THE INDIAN MINING & ENGINEERING JOURNAL

(Incorporating Mineral Markets: The Founder Publisher & Editor: J.F. De. Souza, Mumbai)
www.theimejournal.com

VOLUME 59: Number 12 | **DECEMBER 2020** | ISSN 0019-5944

Published Monthly by IME Publications.
Annual Subscription : Rs.650/- (Incl. Postage)
Unit Price: Rs.50/-
FOREIGN: £ 75 OR US $ 150 (By Air Mail)
Payment by Cheque/Draft. Cheques drawn outside Bhubaneswar must include Rs.50/- (Overseas £1 or US$2) as bank charges and should be drawn in favour of
***"The IM& E JOURNAL"** payable at Bhubaneswar*

IME PUBLICATIONS

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Contents

Technical Papers

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Persons in the News

Shri Somnath Nandi presently Executive Director - Steel Authority of India Limited (SAIL), has been appointed as Director - Technical, NMDC Limited. Shri Nandi will provide technical leadership and support to NMDC's technical teams as well as take up the challenges of NMDC's expansion and diversification plans. His experience in strategic management and technical expertise would enhance implementation of NMDC's growth plans.

Earlier he was serving as Executive Director, Steel Authority of India Ltd (SAIL). He has an experience of more than 36 years in the Steel Industry. After completing his graduation in Mechanical Engineering, he joined SAIL's Rourkela Steel Plant as Management Trainee in the year 1984. He worked in the areas of Coke Ovens, Field Machinery Maintenance, power and blowing station etc. He has rich experience at senior levels as General Manager and Executive Director and was closely involved with the intricacies of integrated steel plant operations at Durgapur Steel Plant and commissioning & stabilizing of IISCO Steel Plant. Prior to joining NMDC he was Executive Director, heading Environment Management Division and Growth Division at SAIL, Kolkata.

He is known for his contribution to the Steel Industry in the manufacturing, engineering, operations, planning and strategy and he is also a vivid speaker in various industry forums. Shri Nandi's rich experience and knowledge along with technical expertise would definitely help NMDC to scale new heights of technical excellence.

Shri Subrata Mandal took charge as the Chief General Manager (CGM), NTPC Bongaigaon with effect from 7th December, 2020. Shri Mandal is B.E in Mechanical Engineering from NIT Durgapur. Shri Mandal has a rich and varied experience in handling key portfolios at NTPC Farakka, Eastern Region - I HQs Patna and NTPC Singrauli. Shri Mandal had joined NTPC as an Executive Trainee in the year 1985 and served in farious areas which includes areas of Operation. Fuel Handling, Mechanical Maintenance, Centre for Power Efficiency & Environmental

Protection and Operation Services of Power plant. Prior to joining NTPC Bongaigaon Shri Mandal was heading Kanti Bijlee Utpadan Nigam Limited (A wholly subsidiary of NTPC Limited) as CEO.

Heartiest congratulations to Dr. Santrupt Misra, Chief Executive Officer, Birla Carbon; Director, Chemicals; Director, Group Human Resources, on winning the HR Lifetime Achievement Award 2020 at the hands of People Business Consulting. Your vision has always helped us look further and move forward with integrity and honesty. You are an epitome of excellence, inspiring individuals and the organization with your decisions and actions. Dr. Misra holds several key positions including Chairman of the Board of the National Institute of Technology, Rourkela and Independent Director on the Board of the Oil and Natural Gas Corporation (ONGC). Under his leadership Birla Carbon has emerged as a global leader in the carbon black space from its beginnings as a regionally focused carbon black supplier. He has been instrumental in developing a strong employer brand for the Aditya Birla Group, which was named the Best Employer in India, Great Place for Leaders to Work, and Top Company for Leaders by Aon Hewitt, Fortune Magazine, and RBL Group respectively. An HR professional and business leader, Dr. Misra has over 30 years of experience in Business Operations, Strategy, Organization Development, Transformation, and Change Management, Business Consulting, and HR Management.

Shri Subhasis Das has been appointed as Managing Director, Alfa Laval India Private Limited with effect from December 1st, 2020. He had previously served as President & Managing Director at Sandvik Mining and Rock Technology India Private Limited. Subhasis brings to Alfa Lava, 28 years of working experience at Coal India, Shell, Reliance Industries & Sandvik. He succeeds Mr. Anantha Padmanabhan, who retires from Alfa Laval on the 31st December 2020 after more than thirty-five years with the group.

Shri P. M. Prasad CMD, CCL elected president of The Mining, Geological and Metallurgical Institute(MGMI) of India during it's 114th AGM. MGMI is a 114 years old institute which promotes mineral industry and is also the largest forum of mining professionals in India. Shri Prasadhas put up 36 years of experience in the varied facets of operations and management.Shri Prasad is a mining engineer from Osmania University. He did M.Tech in 'Open-Cast Mining' from Indian School of Mines (IIT- ISM), Dhanbad.In 1988 he acquired first class mines manager certificate from DGMS. He also obtained degree in law from Nagpur university in 1997. Shri Prasad began his career as an executive trainee with Western Coalfields Limited (WCL), a subsidiary of Coal India Limited (CIL) in 1984. He exhibited dedication, hard work, sincerity and dynamic leadership as he progressed through different roles in the company and became General Manager of Lingaraj area in Mahanadi Coalfields Limited (MCL).

In 1994-95, he was instrumental in reopening of DRC mines which was affected by the underground fire during his posting in WCL. For this remarkable job, he was awarded as 'Best Mines Manager' from Secretary Coal, Ministry of Coal (MoC) and Chairman, Coal India Limited in 1995. During his successful stint as General manager at MCL, he was responsible for successful opening and operations of 'KanihaOpencast Project' from March, 2010. He is also credited for diversion of nallah at Hingula Opencast Area to unlock coal reserve of 26.00 MT in the year 2014-15 and commencement of New Railway Siding No. 9 at Talcher Coalfields. He has a special penchant for safety and the projects with which he was associated have won various prizes at different competitions including hat-trick for two projects i.e. Padmapur Opencast, WCL between 1996 and 1998 and Nandira UG Mine, MCL between 2004 and 2006.

In May,2015 he joined NTPC as Executive Director (Coal mining).He was acknowledged for expediting the process of award of MDO projects and awarded Pakribarwadih coal block (NTPC's first project) and floated NITs for remaining coal blocks. In March 2016, he took charge as Executive Director cum Head of the Project, Hazaribagh,Jharkhand. During his tenure, he led the commencement of coal mining operations at Pakribarwadih mines, Hazaribagh.During his term in 2016 Pakribarwadih was bestowed with the first prize in 'Swarn Shakti Awards'.

In February, 2018 he joined Northern Coalfields Limited (NCL) as Director Technical (P&P) where he was responsible for the operations of five areas of the company along with key departments like Corporate Planning, Civil Engineering, Railway Siding, Environment& Forest, etc. Under his leadership, NCL was awarded at the World Environmental Conference in June 2018 for outstanding work in environment conservation.

He took over the charge of CMD, Bharat Coking Coal Limited (BCCL) in August 2019. Amid the challenging conditions, he led from the front with commitment,vigor,and dedication.He spearheaded the company's fight against the COVID-19 pandemic and was instrumental in various initiatives to transform the overall performance of the company.

Shri Prasad is renowned for his interpersonal skills and is a firm believer in teamwork and possesses excellent technical expertise. Under his guidance the company is poised to attain new milestones and scale further heights of success.

COAL NEWS

100TH FOUNDATION DAY OF SINGARENI COLLIERIES CELEBRATED

The COVID-19 pandemic has had a huge impact on Singareni Collieries Company Ltd (SCCL) as its coal production and sales amounting to Rs. 5,000 crore were hit both due to production loss and low demand during the lockdown period.

This was stated by Chairman and Managing Director of the company N. Sridhar during the 100th Foundation Day celebrations of the company. He stated that the production and sales were rebounding slowly with phased easing of the lockdown measures.

The company had diversified into thermal and solar power generation areas and secured new coal blocks in Odisha as part of its business expansion plans and for longevity of the company beyond the next 100 years, the CMD stated. Speaking at the event, Mr. Sridhar said the company was focusing on reducing the coal production cost to make the coal mining business profitable. Stating that Singareni had the capacity to face challenges, he noted that the company's efforts in implementing welfare measures to the employees were unparalleled in the coal sector. In spite of the COVID-19 impact, the company had paid Rs. 540 crore bonus to its employees this year, he said.

He mentioned that the company had suffered losses continuously for 20 years till 1998, but the hard work of the employees and workers had made it profitable for the last 20 years. In the changing scenario of coal market, Singareni had to compete not only with other public sector coal companies such as Coal India but also private coal companies too, he stated.

To face such challenges, there was a need to reduce the production costs considerably by inducting more machinery and utilising the work hours of employees completely, the CMD said. On the solar power generation by the company, he said establishment of 300 megawatt plants would be completed by 2021-end and another 300 MW capacity floating solar plants would be constructed on reservoirs in the next phase.

Several employees of the company were honoured for their meritorious services at the event attended by several senior officials.

COAL INDIA SET TO DIVERSIFY INTO NON-COAL MINING AREAS IN 2021

Coal India Ltd is set to diversify into non-coal mining areas as well as make major investments in clean technology in 2021 after demand for the dry fuel remained muted for most of this year amid the coronavirus pandemic impacting economic activities. Against all odds, including the slump in coal demand, the government opened up the country's mining sector for private players by auctioning 19 blocks. Coal demand across the world is projected to fall by around five per cent this year compared to 2019 while various sectoral challenges are expected to persist in 2021, analysts said.

"In 2021, we will try to get Coal India Ltd (CIL) to diversify into non-coal mining-related areas. It (CIL) will make major investments in sectors other than coal mining so that it is well prepared to make the transition away from fossil fuel. "So, it (CIL) will make investments in renewable energy, get into aluminium and clean coal technology and will do a lot," Coal Secretary Anil Kumar Jain told. In the coming year, Jain said CIL is also likely to go ahead with its agenda of achieving one billion tonnes of production target by 2023-24. CIL may also "go ahead with one billion tonnes agenda. It is getting approvals. It is gearing up to keep enhancing its production which was 603 million tonnes last year. It is taking upon itself bigger and bigger target. It will be able to achieve one billion tonnes (production target) in 2023-24," he said.

Noting that CIL has taken upon itself an investment plan of Rs 2.5 lakh crore, Jain said that out of the proposed outlay, a significant chunk would be spend on clean coal technologies and diversification. "The rest of it (the investment will be) to increase coal production," he noted. About 2020, Jain said that auction of "commercial coal blocks was number one achievement (in the coal sector). We amended the Act to ease several things".

The auction of coal blocks for commercial mining witnessed "fierce competition" and the 19 blocks that went under the hammer will generate total revenues of around Rs 7,000 crore per annum and create more than 69,000 jobs once they are operationalised. As many as 38 mines were put on auction, which also marked opening up of the country's coal sector to private players. The bidding also saw participation of players from sectors like pharma, real estate and infrastructure. A total of 42 companies participated in the auction and 40 of them were private players. As many as 76 bids were received for 23 mines. Some of the large corporate groups that have bagged blocks include Adani Enterprises, Vedanta, Hindalco Industries and Jindal Power. According to the secretary, the government facilitated the mining plan and made it eco-friendly to promote ease of business.

The coal ministry took initiatives to re-visit old laws with an aim to improve efficiency, ease of doing business, and to open up coal sector to improve domestic coal production and reduce imports. Prior to amendments in the mining law, there was dominance of public sector companies both in exploration and mining of coal. The Mineral Concession Rule, 1960 was governing many aspects of coal mining and required amendment in furthering the coal sector reforms. Noting that the creation of a sustainable development cell was another achievement of the coal ministry, Jain said it will ensure CIL and other companies maintain environmental standards as well as that star rating of mines are done. "Since coal mining is a core activity we do not want there should be any slackening in our endeavour to maintain the highest environment standards," the secretary said.

Sustainable Development Cell aims to promote environmentally sustainable coal mining and address environmental concerns during the decommissioning or closure of mines. The cell also formulates policy framework for the environmental mitigation measures, including the mine closure fund. The coal sector also faced rough weather in 2020 as fuel demand slumped due to sluggish economic activities in the wake of the coronavirus pandemic. A coal ministry official who did not wish to be named said that almost all sectors of the country were hit due to the pandemic and the coal industry was no different. Sale of coal fell as the power sector, a major consumer of the dry fuel, saw a decline amid the lockdown, the official added.

CIL Chairman Pramod Agarwal said the company is planning to produce 650-660 million tonnes of coal this financial year while production of 334 million tonnes was achieved till November. Regarding coal demand in 2021, Jain said it will depend on many things, including movement of the economy. Global coal consumption is estimated to have fallen 7 per cent, or over 500 million tonnes, between 2018 and 2020. In 2019, global coal demand decreased 1.8 per cent after two years of growth as power generation from coal weakened globally, including in India.

Analysts opined that there will be a modest rise in demand in 2021 and prices are also expected to firm up. Coal demand is set to revive by 2021 in India and other Asian nations, including China, which are the major consumers of the fuel, Moody's Investors Service said in a report in October. Coal use is anticipated to increase 3.8 per cent in 2021. In the medium term (to 2025), India has one of the highest potentials to increase coal consumption as electricity demand rises and more steel and cement are required for infrastructure projects, as per the International Energy Agency said.

WESTERN COALFIELDS TO ENTER INTO JOINT VENTURE WITH ORISSA MINERAL DEVELOPMENT CORPORATION

Western Coalfields Ltd (WCL) will enter into a joint venture with Orissa Mineral Development Corporation (OMDC) for peak production capacity of 75 million tonnes of coal. Its Chairman and Managing Director Rajiv R Mishra also said 20 more mines will be opened by 2023-24, which shall sustain the production level over 75 million tonnes. He added that WCL will enter into the joint venture with OMDC taking up five coal blocks in the Raigad district on the Odisha-Chhattisgarh border.

WCL is planning for a peak production capacity of 75 million tonnes. While speaking at a event where he was felicitated by the Press Club here, Mishra spoke about his journey as the WCL chairman and managing director and challenges he had to face to achieve the coal production targets. "We opened up 23 mines in the past six years and acquired 9,522 hectare land. We have achieved the highest-ever coal production of 57.64 million tonnes in 2019-20," he said. Mishra is retiring on December 31 and will be replaced by Manoj Kumar. Currently, Kumar is the Director (Technical) of WCL.

MINING NEWS

JINDAL STEEL AND POWER RECORDS 15% YEAR-ON-YEAR GROWTH IN STEEL PRODUCTION FOR NOVEMBER 2020

Jindal Steel and Power Ltd has reported a 15% y-o-y growth in steel production for November 2020, at 6.14 lakh tonnes. “Our performance is in line with the India Growth Story, Domestic Steel demand is rising in H2 FY 21 and so JSPL’s production,” said JSPL’s Managing Director, V.R. Sharma. With domestic markets recovering the company is focusing more on value-added products. We believe the company’s portfolio will witness further strength in the Q3 & Q4 of the financial year, Sharma added.

"The company witnessed year on year growth of 15% in Standalone Steel Production with 6,14,000 tonnes in November 2020 as compared to 533,000 tonnes of Standalone Steel Production a year ago during the same period," the company said in a media statement. Company's standalone sales rose to 5,62,000 tonnes in November 2020 as compared to 5,57,000 tonnes in the previous year during the same period. "The export sales contributed to 21% of total sales volumes in November 2020. Company's exports also grew at a rate of 10% (Y-o-Y) in November 2020,"the company's media statement said.

REPORT ON 'THE POTENTIAL ROLE OF HYDROGEN IN INDIA",BY TERI'S ENERGY TRANSITIONS COMMISSION (ETC) INDIA PROGRAMME

In the mining sector Hydrogen as a fuel has a greater application over electric vehicles. Global mining companies are increasingly turning to renewables to power operations with landmark projects in Australia including Juwi's Sandfire DeGrussa mine making headlines. Given mines have a limited life span, are in remote, off-grid locations and have vast areas of land nearby, solar and wind power is an obvious choice.

Now French power company Engie and mining giant Anglo American have announced a partnership to develop the world's first hydrogen powered mining haul truck.

Renewables generation and battery assets can be used to source electricity to power mining operations but a significant chunk of the carbon emissions generated by mining companies comes from the diesel consumed by giant, 300-ton capacity haul trucks. Anglo American has pledged to fully decarbonize its operations and plans to integrate a hydrogen generation solution provided by Engie into its trucks. The miner will modify vehicles by replacing diesel with hydrogen tanks and replacing engines with hydrogen fuel cells and battery packs.

The cost of "green" hydrogen will reduce by more than 50 per cent by 2030 and it will start competing with hydrogen from fossil fuels, The Energy and Resources Institute (TERI) said in the above report. "Green" hydrogen is a zero-carbon fuel made by electrolysis, using renewable power from wind and solar to split water into hydrogen and oxygen.

"This is a first-of-its-kind, cross-sector assessment of how hydrogen technologies can support the transition to a zero-carbon energy system in India," said Will Hall, Fellow, TERI, and one of the report authors. The report said hydrogen needs to be targeted in sectors where direct electrification is not possible.

In the transport sector, battery electric vehicles (BEV) will become competitive across all segments, except for very long-distance, heavy-duty transport, which could be fuelled by hydrogen. In the industry sector, hydrogen can start competing with fossil fuels in certain applications by 2030. In the power sector, hydrogen could provide an important source of seasonal storage for variable renewables like solar and wind energy.

Large amounts of seasonal storage will become necessary only when the share of wind and solar in total generation reaches very high levels (60-80 per cent), it said.

Government of India, sees hydrogen as our next big sunrise sector and a transition to the hydrogen economy is the way forward for India. Improvement in technology and fall in cost of hydrogen will happen sooner than estimated.Adding electrolysers to produce hydrogen in the list of industries that are to receive the production linked fiscal incentives recently announced by the government for economic recovery.

