



*Souvenir*



43<sup>rd</sup> ANNUAL

**METALLIFEROUS**

**MINES SAFETY FORTNIGHT OBSERVANCE-2025**

Under The Aegis of Directorate General of Mines Safety  
Bhubaneswar Regions 1 & 2



HOST

**EASTERN ZONE MINING ASSOCIATION**

With  
*Best Compliments from*  
**M/S M G Mohanty**



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# 43<sup>rd</sup> ANNUAL METALLIFEROUS

**MINES SAFETY FORTNIGHT CELEBRATION**

Bhubaneswar Regions 1 & 2

**2025**



# SOUVENIR



**43<sup>rd</sup> ANNUAL METALLIFEROUS  
MINES SAFETY FORTNIGHT CELEBRATION 2025**  
Bhubaneswar Regions 1 & 2

**SAFETY WEEK COMMITTEE**



**Shri Awanish Kumar Mishra**  
Chairman



**N. Balasubrahmanyam**  
Advisor



**T. Hari Prasad**  
Vice Chairman



**Shri Urimela Siva Sankar**  
Vice Chairman



**Shri Rajib Lochan Mohanty**  
Convener



**Shri Prabodh Mohanty**  
Co-Convener



**Shri R. S. Raghuwanshi**  
General Secretary



**Shri Dilip Kumar Pattnayak**  
Joint Secretary



**Shri Harekrushna Swain**  
Treasurer



**Dr. Hari Babu Kambhampati**  
Governor, Odisha



LOK BHAVAN  
BHUBANESWAR - 751 008

February 02, 2026

No: 132/2026

### *Message*

I am delighted to know that 43rd Annual Safety Mines Fortnight Celebration 2025, Bhubaneswar Region -1 and Bhubaneswar Region- 2 was held recently. A Safety souvenir is now being released to commemorate the celebration.

I am hopeful that this annual observance will stand as a testament to the unwavering commitment of the mining community in Odisha towards prioritizing health, safety and responsible mining practices. The release of this Safety Souvenir will serve as a valuable compendium of knowledge, best practices, experiences and achievements, which will continue to inspire and guide mining personnel in upholding the highest standards of safety in their day-to-day operations.

I commend the organizing teams, safety officers and all contributors for their exemplary zeal and professionalism in making this souvenir a success.

**(Hari Babu Kambhampati)**



**MOHAN CHARAN MAJHI**  
CHIEF MINISTER, ODISHA



LOKASEVA BHAVAN  
BHUBANESWAR

### *Message*

I am glad to know that Directorate of Mines Safety is organising 43rd Annual Mines Safety Fortnight Celebration 2025 for Bhubaneswar Region-1 and Region-2 and bringing out a souvenir in commemoration.

Promoting a strong culture of safety in mining operations is of utmost importance. Initiatives such as the Mines Safety Fortnight help create greater awareness about safety standards and encourage all stakeholders to prioritize the health, safety and well-being of mine workers. It will continue to play a vital role in strengthening responsible and sustainable mining practices.

I extend my warm greetings to the organisers on this occasion and wish the celebration all success.

**(Mohan Charan Majhi)**



**BHUTI BHUSHAN JENA**  
**MINISTER**

Commerce & Transport, Steel & Mines.



### *Message*

I am pleased to learn that the 43rd Annual Mines Safety Fortnight Celebration 2025 for Bhubaneswar Region-1 and Region-2 is being organized under the aegis of the Directorate General of Mines Safety, Ministry of Labour & Employment, Government of India.

Odisha stands at the forefront of India's mineral economy. Our rich mineral resources have significantly contributed to national development and industrial progress. However, the true strength of this sector lies not only in production, but in the safety, dignity and well-being of every worker engaged in mining activities.

Observance of Mines Safety Fortnight is a commendable initiative to reinforce awareness, promote best practices, and foster a culture of safety among all stakeholders of the mining industry. Continuous training, technological upgradation, strict compliance with safety norms, and collective commitment are essential to achieve the goal of zero harm in mines

I extend my best wishes for the success of this event and the Safety Souvenir, which will help spread knowledge and best practices across the mining fraternity.

**(Bhuti Bhushan Jena)**



ଶ୍ରୀ ସମ୍ପଦ ଚନ୍ଦ୍ର ସ୍ଵାଇଁ

ରାଷ୍ଟ୍ରମନ୍ତ୍ରୀ (ସ୍ଵାଧୀନ)

ଶିଳ୍ପ, ଦକ୍ଷତା ବିକାଶ ଓ ବୈଷୟିକ ଶିକ୍ଷା

ଓଡ଼ିଶା



## Message

ଭାରତ ସରକାରଙ୍କ ଶ୍ରମ ଏବଂ ନିଯୁକ୍ତି ମନ୍ତ୍ରାଳୟ ଅନ୍ତର୍ଗତ ଖଣି ନିରାପତ୍ତା ମହାନିର୍ଦ୍ଦେଶାଳୟ, ଧାନବାଦଙ୍କ ପ୍ରତ୍ୟକ୍ଷ ତତ୍ତ୍ଵାବଧାନରେ ଏବଂ ଖଣି ନିରାପତ୍ତା ନିର୍ଦ୍ଦେଶାଳୟ, ଭୁବନେଶ୍ଵର ଅଞ୍ଚଳର ସହଯୋଗରେ ଭୁବନେଶ୍ଵର ଅଞ୍ଚଳ-୧ ଏବଂ ଭୁବନେଶ୍ଵର ଅଞ୍ଚଳ-୨ରେ ୪୩ ତମ ବାର୍ଷିକ ଖଣି ନିରାପତ୍ତା ପକ୍ଷ ପାଳନ- ୨୦୨୪ ପାଳନ ଏବଂ ଏହି ଅବସରରେ କେନ୍ଦ୍ରୀୟ ନିରାପତ୍ତା ସ୍ମରଣାକା ପ୍ରକାଶ ପାଉଥିବା ଜାଣି ମୁଁ ଅତ୍ୟନ୍ତ ଆନନ୍ଦିତ ।

ଓଡ଼ିଶା ଏକ ଖଣିଜ ସମ୍ପଦ ସମୃଦ୍ଧ ରାଜ୍ୟ ଏବଂ ଆମ ରାଜ୍ୟର ଅର୍ଥନୀତି ମୁଖ୍ୟତଃ ଖଣିଜ ଦ୍ରବ୍ୟ ଉପରେ ନିର୍ଭରଶୀଳ । ଏହି କ୍ଷେତ୍ରଟି ପ୍ରତ୍ୟକ୍ଷ ଓ ପରୋକ୍ଷ ଭାବେ ଲକ୍ଷ ଲକ୍ଷ ଲୋକଙ୍କୁ ଜୀବିକା ଯୋଗାଇଥାଏ । ତେଣୁ, ଖଣି ଶିଳ୍ପରେ କାର୍ଯ୍ୟରତ ପ୍ରତ୍ୟେକ ବ୍ୟକ୍ତିଙ୍କ ଜୀବନର ସୁରକ୍ଷା ଓ ନିରାପତ୍ତା ବଡ଼ ପ୍ରାଥମିକତା ହେବା ଆବଶ୍ୟକ । ଖଣି ନିରାପତ୍ତା ପକ୍ଷ ଆୟୋଜନ ଖଣି ଶିଳ୍ପ ସହ ଜଡ଼ିତ ସମସ୍ତ ଅଂଶୀଦାରଙ୍କ ମଧ୍ୟରେ ସୁରକ୍ଷା ମାନକ ସଂପର୍କରେ ସଚେତନତା ସୃଷ୍ଟି କରିବାରେ ଏକ ବଳିଷ୍ଠ ପଦକ୍ଷେପ । ଏହି ଅବସରରେ ପ୍ରକାଶ ପାଉଥିବା ସ୍ମରଣାକାଟି ଖଣି କ୍ଷେତ୍ରରେ ନିରାପତ୍ତା ବ୍ୟବସ୍ଥା ସମ୍ପର୍କିତ ଆଲୋଚ୍ୟରେ ସମୃଦ୍ଧ ହୋଇ ଶ୍ରମିକ, ବୈଷୟିକ କର୍ମଚାରୀ ଏବଂ ପରିଚାଳକମାନଙ୍କ ନିମନ୍ତେ ଉପାଦେୟ ସାବ୍ୟସ୍ତ ହେବ ଏବଂ ସମସ୍ତଙ୍କର ମିଳିତ ଉଦ୍ୟମରେ ଶୂନ୍ୟ ଦୁର୍ଘଟଣା ଲକ୍ଷ୍ୟ ହାସଲ ହୋଇପାରିବ ବୋଲି ମୋର ଦୃଢ଼ ବିଶ୍ଵାସ ।

ଏହି ଅବସରରେ ଆୟୋଜକ କମିଟି, ଖଣି ଶିଳ୍ପ ସହିତ ଜଡ଼ିତ ସମସ୍ତ ଅଂଶୀଦାରଙ୍କୁ ମୁଁ ଶୁଭକାମନା କରିବା ସହ ଖଣି ନିରାପତ୍ତା ପକ୍ଷ ଏବଂ ସ୍ମରଣାକା ପ୍ରକାଶନର ସର୍ବସଫଳତା କାମନା କରୁଛି ।

ସମ୍ପଦ  
(ସମ୍ପଦ ଚନ୍ଦ୍ର ସ୍ଵାଇଁ)



**Ujjwal Tah**  
Director General



भारत सरकार / Government of India  
श्रम एवं रोजगार मंत्रालय / Ministry of Labour & Employment  
खान सुरक्षा महानिदेशालय / Directorate General of Mines Safety



## *Message*

It gives me immense pleasure to note that the Eastern Zone Mines Association (EZMA) is organizing the 43rd Annual Mines Safety Fortnight – 2025 at Bhubaneswar, Odisha, along with a commemorative Souvenir to mark this significant occasion.

The mining sector remains a key contributor of Odisha's and India's economic growth, supported by vast natural resources and a large workforce. Ensuring safety in mining operations is both a statutory responsibility and a moral imperative, fostering operational efficiency, workforce protection, and sustainable development.

The Occupational Safety, Health and Working Conditions Code, 2020—which subsumes the Mines Act, 1952—provides a comprehensive legal framework for safe and sustainable mining practices. All stakeholders must implement these provisions in letter and spirit

I am confident that the Mines Safety Fortnight's activities will reinforce awareness of safe practices, promote innovations in safety technologies, and unite stakeholders in minimizing risks.

I extend my best wishes to EZMA, participating organizations, and the dedicated workforce for the successful observance of this event and the Souvenir's publication. Let us continue building a strong safety culture to make Indian mining safer, stronger, and more sustainable.

(Ujjwal Tah)



**Dr. S. S. Prasad**

Deputy Director General of Mines Safety  
DGMS, South-Eastern Zone, Ranchi



भारत सरकार / Government of India  
श्रम एवं रोजगार मंत्रालय / Ministry of Labour & Employment  
खान सुरक्षा महानिदेशालय / Directorate General of Mines Safety  
दक्षिण-पूर्वी अंचल, रांची / South Eastern Zone, Ranchi



## Message

I am happy to learn that the 43<sup>rd</sup> Annual Mines Safety Fortnight, 2025 was observed during the month of November, 2025 under the aegis of DGMS, Bhubaneswar Region 1 & 2, the prize distribution function of which is being organized by Eastern Zone Mines Association (EZMA), and that a Souvenir is also being published to commemorate the occasion.

The mining sector plays an essential role in supporting the nation's industrial growth and infrastructure development. At the same time, it remains an area where safety, vigilance and strict adherence to best practices are of utmost importance. The well being of every worker engaged in mining activities must remain the foremost priority for all stakeholders.

I am confident that the observance of the Mines Safety Fortnight will help in strengthening awareness on safe mining practices, encourage technological improvements, and foster a culture that places safety and human life above all else. Initiatives undertaken during this period will undoubtedly contribute in reinforcing responsible, sustainable and safe mining in the country.

I extend my best wishes to EZMA, participating organisations and all members of the mining community for the successful conduct of the event and the publication of the Souvenir.

(S. S. Prasad)



भारत सरकार / Government of India  
श्रम एवं रोजगार मंत्रालय / Ministry of Labour & Employment  
खान सुरक्षा महानिदेशालय / Directorate General of Mines Safety  
भुवनेश्वर क्षेत्र 1 / Bhubaneswar Region 1

**ए. के. मिश्रा**  
खान सुरक्षा निदेशक  
भुवनेश्वर क्षेत्र-1, भुवनेश्वर

## संदेश

मुझे यह जानकर अत्यधिक खुशी हो रही है कि खान सुरक्षा महानिदेशालय के तत्वावधान में 43 वाँ वार्षिक खान सुरक्षा पखवाड़ा 2025, दिनांक 17.11.2025 से 30.11.2025 तक भुवनेश्वर क्षेत्र 1 और 2 के अधिकार क्षेत्र के अंतर्गत आने वाले धात्विक खानों में आयोजित किया गया था, जिसका पुरस्कार वितरण समारोह ईस्टर्न ज़ोन माइंस एसोसिएशन (EZMA) के द्वारा आयोजित किया जा रहा है, और इस मौके को यादगार बनाने के लिए एक स्मारिका भी प्रकाशित की जा रही है।

खनन सुरक्षा पखवाड़ा का महत्व यह है कि यह खनन कार्यों में सुरक्षा संस्कृति को मजबूत करता है एवं श्रमिकों और प्रबंधन को जागरूक बनाता है।

खान सुरक्षा पखवाड़ा का पालन ऐसी उत्पादन रणनीतियों को तैयार करने के लिए खाका तैयार करने में काम आता है। ऐसे समारोहों से न केवल हितधारकों के बीच जागरूकता फैलती है बल्कि व्यावसायिक स्वास्थ्य और सुरक्षा के क्षेत्र में तत्काल और समयबद्ध कार्रवाई की आवश्यकता वाले मुख्य क्षेत्रों को समझने में भी मदद मिलती है।

यह अभियान श्रमिकों और अधिकारियों को याद दिलाता है कि सुरक्षा हर कदम पर आवश्यक है। यह दुर्घटनाओं और चोटों को रोकने के लिए सामूहिक प्रतिबद्धता को सुदृढ़ करता है। कर्मचारियों, ठेकेदारों, नियामकों और समुदाय को एक मंच पर लाकर सुरक्षा प्राथमिकताओं पर चर्चा करता है। आपातकालीन अभ्यास, प्राथमिक उपचार प्रदर्शन और सुरक्षा ड्रिल से श्रमिकों की तैयारी बेहतर होती है। मौजूदा सुरक्षा प्रथाओं की कमियों की पहचान कर उन्हें सुधारने का अवसर देता है।

खनन सुरक्षा पखवाड़ा केवल औपचारिक आयोजन नहीं है, बल्कि यह एक रणनीतिक पहल है जो सुरक्षित, टिकाऊ और जिम्मेदार खनन सुनिश्चित करती है। यह जागरूकता, प्रशिक्षण, निरीक्षण और सहभागिता के माध्यम से उद्योग को दुर्घटना के रोकथाम की दिशा में आगे बढ़ाता है।

इस अवसर पर मैं वार्षिक खान सुरक्षा पखवाड़ा 2025 के पुरस्कार वितरण समारोह की सफलता की कामना करता हूँ।

(ए. के. मिश्रा)



**N. Balasubrahmanyam**  
Director of Mines Safety  
Bhubaneswar Region 2



सत्यमेव जयते



भारत सरकार / Government of India  
श्रम एवं रोजगार मंत्रालय / Ministry of Labour & Employment  
खान सुरक्षा महानिदेशालय / Directorate General of Mines Safety  
भुवनेश्वर क्षेत्र 2 / Bhubaneswar Region 2



## Message

It gives me great pleasure to note that the 43rd Annual Mines Safety Fortnight (2025) was successfully observed under the aegis of DGMS, Bhubaneswar Regions 1 & 2. As the Eastern Zone Mines Association (EZMA) hosts this prize distribution ceremony and publishes its commemorative Souvenir, we celebrate more than just an event—we celebrate a commitment to life.

The mining sector is a cornerstone of our nation's industrial and infrastructural progress. However, this contribution is only meaningful when built upon a foundation of uncompromising safety and vigilance. The well-being of our workforce is not just a regulatory requirement; it is our primary moral obligation.

I am confident that this observance has deepened the culture of safety across our operations. By embracing technological innovation and rigorous best practices, we continue to move toward a future of truly sustainable and responsible mining.

I extend my heartiest congratulations to EZMA and all participants for their dedication to this vital cause.

*N. Balasubrahmanyam*

(N. Balasubrahmanyam)



**Shri Tangallapally Hariprasad**

Dy. Director of Mines Safety

Bhubaneswar Region-1  
Directorate General of Mines Safety,  
Ministry of Labour and Employment  
Government of India  
E-mail: dgmsbbsr26@gmail.com

### *Message*

It gives me immense pleasure to be associated with the celebration of **43<sup>rd</sup> Annual Metalliferous Mines Safety Week Celebration 2025 (AMMSWC)**, that is being observed under the aegis of Directorate General of Mines Safety, Bhubaneswar Region 1 & 2 from 17<sup>th</sup> November, 2025 to 29<sup>th</sup> November, 2025 discharging all responsibility by M/s EZMA, the Final day Function shall be held at Swosti Premium by M/s EZMA, Odisha Mines division. I am very pleased to be closely involved in preparation of an e-Souvenir slated for release on the occasion of Final Day Celebration.

Mining Industry producing materials from ore to oil and sand to stone used for soil to sky plays an important role for overall development of the country which in turn raises the general standard of living of countrymen including poverty alleviation. All of us aware that economic growth of any country is primarily based on its mineral deposit.

I feel proud that the State of Odisha is a house of hidden treasure with huge deposits in the form of mineral wealth like coal, chromite, iron ore, limestone, bauxite, quartzite, rare earth mineral, graphite, granite and many more. Mining of these minerals poses many challenges and issues related to safety. The Occupational Health, Safety and Welfare of persons employed in the mining industry and development of the mining areas and standard of living of miners is utmost importance for its growth.

Safety Week Celebration, in addition to spreading of safety awareness amongst all concerned, provides an opportunity to give a fresh look into the safety measures being undertaken in the different mines and to exchange the ideas of new technologies. Observance of Mines Safety Week provides an opportunity to inculcate safety consciousness among mine workers, supervisors and officials.

I express my gratitude for the success of Final Day Celebration of **43<sup>rd</sup> Annual Metalliferous Mines Safety Week Celebration 2025 (AMMSWC)** a grand Success.

(Tangallapally Hariprasad)



**Ulimella Siva Sankar**

Deputy Director of Mines Safety,



भारत सरकार / Government of India  
श्रम एवं रोजगार मंत्रालय / Ministry of Labour & Employment  
खान सुरक्षा महानिदेशालय / Directorate General of Mines Safety  
भुवनेश्वर क्षेत्र 2 / Bhubaneswar Region 2

## *Message*

It gives me immense pleasure to learn that Eastern Zone Mining Association has organized the "43<sup>rd</sup> Annual Mines Safety Fortnight" for all Odisha State Metalliferous Mines from 17.11.2025 to 29.11.2025 and the Valedictory Function will be held on .... January, 2025 at Bhubaneswar.

Odisha is endowed with vast resources of a variety of minerals and occupies a prominent place in the country as a mineral rich State and thus playing a major role in the industrial and economic growth of the country. Mining being one of the most hazardous professions challenged with many inherent geo-mining, operational and occupational hazards. Perpetuation of safety is a precondition for any mining operation.

Reduction of exposure of miners to major risks is viably possible through adoption of scientific methods and technological tools with vigilant supervision and Safety management system coupled with promotion of standardized safe work practices.

The Annual Safety Fortnight Observance provide an opportunity to introspect, take stock of the existing safety environment and also inculcate a sense of confidence and better safety awareness among the miners. Such functions also promote synergetic competitiveness for the improvement in safety and production, and facilitates exchanging views and understanding best practices amongst all concerned.

I wish the "Annual Mine Safety Fortnight" a grand success and hope the spirit of safety achieved through this function is carried whole the year for achieving better results in all spheres in all the Metalliferous mines of Odisha State.

*Ulimella Siva Sankar*  
(Ulimella Siva Sankar)



**Rajib Lochan Mohanty**  
President EZMA



Eastern Zone Mining Association  
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## *Message*

It is a great pleasure to note that all mines under the aegis of the Director General of Mines of Bhubaneswar Region–I and Bhubaneswar Region–II are celebrating the **43rd Annual Mines Safety Fortnight, 2025** with great enthusiasm and commitment.

The State of Odisha is richly endowed with a wide spectrum of minerals such as iron ore, manganese ore, chromite, bauxite, coal, and others. This abundant mineral wealth has catalysed the growth of major industries including steel, aluminium, ferro alloys, sponge iron, and power generation, significantly contributing to the nation's economic development. The increasing demand for minerals by the metal, non-metal, and power sectors has led to rapid expansion of mining activities, making safety in mines an issue of paramount importance.

Ensuring safety in mining operations is a collective responsibility of mine owners, management, supervisory staff, and the workforce at large. The Annual Mines Safety Fortnight plays a vital role in creating awareness, instilling safety consciousness, and reinforcing safe work practices among all stakeholders, thereby minimising accidents and promoting a safe and healthy working environment in mines.

On behalf of the Eastern Zone Mining Association, I extend my heartfelt congratulations to the Organising Committee and the host mine for successfully organising the concluding day celebration of the 43rd Annual Mines Safety Fortnight, 2025. I also appeal to all members of the Eastern Zone Mining Association and the entire mining fraternity to continuously strive towards achieving the highest standards of safety through strict compliance with statutory provisions, adoption of best practices, and fostering a strong safety culture at every level.

I wish the **43rd Annual Mines Safety Fortnight, 2025** a grand success and hope that the spirit of safety nurtured during this week continues throughout the year.

**(R. L. Mohanty)**



**Prabodh Mohanty**

Honorary General Secretary  
Eastern Zone Mining Association



### *Message*

It gives me immense pleasure to extend my heartfelt greetings on the occasion of the Concluding Day Function of the 43rd Annual Mines Safety Fortnight – 2025 of Bhubaneswar Region I & II, being organized at Bhubaneswar.

Mines Safety Fortnight is not merely a statutory observance; it is a reaffirmation of our collective commitment to safeguarding the lives, dignity, and well-being of every individual engaged in the mining sector. Safety in mines is not an option — it is a responsibility that we all share.

The mining industry is a cornerstone of Odisha's economy and plays a vital role in nation-building. However, the true strength of this industry lies not only in mineral production but in ensuring that every worker returns home safely at the end of the day. Continuous improvement in safety standards, adoption of modern technology, strict compliance with regulations, and fostering a culture of awareness and accountability are essential to achieving zero-harm workplaces.

The Eastern Zone Mining Association remains committed to supporting all stakeholders in advancing best practices, enhancing skill development, and encouraging innovation in safety management. Let us collectively strive to integrate safety with productivity, sustainability, and operational excellence.

On this occasion, I extend my sincere appreciation to the organizers for bringing out this commemorative Souvenir, which serves as a valuable platform for knowledge sharing and reflection.

I convey my best wishes for the grand success of the Concluding Day Function and reaffirm our shared resolve to make mining safer, smarter, and more sustainable.

With warm regards

**(Prabodh Mohanty)**



**Pramod Tyagi**  
Secretary General



**FEDERATION OF INDIAN  
MINERAL INDUSTRIES**

### *Message*

I am happy to learn that the "**43<sup>rd</sup> Annual Mines Safety Fortnight Celebration 2025**", Bhubaneswar Region-1 and Bhubaneswar Region-2, was held during November, 2025 under the aegis of the Directorate of Mines Safety, Bhubaneswar Region, and with the patronage of the Director General of Mines Safety, Dhanbad, Ministry of Labour & Employment with active participation of mines from across the State of Odisha.

Odisha, being a leading mineral-rich state, plays an important role in the production of minerals and contributes significantly towards the economic growth of the state. Considering the presence of numerous operative mines in the state, it is imperative that safety management in these mines receive enhanced focus for sustainability of mining operations and socio-economic development of the area.

In view of significant technological and statutory changes taking place in the Indian mineral industry, in-built and inter-locked safety systems have become an integral part of technological advancements. However, despite advanced technology, it remains a fact that human interaction with the mining process is inevitable. Protection and safety of employees and surrounding communities are of paramount importance, and a strong safety culture needed to be ingrained in the working of the Indian mining industry. In view of the fact that mining operations are arduous and risky with potential hazards, it is essential to work relentlessly to adopt the highest safety standards to minimize risks in operating mines.

I am confident that this event - "**Annual Mines Safety Fortnight Celebration 2025**" - will bring the desired awareness among employees and stakeholders working and residing in and around the vicinity of mines regarding the need for safety measures, particularly in light of various technological changes, and contribution to the sustainability and effective functioning of mines.

On behalf of the Federation of Indian Mineral Industries (FIMI), as well as on my own behalf, I compliment the organizers of the 43<sup>rd</sup> Annual Mines Safety Fortnight Celebration 2025.

**(Pramod Tyagi)**

**FIMI HOUSE, B-311, Okhla Industrial Area, Phase-I, New Delhi - 110 020 (India)**

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**Alok Kumar Mehta**

Director

Mining & Strategic Projects  
Arcelor Mittal Nippon Steel India**AM/NS  
INDIA**

### *Message*

It gives me immense pleasure to address all stakeholders on the occasion of the **43rd Annual Mines Safety Week – 2025**, being observed under the aegis of the Directorate General of Mines Safety (DGMS), Bhubaneswar Region.

The mining industry plays a pivotal role in nation building, and its success is inseparably linked with the safety, health, and well-being of its workforce. Mines Safety Week offers us a valuable opportunity to reaffirm our leadership commitment towards creating and sustaining a workplace where safety is embedded in every decision, process, and action.

As senior leaders, we recognize that safety excellence starts from the top. Our responsibility extends beyond compliance to setting clear expectations, providing necessary resources, and fostering a culture where safety is regarded as a core organisational value. A strong safety culture is achieved when every individual—from leadership to the front-line worker—takes ownership of safe practices and looks out for one another.

We acknowledge with gratitude the consistent guidance and support extended by the Directorate General of Mines Safety (DGMS) in strengthening statutory compliance, promoting best practices, and driving continuous improvement across the mining sector. Their stewardship remains instrumental in aligning operational excellence with occupational safety and health.

On this occasion, I urge all employees and business partners to actively participate in Mines Safety Week activities, reflect on lessons learned, and proactively identify opportunities to prevent accidents and occupational illnesses. Let us move forward with the shared objective of ensuring zero harm and returning every worker safely to their family at the end of each working day.

Together, let us reinforce our commitment to safe, responsible, and sustainable mining.

Wishing everyone a purposeful and successful Mines Safety Week – 2025.

**(Alok Kumar Mehta)**



**Awanindra Kumar Singh**  
Sr. Vice President  
Jindal stainless Limited Jajpur  
Odisha.



### *Message*

It gives me immense pleasure to hear that 43<sup>rd</sup> Annual Mines Safety Fortnight- 2025 is being observed under the aegis of Director General of Mines Safety (DGMS), Bhubaneswar Region. I am also happy to know that a Souvenir is being brought out to commemorate the occasion.

It is indeed commendable that this practice has been prevalent for over many years under the leadership of the Directorate of Mines Safety.

In the advent of technological upgradation and unprecedented growth of mining activities, Safety is playing a pivotal role in increasing production as well as improving the productivity. Mines Safety Fortnight Celebration provides a common platform for all to reaffirm the need for Mines Safety and creates a conducive atmosphere for self-introspection & commitment towards "SAFETY"

I extend my best wishes to all for the grand success of this great event.

**(Awanindra Kumar Singh)**

#### **Jindal Stainless Ltd.**

Jindal Chromite Mines, Kaliapani-755047, Jajpur (Odisha), India  
**T:** 06726 268545, **F:** 06726 268315, **E:** jindal\_mines@yahoo.com  
Corporate Office: Jindal Center, 12 Bhikaji Cama Place, New Delhi- 110066, India  
Registered Office: O.P.Jindal Marg, Hisar-125005, Haryana, India



**Surya Kanta Mishra**

Nominated Owner

Baphlimali Bauxite Mine

M/s Utkal Alumina International Limited



### *Message*

It is an occasion of exultation that 43<sup>rd</sup> Odisha Metalliferous Mines Safety Week Celebration 2025 is being observed under the aegis of the Director General of Mines Safety (DGMS), Bhubaneswar Region. It's also great to see that a Souvenir is going to be published germane to Mines safety, on this event.

It's my strong belief that observation of Mine safety week aimed at inculcating a sense of confidence amongst the mine operators. Also came to know that the individual mines performance & the grey areas in the field of safety are being measured during this period by expert team members. This celebration is not a tool to educate the mining fraternity but also to promote safety awareness amongst them & improves the workers participation in safety management. Furtherance, from this year onwards We came to know that the half yearly safety week celebration was being carried out under the special drive of the DGMS- Bhubaneswar Region, by involving all individual mines to ensure the implementation of Safety Rules at their places all through the Year.

I am sure that, this initiative would be very successful in preventing unsafe acts, unsafe conditions & unsafe practices and in promoting the ZERO mishaps in Mines.

On this eclectic event, I appreciate the endeavor of DGMS and all participants, and wish for a grand success of this celebration.

**(Surya Kanta Mishra)**

#### **UTKAL ALUMINA INTERNATIONAL LIMITED**

Plant & Off.: Doraguda, Po: Kucheipadar, Dist.: Rayagada- 765015, Odisha,  
India Regd. Office: J-6, Jaydev Vihar, Bhubaneswar. 761013, Odisha, **India**  
CIN No.: U13203OR1993PLC003416 Ph.: 06865287040, Fax: 06865287100  
Ph.: 0674 2360581/540. Fax: 0674 2360321

Website: [www.hindalco.com](http://www.hindalco.com). Email: [ullcal.alumina@ad.tyabirlacom](mailto:ullcal.alumina@ad.tyabirlacom)



**Sandeep B Narade**  
VP, Head-Mining BU & EiC  
Mis IMFA Limited.



### *Message*

It is indeed a matter of great pride and satisfaction to be associated with the 43rd Annual Mines Safety Week\_2025, organized under the aegis of the Directorate General of Mines Safety (DGMS), Bhubaneswar Region, from 17th November 2025 to 29th November 2025. On this memorable occasion, a commemorative souvenir will also be released to mark the event.

In today's era of rapid technological advancement and expanding mining operations, safety remains the cornerstone of sustainable growth. Ensuring safe mining practices is not merely a regulatory requirement but a shared responsibility that drives productivity, efficiency, and the overall well-being of our workforce.

The observance of Mines Safety Week provides an excellent platform to reinforce awareness, exchange best practices, and strengthen the culture of safety across all levels of the mining community. It is also a time to appreciate the dedication of all those who continuously strive to make our mines safer and more productive.

This event encourages us to renew our commitment towards achieving the highest standards of safety and to ensure that every individual return home safely at the end of each working day.

I am confident that the 43rd Annual Mines Safety Week will create a lasting impression, inspiring all stakeholders to integrate safety as an intrinsic part of every mining activity.

I extend my heartiest congratulations and best wishes to all those involved in organizing this important event and wish it grand success.

(Sandeep B Narade)



**Siddharth Rungta**  
Chairman  
Rungta Sons Private Limited



RUNGTA HOUSE  
CHAIBASA - 833201 (JHARKHAND)

### *Message*

I am very delighted to know that, the **43rd Annual Mines Safety Fortnight Celebration-2025 for metalliferous mines of Bhubaneswar Regions 1 & 2** is scheduled to be observed under the aegis of the Directorate General of Mines Safety, Ministry of Labour & Employment, Government of India.

The Mining industry has strengthened our nation **in** terms of supporting growth of manufacturing, infrastructures and many other sectors including MSME Industries with an ultimate objective of sustainable, inclusive and equitable growth towards economic development of the country.

Every year celebration of the Safety Week shows our commitment towards adherence to safety standards in work places & spreading safety awareness among all concerned. This celebration absolutely strengthens safety awareness among the entire workforce and entire mining fraternity. It is an initiative that aligns management, managers, supervisors and stakeholders in respect of their safety values.

In an era where the demand for minerals continues to surge, we must ensure that our operations are not only efficient but also responsible and environment friendly. The Annual Mines Safety Week is not just a celebration; it is a testament to our collective dedication to create a culture of safety. It provides a platform to raise awareness, share best practices and renew our commitment to create a safer work environment.

