainless Ltd (JSL) said it has roped in France-based Dassault Systemes to manage "end-to-end" production and operational functions at its Hisar and Jajpur units. The deal was signed between JSL Managing Director Abhyuday Jindal and Eric Leveugle, Vice President, Worldwide Business Transformation, Dassault Systemes at Dusseldorf in Germany , the company said in a statement. "JSL has inked a deal with Dassault Systemes to strengthen its production planning, scheduling and execution processes. Having recently merged and doubled its capacity to 2.9 million tonne per annum (MTPA), this will enable JSL to seamlessly manage end-to-end production and operational functions between Hisar (Haryana) and Jajpur (Odisha)," it said. By adopting an integrated and fully automated approach to operations management, JSL intends to achieve sharper resource utilisation, faster capacity balancing, live data synthesis and accurate predictions, while maintaining high-quality standards.

"This is another bold step towards creatively demolishing legacy systems and adopting new-age models of digitisation and automation. "We are working towards 360-degree integration of different operational technologies with real-time dashboards to enable faster decision-making. This aligns with our vision to diversify, expand, and drive long-term growth and innovation in stainless steel," Jindal said. "The virtual twin experience of JSL's production systems helps JSL improve operational efficiency and product quality significantly, and facilitates data-driven, fast decisions for the decarbonization of steelmaking," Corinne Bulota, Vice President, Infrastructure, Energy and Materials Industry, Dassault Systemes. Through the deal, JSL said, it intends to optimise its processes and realise significant benefits like reducing lead time by 10-15 per cent and reducing work-in-progress inventory by 8-10 per cent.

INDIA IN TALKS WITH U.S. ON STEEL, ALUMINUM TARIFF EXEMPTION

India is in talks with the United States to seek an exemption on steel and aluminum tariffs that were imposed by former U.S. President Donald Trump, while offering withdrawal of some retaliatory tariffs, three Indian sources told Reuters. Negotiators in New Delhi and Washington are hoping to reach an agreement during Indian Prime Minister Narendra Modi's visit to the U.S. later this month, two Indian government officials and one industry source with direct knowledge of the matter said. India has offered to withdraw retaliatory tariffs on some agricultural goods such as almonds and walnuts in exchange for exemption on steel tariffs, both government sources said.

However, U.S. negotiators were not "flexible", leading to doubts over a possible exemption on tariffs on steel, one of the sources said. "We are discussing, (but) they are not very flexible whether there will be any substantial outcome," the government source said, declining to be identified. India's trade ministry, the Office of the U.S. Trade Representative and the U.S. Department of Commerce did not reply to mail seeking comment. The Indian officials did not want to be named as they were not authorised to speak to media. "PM (Modi) is visiting and by that time, they (U.S.) want to come up with something good, which looks positive for both sides," one of the government source added.

India is willing to discuss other possible trade measures that the U.S. officials may propose, the second government source said. A top executive at a U.S. industry group said he was not aware of "any serious contemplation" on the part of the U.S. government on the tariff issue and said it was unlikely that they would consider such a request. "I really don't think the U.S. government would do that, quite frankly," said Kevin Dempsey, president of the industry trade group American Iron and Steel Institute. Trump had imposed 25% tariff on steel and 10% on aluminum in 2018, using Section 232 of a 1962 act that allows the president to restrict imports.

In retaliation, India had imposed tariffs on 28 U.S. products, including almonds, apples, and walnuts. Last December, The World Trade Organization ruled that U.S. tariffs imposed on steel and aluminium imports by Trump contravened global trading rules, a judgment criticised by Washington. Separately, at a U.S. Congressional Steel Caucus hearing on Wednesday, several steel industry leaders expressed support for keeping the tariffs in place.

CENTRE AIMS AT COVERING REFRACTORIES IN PLI 2.0 TO SUPPORT 300 MT STEEL CAPACITY TARGET BY 2030

The Centre is looking to include refractories in the upcoming Production Linked Incentive Scheme 2.0 for steel as it aims at doubling the country's production capacity for the metal to 300 million tonne by 2030, an official said. Refractories are a critical input for steel production, and India depends on the import of the raw material. The Ministry of Steel is currently in talks with the refractory industry to develop an incentive policy to boost domestic production and reduce the country's dependence on imports from China, he said. "The steel industry is a major user and consumer of refractories. Currently, 70 per cent of the refractory is consumed by the sector. The vision of doubling the steel capacity in the next 6-7 years requires focused attention on the development of the key raw material," Ministry of Steel Joint Secretary Abhijit Narendra said during a recent meeting with industry stakeholders in Kolkata.

The PLI 2.0 scheme is expected to be announced soon, and "consultations are underway for inclusion of refractories", he said. Under the first PLI scheme, the government had approved Rs 6,322 crore to give an impetus to the steel sector with an expectation of facilitating around Rs 30,000 crore investment and additional capacity creation of about 25 million tonne of speciality steel over the next five years. Refractories are materials used by the steel industry to line the internal furnaces for iron and steel making. While the cost of refractory amounts to only 2-3 per cent of steel production, it is an essential component without which not a single tonne of steel can be produced, according to experts. State-run SAIL Bhilai Steel Plant Director Anirban Dasgupta has called for the expansion of the refractory industry and collaboration with the steel sector for a joint mission to become self-reliant. "The refractory industry has to expand in tandem and even at conservative estimates, the consumption of refractories for steel will be 2.5-3 million tonne by 2030 to see steel making getting doubled," Dasgupta said.

He also recommended the beneficiation of magnesite in India, which is "currently missing", to reduce the refractory industry's dependence on single-source raw materials. The Rs 15,000-crore refractory sector is also passing through some challenges in sourcing raw materials and imports from China, an industry official said. The objective of the PLI scheme is to boost domestic manufacturing and attract investments in identified sectors. The scheme provides financial incentives to companies that meet certain production and investment targets.

JSW CEMENT RAISES GREEN DEBT OF $50M

JSW Cement has raised $50 million through a sustainability linked loan agreement with BNP Paribas Singapore. It will be using this capital to fund its capacity expansions. This is the second such green capital raised by the company over the last few months. It had raised $50 million earlier as well, and intends to reach a production capacity of 50 million tonne over the long-term.

ADANI CEMENT EXITS INDUSTRY LOBBY GROUP CEMENT MANUFACTURERS' ASSOCIATION

Adani Cement, which owns Ambuja Cement and ACC, has exited the industry lobby group Cement Manufacturers' Association (CMA), which represents all large cement players in the country, said people in the know. This comes after the Adani Group company had a difference of opinion on multiple issues with the CMA, the people cited above said without clarifying further. Both Ambuja Cements and ACC had stopped sharing production and sales data with the CMA a few years back and have not been active members of the association, said an analyst with a domestic brokerage who did not wish to be quoted. The CMA itself stopped actively collecting data after India's competition watchdog accused the organisation of being part of a cartel that illegally controlled prices of cement. "It is possible that it is more of a procedural thing, just to make sure that they are not involved in any more cases that may come up in the future. It could be a precautionary step," he said.

SANGHI CEMENT GETS NON-BINDING OFFERS FROM NIRMA GROUP, JK ORGANISATION

Nirma group and JK Organisation have submitted non-binding offers to acquire between 40% and 72% stake in Sanghi Cement, creating a three-way contest for the Ahmedabad-based cement manufacturer, which has also drawn interest from at least one other player, according to sources briefed on the matter. ET had reported on April 29 that Bangur family-promoted Shree Cement is in non-binding talks to acquire a stake in Sanghi Cement. Sanghi Cement's promoters are expecting offers that give the company an enterprise value (EV) of ?6,000 crore. Due diligence is yet to commence and any transaction could take at least three months before it is finalised, the sources said. Karsanbhai Patel-promoted Nirma was described as a serious bidder for Sanghi Cement by sources ET spoke with. Bharat Hari Singhania-promoted JK Organisation's interest in Sanghi Cement was said to be exploratory in nature. Executives at Nirma and JK Organisation refused to comment. Sanghi Cements director Alok Sanghi did not respond to ET's request for comment.

While one source described the chances of the stake sale going through as low, saying there was no apparent reason for Sanghi Cement's promoters to sell a stake, another said a deal was imminent as a lot of background work had been done and a formal process had been initiated to invite interest for the company. The EV of ?6,000 crore includes debt of ?1,800 crore. This places the equity value being discussed at ?4,200 crore. At this valuation, bidders could fork out between ?1,680 crore and ?3,024 crore for the quantum of equity stake being discussed if a deal were to work out, not including the cost of an open offer.

ADANI'S AMBUJA CEMENTS PLACES ORDER FOR CAPACITY EXPANSION

Adani Group-owned Ambuja Cements on Friday will be placing orders to expand clinker capacity by 8 million tonnes at Bhatapara and Maratha units, the company said. "The capacity expansion projects will enable production of Blended Green Cement of 14 million tonnes, post all requisite approvals," the company said in its statement. According to the release, these projects are expected to be commissioned in nearly 24 months and the capex will be funded from internal accruals. The brownfield expansion projects are part of the company's strategy which is aimed at doubling the production capacity over the next five years from the current capacity of 67.5 MTPA.

"The ongoing investments in capacity expansion and sustainability will enable us to achieve our long-term objectives, as we remain committed to delivering sustainable growth and value to our stakeholders," said Ajay Kapur, CEO, Cement Business. "The company remains committed to achieving significant size, scale, and market leadership with strong emphasis on margin expansion and world-class ESG standards," the company release stated. Ambuja Cements on Tuesday reported a decline of 10.87 per cent in its consolidated net profit at Rs 763.30 crore for the quarter ended on March 31, 2023. The company had clocked a net profit of Rs 856.46 crore in the January-March quarter a year-ago. Its consolidated revenue from operations was almost flat at Rs 7,965.98 crore during the quarter under review. It was Rs 7,900.04 crore in the corresponding period last fiscal.

The consolidated results of Ambuja Cements include the financial performance of its step-down firm ACC Ltd, in which it owns around 51 per cent stake. Sales volume of Ambuja Cements on a standalone basis was up 2.66 per cent to 7.7 million tonnes (MT) from 7.2 MT. According to Ambuja Cement, it has changed its financial year end from December to March. Over the outlook, the Adani Group firm said it is encouraged by the government's increased spending on infrastructure development, particularly roads, railways, affordable housing and other schemes as announced in the recent Union Budget.

MRPL SHELVES REFINERY GROWTH TO FOCUS ON CHEMICALS BET

India's Mangalore Refinery and Petrochemicals Ltd. shelved a planned refinery expansion to focus on boosting its petrochemical production capacity, which may cost as much as Rs. 47,000 crores ($5.7 billion). "A shifting energy landscape primarily driven by the uptake of electric vehicles has prompted MRPL to focus its efforts on increasing output of chemicals that can be used for plastics and paints," Sanjay Varma, managing director, said in an interview. "The company's major investment will be on a new production plant in Karnataka," he said. Indian and Chinese refiners along with majors such as Exxon Mobil Corp. are betting on petrochemicals to underpin future oil demand as the transition to electric vehicles chips away at consumption of transport fuels.

"The new MRPL plant is likely to be operational in the next three to five years," said Varma. "India is a net-importer of petrochemicals and the country is facing a "make-or-buy" decision," said Larry Tan, vice president of chemical consulting in Asia at S&P Global Commodity Insights in Singapore. "There is better value to capture production locally." MRPL — majority owned by state-controlled Oil and Natural Gas Corp. — plans to spend around 300-400 billion rupees on the new plant, and a further 60-70 billion rupees on smaller petrochemical units, Varma said. "The investment will help "de-risk MRPL's future" during the energy transition," he added. "The investment will contribute to ONGC's overall spend of 1 trillion rupees to expand its petrochemical capacity to 8 million tons a year by 2030, from 3.4 million tons," according to a spokesman for ONGC. While MRPL shelved plans to boost the capacity of its refinery on the west coast to 18 million tons a year from 15 million tons, the plant has still run above operational levels, said Varma. The refinery operated at a record average of 17.1 million tons a year over the 12 months ended March 13, he said.

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Miner Tracking and Safety System Using WSN

Dr Guntha Karthik* Afifa Sameen** Saniya Siddiqui***

ABSTRACT

Mining is indispensable to the creation of goods, infrastructure and services which enhance the quality of their lives. As a society we are blessed to enjoy the many advantages that industry manufactured products provide us by processing these raw materials. Working in the earth presents many different security and health dangers. Frequently the underground environment is shaky or unpleasant. The mines that are deeper, the more dangerous it could be to be running jobs. There's oxygen leak that is restricted, and there are challenges related to leaving a mine if a crisis happens. So, in this paper we propose a mining tracking as well as safety system for the mining industry using microcontroller-based circuit on the worker helmet. The RF based circuitry was used to detect workers moving through the entire mining site. The helmet is integrated with an RF based tracking system which in coordination with the tracker RF systems helps provide data over cloud platform. The system makes use of Atmega microcontroller-based RF tracker circuitry to receive the data transmitted by worker helmet nodes. This helps map the current location of workers through the entire mining site. Moreover, each worker helmet circuit is integrated with a panic/emergency button. This button when pressed shows an emergency sign over the web interface about the worker emergency. This can be used for any emergencies like – toxic gas inhalation, roof falls, physical injury etc. Thus, the system ensures mining worker safety using Wireless sensor Network (WSN).

Keywords: IoT, Tracking, Miner, Safety.

INTRODUCTION

Safety is the most important thing while digging in the coal mines. While current system has some provisions for the human safety including a hard hat with a torch mounted on it, safety goggles, hearing protection, steel toed boots, and ankle straps. Explosions in mining becomes a safety risk in underground mining. Methane increases risk of explosions when it has concentration of 5 to 15%, when released from coal seam or rock strata. Underground mines and surface mines are two common types of excavation, which are used to reach deeper deposits and to mine shallow and less valuable deposits respectively. To avoid any dangerous situation there are some provisions already made comes into force whenever accidents happen, but these provisions are not sufficient for proper rescue of humans.

To monitor different parameters like oxygen levels in that area, increasing or decreasing humidity level, more or less temperature variations, and of course availability of flammable gaseous is done by the sensors mounted over the helmet. This sensed data is compared with the specified limits given to all the sensing gadgets. These sensors are activated when, observed or sensed parameter reaches beyond specified limits. Even though one of the sensors crosses the limits set, it gives sensing alarm to the worker. Considering the noise inside the mines we have developed this helmet. The specified limits have been set by research on some of the health reports published. The alarming and attention system contains the buzzer and the vibrating motor. The whole and sole purpose of this system is to bring the attention of the worker on the danger. The vibrating motor is mounted on one of the nerves of the neck, keeping in mind that it is the most sensitive area in human body. Whenever the accident is to happen, we may rescue or evacuate all the workers. So, the workers can anticipate for their lives in this drastically changing dangerous situation.

Mining is a multifaceted industry which includes complicated operations carried within the tunnels, underground etc. This involves various risk factors which affects the health of miners. The Chasnala mining disaster that took place near Dhanbad in the Indian state of Jharkhand almost killed 372 miners. This was considered as one of the worst disasters in the mining industry. Miners may not be aware of the external conditions such as rise or fall of temperature, pressure etc. Sometimes Miners

*ECE Department, Stanley College of Engineering and Technology for Women (Autonomous), Hyderabad, Telangana
Corresponding Author: gunthakarthik@rocketmail.com

collide with the heavy objects like mining objects, hard rock which risks their life. Another factor that affects the miners is the inhalation of hazardous gases that provokes them in danger. In this situation miners are not able to communicate with the outside world. In this case, the smart helmet system becomes an essential and helpful measure to protect the miners from various accidents. This project aims at designing a smart helmet for hazardous event detection, monitoring the surrounding environmental conditions and updating information like GPS location and sensor data to the central console for easy tracking and providing oxygen supplements to avoid the inhalation of poisonous gases. This secures the life of miners in mining industries. From the Survey, various information is gathered One death every third day in India's most dangerous job is Mining. According to the International Labour Organization (ILO), while mining employs around 1% of the global labour force, it generates 8% of the fatal accidents China has the largest mining industry producing up to three billion tons of coal each year. Though China accounts for 40% global coal output, it is responsible for 80% of mining deaths around the world each year. This survey clearly shows that the requirement for safety measure must be extended to save the life of miners. This survey motivated us for initializing this project.

LITERATURE SURVEY

The following table shows the recent innovations in underground safety systems using wireless sensor networks and Internet of Things.

Table.1.Latest findings on UG safety systems

S. No.	Name of the Authors	Title of the Paper	Year	Important Findings
1.	Boddapati Venkata et al	Design of IOT Based Coal Mine Safety System using NodeMCU.	2019	Coal mining safety system is created using a Thinger.Io platform as a data transmission channel.
2.	D. Prabhu et al,	IOT Based Coal Mining Safety for Workers using Arduino.	2019	Proposed a system where Gas sensor modules are used in the coal mine safety system, fire sensor, humidity/temperature sensor, led and buzzer. Integration of all the sensor to Arduino Uno using IoT.
3.	P. Koteshwara Rao et al, A.	Design and Implementation of Coal Mine Safety Using IoT.	2018	A system controlling of ventilation demand depending upon the atmospheric condition to the mine workers within the mining area.
4.	N. Balaji et al,	An Intelligence Device for Hazardous Event Detection for Mining Industry smart helmet.	2017	The development of acute mining head protectors is derived from this work in order to recognise three types of hazardous situations, such as the maximum level of hazardous gases, the removal of the excavator cap, and accidents.
5.	Bonala Ashwini et al.	IoT Based Coal Mine Safety Monitoring and Control Automation.	2018	The IoT security framework is proposed as a replacement for the current underground mining system in this study.
6.	S.R. Deokar et al.	Coal mine safety monitoring and alerting system.	2017	By constructing a real time monitoring system, this article provides a clear and point-to-point perspective of the underground mine
7.	Keerthana E et al.	A Smart Security System with Monitoring in Mines.	2018	A Smart Security System with Monitoring in Mines in this paper they proposed screening of security framework to the workers and offering security to the workers.

AIM OF THE WORK

Wellbeing is the interminable topic of the coal business. Because of complex geographical conditions and poor creation conditions in coal mines, a large portion of the past checking frameworks depend on the wired system design. Nonetheless, this sort of design additionally brings a few issues: underground organization of these frameworks is troublesome; and in light of the fact that the hardware in view of wired correspondence is poor in versatility and adaptability, it likewise is hard to completely screen all zones of mines. The major objective of this project is to evacuate the area and rescue the workers inside the mines as soon as possible. The helmet is improvised by highly efficient and sensitive sensors, mounted actually over it. A highly cost effective and easily portable system is proposed using the helmet. The helmet can be connected with the outer controlling stations and sensed data can be used for safety purpose for workers as well as valuable commodities. In future RF tracker can be attached to track mine workers and also smart jacket or helmet can be prepared in such a way that all sensors shall be in built of helmet or jacket so that when mine workers will not feel the burden of wearing sensors externally.

Methodology

The figure 1 shows the methodology of work, Figure.2 Shows the transmitter unit and figure.3.shows the receiver block diagram.