Dr Ajay Mathur, Director General, TERI, said, "The falling cost of hydrogen will drive its uptake, with initial scale-up being driven by collaborations between progressive public and private players.' "India has an opportunity to grow an economically competitive low carbon hydrogen sector that can spur job growth, reduce energy imports, whilst drastically reducing emissions," he said.

NMDC, MECL INK PACT FOR JOINT MINERAL EXPLORATION

Iron ore major NMDC Ltd has signed an MoU with Mineral Exploration Corporation Limited (MECL) for joint exploration for iron ore, gold, coal, diamond and other minerals in mutually agreed projects across various States.
NMDC is currently producing about 35 million tonnes of iron ore annually and diamonds from the Diamond Mining Project, Panna in Madhya Pradesh. It has an R&D Centre for the study of ore beneficiation and minerals processing.

Sumit Deb, CMD, NMDC said, "NMDC would like to add value to the Prime Minister's vision of Atmanirbhar Bharat by domestically fulfilling the demands of the steel industry. I hope this venture accomplishes the mission of strategic and beneficial exploration successfully for both the companies."

Coal mining

"NMDC has been pioneer in iron ore mining and is venturing into coal at Tokisud North and Rohne Coal Mines in Jharkhand." MECL has been carrying out mineral exploration from 1972 and is the premier exploration agency in the country.

Ranjit Rath, CMD, Mineral Exploration Corporation Limited said, "MECL is poised to augment and expedite exploration coverage for all mineral commodities across the country." "Earlier, MECL has conducted successful exploration for NMDC in Shahpur East and Shahpur West Coal blocks in Madhya Pradesh."

AMNS KEEN ON EXPANDING PRODUCTION CAPACITY TO 8.5 MT: ADITYA MITTAL

ArcelorMittal Nippon Steel is keen on expanding its current capacity to around 8.5 million tonnes per annum from its current level of 7.5 mt by debottle necking its existing operations in the coming years. "Our long-term production intentions to reach between 12 and 15 million tonnes of annual production still stands. In the short-term, the focus will be on debottlenecking our existing operations so we can increase annual production to around 8.5 million tonnes," said the company's Chairman Aditya Mittal to his colleagues on the occasion of celebrating the company's one year anniversary. The same time last year, in what was called as one of long-pending acquisitions, ArcelorMittal and Nippon Steel's joint venture, AMNS India acquired the bankrupt Essar Steel India Limited for Rs 42,000 crore that entered insolvency court in 2017. "We are currently working on further growing our production, and I expect we will be able to provide some further details on how we plan to do this next year," Mittal said.

AMNS is also planning to develop its downstream capabilities and improve its capacity to produce higher value added auto products as well as introducing other high-value products from the ArcelorMittal range. "When it comes to technological prowess, innovation and R&D, I truly believe our capabilities are unmatched in the global steel industry," said Mittal, adding that it provides AMNS India with a real competitive advantage and a powerful tool to implement the strategy to achieve its vision of becoming a 'new type of steel company' for India. The slowdown following the March lockdown was safely and efficiently managed, as was the ramp up as lockdown measures eased, enabling us to be back at full production levels by mid-May, only six weeks after the lockdown was originally initiated, Mittal said. "In November the company set a new monthly production record in Hazira. On the sales and marketing side, the national network of retail outlets, Hypermart, was extended, and two new high-strength steel brands, Stallion and Maximus, were launched," said the chairman.

ArcelorMittal has now set a net zero 2050 target and is constantly trialing technologies that will reduce emissions, he added. "While this may not feel like the most pressing issue in India today, if we are to set new standards in Indian steelmaking we need to be as conscious of the long-term trends which will shape our industry as we are of the short-term challenges which occupy our thoughts daily," Mittal said.

DALMIA CEMENT (BHARAT) INVESTS RS 360 CRORE IN A 2.3 MT CEMENT-MAKING CAPACITY IN BENGAL

Dalmia Cement (Bharat) has announced a capacity addition of 2.3 million tonnes at its Bengal Cement Works (BCW) unit in West Midnapore with an investment of Rs 360 crore. This addition is in line with the company's business growth plans and will increase the overall capacity of the BCW unit to 4 million tonnes per annum. "Under this project, we now have an installed capacity of 4.0 million tonnes per annum (MTPA) at Bengal Cement Works, Midnapore…This addition will play a pivotal role in addressing demand for cement, ensure sufficient and timely supplies and further help in the growth of infrastructure in the region," said Ujjwal Batria, chief operating officer, Dalmia Cement (Bharat). Post the COVID induced slowdown, the cement demand is expected to improve with affordable housing, mega real estate and infrastructure projects picking up pace, the company said in a statement.

"Through this addition, DCBL will continue to contribute towards nation building, while staying committed to the growing demand from the eastern and north-eastern states of the country," the company said in a statement. The company has deployed the latest machinery and technology for this addition and will be producing only 100% blended cement so as to ensure reduced carbon footprint as part of our commitment to become carbon negative by 2040, said Batria. The plant has already commissioned and has started booking orders, Batria said.

Dalmia will be producing four brands, Dalmia, Dalmia DSP, Konark and Dalmia Infra Pro at the Bengal Cement Works Unit and the commitment through this capacity addition is that the company will supply the products within 8-12 hours by road to its consumers. "This is done so the partners will get the product well in time and also ensure that the consumers in Bengal receive one of the freshest cement for their use," said Indrajit Chatterji, Executive Director and Head - Sales & Marketing (East), Dalmia Cement (Bharat). The company is planning to take the overall cement-making capacity to 31 million tonne from 29 mt by the next financial year.

"We have a second capacity addition coming up in Odisha, which is again a brownfield project. We are putting up a 2.3 mt capacity, which should be ready by Q1 of next financial year. We recently acquired Murli Industries which is a 3 Mt capacity. We are revamping the plant and it will be ready by Q3 of FY22," said Batria.

Today Dalmia has a capacity of around 29 million tonne, we should be going up to 31 Mt by next financial year and by Q3 we will be around 34 Mt, he added. "Rural belt is aiding demand, huge amounts of infra projects are getting executed in the highway sector, rail infra and bridge infra has picked up. We look forward to Bengal and Bihar region's demand picking up substantially," said Chatterji while announcing the capacity addition.

ADANI POWER TERMINATES PACT TO BUY 49 PC STAKE IN ODISHA POWER GENERATION CORPORATION

Adani Power said the agreement to acquire 49 per cent stake in Odisha Power Generation Corporation (OPGC) from the affiliates of the AES Corporation, is formally junked now. The Odisha government, which holds 51 per cent stake in OPGC, had exercised Right of First Refusal (RoFR) to purchase the 49 per cent stake held by AES. In June this year, Adani Power had announced inking a share sale and purchase agreement (SSPA) to acquire from AES OPGC Holding and AES India Pvt Ltd (collectively referred as sellers) total 89,30,237 equity shares held in OPGC representing 49 per cent of the total issued, paid-up and subscribed equity share capital. "The sellers have intimated (on) December 24, 2020 that Government of Odisha...have exercised their RoFR to purchase (49%) shareholding in OPGC. Accordingly, the sellers have transferred the AES Shareholding in OPGC to the agency authorised by the Government of Odisha. As a result of this development, the SSPA has ceased to be effective," Adani Power said in a BSE filing.

OPGC operates 1,740 MW thermal power plant at Banharpalli in Jharsuguda district, Odisha. This plant is the mainstay of Odisha for base load power supply and amongst the lowest cost power generators in the state. The supercritical capacity of 1,320 MW is a recently commissioned modern plant with low carbon footprint. The plant has a long-term power purchase agreement valid for 25 years with the state-owned off taker GRIDCO and sources fuel from a nearby captive mine.

VIKRAM SOLAR COMMISSIONS OVER 900 KW SOLAR PLANT AT FALTA UNIT IN WEST BENGAL

Vikram Solar on Wednesday announced commissioning of a 919.73 kilowatt rooftop solar plant at its Falta facility in West Bengal. The newly commissioned plant will fulfil over 27 per cent of the total electricity requirement of the said unit where the company produces PV (photo-voltaic) modules, Vikram Solar said in a statement. " Vikram Solar commissioned a 919.73 KWp (kilowatt peak) rooftop solar project on their manufacturing facility in Falta, West Bengal earlier this month," it said.

The 919.73 KWp plant consists of 2,574 solar panels ranging from 325Wp to 400Wp covering an area of 6,500 square meters. On an annual basis, the solar plant will generate 1,350.58 MWh (megawatt hour) energy, Vikram Solar said. The company's CEO (chief executive officer) Saibaba Vutukuri said, the rooftop project was envisioned not only to cater to the captive energy requirements of its manufacturing unit but also to make it a green energy unit and enabling India's transition to a low-carbon economy. Vikram Solar is a leading solar energy solutions provider, specialising in efficient PV module manufacturing and comprehensive EPC solutions.

LARSEN & TOUBRO BAGS ORDERS FOR RURAL WATER SUPPLY PROJECT IN MADHYA PRADESH

Larsen & Toubro's water and effluent treatment business has won engineering, procurement and conduction work orders for the execution of rural piped water supply schemes in various districts of Madhya Pradesh, worth in the range of Rs 2,500 crore to Rs 5,000 crore, the company said. The projects are part of Jal Jeevan Mission and cover the districts of Guna, Ashoknagar, Shivpuri, Agar Malwa and Singrauli in the state. The schemes will cater to the drinking water requirement of 3,103 villages covering a population of 48 lakh, the company said.

L&T said that the scope of the order includes design and construction of intake structures, water treatment plants of aggregate capacity 377 millions of liter per day (MLD), transmission and distribution pipelines of length 17,513 kms, construction of main reservoirs and overhead service reservoirs, setting up of pump infrastructure and associated electromechanical and instrumentation works. L&T will also be responsible for operation and maintenance for 10 years. The business has also secured an order to execute integrated infrastructure development works at Gwalior. At 14:30 IST, shares of L&T were trading at Rs 1,260.45 on BSE, almost flat from the previous close.

The Indian Mining & Engineering Journal, Vol. 59, No.12, December 2020, pp.09-14
Printed in India, @ IME Publications, ISSN 0019-5944

Noise Monitoring and Mapping in a Coal Washery

D.P. Tripathy* S. Saste**

ABSTRACT

Now a days mining industry is evolving with use of highly mechanized processes. The use of huge machineries in opencast mines and mineral processing plants is going to create lot of noise as because of large size of operations. So naturally coal beneficiation plants inside mines are highly mechanized too. The primary objectives of the paper were to carry out noise assessment inside a highly mechanized coal processing plant which can give us the idea about noise levels present inside plant area. The data collection phase included visiting to the coal washery plant and to collect noise data as needed. The data was collected using EXTECH 407790 octave band analyzer. The data collected by analyzer was in the form of SPL, Lmax, Leq, LE and Lmin. The data was transferred from band analyzer to computer using software. By looking at noise modelling results, it was observed that noise levels around crusher area were higher than usual. About 10-15 workers were working in this building for 8 hrs. shift without any PPE. Based on observations done at site location, more than 50 percent of building area was open. Installation of walls will reduce the noise propagation to the environment. Noise maps of SPL, LEQ, LAE suggest that noise exposure values near heavy media bath(HMB) and Batac jig were not safe for work. However, less number of people were working near HMB, thus installation of noise walls will reduce the noise levels. The average sound exposure values were calculated based on number of hours' workers were actively working in the area. By considering DGMS noise standard, exposure values near Batac jig and crusher exceeded by 3.4 and 3.6 (dBA).

Keywords- Noise mapping, noise model, ArcGIS, IDW, coal washery

INTRODUCTION

India being the fourth largest energy consumer and one of the countries which has abundant domestic reserves of coal, is utilizing this source of energy in a very efficient way. For better utilization of this energy source for greater production of electricity, this coal is first purified and then used for power generation. Coal, which as of now, records for over half of aggregate primary commercial energy supply in the nation and for around 70 percent of aggregate power era, is probably going to remain a key vitality hotspot for India for in any event the following 30–40 years. In India most of the coal reserves is situated in the states of Jharkhand, Odisha, West Bengal, Bihar, Chhattisgarh, Telangana and Madhya Pradesh. To make the coal suitable for use in power generation, it goes through different processes in the coal handling plant [25].

BACKGROUND OF THE PRESENT RESEARCH WORK

Today mining industry is evolving with use of highly mechanized processes. The use of big rigs and machines is going to create lot of noise as because of large size of operation. So naturally coal beneficiation plants close to mines are highly mechanized too. Therefore, it is very important to assess the noise levels coming from these plants. Generally, there are different working stations present inside a coal washery, (Fig.1) which are mentioned as below-

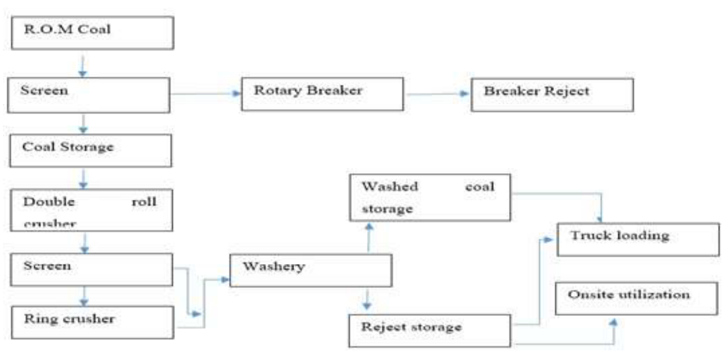

Figure 1: A typical flowchart for coal beneficiation plant [28].

- Crusher: Crushing reduces the overall top size of the ROM coal so that it can be more easily handled and processed within the CPP.
- Thickeners: Thickeners are used for dewatering slurries of either tailings or product.
- Jigs: Jigs are a gravity separation method for coarse coal.
- Cyclones: A cyclone is a conical vessel in which coal along with finely ground magnetite is pumped tangentially to a tapered inlet and short cylindrical

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section followed by a conical section where the separation takes place.

METHODOLOGY

The methodology consists of several phases which are to be followed accordingly. There is need for data preprocessing, because there always going to be noise and redundancy in the acquired data. In order to minimize chances of overfitting, the preprocessing is of most importance. The data collectionphase would include travelling to the coal washery plant after obtaining the necessary permission from them and then travelling there to collect the noise data as needed. It is important to get the monitoring stations right. The data will be collected using EXTECH 407790 octave band analyzer. The data collected by analyzer shall be in the form of SPL, Lmax, Leq, LE and Lmin. The collected data is to be plotted using an ArcGIS software which accepts the data in the form of matrix. The ArcGIS tool was available to noise maps and contours using interpolation method. The inputs and output format is specified by the user. The software has in built interpolation APIs which can be helpful in generating maps. The detailed methodology of work is shown in Fig.2.

PLANT SURVEY

This chapter describes the detailed information about plant survey which was carried out at washery plant. Survey helps to understand brief history about plant, its capacity and method of working. Before doing any type of survey one needs to fully understand of plant area topography, working condition and other factors which can affect the data collection. This chapter contains information about all the above mentioned points.

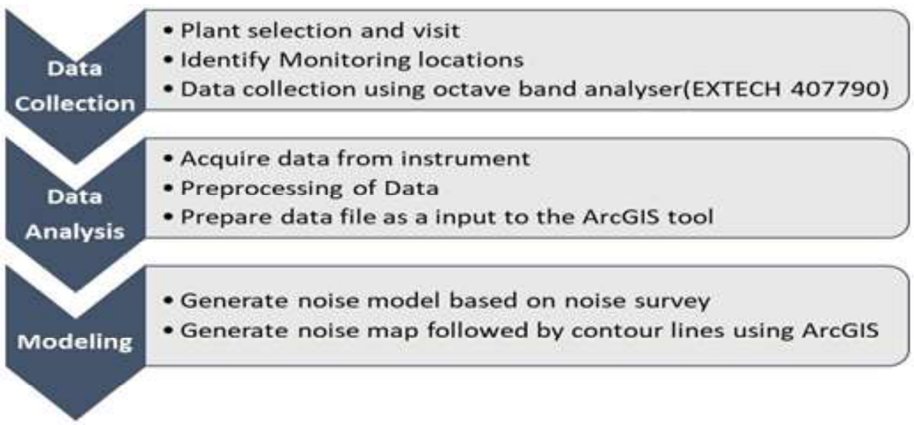

Figure 2. Flowchart of the methodology

Plant Description(Coal Washery-A)

Coal washery is located in the Eastern part of the Jharia Coalfield, District Dhanbad, Jharkhand and covers an area of about 3.5 sq.km. It is situated at about 20km from Dhanbad Railway Station. The coal washery-A in google map is shown in Fig. 3.

Figure 3. Coal Washery Plant-A (Google Maps)

Sources of Noise Inside Coal Washery-A

List of major equipment and their numbers are given below:
(i) Single roll crusher- 1
(ii) Heavy media bath- 2
(iii) Batac jig- 1
(iv) Magnetic separator- 2
(v) Pump- 12
(vi) Thickener- 03
(vii) Screen- 06
(viii) Vibro-feeder- 4
(ix) Poclain 01
(x) Payloader- 3
(xi) Hyva- 5

NOISE MAPPING

The required data for generation of noise contour was collected at different locations in the plant area. The locations were chosen so that one can get considerable variation in data so as to get accurate results. After doing preliminary survey of the property 60 coordinates were selected for data collection purpose. The different noise level values and GPS coordinates were noted so as to generate desired noise contour of the area. The noise contours were generated with help of ArcGIS tool (version 10.3). These generated contours will help the user to locate the critical areas where noise levels were higher. The number of data points were limited but with the help of interpolation techniques such as IDW the noise contours were generated. In mining industry, it is standard practice to use these kind of techniques to generate maps, as minimum deviation from actual data is taken into consideration by the technique.