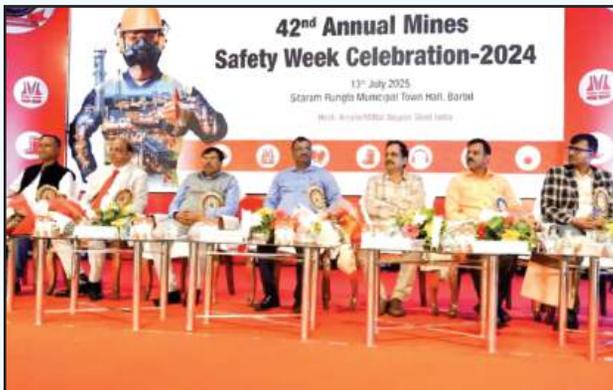
On this note, I would like to urge all to continue our good efforts in technological transformation **in** safety and vigilance **in** keeping good HSE performances and strive towards zero harm in our work place. Let us ensure that "every worker returns home safely every day".

I extend my sincere greetings & Best Wishes for Grand Success of 43rd Annual Mines Safety Fortnight Celebration- 2025 of Bhubaneswar Regions 1 & 2.

(Siddharth Rungta)



## FINAL DAY FUNCTION OF 42ND ODISHA METALLIFEROUS MINES SAFETY WEEK CELEBRATION 2024





## Last Ten Years Annual Mines Safety Week Celebration (Bhubaneswar Regions 1 & 2)

Year	Final Day Host Organization	Celebrating Year
2016	M/s IREL	34th
2017	M/s FACOR	35th
2018	M/s Tata Steel Limited (on behalf of BC Mohanty and Misrilal)	36th
2019	M/s Utkal Alumina Limited	37th
2020	Virtual Mode by M/s UAL	38th
2021	M/s Tata Steel Mining	39th
2022	M/s IMFA	40th
2023	M/s JSW	41st
2024	M/s AM/NS india	42nd
2025	Eastern Zone Mining Association	43rd



## Participating Mines Details 43<sup>rd</sup> Annual Mines Safety Fortnight Celebration 2025 (Bhubaneswar Region 1)

### Group-A1

SI.No	Name of Mine	Name of the Owner
1	Jajang Iron Ore Mines	Mis JSW Steel Limited
2	Thakurani Iron Ore Mines	Mis. AM/NS India Pvt Ltd.
3	Gandhamardan Iron Ore Mines, Block -B	Mis. Odisha Mining Corporation Ltd.
4	Katamati Iron Mine	Mis. Tata Steel Limited
5	Joda East Iron Mine	Mis. Tata Steel Limited
6	Khondbond Iron & Mn Mine	Mis. Tata Steel Limited
7	Guali Iron Ore Mines	Mis. Odisha Mining Corporation Ltd
8	Bolani Ores Mines	Mis. Steel Authority of India Limited
9	South Kaliapani Chromite Mines	Mis. Odisha Mining Corporation Ltd.
10	Sukinda Chromite Mine	Mis. Tata Steel Limited

### Group-A2

SI.No	Name of Mine	Name of the Owner
1	Jilling Langalota Iron Ore Mines	Mis. Odisha Mining Corporation Limited
2	Kasia Iron & Dolomite Mines	Mis. Jindal Steel & Power Limited
3	Balda Iron Ore Block Mines	Mis. Serajuddin & Co.
4	Nuagaon Iron Ore Mine	Mis. JSW Steel Limited
5	Joda West Iron & Manganese Mine	Mis. Tata Steel Limited
6	Jaribahal Iron Ore Mines	Mis. Kashvi International Pvt Ltd.
7	Roida II Iron Mines	Mis. Narbheram Power And Steel Pvt Ltd
8	Daitari Iron Ore Mines	Mis. Odisha Mining Corporation Ltd
9	Orissa Sands Complex (OSCOM)	Mis. IREL (India) Limited

### Group-A3

SI.No	Name of Mine	Name of the Owner
1	Unchabali (Mahaparbat) Iron Ore Mine	Mis. Odisha Mining Corporation Ltd
2	Gandhamardan Iron Ore Mines, BLOCK -A	Mis. Odisha Mining Corporation Ltd
3	Khandbandh Iron Ore Mines	Mis. Sree Metaliks Limited
4	Siljora -Kalimati Iron & Mn Mines	Mis. Debabrata Behera
5	Khandbandh Iron Ore Mine	Mis. Odisha Mining Corporation Ltd
6	Banspani Iron Ore Mines	Mis. Odisha Mining Corporation Ltd
7	Sirkagutu Iron & Manganese Mines	Mis. Prakash Industries Ltd
8	Badampahar Iron Ore Block	Mis. GM Iron & Steel Co. Ltd.
9	Tiringpahar Iron Ore Mines	Mis. Odisha Mining Corporation Ltd
10	Roida -C Iron & Manganese Mines	Mis. Odisha Mining Corporation Ltd

**Group-A4**

Sl.No	Name of Mine	Name of the Owner
1	Bamebari Iron and Manganese Mine	M/s. Tata Steel Limited
2	Tiringpahar Iron & Mn Mine	M/s. Tata Steel Limited
3	Naibaga Iron & Manganese Mines	M/s. Tarini Prasad Mohanty
4	Jururi Iron Ore Mines	M/s. Jagat Janani Services Pvt Ltd
5	Nayagarh Iron Ore Mine	M/s. KCPironPvtLtd
6	Gorumahisani Iron Ore Block	M/s. GhanashyamMisraand Sons Private Limited
7	Murgabeda Iron Ore Mines	M/s. D.R. Patnaik
8	Deojhar Iron Ore Mines	M/s. Tarini Minerals Pvt.Ltd.
9	Bagiaboru Iron Mines	M/s. The OrissaMinerals Development Company Limited
10	Katasahi Mn Mines	M/s. Agrasen Sponge Pvt. Ltd.

**Group-A5**

Sl.No	Name of Mine	Name of the Owner
1	Sukinda Mines (CHROMITE)	M/s. Indian Metals & Ferro Alloys Ltd.
2	Kaliapani Chromite Mines	M/s. Jindal Stainless Limited
3	Sukrangi Chromite Mines	M/s. Odisha Mining Corporation Ltd.
4	Ostapal Chromite Mine	M/s. Ferro Alloys Corporation Limited
5	Kalarangiatta Chromite Mine	M/s. Ferro Alloys Corporation Ltd.
6	Kamarda chromite mine	M/s. Tata steel Limited
7	Saruabil Chromite Mine	M/s. Tata Steel Limited

**Group-A6 (UG)**

Sl.No	Name of Mine	Name of the Owner
1	Mahagiri Mines (Chromite)	M/s. Indian Metals & FerroAlloysLtd
2	Bangur Chromite Mines	M/s. Odisha Mining Corporation Ltd



### Group-A7

SI.No	Name of Mine	Name of the Owner
1	Gobindapur Decorative Stone Mine	M/s.Odisha Mining Corporation Limited
2	Kundakundi Kunda Decorative Stone Quarry, Narangarh	M/s. Odisha Mining Corporation Ltd
3	Logu Decorative Stone Mines	M/s. Meenakshi Granites
4	Barlanda Decorative Stone Mine	Smt. Y. Rajani, Paralakhemundi
5	Laxmi Granite	M/s. Neelachal Granite
6	M. Murali Krishna	M. Murali Krishna
7	Mahughara Hill Decorative Stone Mine	M/s. Nirman Vikas Pvt Ltd
8	Mahughara Decorative Stone Mine	Lessee: SUMITADAS
9	Amarjyoti Granite	Amarjyoti Granite
10	Bhagabanpur granite Mines	M/s. Neelachal Granite
11	IlliyasAhammed	IlliyasAhammed
12	Khamarigaon Granite Mine	M/s. Galaxy Enterprises
13	Badadumula Decorative Stone Mines	M/s.Ajaxpetro
14	Bhagabanpur Decorative Stone Mines	Illiyas Khan
15	Bhagbanpur Decorative Stone Mines	M/s. SobhanKumarMahapatra
16	Bhaganpur Decorative Stone Mines	AN.Baxi
17	Bhagabanpur Decorative Stone Mines	M/s. Royal Granite
18	Pandiapathar Decorative Stone Mines	M/s. MD Irfan Razzak
19	Dindipalli Decoration Stone Mines	Ranjulata Swain



## Participating Mines Details 43<sup>rd</sup> Annual Mines Safety Fortnight Celebration 2025 (Bhubaneswar Region 2)

### Group-B1

Sl.No	Name of Mine	Name of the Owner
1	Sanindpur Iron & Bauxite Mines	M/s. Rungta Sons Private Limited
2	Oraghat Iron Mines	M/s. Rungta Sons Private Limited
3	TRB Iron Ore Mines	M/s. Jindal Steel And Power Limited
4	Narayanposhi Iron and Manganese Mines	M/s. JSW Steel Limited
5	Lanjibema Limestone & Dolomite Mines	M/s. Dalmia Cement Bharat Limited
6	Baphlimali Bauxite Mine	M/s. UtkalAlumina International Limited
7	Panchpatmali (Central & North Block) Bauxite Mine	M/s. NationalAluminium Company Ltd

### Group-B2

Sl.No	Name of Mine	Name of the Owner
1	Kurmitar Iron ore Mines	M/s. Odisha Mining Corporation Ltd.
2	Raikela Iron Ore Mines	M/s. Geetarani Mohanty
3	Ghoraburhani Sagasahi Iron Ore Mine	M/s. AM/NS India Pvt Ltd.
4	Nadidihi Iron Ore Mine	M/s. ESL Steel Ltd (Vedanta)
5	Barsua Iron Mines	M/s. Steel Authority of India Ltd. (SAIL)
6	Kalta Iron Mine	M/s. Steel Authority of India Ltd. (SAIL)
7	KJST Iron, Manganese & Bauxite Mine	M/s. S. N. Mohanty
8	Kodingmali Bauxite Mine	M/s. Odisha Mining Corporation Limited

### Group-B3

Sl.No	Name of Mine	Name of the Owner
1	Taldih Iron Mines	M/s. Steel Authority of India Ltd. (SAIL)
2	Neelachal Iron Ore Mine	M/s. Neelachal Ispat Nigam Limited
3	Patabeda Iron Mines	M/s. MGM Minerals Ltd
4	Nadidihi Iron & Manganese Ore Mine	M/s. ESL Steel Limited
5	Birmitrapur Limestone & Dolomite Mines	M/s. Bisra Stone Lime Company Ltd. Birmitrapur
6	Raikela and Tantra Iron Mines	M/s. Penguin Trading and Agencies Ltd.
7	Panchpatmali (South Block) Bauxite Mine	M/s. National Aluminium Company Ltd.



### Group-B4

SI.No	Name of Mine	Name of the Owner
1	Sanindpur Iron & Mn Mines	M/s. Grewal Minerals & Metals LLP
2	Raikela Iron Ore Mines	M/s. Grewal Minerals & Metals LLP
3	Gonua Iron Ore Mine	M/s. JSW Steel Limited
4	Adaghat Iron Ore Mines	M/s. Grewal Minerals & Metals LLP
5	Kolmong Iron & Manganese Ore Mine	M/s. Yazdani Steel & Power Ltd.
6	Bhanjapali Iron Ore Mines	M/s. JN Patnaik
7	Tantra Iron Ore Mine	M/s. Korp Resources Pvt Ltd
8	Khatkurbahal Limestone & Dolomite Mines	M/s. ShivaCementLtd
9	Khatkurbahal North Block Limestone & Dolomite Mines	M/s. ShivaCementLtd
10	Maliparbat Bauxite Mine	M/s. Hindalco Industries Limited
11	Bandhamandi Graphite Mine	M/s. Pradhan Industries

### Group-BS

SI.No	Name of Mine	Name of the Owner
1	Kanther - Koira Manganese Mines	M/s. P.M. Granite Export Private Limited
2	Mahulsukha Iron & Manganese Mines	M/s. Rungta Sons Pvt. Ltd.
3	Nuagaon Iron & Manganese Mine	M/s. S. N. Mohan ty
4	Bandhal Manganese Mine	M/s. Kanakdhara Mining & Minerals PvtLtd.
5	Patabeda Iron & Mn mine (19.425 Ha)	M/s. MG Mohanty
6	Patabeda Iron Mine (14.00Ha)	M/s. MG Mohanty
7	Chhuinpali Quartzite Mines	M/s. TRL Krosaki Refractories Limited
8	Bhikampali Quartzite Mine	M/s. Dalmia Bharat Refractories Limited
9	Gandabahali Graphite Mine	M/s. Agarwal Graphite Industry
10	Khemabeda Decorative Stone Mine	M/s. Hotha Venkatesh
11	Ampavalli Limestone Mines	M/s. Odisha Mining Corporation Ltd.
12	Peta Decorative Stone Mine	M/s. Chava Venugopal
13	Peta Decorative stone Mine	M/s K. Srinivasa Rao



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## A NEW ERA OF MINING WITH ARTIFICIAL INTELLIGENCE

Jaydev Behera

### INTRODUCTION-

AI is helping the mining industry by improving operational efficiency, and sustainability through automation, real-time monitoring, and data analysis. It enables predictive maintenance for equipment, automates tasks like drilling and hauling with autonomous vehicles, and helps optimize resource extraction while minimizing environmental impact. This leads to better decision-making, reduced downtime, and enhanced productivity in a historically challenging sector.

Artificial Intelligence is designed to perform specific tasks based on predefined rules and patterns. That makes it ideal to run in the background of automated systems and gather data on the performance of the tools and systems. That data can be uploaded to easy-to-read dashboards that give near real-time insight into a piece of equipment or a process's operations. AI can also be used in the exploration process. By setting parameters that indicate the presence of ore or other material you intend to mine.

Safety is another area where AI can stand out. Tracking data from emission and fire detection sensors ensures that alarms go off as soon as a leak or fire is detected. Another valuable area where AI can provide insight is in predictive

maintenance. An AI-powered system can evaluate the operation of any digital-enabled equipment and make note of deviations in present operating parameters. The data collected can be used to optimize equipment performance, help establish preventative maintenance schedules and reduce the cost of unexpected equipment failures and downtime.

Artificial intelligence (AI) enabled applications provide one avenue to potentially speed up this process. AI is already enhancing mining sector economics by boosting productivity, optimizing operational costs, and maximizing profitability. The potential uses go far beyond this to support worker safety environmental management and government monitoring.

### **Current and Potential Roles of AI in Mining-**

There are several already established applications of AI within the mining industry and its operations. The first is prospecting and exploration, which is the initial stage of locating an economic mineral, measuring its economic and market conditions in order to evaluate whether it is worth investing in. This process requires the reconnaissance of the area of interest, collection of geophysical, geological and economic data. Exploration



involves sampling, laboratory work, borehole logging, and further investigation of prospects.

Workplace safety is another area where AI enabled tools are being employed. Mining operations are a high-risk environment due to small workspace, inadequate lighting, contact with toxic waste and gasses and inhalation of particles. For this reason, AI tools have been created to limit worker's exposure to these conditions through machines that autonomously monitor the atmosphere, send signals and warnings, locate problematic areas and work continuously even in dangerous situations.

AI is also being used in operational processes. Autonomous mining haulage trucks, such as from the company Caterpillar, have created a 15% reduction in operating costs due to the fact that these trucks can function continuously without breaks or changes in shifts. This would also likely add to worker/driver safety.

Other AI-enabled tools are in development. To further improve worker conditions, robots or sensors that investigate the areas of concern and collect data on the levels of dangerous gasses, toxic dust and radiation in the mine can be used before human interaction with the area. These systems would additionally trigger alarms or signals and or redirect ventilation networks whenever unsafe conditions occur. This would not only improve working conditions but could also aid in reducing breaks, increasing productivity, and lower risks of accidents and related costs.

Within production, autonomous machines may soon be able to calculate things such as rock strength and hardness. The data from these operations are collected and then used to analyze working conditions so that informed decisions can be made and corrective actions can be taken in the case of error or malfunction.

Another sector with potential applications for AI enabled tools is in mineral processing in which systems use color-sorting, X-ray transmission or near-infrared sensors to eliminate waste. This would be useful in identifying various physical, mineralogical and chemical properties. These processes would, in turn, greatly increase the efficiency of the communication process and reduce energy cost as crushing and grinding are the most energy consuming and least energy efficient parts of the mineral processing cycle. Thus improving efficiency and sustainability.

## **KEY AREAS WHERE ARTIFICIAL INTELLIGENCE CAN BE IMPLEMENTED**

### **Exploration and Mineral Identification :**

In order to locate possible mineral resources, artificial intelligence (AI) algorithms can be used to evaluate geological data, such as drilling data, satellite imaging, and geological mapping. Making decisions about exploratory activities can be aided by machine learning algorithms that anticipate and map mineral deposits.

**Geotechnical Engineering:** AI can be used to assess the stability of rock



structures, analyze slope stability, and predict potential hazards in mining sites. By leveraging AI technologies, geotechnical engineers can better understand the geological conditions and reduce risks associated with mining operations.

**Predictive Maintenance:** By analyzing sensor data to find anomalies and anticipate possible breakdowns, artificial intelligence (AI) can enable predictive maintenance of mining equipment and machinery. This can lessen maintenance expenses, minimize downtime, and increase mining operations' operational effectiveness.

**Safety and Risk Management:** AI-powered systems can be utilized to monitor and analyze safety metrics in mining operations, such as air quality, temperature, and seismic activity. AI can also assist in identifying potential risks and hazards in real-time, thereby enhancing safety protocols and mitigating accidents.

**Optimizing Extraction Processes:** AI can optimize the extraction processes by analyzing operational data to improve efficiency, reduce energy consumption, and enhance resource recovery. Intelligent algorithms can also be used to optimize blasting patterns, ore processing, and material handling in mining operations.

**Environmental Impact Assessment:** AI can play a significant role in conducting environmental impact assessments by analyzing the effects of mining activities on ecosystems, water resources, and air quality. AI models can help in predicting

and minimizing the environmental footprint of mining operations.

**Accident Annalysis:** Data analysis and visualization techniques can be used to analyze causes and factors leading to accidents and preventive measures can be designed with more focus on removing the causes of accident. Intelligent systems designed with a focus on removal of potentially hazardous situations, decrease or complete removal of human presence from dangerous and hazardous works such as transporting , loading and blasting explosives ,installing roof supports ,and removing hazardous gases and dust can help in reducing accidents and fatalities.

#### Advantages of AI in mines

- Unsafe jobs ,work ,and hazardous tasks worked by robots instead of human.
- Increased efficiency of work and processes.
- Reduction in labor cost and improved safety.
- No health , vison and dental insurance , retirement and other costs needed for machines.
- Reduced errors , mistakes and accidents resulting in reduced operational costs.
- Reliable results from a reduced number of experiments.
- Reduction in the number of expensive field and lab experiments and increased reliability of prediction and predictive algorithms.
- 24/7 availability resulting in increased productivity.



- Improved safety as robots doing hazardous work.
- Better guidance and control system for mine rescue and safety operations.
- Systems are filling the gap of labor availability and labor needs in the industry.
- AI systems have more situational awareness and can make better decisions in hazardous accidents and emergency situations.
- Increased speed of good decision.
- Simple and timely solutions to complex problems.
- Ethical implications and responsibilities for unsafe behavior.
- No employment for communities where mines are being developed.

### Conclusion

AI technology have the potential to bring a new revolution to the mining industry by reducing cost , improving productivity and efficiency of operations and by decreasing the environmental foot print of mining through use of intelligent systems . The mining industry is slowly moving towards the implementation of the systems especially in the field of autonomous machines and self driving vehicles. However to realize the full potential of these technologies in various operations of mining more concerted efforts are needed. As more and more mining companies are taking the initiative to implement intelligent systems based on AI and more and more data will be available on the successes and failures of these attempts , their impact on jobs and employment numbers ,future skill and training requirements , economic , societal and social impacts of implementation . This will provide more solid data to analyze various impacts ,to evaluate current issues and future trends and to provide a basis for better understanding of the implications of AI implementations in the mining industry.

### Disadvantages of AI in mines

- Loss of jobs.
- Reliability of results as it is still based on trial and error .
- Loss of control over intelligent machines .
- Improper use of technology like autonomous weapons and explosives .
- Too much reliance on machines can lead to poor decision making as technology has the potential to be misused if not deployed properly .
- Security vulnerability ( bugs ,viruses ,system hacking) .



## COMPREHENSIVE DESIGN AND SAFETY ASSESSMENT OF MINE WASTE DUMPS

Prashant Kumar Nayak

### Abstract

The stability of overburden (OB) and waste dump slopes is a critical geotechnical concern in surface mining, particularly in Indian opencast coal and metal operations where heterogeneous materials, rapid dumping practices, and intense monsoon conditions pose significant challenges. This study presents a comprehensive review of the multifactorial parameters governing dump slope stability, with emphasis on conditions to Indian mines. Material properties, including grain size distribution, cohesion, internal friction angle, bulk density, and moisture retention characteristics, strongly influence the shear strength behaviour of dump constituents. Geometric parameters such as overall slope angle, bench configuration, lift height, and dump elevation control the internal stress distribution and potential failure surfaces. Hydrological influences are important under Indian climatic regimes, where heavy monsoon rainfall increases pore water pressure, reduces effective stress, and frequently triggers slope instability. Including seismic loading, vegetation cover, and construction practices such as dumping rate, layering, and compaction, also play a substantial role in long-term performance.

The review highlights the growing application of numerical modelling techniques for simulating dump behaviour under varying geometric, hydrological, and loading conditions. Parametric studies and model calibration using field and laboratory data provide more realistic estimations of the factor of safety and help identify dominant failure mechanisms. Synthesised figures and tabulated comparisons presented in the study illustrate the relative influence of key parameters and demonstrate practical design and monitoring strategies. The findings support the adoption of integrated, data-driven approaches for dump design, stability assessment, and risk mitigation, contributing to safer, more sustainable waste management practices in Indian surface mining environments.

### Introduction

The construction and long-term stability of large waste dumps in opencast mines represent a critical geotechnical challenge due to the enormous volumes of overburden generated during coal and metal extraction. In Indian conditions, the volume of waste frequently surpasses the quantity of recoverable mineral, necessitating the development of extensive

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internal and external dumps that must remain stable during both operational and post-closure stages. Instability of these dumps can result in serious consequences, including loss of life, damage to haulage systems, disruption of production, and environmental degradation. The problem is intensified by India's monsoonal climate, where heavy rainfall increases pore water pressure, accelerates erosion, and reduces effective stress within dump materials. This review synthesises research and field observations from 1995 to 2025, covering major slope failure mechanisms such as

rotational, translational, and progressive failures, and integrates empirical, case-based, and numerical studies to support improved design and monitoring strategies. Table No. 1 presents a summary of selected Indian case studies on waste dump slope stability, highlighting site conditions, methods used, and key findings. Table 2 presents stages in waste dump development and the associated geotechnical concerns affecting stability and safety. Table 3 comprehensive list of geotechnical, hydrological, and operational factors influencing the stability of waste dump slopes.

**Table 1: Summary of Indian Waste Dump Slope Stability Case Studies**

Sl. No.	Mine	Location	Study Approach	Key Findings
1	<b>Srirampur OCP-II</b>	SCCL, Telangana	Limit equilibrium & FLAC/Slope modelling	Factor of Safety (FoS) dropped below 1.2 at 45° slope; influenced by moisture increase.
2	<b>Sonepur Bazari OCP</b>	ECL, West Bengal	3D numerical analysis & field monitoring	High spoil height (120 m) and poor compaction caused tension cracks.
3	<b>Gevra OCP</b>	SECL, Chhattisgarh	Slope mass rating & geotechnical testing	Weathered shale led to progressive failures near dump toes.
4	<b>Lakhanpur OCP</b>	MCL, Odisha	FLAC2D modelling & inclinometer data	Failure surfaces developed within loose OB layers during monsoon.
5	<b>Noamundi Iron Mine</b>	Tata Steel, Jharkhand	Limit equilibrium with groundwater coupling	FoS is sensitive to pore pressure buildup during wet season.
6	<b>Jayant OCP</b>	NCL, Madhya Pradesh	Drone survey & empirical design	Outer dump stability improved by maintaining bench width ratio 1:1.5.
7	<b>Kalinga OCP</b>	MCL, Odisha	Shear box testing & slope modelling	Weak clay seams within dump material caused circular slips.
8	<b>Singrauli Coalfield</b>	NCL, M.P.	Rainfall-infiltration coupled simulation	Heavy rainfall episodes increased pore pressure by 30-40%.



Sl. No.	Mine	Location	Study Approach	Key Findings
9	Jhingurdah OCP	NCL, M.P.	Field instrumentation & limit equilibrium	Post-blast vibration amplified minor tension cracks.
10	Talcher OCP	MCL, Odisha	Long-term dump monitoring	Surface runoff channels were obstructed, accelerating erosion at toes.
11	Kusmunda OCP	SECL, Chhattisgarh	FLAC3D simulation	Progressive failure during the dump extension phase was observed at height > 90 m.
12	Rajmahal OCP	ECL, Jharkhand	Limit equilibrium + field FoS verification	Old internal dump had FoS < 1.1 due to poor compaction.

Table 2: Stages in Waste Dumps: Geotechnical Concerns

## 1. Excavation Method

Excavation Equipment	Key Effects	Geotechnical Implications
<b>Bulldozer (Ripping)</b>	Increased material breakdown under repeated trafficking	<ul style="list-style-type: none"> <li>• Reduced strength</li> <li>• Lower permeability</li> <li>• Higher susceptibility to rainfall-induced degradation</li> </ul>
<b>Shovel-Excavator-Dragline (Digging)</b>	<ul style="list-style-type: none"> <li>• Well-graded waste, soil to coarse rock</li> <li>• Larger block size</li> </ul>	<ul style="list-style-type: none"> <li>• Increased shear strength</li> <li>• Improved long-term durability with coarser particles</li> </ul>
<b>BWE / Continuous Miner (Cutting, digging, chipping)</b>	<ul style="list-style-type: none"> <li>• More uniform particle size</li> <li>• Finer overall gradation</li> </ul>	Increased permeability

## 2. Transportation

Transport System	Key Effects	Geotechnical Implications
<b>Dragline</b>	<ul style="list-style-type: none"> <li>• Very short haul distance</li> <li>• Minimal rehandling breakdown</li> </ul>	<ul style="list-style-type: none"> <li>• Minimal impact</li> <li>• Slight strength reduction due to any rehandling</li> </ul>
<b>Truck</b>	<ul style="list-style-type: none"> <li>• Smaller particle size due to excavation/crushing</li> <li>• Vibration effects during haulage</li> <li>• Material exposed unless covered</li> </ul>	Potential for liquefaction when transporting fine, cohesive, moisture-rich materials, particularly under rainfall
<b>Conveyor</b>	<ul style="list-style-type: none"> <li>• Consistent particle fragmentation</li> <li>• Mechanical vibration</li> <li>• Open transport unless enclosed</li> </ul>	Minimal effects; material condition largely unchanged



### 3. Dumping

Dumping Method	Key Effects	Geotechnical Implications
<b>Spreader</b>	<ul style="list-style-type: none"> <li>• Geometric constraints cause dumping above/below the equipment</li> <li>• Dynamic loading of dump face</li> <li>• Rapid advance of dump</li> <li>• Poor selectivity</li> <li>• Used in some operations to avoid active dump failure under spreader</li> </ul>	<ul style="list-style-type: none"> <li>• Highly susceptible to local instability</li> <li>• Potential rapid flow slides</li> <li>• Settlement and trafficability issues</li> <li>• Pore-pressure build-up from rapid loading</li> <li>• Difficult to segregate materials, affecting dump quality</li> </ul>
<b>Truck Dumping</b>	<ul style="list-style-type: none"> <li>• Different materials form different repose angles</li> <li>• Crest settlement</li> </ul>	<ul style="list-style-type: none"> <li>• Over-steepened upper slope may fail</li> <li>• Risk of trucks reversing over dump edge</li> </ul>
<b>Dozer (Dumped &amp; Dozed)</b>	Designed to eliminate issues from truck dumping	Minimal impact due to controlled placement
<b>Dragline Dumping</b>	<ul style="list-style-type: none"> <li>• Sequential dumping allows partial selectivity</li> <li>• Extended bench dumping possible</li> <li>• Tight geometric constraints</li> </ul>	<ul style="list-style-type: none"> <li>• Material compaction</li> <li>• Compaction of spoil toe</li> <li>• Poor-quality material placed deeper</li> <li>• High vulnerability to failure</li> </ul>

**Table 3: List of Factors Affecting Waste Dump Slope Stability**

Category	Parameter	Description / Influence on Stability
<b>1. Geometrical Parameters</b>	<b>Slope Height (H)</b>	Greater dump height increases driving forces, leading to higher failure potential unless properly benched.
	<b>Slope Angle (<math>\beta</math>)</b>	Steeper slopes reduce the factor of safety; the optimal design angle depends on material shear strength.
	<b>Bench Width and Berm Spacing</b>	Adequate berms reduce runoff, catch rockfalls, and provide drainage; narrow benches promote erosion and instability.



Category	Parameter	Description / Influence on Stability
<b>2. Material and Geotechnical Properties</b>	<b>Cohesion (c)</b>	Acts as a binding force between particles; loss of cohesion (e.g., due to saturation) lowers stability.
	<b>Internal Friction Angle (<math>\phi</math>)</b>	Defines shear resistance; higher values improve dump stability.
	<b>Unit Weight / Bulk Density (<math>\gamma</math>)</b>	Heavier material generates greater downslope stress; lighter materials improve stability margins.
<b>3. Hydrogeological Factors</b>	<b>Pore Water Pressure (u)</b>	High pore pressure reduces effective stress, decreasing shear strength and promoting slip.
	<b>Unsaturated Suction (<math>\psi</math>)</b>	Negative pore pressure in unsaturated zones increases apparent cohesion and short-term stability.
<b>4. Geological and Foundation Conditions</b>	<b>Foundation Geology</b>	Weak or weathered bedrock, sheared zones, or clay layers beneath dumps can act as failure planes.
	<b>Subsurface Discontinuities</b>	Bedding planes, joints, and faults can localize shear movement and failure initiation.
<b>5. External and Environmental Factors</b>	<b>Blasting Vibration</b>	Dynamic loading from mine blasts induces transient pore pressure rise and progressive slope weakening.
	<b>Rainfall and Infiltration</b>	Intense rainfall saturates dump materials, raises pore pressure, and accelerates erosion.
	<b>Seismic Acceleration</b>	Earthquakes impart inertial forces and cyclic loading, triggering deep-seated failures.
<b>6. Operational and Management Factors</b>	<b>Dump Construction Sequence</b>	Bottom-up vs. top-down deposition affects compaction, drainage, and stability evolution.
	<b>Drainage and Surface Runoff Control</b>	Proper drainage channels and toe drains prevent water accumulation, reducing failure risk.