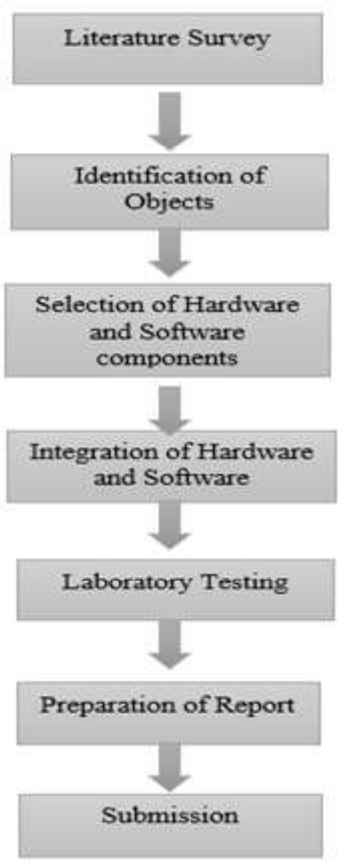


Fig.1.Methodology of the work

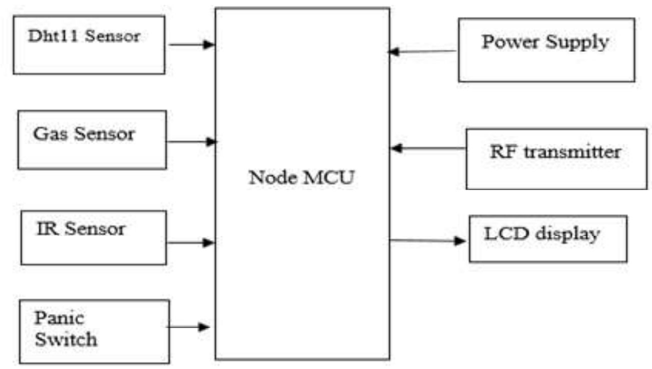


Fig.2. Transmitter Unit

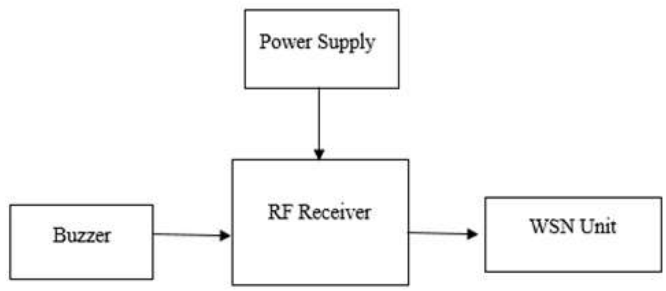


Fig. 3: Receiver Unit

Hardware and Software Components Description

The following Table.2. and Table.3. Shows the basic specifications about the software and hardware modules used for designing of the prototype.

Table.3.Software Specifications

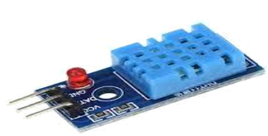
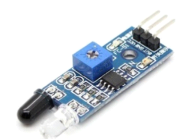
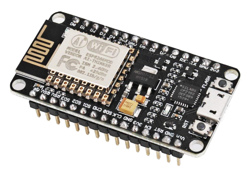
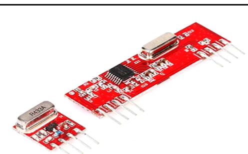
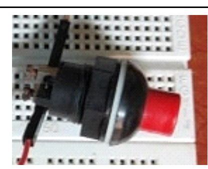
S.no	Components	Description
1.	Adafruit IO	It's an open cloud service platform for storing, retrieving and displaying the data in real time this IoT application has to be connected with internet then we have to login and create an account into it.
2.	Arduino IDE	The Arduino Integrated Development Environment- contains a text editor for writing code, a message area, a text console, a toolbar and a series of menus. It connects to the Arduino hardware to upload the programs and communicate with team.

HARDWARE CONNECTIONS

Schematic circuit diagram

The transmitter board power supply is given from power bank to RST pin of NodeMCU. Data pin of DHT11 sensor is connected to the pin D6 of NodeMCU, VCC and GND pin of sensor is then connected to a parallel supply board.

Table-2: Hardware Specifications

S.no	Components	Picture	Description
1.	MQ4 sensor		It works on 5volts power supply and it will be used to detect any kind of hazardous gases in mine area and send it to controller which will display data on webserver. Its sensing range of 300-10000 PPM.
2.	DHT11 sensor		It is an embedded sensor used to measure temperature & humidity in the surroundings and gives calibrated digital output. . It can measure temperature in the range of 0°C to 50°C. Its humidity range is from 20% to 80%.
3.	IR sensor		Its an infrared active sensor of range 20 cm. An IR sensor can measure the heat of an object as well as detects the motion. Mostly used in obstacle detection systems.
4.	NodeMCU		Node Microcontroller Unit is an open-source platform working at 2.4GHz. It is based upon ESP8266 Wi-Fi Socket On Chip from Espressif Systems. It's of low cost and an excellent choice in (IoT) projects.
5.	Buzzer		It's an audio signalling device works as alert or alarmin system and can attract the focus of the workers on the danger.
6.	LCD		Liquid Crystal Display is used for continuous monitoring and controlling purpose. A 16*2 display system is placed inside the vehicle for displaying sensor alerts.
7.	RF Transmitter and Receiver		This two RF wireless modules that is one is transmitter and the other is receiver using working at 433 MHz. The range of coverage of signals of the module is said to be 500 m.
8.	Panic Switch		Panic switch is manually operated by the miner to seek help from the central console in highly emergency conditions. If the worker feels unwell, they can press it to be rescued.

Gas sensor Dout pin is connected to D5 pin of the microcontroller and GND is then connected to the parallel board supply. For IR sensor the OUT pin is connected to D8 pin of NodeMCU and VCC & GND pin are towards RF transmitter. Panic switch input and output is connected to D3 and GND pins of microcontroller respectively. LCD is given here along with demultiplexer GND and VCC goes towards parallel board supply and SDA and SCL goes to the D1 &D2 pins of NodeMCU. RF transmitter J2 pin is connected to power supply board and J6 pin is going to the TXD of NodeMCU. On the receiver board RF receiver RM1 pin is connected with buzzer input and output is given to the ground. Power supply is given from the PC at the supervising station with help of cable connected to RXD of RF receiver. Figure.4.and 5.Shows the schematic diagram of transmitter and receiver sections.

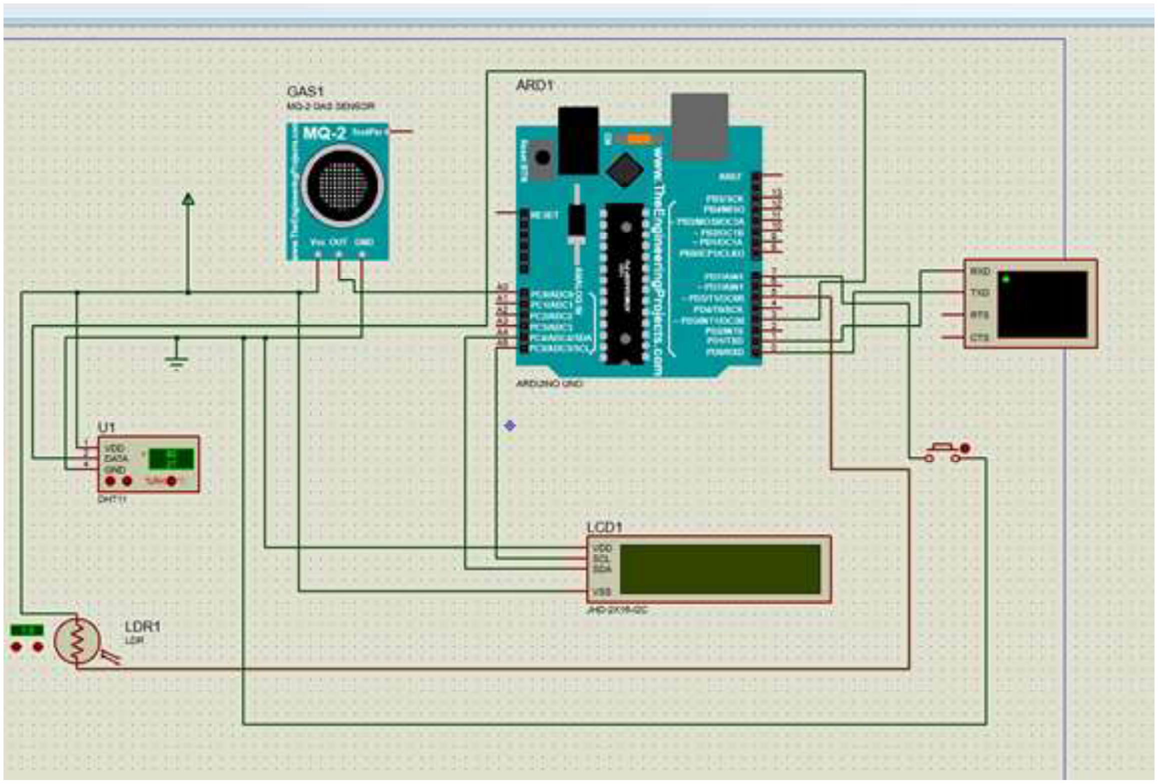


Fig.4: Transmitting Board

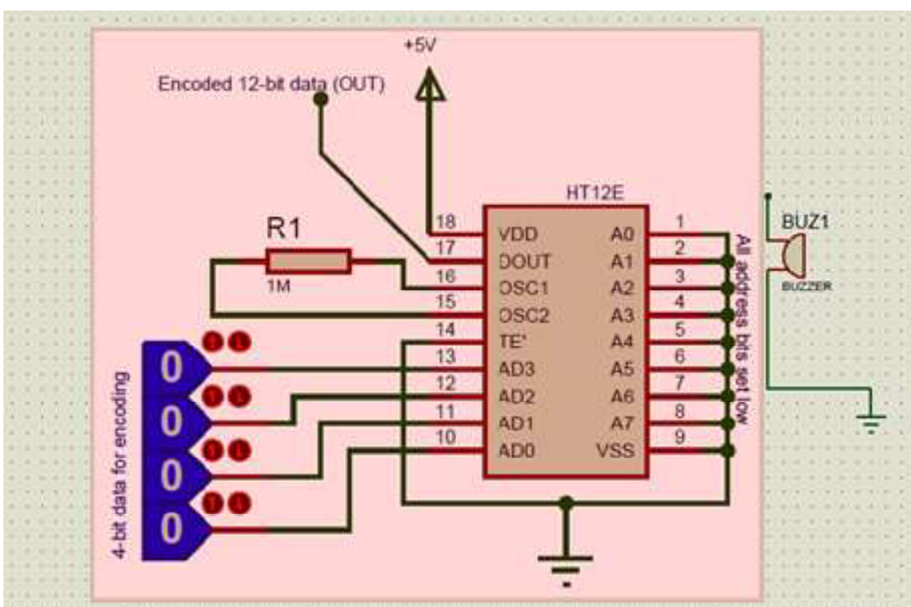


Fig.5: Receiver Board

Working Procedure

The entire system consists of smart helmet, wireless stations and webserver. Miners smart Helmet is used as mobile wireless sensor network node which is composed of rechargeable battery, LED lamp and sensors network. So intelligent helmets could collect sensors parameters Timely, then transmit to wireless base stations, finally upload the data to server. Monitoring Centre can send instruction to miners by wireless communications. DHT11 sensor tested with cold and hot temperature and it work properly values tested on multimeter. NodeMCU Wi-Fi controller tested with mobile hotspot connection and it responded well with AdaFruitIO server by sending and receiving values of light sensor, Gas sensor testing done with direct power supply Arduino compiler installation done on laptop and Led program written on Arduino compiler. Gas sensor data will be played live on web servers gauge simulator on feed and dash board. All sensors like temperature humidity vibration can be viewed on a live webserver.

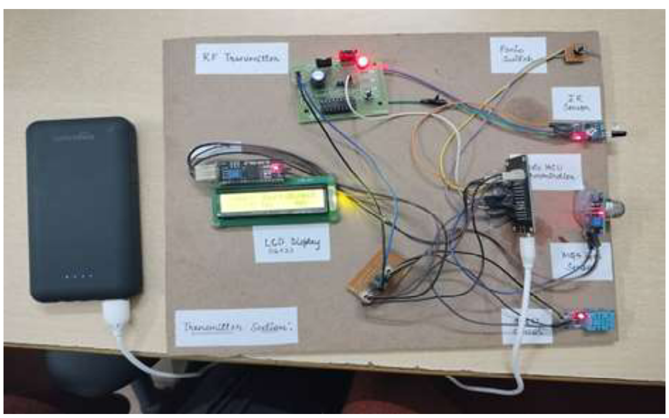


Fig.6: Physical Transmitter Section

Fig.7. Receiver Section: Supervising team

Algorithm

Step 1: Switch on both the transmitter and receiver circuit by giving its power supply.
Step 2: The LCD will get activated and after getting the Wi-Fi connectivity it will display the parameters.
Step 3: The sensor senses the data and if the measured values get increased from the threshold value it generates an alarm through buzzer at the receiver unit.
Step 4: In case there is no increment in the sensor value range it keeps processing the data.
Step 5: And sensor data is updated on the cloud webserver.

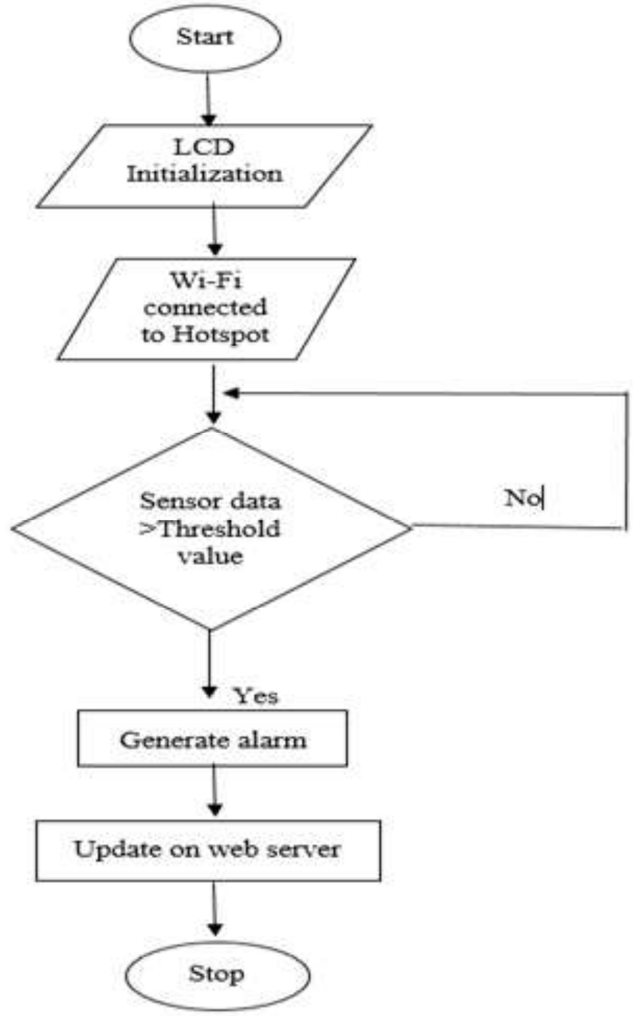


Fig.8 Flow Chart

RESULTS AND DISCUSSIONS

This sections discuss about the functionality of the prototype. At first, turn on the internet from the android phone along with its hotspot on so that it connects with the Nodemcu microcontroller. When miner worker has to wear the transmitter unit which The LCD display the activation.Figure.9 and 10 shows the welcome note on LCD.

Fig.9: Welcome display

Fig.10: Hotspot connectivity

The sensors detect the underground atmospheric temperature and also poisonous gases which are present and updates the value in cloud server timely and when the values reach its peak threshold value that is above its inserted range it sends an alarm at the receiver section through buzzer.Figure.11. Shows the Display of Temperature, Gas and Object values on LCD. Figure.12. Shows the Display of Temperature on cloud platform.

Fig.11. Display of Temperature, Gas and Object values

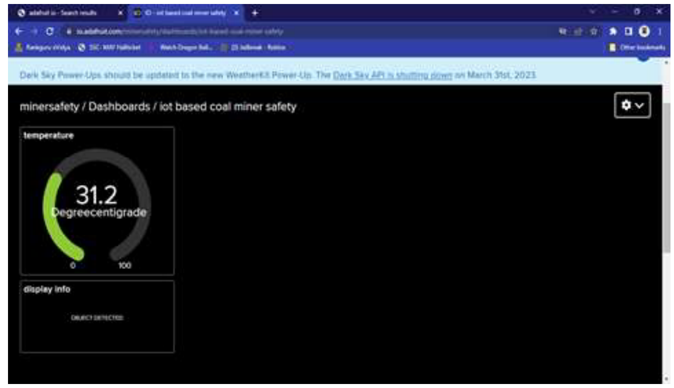


Fig.12: Adafruit Cloud server updating the temperature value

The supervising team monitors the temperature with the help of cloud server and it can detect the rise in the value of temperature easily. Figure.13 shows Graphical representation of temperature on the cloud server.

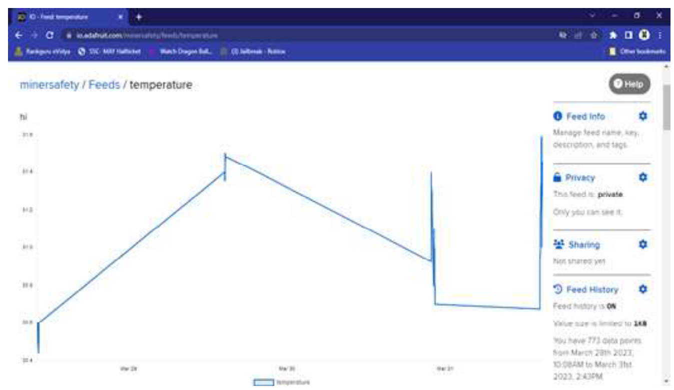


Fig.13: Graphical representation of temperature on the cloud server

When some object or a stone is suddenly falls on the worker the sensor senses it and sends alert to its wireless receiving unit which is at supervising station, resulting in buzzing in buzzer and the cloud service and LCD both display (Figure.14).

Fig.14: Object detection display

And when the worker may feel unwell or kind of dizziness, they may click panic button provided at the transmitter helmet in order they can be rescued by the supervising team and the LCD & Server display (Figure.15).

Fig.15: Panic detection display

Figure 16. and 17 shows, when some hazardous or harmful gases leak, the gas sensor will detect it and sends the alert through buzzer and updates its threshold value in the cloud server.