FREQUENCY(Hz)	31	63	125	250	500	1K	2K	4K	8K	16K
Crusher (dBA)	46.9	70.2	73.9	83.3	92.1	91	88.9	82	72	101.1
HMB (dBA)	48.1	63	70.9	76.8	83	80.9	80.5	75.7	65.5	94.6
Batac Jig (dBA)	54.9	61.2	70.2	76.7	76.6	81.6	81.5	77.2	70.8	96.5
Silo (dBA)	43.8	60.6	73.7	79.5	84.2	85.7	81	80.2	70.4	95.4
Loading Station (dBA)	30.7	45.8	58.8	72.4	77.9	80.5	79.3	74.1	60.7	87
Tippling station (dBA)	33.7	46.8	58.5	70.7	77.1	78.6	77.1	71.7	57.6	82.9

Figure 4: Frequency Distribution represented in graphicalform

NOISE PROPAGATIONMODEL

Thefrequencydistributiondataateachofthesesitewasalso collected to find out what major frequencies responsible for noisegeneration.Thefollowingdatawascollectedusing 1/1 octave band with fast frequency weighting. The results are statedasfollows-Adigitalnoisemodeloflandandbuildings in the area of coal washery plant was created using online noise level modelling tool. The input parameters were taken as per observations done at site locations during the time of visit. The parameters listed are as follows:

- 1-meter by 1-meter grid was taken for interpolation of noise levels throughout thearea.
- All the objects were created as 2D objects using actual size of building and landarea.
- The ground floor refection was taken as hard floor and first-second ground reflection of wave wasconsidered.
- Temperature was taken as 250 Celsius and humidity as 70 percent.
- ISO barrier attenuation limit, barrier perpendicular dimension and propagation around vertical edge were taken intoconsideration.
- Reflection coefficient was taken according to building construction.
- All noise sources were taken as point source. The 1/1 octave band data were taken as input parameters for generation ofmodel.
- 4pixels per meter i.e. resolution of 0.25m was considered for calculation of noise level propagation throughout the area.
- The source sound power level was also predicted using octave band data by considering all input parameters.

The generated noise propagation model shown in Figure5.

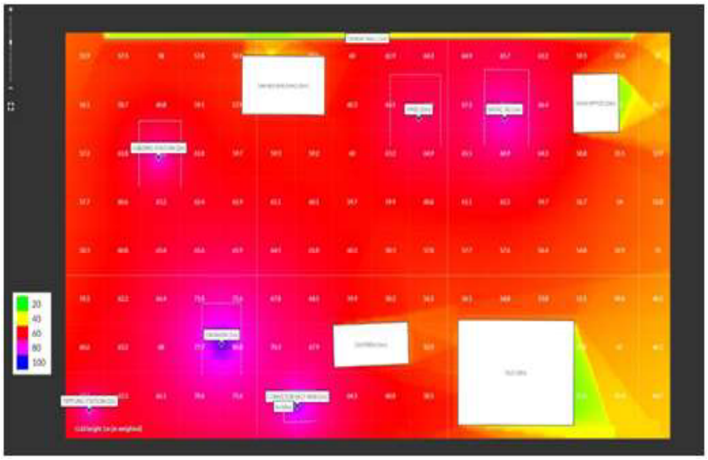

Figure 5 : Noise level propagation model (all values in dBA) [36]

Noise Mapping

Anoisemappingrequiresnoisesurveydataandobservations such as operator/workmen activity, operator position and their movement. This data was included in the noise impact assessment so that one can get better understanding of average exposure value. The data was collected using EXTECH407790 integrating sound level meter. This instrument has type 2 microphone which is recommended for noise monitoring in mining area. Time required for measurement of noise data was taken using nature of noise source present. Location of data measurement was taken based on operator'slocations.

Noise Contour Maps

The details are given in Figs. 6 to 8. [36]

Figure 6: Location of data points

Figure 7: Sound pressure level distribution

Figure 8: Equivalent Sound pressure level distribution

RESULTS AND DISCUSSION

Measurements were taken at each of the working station. For better representation of data, the results are displayed in Table1. Better data visualization leads to good understanding between the different parameters of data. The timerequired for single reading was determined on the basis of time needed for instrument to show no fluctuation in the reading and steady sound pressure level value. Workers in the area were working on 8hr shift basis. In order to find out exact equivalent noise exposure value, the movement of workers around primary noise sources was observed. Based on number of hours' workers working in the area, following LAeq values were calculated. As per the DGMS guidelines the warning limit for noise level is 85dBA and for 8hr shift, it should not exceed above 90 dBA. Above table shows that noise level inside area are below thelimit. The contour maps show the locations of high noise areas inside plant. This will help upper management to set working hours for the workers in these areas.

Table 1: Average noise exposure values

Noise Source	Equivalent Noise Level (dBA)	Max. Noise level (dBA)	Min. Noise level (dBA)	Reference Noise Level (dBA)	Exceedance In dBA
New Building	88.6	98.3	85.1	85	3.6
Old Building	85.8	95.7	82.0	85	0.8
Crusher	88.4	91.2	85.9	85	3.4
Thickeners	83.9	84.7	83.4	85	0
Silos	74.4	79.2	69.8	85	0
Loading Station	81.2	95.1	78.4	85	0
Tippling Station	82.6	96.8	80.1	85	0

CONCLUSIONS

Workers working in the area were exposed to high intensity of noise during 8hr shift period. The Noise modelling and mapping work evaluates the noise exposure level in the area. Therefore, a noise survey was helpful in determining average noise exposure values. By looking at noise modelling results, noise levels around crusher area were higher than usual. About 10-15 workers were working in this building for 8 hr. shift without any PPE. Based on observations done at site location, more than 50 percent of building area was open. Installation of walls will reduce the noise propagation to the environment.

Noise maps of SPL, LEQ, LAE suggest that noise exposure values near HMB and Batac jig are not safe for work. Though less number of people were working near HMB, installation of noise walls will reduce the noise levels. The average sound exposure values were calculated based on number of hours' workers actively working in the area. By considering DGMS noise standard, exposure values near Batac jig and crusher exceeded by 3.4 and 3.6 (dBA) above warning limit of 85 dBA.

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The Indian Mining & Engineering Journal, Vol. 59, No.12, December 2020, pp.15-20
Printed in India, @ IME Publications, ISSN 0019-5944

Recent Practice in Barricade Construction Using Shotcrete – Design and Implementation

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ABSTRACT

Backfilling of the stopes is now a common practice in many parts of the world. Prior to back filling of any stope, it is inevitable to create barricades in all possible entries into the stopes so that the paste fill will not flow into developments. Construction of barricades with the required strength in a lesser time is crucial in maintaining the production schedule. For the ease in erection of barricade, without compromising its strength, steel fiber reinforced shotcrete (SFRS) is proposed for its construction. Arched barricade is simulated with a roadway of dimensions 5.5 m x 5.5 m existing at a depth of about 500 m in a hard rock mine. Strain-softening material model is used for the SFRS shotcrete material during numerical simulation. The strength of the barricade is derived from the displacement curve obtained by gradual increase in hydrostatic pressure head. The study reveals that failure of an arched barricade initiates with horizontal tensile cracks, but the ultimate failure occurs due to the combination of tensile and shear failures at the shotcrete-rock interface. There is almost 15~35% increase in pressure bearing capacity of the barricade when it is reinforced by anchoring into the rock mass using rock bolts. The barricades designed, with safety factor 2.0 considering 100% paste fill pressure, is in practice in some underground hard rock mines in Northern India. Both the field experience and the numerical modelling suggests that the arch shaped SFRS barricades are safer and easier to erect than the conventional wooden and concrete barricades.

Keywords—shotcrete, numerical modelling, barricade, bearing capacity.

INTRODUCTION

The backfilling of underground stopes with paste backfill material is gaining popularity in various parts of the world. Prior to back filling of any stope it is inevitable to create barricades in all possible entries into the stopes so that the paste fill will not flow into developments. Construction of barricades with the required strength in a lesser time is crucial in maintaining the production schedule. There are different types of barricades employed to serve the purpose, they are wooden barricades, muck barricades, concrete barricades and shotcrete barricades. Even though muck barricades are very easy to install, their capability to resist the fluid flow is uncertain. Shotcrete barricades can be constructed with required strength and in a short time span. Sprayed shotcrete is one of the most commonly used paste fill bulkhead designs throughout Australia and North America (Revell & Sainsbury 2007). Shotcrete usually has strong rock bondage and is less prone to shrinkage hence shotcrete barricades are easy to be erected in mines where rock surface is variably fractured, loosened and have irregular profile.

For safe and effective backfilling, the mine operators must be vigilant about the strength and failure mechanism of shotcrete barricade. Based on literature, it is found that there are three types of failures namely flexural failure, shear failure and punching failure associated with fill barricades (Grice 1989). Flexural failure refers to crack starting from corners and ex-tending to centre in about 45° inclination. It is more common in case of flat barricades. Shear failure refers to failure of contact surface of rock around the barricade due to poor bondage with surrounding rock mass. With the introduction of shear pins/ bolts in barricade and rock interface shear strength increases and thereby reduces chances of shear failure. Punching failure refers to a hole punched at the centre of the barricade because of escape of fine material from barricade and formation of erosion pipe and barricade failure under hydrostatic pressure (Grice 1989). However, punching is less likely to occur in paste due to absence of free water (Hughes 2008).

There are some reported failures of paste bulkheads from various parts of the world (Revell & Sainsbury 2007, Hughes 2008, Yumlu & Guresci 2007). Incompetency of ground, material used for construction of barricade, size and position of barricade, size of the roadway, proper-ties of the fill material (water content and binder content), filling rate, shape of barricade, lack of curing time etc. are responsible for the failure of barricades. Dynamic loading and liquefaction of paste may also cause failure. The presence

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of rock fragments near the stope brow may cause leakage of water towards the barricade, which in turn cause increase in pressure on barricade. When filling is done in a continuous manner there can be increase in barricade pressure due to higher pore water pressure and pore water dissipation will be in a slower rate. Staged filling results in lower barricade pressure for same fill rate and attributes to the higher fill strength in the plug fill. When the rest time is higher the porewater pressure dissipates. Water pressure drops as a result of cement consolidation during lag time (Yumlu 2008, Helinski 2007).

Shape of the barricade is an important designing aspect, Bridges (2003) pointed out that curved barricades are stronger than planar barricades in equivalent circumstances. Arching against wall-rock as they deform under load, help the barricade to attain strength. Arching is more efficient for curved barricade than planar barricade. Curved shape barricade keyed to surrounding rock is now becoming a common practice (Kuganathan 2001) as it can withstand large span with lower thickness (Kuganathan 2005). Revell & Sainsbury (2007) also mentioned that barricades with a curve increase the resistance.

In the present study possible failure modes and hydrostatic pressure bearing capacity of steel fiber reinforced shotcrete barricades (SFRS barricades) is analyzed numerically by simulating various configuration of plug formation and thickness of barricade.

DESIGN USING THREE-DIMENSIONAL NUMERICAL MODELLING

A well known software which computes in finite difference method is employed for numerical modelling study, strain-softening material model is assigned for SFRS shotcrete material. Strain-softening material model has been extensively used to simulate failure in rock mass as well as artificial materials like concrete, shotcrete, etc. Insitu stress, rock mass properties and geometry of the proposed stoping region are given as input parameters used for the numerical modelling study. Barricade with and without reinforcements are simulated. Strength reduction technique is employed to reduce the Mohr-coulomb strength parameters of the barricade for the desired safety factor. The standard strength parameters corresponding to M30 shotcrete of 28 days curing such as UCS of 30 MPa, cohesion of 7.5 MPa, angle of internal friction of 37° and tensile strength of 3 MPa are considered. The spraying is done over a period of 24~36 hours; the paste pouring is done only after 24 hours from the final spray. The strength of 24 to 48 hours old shotcrete with accelerator can be assumed to possess 40% strength of 28 day cured shotcrete. Hence for the experimental study, 24~48 hours cured M30 shotcrete is considered to have UCS=12 MPa, cohesion = 3.0 MPa, angle of internal friction = 37° and tensile strength = 1.2 MPa. The strength reduction is applied as per the standard procedure for Mohr-Coulomb elasto- plastic material, corresponding to a safety factor of 2.0 as shown in Table 1.

Table. 1: Reduction of Mohr-Columb material properties corresponding to various safety factors for 40% strength of M30 SFRS

Safety factor	Unconfined compressive strength (MPa)	Cohesion (MPa)	Reduced friction angle (Deg)	Tensile strength (MPa)	Youngs modulus (GPa)	Poisson's ratio
1	12.0	3.0	37	1.2	4.8	0.2
2	6.0	1.5	20.65	0.6	2.4	0.2

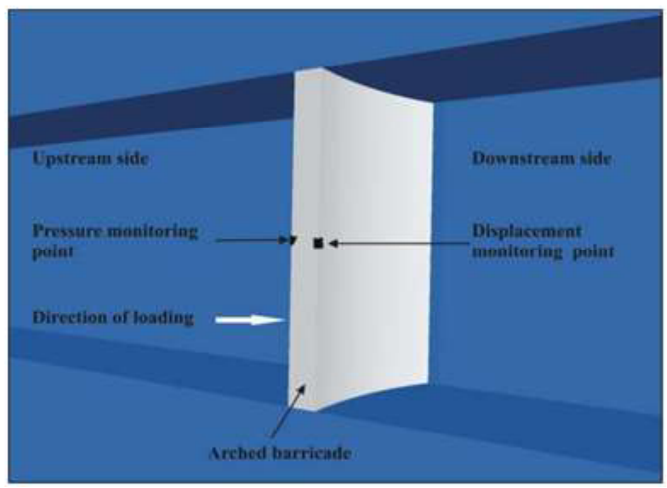

Fig. 1: Three-dimensional grid used for the modeling of the arched barricade

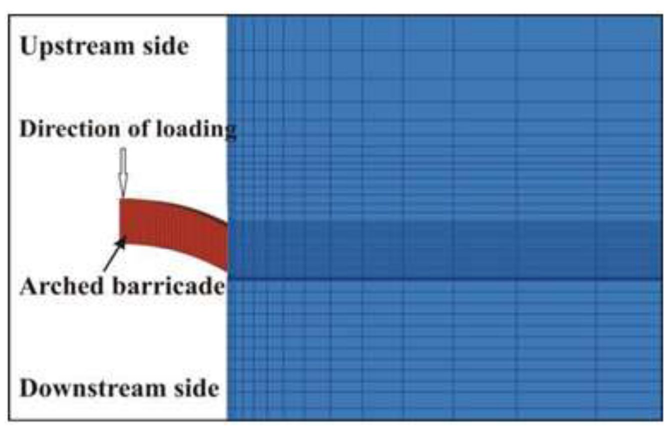

Fig. 2: Plan view of the grid used for modeling

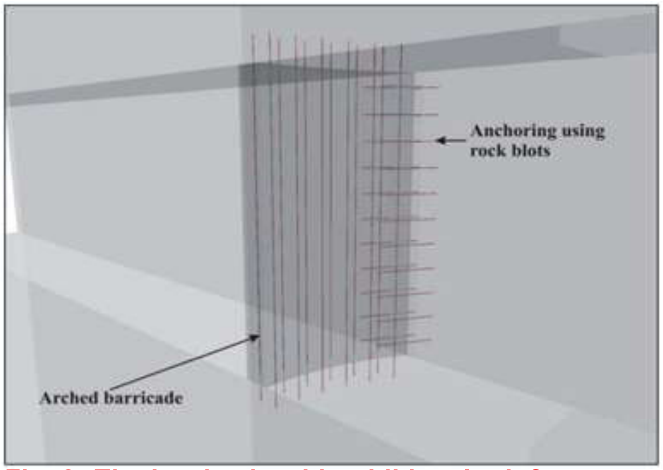

Fig. 3: The barricade with additional reinforcement

The Young's modulus for M30 shotcrete is 12 GPa after 28 days curing, with a Poisson's ratio of 0.2 and density of 2400 kg/m^3. Young's modulus has also been reduced according to the design safety factor as shown in Table 1. The friction angle is reduced as per equation given below.

$$\phi' = \tan^{-1} \frac{\tan \phi}{SF} \qquad (1)$$

where ϕ'is reduced friction angle, ϕ = friction angle and SF = safety factor.

For the simulation, a 3D grid is constructed considering a plane of symmetry along the axis of the roadway and the barricade; thus, the model is constructed with half portion of the roadway (Fig. 1). The boundaries of the model are kept sufficiently away (>30m) from the roadway and the barricade. The barricade is arch in shape and has a radius of curvature of about 5 to 6 m and a height of 5.5 m (Fig 2). The model has been run for shotcrete thickness varying from 400 mm to1200 mm at an interval of 100 mm. These models are run with and without additional reinforcements and anchoring of the SFRS into the rock mass. The arched barricade with additional reinforcements is simulated with two layers of steel rods placed at a spacing of 0.5 m in the horizontal and vertical directions (Fig. 3). The rods are keyed into the rock mass at sides, roof and floor to a depth of 0.5 m. In order to find the maximum pressure that barricade can withstand, a displacement tracking strategy is applied. A point in the center of the barricade in the downstream side is used to serve the purpose. Hydro-static pressure head is applied at the upstream side of the roadway in all directions.