## Design Considerations For Waste Rock Dump Management

Mine waste management is a fundamental component of any surface or underground mining operation, as the volume of overburden, interburden, and waste rock generated during extraction is often significantly larger than the quantity of valuable mineral recovered. The safe and sustainable handling of this material requires systematic planning, sound engineering judgment, and careful environmental consideration. Waste dumps must be designed not only to store large volumes of material but also to remain stable throughout the life of the mine and beyond closure. A well-designed waste dump minimises environmental degradation, reduces the risk of slope failure, and facilitates future reclamation. Therefore, waste dump design integrates geotechnical, hydrological, environmental, and operational aspects into a unified framework. The first and most critical step in the waste dump design process is site selection. The choice of location has a direct influence on the long-term stability of the dump and its environmental impact. An unsuitable site may lead to excessive pore water pressure, erosion, or contamination of nearby water resources. Consequently, site selection must be carried out through a comprehensive evaluation of topography, geological conditions, hydrology, land use,

and ecological sensitivity. Areas with stable foundations, gentle slopes, and minimal environmental constraints are generally preferred. The aim is to identify a location where the dump can be constructed safely with minimal risk to surrounding ecosystems and infrastructure. One of the primary environmental considerations in site selection is the avoidance of stream drainages and groundwater discharge zones. Placing a waste dump in natural drainage channels can obstruct water flow, alter hydrological patterns, and increase the likelihood of contamination. During rainfall, water flowing through the dump can generate leachate, which may contain suspended solids, dissolved salts, heavy metals, or acid-forming compounds. If such leachate enters surface water or groundwater systems, it can lead to acid mine drainage and long-term environmental damage. Therefore, dump sites should be located away from perennial or seasonal streams, wetlands, and groundwater emergence zones. Proper buffer zones should be maintained to prevent any direct interaction between waste materials and natural watercourses. Hydrogeological evaluation is another essential component of site selection. A detailed study of groundwater conditions helps determine the direction of groundwater flow, the depth to the water table, and the permeability of the underlying strata. These factors influence



the potential for seepage through the waste dump and the development of pore water pressure within the waste mass. High pore pressure reduces the effective stress in the material and can lead to slope instability. Therefore, hydrogeological investigations should include borehole data, piezometric measurements, and permeability tests. The results of these studies assist engineers in selecting appropriate locations and designing effective drainage systems to control water movement. Water management is one of the most critical factors affecting the stability of waste dumps. Uncontrolled water infiltration can weaken the waste material, increase erosion, and trigger slope failures. Therefore, the design of an efficient drainage system is essential to ensure the structural integrity of the dump. Surface water must be diverted away from the dump to prevent excessive infiltration. This is typically achieved by constructing diversion channels, contour drains, and catch drains around the dump perimeter. These structures guide runoff safely around or away from the dump area, thereby reducing the risk of erosion and internal saturation. In cases where the dump is located in a valley or on a side slope, special attention must be given to the management of natural drainage paths. Water flowing down a valley should be safely conveyed either around the dump or through a controlled drainage structure. Properly

designed diversion channels prevent the accumulation of water within the waste mass and minimise the risk of instability. The design of such channels should consider expected rainfall intensity, catchment area, and peak discharge rates to ensure adequate capacity during extreme weather events. The construction materials used in drainage systems must also be carefully selected. Drains should be composed of durable, non-slaking materials that can withstand prolonged exposure to water without degradation. Slaking materials tend to disintegrate when wet, which may lead to blockage or collapse of drainage structures. Coarse gravel, crushed rock, or other stable aggregates are commonly used because of their high permeability and resistance to erosion. These materials allow water to flow freely while maintaining the structural integrity of the drainage system. In valley fill dumps, maintaining natural stream flow is particularly important. When a waste dump crosses a natural drainage channel, a rubble drain or underdrain system is typically constructed at the base of the dump. This structure consists of a trench filled with coarse, permeable rock that allows water to pass through the dump without causing internal erosion or instability. The rubble drain must be designed to accommodate peak storm flows and prevent clogging. Adequate capacity ensures that water does not



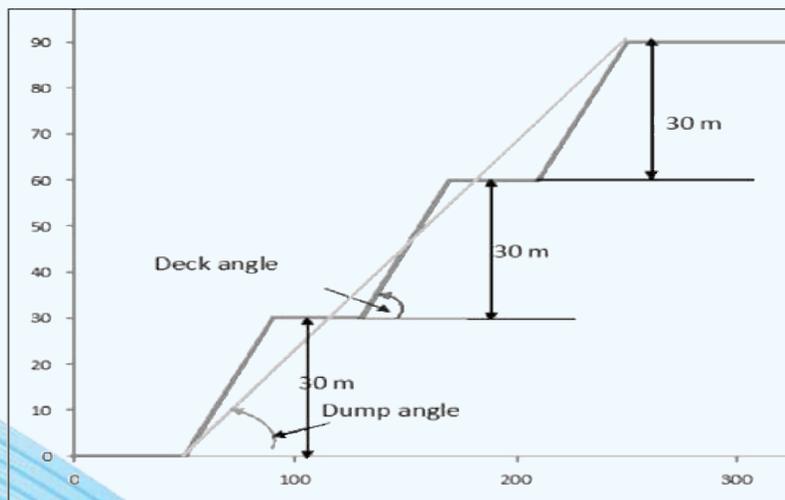
accumulate within the dump, which could otherwise lead to increased pore pressure and potential failure. Geotechnical stability is a central aspect of waste dump design. The stability of a dump depends on factors such as material properties, slope geometry, foundation conditions, and water content. Proper design aims to ensure that the factor of safety against slope failure remains within acceptable limits throughout the life of the dump. This requires careful consideration of the mechanical properties of the waste material, including its shear strength, density, and compaction characteristics. Grading and contouring play a significant role in enhancing the stability of the dump. The overall slope angle must be selected based on the angle of repose of the waste material and the results of stability analyses. Gentle slopes reduce the driving forces acting on the dump and improve its resistance to sliding. Benching is often adopted in large dumps to break up long slope faces and reduce the potential for large-scale failures. Each bench acts as a catchment area for falling material and provides access for maintenance and reclamation activities. The placement of suitable materials at the base and toe of the dump is another important design consideration. Coarse, durable rock placed at the base improves drainage and reduces the buildup of pore water pressure within the dump. This material acts as a drainage layer, allowing water to escape from the

waste mass. At the toe, strong and stable materials provide additional support against sliding forces. This approach improves the overall stability of the structure and reduces the risk of foundation failure. Geotechnical failure analysis is an essential step in the design process. Stability analyses should be carried out using appropriate methods such as limit equilibrium or numerical modelling techniques. These analyses evaluate potential failure surfaces and calculate the factor of safety under different loading and environmental conditions. Both short-term and long-term stability must be assessed, considering factors such as rainfall infiltration, seismic activity, and changes in material properties over time. Foundation analysis is particularly important for large or high dumps. The strength and compressibility of the underlying soil or rock determine whether the foundation can support the load imposed by the waste material. Weak or compressible foundations may undergo settlement or shear failure, leading to instability of the entire dump. Therefore, geotechnical investigations should include soil sampling, laboratory testing, and in situ tests such as standard penetration tests or plate load tests. The results help engineers determine whether ground improvement measures, such as compaction or reinforcement, are required. In addition to structural stability, waste dump design



must consider long-term reclamation and environmental sustainability. The final dump profile should be shaped to blend with the natural landscape and facilitate revegetation. Topsoil or growth media should be placed on the dump surface to support plant growth. Proper drainage and slope design reduce erosion and help establish a stable vegetative cover, which in turn improves the long-term stability of the dump. Safety considerations must also be integrated into the design. Safe working distances from the dump toe, proper haul road alignment, and adequate bench widths are essential for preventing accidents during dumping operations. Monitoring systems, such as slope movement sensors or piezometers, may be installed to detect early signs of instability. Regular inspections and maintenance of drainage systems further enhance safety. In summary, the design of mine waste dumps requires a comprehensive approach that combines environmental awareness with

geotechnical engineering principles. Careful site selection, effective water management, proper slope geometry, and detailed stability analyses are essential for ensuring the safety and sustainability of waste dumps. By integrating these considerations into the design process, mining operations can minimise environmental impacts, reduce the risk of failure, and create stable landforms suitable for future reclamation. Figure 1 recommended profile design of the waste dump showing slope geometry and bench configuration. Figure 2 schematic plan illustrating the safe working area maintained from the dump toe. Figure 3 schematic cross-section showing the safe working distance from the dump toe. Figure 4 placement of coarse durable materials at the base and toe to improve internal drainage and reduce pore pressure. Figure 5 suggests relationship between waste dump slope angle and the effectiveness of revegetation.



**Figure 1:** Recommended Design of Waste Dump

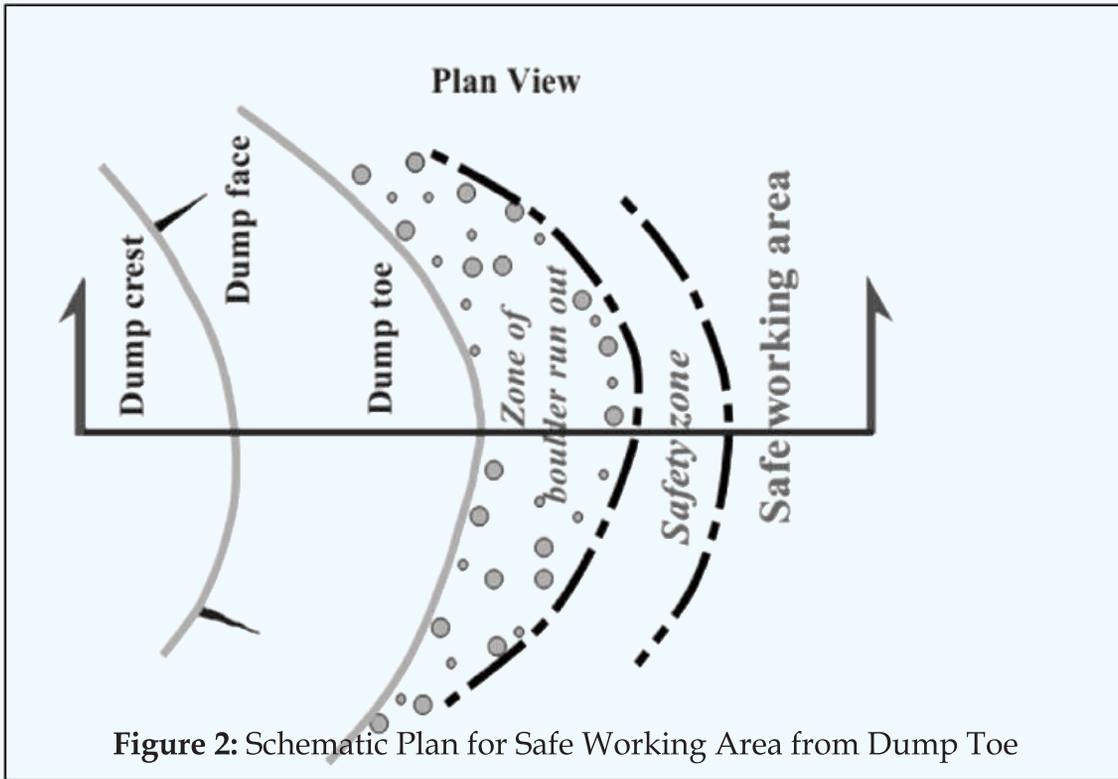


Figure 2: Schematic Plan for Safe Working Area from Dump Toe

Figure 2: Schematic Plan for Safe Working Area from Dump Toe

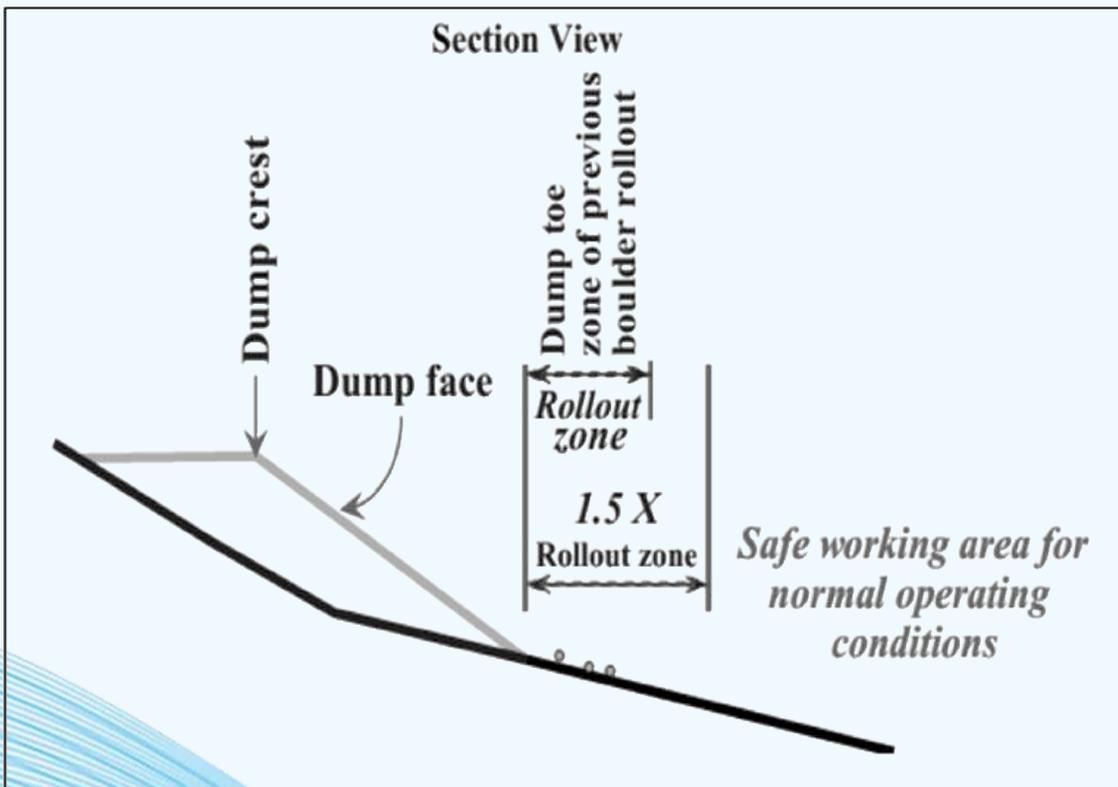


Figure 3: Schematic Section for Safe Working Area from Dump Toe

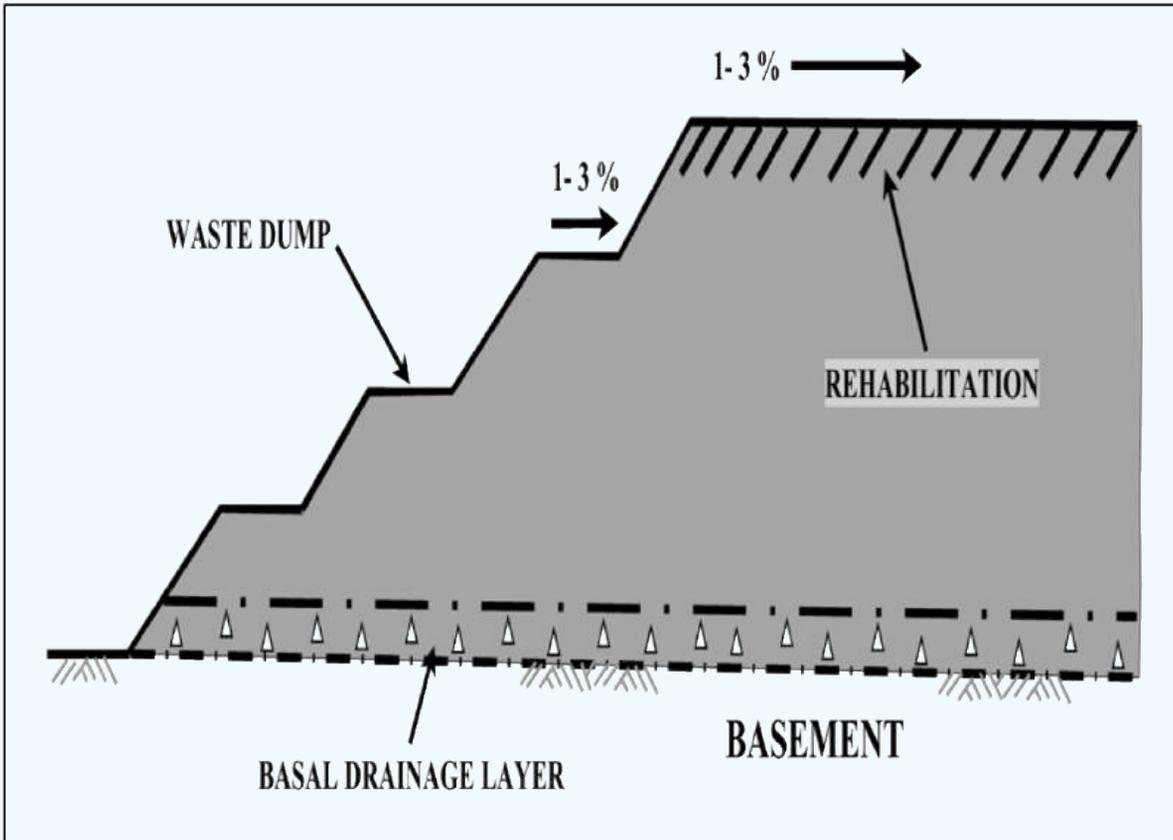


Figure 4: Sketch Showing the Control Measures

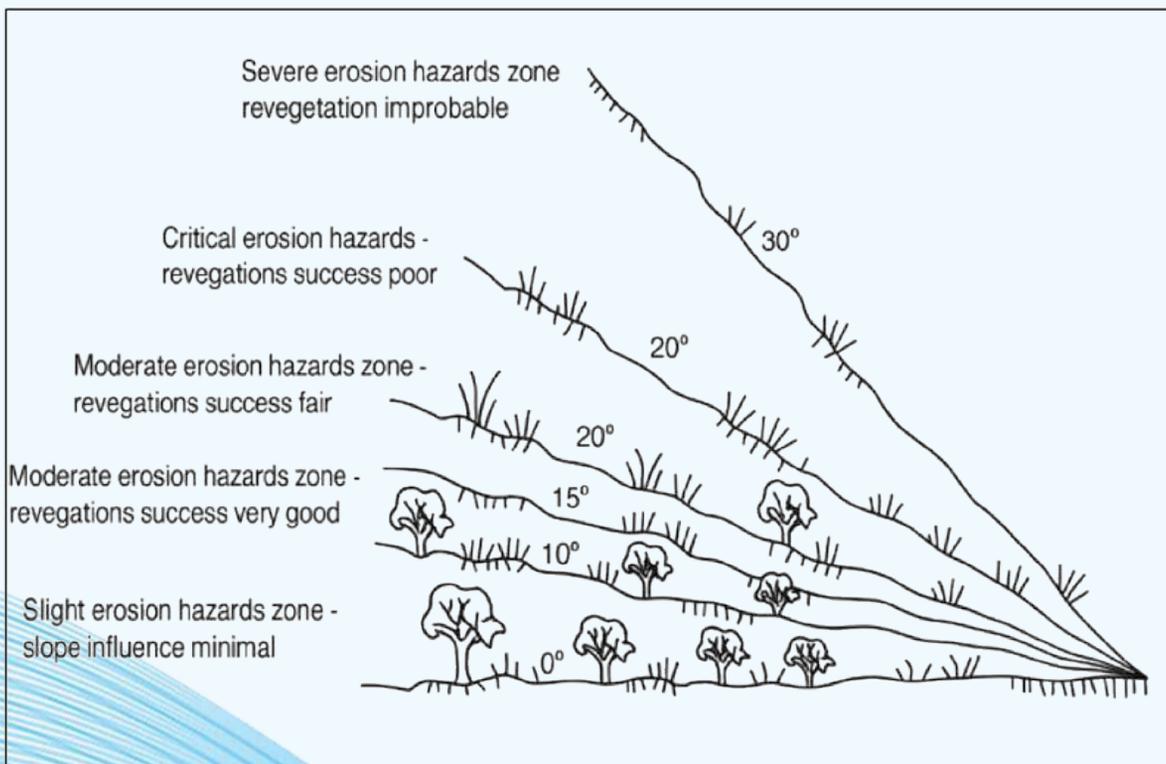


Figure 5: Relationship Between the Angle of Dump Slope and Efficiency of Revegetation



### Safety Requirements for Waste Dumps

For waste dumps, it is essential to calculate the factor of safety (FoS) related to mass stability, water infiltration, and potential for erosion. These calculations should include the assessment of the FoS, which measures the stability of the waste dump by comparing the forces resisting failure with the forces promoting failure. At the present state of the mass, the latter is balanced by the shear stress acting along the possible failure surface.

$$\text{Factor of Safety} = \frac{\text{Maximum resisting force (strength)}}{\text{Driving force (acting stress)}}$$

from that:

- (a) For  $\text{FoS} > 1$ , the strength exceeds the stress, the slope is stable;
- (b) For  $\text{FoS} \leq 1$ , the stress exceeds the strength, the slope is unstable.

Waste dump benches should be constructed to allow for the mass settling of the dump. These benches provide areas where the material can settle without increasing the risk of slope failure. Additionally, they can help improve drainage and stabilise the dump structure by distributing the load more evenly. Hawley and Cuning (2017) acknowledged the significance of design confidence when creating Design Acceptance Criteria (DAC) for waste rock dumps (Figure 6).

		Consequence Category		
		Low	Moderate	High
Design Confidence	Low	FoS 1.3-1.4 PoF 10-15%	FoS 1.4-1.5 PoF 2.5-5%	FoS $\geq 1.5$ PoF $\leq 1\%$
	Moderate	FoS 1.2-1.4 PoF 15-25%	FoS 1.3-1.4 PoF 5-10%	FoS 1.4-1.5 PoF 1-2.5%
	High	FoS 1.1-1.2 PoF 25-40%	FoS 1.2-1.3 PoF 10-15%	FoS 1.3-1.4 PoF 2.5-5%

**Figure 6:** DAC for Waste Rock Dumps by Hawley and Cuning (2017)



**DGMS Guidelines for Waste Dump Management in Indian Metalliferous Opencast Mines** - Waste dump management and slope stability assessment are critical components of safe and sustainable opencast mining in India. Metalliferous mines generate large volumes of overburden (OB), interburden, and rejects, which are commonly placed in external or internal dumps. These dumps, if improperly designed or monitored, can fail through mechanisms such as rotational slip, planar failure, flow slides, and foundation failure. In response to a series of slope-failure-related accidents and the increasing scale of mechanised mining, the Directorate General of Mines Safety (DGMS) has issued multiple technical circulars to regulate systematic design, operation, and monitoring of pit and dump slopes. The literature on mine slope safety in India is therefore strongly anchored around DGMS (Tech) circulars, scientific studies as mandated under the Coal Mines Regulations (CMR) 2017 and Metalliferous Mines Regulations (MMR), national standards, and international best practices. The following sections consolidate and synthesise DGMS guidelines applicable to waste dump management and slope monitoring in metalliferous opencast mines, with emphasis on the most recent circulars: DGMS (Tech) Circulars 02/2001, 02/2010, 02/2020, 03/2020, and Regulation 106 of CMR 2017, all of which serve as reference documents for scientific design and operational safety in both coal and non-coal opencast mines.

**DGMS (Tech) (S&T) Circular No. 2 of 2001: Slope Failure Prevention in**

**Opencast Mines** - The earliest consolidated regulatory guideline on slope stability is the DGMS (Tech) (S&T) Circular No. 2 of 2001, issued after a series of fatal slope collapses in coal mines. Although primarily aimed at coal operations, the circular formed the foundation for slope design requirements in all opencast mines, including metalliferous operations. The circular highlights that slope failures occur primarily because of inadequate design, unscientific working methods, and lack of monitoring. It stresses that both pit slopes and external waste dump slopes must be designed according to geotechnical principles such as shear strength assessment, bench geometry optimisation, and hydrogeological control. In the context of metal mines, these principles remain relevant due to the inherently heterogeneous nature of waste rock, which often exhibits variable fragmentation, angularity, and weathering characteristics. The circular establishes two central principles: (1) Scientific slope design must precede development of benches, haul roads, or dumps. (2) Continuous monitoring must be integrated into daily mine operations to identify precursors of slope instability. This document laid the foundation for subsequent DGMS circulars and encouraged Indian mining industries to adopt geotechnical engineering as a mandatory discipline in mine planning.

**DGMS (Tech) Circular No. 02 of 2010: Design, Control, and Monitoring of Pit and Dump Slopes** - With increasing mechanisation and deeper opencast mines, DGMS issued Circular No. 02 of 2010, which remains the most influential



guideline for slope stability in India. It specifically addresses the complex geomechanical environment of deep excavations and large waste dumps. **Scientific Slope Design Requirements** - The circular mandates that slope design should be supported by: Geomechanical classification of rock masses; Shear strength testing of dump material and foundation strata; Slope stability numerical modelling using analytical or advanced numerical tools; Hydrogeological investigations and pore-water pressure estimation; and Bench design parameters (height, width, face angle, inter-ramp angle) tailored to site conditions This is particularly relevant for metal mines, where dump materials may include hard rock fragments, clay seams, lateritic soils, and weathered ore, leading to zones of variable shear strength and potential weakness. **Waste Dump Hazards and Risks** - The circular identifies specific hazards associated with waste dumps: Alteration of stress distributions due to progressive loading; Steep dump slopes without compaction or controlled placement; Excessive height leading to overstressing of foundation material; Poor segregation of weak and strong materials; and Water ingress and build-up of pore pressures. These hazards are commonly observed in Indian metalliferous mines where the annual excavation output may exceed tens of millions of tonnes. **Monitoring Protocols** - The circular deployment of systematic monitoring, including: Regular surveying of slope profiles; Visual inspection for cracks, tension gaps, subsidence, or oversteepening; Installation of piezometers, inclinometers, settlement markers, and

prism monitoring systems; Evaluation of rainfall data and seepage patterns. These circular forms cornerstone for monitoring programs in large metal mines today.

**DGMS (Tech) Circular No. 02 of 2020: Systematic Slope Monitoring Guidelines -**

Recognising rapid technological advancements, DGMS published Circular No. 02 of 2020, providing updated and highly detailed requirements for slope monitoring in both coal and metalliferous opencast mines. **Deployment of Slope Monitoring Systems** - Every mine must implement a slope monitoring system tailored to site-specific geological and operational conditions. The system should define: Instrumentation types: prisms, total stations, radar-based systems (SSR/TLS), LiDAR, piezometers, extensometers; Monitoring frequency: continuous (automated) or periodic; Data acquisition and interpretation methodology; Pattern and layout of monitoring stations; Organisational hierarchy for monitoring responsibilities. Metal mines with high benches, deep pits, and large external dumps increasingly rely on Slope Stability Radar (SSR) and Real-Time Total Station (RTTS) systems as recommended in this circular. **Trigger Action Response Plans (TARP)** - The circular mandates defining customised trigger levels, commonly: Normal Condition; Warning Level; and Withdrawal Level (Emergency). Each trigger level must be linked with specific operational actions, forming a complete TARP. This structured approach has significantly improved slope risk management in India's large metal mines such as those producing iron ore,



manganese, bauxite, and chromite.

**DGMS (Tech) Circular No. 03 of 2020: Scientific Studies under Regulation 106** - Circular 03 of 2020 supplements the regulatory framework by detailing the requirements for scientific studies widely followed by metalliferous mines as best practice. **Mandatory Scientific Study Components** - Before beginning mechanized opencast operations, the owner/agent must ensure that: Ultimate pit slopes and dump slopes are scientifically designed; The method of working, including benching, haulage layout, and dumping strategy, is scientifically validated; A comprehensive slope monitoring plan is included; and The study report is kept available at the mine office for DGMS inspection. Minimum Factor of Safety (FoS) - DGMS mandates minimum FoS values: 1.50 for permanent/long-standing slopes; and 1.30 for temporary slopes or intermediate benches. These FoS requirements are crucial for metalliferous mine dumps, which often rely on steep engineered slopes to optimise space.

**Applicability to Metalliferous Mines** - It requires: Scientific design of all opencast workings, including dumps; Compliance with safety precautions listed in sub-regulations; Ensuring that all slope-related recommendations from scientific studies are implemented; and Continuous monitoring and documentation. Metal mines adopt these requirements to align with DGMS and maintain uniform standards for opencast slope stability across mineral sectors.

**Numerical Modelling (Finite Difference Method)** - Numerical modelling using the Finite Difference Method (FDM) provides an advanced approach to analysing dump slope behaviour under varying geological and environmental conditions. Software such as FLAC<sup>2D</sup> allows for simulating stress-strain responses, pore pressure evolution, and progressive failure mechanisms within heterogeneous dump materials. The model incorporates realistic boundary conditions, such as fixed bases and free lateral boundaries, to replicate in-situ conditions.

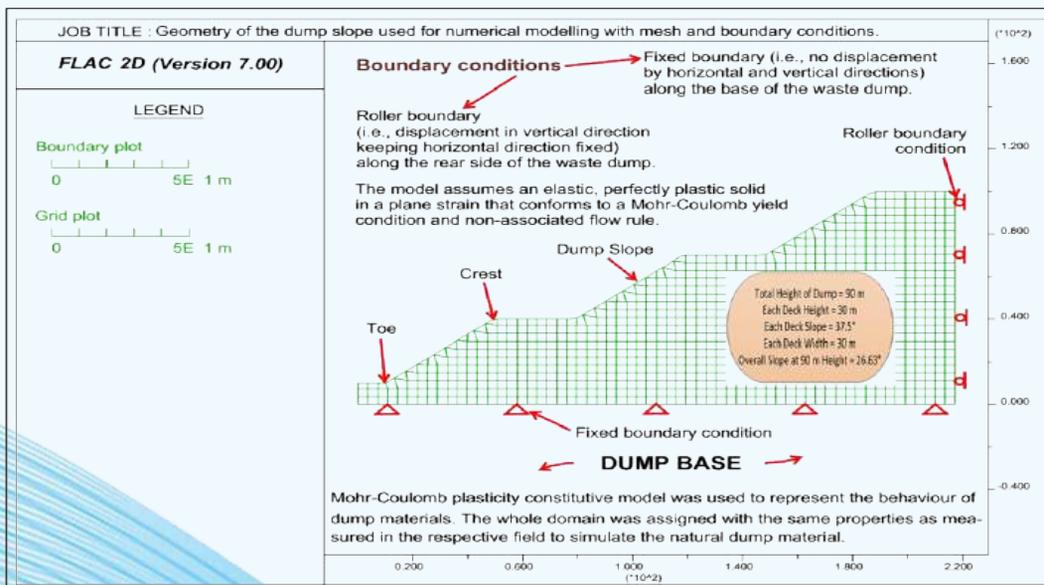


Figure 7: Dump Slope Geometry, Mesh Layout, and Applied Boundary Conditions



Figure 7 illustrates the representative dump slope geometry, including the mesh configuration and boundary zones used for computation. Material properties are defined based on laboratory and field data - cohesion, friction angle, density, and permeability. Simulations enable assessment of Factor of Safety (FoS), potential failure surfaces, and deformation patterns. Numerical frameworks are invaluable for evaluating design alternatives, optimising slope geometry, and validating field observations, ensuring the stability and long-term performance of waste dumps in large opencast mines.

### Conclusion

The design and stability assessment of mine waste dumps represent a complex geotechnical challenge that requires the integration of material characterisation, slope geometry, hydrological control, construction practices, and environmental considerations. In Indian opencast mining conditions, where large volumes of heterogeneous overburden materials are generated and intense monsoonal rainfall is common, the stability of waste dumps becomes a critical safety and environmental concern. The findings discussed across the preceding sections highlight that dump stability is governed by a combination of material properties, construction methods, drainage efficiency, foundation conditions, and external dynamic influences. The geotechnical properties of dump materials play a primary role in determining slope behaviour. Overburden materials in Indian mines are inherently heterogeneous,

consisting of varying proportions of shale, sandstone, clay, laterite, and weathered rock. This variability leads to differences in density, shear strength, permeability, and compaction characteristics. Particle-size distribution and mineralogical composition strongly influence both short-term and long-term stability. Coarse materials contribute to higher shear strength and better drainage, whereas fine-grained clayey components tend to retain moisture, develop excess pore pressure, and reduce effective stress. The reduction in shear strength under saturated conditions, particularly during monsoon periods, remains one of the most significant causes of dump instability. Therefore, proper characterisation of material properties and moisture-dependent strength parameters is essential for realistic stability evaluation. Moisture and seepage conditions are equally important in governing dump performance. Rainfall infiltration, groundwater fluctuations, and poor drainage arrangements can lead to elevated pore water pressures within the dump mass. The presence of low-permeability layers or perched water tables further aggravates instability by creating localised saturated zones. These conditions reduce effective stress and promote the development of slip surfaces, especially near the dump toe. Field observations across several Indian coalfields indicate that a large proportion of dump failures occur during or immediately after intense rainfall events. Consequently, effective drainage design, including surface diversion systems, toe drains, contour



drains, and subsurface drainage layers, is essential for maintaining a stable hydrological regime within the dump. Geometric and structural parameters also exert a strong influence on stability. Dump height, overall slope angle, bench configuration, and berm width collectively determine the stress distribution and potential failure mechanisms. Empirical and numerical analyses consistently show that increases in slope angle significantly reduce the factor of safety. In Indian conditions, maintaining overall slope angles between 26° and 32° for high dumps has proven effective when combined with adequate compaction and drainage. Proper benching and berm design interrupt potential failure surfaces, facilitate runoff control, and provide safe access for inspection and maintenance. Additionally, the strength and compressibility of the foundation must be carefully evaluated, as weak subgrades can lead to differential settlement or rotational failure. Foundation treatment measures such as drainage, compaction, and reinforcement are often required to ensure safe load transfer. Construction methods and compaction practices significantly affect the internal structure and long-term performance of waste dumps. End-dumping, although operationally convenient, produces loose and heterogeneous deposits with high void ratios and low shear strength. Such dumps are more susceptible to saturation-induced failures and long-term settlement. In contrast, layered or controlled dumping, combined with systematic compaction, results in higher density, improved shear

strength, and reduced permeability. Field studies indicate that proper compaction can increase the factor of safety by a substantial margin, highlighting the importance of construction control. Staged dumping further enhances stability by allowing consolidation, pore pressure dissipation, and continuous monitoring during progressive construction. Hydrological and climatic factors, particularly monsoonal rainfall, dominate the stability scenario in Indian surface mines. Intense rainfall leads to rapid infiltration, increased pore pressures, and erosion of dump surfaces. Changes in groundwater levels and phreatic surfaces alter internal moisture distribution, often triggering progressive deformation and eventual slope failure. The incorporation of comprehensive drainage systems, surface protection measures, and regular monitoring of pore pressure and deformation is therefore essential for long-term stability. Numerical analyses have demonstrated significant reductions in factor of safety under saturated conditions, emphasising the need for conservative design approaches that account for worst-case hydrological scenarios. Dynamic and seismic effects represent another important consideration, especially in regions falling within higher seismic zones. Earthquake-induced inertial forces and vibrations from blasting operations can reduce the factor of safety and initiate slope movements. Although such effects are generally short-lived, their cumulative impact on already marginally stable slopes can be significant. Incorporating pseudo-static or dynamic



analyses into the design process helps ensure adequate resilience against these disturbances. Material heterogeneity and internal structural variations further complicate stability assessment. Stratification, differential compaction, and the presence of expansive clay minerals can lead to localised weaknesses and progressive failure mechanisms. Cyclic wetting and drying conditions exacerbate these effects, particularly in clay-rich materials. Detailed field investigations, laboratory testing, and appropriate numerical modelling are therefore essential to capture the complex behaviour of heterogeneous dump materials. Vegetation and reclamation practices contribute to the long-term stability and environmental sustainability of waste dumps. Properly established vegetation reduces surface erosion, improves near-surface shear strength, and enhances ecological recovery. However, reclamation must be carefully planned to prevent excessive infiltration through root channels. Engineered capping systems, combined with bioengineering techniques, provide an effective solution by balancing mechanical stability with environmental restoration.