Fig.16: Gas Detection display

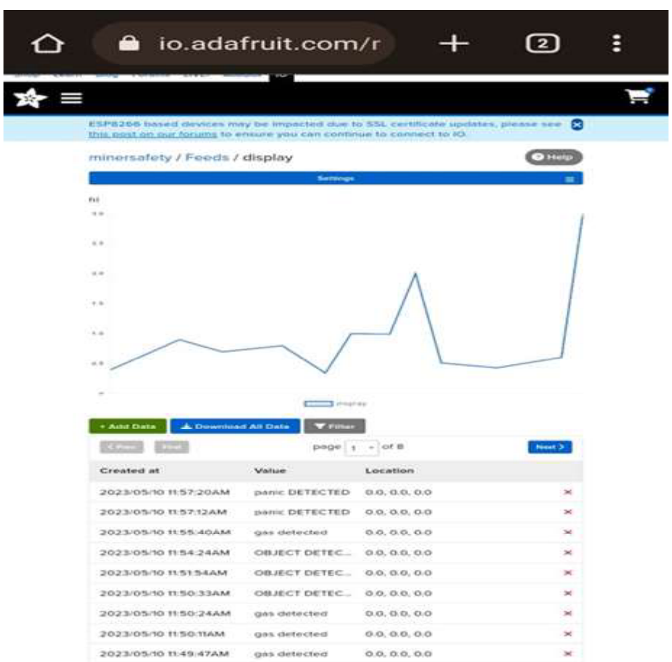


Fig.17: Feed of the cloud server showing the display of all the sensor values in a graphical manner

CONCLUSIONS

This paper provides safety to coal miners and change the way of their working, as well as system controlling the various environmental changes in mines. It will improve system stability and extend accurate position of underground miners in future. The designed Arduino based smart helmet is light in weight, makes it portable and reliable. A keen coat for the miners in light IoT and RF technology is the execution of IoT in remote sensor systems which made utilization of correspondence conventions, for example, NRF, RFID innovation measures. As the aftereffect of wearing this coat, more significance is given to the individual observation and also gives security supervision in the coal mining industry. It additionally alarms the individual in the event of basic crises and furthermore the supervision.

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Haul Road Design and Management – A Case Study

Rajesh Kumar Mahanta*

ABSTRACT

The design of surface mine haul road covers the aspects of haul road design as road alignment (both vertical and horizontal), construction materials, cross slope and drainage provisions, traffic control and design of proper lane width for safe vehicle movement are included as are suggested criteria for road and vehicle safety provision and for runaway vehicle safety provisions. The aim of design surface mine haul road is to promote safety and more efficient haulage route.

Key Words: Haul Road, Statutory Obligations, Super elevation, Geometric Design parameters

INTRODUCTION

The roads which are prepared for playing of heavy earth moving equipment for carrying of overburden and minerals in opencast mines are called haul road. The haul road design and subsequent road management and maintenance form a principal component of a transport operation in surface mines. There is a strong relationship exists between well constructed and maintained roads and safe, efficient mining operations. A well constructed roadway is safe to operate and easy to maintain.

Why Haul road is important in Mines

- The haul road is a critical and vital component of the production process
- It directly impact the mine production and cost.
- It affects operation safety, equipment longevity and productivity.

Advantages Of Good Haul Road

A good haul road will result in numerous advantages like:

- Reduced cost of maintenance of equipment
- Reduced breakdown of vehicles and their better availability.
- Reduction the fuel consumption.
- Achieving better safety standard.
- Improved working environment and ergonomics for the operators.
- Increase in tyre life.

*M-Tech, Mining Engineering, AKS University,Satna, M.P
Corresponding Author: rajmining.rajesh@yahoo.com

A good haul road will

- Increase productivity by 30%
- Reduced fuel consumption by 30%

Statutory obligations

- As per regulation 106(2) (B) of Metalliferous Mines regulation 1961.
- As per DGMS Circular No.08 of 2008.
- Notification by DGMS under G.S.R 976(E) of 1st Oct 2018.

CHARACTERISTICS OF HAUL ROAD AS PER MINES STATUTES

Haul road width

- No road shall be of width less than 3 times the width of the largest dumper plying on the road plus 5meter, if the movement is on a single haul road.
- If the road is provided for single traffic of vehicles with a strong road divider at the centre, the width shall not be less than 2 times the width of largest dumper plying on the road plus 3meter.

Embankment or Bund

Where any road exists above the level of surrounding area, it shall be provided with strong parapet wall / embankment with the following dimensions –

- Width at the top not less than 1 meter
- Width at the bottom not less than 2.5 meter.
- The height of the bund not less than the diameter of the tyre of the largest vehicle plying on the road.

Gradient

- The gradient at any place at haul road shall not be more than 1 in 16.
- In case of small ramps over small stretches, gradient up to 1 in 10 may be permitted -

Visibility

- All corners and bend in haul road shall have a clear view of distance of not less than 3 times the braking distance of the largest HEMM working at 40 KMPH

Haul Road Lighting

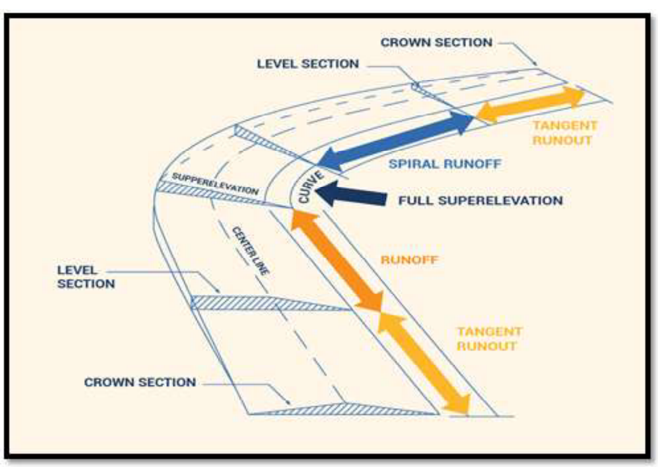
- Required standard of illumination shall be 0.5 to 3.0 Lux (Horizontally)

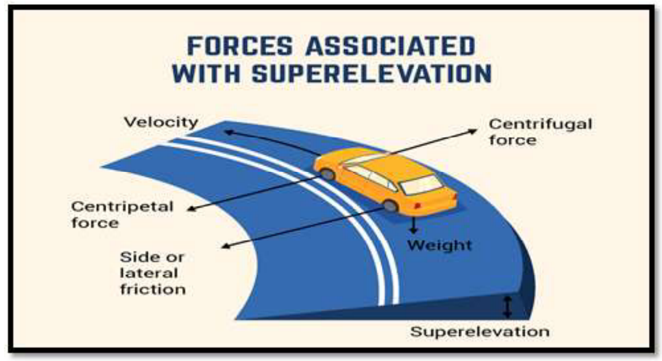
Traffic / Road Signs

The traffic signs may be speed limit signs, stop signs, curving and intersection warning signs which shall be provided at required locations all along the haul roads.

Super Elevation

- The amount by which the outer edge of the road has to be raised is known as super elevation. It is expressed in meter/meter
- Here tan = Centrifugal force / Truck weight
- $= mv^2 / r.mg = v^2/r\ g$
- Here it is noted that angel is independent of the weight of the truck





THE KEY LINES IN USING AN INTEGRATED APPROACH TO ROAD DESIGN

Basic design data
- Truck type, Wheel and axle load
- Traffic volume
- Design life of road
- Construction materials available
- Unit cost

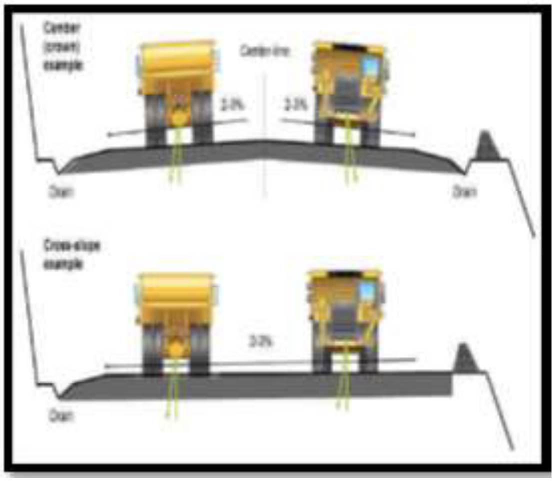
Geometric Design data
- Truck type and key operating dimensions
- Alignment in both the horizontal and vertical planes
- Road width
- Stopping distance
- Sight distance
- Junction Layout
- Berm walls and shoulders
- Drainage designed on and off road

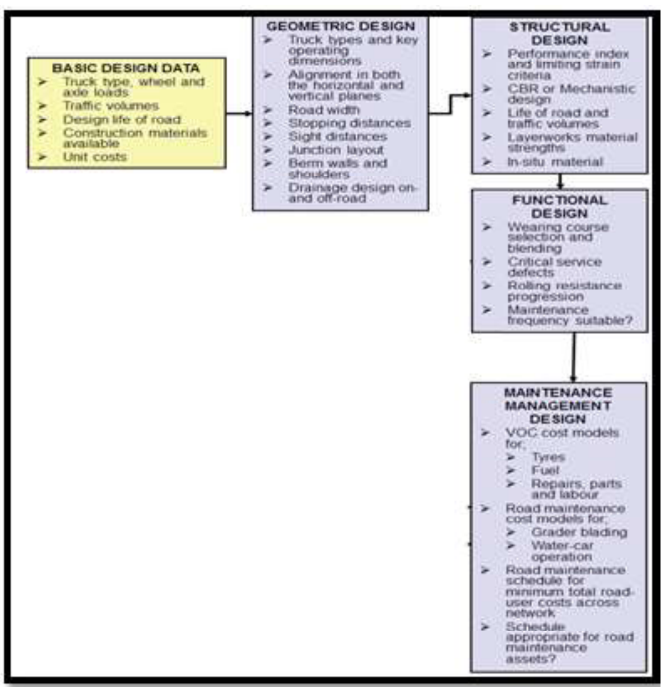
Structural Design
- Performance index and limiting strain criteria
- CBR or mechanistic design
- Life of road and traffic volume
- Layer work material strength
- In situ material

Functional design
- Wearing cores selection and blending
- Critical service defect
- Rolling resistance progression
- Maintenance frequency suitable

Maintenance management design
- VOC cost model for
- Tyre
- Fuel
- Repair, Parts and labour

- Road maintenance cost models for
- Grader blading
- Water car operation
- Road maintenance schedule for minimum total road user cost across network
- Schedule appropriate for road maintenance assets





HAUL ROAD MAINTENANCE

Surface deterioration of roads due to the following reasons

- Wheel rutting
- Spillage of materials from truck
- Heavy rainfall
- Saturating the surface material and turning into around layer
- Flooding of the pavement and causing soft spots and subgrade failure
- Damaged by tracked machines
- Incorrect load positioning on truck

Main functions for dust control

- Watering roads
- Grading roads
- Material spillage
- Maintenance of drains
- Maintenance of sign

Some of the Basic Maintenance requirements are

- Scarify the soft spots
- Remove wet spots and backfill
- Maintain good drainage
- Top up the running surface material
- Remove any trucks spillage material from the windrows when grading
- Maintain the cross fall and super elevation profile
- Adequate water is to be applied during any maintenance grading
- Regularly scarify areas that show sign of laminations

Road maintenance and repair

- All roads deteriorate gradually with time due to the effect of weather and repetitive loading from passing vehicles. Road maintenance can slow the rate of deterioration but eventually a point is reached where repair or rehabilitation is necessary.
- Haul road should not be allowed to remain rutted and grooved.
- Graders are used to keep the road surface smooth to maintain cross slope and to remove loose rocks from the surface.

Drainage requirement

- Poor drainage from the road surface leads to mud and pot holes resulting in the tyre spinning, fast wear, cut, reduces, traction and increased fuel consumption.
- Do not over water haul road for dust suppression as water act as lubricant for rubber.
- Culverts are typically used where road cross streams or natural drainage p.

Dust Suppressants

- Dust generated by moving vehicles is typically reduced by application of water to road surface.
- Watering helps reduce wash boring or corrugation of the haul road surface.
- The quantity of water needed to control dust depends on the nature of the road surface, traffic intensity, humidity, precipitation. It may be 1 to 2 litre/mtr2 / hr in summer.
- Liquid stabilizer and polymers are used which strengthen the surface layer as well as provide a degree of water proofing.

The characteristics of the chemical products used are as follows

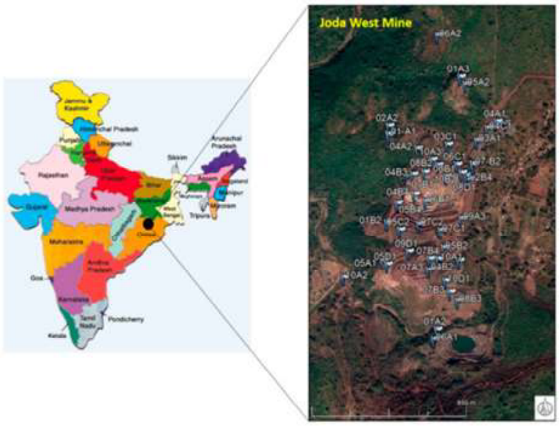
- Emulsified Asphalt- it contains an emulsifying agent, water and asphalt and caused by evaporation of water from the mixture. DL-10 is designed to remain flexible after curing allowing for road maintenance without loss of dust control effectiveness.
- Calcium Chloride – A hygroscopic compound that extract moisture from the atmosphere and dampens the road surface. The product is natural salt brine with a minimum calcium chloride contain of 26%.
- Calcium Lignosulfonate- An organic product of the sulphite wood pulping process that can be used to physically binds soil particles together.
- Surfactant – Substances capable of reducing the surface tension of the transport liquid, thereby allowing available moisture to wet more dart particles pore unit volume. Alchem 8808 is used for this application.

Truck haulage is responsible for a majority of cost in a surface mining operation. Diesel fuel, which is costly and has a significant environmental footprint, is used as a source of energy for haul trucks in surface mines. Reducing diesel fuel consumption would lead to a reduction in haulage cost and greenhouse gas emissions. The determination of fuel consumption is complex and requires multiple parameters including the mine, fleet, truck, fuel, climate and road conditions as input. Data analytics is used to simulate the complex relationships between the input parameters affecting the truck fuel consumption. This technique is also used to optimise the input parameters to minimise the fuel consumption without losing productivity or further capital expenditure for a specific surface mining operation. The aim of this research thesis is to develop an advanced data analytics model to improve the energy efficiency of haul trucks in surface mines. The most important controllable parameters affecting fuel consumption are first identified, namely payload, truck speed, road gradient and total resistance.

FIELD STUDY

To meet the objective of the study, the field study was conducted at Joda West Iron and Manganese mines of Tata Steel Limited, situated at Keonjhar district of Odisha. In Joda West Iron & Mn. Mine a new quarry named

Gangaigora was developed. During the development of the quarry special emphasis was given for construction of haul road as per the MMR 1961.



RESULT AND DISCUSSION

The study was conducted in to different time with to different haul road gradient. When the gradient of old haul road is more than 1 in 16 in some stretches the average fuel consumption per hour of 10 dumpers are:

FUEL CONSUMPTION PER HOUR OF MAY-2022				
SL.NO	EQUIPMENTS	RUNNING HOUR	HSD CONSUMOTION	HSD CONSUMOTION/ HOUR
1	OD 09S-3369	264.100	3430.755	12.990
2	OD 09S-3469	229.500	3105.065	13.530
3	OD 09S-3569	256.400	3323.340	12.962
4	OD 09S-3669	220.100	2941.305	13.363
5	OD 09S-3769	279.500	3443.890	12.322
6	OD 09S-3869	254.400	3448.875	13.557
7	OD 09S-3969	271.400	3462.820	12.759
8	OD 09T-4069	266.700	3224.925	12.092
9	OD 09T-4169	270.000	3284.055	12.163
10	OD 09T-4269	258.700	3528.600	13.640
TOTAL		2570.800	33193.630	12.912

After construction of new haul road having gradient less than 1 in 16, the average milage per litre fuel of 10 dumpers are:

FUEL CONSUMPTIN PER HOUR OF NOV.-2022				
SL.NO	EQUIPMENTS	RUNNING HOUR	HSD CONSUMOTION	HSD CONSUMOTION/ HOUR
1	OD 09S-3369	237.100	2401.430	10.128
2	OD 09S-3469	203.200	2104.160	10.355
3	OD 09S-3569	275.800	2857.110	10.359
4	OD 09S-3669	184.800	1736.760	9.398
5	OD 09S-3769	287.900	2691.650	9.349
6	OD 09S-3869	255.100	2426.610	9.512
7	OD 09S-3969	224.100	2215.460	9.886
8	OD 09T-4069	241.900	2484.440	10.271
9	OD 09T-4169	237.200	2233.430	9.416
10	OD 09T-4269	254.800	2438.880	9.572
TOTAL		2401.900	23589.930	9.821

When the gradient of old haul road is more than 1 in 16 in some stretches the average milage per litre fuel of 10 dumpers are:

MILAGE PER HOUR OF JUNE-2022				
SL.NO	EQUIPMENTS	RUNNING KM	HSD CONSUMOTION	MILEGE / LITRE
1	OD 09S-3369	1213.600	2401.430	0.505
2	OD 09S-3469	1176.300	2304.160	0.511
3	OD 09S-3569	867.000	1757.110	0.493
4	OD 09S-3669	890.000	1736.760	0.512
5	OD 09S-3769	959.900	2091.650	0.459
6	OD 09S-3869	1228.700	2426.610	0.506
7	OD 09S-3969	1151.900	2215.460	0.520
8	OD 09T-4069	1066.400	2584.440	0.413
9	OD 09T-4169	1131.000	1933.430	0.585
10	OD 09T-4269	1236.400	2438.880	0.507
TOTAL		10921.200	21889.930	0.499

After construction of new haul road having gradient less than 1 in 16, the average milage per litre fuel of 10 dumpers are:

MILAGE PER HOUR OF DEC.-2022				
SL.NO	EQUIPMENTS	RUNNING KM	HSD CONSUMOTION	MILEGE / LITRE
1	OD 09S-3369	2401.430	3430.755	0.700
2	OD 09S-3469	2304.160	3305.065	0.697
3	OD 09S-3569	1757.110	3323.340	0.529
4	OD 09S-3669	1712.100	2941.305	0.582
5	OD 09S-3769	2149.100	3443.890	0.624
6	OD 09S-3869	1995.100	3448.875	0.578
7	OD 09S-3969	2062.600	3462.820	0.596
8	OD 09T-4069	1935.500	3224.925	0.600
9	OD 09T-4169	2107.800	3284.055	0.642
10	OD 09T-4269	2125.300	3728.600	0.570
TOTAL		20550.200	33593.630	0.612

CONCLUSION

Well designed and maintained haul roads are the key to minimizing truck haulage on road hazards and costs as well as increasing productivity. However practically designing and managing a haul road for optimal performance is often difficult to achieve. We can be think of how a road design is developed and critically the interplay between a good design and safe cost efficient haulage.

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Management of Fugitive Dust in Opencast Mines

Amulya Kumar Panda*

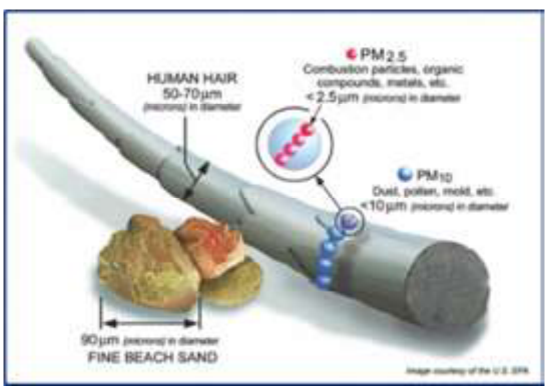
ABSTRACT

Fugitive dust emissions related to process operations is one of the major environmental challenges for Mining Industry. Fugitive dust is of concern due to the potential health impacts associated with the particulate matter. In mining, this is coupled with the potential for elevated levels of metals to be present in the particulate matter. For these reasons, fugitive emissions are required to be assessed when facilities are seeking regulatory approvals. Managing fugitive releases can help the approvals process and prevent complaints related to dust issues.