On all grid points on the upstream side of the roadway including the barricade surface, hydro-static pressure head is applied as normal stress. Initially a hydro-static pressure of a lower magnitude (<100 kPa) is applied and the model is brought to equilibrium and then it is in-creased by 10 kPa and so on and so forth. When the model is equilibrated for a particular hydrostatic pressure head, the displacements at the barricade axis tend to stabilize when the barricade is in stable state. When the hydro- static pressure exceeds the limit, the displacements are expected to increase rapidly and do not stabilize. Based on the above criteria barricade stability for a particular hydro-static pressure head is determined. The last hydro-static pressure at which the displacement tends to stabilize is taken as the maximum stable hydro-static pressure head. This method has been earlier adopted for assessing the pressure bearing capacity of water dams (Porathur et al. 2018). In strain-softening elasto-plastic analysis, some elements go into plastic state when the hydro- static pressure head is applied, however this does not indicate the failure of the entire barricade. At the time of overall failure, a large number of elements in the barricade can be seen failed in either shear or tension. The yielding can also be seen completely passing across the barrier axis at the time of failure. The horizontal stress acting on the upstream side skin element of the barricade in the direction of the axis is also monitored to check the model convergence and stress stabilization. This stress when stabilized will be approximately equal to the hydro-static pressure head applied. From the history plots the maximum hydrostatic pressure head at which the barricade displacement stabilizes is obtained.

INUMERICAL MODELLING RESULTS

The numerical simulation for various barricade thickness, 400 mm, 500 mm, 600mm, 700 mm, 800 mm, 900 mm, 1000 mm and 1200 mm with and without reinforcements to the SFRS and anchorage to the rock mass is performed. From the study it is found that in case of arched barricade the failure initiates with horizontal tensile cracks on the downstream face. The barricade ultimately fails in a combination of tensile and shear failures at the shotcrete-rock interface. The strength in terms of maximum stabilised hydro- static pressure for various thickness of the shotcrete barricade has been plotted. From the study it has been found that the increase in shotcrete thickness will increase the barricade strength almost linearly. A reinforced barricade will have about 15~35% more strength than non reinforced barricades of equal thickness. For all models the reinforcements and anchoring are same, hence gain in strength with reinforcement is found to be more in lower shotcrete thickness.

The maximum stable hydrostatic pressure obtained for various barricade thicknesses with-out and with reinforcement is shown in the Table 2. The plasticity states of failed barricade along with the history plots of displacement and horizontal stress on the barricade face are plotted for 400 mm and 1000 mm thick barricades without reinforcement in Figures 4 and 5 respectively.

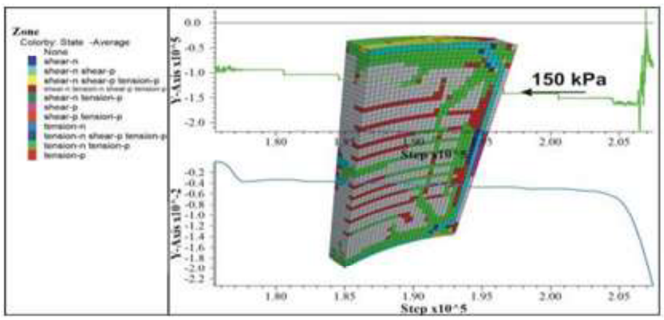

Fig. 4: Maximum stabilized hydro-static pressure for 500 mm barricade thickness

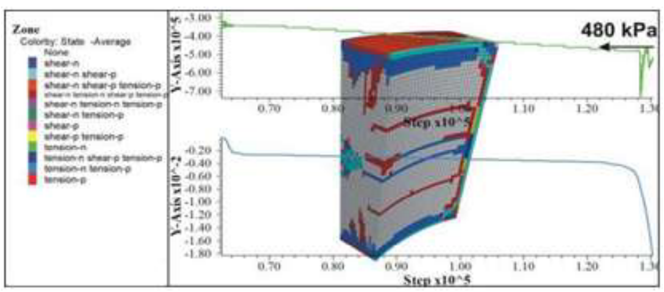

Fig. 5: Maximum stabilized hydro-static pressure for 1200 mm barricade thickness.

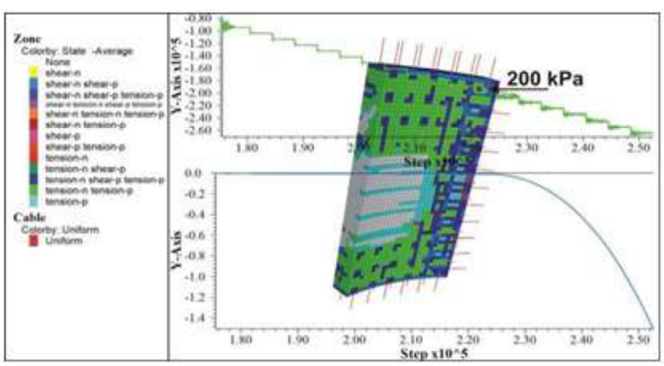

Fig. 6: Maximum stabilized hydro-static pressure for 500 mm barricade thickness with reinforcements

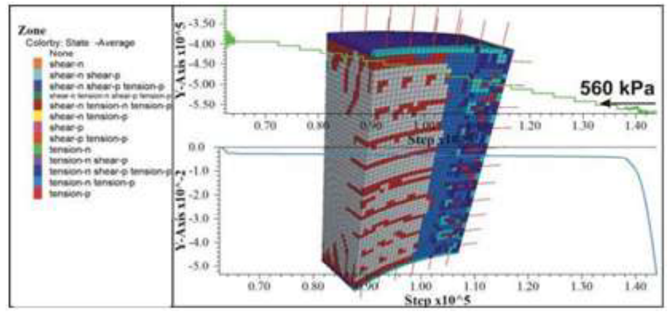

Fig. 7: Maximum stabilized hydro-static pressure for 1200 mm barricade thickness with reinforcements

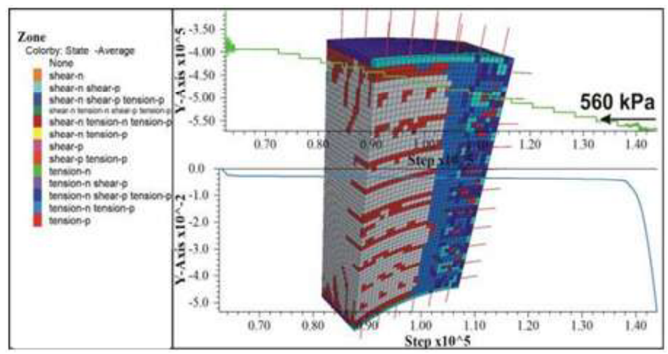

Fig. 8: Maximum stabilized hydro-static pressure for 1200 mm barricade thickness with reinforcements

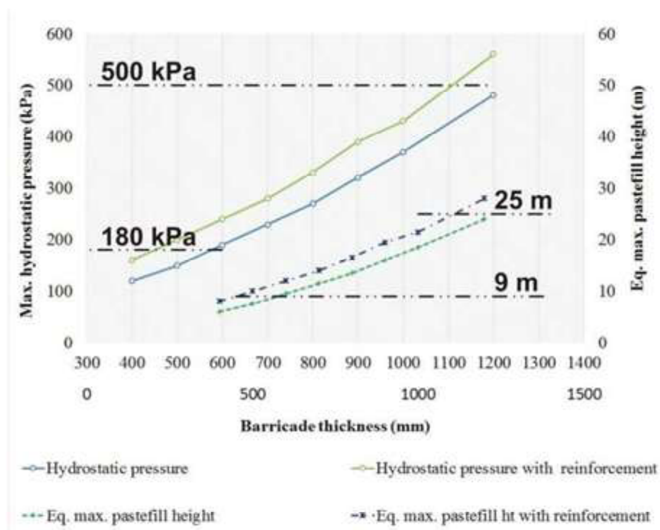

Fig. 9: Maximum stable hydro-static pressure head and equivalent maximum paste fill height against barricade thickness.

The figures also indicate the maximum stabilized pressure on the barricade, which is taken as its ultimate pressure bearing capacity. Similarly, the history plots and plasticity states for barricades of 400 mm and 1000 mm with reinforcement and anchorage are shown in Figures 6 and

7 respectively. The equivalent pastefill height for the maximum hydro-static pressure has been calculated by applying a density of about 2000 kg/m^3 for the wet pastefill. The pastefill mix is a non-newtonian fluid and starts consolidating during pouring, which results in reduced pressure at the barricade face. The horizontal pressure actually acting on the barricades by freshly poured paste fill shall not be more than 60% of its weight, depending on the rate of pouring and water percentage in the mix (Yumlu 2008). Figure 9 is a graphical representation of the relations obtained for strength of barricades of various thickness.

Table. 2: The maximum stable hydrostatic pressure obtained for various barricade thickness

Barricade thickness (mm)	Hydro-static pressure without reinforcement (kPa)	Hydro-static pressure with reinforcements (kPa)
400	120	160
500	150	200
600	190	240
700	230	280
800	270	330
900	320	390
1000	370	430
1200	480	560

FIELD IMPLEMENTATION

The barricade design mentioned in the study is being successfully implemented in some metal mines in Northern part of India. The barricade is found to withstand the pressure that may produce during paste plug formation. The barricades are erected in a 5.5 m wide roadway which connects to a stope of 25 m height. The 500 mm thick arch shaped barricade is constructed with a radius of curvature of 6 m, using SFRS material. The thickness of the barricade is decided after examining the figure 8. From the graph it can be seen that for plug formation, with a maximum of 9 m paste fill height, a shotcrete barricade of 400 ~ 500 mm shall be suitable with reinforcements, after assuming that 100% weight of the paste fill is translated into the side pressure.

Fig. 10: A barricade constructed for paste fill plug formation (9 m height).

If we have to go for full stope height (25m) pouring without forming a plug, the thickness of shotcrete barricade required shall be 1100 ~1200 mm with reinforcement and anchorage. But full stope filling is not yet practiced in any Indian mine. From the field experience it is found that the arch shaped shotcrete barricade is easy to erect in a short time span than the conventional wooden and concrete barricades. The barricade is found to be safer for plug formation. The faster barricade construction using shotcrete helps to reduce the production cycle.

CONCLUSION

In the present study numerical modelling has been successfully conducted based on strain softening material model to perceive the extreme pressure bearing capacity of the shotcrete barricades. The maximum stabilized pressure is found from displacement history during gradual increase in hydrostatic pressure head. From modeling it has been found that, for arched barricades, the failure initiates with horizontal tensile cracks, but the barricade ultimately fail in a combination of tensile and shear failures at the shotcrete-rock interface. Shotcrete barricade reinforced, with steel rods anchored into the rock mass, will have pressure bearing capacity 10~35% more than that of the non-reinforced one. The designed barricade will have a mini-mum safety factor of 2.0 with 100 % weight of the paste fill assumed to be acting on the barricade wall. It has been found that the arch shaped shotcrete barricades are having greater strength than the conventional barricades. The designed barricades are currently in use for paste plug formation in some underground hard rock mines in Northern part of India and it is found to be effective and safer.

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The Indian Mining & Engineering Journal, Vol. 59, No.12, December 2020, pp.21-28
Printed in India, @ IME Publications, ISSN 0019-5944

Performance Evaluation of Potential Constitutive Models for Simulation of Longwall Goaf Compaction Using Modulus Updating Technique

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ABSTRACT

The design and stability analysis of a longwall working critically depends on the accurate estimation of the redistributed load on the structures. Since the supporting capability of the gob material significantly influences the distribution of the stress and over the large area, realistic and accurate modelling of the gob behaviour is an inevitable requirement in the numerical simulation codes. In this paper, an approach for the modelling of gob behaviour has been developed using the modulus updating technique. The algorithm has been presented for the same, and its robustness has been established by through single-element model by calibrating the model response against the characteristics obtained from the theoretical gob models. The developed algorithm has been further implemented in the plane strain modelling of a longwall panel for the study on the performance evaluation of the three prominent gob models – Salamon, Terzaghi, and Strain-Hardening models. The findings of the plane strain models have been verified against the theoretical considerations and previous research works. The study shows that the Salamon and the Terzaghi models can be used for the realistic modelling of gob behaviour.

Keywords— Longwall, Gob compaction, Strain hardening, Modulus updating technique, Cover Pressure Distance

INTRODUCTION

During the longwall mining of a panel, the roof rocks behind the shield supports fall onto the floor till it comes into the contact of the fractured stratum. As the mining progresses further, the gob material (caved rock fragments) compacts under the combined effect of the sagging roof, the heaving floor and the bulking of the material. The degree of compaction of the gob material varies into the gob depending on the distance from the gob edge, with the material at the centre of the gob having maximum compaction. Thus, the supporting capability of the gob material is the function of the distance into the gob from the gob edge. Since the gob material affects the redistribution of stresses over a significant distance in its surroundings, the worthiness of design and stability analysis of a longwall structure critically depends on the accurate modelling of the gob behaviour.

Due to the inaccessibility of the gob area, several researchers have adopted indirect methods for estimating the gob stress distribution. Wilson (1981) found that the cover pressure is attained at a distance of 0.2 – 0.3 times the cover depth from the gob edge based on the observations of the gate road stability behind the longwall face. Smart and Haley (1987) reported that the cover pressure distance is 0.12 times the cover depth based on the strata tilt theory. King and Whittaker (1971) estimated this distance as 0.6 times the cover depth for British conditions, using a subsidence model. Choi and McCain (1980) estimated this distance to be 0.32 times the cover depth for the USA conditions based on the concept of negative angle of draw. Mark (1987) reported that the cover pressure distance for USA conditions is 0.38 times the working depth based on the field observations. Based on the field observations in Indian conditions, Sheorey (1993) reported the cover pressure distance to be 0.3 times the cover depth. Trueman (1990) noted that the findings of Smart and Haley (1987) overestimated the cover pressure distance as the tilt angle decreases with the distance away from the gob edge and the roofline and opined that the cover pressure distance of 0.2 – 0.6 times the cover depth seems to be a practically reasonable range.

The stress-strain characteristics of the gob material are non-linear strain-hardening in nature. Previous researchers have proposed different models to characterise this behaviour. Salamon (1990) proposed a hyperbolic stress-strain relation for the gob constitutive behaviour, as shown in Equation 1. Smart and Haley (1987) suggested a fourth-degree equation (Equation 2) to define the stress-strain characteristics of the gob material. Trueman (1990) opined

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that the Smart and Haley (1987) stress-strain relationship is not valid for compaction greater than 25% proposed a hyperbolic relationship between the stress and strain (Equation 3) for a bulking factor of 1.5. Terzaghi (Pappas and Mark 1993) proposed an exponential stress-strain relationship (Equation 4) to characterize the gob constitutive behaviour. Modelling methods such as MULSIM/NL, a non-linear multi-seam boundary element code, and LAMODEL which also incorporates bedded units in the overburden are equipped with Strain- Hardening material model (Equation 5) to simulate the gob behaviour (Badr 2004). The comparison of the laboratory tests results with the Salamon model and Terzaghi model showed that both the models can be used for representing the stress-strain behaviour (Pappas and Mark 1993).

$$\sigma = \frac{E_0 \varepsilon_m \varepsilon}{\varepsilon_m - \varepsilon} \tag{1}$$

$$\sigma = 512.9\varepsilon^4 - 294\varepsilon^3 + 121\varepsilon^2 - 1.7\varepsilon + 0.007 \tag{2}$$

$$\sigma = \frac{\varepsilon}{(0.164 - 0.44\varepsilon)} \tag{3}$$

$$\sigma = \frac{E_0}{a}\left(e^{\varepsilon a} - 1\right) \tag{4}$$

$$\sigma = \left[\frac{E_I \sigma_u}{E_F - E_I}\right]\left[e^{\left(\frac{E_F - E_I}{n\sigma_u}\right)\varepsilon} - 1\right] \tag{5}$$

where σ is vertical stress; E_0 is the initial modulus; ε_m is the maximum strain; ε is the strain; a is dimensionless constant; E_I is the initial modulus; σ_u is the virgin vertical stress; E_F is the final modulus; n is the gob height factor, the ratio between the height of the caved zone and the extraction height.

For the implementation of the above gob models, previous researchers have adopted a number of techniques as most of the numerical simulation codes do not have any built-in method for the same. Badr (2004) and Sinha and Walton (2019) updated the modulus of the elastic gob model as a function of the strain following a theoretical gob model. Badr (2004), Bai et al. (2014), and Song et al. (2017) simulated the supporting capability of the gob material by applying pre-set grid forces along the roof. Basarir et al. (2019) and Cheng et al. (2010) modelled the gob material a soft elastic material. Li et al. (2015) and Shen et al. (2018) used the double-yield constitutive model for simulating the gob mechanical response. The grid force method takes excessive time for the model to converge to a solution. Therefore, its implementation in large size model can compromise with the modelling efficiency (Badr 2004). On the other hand, the double- yield model requires several input parameters such as a cap-pressure table, multiplier, maximum moduli. These parameters can be determined by the back-calculation method by calibrating the model against a theoretical gob model or laboratory results using trial-and- error methods, but it takes several iterations for the calibration. Further, the method of simulation of the gob behaviour using soft elastic material does not consider the non- linear stress-strain characteristics of the gob material. In the modulus updating method, the stress and moduli determined from the non- linear stress-strain relationship of a gob model both are updated at a regular interval of timesteps in the linear elastic constitutive model. Therefore, it violates the Hook's law.

In this paper, an algorithm has been developed for simulation of strain hardening behaviour of the gob material using modulus updating technique. It is considered that the non-linear stress-strain characteristic of the gob material is comprised of several infinitesimal linear segments. The accuracy of the algorithm is established by calibrating the stress-strain characteristics of the single-element model aginst three different gob models in a modelling environment similar to that in confined uniaxial compression tests conducted by Pappas and Mark (1993). The three different models considered here for comparative study are Salamon (1990) model, Terzaghi (Pappas and Mark 1993) model, and Strain-Hardening model (Badr 2004). The above three models have been implemented in a field-scale plane strain model of a supercritical working. The finding of the models in terms of the maximum subsidence, the gob stress distribution, peak abutment stress and Load Transfer Distance (LTD) have been verified against the theoretical solutions and field observations reported by previous researchers.