Overall, the stability of mine waste dumps is not governed by a single factor but by the interaction of multiple geotechnical, hydrological, geometric, and operational parameters. A systematic and integrated approach to design and monitoring is therefore essential. This includes detailed material characterisation, appropriate slope geometry, controlled construction

practices, effective drainage systems, and continuous geotechnical monitoring. Numerical modelling tools, such as limit equilibrium and finite difference methods, provide valuable insights into stress-strain behaviour and failure mechanisms, enabling more reliable design decisions. In conclusion, safe and sustainable waste dump management requires a holistic geotechnical framework that integrates engineering principles with environmental and operational considerations. By adopting controlled dumping practices, ensuring proper drainage, optimising slope geometry, and incorporating real-time monitoring, mining operations can significantly reduce the risk of dump failures. Such an approach not only enhances worker safety and operational continuity but also supports long-term environmental reclamation and regulatory compliance. The application of these principles is particularly crucial in Indian mining conditions, where high dump heights, heterogeneous materials, and intense monsoonal influences demand robust and scientifically grounded design methodologies. As metalliferous mines continue to deepen and expand, adherence to the DGMS guidelines will remain critical for long-term mine stability and operational safety.

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## DESIGN AND SAFETY ASSESSMENT APPROACH FOR MINE WASTE DUMPS

Prashant Kumar Nayak

### Abstract

The stability of overburden (OB) and waste dump slopes remains one of the most crucial geotechnical issues in surface mining operations, especially in Indian opencast coal and metal mines. This comprehensive literature review evaluates the multidimensional factors influencing dump slope stability and synthesises findings focusing on the Indian context. Material characteristics – such as grain size distribution, cohesion, internal friction angle, density, and moisture retention – play a fundamental role in determining the shear strength of dump materials. Geometric factors, including overall slope angle, bench configuration, and dump height, further influence the internal stress regime and potential slip surfaces. Hydrological factors are especially critical in Indian conditions, where intense monsoon rainfall elevates pore water pressures and reduces effective stress, thereby triggering slope failures. Additional aspects such as seismic loading, vegetation cover, and construction methodology, including dumping rate and compaction practices, also contribute significantly to stability outcomes. Numerical modelling techniques using

FLAC and FLAC/Slope have become essential tools for predicting dump performance under varied load, moisture, and geometric conditions. Parametric analyses and calibrated models based on field data provide a more realistic estimation of the factor of safety and failure mechanisms. Figures and tabulated summaries presented in this study enhance understanding of critical factors and demonstrate practical approaches for ensuring long-term stability and sustainable waste dump management in Indian surface mining operations.

### Introduction

In many mining projects, more environmental damage results from waste rock disposal than any other component of the operations. It is also usually the most visible component. The area occupied by waste rock storages commonly represents a large part of the project 'footprint', often much more extensive than the mine itself. In an open pit mine, the overall stripping ratio is determined by the dimensions and geometry of the ore body, the value of the ore and the shape of the pit, which itself may be determined by slope stability

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considerations. The phrase "mine waste dump" refers to waste/overburden material that has been mined/excavated and moved primarily by truck and by other means of transport/transportation systems, either to the mined-out area or outside the final/ultimate pit boundary, and is then discharged/deposited to form large dumps. These loose waste/overburden materials produced during mining operations are known as internal overburden dump when backfilled into the mined-out regions and as external waste dumps when placed outside the pit area. Under specific mining and geological circumstances (horizontal or flatly lying deposits up to 100), internal dumps are usually generated using transportless mining techniques. Stripping costs for internal dumping on equipment and dump re-handling are significantly higher than those for external dumps. The successful completion of the mining operation as well as the subsequent restoration and reclamation of the mined-out area and waste dumps are directly and significantly impacted by the handling of such overburden/waste materials produced during open-pit mining. Loose open-pit waste dump planning, design, construction, and layout, as well as the process of disposing of them, are crucial and integral parts of surface mine (open pit/opencast/quarry, etc.) planning and the unit operations, and these are as important as that of the open-pit mine proper, as they have a significant impact on the cost of production and safety (Mukhopadhyay, 1988).

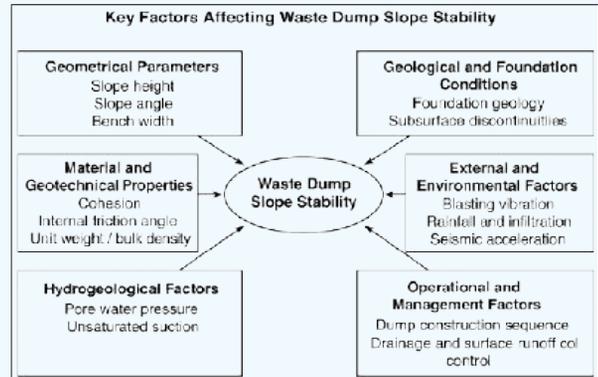


Figure 1: Showing the interaction of key factors in a stability framework

The following objectives apply in planning the storage and disposal of waste rock to minimise environmental damage (Kesler & Simon, 2015):

- ◆ The area occupied by the waste rock storage (i.e., its 'footprint') should be minimised in so far as this is consistent with other objectives;
- ◆ The new landform created by the waste rock storage should be consistent with its future land use(s), in terms of slopes, accessibility, surface roughness;
- ◆ The new landform should be stable;
- ◆ The new landform should not be any more erodable than comparable natural landforms in the vicinity;
- ◆ If the waste rock includes materials that have the potential to generate acid drainage, the storage should be designed to prevent or control this occurrence (e.g., avoidance of run-off from upstream catchment areas);
- ◆ The surface of the waste rock storage should be amenable to rehabilitation, consistent with its future land use(s); and
- ◆ If possible, the new landform should be congruent with its surrounds, meaning that it should not be visually intrusive.

This review synthesises research findings and field observations from 1995 to 2025,



encompassing both coal and metal mining environments. It evaluates key slope failure mechanisms, such as rotational slips, translational slides, and progressive failures, and identifies the dominant influencing factors. By integrating insights from empirical studies, case-based

analyses, and numerical simulations, the review aims to assist geotechnical engineers and researchers in formulating robust, data-driven design and monitoring strategies for safer and more sustainable waste dump management in Indian opencast mines.

**Table 1: Extended Summary of Indian Waste Dump Slope Stability Case Studies**

Sl. No.	Mine / Site	Location	Study Approach / Tools Used	Key Findings	Recommended Mitigation Measures
1	<b>Srirampur OCP-II</b>	SCCL, Telangana	Limit equilibrium & FLAC/Slope modelling	Factor of Safety (FoS) dropped below 1.2 at 45° slope; influenced by moisture increase.	Reduce overall slope to 37°, improve surface drainage, add retaining toe bunds.
2	<b>Sonepur Bazari OCP</b>	ECL, West Bengal	3D numerical analysis & field monitoring	High spoil height (120 m) and poor compaction caused tension cracks.	Layer-wise dumping, compaction by dozers, and installation of piezometers.
3	<b>Gevra OCP</b>	SECL, Chhattisgarh	Slope mass rating & geotechnical testing	Weathered shale led to progressive failures near dump toes.	Maintain minimum FoS > 1.3; vegetation for surface erosion control.
4	<b>Lakhanpur OCP</b>	MCL, Odisha	FLAC2D modelling & inclinometer data	Failure surfaces developed within loose OB layers during monsoon.	Provide drainage trenches, reinforce slope toes with boulder pitching.
5	<b>Noamundi Iron Mine</b>	Tata Steel, Jharkhand	Limit equilibrium with groundwater coupling	FoS is sensitive to pore pressure buildup during wet season.	Construct subsurface drains, monitor groundwater head continuously.
6	<b>Jayant OCP</b>	NCL, Madhya Pradesh	Drone survey & empirical design	Outer dump stability improved by maintaining bench width ratio 1:1.5.	Regrade outer dump slopes; install rock-armored channels.



Sl. No.	Mine / Site	Location	Study Approach / Tools Used	Key Findings	Recommended Mitigation Measures
7	<b>Kalinga OCP</b>	MCL, Odisha	Shear box testing & slope modelling	Weak clay seams within dump material caused circular slips.	Geotextile layers and proper placement of cohesive materials.
8	<b>Singrauli Coalfield</b>	NCL, M.P.	Rainfall-infiltration coupled simulation	Heavy rainfall episodes increased pore pressure by 30-40%.	Early drainage installation and grass turfing to reduce infiltration.
9	<b>Jhingurdah OCP</b>	NCL, M.P.	Field instrumentation & limit equilibrium	Post-blast vibration amplified minor tension cracks.	Limit blast charge per delay; maintain safe distance from dump crest.
10	<b>Talcher OCP</b>	MCL, Odisha	Long-term dump monitoring	Surface runoff channels were obstructed, accelerating erosion at toes.	Regular de-silting of drains and maintaining vegetation covers.
11	<b>Kusmunda OCP</b>	SECL, Chhattisgarh	FLAC3D simulation	Progressive failure during the dump extension phase was observed at height > 90 m.	Dump re-profiling, controlled height sequencing, and installation of drainage benches.
12	<b>Rajmahal OCP</b>	ECL, Jharkhand	Limit equilibrium + field FoS verification	Old internal dump had FoS < 1.1 due to poor compaction.	Regrading, compaction by crawler dozers, and implementation of staged deposition.



Table 2: Comprehensive List of Factors Affecting Waste Dump Slope Stability

Category	Parameter	Description / Influence on Stability
<b>1. Geometrical Parameters</b>	<b>Slope Height (H)</b>	Greater dump height increases driving forces, leading to higher failure potential unless properly benched.
	<b>Slope Angle (<math>\beta</math>)</b>	Steeper slopes reduce the factor of safety; the optimal design angle depends on material shear strength.
	<b>Bench Width and Berm Spacing</b>	Adequate berms reduce runoff, catch rockfalls, and provide drainage; narrow benches promote erosion and instability.
<b>2. Material and Geotechnical Properties</b>	<b>Cohesion (c)</b>	Acts as a binding force between particles; loss of cohesion (e.g., due to saturation) lowers stability.
	<b>Internal Friction Angle (<math>\phi</math>)</b>	Defines shear resistance; higher values improve dump stability.
	<b>Unit Weight / Bulk Density (<math>\gamma</math>)</b>	Heavier material generates greater downslope stress; lighter materials improve stability margins.
<b>3. Hydrogeological Factors</b>	<b>Pore Water Pressure (u)</b>	High pore pressure reduces effective stress, decreasing shear strength and promoting slip.
	<b>Unsaturated Suction (<math>\psi</math>)</b>	Negative pore pressure in unsaturated zones increases apparent cohesion and short-term stability.
<b>4. Geological and Foundation Conditions</b>	<b>Foundation Geology</b>	Weak or weathered bedrock, sheared zones, or clay layers beneath dumps can act as failure planes.
	<b>Subsurface Discontinuities</b>	Bedding planes, joints, and faults can localise shear movement and failure initiation.
<b>5. External and Environmental Factors</b>	<b>Blasting Vibration</b>	Dynamic loading from mine blasts induces transient pore pressure rise and progressive slope weakening.
	<b>Rainfall and Infiltration</b>	Intense rainfall saturates dump materials, raises pore pressure, and accelerates erosion.
	<b>Seismic Acceleration</b>	Earthquakes impart inertial forces and cyclic loading, triggering deep-seated failures.
<b>6. Operational and Management Factors</b>	<b>Dump Construction Sequence</b>	Bottom-up vs. top-down deposition affects compaction, drainage, and stability evolution.
	<b>Drainage and Surface Runoff Control</b>	Proper drainage channels and toe drains prevent water accumulation, reducing failure risk.

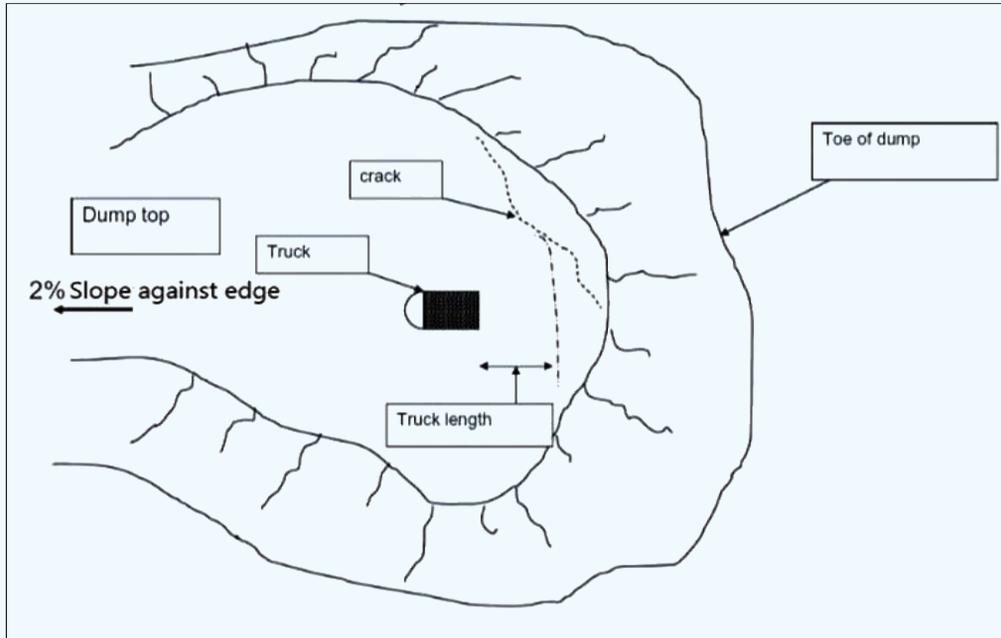
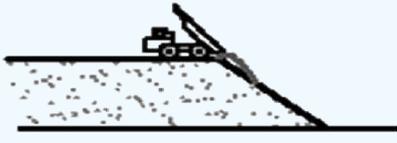
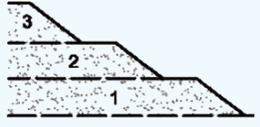
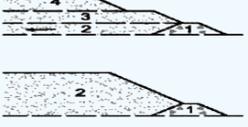
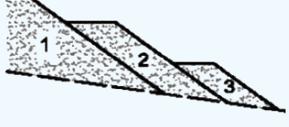


Figure 2: Showing Sketch of Waste Dump

	Dump and Doze	End Dumping	
Construction			
Type			
Geometry			
Lift Heights	2.5-40m	2.5-40m	20-100m
Overall Angle	<30° to 31°	<33°	<28°
Base Angle	≤10°	≤10°	<20°
Geotechnical Criteria for Selection	<ol style="list-style-type: none"> <li>1. Low strength rock or soil.</li> <li>2. Poor foundation conditions.</li> <li>3. Sloping base.</li> <li>4. Limit on maximum allowable overall angle.</li> </ol>	<ol style="list-style-type: none"> <li>1. Poor quality waste.</li> <li>2. Good foundations under toe.</li> <li>3. Sloping base.</li> <li>4. Permanent outside dump face.</li> <li>5. Initial dump in creek or water.</li> <li>6. Unstable natural slopes within the dump area.</li> <li>7. Containment of weak material between toe and dump base.</li> </ol>	<ol style="list-style-type: none"> <li>1. Materials of variable geotechnical quality.</li> <li>2. Curved or irregular foundation.</li> <li>3. Need for toe support.</li> </ol>



## Stages in Waste Dumps: Geotechnical Concerns

### 1. Excavation Method

Excavation Equipment	Key Effects	Geotechnical Implications
<b>Bulldozer (Ripping)</b>	Increased material breakdown under repeated trafficking	<ul style="list-style-type: none"> <li>• Reduced strength</li> <li>• Lower permeability</li> <li>• Higher susceptibility to rainfall-induced degradation</li> </ul>
<b>Shovel-Excavator- Dragline (Digging)</b>	<ul style="list-style-type: none"> <li>• Well-graded waste, soil to coarse rock</li> <li>• Larger block size</li> </ul>	<ul style="list-style-type: none"> <li>• Increased shear strength</li> <li>• Improved long-term durability with coarser particles</li> </ul>
<b>BWE / Continuous Miner (Cutting, digging, chipping)</b>	<ul style="list-style-type: none"> <li>• More uniform particle size</li> <li>• Finer overall gradation</li> </ul>	Increased permeability

### 2. Transportation

Transport System	Key Effects	Geotechnical Implications
<b>Dragline</b>	<ul style="list-style-type: none"> <li>• Very short haul distance</li> <li>• Minimal rehandling breakdown</li> </ul>	<ul style="list-style-type: none"> <li>• Minimal impact</li> <li>• Slight strength reduction due to any rehandling</li> </ul>
<b>Truck</b>	<ul style="list-style-type: none"> <li>• Smaller particle size due to excavation/crushing</li> <li>• Vibration effects during haulage</li> <li>• Material exposed unless covered</li> </ul>	Potential for liquefaction when transporting fine, cohesive, moisture-rich materials, particularly under rainfall
<b>Conveyor</b>	<ul style="list-style-type: none"> <li>• Consistent particle fragmentation</li> <li>• Mechanical vibration</li> <li>• Open transport unless enclosed</li> </ul>	Minimal effects; material condition largely unchanged

### 3. Dumping

Dumping Method	Key Effects	Geotechnical Implications
<b>Spreader</b>	<ul style="list-style-type: none"> <li>• Geometric constraints cause dumping above/below the equipment</li> <li>• Dynamic loading of dump face</li> <li>• Rapid advance of dump</li> <li>• Poor selectivity</li> <li>• Used in some operations to avoid active dump failure under spreader</li> </ul>	<ul style="list-style-type: none"> <li>• Highly susceptible to local instability</li> <li>• Potential rapid flow slides</li> <li>• Settlement and trafficability issues</li> <li>• Pore-pressure build-up from rapid loading</li> <li>• Difficult to segregate materials, affecting dump quality</li> </ul>
<b>Truck Dumping</b>	<ul style="list-style-type: none"> <li>• Different materials form different repose angles</li> <li>• Crest settlement</li> </ul>	<ul style="list-style-type: none"> <li>• Over-steepened upper slope may fail</li> <li>• Risk of trucks reversing over dump edge</li> </ul>
<b>Dozer (Dumped &amp; Dozed)</b>	Designed to eliminate issues from truck dumping	Minimal impact due to controlled placement
<b>Dragline Dumping</b>	<ul style="list-style-type: none"> <li>• Sequential dumping allows partial selectivity</li> <li>• Extended bench dumping possible</li> <li>• Tight geometric constraints</li> </ul>	<ul style="list-style-type: none"> <li>• Material compaction</li> <li>• Compaction of spoil toe</li> <li>• Poor-quality material placed deeper</li> <li>• High vulnerability to failure</li> </ul>



## Design Considerations For Waste Rock Dump Management

Mine waste management is an integral part of the overall mining operation, and the proper design and planning of waste dumps are essential to ensure both environmental sustainability and the structural stability of mining operations. The following details the key considerations for designing mine waste dumps, focusing on their environmental and geotechnical stability, reclamation potential, and safety measures.

**Site Selection for Waste Dumps:** The first step in the waste dump design process is the careful selection of the dump location. The site selection process must take into account several factors, including hydrology, geology, and environmental impacts.

**Avoidance of Stream Drainages and Groundwater Discharge Areas:** Waste dumps should not be located in stream drainages, groundwater discharge zones, or areas that could potentially disrupt water quality. These locations can lead to contamination of water resources through runoff and leachate, which is especially harmful when toxic materials, such as heavy metals or acid-generating minerals, are involved. Waste dumps located in such sensitive areas increase the risk of acid mine drainage (AMD) and other water quality issues.

**Hydrogeological Considerations:** A study of local groundwater conditions and hydrological factors is essential. Hydrogeological studies help to

understand how water behaves in the area, including groundwater flow and the potential for seepage or contamination. The hydrological assessment should determine whether groundwater could interact with the waste dump and if it would result in contamination or increased pore pressure in the waste materials.

**Drainage Design and Water Flow Management:** Proper drainage is a critical factor in the stability of mine waste dumps. Water infiltration and erosion can contribute to waste dump failures. Effective drainage systems must be incorporated into the design of the dump.

**Diverting Drainage Around or Through the Dump:** Drainage should be directed around the dump or through the head of the valley or sidehill dumps to prevent excessive water from infiltrating the waste dump. Adequate surface water diversion ensures that water does not accumulate in or around the dump, reducing the likelihood of erosion, sedimentation, and structural failure.

**Durable Drain Construction:** Drains should be constructed using durable materials that are resistant to erosion and slaking (disintegration of rocks when exposed to water). Non-slaking rocks or gravel are often the preferred materials, as they are stable over time and able to handle the volume of water that will flow through them.

**Stream Flow through Valley Fills:** For cross-valley fills, it is essential to maintain stream flow through the base of the waste dump. This is usually accomplished by



constructing a rubble drain – a rock-filled trench designed to carry water through the dump without compromising the stability of the material. The rubble drain should be designed to handle a design storm flow, ensuring that the water flow capacity is sufficient for extreme weather conditions and heavy rainfall.

**Geotechnical Stability and Dump Design:** The geotechnical stability of waste dumps is a key consideration in preventing slope failures, erosion, and other hazards. Proper design ensures that the waste material is stable and that the dump will not pose a risk to surrounding environments, communities, or infrastructure.

**Grading and Contouring for Mass Stability:** The waste dump should be graded or contoured in such a way as to enhance its mass stability. The slope angle of the dump is determined based on the material properties and the angle of repose, which refers to the steepest angle at which a material can remain stable without sliding. Figure 3, Figure 4 and Figure 5 suggest the profile design of the recommended waste dump and illustrate the schematic plan for a safe working area from the dump toe and the schematic section for a safe working area from the dump toe.

**Base and Toe Materials:** The placement of coarse durable materials at the base and toe of the waste dump can improve internal hydrologic stability and reduce pore pressure within the dump (Figure 6). This helps distribute the weight of the dump more evenly and lowers the risk of failure due to water infiltration.

**Geotechnical Failure Analysis:** A geotechnical failure analysis is critical in identifying potential risks in the waste dump structure. This analysis should be performed during the design phase to assess the potential for slope failure. A foundation analysis is important for large waste dumps to ensure that the dump base is stable and can support the weight of the waste materials. This analysis should consider the material properties of both the waste rock and the underlying soil or bedrock.

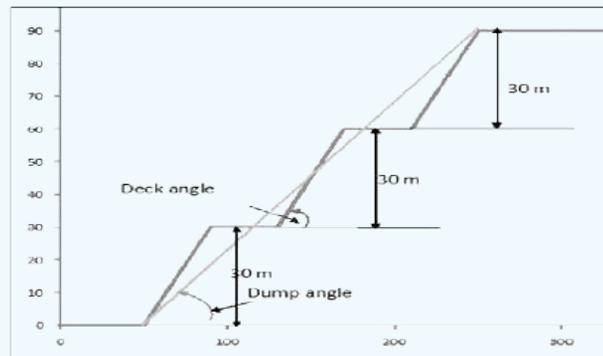


Figure 3: Recommended Design of Waste Dump

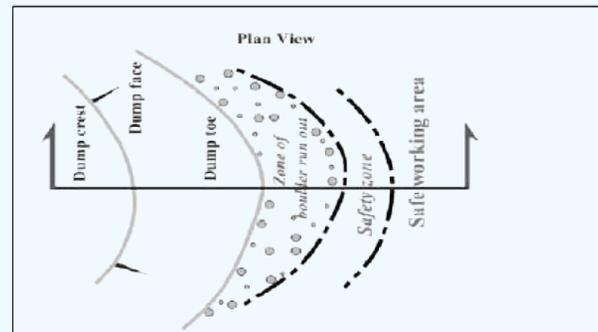


Figure 4: Schematic Plan for Safe Working Area from Dump Toe

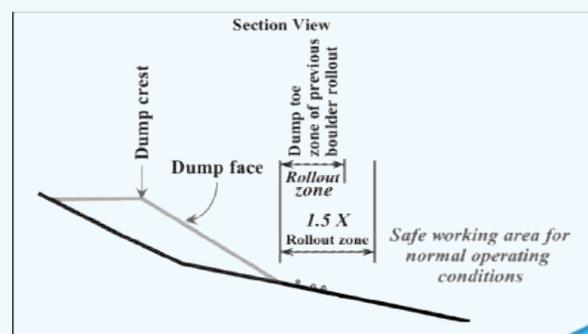


Figure No. 5: Schematic Section for Safe Working Area from Dump Toe

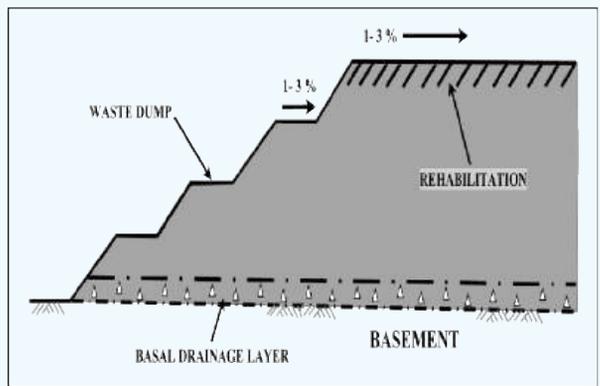


Figure No. 6: Sketch Showing the Control Measures

**Erosion Control and Environmental Protection:** Erosion control is a critical aspect of waste dump design, as uncontrolled erosion can lead to sedimentation in nearby water bodies and damage to the surrounding environment. The design must incorporate features that minimise erosion, reduce surface runoff, and enhance the long-term stability of the waste dump.

**Controlled Water Flow and Erosion Prevention:** The design should ensure that water flow is controlled to minimise the potential for erosion. This involves both surface and subsurface drainage systems, as well as vegetation to stabilise the surface. By ensuring controlled water flow, the waste dump is less likely to experience significant erosion, which could destabilise the structure and contaminate nearby ecosystems.

**Topsoil and Growth Medium Management:** As part of the reclamation process, topsoil or other suitable growth media should be removed from the proposed dump site and stockpiled for later use in reclamation. These materials will serve as a foundation for planting

vegetation, which helps to stabilise the dump surface and prevent erosion. Finer-textured waste materials that are more adaptable for use as a growing medium should be placed on the exterior of the dump to facilitate plant growth.

**Use of Vegetation in Reclamation:** After the dump has been shaped and graded, available topsoil or other selected subsoils should be spread over the surface of the dump as a growing medium. Vegetation helps in controlling erosion, improving soil structure, and providing habitat for wildlife. Planting native species that are adapted to the local environment is recommended to enhance the ecological restoration of the site. For general guidance in this regard, it may be helpful to keep in mind the predicted relationship between the angle of the dump slope and the effectiveness of revegetation, as shown and illustrated in Figure 7.

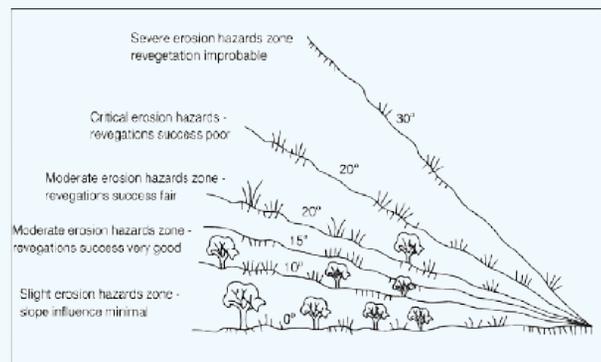


Figure 7: Relationship Between the Angle of Dump Slope and Efficiency of Revegetation

### Safety Requirements for Waste Dumps

Safety is a key consideration in the design of waste dumps. The design must take into account potential hazards such as slope failures, settlement, and water-



related risks, which could impact the health and safety of workers, nearby communities, and the environment.

**Safety Calculations for Waste Dumps:** For waste dumps, it is essential to calculate the factor of safety (FoS) related to mass stability, water infiltration, and potential for erosion. These calculations should include the assessment of the FoS, which measures the stability of the waste dump by comparing the forces resisting failure with the forces promoting failure. At the present state of the mass, the latter is balanced by the shear stress acting along the possible failure surface. So, the definition of the factor of safety is:

$$\text{Factor of Safety} = \frac{\text{Maximum resisting force (strength)}}{\text{Driving force (acting stress)}}$$

from that:

- For  $\text{FoS} > 1$ , the strength exceeds the stress, the slope is stable;
- For  $\text{FoS} \leq 1$ , the stress exceeds the strength, the slope is unstable.

**Dump Bench Design:** Waste dump benches should be constructed to allow for the mass settling of the dump. These benches provide areas where the material can settle without increasing the risk of slope failure. Additionally, they can help improve drainage and stabilize the dump structure by distributing the load more evenly. Hawley and Cuning (2017) acknowledged the significance of design confidence when creating Design Acceptance Criteria (DAC) for waste rock dumps (Figure 8). As potential implications grow, acceptance becomes more cautious in accordance with

the criteria stated above. The usage of a matrix where the criteria are directly related with the possible repercussions of failure and the confidence in design was a very helpful method for presenting the proposed criteria in Hawley and Cuning (2017).

		Consequence Category		
		Low	Moderate	High
Design Confidence	Low	FoS 1.3-1.4	FoS 1.4-1.5	FoS $\geq 1.5$
		PoF 10-15%	PoF 2.5-5%	PoF $\leq 1\%$
	Moderate	FoS 1.2-1.4	FoS 1.3-1.4	FoS 1.4-1.5
		PoF 15-25%	PoF 5-10%	PoF 1-2.5%
	High	FoS 1.1-1.2	FoS 1.2-1.3	FoS 1.3-1.4
		PoF 25-40%	PoF 10-15%	PoF 2.5-5%

Figure 8: DAC for Waste Rock Dumps by Hawley and Cuning (2017)

DGMS Guidelines for Waste Dump Management in Indian Metalliferous Opencast Mines - Waste dump management and slope stability assessment are critical components of safe and sustainable opencast mining in India. Metalliferous mines generate large volumes of overburden (OB), interburden, and rejects, which are commonly placed in external or internal dumps. These dumps, if improperly designed or monitored, can fail through mechanisms such as rotational slip, planar failure, flow slides, and foundation failure. In response to a series of slope-failure-related accidents and the increasing scale of mechanised mining, the Directorate General of Mines Safety (DGMS) has issued multiple technical circulars to regulate systematic design,



operation, and monitoring of pit and dump slopes. The literature on mine slope safety in India is therefore strongly anchored around DGMS (Tech) circulars, scientific studies as mandated under the Coal Mines Regulations (CMR) 2017 and Metalliferous Mines Regulations (MMR), national standards, and international best practices. The following sections consolidate and synthesise DGMS guidelines applicable to waste dump management and slope monitoring in metalliferous opencast mines, with emphasis on the most recent circulars: DGMS (Tech) Circulars 02/2001, 02/2010, 02/2020, 03/2020, and Regulation 106 of CMR 2017, all of which serve as reference documents for scientific design and operational safety in both coal and non-coal opencast mines.