Key Words: Fugitive Dust, Particulate Matter, Regulatory Approval

INTRODUCTION

Generation of dust is invariably associated with mining, as most mining operations cause size reduction of rocks and minerals due to drilling, cutting, crushing, grinding, etc. In recent years, heavy mechanisation of the mines due to increased demand for minerals has resulted in a sharp increase in dust generation and the miners' health risk (Biffi and Belle, 2003).

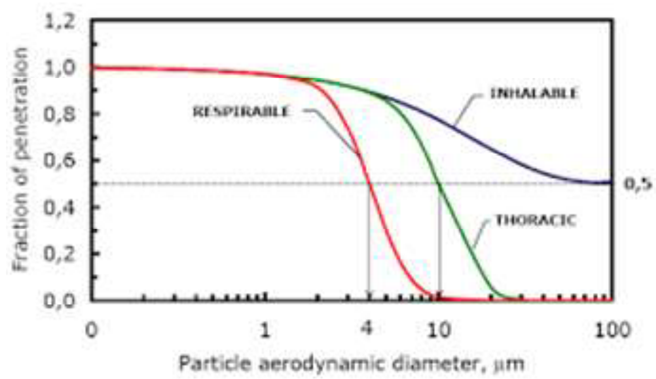


Mining induced dust originates at impact points (including drilling, blasting, loading, unloading, crushing and grinding), from previous accumulations, or from weathering. A wide range of particle sizes can be produced during a dust generating process. Larger particles settle more quickly than smaller particles, and the smallest particles can remain suspended in the air indefinitely. Dust is typically measured in micrometers (commonly known as microns). Coal or Rock dust can range in size from over 100 μm to less than 2 μm. As a comparison, red blood cells are typical 8 μm and human hair ranges from 50-75 μm in size.

*Sr Manager (Drilling and Blasting), Mn Group of Mines, FAMD, Tata Steel Limited, Manganese Group of Mines, Joda, Odisha
Corresponding Author: rajmining.amulya@tatasteel.com

Inhalable dust (smaller than 100 micrometres (μm) - visible dust which can affect your upper respiratory system (the nose, mouth, throat or upper respiratory tract).

Respirable dust (smaller than 10 μm) - these dust particles are so small that they are invisible under normal lighting conditions.



Airborne Respirable Dust is identified as an important component responsible for causing respiratory diseases, such as silicosis, a prominent occupational health hazard in mines (IARC, 1997)

This comprehensive review focused on associated health risks and effective dust control measures against inhalable and respirable dust at mining workplaces to reduce the occupational health impact arises out of dust exposure at workplace.

HEALTH AND SAFETY IMPACTS

Most dust clouds contain particles of widely varying sizes. Hazardous dust is not always visible. The larger particles that can be breathed in are called inhalable or inspirable dust particles. Inhalable dust particles are visible to the naked eye and are deposited in the nose, throat, and upper respiratory tract. Respirable dust contains dust particles so small they are invisible to the naked eye and reach deep into the lungs. Breathing in dust can result in a range of occupational illnesses and diseases depending on:

- **Size** of dust particles
- **Composition** of the dust particle and its effect on the body
- **Concentration** of dust particles in the breathing zone of the worker
- **Exposure** in dusty atmosphere: how often and how long a person breathes in the dust.

The potential health effects of some common dusts in mines and quarries are summarised as follows:

Health Effect	Dust Particle Content
Systemic toxic effects caused by absorption into the blood	Lead, manganese, cadmium, zinc
Allergic and hypersensitivity reactions	Certain woods, organic and inorganic chemicals
Bacterial and fungal infections	Viable organisms or spores
Lung scarring and fibrosis	Asbestos, quartz (crystalline silica)
Cancer	Chromates, asbestos, quartz (crystalline silica)
Irritation of the mucous membranes of the nose and throat	Acid, alkali, other irritating particles
Pulmonary disease (e.g. coal workers' pneumoconiosis (CWP) and chronic obstructive pulmonary disease (COPD) such as bronchitis and emphysema)	Coal dust

- High levels of dust can reduce visibility and become a safety hazard.

Other Impacts

- Apart from adverse health effects, the corrosive effect of dust particles reduces the life of lubricants used in heavy earth moving machineries (HEMM) and in turn, increases their maintenance cost due to excessive wear and premature failure of the machine components (Pandey, 2012).

RISK ANALYSIS OF DUST- EFFECTS OF AIR POLLUTION ON HUMAN BODY

When suspended in air, smaller airborne particles of dust can be a great risk to the miners' respirable system. It has been proved that the smaller the aerodynamic diameter of the inhaled dust particle, the more likely it will be deposited more deeply in the respirable tract (Prata 2018; Gasparotto et al. 2018; Gianoncelli et al. 2018; Entwistle et al. 2019; Graczyk and Riediker 2019). Pyramid of Effects from Air Pollution has been shown in Fig.1.

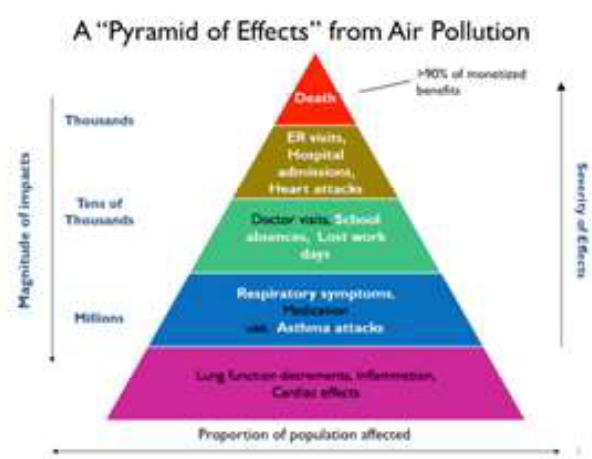


Fig.1: Pyramid of Effects from Air Pollution

Various studies have indicated that nano-scale particles pose a higher risk of human health due to their specific characterizations, such as highly developed surface area per unit weight or volume, which may cause a larger lung deposited surface area (LDSA) with a different toxicology compared to the same mass concentration of dust with relatively large size (Arias-Andres et al. 2018; Johnson et al. 2019; Zhao et al. 2019). Deposition of dust particles in the respiratory system, depending on the size of the dust particle is shown in Fig.2

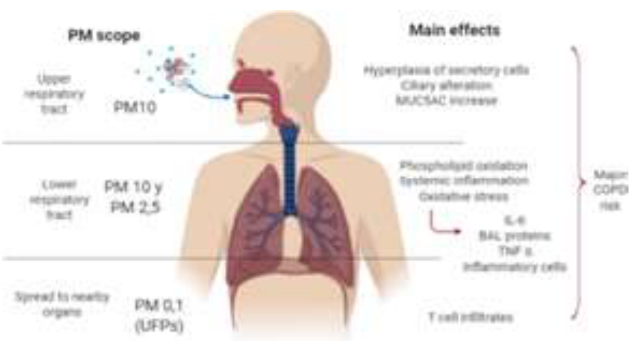


Fig.2 : Dust particle deposition in the respiratory system

PM10 refers to particles with an aerodynamic diameter smaller than 10 µm, and PM2.5 refers to particles with an aerodynamic diameter smaller than 2.5 µm. PM10 called coarse dust and PM2.5 called fine dust. PM10 and PM2.5 are both forms of particulate matter, but the difference in aerodynamic diameters comes into play when discussing the health effects of particle pollution exposure. Fig.3 represents the impact zones of various sizes of dust inhalation.

SOURCES OF DUST GENERATION IN MINING ACTIVITY

Mining induced dust originates at impact points (including drilling, blasting, loading, unloading, crushing and grinding), from previous accumulations, or from weathering. A wide range of particle sizes can be produced during a dust generating process. Larger particles settle more quickly than smaller particles, and the smallest particles can remain suspended in the air indefinitely. Some studies have also reported the generation and estimation of mine dust in surface mining operations (Chakraborty et al., 2002; Ghose, 2004; Gautam and Patra, 2015; Patra et al., 2015). Generation of dust is invariably associated with mining, as most mining operations cause size reduction of rocks and minerals due to drilling, cutting, crushing, grinding, etc. In recent years, heavy mechanisation of the mines due to increased demand for minerals has resulted in a sharp increase in dust generation and the miners' health risk (Biffi and Belle, 2003).

The key steps in the mining process include extraction, storage and disposal. In each of these steps, there is a potential for releases of fugitive dust. Specific mining activities that may result in fugitive dust emissions include

- Site preparation (bulldozing, land clearing)
- Open Cast drilling and blasting
- Material movement (Loading/unloading, Hauling & stockpiling)
- Crushing/screening ore and waste rock
- Tailings and storage piles (wind erosion)

Long Fan, Shimin Liu (2021) have examined the dust exposure and the recognized mining-related nano-particulates sources, which have adverse health impact on miners and their substantial detriment as a potential respiratory hazard.

The dust generated easily liberates into the confined working environment, forming a dust cloud if its concentration is high and with proper sizes. This type of dust cloud, obviously, is having a great health threat to the mining operation personnel. In addition to this, high dust level can impede visibility and thus directly affects the safety of workers. The various sources of air borne fugitive dust are depicted in fig. 4 & 5.

Fig. 4, 5: Mining related nano-dust sources

Respirable dust (PM10) in Mines

(PM10) refers to dust which is typically less than 10 microns in size.

- The largest source of PM10 in mines comes from haul trucks travelling along haul roads (40%).
- However other sources of dust can include:
- Wind erosion of overburden (27%)
- Bulldozers (8%)
- Blasting (6%)
- Dumping overburden (4%)
- Others (18%) (Drilling, Crushing & Screening, Maintenance activities)

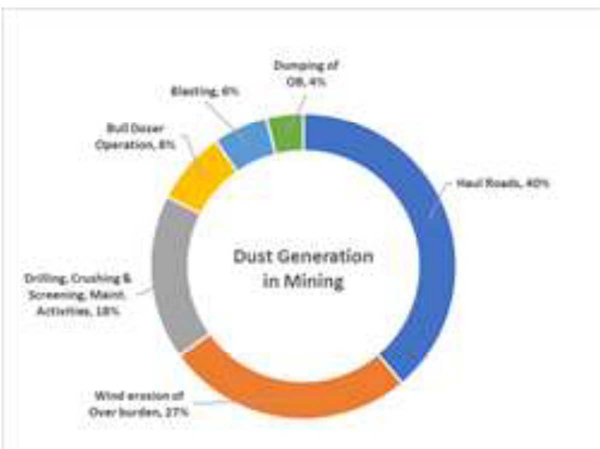


Fig. 6, Contribution % in Dust Generation due to Mining activities

FIELD STUDY

Field study was carried out at the Guruda Pit of Tiringahar Manganese Mines of M/s Tata Steel Ltd.

Mining operations contribute towards air pollution in two ways: addition of gaseous pollutants to the atmosphere and the dust particles. The gaseous pollutants include NOx, SO2 and Hydrocarbons. The sources of particulate / gaseous pollutants from the mining activity include:

- Operation of HEMM, which mostly run-on diesel.
- Loading/unloading operations.
- Transportation of ore/overburden/waste rock in dumpers.
- Drilling and blasting.
- Screening and crushing operations.

Apart from dust generation the other sources of air pollution are the gaseous pollutants, which are not focussed on this study, though other data related to NOx and Sox are evaluated.

Monitoring and Quantification of Ambient Air Quality

The ambient air quality with respect to the study zone of 10 km radius around the Mining Lease area forms the status of baseline air quality. The study area represents mostly rural setting surrounded by a few water bodies. The various sources of air pollution in the region are existing mining operations, vehicular traffic, dust arising from unpaved village roads and domestic fuel burning. The prime objective of baseline air quality survey was to assess the existing air quality of the study area. This will also be useful in the prediction of incremental changes to the air quality (existing) due to proposed expansion plans.

The baseline results for the study period for three months from 1st March to 31st May 2022 are presented in following sections.

METHODOLOGY

Selection of Sampling Locations

The baseline status of the ambient air quality has been assessed through a scientifically designed ambient air quality monitoring network. The design of monitoring network in the air quality surveillance program has been based on the following considerations:

- Meteorological conditions;
- Topography of the study area;
- Likely impact areas; and
- Sensitivity of the receptors.

Location of ambient air quality monitoring stations were selected based on the analysis of wind pattern based on IMD data. This determines the likely direction/ distance of occurrence of likely maximum concentration. The locations of the selected AAQM stations are given in **Table-5.1.1(a)** and illustrated in **Figure-5.1.1(b).**

TABLE-5.1.1 (a)

Ambient Air Quality Monitoring Stations Code	Name of the Location	Distance w.r.t ML Area (km)	Direction w.r.t ML Area	Wind Scenario	Environment Setting
AAQ1	ML Area (Guruda Block)	Within ML Area	within ML Area	--	Core/Industrial
AAQ2	Khandbondh (Reserve forest)	2.0 Km	N	Cross wind	Sensitive Area
AAQ3	Bichakundi Village	6.3 Km	N	Cross wind	Residential/Commercial Area
AAQ4	Khuntapani (Reserve Forest)	6.8 Km	NNE	Down wind	Residential/Rural Area
AAQ5	Jadibahal Village	1.6 Km	NE	Down wind	Residential/Rural Area
AAQ6	Palsha Kha (School)	0.9 Km	E	Cross wind	Sensitive Area
AAQ7	Bamebari Village	3.0 Km	SE	Cross wind	Residential/Rural Area
AAQ8	Siljora (School)	2.9 Km	SW	Up wind	Sensitive Area
AAQ9	Ganua Village	3.0 Km	W	Cross wind	Residential/Rural Area
AAQ10	Chormalda Village	4.9 Km	NW	Cross wind	Residential/Rural Area
AAQ11	Joda Town	9.3 Km	NNE	Cross wind	Residential/Rural Area

Figure 5.1.1(b) Locations of the selected AAQM

PHOTOGRAPHS SHOWING AMBIENT AIR QUALITY MONITORING

AMBIENT AIR QUALITY MONITORING STATIONS

AAQ1: ML Area (Guruda Block)

AAQ2: Khandbondh (Reserve Forest)

AAQ3: Bichakundi Village

AAQ4: Khuntapani (Reserve Forest)

AAQ5: Jadibahal Village

AAQ6: Palsha Kha (School)

AAQ7: Bamebari Village

AAQ10: Chormalda Village

AAQ11: Joda Town

Frequency and Parameters for Sampling

Ambient air quality monitoring was done at a frequency of two days continuous per week for three months (1st March to 31st May 2022) at all eleven monitoring stations. The baseline data of air environment was monitored for parameters mentioned below as per revised NAAQS Standards as prescribed by the CPCB vide notification dated 18th November 2009.

• Respirable Particulate Matter (PM10);
• Fine Respirable Particulate Matter (PM2.5);

The air samples were analysed as per standard methods specified by Central Pollution Control Board (CPCB), IS:5184 (2001) and American Public Health Organization (APHA).

SAMPLING AND ANALYTICAL TECHNIQUES

Particulate Matter (PM10)

Respirable dust samplers APM-460 BL attached with APM-151 instruments have been used for sampling of respirable dust (<10 microns) and having impinger attachments for gaseous pollutants like SO2 and NO2.

PM10 (<10 ìm) present in ambient air is drawn through the cyclone. Coarse and non-respirable dust (>10 ìm) is separated from the air stream by centrifugal forces acting on the solid particles. These separated particulates fall through the cyclone's conical hopper and collect in the sampling cup placed at the bottom of the cyclone. The fine dust (<10 microns) forming the respirable fraction passes through the cyclone and is retained by the filter paper.

A tapping is provided on the suction side of the blower to provide suction for sampling air through a set of impingers. Samples of gases are drawn at a flow rate of 0.2 litres per minute (lpm). The air samples were analysed as per standard methods specified in IS: 5182 (2001).

Particulate Matter (PM2.5)

APM 550 Fine Particulate Sampler (PM2.5) attached with impactor have been used for sampling of fine particulate (<2.5 microns).

An electrically powered air sampler draws ambient air at a constant volumetric flow rate (16.7 lpm) maintained by a mass flow / volumetric flow controller coupled to a microprocessor into specially designed inertial particle-size separator (i.e. cyclones or impactors) where the suspended particulate matter in the PM2.5 size ranges is separated for collection on a 47 mm polytetrafluoroethylene (PTFE) filter over a specified sampling period. Each filter is weighed before and after sample collection to determine the net gain due to the particulate matter.

Duration of Sampling

The duration of sampling of PM10, PM2.5, SO2 and NO2 was each twenty four hourly continuous sampling per day and CO and Ozone were sampled on 8 hourly continuous basis (thrice in 24 hours duration of monitoring). The monitoring was conducted for two days in a week for three month. This is to allow a comparison with the present revised NAAQ Standards as prescribed by the CPCB vide notification dated 18th November 2009. The ambient air quality parameters along with their frequency of sampling are given in **Table-5.2**.

TABLE-5.2

Monitored Parameters and Frequency of Sampling	Sampling Frequency
Particulate matter (PM10)	24 hourly sample twice a week for three months
Particulate matter (PM2.5)	24 hourly sample twice a week for three months

Instrument for Sampling

Dust samplers of Pollutech instruments were used for monitoring PM10 (<10 microns), PM2.5 and gaseous pollutants like SO2 and NO2. Glass tubes were deployed for collection of grab samples of carbon monoxide. Gas chromatography techniques have been used for the estimation of CO.

Methodology of Sampling and Analytical Techniques

The techniques used for ambient air quality monitoring and minimum detectable levels are given in **Table-5.3.** The results have been summarized in **Table- 5.4 (A&B)**.