ALGORITHM FOR UPDATING MODULUS

The laboratory tests conducted on the graded down gob material have established that the constitutive behaviour of the material is defined by the non-linear strain-hardening characteristics (Pappas and Mark 1993). The stress-strain curve is considered to be comprised of several infinitesimal linear segments in the modulus updating technique proposed in this paper (Fig. 1). The stiffness of the elastic material model of FLAC3D is updated for these linear segments depending upon the current value of the strain in the model.

Strain value (ε_c) is less than ε_u or not. When 'ε_c' in the model exceeds 'ε_u' of the current segment, 'ε_u' of the present segment becomes the 'ε_l' for the next segment and the 'ε_u' for the next segment is determined by adding 'δ_ε' to the 'ε_l' of the segment. The same process for determining and updating moduli values is repeated in the model until 'ε_c' approaches closer to the maximum strain value (ε_m), where it is ensured that 'ε_u' does not exceed 'ε_m' for the last segment.

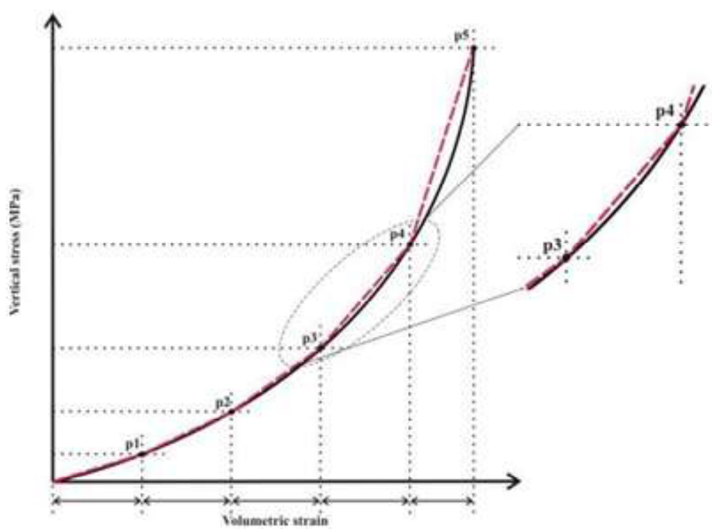

Fig. 1: Approximation of the hyperbolic hardening curve by linear segments

Fig. 2 depicts the flowchart for updating the modulus. The model requires four input parameters: strain interval, δ_ε, the maximum possible strain, ε_m, Poisson's ratio, í, and initial gob modulus, E_o. The segment size is prescribed in terms of the input strain interval (δ_ε). The strain (ε_u) corresponding to the upper end of the segment is determined by adding äå to the strain (ε_u) at the lower end, which is zero at the beginning. Stresses corresponding to the upper end (σ_u) and the lower end (σ_u) are evaluated by substituting the respective strain values in a gob model (for instance, Salmon (1990) model).

The elastic stiffness (E_c) of the segment corresponding to the strain in the model is determined using the stress and strain values determined earlier and updated in the numerical model in terms of bulk and shear moduli. After that, the model is run for finite timesteps, and it is checked whether current.

COMPARATIVE STUDY OF THE GOB MODELS

The Salamon (1990) model, Terzaghi model (Pappas and Mark 1993), and Strain- Hardening model (Badr 2004) were considered for their performance evaluation in terms of their ability to model the supporting capability of the gob material.

A. Plane Strain Model

A supercritical longwall working pertaining to Bishrampur Coalfield was considered using plane strain condition in FLAC^{3D} code (Itasca 2015). In the working, a 150m long face was mined out with extraction height of 2.2m under the average cover depth of 71m. The ratio of extraction width to the cover depth is 2.1, which renders the working supercritical in nature. The width and height of the gate roads are 5m and 2.2m, and the chain pillar width is 21m. The plane strain model of the working includes half of the panel width, which in turn includes half-length, two gate roads and a chain pillar, using the symmetry conditions (Fig. 3).

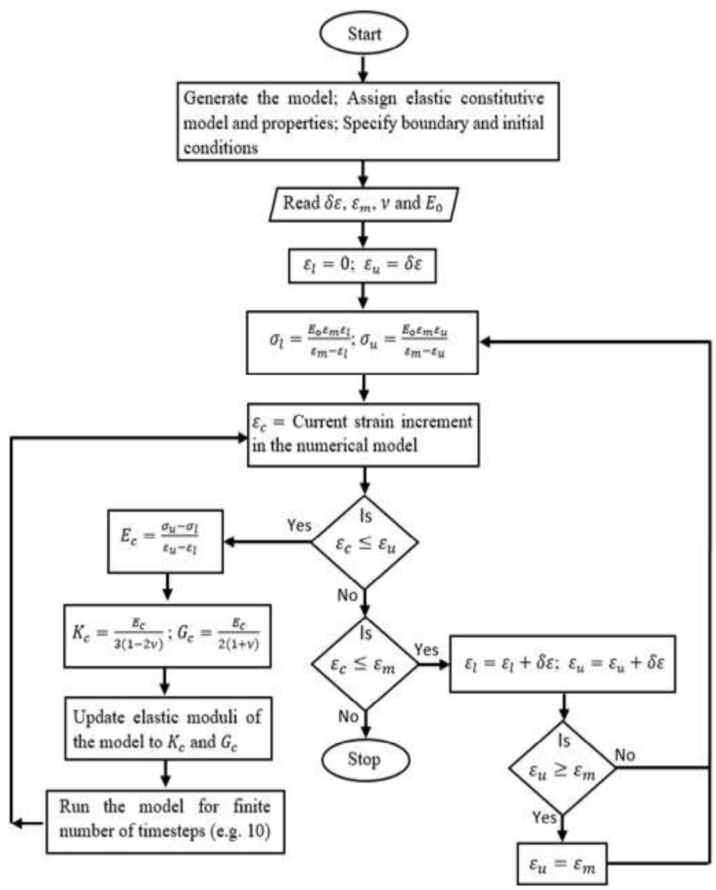

Fig. 2: Algorithm used in modulus updating method

The zone size within the zone of interest was kept uniform at 1m × 1m × 1m and was increased gradually using a geometric ratio of 1.1. The zone size along z-direction in the roof strata was kept uniform to study the mining- induced surface subsidence. The lateral side of the model was roller constrained at a distance of two times the face length from panel edge while the bottom of the model was constrained using fixed boundary at a distance of 50m below the seam floor.

The caving height equal to ten times the extraction height was considered in the model based on findings of the literature reviews and the field observations (Singh and Singh 2011).

In the absence of field measurement data for in situ stresses, the vertical and horizontal stresses were initialised using gravity loading and the elastostatic thermal stress model (Sheorey 1994). The Mohr-Coulomb constitutive model was used to model the coal and floor strat, whereas the ubiquitous joint model was assigned to the overlying strata within the fractured zone to simulate the mining-induced damage. Table 1 shows the input properties to the numerical model of the working. Following are the joint properties of the ubiquitous joint model: joint cohesion (c_j) equals to 0.1MPa, joint friction angle $(\tilde{O}_j)$ equals to 25°, and joint tension limit (σ^t) j equals to 0 MPa.

The simulation was done in three stages to replicate the actual mining process. In the first stage, to represent the pre-mining state, all velocities and displacements were initialized to zero after the virgin model attained equilibrium. In the second stage, the model was run to equilibrium after the development of gate roads. In the third stage, The caved zone was delineated following a caving angle of 65° (Das 2000) and the material in the zone was instantly replaced by the elastic gob material. The model was solved further until it attained equilibrium.

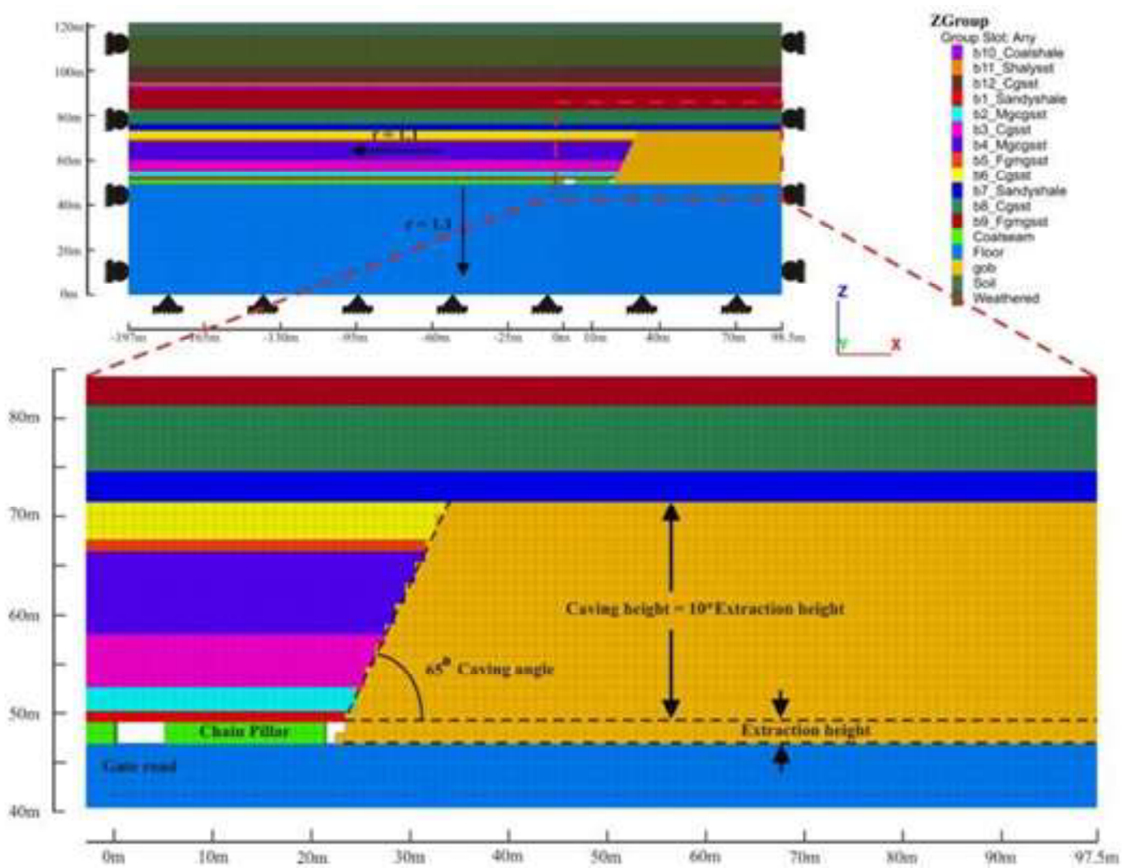

Fig. 3: The geometry of the plane strain model after extraction of the panel (a. Full view, and b. Magnified view of the zone of interest)

Table. 1: Rock strata properties used in the plane strain model

Rock strata	Thickness (m)	Density (kg/m³)	Shear Mod. (GPa)	Bulk Mod. (GPa)	Tensile strength (MPa)	Cohesion (MPa)
Soil	6.0	1600	0.24	0.41	0.04	0.09
Weathered rock	14.0	1700	2.02	3.37	0.16	0.76
Cgsst	7.4	1955	2.02	3.37	0.15	0.70
Shaly sst	1.1	2280	2.36	3.93	0.59	1.55
Coal/Shale	1.5	1400	2.23	3.72	0.29	0.67
Fgmgsst	9.3	2110	3.24	5.41	0.53	2.14
Cgsst	6.6	1955	2.02	3.37	0.25	1.16
Sandy shale	3.0	2280	2.36	3.93	0.49	1.29
Cgsst	3.8	1955	2.02	3.37	0.15	0.72
Fgmgsst	1.2	2110	3.24	5.41	0.47	1.89
Mgcgsst	8.3	2023	2.63	4.39	0.27	1.24
Cgsst	5.3	1955	2.02	3.37	0.26	1.20
Mgcgsst	2.4	2023	2.63	4.39	0.43	1.96
Sandy shale	1.1	2280	2.36	3.93	0.26	0.69
Coal	2.2	1400	0.80	1.33	0.36	0.84
Floor	50.0	2300	2.43	4.05	0.37	1.41

B. Gob Modelling

The preliminary estimate of the initial tangent modulus, E_(0,) of the gob material was made using the relation proposed by Yavuz (2004). The trial-and-error technique was adopted to further refine the modulus by matching the maximum model subsidence with the subsidence estimated from the Saxena (2003) subsidence model. The Poisson's ratio of the gob material was taken as 0.2. Table 2 presents the input parameters considered in the three gob models for the numerical simulation. was updated at a regular timestep interval using the algorithm developed above.

Fig. 4 shows the stress-strain characteristics of the numerical model and the three gob models. As can be seen, the model is able to capture the hardening characteristics of each of the gob models. Therefore, the developed algorithm can be used further with confidence for studying the performance evaluation of these gob models.

Table. 2: Input parameters of the gob models considered in the numerical modelling

	Remarks
Salamon (1990) model $\varepsilon_m = 0.091$ $E_{0,} = 11$ MPa	$\varepsilon_m = \frac{b-1}{b}$, b is the bulking factor (=1.1) Estimated by back-calculation
Terzaghi model (Pappas and Mark 1993) $a = 11$ $E_{0,} = 11$ MPa	Pappas and Mark (1993)
Strain-Hardening (Badr 2004) $\sigma_u = 1.35$ MPa $E_{0,} = 11$ MPa $E_F = 6.1$ GPa $n = 10$	Determined by using the concept of Composite elastic modulus (Harrison and Hudson 2000)

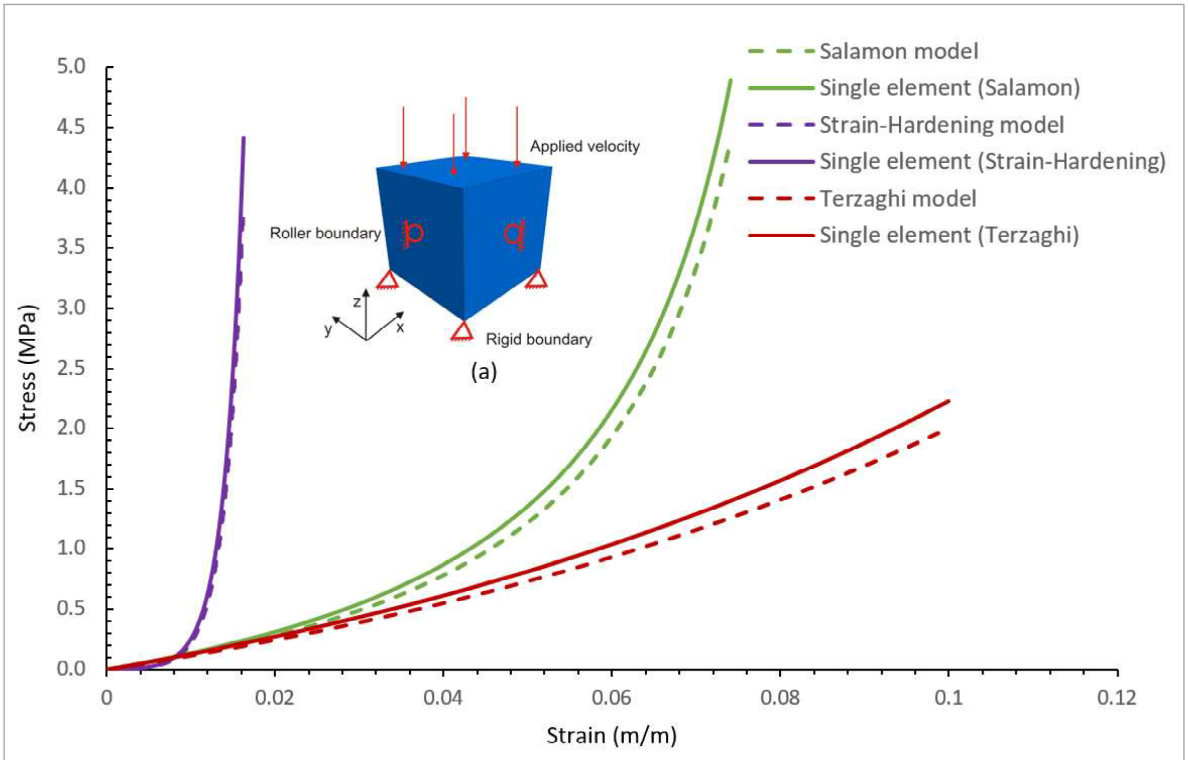

Fig. 4: Comparison of the stress-strain plot obtained from the numerical model and the three gob models.

A single element model was developed in FLAC3D to check the robustness of the developed algorithm. The size of the model is 1m×1m×1m, and the lateral and the bottom sides of the model roller and rigid constrained, respectively (Fig. 4). The boundary conditions are similar to that in the laboratory tests performed by Pappas and Mark (1993). A constant velocity of 1×10^{-6} m/timestep was applied at the top of the model to load the gob material. The elastic modulus of the material.

RESULT AND DISCUSSION

The initial tangent modulus of the gob material arrived from Yavuz (2004) is 109 MPa while their calibrated value is 11 MPa for the maximum subsidence of 1.71 m. Fig. 5 shows the profile of the surface subsidence obtained from the numerical model for the three gob models. As can be seen, the profiles are in line with the supercritical nature of the working. The Salamon and Terzaghi gob models yield the maximum subsidence of about 1.7 m which agrees well with the Saxena (2003) model. However, the Strain-Hardening model yields unrealistically high value (around 7.5m) of the maximum subsidence.

Fig. 6 shows the profile of the redistributed vertical stress due to the extraction of the panel. The stress in the gob increases non- linearly from zero at the gob edge and attains the cover pressure value at the distance of 0.38 times (27 m) the working depth. The gob stress distribution is in line with the supercritical nature of the working and is in good agreement with the theoretical considerations and thefindings reported by other researchers (cover pressure distance lies in the range of 0.2 to 0.6 H). The gob stress profile for the Salamon and the Terzaghi models are almost similar. The profile between the gob edge and the cover pressure distance of the Strain- Hardening model has less curvature than that of the other two models.