DGMS (Tech) (S&T) Circular No. 2 of 2001: Slope Failure Prevention in Opencast Mines - The earliest consolidated regulatory guideline on slope stability is the DGMS (Tech) (S&T) Circular No. 2 of 2001, issued after a series of fatal slope collapses in coal mines. Although primarily aimed at coal operations, the circular formed the foundation for slope design requirements in all opencast mines, including metalliferous operations. The circular highlights that slope failures occur primarily because of inadequate design, unscientific working methods, and lack of monitoring. It stresses that both pit slopes and external waste dump slopes must be designed according to geotechnical principles such as shear strength assessment, bench geometry optimisation,

and hydrogeological control. In the context of metal mines, these principles remain relevant due to the inherently heterogeneous nature of waste rock, which often exhibits variable fragmentation, angularity, and weathering characteristics. The circular establishes two central principles: (1) Scientific slope design must precede development of benches, haul roads, or dumps. (2) Continuous monitoring must be integrated into daily mine operations to identify precursors of slope instability. This document laid the foundation for subsequent DGMS circulars and encouraged Indian mining industries to adopt geotechnical engineering as a mandatory discipline in mine planning.

DGMS (Tech) Circular No. 02 of 2010: Design, Control, and Monitoring of Pit and Dump Slopes - With increasing mechanisation and deeper opencast mines, DGMS issued Circular No. 02 of 2010, which remains the most influential guideline for slope stability in India. It specifically addresses the complex geomechanical environment of deep excavations and large waste dumps. Scientific Slope Design Requirements - The circular mandates that slope design should be supported by: Geomechanical classification of rock masses; Shear strength testing of dump material and foundation strata; Slope stability numerical modelling using analytical or advanced numerical tools; Hydrogeological investigations and pore-water pressure estimation; and Bench design parameters (height, width, face angle, inter-ramp angle) tailored to site



conditions This is particularly relevant for metal mines, where dump materials may include hard rock fragments, clay seams, lateritic soils, and weathered ore, leading to zones of variable shear strength and potential weakness. Waste Dump Hazards and Risks - The circular identifies specific hazards associated with waste dumps: Alteration of stress distributions due to progressive loading; Steep dump slopes without compaction or controlled placement; Excessive height leading to overstressing of foundation material; Poor segregation of weak and strong materials; and Water ingress and build-up of pore pressures. These hazards are commonly observed in Indian metalliferous mines where the annual excavation output may exceed tens of millions of tonnes. Monitoring Protocols - The circular deployment of systematic monitoring, including: Regular surveying of slope profiles; Visual inspection for cracks, tension gaps, subsidence, or oversteepening; Installation of piezometers, inclinometers, settlement markers, and prism monitoring systems; Evaluation of rainfall data and seepage patterns. These circular forms cornerstone for monitoring programs in large metal mines today.

DGMS (Tech) Circular No. 02 of 2020: Systematic Slope Monitoring Guidelines - Recognizing rapid technological advancements, DGMS published Circular No. 02 of 2020, providing updated and highly detailed requirements for slope monitoring in both coal and metalliferous

opencast mines. Deployment of Slope Monitoring Systems - Every mine must implement a slope monitoring system tailored to site-specific geological and operational conditions. The system should define: Instrumentation types: prisms, total stations, radar-based systems (SSR/TLS), LiDAR, piezometers, extensometers; Monitoring frequency: continuous (automated) or periodic; Data acquisition and interpretation methodology; Pattern and layout of monitoring stations; Organizational hierarchy for monitoring responsibilities. Metal mines with high benches, deep pits, and large external dumps increasingly rely on Slope Stability Radar (SSR) and Real-Time Total Station (RTTS) systems as recommended in this circular. Trigger Action Response Plans (TARP) - The circular mandates defining customized trigger levels, commonly: Normal Condition; Warning Level; and Withdrawal Level (Emergency). Each trigger level must be linked with specific operational actions, forming a complete TARP. This structured approach has significantly improved slope risk management in India's large metal mines such as those producing iron ore, manganese, bauxite, and chromite.

DGMS (Tech) Circular No. 03 of 2020: Scientific Studies under Regulation 106 - Circular 03 of 2020 supplements the regulatory framework by detailing the requirements for scientific studies widely followed by metalliferous mines as best practice. Mandatory Scientific Study Components - Before beginning



mechanized opencast operations, the owner/agent must ensure that: Ultimate pit slopes and dump slopes are scientifically designed; The method of working, including benching, haulage layout, and dumping strategy, is scientifically validated; A comprehensive slope monitoring plan is included; and The study report is kept available at the mine office for DGMS inspection. Minimum Factor of Safety (FoS) - DGMS mandates minimum FoS values: 1.50 for permanent/long-standing slopes; and 1.30 for temporary slopes or intermediate benches. These FoS requirements are crucial for metalliferous mine dumps, which often rely on steep engineered slopes to optimize space. Applicability to Metalliferous Mines - It requires: Scientific design of all opencast workings, including dumps; Compliance with safety precautions listed in sub-regulations; Ensuring that all slope-related recommendations from scientific studies are implemented; and Continuous monitoring and documentation. Metal mines adopt these requirements to align with DGMS expectations and maintain uniform standards for opencast slope stability across mineral sectors.

Relevance to Metalliferous Mines in India - Metalliferous mines present unique geotechnical challenges: Highly variable waste rock gradation; Complex weathering patterns; High dump heights; Seasonal monsoon impacts leading to rapid pore pressure rise; Progressive dump expansion requiring staged design. DGMS circulars

collectively guide metal mines to adopt: Engineered dumping with controlled lifts and compaction; Staged dump development with drainage and stability berms; Advanced slope monitoring including radar, drones, and LiDAR; Predictive modelling using FLAC, Phase2, PLAXIS, and SLOPE/W; and Risk-based slope management aligned with TARP. These guidelines are now consistently referenced in scientific studies submitted to DGMS for mine plan approvals.

Numerical Modelling (Finite Difference Method) - Numerical modelling using the Finite Difference Method (FDM) provides an advanced approach to analysing dump slope behaviour under varying geological and environmental conditions. Software such as FLAC/Slope and FLAC2D allows for simulating stress-strain responses, pore pressure evolution, and progressive failure mechanisms within heterogeneous dump materials. The model typically incorporates realistic boundary conditions, such as fixed bases and free lateral boundaries, to replicate in-situ conditions accurately. Figure 9 illustrates the representative dump slope geometry, including the mesh configuration and boundary zones used for computation. Material properties are defined based on laboratory and field data – cohesion, friction angle, density, and permeability. Simulations enable assessment of Factor of Safety (FoS), potential failure surfaces, and deformation patterns under static and dynamic conditions. Such numerical frameworks are invaluable for evaluating design



alternatives, optimising slope geometry, and validating field observations, ensuring the stability and long-term performance of waste dumps in large opencast mines.

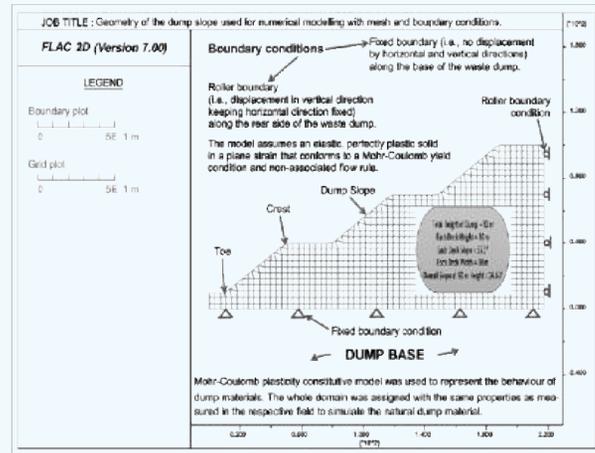


Figure 9: Dump Slope Geometry, Mesh Layout, and Applied Boundary Conditions

### Conclusions

The planning, design, and management of mine waste dumps are complex and require careful attention to various environmental, geotechnical, and safety considerations. By adhering to the guidelines outlined in this paper, mining operators can minimize environmental damage, improve structural stability, and ensure the long-term sustainability of their operations. Proper waste dump management is crucial not only for minimizing environmental impact but also for ensuring the safety of mining personnel and surrounding communities. Incorporating a holistic approach that integrates geotechnical analysis, environmental protection, and reclamation practices will lead to the proper design and management of waste dumps. Design considerations for waste dumps should

consider local groundwater conditions and geo-hydrologic factors. The dump should be placed in a valley, with drainage diverted around or through the head. Durable, non-slaking rock or gravel drains should be used. The dump should be graded or contoured for mass stability. Geotechnical failure analysis and foundation analysis are recommended. Placement of coarse durable materials at the dump's base and toe provides additional stability. Controlled water flow minimizes erosion and enhances structural stability. Cross valley fills should provide stream flow through the dump. Toxic materials should not be placed in valley fills. DGMS regulations and circulars form the backbone of slope stability and waste dump management protocols in Indian metalliferous opencast mines. Circulars from 2001 to 2020 progressively enhance regulatory expectations, shifting from conventional design to scientifically engineered slopes, systematic monitoring, and risk-based response frameworks. Compliance with DGMS guidelines ensures safer mine operations, reduces slope failure risks, and promotes sustainable waste dump design. As metalliferous mines continue to deepen and expand, adherence to these DGMS guidelines - supported by numerical modelling, geotechnical testing, and real-time monitoring technologies - will remain critical for long-term mine stability and operational safety.



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## Safety: An Emotion That Drives Excellence

Malayaranjan Acharya

Safety is more than a compliance requirement—it is a deeply rooted value and an emotion that shapes culture. Every action, decision, and innovation reflect an unwavering commitment to protect lives and create an environment where everyone feels secure and empowered.

### Journey Towards Zero Harm

The vision of Zero Harm is not just a slogan; it is a commitment. Through robust safety management systems, advanced technologies, and continuous training, we strive to build an ecosystem where risks are proactively identified, mitigated, and eliminated.”

### Key Pillars of Safety Excellence

- **Leadership Commitment:** Safety starts at the top, with leaders championing initiatives and setting the standard through their actions.
- **Employee Engagement:** Every employee is a safety ambassador, empowered to stop unsafe work and report hazards without hesitation.
- **Technology Integration:** IoT sensors, AI-driven predictive analytics, and automation enable real-time monitoring and control for enhanced safety.

- **Behavioral Safety:** Programs such as *Safety Culture Transformation* focus on mindset change, positive reinforcement, and building a strong safety culture.

### Safety Beyond Boundaries

Safety extends beyond plants and mines. Contractors, suppliers, and partners form an integral part of the safety ecosystem. Through collaborative programs, rigorous audits, and capability-building initiatives, safety standards are upheld across the entire value chain.

### Safety as a Competitive Advantage

Safety is not just about preventing incidents—it is about building trust, enhancing productivity, and sustaining excellence. A safe workplace attracts talent, fosters innovation, and strengthens reputation as a responsible leader.

### Conclusion

Safety is an emotion that inspires care for one another and drives the pursuit of perfection. This emotion fuels the journey toward a future where every individual return home safe, every day. Safety is not just a priority—it is a way of life.

*“Safety is an art that serves humanity, carrying profound meaning—it reflects care, responsibility, and excellence in every action.”*

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Designation -Area Manager -Safety (Joda)  
Joda East Iron Mine, Tata Steel Ltd



# Tyre Life Optimization at Joda East Iron Mines: A Strategic Overview

Pradeep Kumar Singh

## 1. Introduction: The Pivotal Role of Tyre Management in Mining Operations

Tyres are indispensable assets in open-cast mining, performing critical functions such as supporting vehicle load, ensuring traction, facilitating effective braking, and enabling precise directional control for heavy machinery. Their operational significance is further highlighted by their substantial cost contribution, ranking as the third-largest expense category, directly following diesel and explosives. The longevity and performance of these vital components are intricately linked to a combination of factors, including robust Tyre Management Practices, the structural integrity of Haul Roads, and meticulous Operational Practices encompassing loading patterns, driving behaviours, and the intrinsic condition of the tyres themselves.

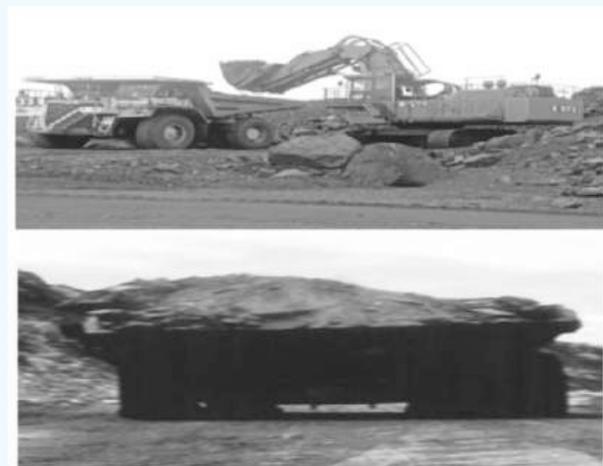
Effective Tyre Management is a multi-faceted discipline, involving:

- **Judicious Tyre Selection:** Choosing the right tyre for specific.
- **Optimal Storage Conditions:** Ensuring tyres are stored in environments that preserve their integrity.
- **Precise Inflation Medium Management:** Controlling the type and quality of inflation.

- **Diligent Tyre Pressure Monitoring (TPMS):** Real-time tracking of tyre pressure.
- **Standardized Dismantling and Assembling Procedures:** Ensuring proper handling during maintenance.
- **Meticulous Tyre Matching:** Pairing tyres for optimal performance.
- **Strategic Tyre Rotation:** Implementing a planned schedule for tyre movement.

This article provides a detailed review of current tyre management practices at the Joda East Iron Mine, identifies key factors influencing tyre life, and outlines both achieved successes and opportunities for further enhancement and widespread application of best practices.

## 2. Unpacking Tyre Failure: Identifying Core Root Causes



*Sr. Area Manager (Dumper & Drill).*



Premature tyre failure significantly impacts operational efficiency and cost. Analysis reveals several predominant causes:

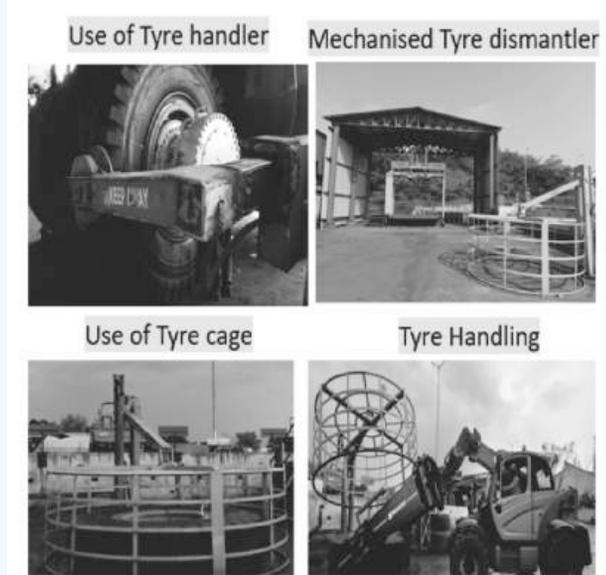
- **Suboptimal Haul Road Conditions:** Undulating Road surfaces and excessive material spillage lead to uneven stress distribution across tyres, dramatically increasing the risk of punctures and abrasions.
- **Challenging Underfoot Conditions:** The presence of boulders and uneven terrain at loading points often results in severe damage to tyre sidewalls and treads.
- **Asymmetrical Loading (One-Side Load):** Improper distribution of load on dumpers imposes disproportionate strain on tyres on one side, accelerating wear and heightening the risk of failure.
- **Consistent Overloading:** Systematically exceeding the manufacturer-specified load capacity drastically reduces tyre lifespan and increases the potential for catastrophic failure.
- **Inconsistent Linear Grades:** Variable road grades compel frequent transmission shifts and erratic braking,

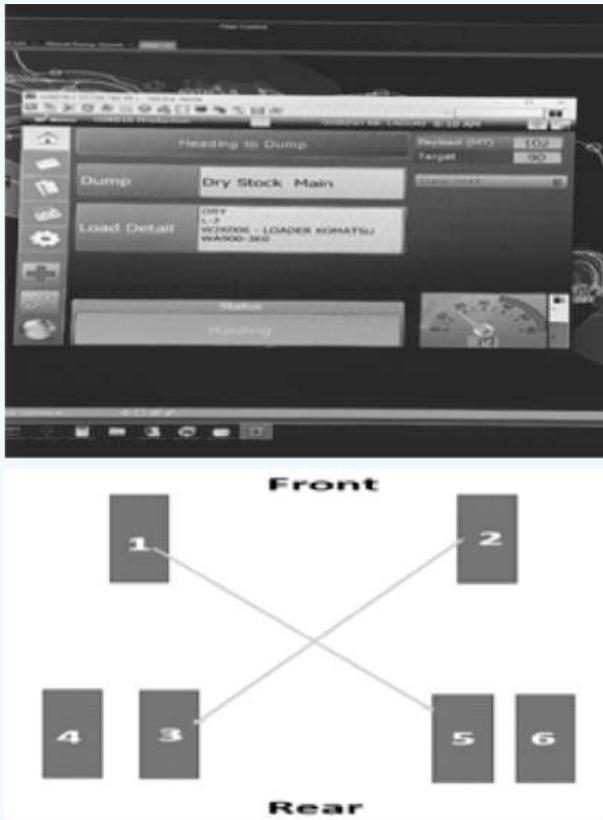
leading to increased tyre stress, elevated fuel consumption, reduced average speeds, and greater material spillage. Conversely, uniform, constant grades optimize efficiency by minimizing shifts and enabling consistent braking.

- **Stone Trapping:** Stones becoming lodged between dual tyres or within tread patterns can deeply penetrate the tyre casing, causing internal damage and eventual failure.
- **Tyre Mismatch:** Significant disparities in Rolling Tyre Diameter (RTD) and tread pattern between tyres on the same axle are critical contributors to accelerated wear and premature failure. For instance, observations of dual mismatches with differences up to 65mm underscore the imperative for identical RTD and pattern for all tyres on a given axle to ensure optimal operational life.

### 3. Best Practices in Tyre Management at Joda East Iron Mine

Joda East Iron Mine has proactively adopted and implemented several leading





practices to enhance tyre longevity and operational safety:

- **Advanced Tyre Handling Equipment:** The mine employs specialized tools such as tyre handlers, mechanized tyre dismantlers, and robust tyre cages. The integration of dedicated tyre handling machines (e.g., MANITOU) ensures that all tyre-related operations—from installation to removal and maintenance—are conducted safely and efficiently, minimizing potential damage.
- **Real-time Tyre Pressure Monitoring System (TPMS):** All operational tyres are equipped with a state-of-the-art TPMS, a cornerstone of effective tyre life management. This system provides real-time data on both tyre pressure and

temperature. Automated, customizable, and configurable alerts for incorrect, over-inflated, or under-inflated tyres are immediately transmitted via the network to maintenance teams and the Fleet Management System (FMS). Furthermore, multi-tyre inflators with automatic cut-off features are utilized to guarantee precise inflation levels, preventing both over and under-inflation.

- **Dynamic Load Monitoring on Dumpers:** Continuous monitoring of dumper loads is maintained, with real-time overload alerts communicated directly to the FMS via the network. This proactive system is crucial in preventing excessive stress on tyres due a load violations.

- **Strategic Tyre Rotation Protocol:** A systematic and data-driven tyre rotation policy is rigorously adhered to:

New tyres, initially fitted on the front axle, are strategically rotated to the rear inner position once their Remaining Tread Depth (RTD) decreases to a range of 40-45 mm.

Tyres positioned on the rear axle are maintained in service until their RTD falls within the 20-25 mm threshold, after which they are removed for re-treading.

Re-treaded tyres are exclusively deployed on the rear axle, leveraging their extended life while ensuring safety.

- **Comprehensive Tyre Wear Reporting and Monitoring:** Regular measurements of RTD are systematically conducted, and the operational life of each tyre is



meticulously monitored on a monthly basis. Detailed tyre wear reports capture essential parameters such as tyre number, make, vehicle position, fitment and removal dates/Hour Meter Readings (HMR), previous and current life in hours, and the specific cause of removal (e.g., through-cut, punctured, air bubble, life completed, rejected due to deformation). As of November 2025, 12 tyre changes were recorded for the current month. Illustrative examples from recent reports include:

- **Proactive Haul Road Maintenance and Optimized Loading:** Significant emphasis is placed on maintaining haul roads that are adequately wide, uniformly compacted, and completely free of spillage. The deployment of road rollers and vibrators is integral to achieving this. Concurrently, strict adherence to correct load distribution

within dumpers is enforced to prevent uneven tyre wear and ensure vehicle stability.

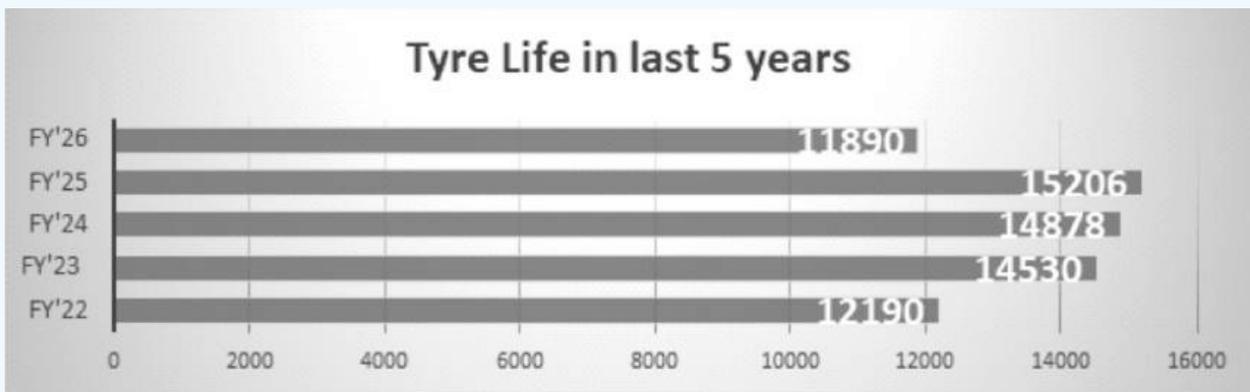
**4. Tyre Performance Metrics and Notable Achievements**

The consistent application of these best practices has demonstrably led to significant improvements in tyre life at Joda East Iron Mine.

**4.1. Trend in Average Tyre Life (Last 5 Financial Years)**

The data clearly illustrates a positive trend in average tyre life, reflecting the efficacy of implemented management strategies:

- **FY'22:** 12,190 hours
- **FY'23:** 14,530 hours
- **FY'24:** 14,878 hours
- **FY'25:** 15,206 hours
- **FY'26:** 11,890 hours (Note: This likely represents partial year data and is



expected to increase as the financial year progresses)

This trajectory underscores the continuous improvement driven by strategic interventions and operational discipline.

**4.2. Comparative Tyre Performance by**

**Make (FY'25)**

An analysis of tyre performance by manufacturer in FY'25 reveals notable differences:

- **Bridgestone:** 13,937 hours
- **Goodyear:** 14,287 hours



- **Michelin:** 17,396 hours

Michelin tyres emerged as the top performer in FY'25, demonstrating an average lifespan significantly greater than its counterparts. This data provides valuable insights for future procurement and strategic partnerships.

#### 4.3. Highest Achieved Tyre Life Record

Joda East Iron Mine has achieved an exceptional milestone in tyre longevity on a specific unit, serving as a benchmark for potential performance:

- **Tyre Make:** Bridgestone
- **Tyre Size:** 27.00 R 49
- **Vehicle Application:** Komatsu HD 785



Dumper

- **Tyre Identification Number:** BON000851
- **Total Operational Life:** An outstanding 17,565 Hours
- **Operational Period:** Fitted in Q1 July 2021, and removed on September 10, 2025.

This remarkable achievement highlights the potential for extended tyre life under optimal and rigorously managed conditions.

#### 5. Conclusion and Strategic Recommendations

The ongoing dedication to implementing and refining best practices in tyre management at Joda East Iron Mine has undeniably contributed to the observed improvements in tyre life over recent financial years. The established systems for advanced tyre handling, real-time pressure monitoring, precise load control, and systematic rotation, coupled with diligent haul road maintenance, form the bedrock of this success. While overall tyre life has enhanced, performance variations among different tyre manufacturers present opportunities for further strategic optimization. The record-setting performance of a specific Bridgestone tyre provides a compelling case study for aspirational benchmarks.

To further elevate tyre life, optimize operational costs, and reinforce safety standards, the following strategic recommendations are proposed:

- **Sustained Enforcement of Best**



- Practices:** Continue to rigorously enforce all existing best practices, with a particular focus on maintaining pristine haul road conditions and ensuring optimal loading patterns for dumpers. Regular audits and refresher training should be conducted.
- **In-depth Performance Analysis for Procurement:** Conduct a more granular analysis of the performance disparities observed across various tyre manufacturers. This deep dive should inform and guide future tyre procurement strategies, prioritizing makes and models that consistently demonstrate superior longevity and cost-effectiveness, as evidenced by tyre performance in FY'25.
  - **Identification of Success Drivers:** Undertake a detailed investigation into the specific operational and environmental factors that contributed to the exceptional achieved tyre Life. The insights gained from this analysis should be systematically documented and horizontally deployed across the fleet to maximize overall tyre life.
- Through these continuous improvements and strategic adjustments, Joda East Iron Mine is well-positioned to further reduce operational expenditures, significantly enhance safety protocols, and establish new industry benchmarks for tyre management efficiency and longevity in the challenging mining environment.



## Improvement in Mining Operation with Smart Mining

Amulya Swain

When mining companies adopt private cellular networks, mining operations can be safer, more productive, and more cost efficient. Cellular's enhanced connectivity allows for remote control of machinery, such as autonomous haulage vehicles, taking mining workers out of harms.

### 5 Ways to Make Mining More Sustainable:

Despite technological advancements that have made the industry greener, mining still uses significant amounts of resources – water, land, carbon and energy – and often causes severe harm to the environment. This damage, if not correctly handled, can last for decades after mining operations have shut down, make the land more vulnerable to natural processes like soil erosion and can worsen after the equipment is out.

Now, as industries and governments around the world look for ways to reduce carbon output and environmental impact, experts, and individuals from in and out of mining are pushing the industry to take a serious look at how it can reduce its footprint.

### 1. LOWER-IMPACT MINING TECHNIQUES:

Traditional mining techniques can have a severe impact on the environment, and some popular methods – like open pit and underground mining – present some of the most significant environmental risks.

By instead using new, alternative low-impact mining techniques – like in-situ leaching – mining companies can reduce their environmental impact.

With many of these techniques, companies can significantly reduce surface disturbance at mining sites, lower soil erosion and move less material that would need backfilled. Lowering interference in this way can both reduce environmental impact and result in less work when preparing a site for quicker revegetation or rehabilitation.

### 2. REUSING MINING WASTE

Mining naturally produces significant amounts of waste – such as tailings, rocks and wastewater. In many cases, businesses leave waste behind when mining operations cease – or, in the case of tailings, stored in large structures like tailings dams, which are prone to failure and, as a result, cause severe environmental damage.

Luckily, for almost every category of mining waste, there are at least one or two ways to reuse that waste on- or off- site.

Companies can use waste rocks in simple on-site construction, like backfilling voids and reconstructing mined terrain in a way that prevents soil erosion.

When adequately treated, mine water can be reused in just about any fashion –



for agriculture, as coolant, in on-site dust suppression and for drinking water. Even tailings, often toxic and left behind in mine sites or stored in large-scale tailings dams, can find eco-friendly use. Depending on the mineral and chemical composition of the tailings, businesses can use them in the production of bricks, as paint extenders or in agroforestry.

Some new technologies even make it possible to further mine from these tailings, reducing the overall amount of minerals that get left behind in mining sites while also reducing the volume of waste stored in tailings dams.

However, not all of the applications are economic right now. The mining industry will likely need to invest in further research and development in the areas of mine waste reuse to make some of the methods workable at scale.

### **3. ECO-FRIENDLY EQUIPMENT**

Mining companies wanting to reduce their environmental impact can switch to more eco-friendly equipment.

Battery-driven mining equipment is often powerful enough to replace diesel-driven options. Replacing diesel engines with electric engines where possible can significantly reduce the amount of CO<sub>2</sub> produced by mining operations.

In general, the mining industry is already moving in the direction of electric equipment, with more and more mining manufacturers offering eco-friendly alternatives. Some are making more significant commitments – like Swedish

mining equipment manufacturer Epiroc, which plans to be 100 percent electric within the next few years.

A push towards exclusively using electric mining equipment could easily result in massive carbon savings for mining companies.

Businesses wanting to become more sustainable could also upgrade to more advanced, durable equipment that lasts longer, reducing the turnover of machinery and decreasing the resources needed. Improved durability can also reduce the environmental costs of damaged equipment – like rubber or plastic shed as a piece of equipment breaks down.

Simple switches, for example – like adopting tires that provide better longevity and higher ROI in rock-strewn environments – can cut down on equipment costs over time while also reducing how much rubber and plastic a mining operation outputs.

### **4. REHABILITATING MINING SITES**

Many modern mining techniques cause significant disruption to the environment – like stripping the topsoil layer necessary for plant growth and raising soil and water acidity, making the area inhospitable to new vegetation and leaving it prone to soil erosion.

Worse, this erosion can often continue for years after a mining company has packed up and moved out. As a result, many former mine sites are left unproductive, unusable by landowners and, in some cases, almost entirely



inhospitable to plant and animal life. However, this damage isn't guaranteed to be permanent. Companies can use many land rehabilitation techniques to make mined land productive again or speed up the land's natural recovery process.

For example, it's possible to use biosolids to replenish depleted topsoil. Soil with biosolids, if seeded and watered, can produce vegetation capable of preventing further soil erosion within as few as 12 weeks. Combined with other rehabilitative techniques – like the use of waste rocks to fill in excavated areas – it's possible to significantly reduce the disruption caused by mining.

Some mining companies – like Alcoa in Australia – have gone further and implemented large-scale reforestation schemes that look to restore every local species present at a mine site before operations began.

## **5. SHUTTING DOWN ILLEGAL MINING**

Illegal mining remains a significant issue for the industry – for example, experts estimate that around 14,000 people are currently involved in illegal mining in South Africa. There, illegal mining often takes place on properties not suited for large-scale mining and without regard to regulations that reduce the environmental impact.

Preventing illegal or unregulated mining operations can help ensure that all mining is bound by the same environmental standards and ensure accountability.

## **I M P R O V I N G M I N I N G S U S T A I N A B I L I T Y**

Despite recent strides and new technology, the mining industry remains unsustainable in many areas. Fortunately, there are a variety of technologies and techniques – both in-use and in development – that the sector can use to reduce its environmental impact.

Advanced land rehabilitation techniques, coupled with low-impact mining methods and reuse of mine waste, can cut back on the impact that mining operations have on their immediate environment. Companies can also use new equipment powered by electric engines to reduce their carbon footprint and become more eco-friendly.

Not all of these technologies are economical yet. However, the mining industry does seem to be moving in the direction of sustainability. Over the next few years, these technologies should become more practical. As a result, it may be easier for companies to make themselves more eco-friendly.



## Safety Challenges in Electrical Installation at Tata steel and safe handling of HT Appliances

Mr. M R Rath\*

Mr. K P Dash\*\*

Mr. Manzoor Ahmad\*\*\*

### ABSTRACT

Tata Steel's Raw Material Division is responsible for sourcing and supplying raw materials for steel production. The division operates various mines in India, providing iron ore and coal to Tata Steel's facilities<sup>1</sup>.

The Raw Material Division has several key operations, including:

\*Iron Ore Mining\*: Tata Steel operates iron ore mines in Noamundi, Joda, Katamati, and Khondbond with other upcoming mines.

- \*Coal Mining\*: The company has coal mines in West Bokaro, Jamadoba, and other locations

- \*Chromite and Manganese Mining\*: Tata Steel's Ferro Alloys and Minerals Division (FAMD) manages chromite and manganese ore reserves in Odisha<sup>4</sup>.