TABLE- 5.3

Techniques used for the Ambient Air Quality Monitoring Sr. No.	Parameter	Technique	Technical Protocol	Minimum Detectable Limit (g/m3)
1	Particulate Matter (PM10)	Respirable Dust Sampler (Gravimetric Method)	IS-5182 (Part-XXIII)	10.0
2	Particulate Matter (PM2.5)	Fine Respirable Dust Sampler (Gravimetric Method)	CPCB Guidelines	5.0

5.4 AMBIENT AIR QUALITY

Code	Name of the Location	PM_{10} ($\mu g/m^3$)				$PM_{2.5}$ ($\mu g/m^3$)			
		Min	Max	Avg	98th %	Min	Max	Avg	98th %
AAQ1	ML Area (Guruda Block)	58.4	70.1	63.3	69.4	37.1	46.8	43.1	46.8
AAQ2	Khandbondh (Reserve forest)	42.2	47.1	44.5	46.9	28.3	31.9	29.9	31.8
AAQ3	Bichakundi Village	49.6	56.8	52.3	55.8	35.3	42.3	38.7	42.3
AAQ4	Khuntapani (Reserve Forest)	41.7	46.8	44.2	46.8	27.3	34.1	30.6	34.1
AAQ5	Jadibahal Village	58.2	62.0	60.3	62.0	34.1	40.7	37.2	40.2
AAQ6	Palsha Kha (School)	53.7	60.2	57.7	60.2	34.3	41.8	37.5	40.8
AAQ7	Bamebari Village	51.7	57.3	54.8	57.1	34.9	40.2	37.1	39.8
AAQ8	Siljora (School)	51.9	54.7	53.2	54.7	34.4	37.9	36.1	37.8
AAQ9	Ganua Village	48.9	53.2	51.1	53.1	35.4	38.6	37.0	38.6
AAQ10	Chormalda Village	43.7	51.3	47.5	51.2	33.8	37.3	35.1	37.1
AAQ11	Joda Town	49.8	57.8	54.0	57.4	30.1	34.0	32.1	33.9
Range		41.7 - 70.1				27.3 – 46.8			
NAAQ Standards		100				60			

RSPM CHEMICAL CHARACTERIZATION (%)

Sr. No.	Parameter	AAQ1 ML Area (Guruda Block)		AAQ2 Khandbondh (Reserve forest)		AAQ3 Bichakundi Village		AAQ4 Khuntapani (Reserve Forest)		AAQ5 Jadibahal Village	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1	Free Silica	4.71	5.65	2.89	3.18	3.75	4.31	2.89	3.18	4.05	4.84

Sr. No.	Parameter	AAQ6 Palsha Kha (School)		AAQ7 Bamebari Village		AAQ8 Siljora (School)		AAQ9 Ganua Village		AAQ10 Chormalda Village		AAQ11 Joda Town	
		Min	Max	Min	Max	Min	Min	Max	Max	Min	Max	Min	Max
1	Free Silica	3.97	3.96	3.65	4.31	3.74	4.05	3.11	3.48	3.13	3.42	3.43	4.43

SUMMARY & OBSERVATIONS

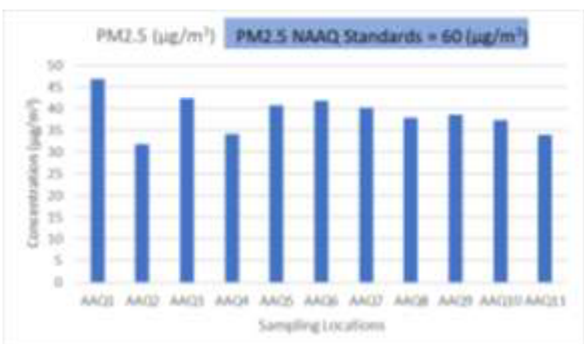
Various statistical parameters like 98th percentile, average, maximum and minimum values have been computed from the observed raw data for all the AAQ monitoring stations. The raw data of monitoring carried out for three months are presented in **Annexure-XXIV** and the summary of the results are presented in **Table-5.4(A&B).** These are compared with the standards prescribed by Central Pollution Control Board (CPCB).

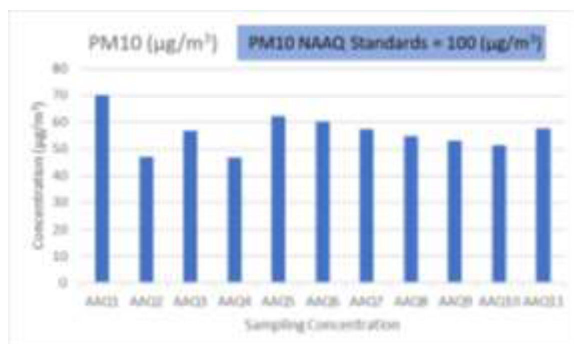
• ***Particulate Matter (PM2.5)***

The minimum and maximum concentrations for PM2.5 were recorded as 27.3 ?g/m3 and 46.8 ?g/m3 respectively. The minimum concentration was recorded at Khuntapani - Reserve Forest (AAQ4); whereas maximum concentration was recorded at ML Area (AAQ1).

• Particulate Matter (PM10)

The minimum and maximum concentrations for PM10 were recorded as 41.7 ?g/m3 and 70.1 ?g/m3 respectively. The minimum concentration was recorded at Khuntapani - Reserve Forest (AAQ4); whereas maximum concentration was recorded at ML Area - Garuda Block (AAQ1).





DISCUSSION AND CONCLUSION

As discussed above, there will be increase in terms of dust load due to mining operations and by maintaining proper environmental measures this can be reduced. Mining associated surface activities such as dozing and grading also cause insignificant emissions and will be confined to the lease area only and will not have any adverse impact on the outside community.

Mitigation Measures

Mitigative measures suggested for air pollution controls are based on the baseline ambient air quality of the area. From the point of view of maintenance of an acceptable ambient air quality in the region, it is desirable that air quality is monitored on a regular basis to check compliance of standards as prescribed by regulatory authorities. Fugitive dust will be generated in an opencast mine due to drilling, blasting, handling of overburden and ore transportation. To control dust from various operations following measures are in place which will be further strengthened.

a. The production of blast fumes containing noxious gases is reduced by the following methods/ Techniques of controlled blasting:

- Proper and proportionate mixing of fuel oil with ammonium nitrate to ensure complete detonation (proposed in case of ANFO based explosive which may be explored in future for usage)
- Use of adequate booster/primer; and
- Proper stemming of the blast hole.

b. **Dust due to drilling**

- Inbuilt dust suppression system provided in all drills to minimize fugitive dust generation. Wherever possible inbuilt dust extractor-based drills are also deployed.

c. Regular maintenance of vehicles and machineries is being carried in order to control emission.

d. AC cabins for shovel and dumper are provided which leads to minimum exposure of the operator to the external environment.

e. Dust suppression on exposed area is being done using water tankers and sprinkler provided on the approach to mine, beneficiation plant;

f. Dust generated due to traffic on haul roads is reduced by water spraying at regular interval of time. A major portion of the permanent haul road shall be provided with fixed sprinkling system.

g. Greenbelt development is being developed all along the haul roads and overburden dumps which will further be strengthened in view of proposed expansion.

h. Dust generation due to ore processing at the proposed screening and crushing plant is to be controlled by providing dust extraction system at hopper area, dry fog system at all transfer points, network of conveyors, minimize spillage by better management of conveyor system and housekeeping. Further portable dust barriers such as wind breaker have been envisaged near the screening cum crushing plant.

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Underground Occupational Accidents and Prevention Techniques – An overview

Dr. Banda Srikanth*

ABSTRACT

Occupational accidents in underground mining continue to be a major concern worldwide, resulting in fatalities, injuries, and property damage. This paper provides an overview of the causes of underground occupational accidents and reviews the prevention techniques employed to mitigate the risks. The paper discusses various preventive measures such as safety training, use of personal protective equipment, implementation of safety regulations, hazard identification and risk assessment, and emergency response plans. It also covers the role of technology in preventing underground occupational accidents, including the use of advanced sensors, automation, and communication systems. Finally, the paper highlights the need for collaboration between stakeholders, including employers, employees, regulatory bodies, and researchers, to achieve a safer underground mining environment.

INTRODUCTION

The demand for energy is growing at a much higher rate than the growth rate of the economy in India. It will continue rising in India due to the increasing pressure of population, continuing urbanization, significant expansion of better living standards of the middle-class peoples, electrification in more and more villages, expansion of electrification of Indian railways, more demand of electric vehicles, and modernization of agriculture, infrastructure and manufacturing sectors [1]. In India, coal is a major fossil fuel and it is used for electricity generation, steel production and various other purposes. In India, coal will remain the most important source of energy till 2031–32 and possibly even further. Majority of coal reserves in India are amenable to underground mining. The Government of India (GoI) has an ambitious plan to increase underground coal production from 35 Mt/year (current) to 100 Mt/year (by 2019). CSIR-Central Institute of Mining and Fuel Research (CSIR-CIMFR), the only premier research institute of its kind in India has kept ‘‘development and adoption of coal production technology (especially related to mass production) in underground mining” as an important thrust area of research [2]. World coal production is depicted in figure 1.

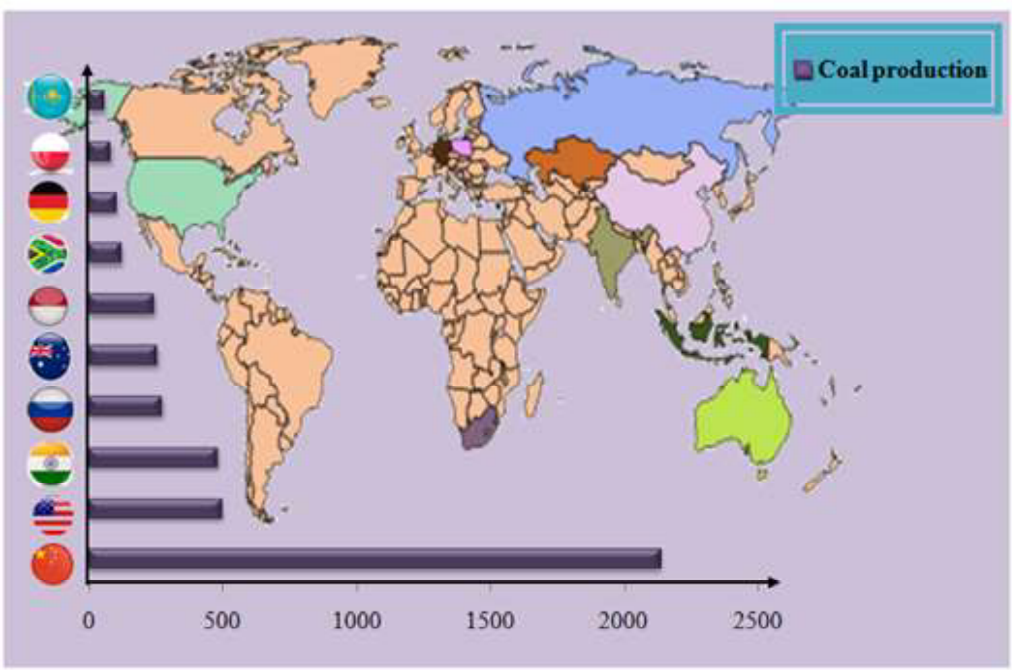

Figure 1: Coal production in world countries

**Assistant Professor, ECE Department“UCE,Kothagudem-Telangana*

Corresponding Author: bsrikanthiitkgp@gmail.com

Underground coal mining is a complex organization of many work disciplines that requires serious experience and knowledge as well as continuous control. Due to the natural negative conditions of underground coal mines, a significant number of occupational accidents occur and often cause fatalities. Underground coal mines are dangerous working environments that have the highest rate of fatal accidents and injuries compared with other workplaces [3]. [4] The highest incidence rate occurs in unaffiliated companies. The type of mine accidents include poisonous gas leakage such as falling stone, blasting, run over, electrocuted and trapped by machinery, hydrogen sulphide or explosive natural gases such as firedamp or methane, toxic gases arising from mine fires, dust explosions, collapsing of mine stopes, mining-induced seismicity, roof fall, flooding, or general mechanical errors from improperly used or malfunctioning mining equipment [5][6].

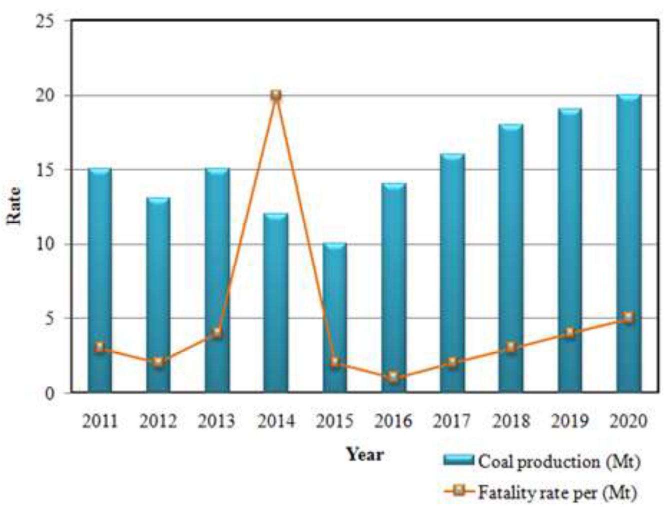

Figure 2: Coal production and fatality rate in India till 2020

Coal mine roadway junctions in mining are more vulnerable to roof fall due to the excavation induced stresses as well as general stress loading pattern inherent to the typical cross-section achieved in practice [7][8].

OCCUPATIONAL ACCIDENTS AND RISK CONTROL IN UNDERGROUND COAL MINES

A risk pre-control management system for safety in underground coal mines was built by ***Liu et.al [31]***. Specifically, the risk pre-control management system for safety in underground coal mines uses hazard identification and risk assessment as its basis, risk pre-control as its core, and unsafe behaviour control as its focus. The system was composed of four main parts: scope, normative reference documents, terms and definitions and management elements and requirements. Thus, the management elements and requirements were the core of the system that consists of 8 first-level basics and 46 s-level basics. Moreover, an illustration was provided to show the process of building a risk pre-control management system for safety in underground coal mines. In addition, the application software Risk Pre-control Management System for Safety was developed and applied by the Shen Hua Ningxia Coal Industry Group in China.

Pramod Kumar et. al [32] proposed a methodology for the estimation of human error rate from a retrospective analysis of accident reports using fuzzy mathematical concepts. The work emphasises only two aspects such as activity and human error of system safety. System operation comprises a set of human interactions called activities, and the accident statistics vary with the type of activity. The approach uses accident reports of underground coal mines for assessing the human error rates of essential mining activities, identifying the critical activities and error types. It also suggests some error reduction strategies for devising an intervention to accidents.

Safa Eslambolchi S. et.al [33] emphasised to understand the changes in the safety measures of U.S. underground coal mines across different mine-size categories during the period 2005–2014. Empirical data were collected from the MSHA Address/Employment and Accident/Injury files, for the period 2005–2014. The differences in the means of two normalized safety measures, Non-fatal Days Lost Incident Rate (NFDLIR) and Severity Measure/100(SM/ 100) as well as the changes in their trends, were examined across five mine-size categories, Very Large, Large, Medium, Small and Very Small, over the periods 2005–2009 and 2010–2014, before and after the institution of Mine Safety and Health Administration's (MSHA's) Impact Inspection program. Both NFDLIRs and SM/100s of the Very Large, Large, Medium, and Small mines were found to be significantly lower in the second period compared to the first period that can be attributed to MSHA's Impact Inspection program in 2010. No significant differences were found in the NDLFIRs and SMs of Very Small mines from the first period to the second period. A drastic decrease of more than 50% in the SM/100 mean of Small mines in the second period was observed and can be attributed to the closure of several small mines during that period.

Methane explosion accidents that occurred in Turkey's underground coal mines between the years of 2010 and 2017 were statistically analysed by ***Arif Emre Dursun et.al [34]***. It showed that the number of deaths in Turkey's underground coal mines between 2010 and 2017 was 578 and the mortality rate was found to be 92.63%. The rate of the death toll caused by methane explosions and other gas-related accidents was 68.34%. For this, some countermeasures were suggested and both prevent and control gas-related accidents. Furthermore, some recommendations for a decrease in the number of errors made in Turkey's underground coal mines were also presented.

To improve the safety management model in underground coal mines from passive management to active management, the risk pre-control continuum and risk gradient control in underground coal mining were proposed by ***Quanlong Liu et.al [35]***. There were three risk state correspond to three management models. The stable safety state corresponds to the hazard management model; the unstable safety state corresponds to the defect management model; the emergency accidents state corresponds to the emergency management model. Those three management models exist simultaneously, and each management model plays a role in pre-control to eliminate or reduce certain risks. The management level of those three management models determines the risk pre-control level and risk level of a coal mining enterprise. Finally, the idea of risk gradient control was proposed based on the risk pre-control continuum that includes three gradients from high to low, namely, hazard control, hidden danger control, and emergency control.

Rafa³ Czarny et.al [36] used passive seismic interferometry to monitor temporal variations of seismic wave velocities at the area of underground coal mining named Jas-Mos in Poland. Ambient noise data were recorded continuously for 42 days by two three-component broadband seismometers deployed at the ground surface. The sensors were about 2.8 km apart and measured the temporal velocity changes between them using cross-correlation techniques. Using causal and acausal parts of nine-component cross-correlation functions (CCFs) with a stretching technique, they obtained seismic velocity changes in the frequency band between 0.6 and 1.2 Hz. Correlation between average velocity changes and seismic events induced by mining was discovered. Especially after an event occurred between the stations, the velocity decreased by 0.4%. Finally, they concluded that it monitors the changes of seismic velocities that are related to stiffness, effective stress and other mechanical properties at subsurface caused by mining activities even with a few stations.

Petr Konicek et.al [37] commented on the main causes of rock bursts and summarised the strategic measures taken against them of the recent opinion on rock burst issues in the Ostrava–Karvina Coalfield. They highlighted the main mistakes in mine design of rock mass that lead to a rock burst risk and supports those arguments with illustrative examples from Czech hard coal mining. Long-term analyses of the causes of rock bursts provided recommendations on proper mining techniques for excavation of a rock mass with rock burst risk.

Melih Iphar and Ali Kivanc Cukurluoz [38] identified the safety hazards present in Indian underground coal mines and to build a preliminary database of the identified hazards. Accident data were collected from the Directorate General of Mines Safety in India and a public sector coal mining company was studied to identify safety hazards that may probably lead to accidents. The database could help mine management to improve decision making after analysing and evaluating the safety risks of identified hazards.

Erdogan H. H. et.al [39] proposed a quantitative methodology for the analysis and assessment of hazards associated with occupational accidents. The application of the proposed approach is performed on the mines of Turkish Hard Coal Enterprises (TTK). The accidents in TTK between the years 2000 and 2014 were first statistically analysed with respect to the number, type and location of accidents, age, experience, education level and main duty of the casualties and also injuries resulting from such accidents. The hazards were classified as individual, operational and locational hazards and quantified using contingency tables, conditional and total probability theorems. Lower and upper boundaries of hazards were determined and event trees for each hazard class were prepared. Total hazard evaluation results showed that Armutcuk, Karadon and Uzulmez mines have relatively high hazard levels while Amasra and Kozlu mines have relatively lower hazard values.