Nevertheless, the abutment stress distribution for all of the three models is almost the same. The peak side abutment stress is about 2.1 times the cover pressure, which is in line with the typically observed peak abutment stress in the Indian geo-mining conditions. The abutment stress follows an exponential decay lay. Wilson (1983) curve fitted to the abutment stress curves yields the abutment load of 17 MN/m.

The Load Transfer Distance (LTD) is 105m, which is much larger than the value estimated by Peng and Chiang (1984) model. Unlike Peng and Chiang (1984), Larson (2015) reported that the LTD is also the function of geological conditions of the strata along with the cover depth based on field observations and estimated LTD significantly greater than the value estimated by Peng and Chiang (1984). Given the presence of the massive sandstone formations in the roof of the working, the higher LTD is justified.

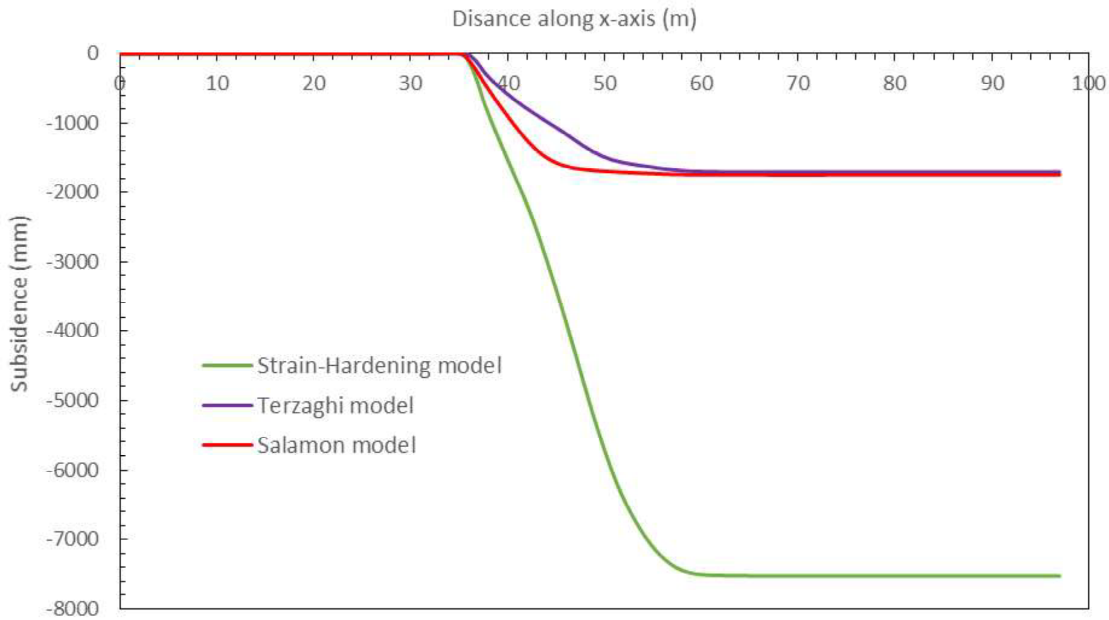

Fig. 5: Subsidence curves of the numerical model employing different gob models

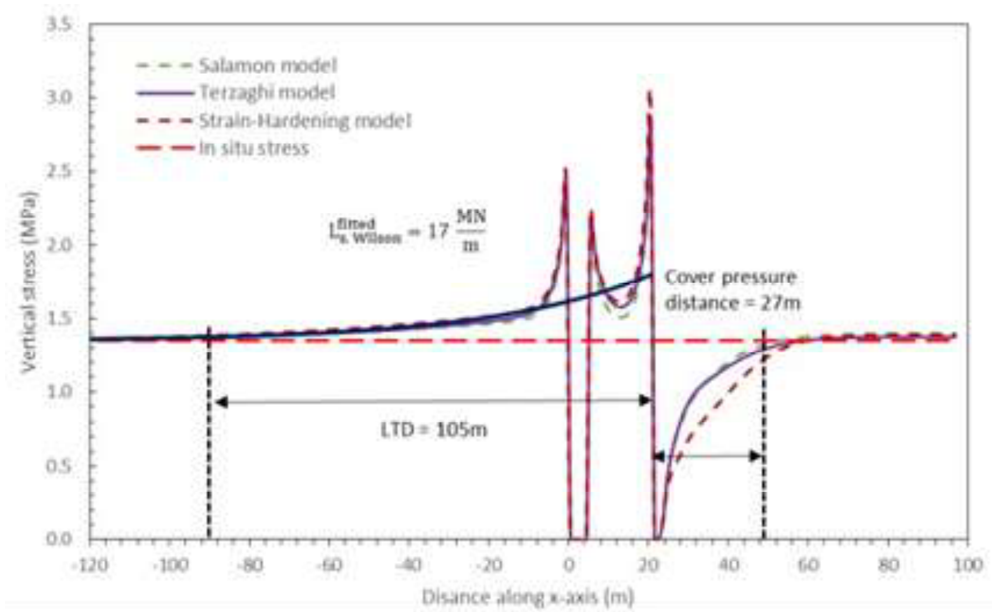

Fig. 6: Distribution of vertical stress at the seam level at the pre-mining stage (red dashed line), post-mining stage (green dashed, purple solid, and brown dashed lines), and Wilson's abutment stress decay curve fitted

CONCLUSION

This paper presents a comparative evaluation of the performance of the gob models using modulus updating technique. An algorithm was developed to implement the three most significant gob models. The algorithm considers the entire non-linear hardening curve to be comprised of numerous infinitesimal linear segments. Based on the current strain value in the numerical model, the corresponding linear segment is identified and its modulus is updated. The capability of the developed algorithm to model the strain-hardening characteristics of the gob material is demonstrated by calibrating the single-element model against the three gob models, which represent a varying range of gob mechanical behaviour. Then the modulus updating technique was implemented in the plane strain model developed in FLAC3D for the study of gob models. The initial modulus was determined by trial-and-error technique to match the surface subsidence in the model with the field subsidence of the panel.

The cover pressure distance in the model is about 0.38 times the cover depth for all the three gob models. The abutment stress follows the exponential decay law. These findings are in good agreement with the findings of previous researchers. The Load Transfer Distance (LTD) is significantly greater than that reported by Peng and Chiang (1984) but agrees well with the findings of Larson (2015). The findings of the paper suggest that the Salamon and Terzaghi models can be used for the simulation of the gob behaviour as they yield model behaviour in line with the theoretical considerations and findings of previous researchers. On the other hand, the Strain-Hardening model yields unrealistically high value of the surface subsidence. Nevertheless, the gob stress distribution for all the three models is almost similar. Although the Salamon and the Terzaghi models yield similar model behaviour, the response of the model could change for deep workings, where the gob material would be subjected to greater compaction to attain the cover pressure.

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The Indian Mining & Engineering Journal, Vol. 59, No.12, December 2020, pp.29-30
Printed in India, @ IME Publications, ISSN 0019-5944

Plasma Blasting Technique - Blasting Without Explosives

S P Singh*

ABSTRACT

This paper highlights the role of Plasma blasting Technique which includes low energy cost, high productivity, long equipment life and lower mining cost. This method is reliable and efficient and the simple operation this technology can be used in opencast for soft and hard rock blasting, blasting of coal, and secondary blasting for big boulders without generation of fly rocks. The method can be also used for blasting in hot strata where charging and blasting of explosive pose serious safety hazards.

Keywords— blasting, plasma, plasma blasting, blasting without explosives

INTRODUCTION

Throughout the history of mining and quarrying a great deal of effort has been put in to the search for greater productivity in rock excavation. Drilling and blasting method have been speeded up mostly by better drilling and blasting techniques but the process is still slowed down by time lost during drilling, blasting and for fume dispersal. The regulation and safety routines involved in handling transportation and use of explosive is a unproductive expenses. Explosive is a just like a black cobra as it has a chemical energy. There are so many ill effects of blasting like problem of noise, vibration fly rocks, dust and toxic fumes. After many years of research scientists at Noranda technology centre (Canadian Mining Company) by exploiting an Electrical technique called Plasma blasting technique have developed a practical and economically viable alternative to conventional blasting. Plasma blasting is a safe and environmentally friendly technology. In this technology there are no toxic fumes, dust and debris noise and vibrations. Plasma blasting get rid of the safety hazards that come with use of explosives.

This technology involved transformation of an electrolyte solution in a bore hole by electrical energy in to high pressure, high temperature plasma. The plasma produced by transferred energy expands faster than normal seismic wave propagation velocity and forms a shock wave which is in turn produces a stress field that shatters the rock without producing excessive dust and debris. This fast energy transfer into the confined space is a process quite similar to lightning strike on a tree or a rock, the electrical energy for the lightening is stored in a capacitor formed by the clouds and the earth and fast discharge of the energy sends a rush of electrons to the earth's surface. The fast moving electrons generate heated by colliding with the matter inside the confines of the tree or rock and because of heated substance can't expand initially because of its confinement, high pressure results which eventually fractures the tree or rock.

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SAFETY ASPECTS OF PLASMA BLASTING TECHNIQUE

- No Fly rock
- No Vibration
- No Noise
- No Dust and Debris
- No Toxic fumes
- No Chances for Pilferage
- No back break and Over break
- No needs of Magazine
- Eco friendly Technology
- No hindrance to nearby works / infrastructure.

All this advantages allow us to use the technology near the sensitive areas such as existing structures, plants, buildings, rail tracks, airstrip, dams, canals, pipelines etc. Direct cost of the technology usage increases the overall cost of the project but when the benefits & commercial advantages are considered due to early completion of the rock excavation with total Safe operation system, the project owners can visualize their faster & better returns on his investment.

TECHNICAL PARAMETERS

- Typical rate of energy delivery – 200 megawatts/micro second
- Power – 3.5 gigawatts.
- Pressure – 2 gigapascals enough to fracture the rock.
- Electrolyte – 5% Solution $CUSO_4$ + Slight Bentonite
- Capacitor – Charge through a Constant Current Power Supply
- Co-axial Power cable, Co-axial Blasting Electrode

The electrical energy required for the blast is conveniently stored in a capacitor bank which is electrically charged by a suitable D.C. power supply. A high current switch is used to direct typically 500 kiloamperes to the blasting electrode at the time of blast. A triggering device triggers the switch which is initiated by a remote trigger through a fibre optic cable or a pneumatic tube to provide perfect electrical isolation for the operator. The capacitor bank is connected to the blasting electrode through an electrical circuit including a coaxial power cable which is designed for minimum inductance and resistance to reduce power losses and ensure rapid discharge of energy into the rock for the development of an intense shockwave.

Prior to the blast, the electrode is maintained at ground potential but when the switch is triggered the centre lead of the coaxial electrode is raised to the high voltage of the capacitor bank. The electrolyte in the hole then suffers a dielectric breakdown producing a plasma at extremely high temperature and pressure. In this manner, a great amount of energy is transferred within a very short time from the capacitor bank into the small amount of electrolyte in the confined area around the electrode thereby instantaneously transforming this entire finite amount of electrolyte into plasma which must then release this energy by way of a pressure wave, thus resulting in a blast similar to that made by dynamite or other chemical explosives. The plasma electrode may be equipped with a recoil mechanism to damp out the destructive effect of the blast on the electrode.

APPLICATION OF BLASTING PLASTING TECHNIQUE

A. Application of PBT in O/C

For OB Blasting

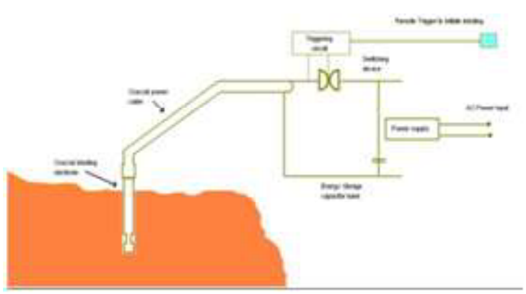

Fig. 1: Schematic Drawing of Plasma Blasting Equipment

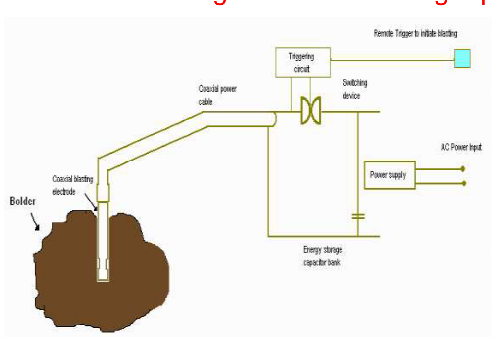

Fig. 2: Schematic Drawing of Plasma Blasting Equipment

For Coal Face Blasting

For Secondary Blasting

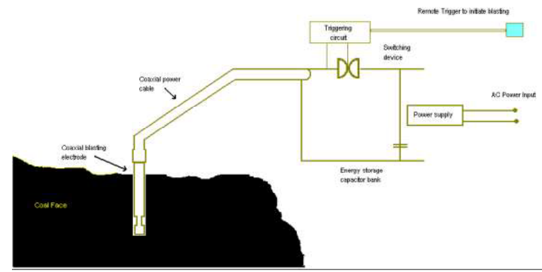

Fig. 3: Schematic Drawing of Plasma Blasting Equipment

USEFULNESS

- Low energy cost
- High Productivity
- Long equipment life due to less marching and shifting of machine.
- Low maintenance cost
- Low mining cost
- Reliable and Efficient

INTERPRETATION

The Traditional method of blasting is a batch process with the following sequence; The holes are drilled in the rock chemical explosives are placed in the holes again after stemming the mine personnel are evacuated then the explosives are detonated causing quantity of rock to be separated from the solid rock mass. Entire process is time consuming and less explosive energy is utilised and more energy is wasted in forms of vibration, noise etc. Plasma Blasting is very fast process and environment friendly. In it utilisation of explosive is proper.

CONCLUSIONS

In Nut shell to make entire blasting operation safer, easier and environment friendly, PBT is real tool which minimize all ill effects of conventional blasting like noise, vibration, dust, air blast etc. Hence it is felt that plasma blasting will better serve the needs of the mining and other industry, which is need of the day.

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The Indian Mining & Engineering Journal, Vol. 59, No.12, December 2020, pp.31-34
Printed in India, @ IME Publications, ISSN 0019-5944

Energy Conservation by Reuse of Recycled and Manufactured Aggregates

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ABSTRACT

Aggregates constitute a major resource to build and maintain the infrastructure of a country. However the environmental impacts associated with mining of aggregates are benign. Acid mine drainage, loss of habitat, noise and dust produced due to blasting effects, sedimentation are some of the negative impacts associated with it. However quarrying cannot be avoided since mining is the backbone to drive the progress of nation. The use of recycled aggregates can prove to be an effective solution to minimize the burden. The recycling of aggregates is an impetus not only to reduce the overexploitation of quarries but also to reduce the consequent energy consumption and Greenhouse gas (GHG) emissions, especially CO2 in the associated industrial applications. The paper highlights the advantages of energy conservation and environmental conservation by the use of recycled aggregates and their subsequent applications.

Keywords— aggregates, mining, quarrying, recycling, energy conservation

INTRODUCTION

The quarrying of aggregates provides an economic base to improve the quality of human life. Concrete, as the most widely used construction material worldwide, its production and consumption has raised environmental concerns (Benhelal et al., 2013;Henry and Kato, 2014;Yang et al., 2015). Concrete materials, including Portland Cement and natural aggregate, their manufacturing or processing process are either being energy- intensive, emitting greenhouse gas, or causing depletion of natural resources (Langer and Arbogast, 2002;Bentz, 2010;Bondar et al., 2011;Tapali et al., 2013;Shafigh et al., 2016). In industrialized countries, inert materials represent 10% of the gross national product (prodotto interno lordo [PIL]). The sustainable cycle of development represents an important part of green building materials, in fact establishes a beneficial reutilization of waste resources. Some actions can be taken up to reduce the quarrying activities. A maximum threshold of demand must be defined. The transfer of inert materials should be legalized. The recycling process of aggregates should follow a systematic planned approach. The regional quarrying data for each mine needs to be collected and stipulated. A regional waste plan also needs to be produced for eeach mine.

Installation of inert material treatment facility should be done wherever possible. The physical and chemical analysis of the waste generated must be carried out and proper application based analysis needs to be carried out. In order to meet the demand for aggregates in a local region, a crucial step is to know the amount of material consumed in the region of interest during a specified period. Mining plans use this information to estimate the demand for aggregates of a region. Despite of recycling of Construction & demolition waste, aggregates can also be manufactured using iron slag, steel slag, copper slag and bottom ash from thermal power plants. IS 383: 2016 has defined limits for the extent of utilization of these recycled and manufactured aggregates for partial substitution in plain cement concrete, reinforced cement concrete and lean concrete. These aggregates must be analysed for the deleterious substances like coal, lignite, clay lumps, mica, shale and soft fragments. The limits of deleterious substances have been defined as per Clause 5.2.1 (Table 2: Limits of deleterious materials) by IS 383:2016. Alkali content, acid soluble chloride content, sulphate content, water absorption and specific gravity of fine aggregates. Though poor quality of recycling process, is likely to affect the quality of concrete, the concrete to be made with recycled or manufactured aggregates can be strengthened by proper adjustment of mix design and production process. Little attention has been paid to the use of manufactured and recycled aggregates. Investigating the environmental potential of the combination of natural and recycled aggregates, this study could act as a minimum effort to encourage the standards' officials to pay attention to the combination of Natural and recycled aggregates. The world's use of aggregates for concrete can be estimated at 25.9 billion to 29.6 billion tonnes a year for 2012 alone. This production represents enough concrete to build a wall 27 metres high by 27 metres wide around the equator. Aggregates also contribute to 90% of asphalt pavements

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and 80% of concrete roads and the demand for aggregates stems from a wide range of other sectors, including production of glass, electronics and aeronautics.