OMQ Division of Tatasteel deals with Iron ore Mining from four locations at present which involves lot of EHT, HT Electrical Installations.

Electrical installations pose significant safety risks if not designed, installed, and maintained properly with improvements, upgradations and proper protective

systems. Moreover, handling of HT appliances has a crucial role in achieving zero Harm at Tata Steel. This paper highlights the major safety challenges associated with electrical installations, including hazards involved in handling HT appliances. Furthermore, the importance of adhering to international safety standards and regulations, such as the National Electric Code (NEC) and the CEAR Guidelines, is emphasized. The paper also discusses the mitigation measures taken for each challenges and their results.

The Key Challenges identified are Overhead lines, Temperature and Humidity inside appliances, Fire and Explosions, Breaker Maintenance, Fault identification inside Mines and their mitigation measures. Tata Steel's focus on Zero Harm and commitment for Injury free steel is emphasized through this Paper as far as electrical installations are concerned and some cutting edge technologies implemented.

**Keywords:** Zero Harm, Temperature, Communication, Steel, Overhead lines, Safety challenges.

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## INTRODUCTION

### Role of Electrical Installation in Mining operation at Tata Steel

Electrical installations play a crucial role in Tata Steel's mining operations, ensuring the safe and efficient extraction of iron ore and other minerals. Here are some key aspects highlighting the importance of electrical installations in mining at Tata Steel:

#### Safety

1. **\*Reduced risk of accidents\*:** Proper electrical installations minimize the risk of electrical accidents, ensuring a safer working environment for workers and their families including contractual labours.
2. **\*Protection against electrical hazards\*:** Electrical installations are designed to protect against electrical hazards, such as electrical shock, arc flash, and fires.

#### Efficiency

1. **\*Reliable power supply\*:** Electrical installations provide a reliable power supply to mining equipment, ensuring continuous operation and minimizing downtime.
2. **\*Optimized energy consumption\*:** Efficient electrical installations help reduced energy consumption, lowering operational costs and environmental impact.

#### Productivity

1. **\*Increased productivity\*:** Well-designed electrical installations enable mining equipment to operate at optimal levels, increasing productivity and output.
2. **\*Improved equipment performance\*:** Proper electrical installations ensure that

mining equipment performs reliably, reducing maintenance and repair needs.

#### Compliance

1. **\*Regulatory compliance\*:** Electrical installations at Tata Steel's mining operations comply with relevant regulations and standards, ensuring a safe and responsible working environment.
2. **\*Industry best practices\*:** The company adheres to industry best practices for electrical installations, ensuring a high level of safety and efficiency.

#### Key Electrical Installations

1. **\*Power distribution systems\*:** Tata Steel's mining operations rely on robust power supply and distribution systems to supply electricity to various equipment and facilities. In OMQ operation we receive power at 2 levels from grid. At Joda in 220 KV Level and at Noamundi in 132 KV Level.

Electrical substations play a critical role in stepping up or stepping down voltage levels to meet the needs of different mining equipment and applications. Hence EHT, HT and Medium voltage Substations are there. Tata steel uses state of the art technology to cater it's power distribution needs like gas insulated switch gears etc.

2. **\*Cable management and overhead line management systems\*:** Effective cable management systems and management of overhead lines ensure the safe and efficient distribution of electrical power throughout the mining operation. HT



cables of several kilometres are there in all areas which poses a great challenge.

3. Safe handling of HT appliances are very much essential to maintain a steady and safe distribution of electricity reducing the chance of electrocution, flash, fire and explosion.

By prioritizing electrical installations, Tata Steel ensures a safe, efficient, and productive mining operation, ultimately contributing to the company's success and growth.

But there are a lot of challenges in ensuring safety of electrical installations and handling of critical appliances in general and HT appliances in Particular.

### **OVERVIEW OF ELECTRICAL SYSTEM, TATASTEEL LTD, OMQ**

Tata steel OMQ receives power at different voltage levels from Grid. At Noamundi it receives power at 132 KV level from Jharkhand Urja vitaran and at Joda power is received at 220 KV Level from Odisha Power Transmission . Both the places have Main receiving substations having ABB and Siemens GIS respectively. Then Power is stepped down and fed to Mining Main substations at 33 KV Level.

Thus the system is vast and hence poses key challenges to safety as far as electrical installations are concerned.

### **Protective systems in electrical installations across OMQ**

Electrical protective systems are designed to prevent or minimize damage to electrical equipment and ensure the safety of people and the environment. However,

there are several concerns related to electrical protective systems, including:

- Challenges in Electrical Installations protective systems
- Reliability and Effectiveness
- Design for Coordination and Selectivity
- Speed and Response
- Cyber Security
- Environmental conditions

### **Reliability and Effectiveness/Design and Installation/Cybersecurity**

Only Numerical Relay being used in 220/132/33/11KV Switchgear. No electromechanical relays are being used to ensure accuracy and reliability as well as to avoid false tripping . Relays are special software enabled (Digi) and all disturbances are recorded as well as can be retrieved through disturbance records in graphical form.

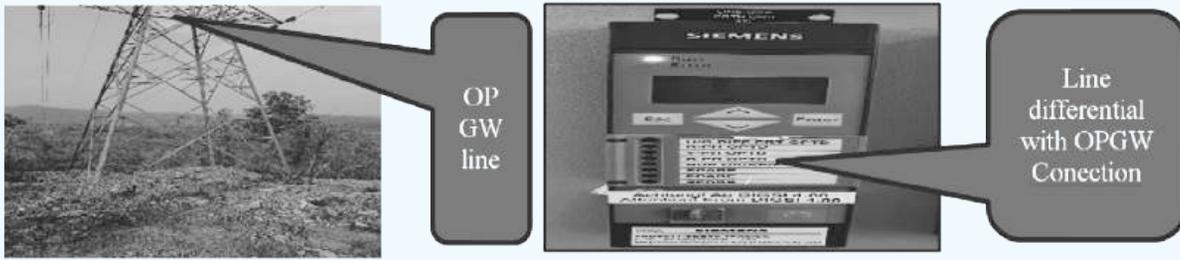
- 1) Distance Protection Relay
- 2) Line Differential Relay
- 3) Transformer Differential
- 4) Bus Bar Differential Relay
- 5) Feeder Protection Relay

### **Use of OPGW for Line differential Protection.**

- 1) Optical Ground Wire communication system used in 33KV overhead line for line differential relay.it serves dual functionality like ground wire and also fibre optic communication for fast acting.
- 2) It also shields the high-voltage conductors from lightning strikes. It is faster than directional. It does not depend on impedances as of directional.



3) OPGW is safer to install than underground cables as under ground cable can be damaged during excavation. Hence it is more reliable.



**Environmental Condition**

Humidity and Temperature monitoring system in HT room is required to be maintained in a HT room/battery room/GIS room as per OEM prescribed limit for safe operation. These two are important parameters for a good health of Electrical Appliances

**Challenges.**

Temperature and Humidity readings needs manual intervention thus not reliable

Distributed Temperature and Humidity sensors across plants

Delayed alerts on thresholds breaches and alerts generation

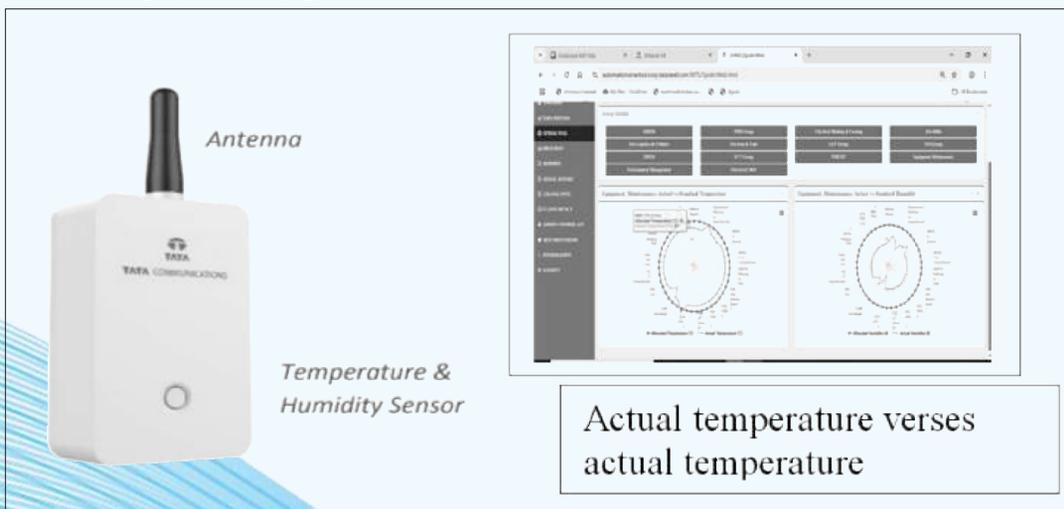
Costlier wired infrastructure across the plant

**Mitigation**

- Use of Lora WAN which is a low-power, wide-area networking (LPWAN) protocol, built on

LoRa modulation, designed to connect battery-operated IoT devices to regional, national, or global networks, enabling long-range, secure, and bi-directional communication . **Here in Tata steel we use Tata Communication Platform for recording and alert generation of temperature and humidity.**

- Central monitoring hub for health status of each sensor and the alarm status is displayed
- Complete wireless system for easier installation and maintenance
- Fewer single boosters or routers due LoRa technology advantages
- Early detection of electrical failures and prevent over heat, insulation breakdown and moisture
- related issue
- Remote monitoring: - of a- live data b-Analysis of change in parameter & trend





**Condition Monitoring of Transformers**

**Power Transformers are most important device in a Power Main Receiving Substation/Power centers.**

**Challenges:**

Transformer oil DGA testing being done once in a year so, real time oil condition monitoring was not possible.

Transformer Oil Partial discharge monitoring system was not done.

**Mitigation of this Challenge**

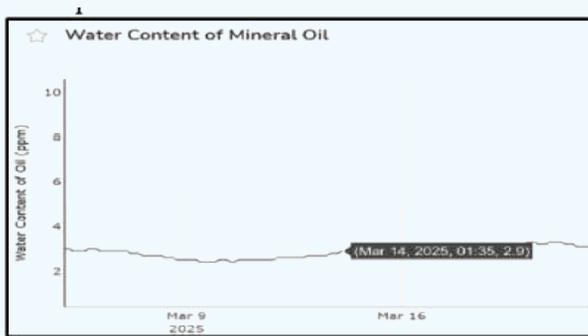
Sensor for oil transformers and advanced software analytics, Eco Struxure

Transformer Expert (Schneider Electric) which measures the health of critical transformers as per following parameters, sends data to cloud and captured through web based application. Water Content of Transformer Oil Water Content of Paper Breakdown Voltage of Oil

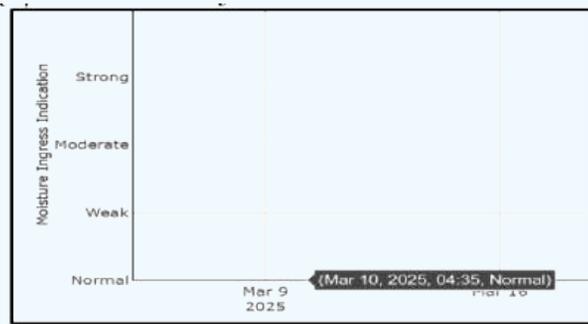
Partial Discharge

Overheating

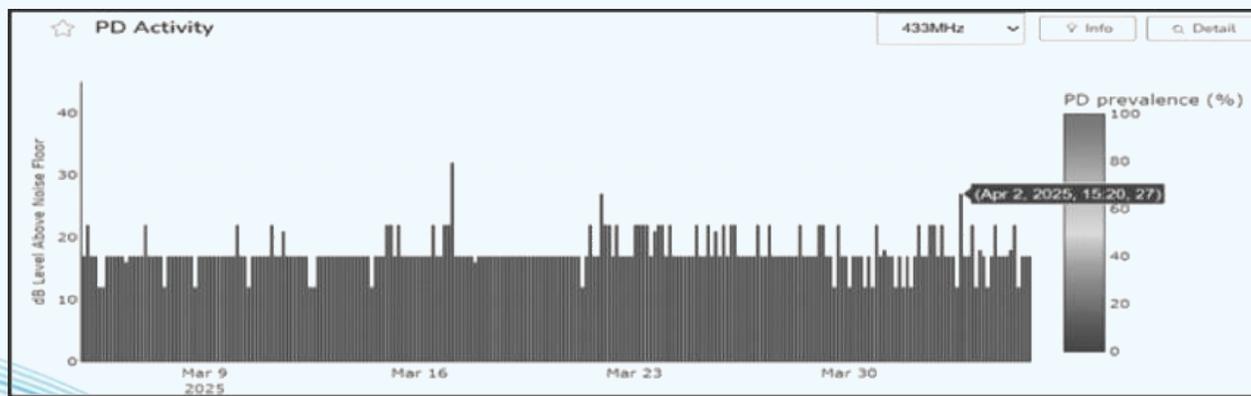
This device connected with internet and shows real time condition of transformer oil, which will help us for predictive maintenance of transformer and protects from major breakdown



Water Content of Transformer Oil



Moisture Ingress Transformer Oil



Partial Discharge of oil



**Cable Management and Overhead line safety**

High resolution Thermal imaging camera for Overhead line

It is very difficult to find out hot spots in overhead lines which creates major fault.

**Challenges:**

- Height and access
- Remote locations

Weather Conditions

Fault Detection and analysis

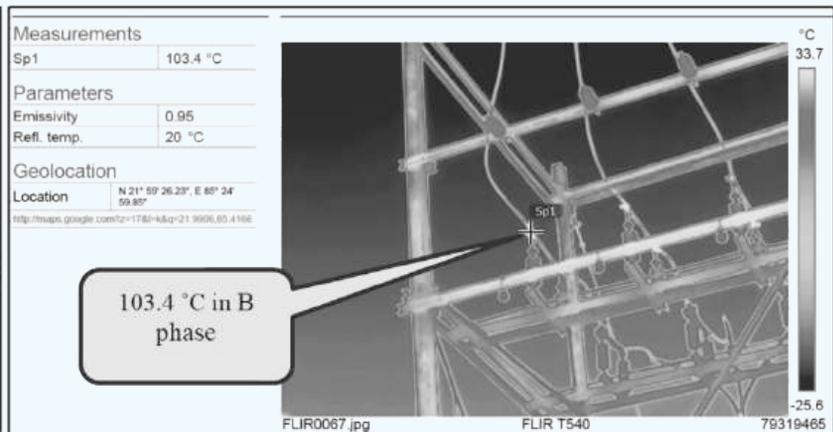
**Mitigation:**

**Early Problem Detection:**

FLIR T540 Thermal imaging camera detects the temperature variations that indicate potential problems in electrical equipment before they become major issues, such as overheating, loose connections, or insulation breakdown.



Thermal Imaging camera, T540



Overheating detection in GOAB switch socket, Practical example in Khondbond Line.

**Handling of HT Breakers**

Handling of HT Breakers involves lot of safety precautions and any flash over may result severe burn/fatality. Although we have been using ARC Flash suit for this but Engineering solution can eliminate this process.

Challenge

Arc Flash Potential:

Racking a circuit breaker involves moving a large component within the gear, which can create loose connections and debris, increasing the risk of arc flash incidents.

**Aging Infrastructure:**

Mechanical wear and tear in older equipment can lead to loose connections and other issues that increase the chances of arc flash incidents.

**Mitigation:**

We are using Bluetooth enabled Intelligent remote Rack-in/ Rack-out device for VCB in HT system which has following advantages.

**Reduced Risk of Arc Flash:**

IRRIDs allow operators to perform racking



operations from a safe distance, minimizing exposure to potential arc flash hazards.

**Eliminates Manual Racking Risks:**

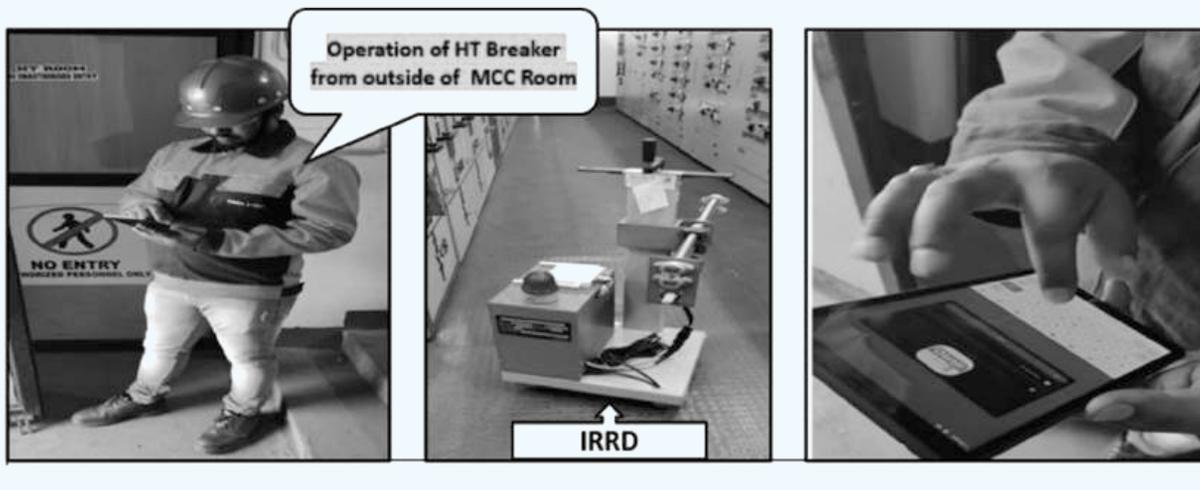
By using motorized or automated mechanisms, IRRDs reduce the chances of workplace injuries associated with manual racking.

**Closed-Door Racking:**

Some IRRDs facilitate closed-door racking, further enhancing safety by keeping operators outside the arc flash boundary.

**Operator Safety:**

IRRDs place the operator outside the arc-flash protection boundary, ensuring safety during racking operations.



### **Conclusion:-**

the mitigation of safety challenges in electrical installations at Tata steel has a multifaceted approach that involves:

1. **\*Proper design and installation\*:** Ensuring that electrical installations are designed and installed with safety in mind, taking into account factors such as load calculations, voltage drops, and short-circuit currents.
2. **\*Regular maintenance and inspection\*:** Regularly inspecting and maintaining electrical installations to identify and address potential safety hazards before they become major issues.
3. **\*Engineering Solutions\*:** Implementing state of the art technologies to mitigate the hazards involving Electrical installations.
4. **\*Implementation of safety protocols\*:** Implementing safety protocols such as lockout/tagout, arc flash analysis, and electrical safety procedures to minimize the risk of electrical shock, arc flash, and other hazards.



## Applications of Advanced Vibration Management System for Controlled Blasting at Khondbond Iron Mine, Tata Steel Limited

Rajesh Kumar<sup>1</sup>, Abhishek Singh<sup>2</sup>  
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### Abstract:

Khondbond Iron Mine, a captive mine of Tata Steel located in Odisha, faced a critical challenge in Pit-2, where blasting operations were required in close proximity to permanent and non-permanent structures, including a Crushing & Washing Plant facility. **Advanced Vibration Management (AVM)** utilized Electronic Blasting Systems (EBS), Monte Carlo simulation modeling, and SHOTPlus® 5 software for precise blast design and vibration prediction. Trials with NONEL and EBS detonators were conducted, and site-specific vibration propagation constants were determined. The AVM project achieved 90% accuracy in vibration prediction, ensured 100% compliance with the 5 mm/s PPV limit at Points of Interest, and eliminated any flyrock incidents. This paper presents the technical approach, implementation strategy, and results of the AVM project, demonstrating the effectiveness of advanced blasting technologies in sensitive mining environments.

**Keywords:** Advanced Vibration Management, Electronic Blasting System

(EBS), Monte Carlo Simulation, Shotplus® 5, Controlled Blasting, Ground Vibration, Fly rock Mitigation.

### Introduction:

Blasting is a vital process in mining, enabling efficient rock fragmentation for ore access and operational space. However, it also produces adverse effects such as ground vibration, fly rock, air overpressure, and noise, which can damage structures and pose safety risks. Maximum Charge Per Delay (MCPD) refers to the maximum explosive quantity detonated within a single delay interval. Before delay detonators were introduced, multiple rows of boreholes were fired simultaneously, causing excessive vibration and poor fragmentation, especially in hard strata.

Modern research focuses on optimizing delay timing to control vibration and improve fragmentation in open-pit operations. Proper fragmentation enhances downstream processing and productivity. DGMS guidelines specify permissible vibration limits based on structure type. Studies show shorter delays (0–3 ms) produce finer fragmentation, while longer

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delays (>6 ms) result in coarser fragments. Non-electric delay blasting uses millisecond detonators to create free surfaces and reduce charge weight. Electronic detonators allow precise delays as short as 1 ms, improving vibration control and fragmentation. Experimental

evidence confirms that rock breakage is primarily driven by explosion-induced stress waves rather than detonation gases. These advancements underscore the importance of controlled blasting for safety, efficiency, and environmental compliance in mining.

Type of structure	Dominant excitation frequency, Hz.		
	<8 Hz.	8-25 Hz.	>25 Hz.
<b>(A) Buildings/Structures not belonging to the owner</b>			
1. Domestic houses/structures (kuccha, Brick & cement)	5	10	15
2. Industrial buildings (R.C.C & Framed Structures)	10	20	25
3. Objects of historical importance & sensitive structures	2	5	10
<b>(B) Buildings belonging to owner with limited span of life</b>			
1. Domestic Houses/structures (kuccha, Brick & cement)	10	15	25
2. Industrial buildings (R.C.C. & Framed Structures)	15	25	50

**Table 1:** Permissible Peak Particle Velocity (PPV) at the foundation level of structures in mining Areas in mm/s. [6] DGMS (Tech) (S&T) Circular No.7 of 1997.

#### **Problem Statement:**

Blasting operations were required in Pit-2 of Khondbond Iron Mine (KIM), where both permanent and non-permanent structures, as well as a major infrastructure - Crushing & Washing Plant facilities were located within a 250-meter radius of the blasting area. The challenge was to excavate all mineralized zones safely while keeping environmental impacts such as ground vibration and air overpressure within DGMS limits and ensuring zero fly rock incidents. This situation demanded advanced blasting techniques and precise vibration control to protect nearby structures and maintain operational safety.

#### **Technical Approach and Implementation:**

Trials were conducted multiple times with both NONEL and electronic detonators,

while continuously monitoring key parameters such as ground vibration, fly rock, and air overpressure. Through the AVM study, blast vibrations at different Points of Interest (POIs) could be pre-determined. Based on this, derived a solution to reduce ground vibrations and achieving zero-fly rock through the **AVM (Advanced Vibration Management)**. Lower scattering effect by blasting through AVM using electronic detonators in comparison to NONEL is a key factor in getting the desired results of Vibration, fragmentation, flyrock, air overpressure etc.

After visiting the site, recommended using the latest generation **Electronic Blasting System (EBS)** to ensure better accuracy and flexibility in delay patterns. To deliver the required technical solutions, employed a



Monte Carlo simulation model generated from multiple single blastholes, incorporating statistical analysis to determine site constants for the vibration propagation equation. This model was designed to predict the expected vibration produced by each blast. The safe limit for

Peak Particle Velocity (PPV) was set at 5 mm/s at the Points of Interest, based on DGMS criteria and human perception, to minimize complaints.

The situation required complex blast designs with highly efficient delay patterns, which were successfully achieved using SHOTPlus® 5 software.

Sl. No.	NONEL Blasting			Electronic Blasting		
	SME (kg)	Point of Interest Distance(m)	Vibration Limit (mm/sec)	SME (kg)	POI Dist.(m)	Vibration Limit (mm/sec)
1	150	240	3.5	75	250	1.6
2	120	280	3.2	60	260	1.2
3	60	360	2.8	60	320	0.5
4	80	340	2.5	80	310	0.8
5	161	240	2.8	80	160	1.8

**Table-2:** Experiments of blasting operations with Nonel & Electronic blasting

1. For NONEL blasting, an SME of 150 kg at a point of interest (POI) distance of 240 meters resulted in a vibration limit of 3.5 mm/sec. In comparison, electronic blasting with an SME of 75 kg at a POI distance of 250 meters achieved a significantly lower vibration limit of 1.6 mm/sec.
2. At an SME of 120 kg for NONEL blasting and a POI distance of 280 meters, the vibration limit was recorded at 3.2 mm/sec. Conversely, electronic blasting with an SME of 60 kg at 260 meters reduced the vibration limit to 1.2 mm/sec, demonstrating better control.
3. NONEL blasting with an SME of 60 kg at 360 meters produced a vibration limit of 2.8 mm/sec. Electronic blasting under similar conditions (SME 60 kg, POI 320 meters) achieved a much lower vibration limit of 0.5 mm/sec, highlighting its superior performance.
4. An SME of 80 kg for NONEL blasting at 340 meters resulted in a vibration limit of 2.5 mm/sec. Electronic blasting with the same SME at a slightly shorter POI distance of 310 meters recorded a vibration limit of 0.8 mm/sec, reinforcing its effectiveness.
5. For NONEL blasting, an SME of 161 kg at 240 meters yielded a vibration limit of 2.8 mm/sec. Electronic blasting with an SME of 80 kg at 160 meters maintained a vibration limit of 1.8 mm/sec, still offering better control compared to NONEL.

**Results:**

The AVM project at Khondbond Iron ore mine was executed from July 2024 to June 2025 helping to excavate the critical areas with the close proximity to structures.

With the use of EBS in conjunction with technical services support and Monte Carlo simulation model, following results were achieved:

- a) 90% accuracy was achieved while predicting blast induced ground vibrations using Monte Carlo prediction model.
- b) 100% blasts with blast induced vibration levels within 5mm/s at agreed point of interests.
- c) No fly rock achieved for 100% of the blasts.

**Conclusion:**

The Advanced Vibration Management (AVM) system implemented at Khondbond Iron Mine demonstrated the effectiveness of modern blasting technologies in sensitive mining environments. By integrating Electronic Blasting Systems (EBS), Monte Carlo simulation modeling, and SHOTPlus® 5 software, the project achieved precise vibration prediction and compliance with DGMS standards. The results—90% prediction accuracy, 100% adherence to the 5 mm/s PPV limit, and zero flyrock incidents—highlight the critical role of advanced vibration control in ensuring operational safety and

environmental compliance. This approach not only safeguarded nearby infrastructure, including Crushing & Washing Plant facilities, but also optimized blasting efficiency in challenging conditions. The success of AVM underscores the importance of adopting data-driven design, simulation tools, and electronic initiation systems for sustainable and safe mining practices. Future work should focus on scaling these technologies across other mines and exploring AI-driven predictive models for further improvements in blasting performance and risk mitigation.

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## Safety Enhancement and Carbon Footprint Reduction in Opencast Mining: A Case Study of Khondbond Iron Mine, Tata Steel Limited

Rajesh Kumar<sup>1</sup>, Anup Kumar Roy<sup>2</sup>,  
Jivitesh Kumar Anokhe<sup>3</sup> Abhishek Singh<sup>4</sup>,  
Sanapathi Gowrisankar<sup>5</sup>

### Abstract:

This study outlines strategies to reduce fuel consumption and improve traffic efficiency at Khondbond Iron Mine, Odisha, India. By analyzing operational data and implementing design interventions, such as replacing heavy dump bodies with lightweight alternatives, the study achieved measurable improvements in fuel efficiency and payload optimization. Results indicate a reduction of 1-2 liters of diesel per hour per dumper and a 3-5% increase in payload efficiency. These findings highlight the importance of equipment optimization and adherence to OEM loading policies for sustainable mining operations.

**Keywords:** Payload statistics, Light weight dump body, HSD Consumption.

### Introduction:

Fuel consumption has always been a critical consideration in mining due to its economic and environmental implications. The industry primarily depends on fossil-based fuels such as diesel, which significantly contribute to greenhouse gas emissions through CO<sub>2</sub> release. Studies by Adak et al.

(2016), Norgate and Haque (2010), and Kecejevic and Komljenovic (2010) reveal that material handling accounts for the largest share of emissions among mining operations. Therefore, improving fuel efficiency in hauling systems can substantially reduce environmental impact.

Khondbond Iron Mine, operated by Tata Steel Ltd., is a fully mechanized open-pit mine located in Keonjhar district, Odisha, spanning 978 hectares. The mine employs shovel-dumper combinations for ore transportation, with an annual excavation capacity exceeding 10 million tons. However, operational analysis for FY25 revealed inefficiencies in fuel consumption, averaging 40-43 liters per hour per dumper, despite payload variations between 95 and 102 tons. These inconsistencies suggest deviations from OEM loading policies and design limitations, such as heavy dump bodies reducing effective payload capacity and increasing traffic in mines due to utilization of all hauling fleets.

To address these challenges, this study focuses on optimizing hauling operations

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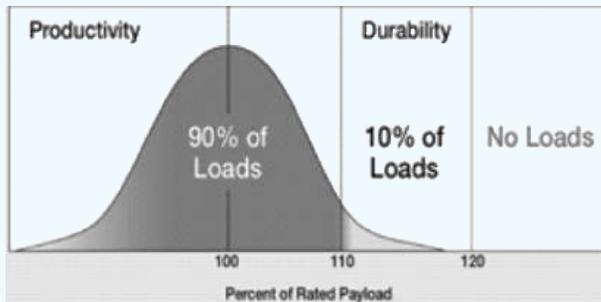
5. Assistant Manager Mining, Khondbond Iron Mine, OMQ Division, Tata Steel Limited, India.



through equipment design improvements and strict compliance with OEM guidelines. The primary objective is to reduce fuel consumption, enhance payload efficiency, and align operations with sustainability goals.

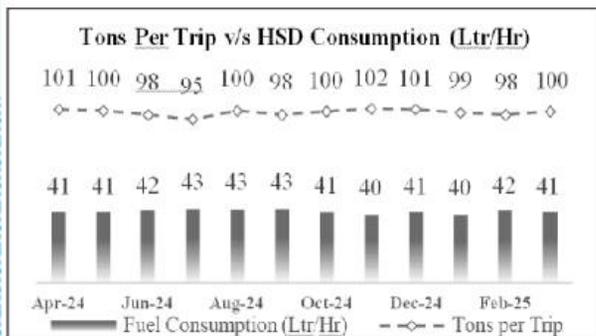
**Problem description and field investigations:** The Khondbond Iron Mine, operated by Tata Steel Ltd., has an annual production target of 10 million

tons, which is highly dependent on the efficiency of its hauling fleet. The current fleet consists of ten dumpers, each consuming approximately 42 liters of diesel per hour and achieving an average tons per dumper (TPD) of 99.3 tons.



**Figure-1:** OEM Loading policy According to the OEM loading policy:

- a) 90% of loads must be below 110% of rated payload of 91.7Tons.
- b) 10% of all loads may be between 110% and 120% of the rated payload of 91.7Tons.



**Chart -1:** Relation between Tons Per Trip v/s HSD Consumption (Ltr/Hr) However, analysis of operational data for FY25 shows that fuel consumption remains relatively constant at 40–43 liters per hour, while tons per trip fluctuate between 95 and 102 tons. This inconsistency indicates inefficiencies in the hauling process, leading to increased fuel costs and higher greenhouse gas emissions. Field investigations and data analysis revealed several root causes contributing to the problem.

- a) The existing dump body weighs approximately 10 tons, which reduces the effective payload capacity and increases fuel consumption.
- b) Deviations from the OEM loading policy result in inconsistent payloads, affecting fuel efficiency.

**Methodology:**

To address these issues, a systematic approach was adopted. Initially, data on fuel consumption and tons per trip was collected and analyzed to identify trends and deviations from OEM guidelines. Based on this analysis, a design intervention was introduced by replacing the existing heavy dump body with a lightweight version weighing approximately 5 tons lighter than the previous design. This modification aimed to increase payload capacity without breaching OEM limits and reduce fuel consumption. Field trials were then conducted by installing lightweight bodies on selected dumpers and monitoring their



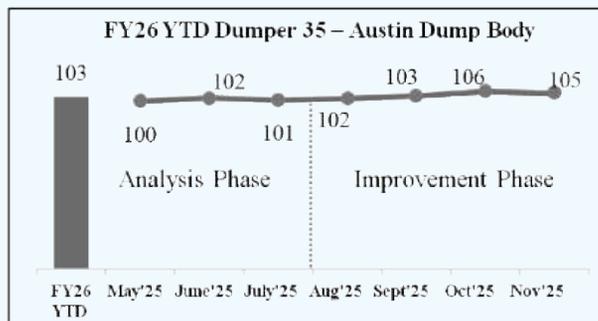
performance over a defined period. The evaluation focused on comparing pre- and post- intervention data for fuel consumption, payload efficiency, and compliance with OEM loading policy.