Table 1: Various case studies on occupational accidents in underground coal mining

Author	Type of investigation	Evaluation technique used	Findings and Recommendations
Czarny et al.,2016	Monitoring Velocity Changes in coal mines	Passive seismic interferometry	The seismic velocities decrease with a large event that occurred close to the direct wave path between two receivers used, and the sensitivity relates to the receiver location, noise environment, and local geology.
Safa et al.,2019	Policy changes in safety enforcement	Non-fatal Days Lost Incident Rate (NFDLIR) and Severity.	Recommended to create a separate model for each mine-size category, as mines of like size have similar characteristics and fewer variations are observed. Moreover, to consider a random effect regression model for mine ID and the interaction between the mine size and year is also recommended
Erdogan et al.,2019	Quantitative hazard assessment	Probability theorem	Being one of the high rates of accident occurrence rates,analyses and implementation on Turkish data give important information on reducing and mitigating the underground mine accidents in Turkey. These results are expected to guide decision-makers, regulators, and managers to re-structure the system
Petr et al.,2019	Long-Term Czech Experiences with Rockbursts	Software Phase using FEM	The knowledge level is high in the USCB, both in the Czech Republic and in Poland and it should still be improved even if only a single ton of coal will be mined. In addition, the Czech experiences are based on Carboniferous sedimentary coal deposits, many of them may be useful in underground mining.
Liu et al.,2019	Risk pre-control management	Scope, normative reference documents, terms, definitions, management elements and requirements	The risk pre-control management system was built based on the study of risk pre-control continuums, hazards polarized management, the development, and evolution of safety management, accident causes. It takes hazards identification and risk assessment as its basis, risk pre-control as its core, and unsafe behavior control as its focus
Pramod et al.,2020	The human error rate in underground coal mines	Fuzzy based mathematical rules	Showed a human error criticality-based approach for managing and control of accidents, then the analysis serves as a guiding tool for the safety improvement in the Indian mining industry.

PREVENTION TECHNIQUES

To prevent occupational accidents in underground mining, various techniques have been developed and implemented over the years. These techniques aim to identify and mitigate the hazards associated with mining activities, as well as to improve the safety culture and practices of the workers.

One of the most effective techniques for preventing underground mining accidents is risk assessment. Risk assessment involves identifying potential hazards in the workplace, evaluating their likelihood and severity, and developing measures to control or eliminate them. Risk assessment is a continuous process that involves regular inspections, audits, and reviews of the workplace and the mining processes.

Another important technique for preventing accidents in underground mining is training and education. Workers must be trained on the hazards associated with their work, as well as on the proper use of equipment, tools, and personal protective equipment (PPE). They must also be trained on emergency response procedures and evacuation plans. Regular training and education sessions can help improve the safety culture of the workplace and ensure that workers are aware of the risks associated with their work.

Engineering controls are also an essential technique for preventing accidents in underground mining. Engineering controls involve designing the workplace and mining processes to reduce or eliminate hazards. For example, ventilation systems can be installed to control dust and gases, and roof supports can be installed to prevent rock falls. The use of technology, such as remote-controlled equipment and sensors, can also help reduce the risks associated with mining activities.

Personal protective equipment (PPE) is another critical technique for preventing accidents in underground mining. PPE includes equipment such as hard hats, gloves, safety glasses, and respirators. PPE is essential for protecting workers from hazards such as falling objects, dust, and harmful gases. However, PPE should not be relied upon as the primary means of protection, and it should be used in conjunction with other prevention techniques.

CONCLUSION

The mining industry is a high-risk occupation, and accidents in underground mining can have severe consequences. However, by implementing effective prevention techniques, such as risk assessment, training and education, engineering controls, and personal protective equipment, the risks associated with underground mining can be mitigated. The mining industry must continue to prioritize worker safety and invest in measures to prevent and mitigate occupational accidents. By doing so, the industry can ensure the health and well-being of its workers and contribute to the sustainable development of the global economy.

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The Study of the Rock Mechanics Measurements of Strata Movement Around Excavation

Radhe Krishna* Bunda Besa* Mayamiko Ndala*

ABSTRACT

The study of the mechanics of strata movement around mining excavation must be a primary objective in investigations of the control of the within the mining area. The present growth which is defined as- of rock mechanics research , which is defined as 'the study of rock behavior of the rock mass which is disturbed by the mining process and the application of strata control principles based on data provided from the rock mechanics investigations , is of primary importance to the mining engineers . The mining engineer, however, has difficulty to accept to the necessarily of control equipment, whose safe limit, is not yet fully understood. It is, therefore, imperative that the production engineer in the mining industry needs the instrumentation to guide him in making decisions relating to strata control for which there is no still t clear understanding of the influence of rock mass movement and strata pressure redistribution, as mining proceeds. Two different investigations from widely different conditions are described in this paper to emphasize the similarity of approach and to show how the analyses of rock-mass movement related to different conditions remarkably alike

KEYWORDS: Rock-mass movement, pressure re-distribution, safe limit, design parameters MultipoiBorehExtensometer (MPBXs), displacement and pressure

INTRODUCTION

Some degree of rock-mass movement over mined-out area is often inevitable .Such movement can create problems of ground stability and may have deleterious effects on structure and environment. Although the bird and pillar mining method is in use extensively all around the world, in one form or the other, a little information has been compiled or published regarding the correlation of surface subsidence with deformation parameters in underground and intervening strata.

In the back ground of the aforesaid need a comprehensive project was taken from two different situation widely different conditions, one fin India, bord and pillar mining and the other from the United Kingdom, Durham Coal Field.

ROCK- MASS MOVEMENT ABOVE THE BORD AND PILLAR WORKING

The field investigations reported here is part of the studies carried out by the main author titled " Correlation of surface subsidence with deformation parameters in underground and intervening strata "funded by S& T grant of Department of Coal Ministry of Energy, Government of India,

*University of Zambia, School of Mines, Department of Mining Engineering.
Corresponding Author: m.c.ndala@gmail .com

Site description

The Ratibati Colliery (ECL)in Ranijung Coalfield, one of the main source of coking coal, was facing tremendous problems due to mine induced- subsidence as a result of underground mining of coal seams. The occurrence of thick seams in close proximity at shallow depth followed by changes in the nature of superincumbent strata, greatly from place to place and by large the slow rate extraction in almost all the underground mines has caused working.

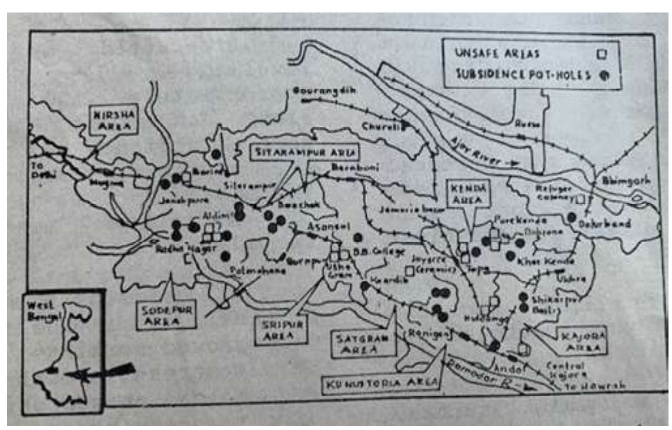


Fig.1: Ranijung coalfields (Geological Survey of India)

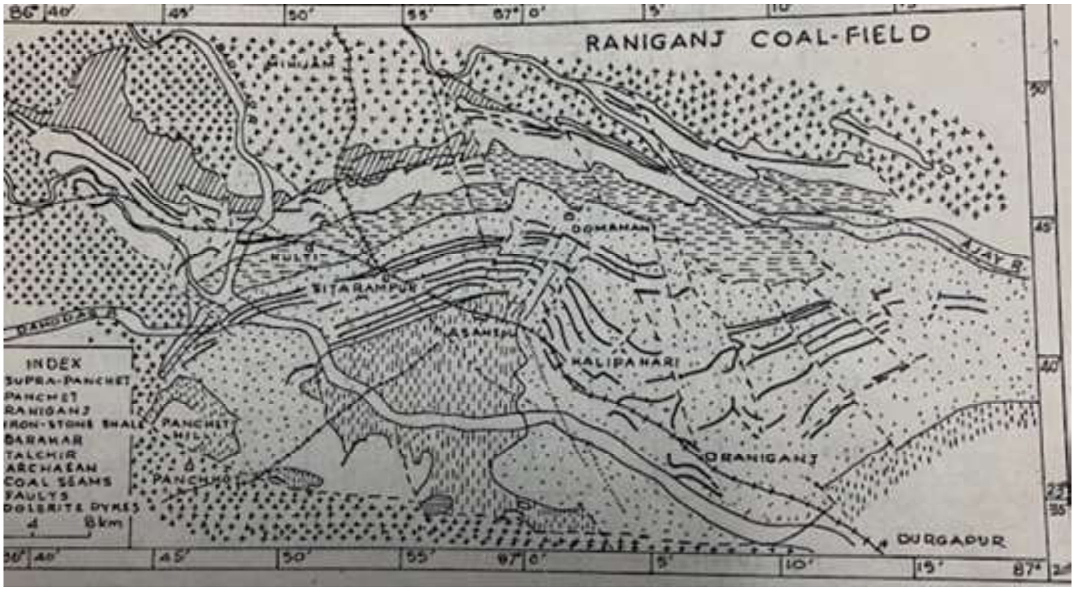


Fig.2: Geological sketch plan of Ranijung coalfield

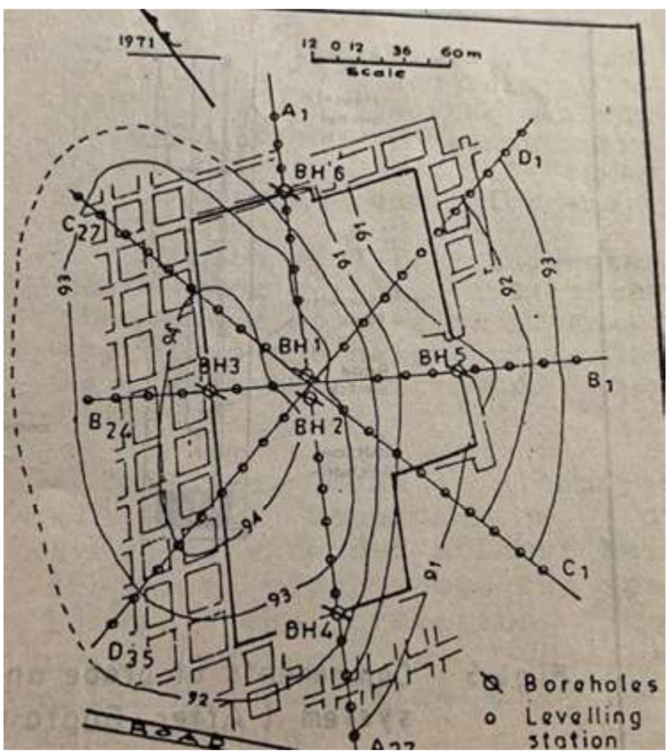


Fig.3: Location of borehole and levelling stations over panel (NS 12)

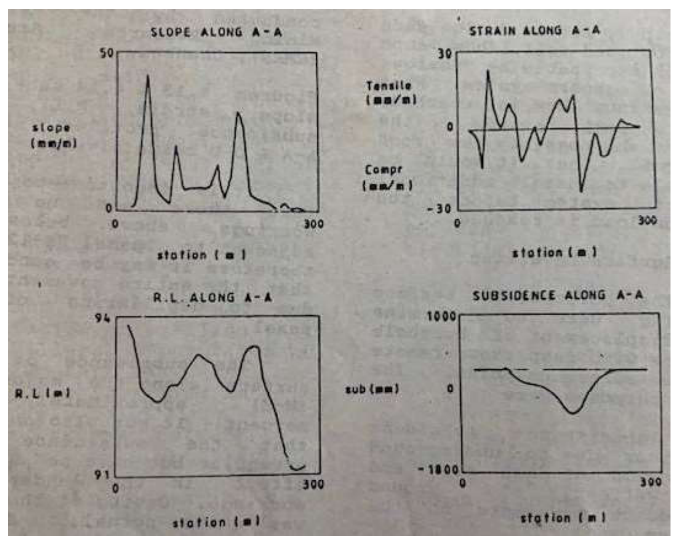


Fig. 4: Slope, Sprain, R.L. & Subsidence Curve along A-A, panel N-S 12

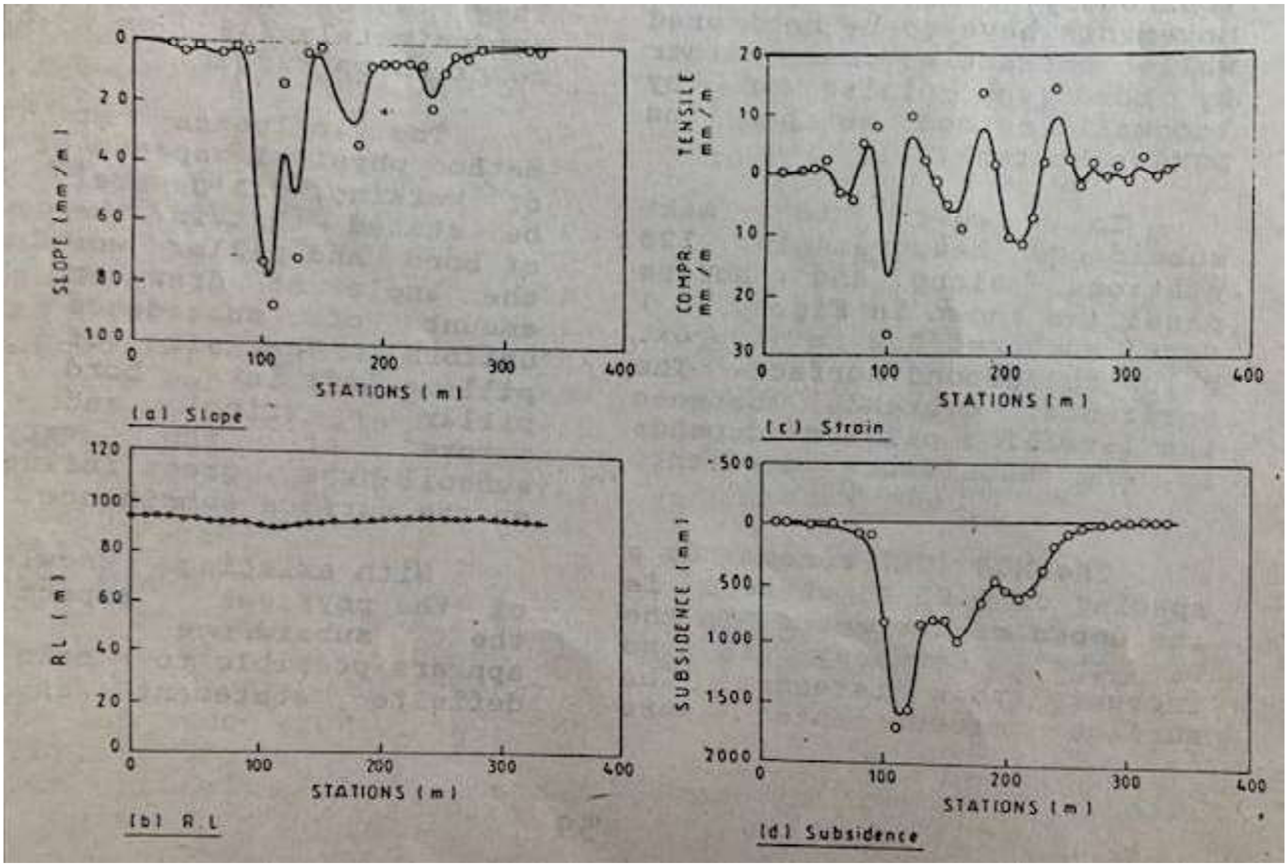


Fig.5: Slope,R,L, strain and subsidence curves along D-D

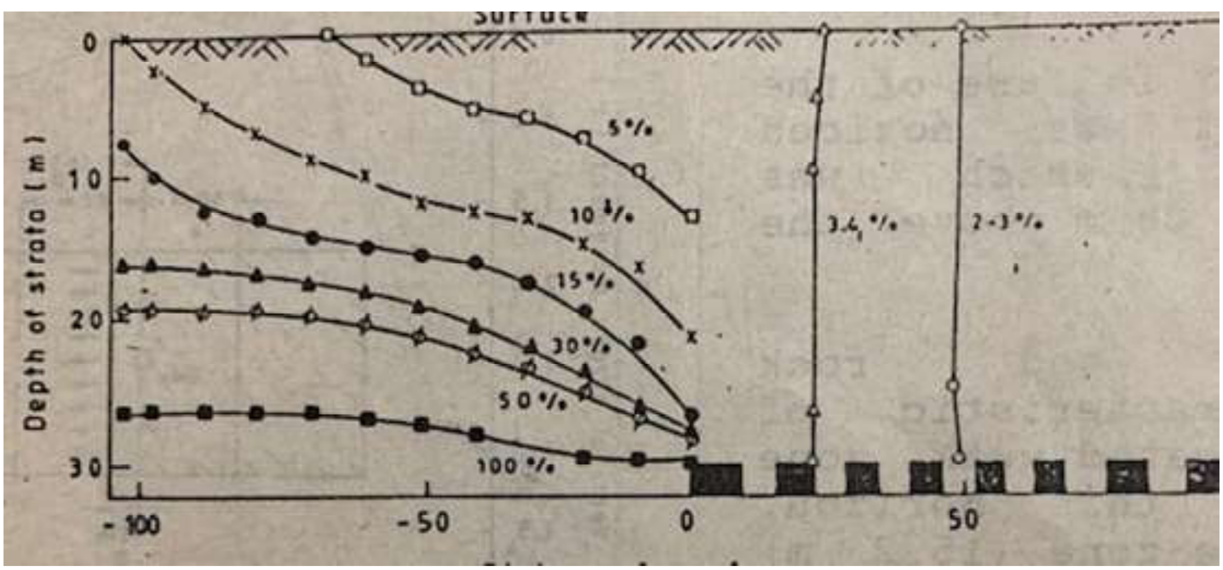
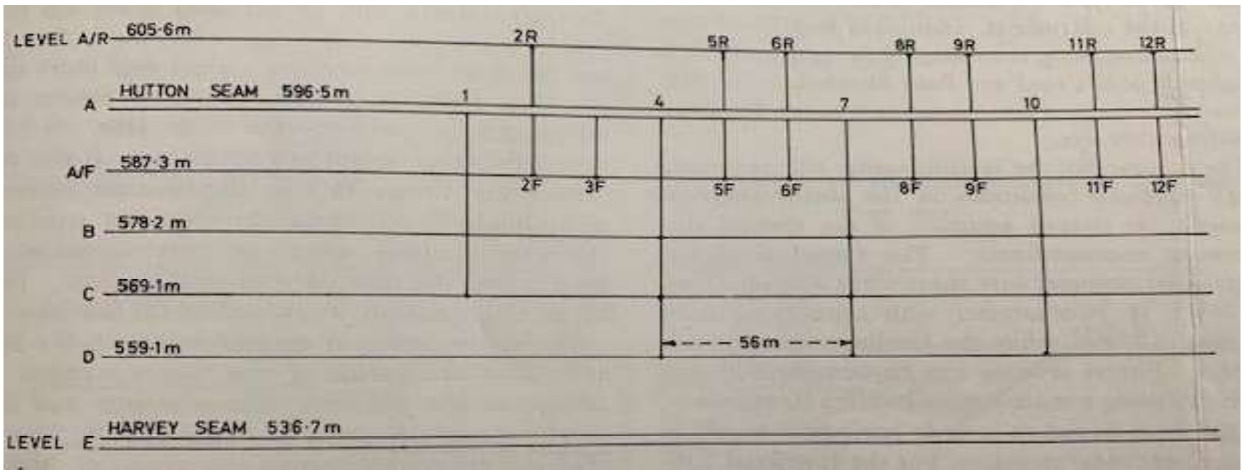