LIFE CYCLE ASSESSMENT & INVENTORY MODELING

Life-cycle assessment (LCA) is an efficient method for evaluating the performance of a product during its lifetime. Research has shown that this approach can be easily adopted for materials such as concrete. In the inventory of LCA model of this study, the inputs include the aggregate production and recycling processes, the number, type and specifications of machinery, and the cost, energy consumption, and CO2 emission of each piece of equipment, and the outputs are the total amounts of CO2 emission, energy consumption, and cost.

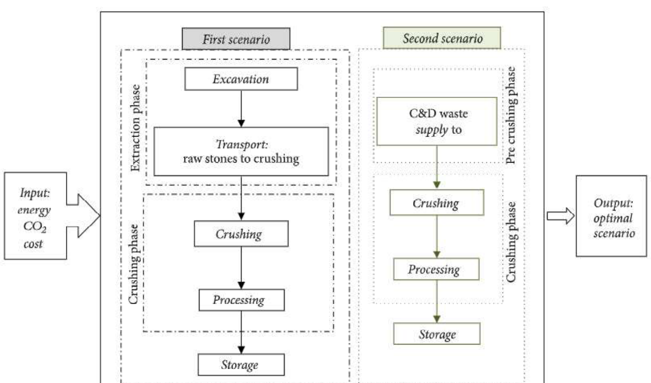

Fig. 1: Life cycle sketch of aggregate production

Cradle-to-grave life-cycle of aggregates is illustrated in Figure 2. Cradle-to-gate is the whole phases of Figure 2 except concrete/asphalt plant and construction site/road. As other phases are similar and same for the natural and recycled aggregate, they

have not been evaluated. On the other hand, cradle-to-gate assessments are sometimes the basis for environmental product declarations (EPD) termed business-to-business EDPs. The development of mining provides an economic base and use of a natural resource to improve the quality of human life. Wisely restoring our environment requires a design plan and product that responds to a site's physiography, ecology, function, artistic form, and public perception. Forward-looking mining operators who employ modern technology and work within the natural restrictions can create a second use of mined-out aggregate operations that often equals or exceeds the pre-mined land use.

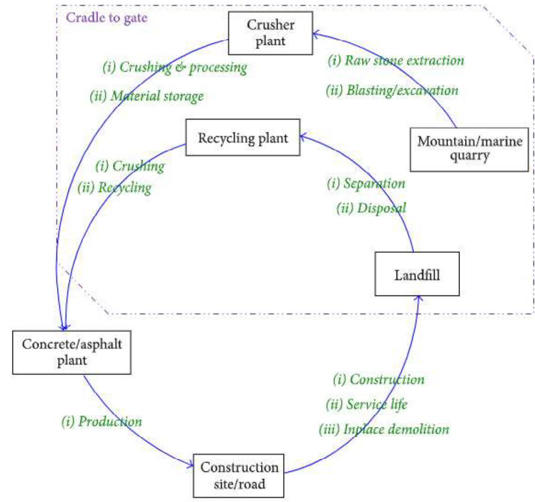

Fig. 2: Cradle-to-grave and cradle-to-gate life-cycle assessment for aggregate.

GREEN HOUSE GAS MITIGATION POTENTIAL

Apart from resource conservation, use of C&D waste will also help mitigate CO2 emissions from processing of natural stones into aggregates. Aggregate production from natural stones such as granite and basalt has significant environmental impact, not least in terms of CO2 emissions from the use of fossil fuels and electricity. It is estimated that about 20 kg of CO2 is emitted from processing 1,000 kg of natural aggregate. Processing includes quarrying, crushing and transport of aggregates. In contrast, processing 1,000 kg of recycled aggregate (C&D waste) emits about 12 kg of CO2 (a 40% reduction). Thus, use of 1,000 kg of recycled aggregates translates to CO2 savings of about 8 kg. Aggregate demand in concrete and road laying in India is estimated to be about 1.1 billion tonnes per annum. If all of the aggregate is replaced by C&D waste there is a potential to save about 8 million tonnes of CO2 per annum. Along with growth of mankind, the mining industry has also grown in parallel to supply the raw material for various purposes along with infrastructure development. The main condition of mine waste utilization is that the materials should satisfy all the geotechnical criteria and is environmental friendly. A thorough characterization of mine waste is essential as it must not be a source of contamination. The value of utilization of mine waste can be enhanced on the basis of geotechnical properties and environmental constraints.

REPLACEMENT FOR FINE AGGREGATES

Iron ore tailings (IOT) comprise fine materials, mainly containing silica, together with iron oxides, alumina and other minor minerals. This constitution indicates their potential as construction material, such as aggregate for mortar and concrete (Yellishetty et al. 2008, Huang, et al. 2013, da Silva et al. 2014). The comprehensive utilization of iron ore tailings (IOT) has received increasing attention all over the world. The major utilization of IOTs includes land reclamation (Maiti et al. 2005), reextraction of iron or other metals using advanced technology (Li et al. 2010, Sirkeci et al. 2006), and as raw ingredients in producing infrastructure materials, backfilling materials and fertilizers (Zhang et al. 2006, Zhu et al. 2011).

Wang and Wu (2000), Zheng et al. (2010) reported utilization of tailings in clinker and concrete respectively. Iron ore tailings used as replacement of sand in concrete (Cai et al. 2009), as siliceous materials in ceramics (Liu et al. 2009, Das et al. 2000) and autoclaved aerated concrete (Li et al. 2011). The use of IOTs in the production of infrastructure materials promotes the sustainability of the mining industry and simultaneously enhances the greenness of the construction industry by reducing the demand for raw materials like river sand. Ravi Kumar et al. (2012) investigated the properties of Interlocking Concrete Block Paver (ICBP) mixed with Iron Ore Tailings (IOT) as partial replacement of cement. For M25 grade of concrete, by varying the percentage of iron ore tailings, it resulted in an increase in compressive strength with IOT 5% to 15% and decrease in compression strength for IOT 15% to 25%. Sun et al. (2011) investigated the properties of cement stabilized iron ore tailing gravel as a highway construction material by performing various experiments and resulted in higher strength, rigidity, good water stability and frost resistance. When the cement content was more than 5.5%, 7 days-age compressive strength of cement stabilized iron ore tailing gravel is more than 2.5 MPa. So, it can be used as sub-base course material for heavy duty traffic asphalt pavement and base course material of low duty traffic asphalt pavement.

REPLACEMENT FOR COARSE AGGREGATES

Yellishetty (2008) used iron ore waste from Goa and conducted an experimental study. In the concrete mix, 40% of coarse aggregates were replaced with iron ore tailings and concrete blocks were made for 28 days curing. It resulted in the compressive strength of 21.93MPa to that of granite aggregate of 19.91 MPa. Hence, the increase in the compressive strength was noticed with iron ore tailings with respect to the conventional coarse aggregate. Park (2003) considered three different aggregates, those are, recycled concrete aggregate (RCA), crushed stone aggregate (CSA) and gravel (GRA) and conducted laboratory study with Gyratory Testing Machine and field study with the falling weight deflectometer to investigate the characteristics and performance of dry and wet recycled concrete aggregates (RCA) as a base and sub base materials for concrete pavements. The physical properties of the RCA were investigated in terms of moisture-density relationship, particle index and fine aggregate angularity. Performance concerns have focused on compactibility, stability, shear resistance and particle breakage of the RCA. It resulted in the compactibility of RCA same as that of CSA and GRA. Breakage of aggregate particles increased in severity from GRA to RCA. The stability and the shear resistance of the RCA in wet conditions are lower than dry conditions however, the reduction rate is comparable with observed values in CSA and GRA. The deflection of the RCA section using the FWD in the field was similar to that of CSA section.

CASE STUDY

In this case study, iron slag is used as partial replacement of sand to concrete. As slag is a industrial by- product, its productive use grant an chance to relocate the utilize of limited natural resources on a large scale. Iron slag is a by product obtained in the manufacture of pig iron in the blast furnace and is produced by the blend of down-to-earth constituents of iron ore with limestone flux. Iron and steel slags can be differentiating by the cooling processing when removed from the furnace in the industry. Mostly, the slag consists of, magnesium, aluminium silicates calcium and manganese in various arrangements. Even though the chemical composition of slag same but the physical properties of the slag vary with the varying method of cooling. The slags can be used as cement major constituents as they have greater pozzolanic properties.

The materials used for this case study were Ordinary Portaland Cement (OPC) of 43 Grade (JK cement) was used in this investigation. The cement was free from lumps. The physical properties of the cement as determined from various tests conforming to Indian Standard IS: 8112:1989 were listed in Table I. The aggregates having maximum size of 20 mm was used this study and were tested as per IS: 383-1970. The specific gravity of coarse aggregate was 2.69 and fineness modulus of coarse aggregates was 6.95. The fine aggregate was natural sand of maximum size of 4.75mm. The specific gravity of fine aggregate was 2.54 and fineness modulus of fine aggregates was 2.62. Its grading confirmed to zone II. The Iron Slag was obtained from the Dhiman Iron and Steel industry located at Mandi Gobindgarh, Punjab. The Fineness Modulus of iron slag was 2.10 and was in black grey colour.

Mixture Proportioning: The two types of mixture were prepared in this investigation. The reference concrete mixture composed of cement (360 kg/m3), fine aggregate (573.86 kg/m3), coarse aggregates (1233.54 kg/m3) and water to cement ratio is 0.5. The other concrete mixtures were prepared with the iron slag replacing 10 %, 20 % and 30 % of fine aggregates with the same amount of cement, coarse aggregates and same water cement ratio. The curing period of all the concrete mixes was 7, 28 and 56 days.

Test Procedure and Results Test specimens of size 150 × 150 × 150 mm were prepared for testing the compressive strength concrete. The concrete mixes with varying percentages (0%, 10%, 20% and 30%) of iron slag as partial replacement of fine aggregate (sand) were cast into cubes for testing. In this study, to make concrete, cement and fine aggregate were first mixed dry to uniform colour and then coarse aggregate was added and mixed with the mixture of cement and fine aggregates. Water was then added and the whole mass mixed. The interior surface of the moulds and the base plate were oiled before concrete was placed. After 24 hours the specimens were removed from the moulds and placed in clean fresh water at a temperature of 270 ± 2 0C. The specimens so cast were tested after 7, 28 and 56 days of curing measured from the time water is added to the dry mix. For testing in compression, no cushioning material was placed between the specimen and the plates of the machine. The load was applied axially without shock till the specimen was crushed. Results of the compressive strength test on concrete with varying proportions of iron slag replacement at the age of 7, 28 and 56 days are given in the Table II. The cube strength results of concrete mix are also shown graphically in Figure 3.2. The compressive strength increases as compared to control mix as the percentage of iron slag was increased. After adding 10% iron slag in the mix, there was an increase of 26% after 7 days, 50% increase after 28 days and 43% increase after 56 days as compared to the control mix. By adding 20% and 30% iron slag , there was large amount of increase in percentage i.e. 68%, 91%, 78% and 125%, 113% , 87% after 7, 28 and 56 days respectively.

Table. 1: Average compressive strength oif control mix (CM) versus replacement ratios

Mix	Average Compressive Strength (N/mm2)		
	7 day	28 days	56 days
CM	19.75	26.09	32.05
10%	25.02	39.33	46.06
20%	33.52	49.90	57.07
30%	44.44	55.68	60.21

CONCLUSIONS

1. After adding 10% iron slag in the mix, there was an increase of 26% after 7 days, 50% increase after 28 days and 43% increase after 56 days as compared to the control mix. By adding 20% and 30% iron slag , there was large amount of increase in percentage i.e. 68%, 91%, 78% and 125%, 113% , 87% after 7, 28 and 56 days respectively.
2. The studies on utilization of mine waste in concrete, combination of the iron ore mine waste and tailings has not been completely explored as aggregates in concrete pavements. Hence, the utilization of these waste materials in concrete as partial replacement of fine and coarse aggregates in concrete can be done and its durability and mechanical properties can be determined in the application of concrete pavements by laboratory experimental investigations viz., compression, flexural and fatigue testing.

ACKNOWLEDGEMENT

The authors are thankful to the Department of mining engineering as well as Prof. Dr. Ritesh Lokhande for his timely help and valuable contribution.

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The Indian Mining & Engineering Journal, Vol. 59, No.12, December 2020, pp.35-40
Printed in India, @ IME Publications, ISSN 0019-5944

Mineralogical Characterization of MIOM Deposits with effects on Beneficiation

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ABSTRACT

With growing population and increasing demand of iron ore in steel industry and depleting higher grades of iron ore resources, there will be tremendous pressure on nations to exploit & promote the mineral beneficiation technology to upgrade the Iron ore. Iron is the second most abundant metallic element in the Earth's crust and by mass the most common element on Earth. Indian iron ores are generally quite soft and friable in nature and generate significant amount of fines while mining, processing and handling. Also on crushing and sizing of ores, the high alumina bearing laterite and friable ores have greater propensity to break down into fine sizes as compared to hard ores. However, Iron ores from different sources have their own peculiar mineralogical characteristics and require the specific beneficiation and metallurgical treatment to get the best product out of it. An intimate knowledge of the mineralogical characteristics of the ore is essential before efficient processing is to be carried out. Low grade iron ores cannot be used as such for the production of iron and steel and need to be upgraded to reduce its gangue content and increase its Fe content. The Beneficiation process is adopted to upgrade the Fe content of iron ore. Mineral processing technology is developed to separate and recover ore minerals from gangue in a commercially viable method and is mainly based upon the process of mineral liberation and the process of mineral separation. In this study, low grade iron ore sample was collected from Meghahatuburu iron ore Mines. The assaying values are Fe-37.32%, SiO2-10.64%, Al2O3-20.31 and LOI- 15.43. During the Physical Characteristic study of the sampling area, the huge quantity of partially weathered goethite ore, interlocked with hematite and presence of gangue minerals like kaolinite, gibbsite at different proportion are seen by physical appearance in Meghahatuburu iron Ore Mines.

Keywords— mineralogical study, beneficiation, low grade: goethite

INTRODUCTION

The reserve of iron ore in India is around 13 billion tons, in which around 10 billion tons of hematite ores and around three billion tons of magnetite ores (Indian mineral year book, 2006) [Chakraborty et al, 1986]. Fifty eight percent of these reserves are confined to the eastern part of India, mainly in the states of Orissa and Jharkhand. The remaining ores are distributed in the states of Chhattisgarh and Madhya Pradesh (20%), Karnataka (11%) and Goa (10%). Jamda-Koira valley in the Singhbhum Orissa Iron Ore Craton (SOIOC) hosts major hematite iron ore deposits in eastern India. Noamundi, Joda, Khondbond, Bolani, Barsua, Gua, Kiriburu and Meghataburu are the major deposits in this region.

Due to increasing demand of steel in domestic market and depletion of high- grade iron ores day by day, Mineralogical study of ore is play very vital role and basic aspect before attempt for its processing. Mineral processing technology is evolved to separate and recover ore minerals from gangue in a commercially viable method and is mainly based on the process of mineral liberation and the process of mineral separation [Wills et al]. The Iron ore is mined with the highest efficiency of the technology, the excavated ore gets partly contaminated by the surrounding host rock (overburden) and the geological material closely associated with the ore during mining [Mishra et al, 2007]. So from mineral processing point of view, it is important to identify the desired (ore) and undesired (gangue) and their textural relationship [Upadhyay et al, 2006].

The Performance of steel plant in respect of productivity of blast furnace and subsequent reduction in coke consumption, some of the issues relating to Iron ores are identified like chemical composition of Iron ore with low Fe content and high Al: Si ratio, low temperature softening and melting behaviour of Iron ores, etc (Nayak, N. P, 2013 & Kumar et al, 2005). These characteristics of iron ore such compositional characteristics, soft nature of some of the ores and high alumina as well as high silica content are main factors which may addressed as difficulties for processing and utilization of lean grade iron ores. In other hand, none of the Indian iron ore deposits can produce iron ores having alumina below 2% preferred by blast

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furnaces [Nayak, N. P, 2013 & Saha et al, 1994]. Above or about 65% Fe content in iron ores are enviable to accomplish better productivity either in blast furnace or direct reduction[Saha et al, 1994]. Due to iron ore deposit is heterogeneous in nature, the composition of the Indian iron ores is typified by high iron content with relatively higher amount of alumina (as high as 10% to 15%). To overcome this disadvantage of Indian iron ores, efforts have been directed to reduce alumina in iron ore lumps as well as fines so as to bring down the levels of alumina in sinter to at least around 2.5% which is still higher than the International standards of less than 2% alumina. Another problem is the utilization of huge amounts of iron ore fines and slimes which are not only a loss of the very important iron ore resource, but also pose severe long term environmental problems (Nayak, N. P, 2013).

After mineralogical studies, occurrences of certain undesirable minerals and deleterious would expose such as Al, Si, P, S and alkalis. When these elements are present in the minerals, lead to deleterious effects in the subsequent metallurgical operations. It has also been established that the adverse effects of high alumina to silica ratio (ideally it should be < 1) is detrimental to blast furnace as well as sinter plant productivity.

This paper presents mineralogical studies of low grade iron ore and their implication in beneficiation process at Meghahatuburu Iron ore Mines in eastern India with a view to understanding their amenability to beneficiation (Fig. 1B).

GEOLOGICAL OVERVIEW

According to Jones (1934), the iron ores of eastern India are part of the Iron Ore Group (IOG) that occurs within the Archean Singhbhum-North Orissa Craton [4]. The Banded Iron Formation (BIF) is an important volcano-sedimentary rock formation of the Iron Ore Group (IOG) of Singhbhum and Orissa[2,3]. The geological age of Precambrian Iron Ore Group is ~3.1–3.3 Ga which contains meta-volcanic and meta-sedimentary rocks, shales and tuffs. These rocks are underlain or inter layered with the Banded Iron Formation, which consists of the units of Banded Hematite Jasper (BHJ) and Banded Hematite Quartzite (BHQ) [Upadhyay et al, 2006].