**Results:**

The implementation of lightweight dump bodies demonstrated significant improvements. Fuel consumption per hour showed a projected reduction of 1-2 liters per dumper, while payload efficiency improved by 3-5%, contributing to overall productivity gains.



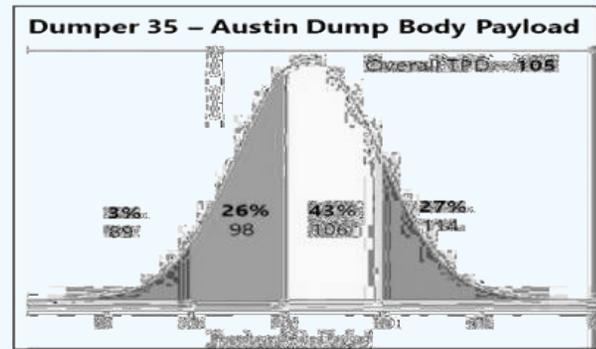
**Figure -2:** Light weight Dump Body Installed dumper



**Chart -2:** Trend of Light weight dump body - Tons Per Trip

After installation of light weight dump body, in the May'25, June'25, July'25 observed no increase in tons per trip. Analyzed the Aug'25 also then the lightweight dump body fitted dumper (Dumper 35) engaged in Hard Ore mostly

on priority basis represented in increasing of the tons per trip subsequently observed decrease in fuel consumption for the Dumper 35.



**Chart -3:** Distribution of payload for Dumper 35

These changes not only reduce operational costs but also help lower greenhouse gas emissions, aligning with sustainability goals and reduces traffic congestions due to increase in productivity. The results indicate that optimizing equipment design and operational practices can have a substantial impact on fuel efficiency and environmental performance in mining operations.

**Conclusion:**

The implementation of lightweight dump bodies at Khondbond Iron Mine demonstrated tangible benefits in fuel efficiency and payload optimization. A reduction of 1-2 liters of diesel per hour per dumper and a 3-5% improvement in payload efficiency were observed during field trials. These changes not only lower operational costs but also contribute to reducing traffic in mining & greenhouse gas emissions, supporting Tata Steel's



sustainability objectives. Future work should focus on scaling this intervention across the entire fleet and exploring additional design innovations to further enhance energy efficiency in mining operations.

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## Safety Excellence in Mining Operation & Equipment Maintenance

Khondbond Iron & Mn. Mine, OMQ Division, Tata Steel Limited, Joda - 758034, India

**Atul Kumar Bhatnagar\***  
**Gedela V Satyanarayana\*\***  
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### Abstract

The Indian mining industry faces notable safety challenges with significant growth in production of key minerals driven by robust demand from steel, aluminum, and other industries. In contrast to countries like Australia, Canada, and the USA, where digital mining practices are more advanced, the Indian mining industry has been gradually adopting these technologies. In recent years, the integration of digitalization and automation technologies in mining have become a transformative force offering new opportunities for productivity and safety enhancement. Tata Steel has taken a pioneer role by investing in digital infrastructure & innovations within its Raw Material Division, undertaking digital initiatives such as Online vehicle fitness system, Digital safety management plan, Haul Road analysis with Real Disp study, in blasting practice and developments like Dala raised control system in tippers, Fast fueling system in Shovels, Boulder detection system in Shovels etc. These initiatives underscore Tata Steel's commitment to embrace digital

technologies and innovations in mining, with the potential to significantly transform the Indian mining landscape.

### Introduction

Khondbond Iron & Manganese Mine with leasehold area of 978 Ha located in Khondbond village of Bichakundi, PO, Keonjhar district of Odisha, is a captive Iron ore supplier of Tata Steel Ltd. Khondbond Iron & Mn. Mine began its mining operations in the year 1994 by Opencast method of mining. KIMM is Certified with ISO 9001:2015, ISO 14001:2015 & ISO 45001 in recognition of its commitment to continuously improve the quality, environmental, occupational, health, and safety management system performance, and for complying with all applicable legal and contractual requirements while adopting best technologies. Khondbond Iron & Mn. Mine has implemented various best practices to attain excellence in its Operations, Health & Safety, Environment and Human development.

This paper highlights safety challenges in bulk material handling equipment such as

- 
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  3. Head Safety, OMQ Division, Tata Steel Limited
  4. Head Equipment Maintenance, Khondbond, OMQ Division, Tata Steel Limited
  5. Senior Area Manager Equipment Maintenance, OMQ Division, Tata Steel Limited



100T Dumpers, 5.9 m3 Shovel, etc plying in Metalliferous Mine and the implementation of IOT, machine learning to capture data in real time for inspection & control , also automation in HEMMs in field of maintenance and operator safety.

**Safety Digital Excellence**

**1. Digital Safety Management Plan**

DGMS (Directorate General of Mines Safety) in its Tech circular No.3 of 2019, advised to introduce appropriate digital/IT mechanisms for SMP implementation. An IT system for Safety Management Plan (SMP) has been developed for all mines in the Tata Steel as per the DGMS guidelines. It covers all departments of the Mines (Mining operations to Canteen Service). Auto generated report in DGMS Quarterly Return Format. Mandatory upload of evidence of task execution for Principal Hazards. Appointing key safety personnel ensures diligent task execution and compliance monitoring. A robust safety management system, complemented by thorough documentation and a focus on continuous improvement, fosters a culture of safety and mitigates potential risks.

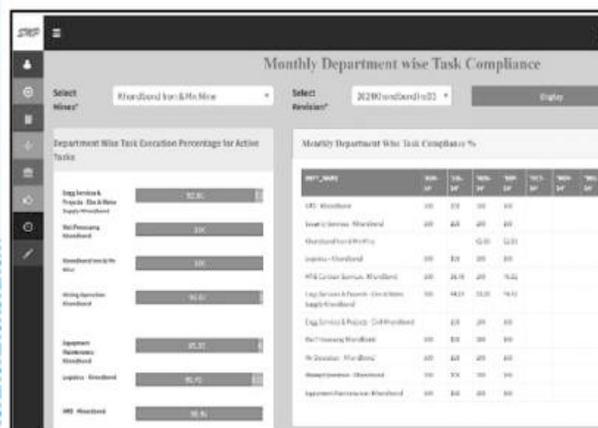


Fig. 2 : Interface of SMP

**2. Online Vehicle Fitness System**

The online vehicle fitness system is a digital solution designed to monitor and grant vehicle fitness to ensure safety and compliance of vehicles deployed inside mines. It allows, tracking and assessment of each vehicles condition, necessary checks to grant vehicles fitness. This system is designed integrating all clearances such as security, legal and vehicle’s condition in a single platform monitored and cleared by respective departments at various level.

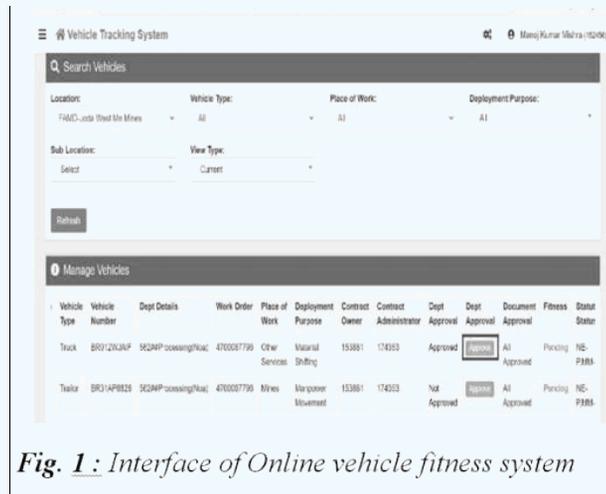


Fig. 1 : Interface of Online vehicle fitness system

Implementation of online vehicle fitness system enhanced safety is a priority that can be achieved through a quick process of vehicle fitness assessments and regulatory compliance.

**Merits :**

- a) Maintaining a digital record of a vehicle's fitness streamlines the checking process, making it easier for both vehicle owners and inspectors
- a) Effective hazard identification and safety risk assessment enhance workplace safety by establishing clear accountability and responsibilities.



- b) It provides data driven insight that support ongoing Improvement of safety system and practices. to access necessary information.
- b) Additionally, implementing scheduled inspections of vehicles for fitness ensures that vehicles remain in optimal condition, promoting safety on the roads.

**3. Online Driver Fatigue Monitoring System** An Online Driver Fatigue Monitoring System (DFMS) with two-way communication is a technology designed to enhance road safety by monitoring driver alertness in real-time through control room. This system utilizes various sensors and algorithms to assess signs of fatigue, such as eye movement and head position. If fatigue is detected, the system transmits alerts to the driver and can communicate with fleet management or emergency services.



Fig. 3 : DFMS control room interface and alerts.

Merits :

- a) It allows for immediate feedback and intervention, enabling drivers to receive real-time assistance or encouragement to take breaks, ultimately reducing the risk of accidents caused by drowsiness.



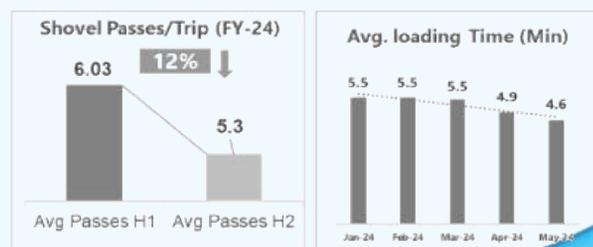
Fig. 4 : i-RMSC control room.

#### 4. Integrated Raw Material Supervision Centre

At i-RMSC, all processes, from mining to logistics, are meticulously monitored from a centralized location, ensuring streamlined operations and improved oversight. This integrated approach enables a comparative analysis of productivity KPIs across different mines, fostering insights that drive operational excellence throughout the entire process. By leveraging real-time data and analytics, i- RMSC is able to identify best practices, optimize resource allocation, and sustainable mining operation. This commitment to continuous improvement in productivity.

Merits:

- a) Improved Operational Efficiency
- b) Reduced Infrastructure Requirements
- c) Enhanced Safety Measures
- d) User-Friendly Access Control





## 5. Automated Boulder Detection System

This system integrates advanced In-situ Imaging technology alongside a sophisticated Deep Learning Model. The primary function of this system is to analyze images in real time to

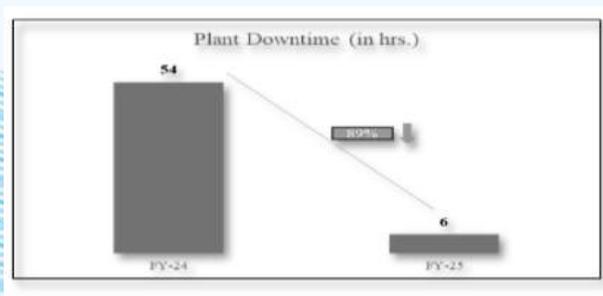


Fig. 5: Boulder detection system.

accurately identify the presence of boulders within dump loads. Generally during dumping of loaded ore material in hopper of processing plant if the boulders which are of bigger size gets dumped in the hopper, then it's gets stuck if its size is greater than 1m , so for removing this boulder EOT cranes are used that leads to significant downtime of Plant which eventually hampers the productivity of Mining operation.

Merits:

- Early detection and removal of big sized boulders at loading points
- Reduction downtime up to 89% of Processing plants and eventually leading to increased production.



## 6. IoT based WISE System

WISE (Web-enabled Illumination Surveying Equipment) is an innovative solution designed to transform the way illumination surveys are conducted across designated Areas of Interest (AOI). By offering a portable device coupled with integrated software, WISE simplifies the surveying process, allowing professionals to gather critical data efficiently and accurately. This modern approach not only enhances the quality of data collected but also facilitates seamless integration into existing workflows.

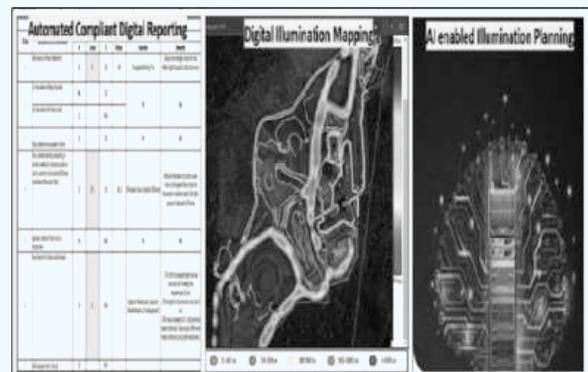


Fig. 6: WISE System and Illumination Mapping

Merits:

- One of the primary benefits of WISE is its ability to significantly improve data collection time, accuracy, and transparency.
- Mining active area coverage increased by 33% for illumination survey.

## 7. Haul Road Monitoring and Optimization using Real Disp. Study

A technology-enabled solution is devised to identify and address haul road undulations through a systematic and data-driven



process. Sensors installed on dumpers to measure suspension pressure in real time GPS coordinates and camera systems used to capture images and videos of haul road conditions. A severity rating scale (1-10) is applied, and haul roads are color-coded: Blue: Acceptable ( $< 12000$  kPa), Green : Regular (12000- 14000 kPa), Red : Warning ( $>14000$  kPa).

Additionally, optimized road conditions can lead to improved tire life, with documented increases from 7,800 to 8,800 hours, resulting in substantial cost savings on replacements— amounting to around ₹22.5 lakhs annually.

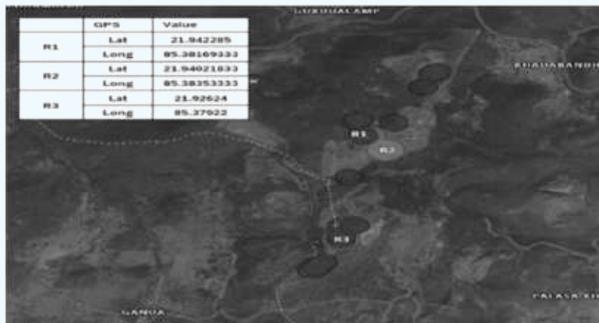


Fig. 7: Undulation mapping

Merits:

- This approach minimizes use of the breaks of the dumper enabling it to travel at a constant speed thus improving the cycle time, fuel consumption, and boosting productivity.
- Data-driven insights generated from these studies enable swift action on undulation.

## Operational Safety Excellence

### 1. Hole Navigation System (HNS)

Implemented a Hole Navigation System (HNS) to automate drilling and measure while drilling, ensuring optimal blast outcomes. DGPS base stations were set up at Khondbond for precise execution of drilling operations. The "Measure While Drilling" technique allows for visualization of strata hardness, facilitating effective blasting planning. Charging operations can be tailored based on the visualized strata conditions. valve (NRV), and it is powered by an hydraulic power pack. Operation is simplified through a conveniently located switch, while a mechanical catcher provides automatic locking in the elevated position for added security.

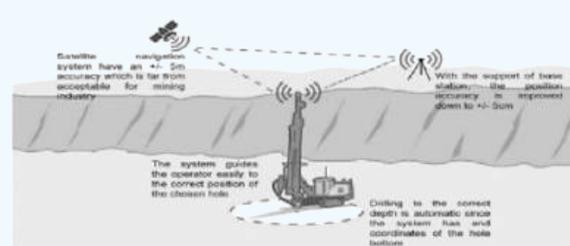


Fig. 8 : Hole navigation system

Merits:

Furthermore, to safeguard both the ladder and the operator using it during ascent and descent, we have incorporated an interlock system that a) The Surface Manager presents data in a user-

friendly layout, enabling users to map drill usage, assess production statistics, monitor consumables, and compare planned outcomes with actual results.

### 2. Hydraulic power ladder in shovel and Dozer



The operator cabin is positioned at a height of 2.5 meters and is currently accessed via a three- step ladder designed by the OEM, and through track chain. This configuration poses slip, trip, and fall hazards, particularly during the rainy season when the ladder may become muddy and prone to slipping.

To eliminate the safety concerns, we have engineered a in house hydraulic power ladder featuring eight anti-skid steps. This innovative design ensures secure access from ground level while allowing operators to maintain three-point contact . The ladder operates through a hydraulic cylinder with fall protection by a non-return restrict the swing of the upper frame.



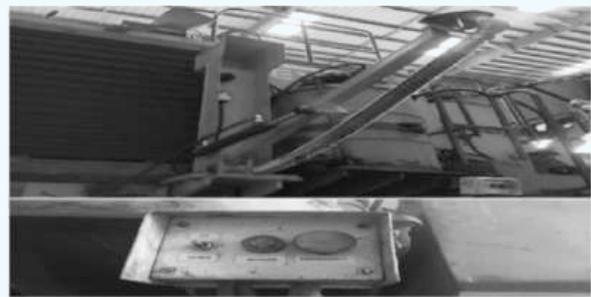
*Fig. 9 : Hydraulic power ladder*

### 3. Hydraulic operated fast fuelling system in Shovel

Manual refuelling of an excavator requires approximately 20 to 30 minutes per unit and requires personnel to ascend onto the upper frame while handling a 2 kg diesel dispensing hose. This procedure not only increases the risk of fuel contamination but also poses safety hazards related to slip, trip, and fall, particularly given that the

diesel tank nozzle is situated nearly 2.5 meters above the ground.

To mitigate these challenges, we have developed a in house hydraulic operated fast fuelling system that enables refuelling from a ground level of 1 meter via a robotic arm. The process is initiated when the diesel operator positions the bowser near shovel Subsequently, the hydraulic fuelling system is activated by pressing a switch, which extends the robotic fuelling arm to an easily accessible height.



*Fig. 10 : Fast fuelling system.*

### 4. DRCS Mechanical Gear Interlock System in Tippers

Tipper operating at speeds exceeding first gear can cause a shift in the centre of gravity when the dump body is raised, significantly increasing the risk of toppling during the dumping process. The in-house designed and developed Mechanical 1st Gear Interlock System features a cassette plate located beneath the gear lever, allowing selection of first gear only while preventing engagement of higher gears when the dump body is raised. A limit switch identifies if the body is not properly seated and continue to activate the interlock mechanism.

This static mechanical system does not interfere with or impact any pneumatic or



hydraulic systems within the tipper, and it represents the simplest form of a 1st Gear interlock, enabling



This static mechanical system does not interfere with or impact any pneumatic or hydraulic systems within the tipper, and it represents the simplest form of a 1st Gear interlock, enabling the operator to maintain original operating procedures. The Mechanical 1st Gear Interlock System at the Khondbond Iron Mine complies with the guidelines set forth in DGMS Circular No. 6/2020.

#### 5. 360 degrees camera

The 360-degree camera improves visibility by eliminating blind spots. With its ability to capture all surrounding areas of dumper in real-time without latency, it enhances situational awareness and safety.



This innovative technology provides comprehensive coverage, ensuring that operators have a complete view of their environment, significantly improving navigation and security.

#### Way Forward

The successful implementation of these initiatives has significantly enhanced the efficiency, safety, and sustainability of our heavy equipment operation in mining operations. Going forward, it is aimed to further leverage emerging technologies such as artificial intelligence, machine learning, and automation to continuously optimize operations and improve the longevity.



**“विकसित खदान, विकसित भारत ”**  
**Safety Initiatives at Lanjiberna Limestone**  
**and Dolomite Mine (Dalmia Cement Bharat Limited)**

**Rama Ranjan Bhuyan**

### **Company Overview**

Dalmia Cement Bharat Limited is the only cement company with at least one plant in each of the four key eastern states—**West Bengal, Bihar, Jharkhand, and Odisha**. Through its marquee brands—**Dalmia Cement, Dalmia DSP, and Konark Cement**—the company offers a diverse range of cement variants.

The **Rajgangpur Cement Plant** sources limestone from its **captive mines** spread across a **Mining Lease Area of 873.057 hectares**, covering villages such as Alanda, Bihabandh, Jhagarapur, Kesramal, Raiberna, Katang, Dhauraada, Lanjiberna, and Kukuda in Kutra and Rajgangpur Tehsils, Sundargarh District, Odisha.

### **Health & Safety Standards**

We have successfully implemented and regulated safety protocols/standards across **13 critical jobs/areas**, ensuring comprehensive risk management:

- Mines & HEMM Safety
- Working at Height
- Scaffolding Safety
- Hot Work Safety
- Material Handling & Lifting Operations
- Fire Risk Management
- Electrical Safety
- Road & Driving Safety
- Lock Out Tag Out Try Out (LOTOTO)
- Confined Space Safety

- Permit to work
- Hazard Identification & Risk Assessment (HIRA)
- Machine Guarding

### **Recognition Policy for Safety Improvements**

At Lanjiberna Mines, we celebrate employees' contributions to safety excellence through structured recognition programs:

- **Reporting unsafe acts, unsafe conditions, and near-miss incidents**
- **Suggesting engineering controls** to improve workplace safety
- **Winning safety competitions** that encourage proactive participation

### **KAVACH – My Safety, My App**

Developed in-house, **KAVACH** is a digital platform for reporting and tracking safety compliance:

- Employees report **lead indicators** directly through the app.
- **Department-wise compliance** is monitored daily during production meetings chaired by the Unit Head/Mines Head.
- **Lead and lag indicators** are reviewed during apex and central safety committee meetings, ensuring accountability and continuous improvement.

### **Safety Awareness Campaigns**

Every month, we design **theme-based campaigns** to enhance employee awareness and engagement:

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*Safety Manager*  
*(Lanjiberna Limestone & Dolomite Mines)*



- Toolbox Talks
- Safety Training Sessions
- *Nukkad-Natak* (street plays)
- Quiz Competitions
- Safety Audits

*These initiatives foster a culture of vigilance and responsibility across all levels of the workforce.*

**Monthly Safety Gate Meetings**

Held during the **first week of each month**, these meetings serve as a platform to:

- Share **safety performance updates**
- Honour employees demonstrating **exceptional safety behavior**

- Provide **health tips** by medical professionals
- Deliver **motivational speeches** by Mines Managers and Heads
- Recognize the **most safety-conscious workers**

**In summary:**

The safety culture at Lanjiberna Mines is built on **structured standards, digital innovation, employee recognition, and continuous awareness campaigns**. By combining technology (KAVACH), proactive training, and monthly recognition, Dalmia Cement ensures that safety is not just a compliance requirement but a **shared value across the organization**.

**Implementation of Mines Safety & HEMM Safety Standard-**





Implementation of Hot work, LOTOTO, Working at Height, Material handling by crane, Electrical safety at Mines



Monthly safety gate meeting, sharing best practices, Motivation & recognition of workers for best performance towards safety, Environment, Health, Innovation & Productivity at Mines-





## HR Practices in Safety Training

Ajay Kumar Kar

Teaching one safety class and assuming workers have all the training they need is a risky proposition. Managers and other leaders should follow up with department heads, foreman and other supervisors to see implementing the training they have received. If a worker performs a task in an unsafe manner coaching or retaining should happen immediately. In the moment assistance is far more effective than assurance after an injury has occurred.

In fact, supporting a culture of safety means that workers must take ownership of occupational safety and health within their work areas. After all, their lives at stake, involving employees in the development of safety and health policies and training increases engagement. It also ensures that their training is relevant and addresses the most common issues in that specific work environment. Some business form safety committee run by workers and not by managers. They become resources for their colleagues when it comes to safety issues, and they can also report issues, like poor equipment function, before those issues lead to injuries. Because they are closet to the actual work, they become valuable eyes and ears when it comes to safety issues.

Giving employees' ownership over the health and safety of the work environment also means demanding accountability as well. Safety responsibilities should be a part of every job description, with adherence to safety policies and practices a part of performance reviews. When employees engage in unsafe practices or behaviours, they should be disciplined and retained if necessary.

By the same token, employees who demonstrate commitment to safety and actively support safety goals should be rewarded. Track key performance indicators related to occupational safety and health, such as injury rates, lost time for injury and illness, and severity of workplaces injuries or illness associated with work activities, and communicate the entire staff. Facilities or departments that make notable improvements should receive incentives or awards, including individual recognition for leaders and top performers. If goals are not being reached, investigate the causes and look for employee input into issues and challenges that can be made to achieve those goals.

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D.G.M.(HR)



## Key themes in Safety Week

Kailash Chandra Patra

- **Workplace safety:**

Many articles highlight efforts to improve industrial safety through regular audits, training, and adherence to best practices to prevent accidents like fires and gas leaks.

- **Road safety:**

Some articles focus specifically on road safety, emphasizing rules, awareness campaigns, and the role of technology in preventing accidents, such as those involving pedestrians and cyclists.

- **Mental health:**

A growing focus is placed on the link between mental well-being and physical safety, with awareness programs aimed at reducing stress and burnout to prevent accidents in high-stress environments.

- **Technology in safety:**

Articles often discuss the integration of technology, including smart devices and

AI-driven monitoring systems, to enhance safety in both workplaces and public spaces.

### Activities and objectives:-

- **Campaigns and events:**

Organizations host a variety of events, such as rallies, slogan and poster competitions, quizzes, and awareness training sessions.

- **Employee engagement:**

An important objective is to involve all employees in safety activities, empowering them to identify hazards and take ownership of their safety and that of their colleagues.

- **Proactive measures:**

The week serves as a reminder for both employers and employees to be proactive in implementing safety measures, conducting regular safety checks, and establishing professional management systems.



## Role of Geologist in Ensuring Mines Safety

Sahasransu Pradhan

### INTRODUCTION:

Mining is one of the principals and influential factors in the global economy as well as the first place in the supply chain for industrial and agricultural products for human needs. Mining activity is one of the important requirements of development and economic growth. Excavation is the major activity in any mining industry. The movement and operation of excavator is quite different from the other equipment and roughly it works in almost an uneven terrain and front of mining face. So safety of man and machine is very important. The prominent Physicist Max Planck has said that “Mining is not everything, but without mining, everything is nothing”.

### A COMMITMENT BEYOND COMPLIANCE:

Mines safety is the cornerstone of sustainable mining operations. It encompasses the protection of life, health, and the environment through proactive risk management, technological innovation and a strong safety culture. Modern mining emphasizes not only adherence to safety regulations but also continuous training, hazard identification, and emergency preparedness.

A safe mine is not achieved by equipment or technology alone- it thrives on awareness, responsibility, and teamwork.

### ROLE OF GEOLOGIST IN ENSURING MINES SAFETY:

Geologist play a crucial role in monitoring and enhancing mines safety. A deep understanding of geological formations, rock behavior, and ground conditions is essential for preventing accidents and ensuring smooth mining operations. According to safety purpose, it is important to recognize that the foundation of safe mining lies in accurate geological assessment and timely interpretation of data.

From the initial exploration stage to final phase of mine closure, geologists help identify potential hazards such as weak strata, fault zones, water inflow risks and gas accumulations. Their observations and mapping are guide the design of safe pit slopes and support systems. Regular monitoring of ground stability and timely geological reporting can prevent slope failure and some of the most serious hazards in mining.

Modern techniques like 3D geological modelling, remote sensing, and



geotechnical monitoring have empowered geologists to predict and mitigate risks more effectively. However, technology is only as effective as the vigilance of the professional behind it.

### **KEY ROLES OF A GEOLOGIST IN MINE SAFETY:**

#### **1. Geological Mapping and Hazard Identification**

- Conducts detailed mapping of rock formations, faults, joints, and fractures.
- Identifies potentially unstable zones, weak strata, and water-bearing layers.
- Assesses ground conditions to predict areas prone to collapses, landslides, or rockbursts.

#### **2. Slope Stability and Ground Control**

- Analyzes slope stability in open-pit mines to prevent wall failures.
- In underground mines, helps design support systems (e.g., rock bolts, mesh, shotcrete) based on rock mass properties.
- Uses geotechnical data to recommend safe excavation angles and sequences.

#### **3. Hydrogeological Assessment**

- Studies groundwater flow and pressure, which can affect slope stability and cause flooding.
- Plans for dewatering systems and drainage to maintain dry, stable working conditions.

#### **4. Mine Planning and Design Support**

- Provides input to engineers on safe mine layouts, extraction methods, and sequencing.
- Ensures that geological features are incorporated into safety plans and operational designs.

#### **5. Training and Safety Awareness**

- Trains mine staff to recognize hazardous geological conditions (e.g., signs of impending rockfalls).
- Promotes safety culture by emphasizing geological awareness in daily operations.

#### **6. On-site support and technical guidance:**

- Offer on-site geological support during activities like drilling and blasting.
- Collaborate with mining engineers to ensure the extraction process is both efficient and safe.
- Work with other specialists, such as geologists and engineers, to design and implement safer mining methods.

#### **CONCLUSION:**

As we celebrate mines safety week, let us reaffirm our responsibility as geologists to integrate safety in to every geological decision. Because every safe ton of ore produced begins with sound geological judgement.



## Risk Assessment in Mechanical Operations: Identifying and Mitigating Hazards in Iron Mines

Abu Talib Ansari

### *Introduction*

In the mining industry, particularly in iron mines, mechanical operations are complex and inherently risky. Heavy-duty machinery such as dumpers, excavators, loaders, and drilling rigs operate under demanding environmental conditions. Mechanical failures or human error can lead to severe consequences, including injuries, production losses, and environmental damage. Risk assessment serves as a crucial tool in identifying such hazards, assessing their potential impact, and implementing measures to mitigate risks and safeguard the workforce and operations.

### *Understanding Risk Assessment*

Risk assessment is a systematic process of identifying hazards, evaluating risks, and prioritizing control measures. In mining operations, it helps engineers and safety officers recognize critical points in the mechanical workflow where failures or unsafe practices could lead to incidents. The process involves hazard identification, risk analysis, risk evaluation, and the implementation of suitable control measures to minimize the likelihood or impact of accidents.

### *Importance of Risk Assessment*

- Enhances Safety: Protects workers by identifying and mitigating mechanical hazards.
- Ensures Compliance: Meets DGMS and other statutory safety requirements.
- Improves Efficiency: Minimizes breakdowns and downtime, improving productivity.
- Reduces Cost: Prevents expensive repairs, penalties, and compensation costs.

### *Identifying Hazards in Mechanical Operations*

Common hazards in mechanical operations within iron mines include mechanical failures, hydraulic leaks, overloading, equipment fires, and collisions. The table below highlights the frequency of common mechanical hazards observed in iron mining environments based on sample data.

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*Dy. Manager (Mechanical)*  
*M/s M G Mohanty*

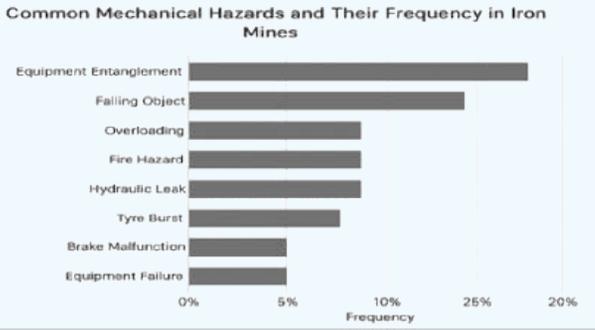


Figure: Common Mechanical Hazards and Their Frequency in Iron Mines

**Risk Evaluation**

Risk evaluation involves analyzing the likelihood of a hazard occurring and its potential severity. This evaluation assists in

prioritizing control measures to address the most significant risks first. A typical risk matrix used in mining operations is illustrated below.

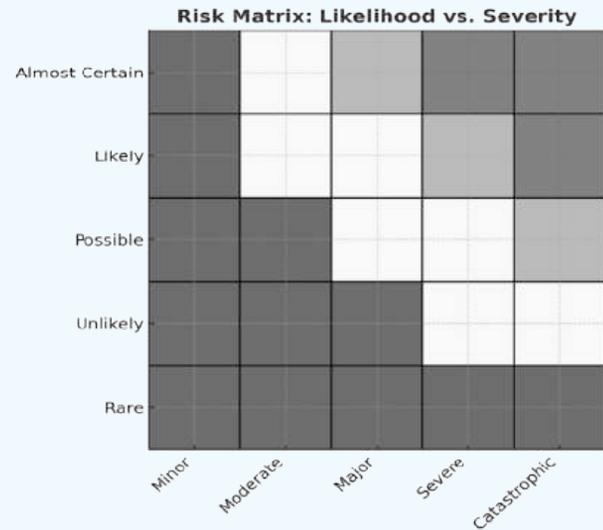


Figure: Risk Matrix – Likelihood vs. Severity of Mechanical Hazards  
Iron Mines Risk Assessment Color Code

Color	Risk Level	Meaning in Iron Mines Context	Action Required
<b>Red</b>	High / Extreme Risk	Conditions that could lead to fatal injuries, mine collapses, major explosions, or severe equipment failure.	Immediate action required – stop operations until risk is mitigated.
<b>Orange</b>	Significant Risk	Potential for serious injury (e.g., rock fall, machinery entrapment, or electrical hazards).	Urgent mitigation – corrective actions must be taken promptly.
<b>Yellow</b>	Moderate Risk	Could cause minor injuries or short-term environmental damage (e.g., dust exposure, noise).	Monitor closely and control through standard procedures.
<b>Green</b>	Low Risk	Routine operations with minimal hazard potential (e.g., well-maintained transport, PPE use).	Acceptable with standard safety practices.