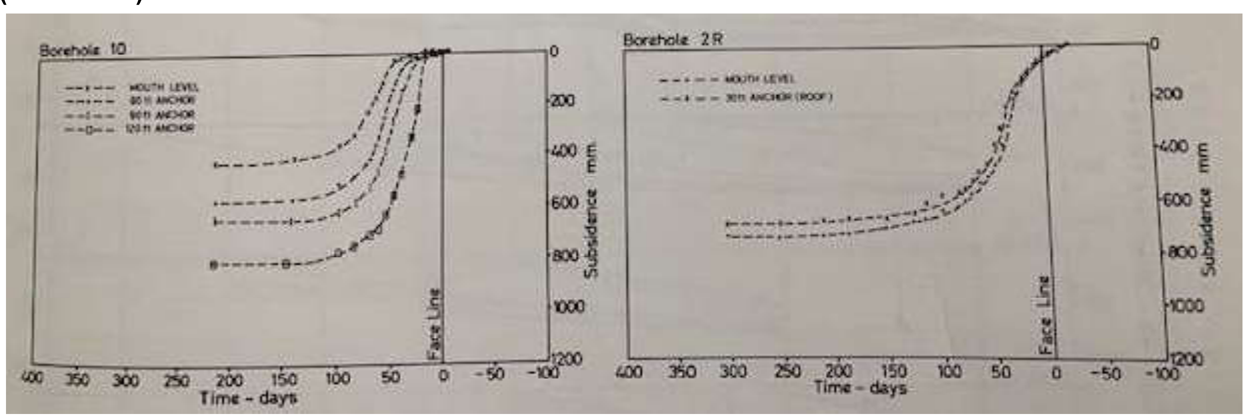
Fig. 6: Vertical Movement in the overburden (expressed as % of extracted seamheight)

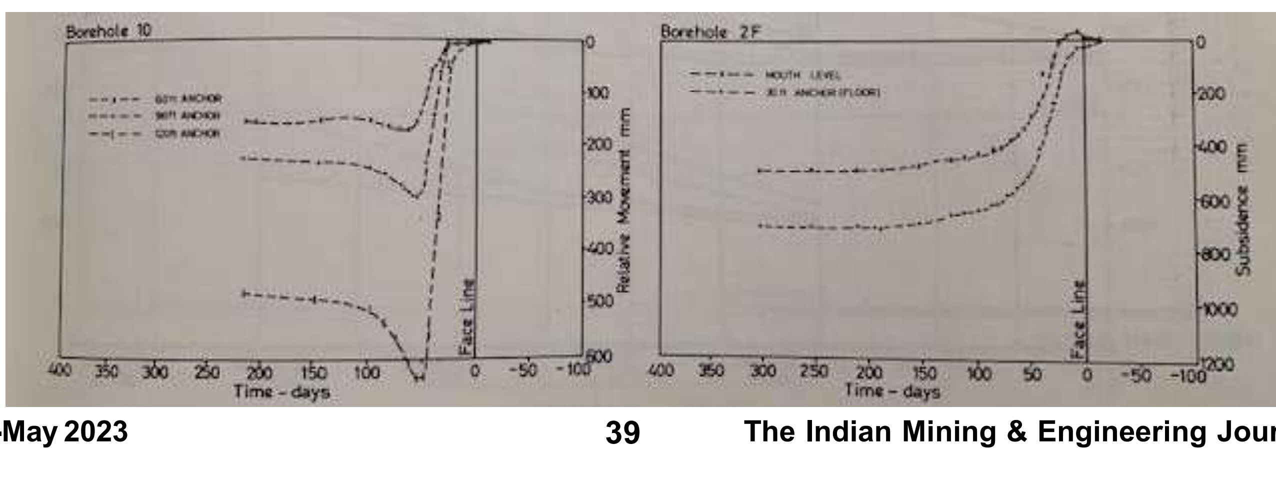
ROCK-MASS MOVEMENT ABOVE A LONGWALL FACE

This investigation was made by Post's in the United Kingdome, ta Whitburn, Durham, England, The purpose of investigation was to develop a comprehensive picture of rock-mass movement at great depth, and in this case, it was 463.3 metres f-rom the surface. The face was 182 metres, single-unit longwall face with plough (Anbau-Hobel). Hydraulics p, strap type, were in use. The seam thickness varied considerably, the maximum was 1.24 m and the minimum 0.85 m.rises only about 5 degrees in the direction of advance and the influence of this inclination was considered negligible on the results of the measurements.



Fig,7. Layout of the investigation at Whitburn and Wearmouth Collieries, Country Durham, England (after Potts)





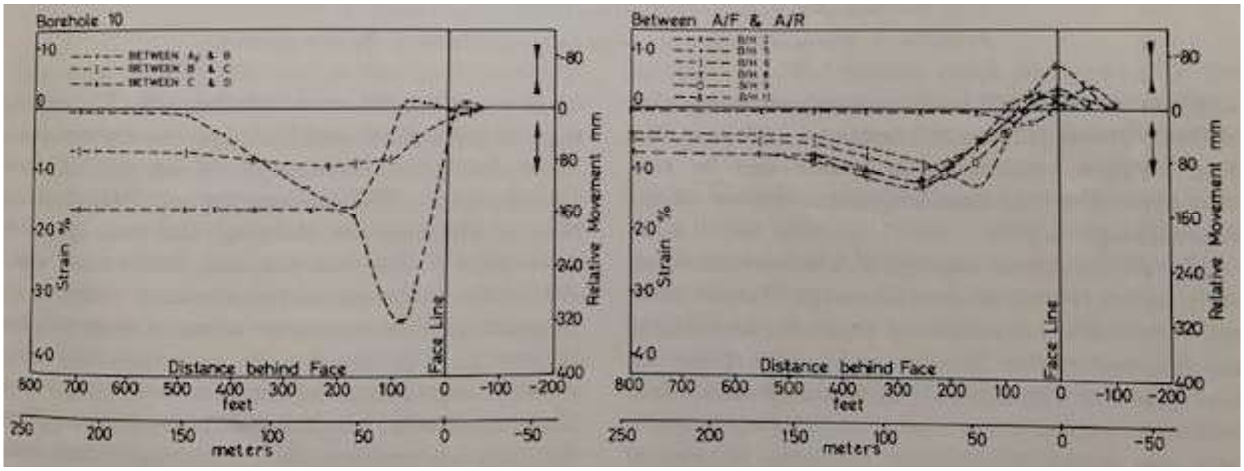
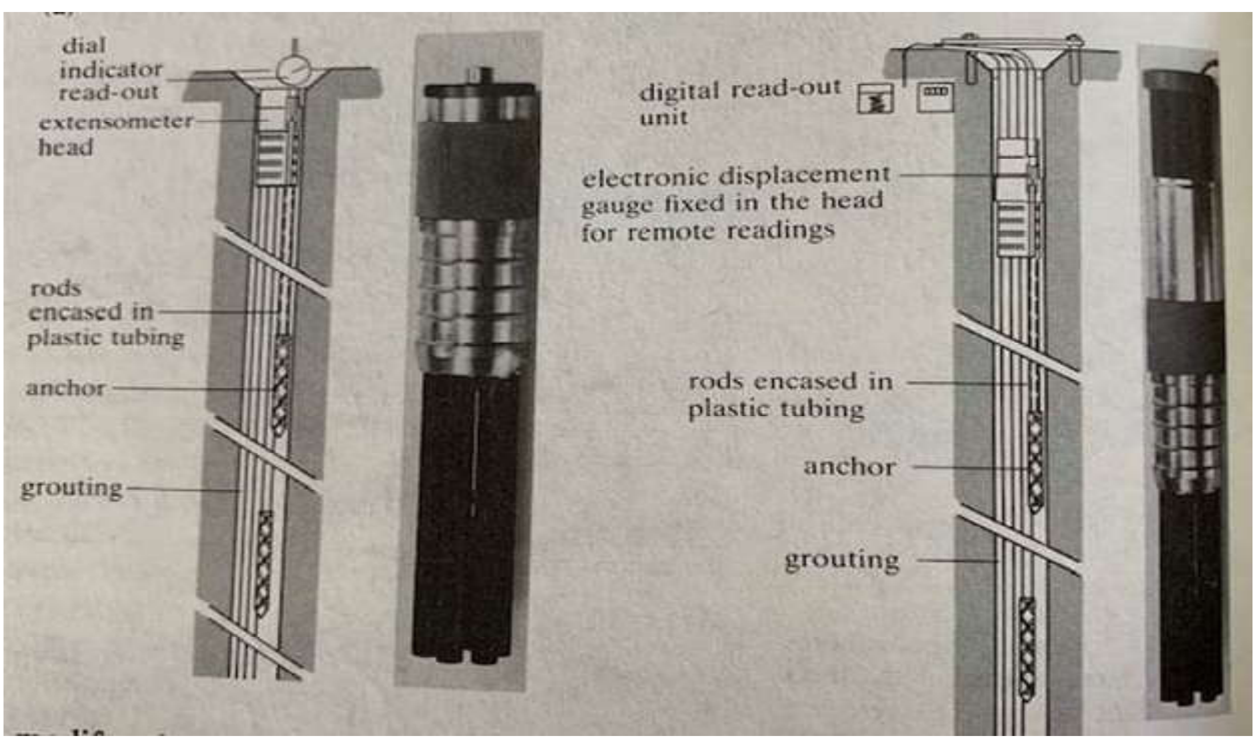


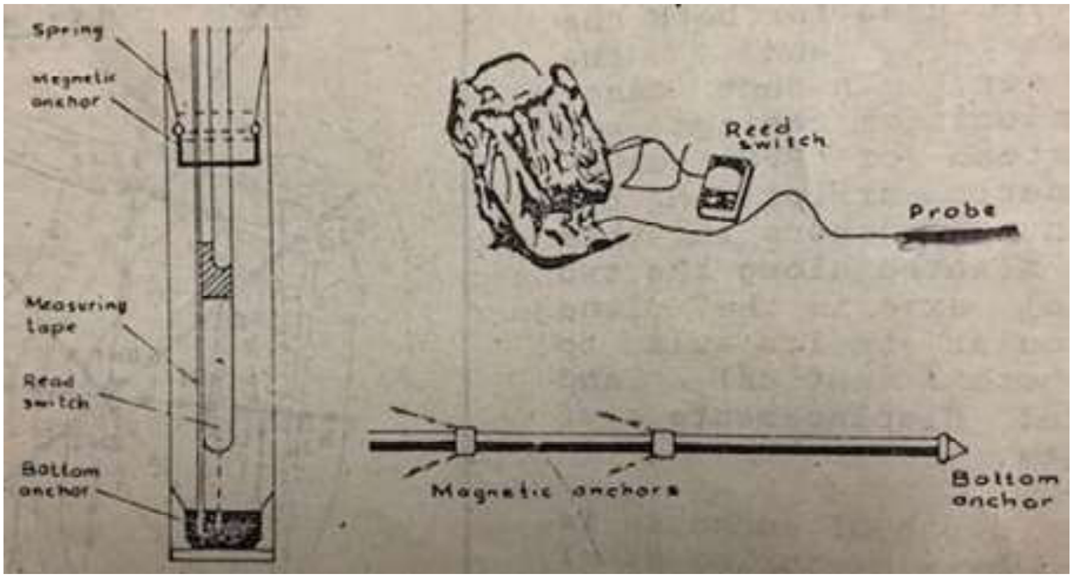
Fig.8: Graphical analysis of typical borehole extensometer measurements at Boreholes 2R, 2F and 10,(after Potts)

INSTRUMENTATION

Figure 9 shows a modern mechanical multi-point borehole extensometer. Up to six measuring point may be used in an 86 mm diameter borehole. Read-out may be by a dial gauge or by a permanently fitted inductance transducer. With the measuring head near the rock surface, this system gives a measuring range of 150 mm and a sensitivity of 0.01 mm. The electrical transducer has a measuring range of 40 mm and sensitivity of 0.01 mm. A special feature of this extensometer is that the measuring head may be placed up to 70 mm from the collar the borehole, with the readings being transmitted to the read-out units by electrical cable Several measuring heads may be located in the same borehole.



(a)



(b)

Fig. 9: (a),(b) Multi-Point Magnetic-type borehole extensometer(MPBEXs)

CONCLUDING REMARKS

The approach described in this pipe is capable of providing an adequate technique for the study of rock-mass movement around mining excavations. The two investigations were completely different in geological conditions and in mining design, but approach was the same in both. It is suggested that a wider application of the borehole extensometer type of measurement is required in rock mechanics and strata control investigation with carefully considered network of borehole measurements. In many rock mechanics and strata control investigations, this approach is likely to provide the broad picture of rock-mass movement not yet fully understood. Within which anomalies scan be detected and which would then be the subject of more detailed study in relation to their influence on control and mining design problem.

The techniques are lend s itself in adaption as a control tol particularly in stability problems The method has been successfully applied in investigations in rock-salt mining in Cheshire , and in Potash mining England, in Alsace ,France, as well as to two coalmines in South Africa and in several metalliferous and coal mines in India.

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Investigation into Drilling and Blasting Operation in Opencast Iron Ore Mines for Its Optimisation-A Case Study

Chaturbhuja Sahoo*

ABSTRACT

In mining industry, drilling & blasting is one of the most important operations without which extraction of minerals is almost impossible in the mines having medium to hard rock strata formation. Drilling and blasting in open cast mines represent 15 to 20% of the total mining cost and it is the most hazardous operation in mines. The main purpose of this study is to analyse the existing drilling and blasting practices precisely to optimise it at various levels to ensure utmost safety and reduce the overall mining cost.

INTRODUCTION

The cost of drilling & blasting per metric tonne of ore varies from Rs. 18.00 to Rs. 20.00 now- days with stripping ratio of around 1:0.5 in open cast iron ore mines. This cost is very big amount for mines producing more than 1 million tonnes ore per annum. The investment needed towards drill equipment and its accessories is also more than so many crore. Presently the cost of cartridge type 83mm dia (slurry/emulsion) explosives is around Rs.100.00 per kg excluding transportation cost.

Blasting is an important process which influences directly on loading, hauling and crushing phase. So it affects the overall cost of production of ore in every mine.

It is essential to obtain permission under Regulation 106(2)(b) of Metalliferous Mines Regulation 1961 from DGMS to work by deployment of HEMM with use of deep hole blasting in any Metal Mines. The permission is obtained only when there is no permanent building or monuments not belonging to owner lies within 300 m of blasting zone. The permission is given for a maximum period of 5 years by Director of Mines Safety of respective region .But in case of permanent building or other structures not belonging to owner present within 300m of danger zone then owner has to take special permission under Regulation 164(1-B) of MMR1961.

Moreover, as per **Safety Management Plan (SMP)** formulated in each mine the risk associated with drilling and blasting operation is very high. So every mining engineer should study all the aspects of drilling and blasting operation precisely to optimise it for the sake of ensuring safety, protection of environment and overall cost control. For example we can save rupees 20 lakh if only Rs.2.00 is saved on account of drilling and blasting per metric tonne of ore production in a mine producing 1 million tonne of ore per annum.

**M-Tech Mining Engineering student (Semester –IV) AKS University, Satna (MP), India*
Corresponding Author: sahoo.chaturbhuja@gmail.com

FIELD STUDY , LAB WORK AND ANALYSIS

To meet the objectives, the field study was conducted at Patabeda Iron Mines of MGM Minerals Ltd. The mine is situated in village Patabeda, Tehsil:Koira, Distt: Sundergarh, State –Odisha, India. The drilling and blasting was studied in all the hard massive ore benches as well as BHJ/BHQ benches. There was no overburden bench. Only intercalated waste like BHJ/BHQ, and shale are found sparsely in ore benches.

The iron ore was normally of i) hard laminated, ii) soft laminated iii) blue dust, iv) float ore ,v) limonitic fines vi) Goethitic etc. In mines there were 8 ore benches from top mrl 700 m to bottom mrl 620 m.The study benches were 10m height and 15 m width. Excavation was with 2.5 cum bucket capacity back hoe excavator in conjunction with 30 mt Volvo dumper. Normally the rock strata were fractured due to lateritisation. So the bouldary deposit was prominent in the ore benches. The diameter of blast hole was 102 mm to 120 mm. Two drill equipments were there (one is Atlas Copco ROC L6 and the other one is DP 1100 of Sandvik). Length of hole was 10.2 m to 10.5 m. The burden, spacing, subgrade drilling and angle of drilling were varies as follows:
Burden: 2.0 m to 2.7 m
Spacing: 3.0m to 3.5 m
Subgrade drilling: 1% to 5% of hole depth
Angle of hole: 80^0 from horizontal or parallel to bench slope.

Both staggered and square pattern drilling was done with multiple rows up to maximum 3 rows. Both the slurry and emulsion explosives of 83 mm dia catridges were used .NONEL of 17ms to 25 ms and electric detonator were used for initiation. The bulk density of RoM ore was found to be 3.1 mt/m^3 to 3.4mt/m^3. In the mines all the parameters related to drilling and blasting were studied as mentioned below:

A) Blast hole diameter in mm
B) Length of hole (m)
C) Angle of hole
D) Burden (m)
E) Spacing(m)
F) Stiffness ratio
G) Stemming length (m)
H) Stemming Material
I) Type of explosives
J) Delay sequence
K) Firing pattern
L) Sound
M) Blasted muck pile
N) Ground vibration
O) Smell and dust after blasting
P) Frequency of blasting in a month
Q) Photos of muck pile by camera to study the fragmentation through WIPFRAG software.

The general layout of Patabeda Iron Mines is shown in fig.1 & 2, general layout of blast hole section in fig-3 , firing pattern in fig .4,fragmentation analysis through wipfrag software in fig-5,ground vibration study by micromate in fig-6,blasted muck pile in fig-7,solid blast muck pile in fig-10.