The Banded Iron Formation (BIF) is one of the most distinctive types of rock that is widespread in space and time in the early Precambrian in all the shield areas of the world. The well-known iron ore deposits of North Odisha Iron Ore Craton (NOIOC), Eastern India are part of the volcano- sedimentary basins containing iron and manganese deposits belonging to the Iron Ore Group of Archean age[(Chakraborty,1986), (Sci., 116, 245–259), (Jones et al, 1934) & (Upadhyay et al, 2006)] (Fig. 1A). The Jamda-Koira valley is a northerly plunging broad synclinorium, of which the western limb is overturned [(Sci., 116, 245– 259), (Majumder et al, 2005), & (Mining Plan of SAIL, 2015)] and hosts the major iron ore deposits (Fig. 1).

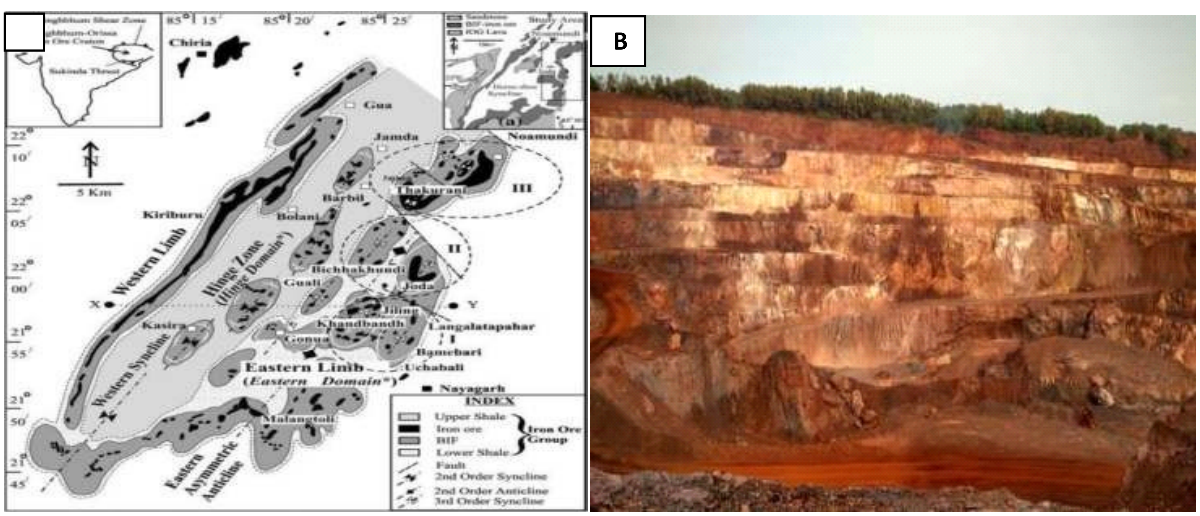

Fig. 1: A. Location of Meghahatuburu Iron Ore Mines. B. View of Existing Pit of Meghahatuburu Iron Ore Mines along with Low grade Iron ore.

Table 1: Mineral composition of different iron ores and Banded Hematite Jasper (Modified by R.K. Upadhyay et.al. 2010)

Ore Type	Ore Minerals	Gangue Minerals
Hard or Hard Massive ore	Hematite replaced by Goethite. Traces of Martite and Magnetite	Quartz, Jasper and Minor clay minerals
Flaky ore or Flaky friable ore	Hematite and Mertite	Lateritic clay minerals in trace amount
Blue dust or Powdery ore	Hematite with traces of Goethite	Quartz
Laterite or Lateritic ore, Goethitic ore and Shaly Powdery Ores	Goethite, Limonite and Hematite	Quartz, clay minerals, gibbsite and chert
Banded Hematite Jasper (BHJ)	Hematite and Martite	Quartz, Chert and Jasper

These deposits occur as large stratified formations which generally strike in a NNE- SSW direction and dip 30°–40° towards either east or west. The Precambrian iron ore of Singhbhum-North Orissa region of eastern India occurs as part of the horseshoe-shaped broad synclinorium known as the Iron Ore Group (IOG) of rocks, which hosts the most important iron ore deposits in India.

ORE TYPES

Iron ore textures are complex due to deformation, alteration and supergene processes.

Micro structural and textural features observed include micro folds, breccia, microfaults and microbands (Upadhyay et al, 2006 & Roy et al, 2007). The iron ores were classified into hard massive, flaky-friable, blue dust and lateritic ores (Table 1).

The hard massive ores are looks like grey in colour and lumpy in nature and are partly laminated.

Bulk density of these ores varies between 2.1 and 2.9 and the specific gravity ranges from 3.4 to 4.7.

Lateritised hard ores are also found along with this ore type. Chemical analysis of different size fractions of hard massive ores indicates that there is a gradual decrease in iron content and increase in alumina content from coarser to finer size fractions.

During processing, they are resistant to the crushing, resulting in generation of coarser fractions.

The sized ore or lumps, having size from 10 to 40 mm, are generally rich in iron, low in alumina and used in the blast furnaces as calibrated sized ore feed.

SAMPLE AND MATERIAL

In this study, a very low grade iron ore sample collected from Meghahatuburu Iron ore Mines (MIOM) of Eastern India. The sample contains Fe-37.32%, SiO2- 10.64%, Al2O3- 20.31 and LOI- 15.43. The Physical appearances of Goethite- Lateritic ore is dull earthy in colour with limonitic red, yellow and dull white patches (Fig. 1B). However, in fresh surface, it appears darker. The generally such minerals like goethite, hematite, kaolinite, gibbsite and quartz are occurrences in. Micro platy hematite, goethite with clay patches are common features in this type of ore. Goethite which is common in lateritic profile/ surfaces of iron ore deposits is abundant in all the samples.

This study is emphasized to understand and characterize the low grade iron ore such Goethite-Lateritic ore to ascertain the feasibility of their beneficiation for value addition. The ore samples were cut into small sizes by diamond saw and then with low speed saw. For microscopic study, polishing was done by the conventional polishing technique. In the present work, the mineralogy, texture, micro-structure, grain size distribution patterns in respect to various ore types were attempted to know the nature, distribution and textural patterns of silicates and other types of gangue minerals vis-à-vis different rock and ore types.

MINERALOGICAL STUDIES

A. Lateritic Ore

The lateritic ore is dominantly constituted of goethite (Fig. 3A). Clay bearing laterites have a high percentage of kaolinite and gibbsite, which are intimately intergrown with limonite. Presence of these particles, though smaller in quantity, lowers the quality of the ores by their higher alumina and phosphorus contents. The finer fractions, particularly 0.15– 1.0 mm size fractions of lateritic ores contain a very high proportion of goethite (63–75%) and limonitic clay. Micron-scale replacement of hematite grains by goethite is observed in lateritised massive ores. The nature and composition of the lateritised ores depend on the original ore types from which these have been derived [Majumder et al,1982]. Generally appreciable amounts of goethite along with hematite are observed in the lateritic ores, however, in -150 micron size fractions, other.

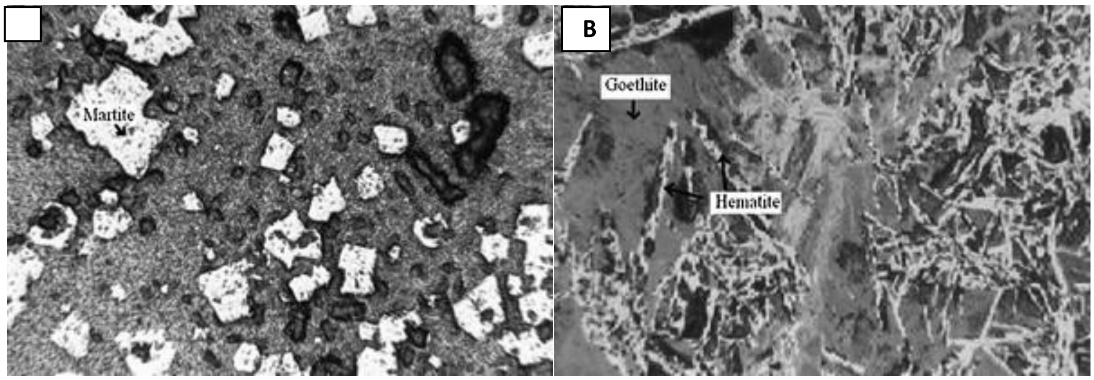

Fig. 2: A) Martite grains in massive ore. B) Goethite with altered and dissected hematite. (Modified by Upadhyay et. al., 2010)

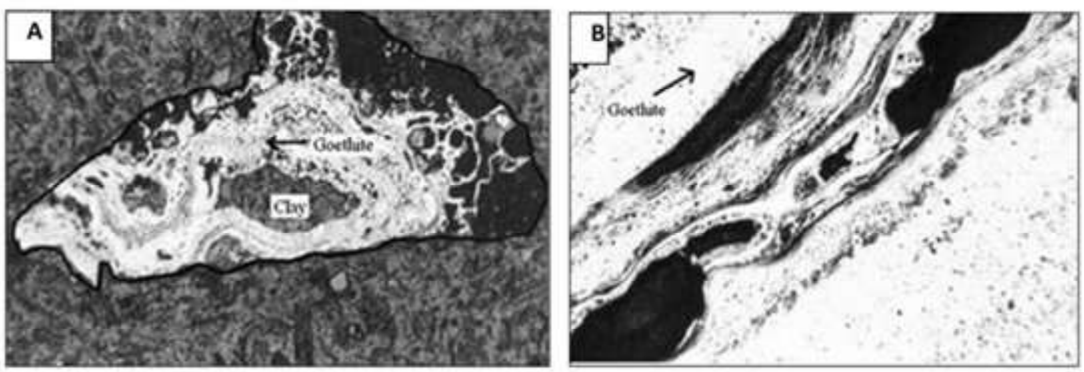

Fig. 3: A) Goethite in Lateritic Ore. B) Goethite in Goethitic Ore. (Modified by Upadhyay et. al. 2010)

Table 2: Granulometry & their chemical analysis

S.No	Particle Size (μm)	Weight (%)	Assay Value (Fe %)
1	2000	39.2	39.45
2	1000	9.8	37.23
3	853	6.36	38.56
4	600	7.66	38.23
5	500	5.89	37.25
6	300	4.78	36.54
7	200	4.29	36.77
8	150	3.23	36.23
9	100	2.23	37.21
10	75	3.76	36.84
11	66	0.82	36.64
12	<66	11.9	33.62

B. Goethitic ores

Goethite is present as a major mineral (Fig. 3B) while hematite is found in traces along with all other minerals found in lateritic ores of the goethitic and limonitic variety (Majumder et al,1982 & Majumder et al,2005). In clay bearing laterites, appreciable amounts of kaolinite along with gibbsite, goethite and hematite are identified. Relatively larger grains of gibbsite enclosed within goethite grains are noted along with minor occurrence of phosphorous in iron phase.

ELECTRONIC MICROSCOPIC STUDY (EMS)

It is observed through EMS that the most of the lateritic samples show high degree of porosity. These pores are the most encouraging for clay deposition. This clay deposition is mainly responsible for the high alumina content which is difficult for use in iron making without scrupulous beneficiation.

In Fig 2A, it is observed that the gibbsite and kaolinite are also partly filled into these cavities. In the Figure 2B, Spongy hematite and martite partly or wholly transformed to goethite and later concreted by goethite precipitation along the wall of the tubular pores (Mishra et al,2007 & Nayak et al,2013).

This ore also exhibits multiple joint and fracture surfaces along which the clay and goethite precipitation takes place. Lateritic iron ores result from weathering. The clay bearing laterite contains clusters of gibbsite grains in the voids and fine kaolinite needles in the nodules (Majumder et al, 2005). Goethite replaces hematite indifferent degrees (Fig.3 A). Colloform texture of weathered goethite is observed in Fig 3B. Kaolinite being the main gangue occurs intimately with goethite but free quartz grains are very rarely observed. Majority of the kaolinite minerals are embedded with iron oxide/ hydroxide minerals. Goethite changes to limonitic clay due to dissolution and re-precipitation. Goethite occurs as massive mass occasionally with secondary hematite (Fig 3B).

LIBERATION STUDIES

The Liberation studies of as received goethite lateritic ore sample, was carried out by weight sieving techniques to know the distribution of Fe% in respect of various size fractions is shown in Table-2 [Nayak et al,2013, Nayak N. P,2013 & Upadhyay et al, 2006]. The different size fractions thus obtained were subjected to chemical analysis to ascertain the different quantitative elemental composition of the sample. The complete chemical analysis of the goethite lateritic ore sample was carried out by wet chemical analysis. With the help of size measurement it is evident that the ore is coarse grained in nature. At the same time, the finer fraction (<150) accounts for 20% indicating significant amount of slime generation during washing. The coarser fraction requires suitable grinding for proper liberation. The Fe assay is almost uniform across the entire size range.

In Liberation analysis, coarser fractions percentage of interlocking is very high which decreases with decreasing particle size. Low free hematite content and higher gangue contents indicate very low grade of this type of iron ore. Complex interlocking nature of the particles can be achieved below 150m size in liberation. Due to the complexity of interlocking, it is very difficult to achieving high purity concentrate in beneficiation of this ore. To attain superior liberation, Proper comminution is required to break the interlocking in this case.

BENEFICIATION STUDIES

In order to understand the beneficiation process of Meghahatuburu Iron Ore Mines, screen plant is delineated. Three screening lines with a capacity of 600 tph each are established in screen plant. During wet screening, two lines need to be operated at a time for processing the required tonnage[Mining Plan of SAIL]. The third line is kept on standby for maintenance. When dry screening is resorted to all the three lines are required to be operated to process the required tonnage. Each screen has double deck (12-15 mm and 10 mm) (Fig.4). The oversized products from the top and the bottom decks of the screens constitute the lump ore which is conveyed to the stockpile by a lump ore conveyor of 600mm width.

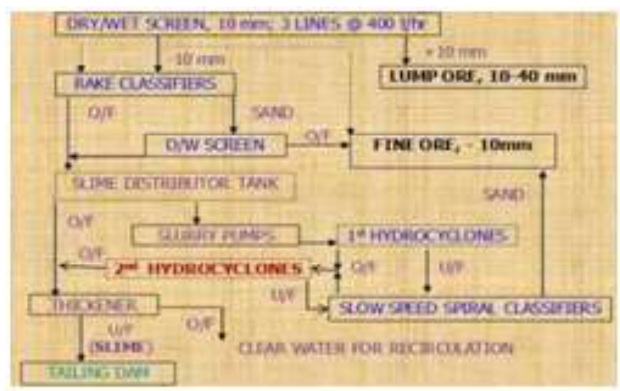

Fig. 4: Flow Diagram of Beneficiation Process at Meghahatuburu Iron Ore Mines

The screen under sized (-10mm fines) product is carried into the classifier by the addition of water on the screen. By controlling the feed rate of solids and water, the classifiers are operated under optimum conditions in such a way that the overflow from the classifiers contains only 25% solids for optimum size operations. The raked product from the classifier contains about 15-18% moisture and is fed on dewatering screen, fitted with wedge wire bar screen decks with 0.2m to 0.3 m opening. The oversized product of dewatering screen is conveyed through a short conveyor to the fine ore conveyor. During dry operations the undersized is collected by a 1000mm conveyor and discharged into another conveyor. The classifier overflow and dewatering screen water from all the three lines are carried through a common pipeline to one sump for pumping into the cyclones. All floor washings also join the common sump and distributor. This pulp is further diluted to the required pulp density by addition of water. There are three pairs of pump (3 nos. working and 3 nos. standby) to pulp this slurry into a battery of six hydro cyclones (4 in operations and 3 in standbys) for recovery of iron ore from the slurry. The cyclone underflow is fed to slow speed classifier and overflow slime is discharged to the tailing pond through the thickeners.

CONCLUSIONS

Mineralogical and geochemical characterization using SEM, were carried out on BIF and iron ores of the Meghahatuburu Iron Ore Mines in Singhbhum North- Orissa Craton of eastern India. Hard massive, flaky- friable, blue dust, lateritic and goethitic ores are the major iron ore types occur in the study area. Lateritic ores and goethitic ores are considered as low grade ores as they are poor in iron contents while richer in alumina and phosphorous. Loss on ignition in such ores is also more due to the presence of hydroxyl- bearing minerals [Roy et al, 2007 & Kumat et al, 2005].

The feasibility of beneficiation of goethite- lateritic ore is explained in the present study. Based on the mineralogical study, it reveals that the iron occurs mainly in hydroxy form as goethite interlocked with kaolinite and gibbsite and through Microscopic studies; it revealed the iron bearing grains are highly weathered due to the surface weathering of the bulk ore in the deposit. According to present study and based on the mineralogical study, occurrence of significant amounts of impurities or unwanted materials renders the ore low grade which may create a problem to steel making process. Hence, these ores must be improved by thorough and comprehensive processing after adequate comminution to attain liberation. Due to presence of goethite in wealthy form, the concentration criterion for these ores is less than 2.5. Therefore, simple gravity separation will not be much effective. These ores may be improved through advanced gravity separation techniques. Further purification may be achieved using high intensity magnetic separation and floatation may be used to remove the gangue and upgrade the ore if advanced gravity separation will fail to achieve the required grade.

ACKNOWLEDGMENTS

I am very thankful to Director (RML) & Executive Director (RPE & O), RMD, SAIL, India for providing support at MIOM. We also great thankful to Dr. Ritesh Lokhande, Assistant Professor, VNIT Nagpur and other anonymous members of the editorial committee for their valuable suggestions and assistance during the manuscript handling.

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