Figure-1:(top view)

Figure-2:(front view)

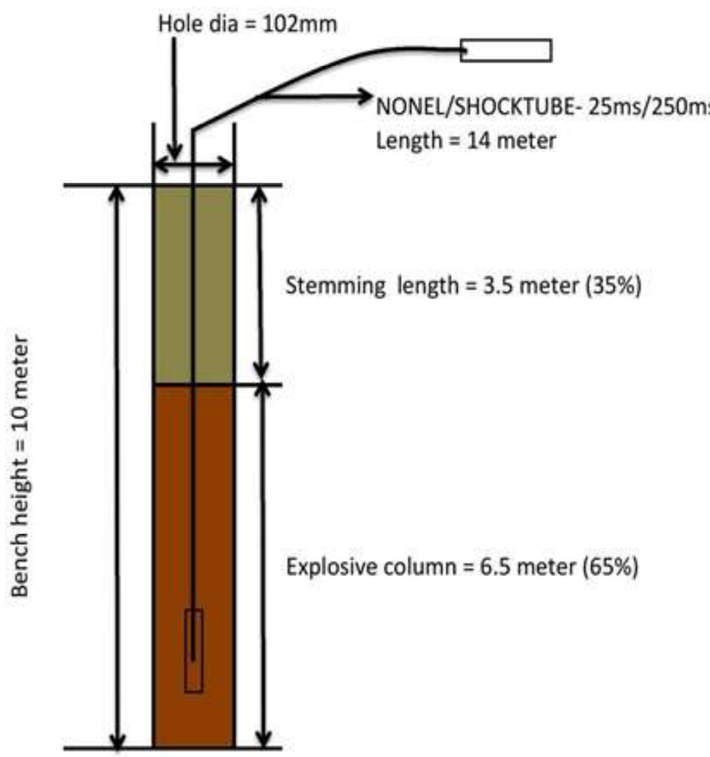
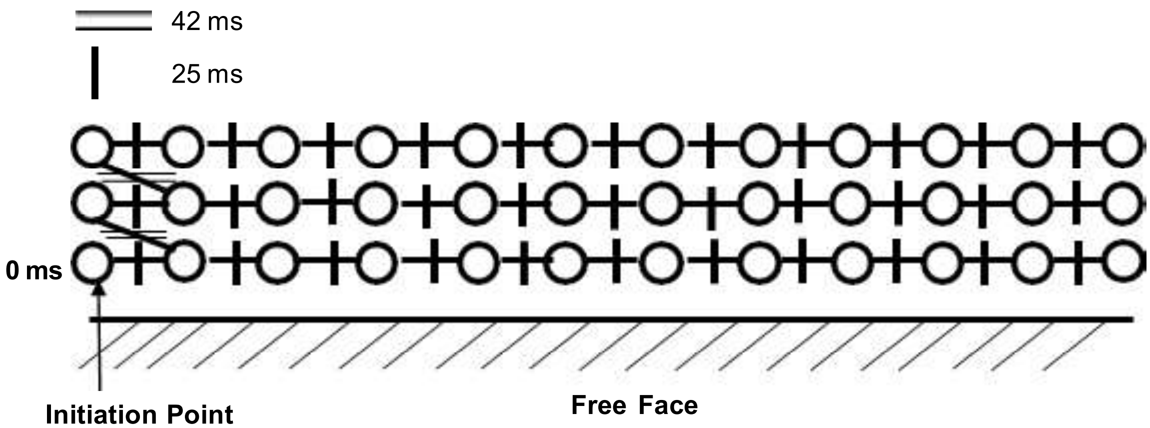


Figure-3: General Layout of the blast hole section



In the field the photos of muckpile was taken keeping one straight object whose dimension is taken before placing it on muck pile and then it was processed through wipfrag software. The image of blasted muck pile with distribution curve is shown as below. It is very much helpful to design the burden, spacing and charge distribution in blast hole to optimize the fragmentation.

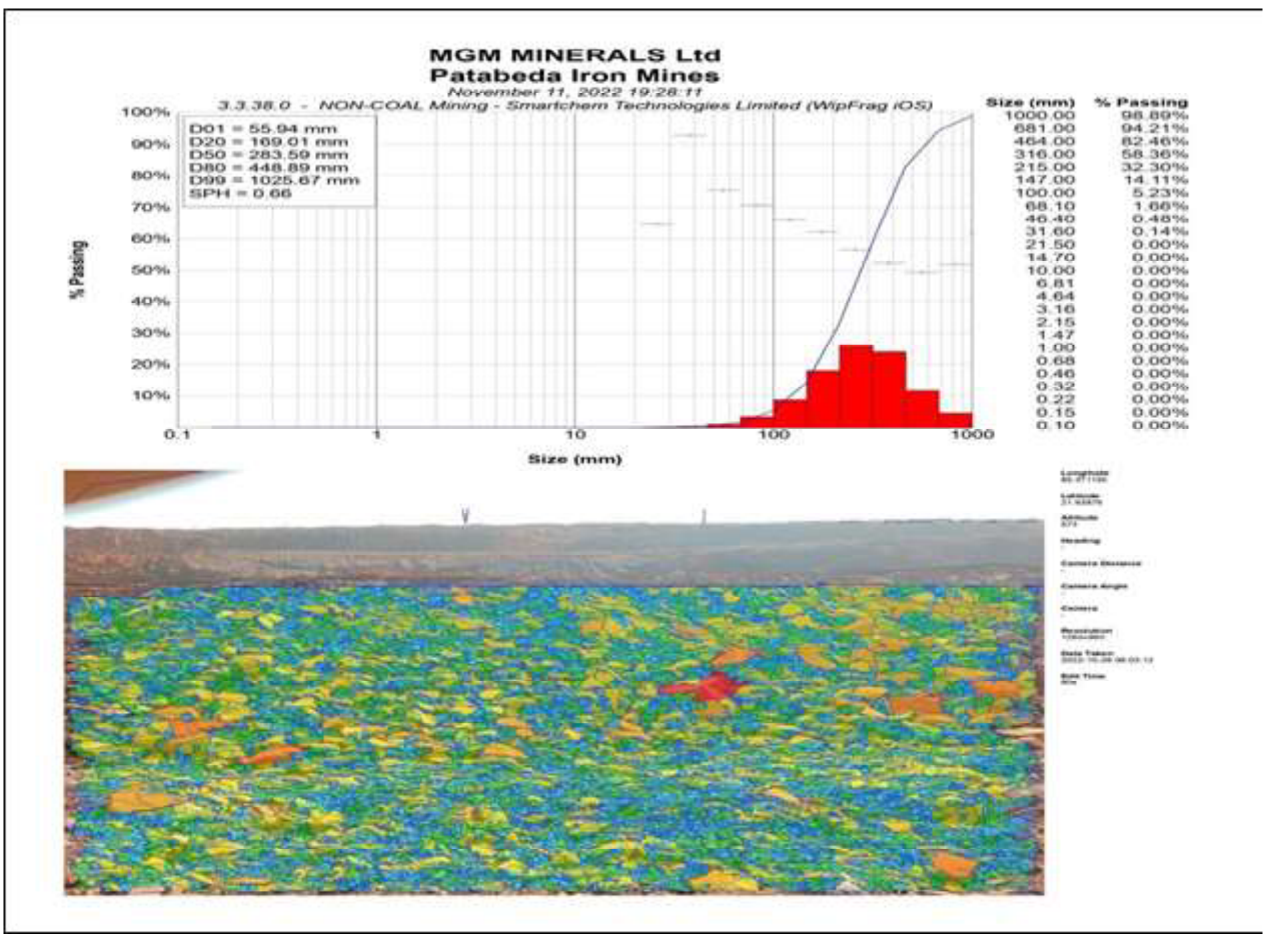


Figure-5: Image of blasted muck pile through wipfrag software and the distribution curve

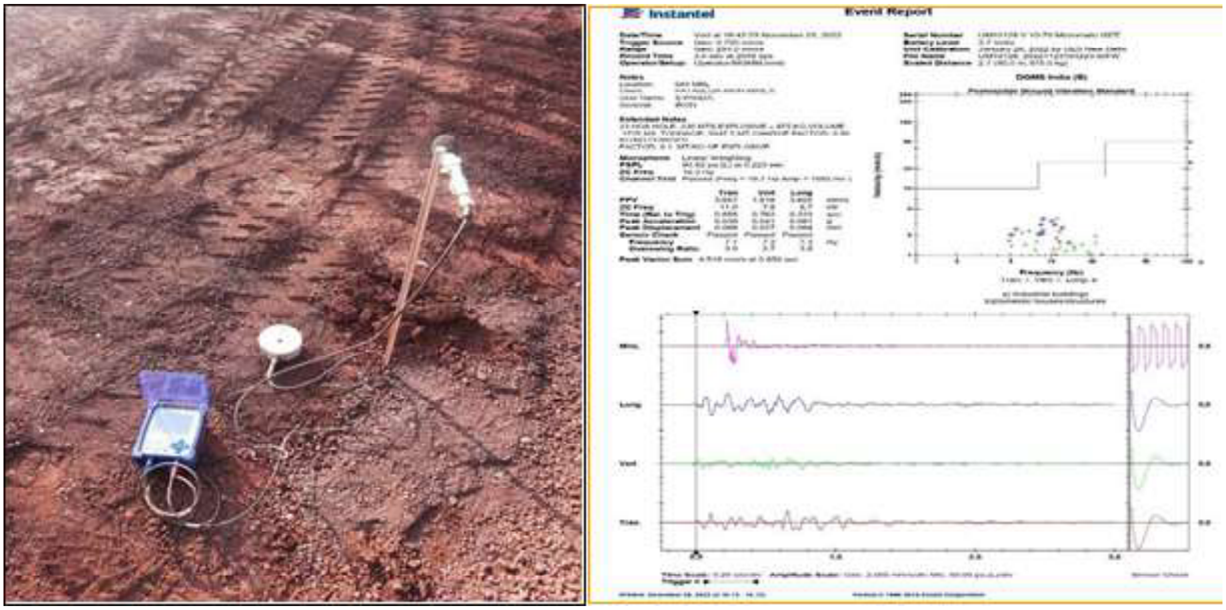


Figure-6: Ground vibration study by micromate (Instantel) and the report

Figure -7: Blasted muck piles (4 Nos)

RESULTS AND DISCUSSIONS

MRL	STRATA	DRILLING TYPE	DRILLING EQUIPMENT	PENETRATION RATE (m/hr)	DRILL RATE (m/hr)	DRILL BIT LIFE (in meter)
640	Stratified HMO	DTH/ Bottom hammer	Atlas Copco ROC L-6	32	21	422 m
680	Homogeneous SLO	Top hammer	Sandvik DP-1100	34	23	448 m
630	HMO with laterisation	DTH/ Bottom hammer	Atlas Copco ROC L-6	32	22	431 m
660	Homogeneous HMO	DTH/ Bottom hammer	Atlas Copco ROC L-6	33	22	384 m

Fig-8: Relationship of penetration rate, drill bit life with rock strata

MRL	STRATA	NO OF HOLES	HOLE DEPTH	HOLE DIA (in mm)	SPACING (in m)	BURDEN (in m)	LOAD DENSITY (in kg/m)	CHARGE FACTOR (in kg/cum)	TOTAL EXPLOSIVE (in kg)	% OF INFLUENCE	EXCAVATED TONNAGE (in mt)	POWDER FACTOR on excavated tonnage	POWDER FACTOR (in mt/kg)
640	Stratified HMO	52	10	120	3.5	2.5	4.5	0.51	2340	24.00%	16517	7	6
680	Homogeneous SLO	68	10	102	3.5	2.5	4.2	0.48	2856	21.00%	21599	8	6
630	HMO with lateritisation	56	10	120	3.5	2.5	4.5	0.51	2520	25.00%	17787	7	6
660	Homogeneous HMO	58	10	120	3.5	2.5	4.4	0.50	2552	26.00%	18422	7	6
700	HMO with lateritisation	55	10	102	3.2	2.7	4.0	0.46	2200	21%	17824	8	6.6
630	HMO with lateritisation	40	10	102	3.0	2.5	4.0	0.53	1600	20%	11160	6.96	5.8

Fig-9: Blasting result analysis with different rock strata

POINTS FOR OPTIMISATION

BLASTHOLE DIAMETER: It was observed that for 83mm dia catridge explosive the hole dia of 102mm was better than 120 mm dia due to better coupling and increase height of explosive charge column in the blast hole.

VERTICAL HOLE VERSUS INCLINED HOLE: In Iron ore mines inclined blast hole is preferred over vertical holes though drilling cost is more. Due to fracture in the in-situ benches the chances of overhang and undercut is more in case of vertical benches. Thus bench slope safety can be ensured by inclined hole drilling parallel to bench slope.

BURDEN AND SPACING: The burden may be varied from 2.25 m to 2.5 m considering site specific conditions. The spacing of holes may be varied from 3.0m to 3.25 m considering site specific conditions when the bench height is 10m.

STEMMING HEIGHT: The stemming height may be kept at 35% of the hole depth or say 3.5m in case of 10 m blast hole depth to avoid undercharging or overcharging of blast holes.

STIFFNESS (ratio of bench height and burden): The ratio of bench height to burden i.e. 10m/2.5m=4 is the most desired ratio for fragmentation and control of air blast, fly rock and ground vibration.

STEMMING MATERIAL: The drill cuttings mixed with crushed fines found to be much effective for stemming material as the grains lock each other and the weight of the crushed fines is more than screened fines for which venting of gases is almost zero.

TYPE OF EXPLOSIVES: Emulsion explosives gives better result over slurry explosives as its strength is more compared to slurry explosives. The cost of emulsion is around 5% higher than slurry explosive but the strength of emulsion explosive is comparatively 15% more than the slurry explosives. The comparison is as follows:

SLNO	PROPERTIES	SOLAR PRIME E (83mm) SLURRY EXPLOSIVES (BOOSTER)	POWERGEL C (83mm) EMULSION EXPLOSIVES (BOOSTER)	SOLARGEL E (83mm) SLURRY EXPLOSIVES (COLUMN)	POWERGEL 1 (83mm) EMULSION EXPLOSIVES (COLUMN)
1	Density	1.15+-0.5g/cc	1.15+-0.1g/cc	1.15+-0.5g/cc	1.20+-0.1g/cc
2	Relative weight strength (RWS)	88%	103.54%	82%	93.25%
3	Relative Bulk strength (RBS)	125%	146.17%	100%	137.13%
4	Velocity of detonation	4.0km/sec	4.5km/sec	3.8km/sec	4.0km/sec

DELAY SEQUENCE: Normally 17ms and 25 ms hole to hole delay NONEL (shock tube) is being used in the study mines. In the mines with maximum 3 rows ,25ms shock tube was found to give better result than 17 ms shock tube.42 ms trunk line delay was being used as shown in figure -6.

FLY ROCK AND SHAPE OF MUCKPILE: Almost zero flyrock was noticed during blasting at Patabeda Iron Mines. The muck pile is spread upto 15 m to 20 m making angle of about 45^0 from horizontal as shown in figure -6.

GROUND VIBRATION: The ground vibration was being studied by instrument micromate (Instantel) being placed at a distance of 80 m to 100 m from site of blasting. The report is shown in figure-6.The ground vibration is found to be much below the permissible limit recommended by DGMS due to hole to hoe delay pattern.

FUMES OR SMELL AFTER BLASTING: No smell of fumes is found in case of blasting with emulsion explosives. So there was perfect oxygen balance in emulsion explosives. If smell is found then it would be concluded that there is no oxygen balance in the explosive mixture or compound. If the explosive is properly oxygen balanced then the resulting gases after blasting are CO_2, H20 and N_2.If oxygen balance is disturbed then fumes like CO, NOX etc are released after blasting which are dangerous.

DUST: Huge dust is released to atmosphere during blasting. This is controlled up to 50% by wetting the blasting face before blasting by spraying water. The frequency of blasting was also reduced to 3 times in a month from 4 times.

BLASTING IN SOLID FACE HAVING NO FREE FACE: This is done by leaving uncharged holes in between rows which act as free face as shown in below diagram. This is required when new bench is needed for development in the bottom most bench or in other cases where there is no free face. This pattern is very much effective and no fly rock is noticed. The muck pile is raised just above the surface as shown in the figure-11.

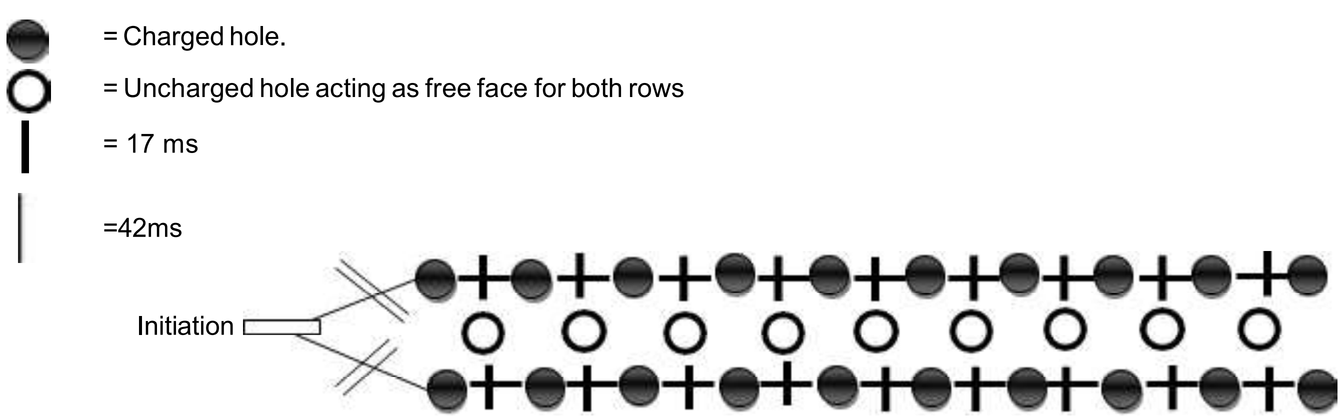


Fig-10: Charged holes in Solid face having no free face

Fig-11: Blasted muck pile of solid face blasting

FREQUENCY OF BLASTING: Normally in every blasting operation the production process is affected for minimum 2 hours .Extra diesel oil is burnt for shifting the HEMM. Previously the blasting frequency was 4 times in a month in the study mines. Now it has been reduced to 3 times in a month without compromising the smooth supply of blasted ore to crushing plant.

CONCLUSION

The difference between blast hole diameter and explosive cartridge diameter should be with in 17mm to 20 mm for better coupling.

Emulsion explosive gives better result in iron ore mines of Keonjhar and Sundergarh districts of Odisha state.

Crushed fines acts better stemming material than screened fines due to its better locking characteristics and higher density.

10% Sub-grade drilling is not required in iron ore benches having fracture in the rock mass. Sub-grade drilling may vary from 1% to 5% depending upon site specific conditions which may be decided by the Mines Manager out of his experience from previous blasting.

Use of electronic detonator gives better result in iron ore mines compared to NONEL. Delay can be set as per requirement and 'V' Pattern firing sequence can be achieved easily which gives better fragmentation and smooth muck pile. In electronic delay detonator there is no scatter effect in delay time.

Load density of explosives should be reduced in case of BHJ/BHQ where there is no fracture in the rock mass. Here the explosive energy is utilized better for fragmentation due to absence of fracture. Load density may be reduced to 3.5kg/m from 4.0 kg/m.

In lateritised hard laminated iron ore formation additional explosives to standard load density will not give better result due to venting of gases in weak zones .So charging of explosives should be limited to 65% of the hole depth. Excess charging than this will be only waste of money and manpower.

The stiffness (ratio of bench height to burden) to be maintained at 4 for better fragmentation and control of fly rock, air overpressure and ground vibration.

Ground vibration can be maintained easily with in permissible limit prescribed by DGMS by hole to hole delay either by NONEL or by electronic detonator.

If there is smell of fumes observed after blasting then it is sure that the oxygen balance of explosive compound has been disturbed. It is to be noted that the blasting efficiency will certainly be reduced when oxygen balance is disturbed.

The frequency of blasting should be limited to 2 to 3 times in a month in large opencast iron mines so that the down time of equipments owing to blasting operation can be minimized and simultaneously risk and dust factors can be reduced.

So precise analysis is essential by Mines Manager of every opencast iron mine to optimize the drilling and blasting operation as the site specific conditions and requirement of fragmentation vary from mines to mines. It is to be noted that only 20% of the explosive energy do the useful work in a properly designed and executed blast and rest energy is converted into ground vibration, air blast etc.

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