### *Mitigation and Control Measures*

Effective risk control measures can significantly reduce mechanical hazards. These include proper maintenance schedules, operator training, installation of automatic fire detection and suppression

systems, use of proximity detection devices, use of fatigue monitoring system and adherence to preventive maintenance protocols. The overall risk assessment and mitigation process is illustrated below.

## Risk Assessment and Mitigation Process

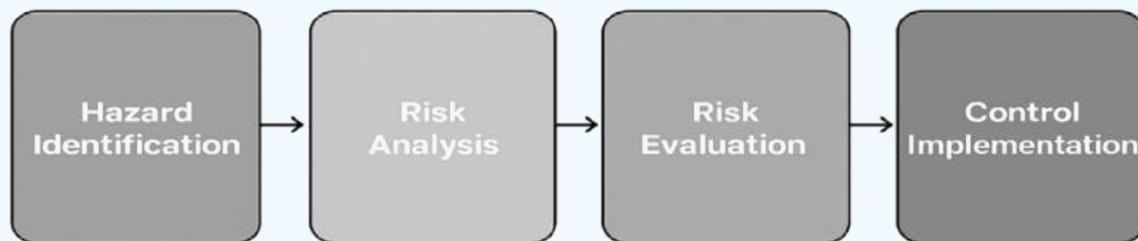


Figure: Risk Assessment and Mitigation Process in Mining Operations

### Hazard Identification

This is the first and most critical step. It involves **recognizing anything in the mining environment that has the potential to cause harm.**

Examples of hazards include:

- Unsafe geological conditions (like weak strata/**fragile layers** or water seepage)
- Equipment malfunctions or electrical faults
- Dust, gas, or chemical exposure
- Human factors such as fatigue or improper training

The goal is to **list all possible hazards**—no matter how minor—before they lead to accidents or injuries.

Methods: workplace inspections, worker feedback, incident reports, and safety audits.

### Risk Analysis

Once hazards are identified, the next step is to **analyze the risk** associated with each one.

This means determining:

- **Likelihood:** How probable is it that this hazard will cause harm?
- **Severity:** If it does occur, how serious could the consequences be?

By combining these two factors, risks can be **ranked or categorized** (e.g., low, medium, or high risk).

In mining, this could involve assessing the



probability of roof falls, machinery entrapment, or explosion hazards.

#### Risk Evaluation

After analyzing the risks, the next step is to **evaluate which risks are acceptable and which need urgent control.**

- Compare identified risks against **legal standards, safety policies, and risk criteria.**
- Decide on **priority actions** – which hazards must be addressed immediately and which can be monitored.

In this stage, the management team determines **tolerable vs. intolerable risks**, ensuring that critical hazards receive immediate attention.

#### Control Implementation

Finally, once risks have been prioritized, **control measures** are implemented to eliminate or reduce them.

Controls follow the **hierarchy of risk control**:

1. **Elimination** – Remove the hazard entirely (e.g., replace a hazardous process).
2. **Substitution** – Use safer materials or methods.
3. **Engineering Controls** – Isolate people from the hazard (e.g., proper ventilation or guards).
4. **Administrative Controls** – Change work procedures, provide training, and enforce safety rules.
5. **Personal Protective Equipment (PPE)** – Last line of defense (e.g., helmets, respirators).

#### *Case Study: Risk Assessment for Haul Road Safety*

In an opencast mines, multiple minor accidents occurs due to poor road conditions and speeding on haul roads during night shifts.

Objective:

To assess haul road risks and implement measures to ensure safe HEMM movement.

#### **Hazards Identified:**

Hazard	Likelihood	Severity	Risk Category
Poor road gradient	High	High	Critical
Absence of berms	Medium	High	High
Speeding	High	Medium	High
Poor illumination	High	Medium	Medium



In short:

- **Critical** → **Life-threatening, stop work immediately.**
- **High** → **Dangerous, act urgently to reduce risk.**
- **Medium** → **Manageable, but must be monitored.**

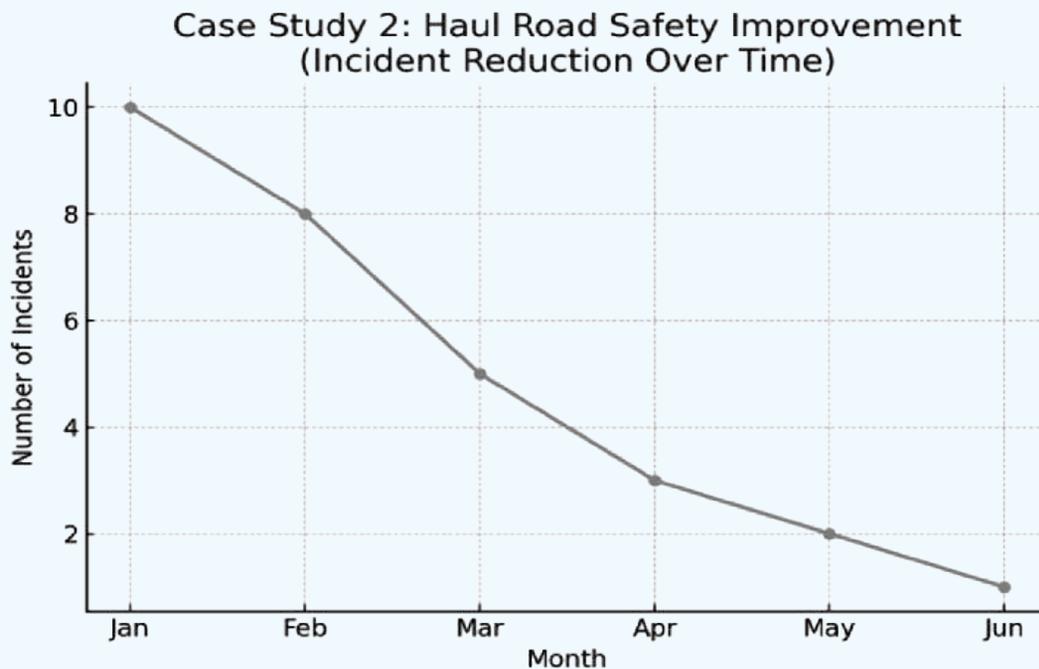
#### Control Measures:

Reconstructed haul road with proper gradient (1:16). Built earthen berms of half

tyre height. Installed solar blinkers and reflectors. Enforced speed limit (20 km/h) with radar monitoring.

#### Results:

Over a 6-month observation period: Accident frequency reduced by 70% Near-miss reports increased (positive safety reporting). Vehicle downtime reduced by 20%.



#### Conclusion

A strong safety culture is the foundation of successful iron mining operations. Through comprehensive risk assessment and proactive mitigation, potential mechanical and operational hazards can be controlled before they escalate into critical incidents. By integrating hazard identification, risk analysis, risk evaluation, and control

implementation into everyday practice, the mining workforce not only ensures compliance but also strengthens resilience and reliability across all operations.

Continuous improvement, driven by regular monitoring and technological innovation, transforms safety from a regulatory obligation into a shared value – protecting people, preserving assets, and promoting sustainable mining growth.



## THE CRITICLE TRILOGY: GROUNDING, GROUND FAULT & SHORT CIRCUIT

Suresh Chandra Dash

Due to the rapid development of technology, accompanied by a constant increase in the power and productivity of machines, the speed of the working bodies, worker's conditions at workplaces of industrial enterprises and mining fields are tough. Electrical safety is the vital part for operation and processing of minerals. So every reliable and safe electrical system is built upon three fundamental concepts:

**Grounding, Ground Fault Protection, and Short Circuit Protection.** While often mentioned together, they serve distinct and vital roles.

When electrical equipment & circuit are not properly grounded, a potential dangerous situation exists. Grounding is one of the most effective ways of prevention of electrical accident. As per study it is found number of electrical hazard occurs due to faulty Grounding system. If we are careless about grounding, we could add to the number of deaths either with our own or with someone else's.

### Terminology:

**Grounding:** -Grounding connects electrical systems to the earth to ensure safety and stability. It provides a safe path for electricity to follow during faults, protects people from shocks, and helps equipment function properly.

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AGM, Electrical  
M/s.M.G. Mohanty

**Ground Fault:** -A ground fault happens when electricity escapes its intended path and flows to the ground, often through a person or equipment. These faults can be dangerous even with small currents, especially in wet locations. Special protection like GFCIs detects these faults and cuts power quickly.

**Short Circuit:** -A short circuit occurs when electricity takes a "shortcut" between conductors, bypassing the normal load. This creates extremely high currents that can cause immediate damage, fires, or equipment destruction. Standard breakers and fuses are designed to stop these faults rapidly.

**GFCI (Ground Fault Circuit interrupter):** - A device that interrupts a circuit when it detects a ground fault.

### Purposes of Grounding:-

#### 1. Safety Grounding (Protective Earthing)

- o Prevents dangerous voltages on equipment enclosures during insulation failures
- o Provides a low-resistance path for fault currents to trip protective devices

#### 2. System Grounding (Functional Earthing)

- o Stabilizes system voltage to ground during normal operation
- o Provides a reference point for voltage-sensitive equipment



- o Reduces electromagnetic interference

### 3. Lightning Protection

- o Dissipates lightning strike energy safely into earth

#### Types of Grounding

##### TT SYSTEM (Terra-Terra)

- **Description:** The power source's neutral is earthed (first 'T'), and the consumer's equipment also has its own separate earth connection (second 'T').
- **Key Feature:** Independent earth for the installation, minimizing interference from the supply network.
- **Best for:** Sensitive electronics, areas where supply earth is unreliable, requiring RCDs for protection.

##### TN SYSTEM (Terre-Neutral)

- **Description:** The neutral point of the source is solidly earthed, and equipment casings are directly connected to this earthed neutral via a protective conductor (PE).
- **Sub-types:**
  - o **TN-S (Separate):** Neutral (N) and Protective Earth (PE) conductors are separate throughout the system.
  - o **TN-C (Combined):** Neutral and Protective functions are combined into a single PEN (Protective Earth and Neutral) conductor.
  - o **TN-C-S (Combined-Separate):** PEN conductor for part of the system, then split into separate N and PE conductors.
- **Best for:** General installations needing fast fault disconnection due to low fault

loop impedance.

##### IT SYSTEM (Isolated-Terra)

- **Description:** The source's neutral is either isolated from earth or connected via a high impedance.
- **Key Feature:** First fault doesn't immediately trip the system, allowing continuous operation in critical settings.
- **Best for:** Hospitals (operating theaters), data centers, industrial processes where uninterrupted power is crucial.

##### Nomenclature Breakdown

- **First Letter (Source):** T (Terra/Earth) or I (Isolated).
- **Second Letter (Equipment):** T (Terra/Earth for equipment) or N (Neutral conductor connected to earth).
- **'S' (Separate):** Neutral and Protective conductors are separate.
- **'C' (Combined):** Neutral and Protective conductors are combined (PEN).

##### Protection Against Ground Faults

Depending on conditions and on the nature of the contact, a ground fault has either high or low resistance. When the resistance is low, large amounts of current can flow, blowing the fuse or tripping the circuit breaker. When this happens, the fault current exists only for the very short time that it takes the fuse or circuit breaker to cut off the current in the circuit.

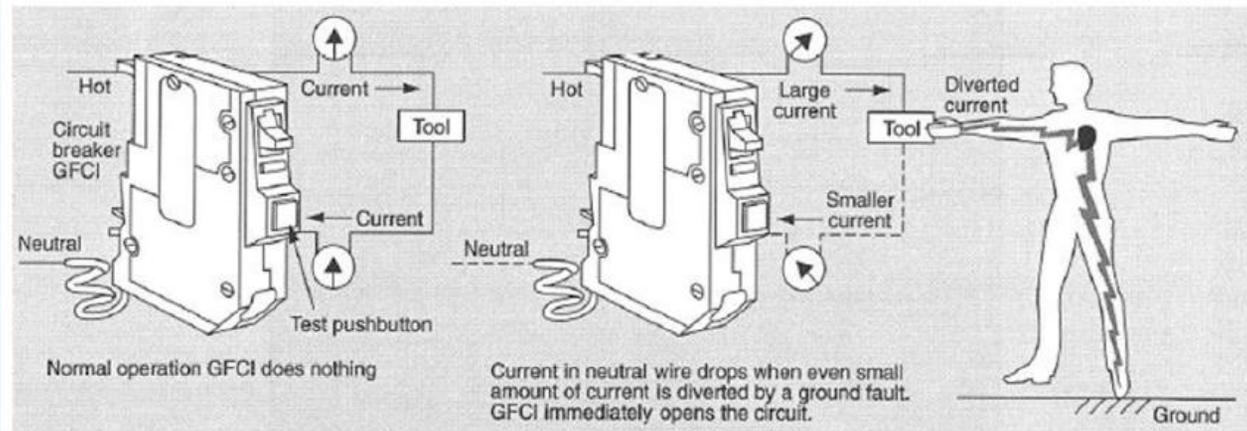
When the fault circuit has a high resistance, a ground-fault circuit interrupter (GFCI) provides the necessary protection. Under normal conditions as shown in Figure the current in the two conductors is equal and



the GFCI does nothing. However, the instant a ground fault occurs, as shown at the right in the figure, the current in the two wires becomes unequal. The GFCI compares the current in the two conductors of a circuit. If the current differs even slightly, as happens when a ground fault allows part of the current to bypass a section of one conductor, the GFCI opens the circuit stopping the flow of all the current in the circuit.

Because the GFCI operates in a split second, it is the only method of reliably protecting

personnel from injury. Built-in GFCIs have been required in many circuits since about 1970 even if these circuits are also protected by fuses or circuit breakers. Fuses and circuit breakers simply do not respond quickly enough to protect human life. GFCIs generally respond to hot-to-neutral wire faults and line-to-line faults as well as ground faults. They add to the protection offered by fuses and circuit breakers because they can be tripped by a very small amount of current (as little as 5 mA) acting for only a fraction of a second.



Some GFCIs are small enough to be carried in a toolbox and plugged in at the point of use. A portable GFCI is shown in Figure. Others are installed in the power distribution center. Either type satisfies the NEC. Because of the protection they provide, GFCIs are being installed in many 120 V circuits especially those used for portable electric tools. Receptacles installed outdoors or in bathrooms must be equipped with GFCIs. Most GFCI instructions include a simple test procedure involving a pushbutton. To ensure satisfactory operation, it is essential that the manufacturer's test be performed regularly.

#### **Conclusion: (The Interlocking Safety System)**

Grounding, ground fault, and short circuit are not isolated concepts, but an **interdependent**

#### **safety trilogy.**

- **Grounding** is the preventive foundation—the intentional path created for safety.
- **A Ground Fault** is the failure—the dangerous escape of current to ground.
- **A Short Circuit** (often caused by that fault) is the trigger—the high-current event that forces protective devices (breakers, fuses) to act.

In essence, **proper grounding ensures a ground fault becomes a detectable short circuit, allowing the system to shut down predictably and safely.** This integrated cycle—path, failure, response—forms the critical backbone of electrical protection, safeguarding both life and equipment.



## Web-Based Illumination Survey (Smart/IoT-based) vs Conventional method in Opencast Mines

Chiranjibi Barik

Web-based illumination surveys, which typically use Internet of Things (IoT) sensors and cloud-based platforms, offer significant advantages in automation, efficiency, and data analysis compared to conventional methods that rely on manual measurements and human operation.

### Comparison between

### Web-Based Illumination Survey (Smart/IoT-based) & Conventional Illumination Survey

#### ❖ Web-Based Illumination Survey (Smart/IoT-based):-

This method involves deploying sensors that automatically measure light levels (lux values) and environmental conditions in real-time. The data is then transmitted wirelessly to a cloud server, where it can be monitored and analysed via a web-based interface or dashboard.

- **Automation and Real-Time Data:** The system continuously collects data without human intervention, providing immediate, real-time information.
- **Optimize illumination gaps with Artificial Intelligence: Detect dimly lit regions, improve illumination plan and adhere to regulatory compliances.**
- **Modernize illumination planning:** Digitalizes the process of illumination surveying, identifying dark and bright

zones, enhancing the productivity and safety standards.

- **Enhanced Efficiency and Speed:** Large or complex areas can be monitored quickly and efficiently, as data gathering is automated.
- **Rich Data and Analysis:** It generates detailed 3D models or lux maps that allow for sophisticated analysis and integration with other systems like GIS or CAD software.
- **Energy Savings and Optimization:** The data enables the use of intelligent control systems (e.g., occupancy sensors, daylight harvesting) to optimize energy consumption and achieve significant savings.
- **Remote Management:** Lighting systems can be monitored and controlled remotely via the web interface, simplifying maintenance and troubleshooting.
- **Improved Safety:** By identifying non-compliant lighting conditions instantly, potential hazards are avoided more effectively.
- ❖ **Conventional Illumination Survey:-**  
This traditional method involves a person physically taking measurements point-by-point using manual tools like a light meter (lux meter).



- **Manual Operation:** Requires a designated individual to perform all measurements and operations, which is labour-intensive.
- **Time-Consuming:** Data collection can take days or weeks for large areas, depending on the terrain and accessibility.
- **Localized Accuracy:** Can provide high accuracy for specific, measured points in a small area, but may lack comprehensive data for the entire space.
- **Simpler and Lower Upfront Cost:** Traditional equipment is often simpler and less expensive initially, making it cost-effective for small-scale projects with budget constraints.
- **Limited Data Scope:** Typically produces 2D drawings and basic measurements, requiring extra interpretation for complex analysis.

**Summary of Differences: -**



<b>Feature</b>	<b>Web-Based (Smart/IoT)</b>	<b>Conventional (Manual)</b>
<b>Data Collection</b>	Automatic, continuous, real-time	Manual, point-by-point, periodic
<b>Efficiency</b>	High (fast for large areas)	Low (slow, time-consuming)
<b>Data Type</b>	Detailed 3D models, extensive datasets	2D maps and basic measurements
<b>Energy Optimization</b>	Enables intelligent control systems	Limited to basic switches/timers
<b>Management</b>	Remote, centralized web dashboard	On-site human operation
<b>Upfront Cost</b>	Higher (sensors, server setup)	Lower (basic equipment)
<b>Long-Term Value</b>	High (energy savings, detailed records)	Lower (less efficient, ongoing labour)



- In essence, web-based surveys are part of the shift towards offering a modern, efficient, and data-rich solution for managing illumination systems, while conventional methods remain a reliable, budget-friendly option for simpler, smaller-scale tasks.

### How the Web-Based Illumination Survey (Smart/IoT-based Works)

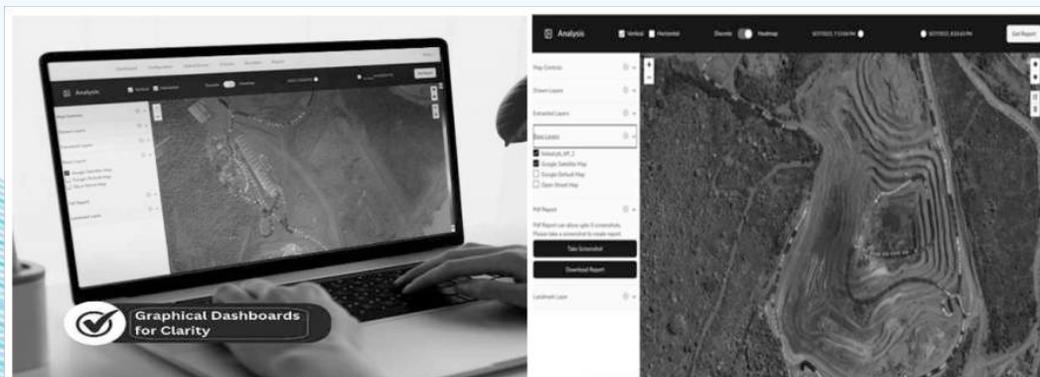
1. *Quick Setup, Fast Surveying.*
2. *Complex Data Represented Graphically.*
3. *Digital Reports for Regulatory Compliance/Statutory Report Generation.*
4. *Illumination Gap Analysis & Geographical coordinate points.*
5. *Preferred survey method.*

#### 1. Quick Setup, Fast Surveying.



- Conducting surveys requires no extra effort as you only need to attach the device to the vehicle, switch it on and let the device take care of the rest.
- Compact IOT illumination survey tool that eliminates manual data collection while capturing geographical coordinates. Integration with moving vehicle leading to significant reduction in survey time.

#### 2. Complex Data Represented Graphically





- The dashboard allows to visualize all the illumination data points on your site map. Choose time frames, selective locations, and other features for easier understanding.
- Detection of dimly lit regions, improving it through AI suggested illumination plans, and most importantly, a comprehensive report that adheres to the regulatory compliance for illumination reporting

### 3. Digital Reports for Regulatory Compliance/Statutory Report Generation



- The software allows to generate comprehensive survey reports for maintaining regulatory standards, while also informing about the under and over illuminated areas.
- A visually insightful dashboard that graphically displays survey data points for quicker analysis. Generate detailed reports and use AI-driven simulations to address illumination gaps effectively.
- Create a quick and digital comprehensive report for the surveyed illumination data. Perfect for adhering to regulatory guidelines, while simultaneously tracking improvement and loopholes.

### 4. Illumination Gap Analysis & Geographical coordinate points



- Get in-depth knowledge of the dark zones as well as over illuminated zones. Thus, locate regions where operation safety is compromised, and places where energy efficiency is reduced.



- Have accurate mapping of data points in mines or plants through the integrated GPS in the device. Also, helps mark separate illumination zones for a single location.
5. **Preferred survey method**



- Conduct vehicular or handheld surveys based on site requirements.
- For indoor areas where vehicle surveys are challenging, use the handheld method for more precise data collection.

v **Conclusion: -**

Web based illumination survey is mostly crucial for Energy efficiency and cost reduction, Integration of IoT and automation, Improved user Well-being with Safety, Simulation and data validation.

Moreover, it is more accurate and time saving than conventional method where the lux meter is used. So, it would be more appropriate and beneficial for the opencast mines to adopt Web-Based Illumination Survey (Smart/IoT-based) in Mines.

It will be definitely proved as a testament in the field of digital application in opencast mines.



## SAFETY IN BENEFICIATION PLANT AND SLURRY PIPELINE TRANSPORTATION

Purvi Mohapatra\*  
Smrutipragyan Padhi\*\*  
Himadri Tanaya Acharya\*\*\*

### Introduction

Safety is the backbone of any industrial operation, especially in mineral beneficiation plants. Our beneficiation plant follows stringent safety standards, operational discipline, and advanced technologies to ensure accident-free production while maintaining environmental sustainability.

One of the major safety advantages of our plant is the use of slurry pipeline transportation for final product movement instead of road transportation. This system significantly reduces road accidents, improves operational efficiency, minimizes environmental impact, and ensures long-term mineral conservation and environmental protection.

### 1. Safety in Beneficiation Plant Operations

#### 1.1 Equipment Safety

All crushers, mills, screens, pumps, conveyors, and classifiers are equipped with:

- Emergency stop switches
- Interlocks and guards
- Overload protection systems

Regular preventive maintenance is carried out to avoid breakdowns and unsafe conditions.

Lock-Out Tag-Out (LOTO) procedures are strictly followed during maintenance activities.

#### 1.2 Material Handling Safety

#### 1.3 Fire and Emergency Safety

- Fire hydrant systems, extinguishers and alarms are installed at critical locations.
- Emergency evacuation routes are clearly marked.

#### 1.4 Personal Protective Equipment (PPE)

- Use of helmet, safety shoes, goggles, gloves, reflective jackets & ear protection.
- PPE compliance is monitored continuously.

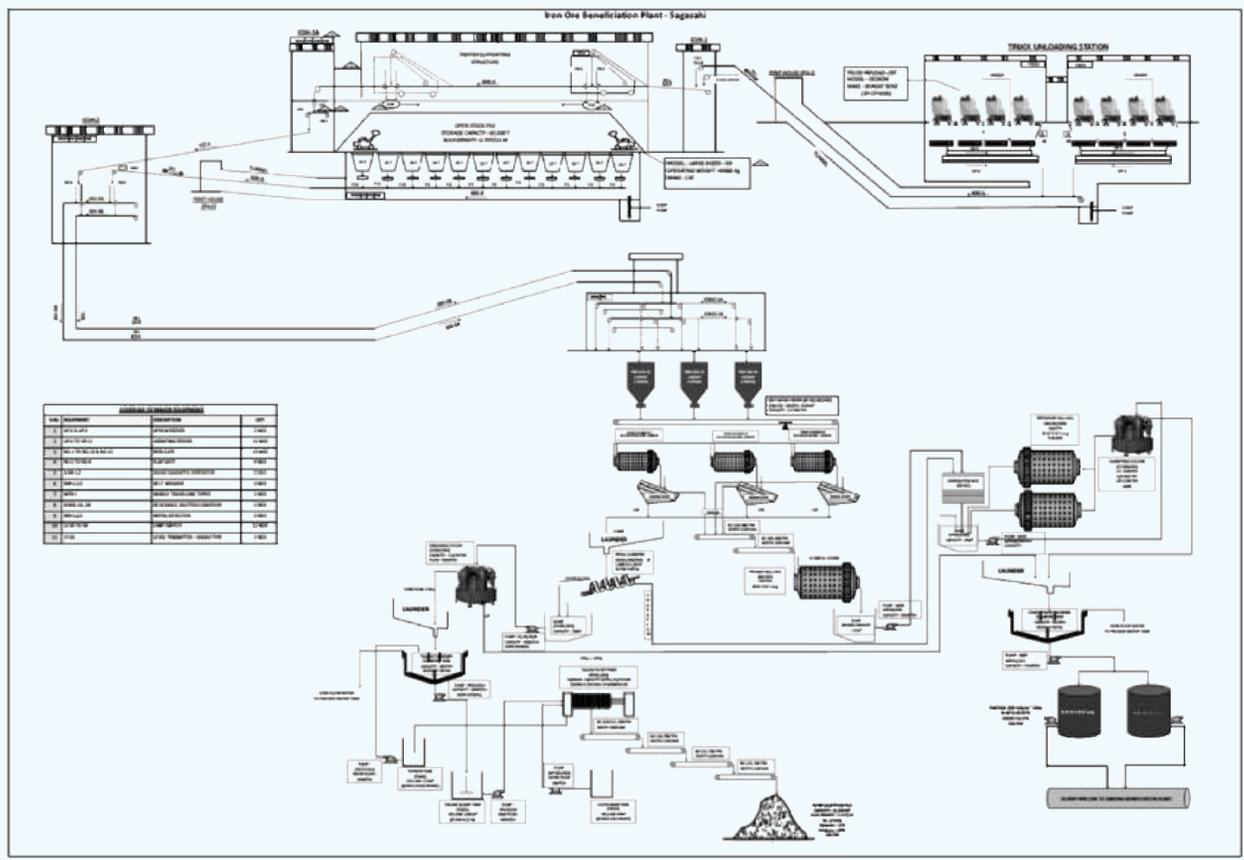
\*BP Operation - Mechanical Maintenance ArcelorMittal Nippon Steel India Pvt. Ltd

\*\*BP Operation - E&I ArcelorMittal Nippon Steel India Pvt. Ltd

\*\*\*BP Operation - Mechanical Maintenance ArcelorMittal Nippon Steel India Pvt. Ltd



## FLWSHEET



### 2. Slurry Pipeline Transportation – A Safer Alternative

Our plant uses slurry pipeline transportation for transporting final products, which offers significant safety and environmental benefits compared to road transportation.

- Prevention of Road Accidents

Road transportation typically involves 400-500 trucks per day, increasing the risk of Traffic accidents, Pedestrian injuries, Highway congestion, Vehicle breakdown hazards.

Slurry pipelines eliminate heavy truck movement on highways such as NH corridors, ensuring:

- Reduced accident probability
- Less traffic pressure
- Enhanced community safety

This directly supports national road safety initiatives and protects nearby villages and commuters.

### 3. Cost-Effective Transportation System

Slurry pipeline transportation is economically efficient - Reduced fuel consumption, Lower manpower requirements, Minimal vehicle maintenance and spare parts.

Compared to roadways, pipeline transportation provides stable operating costs and higher reliability, improving overall productivity.



#### 4. Reduction in Carbon Footprint and Environmental Protection

- Lower Greenhouse Gas Emissions
- Dust Emission Control
- Mineral Conservation and Environmental Protection

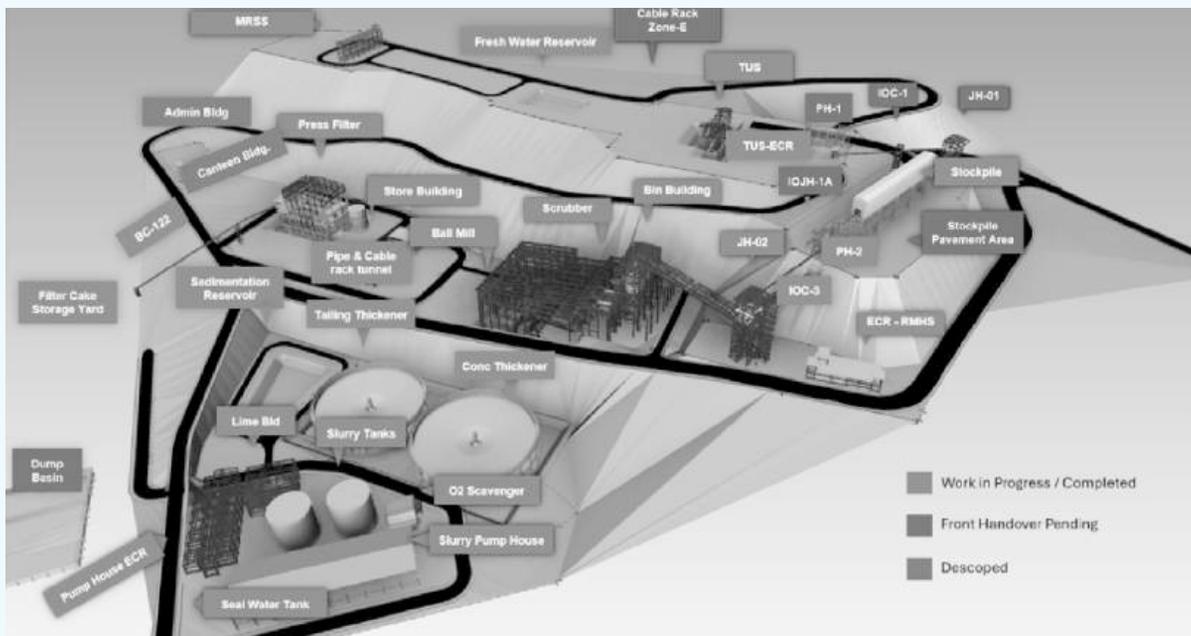
#### 5. Safety Measures in Slurry Pipeline System

- Pipeline Design and Monitoring
- Leak Prevention and Emergency Response

- Environmental Safeguards

#### 6. Training and Safety Culture

- Regular safety training programs and tool-box talks are conducted such as **LSGR**.
- Safety audits and inspections identify improvement areas.
- Near-miss reporting encourages proactive safety behaviour.
- Employees are empowered to stop unsafe work.



#### 7. Conclusion

The integration of strict safety practices in the beneficiation plant and the adoption of slurry pipeline transportation has significantly enhanced operational safety,

environmental sustainability, and economic efficiency. By eliminating heavy road transport, the plant prevents road accidents, improves public safety, reduces carbon footprint, controls dust emissions, and ensures mineral conservation.



## Occupational Lung Diseases and Their Prevention

Dr B. N. Mohapatra

1. Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere, household combustion devices motor vehicle, Industrial pollution and forest fires are common source of Air Pollution and is a major Environmental health problem affecting everyone in developed and developing countries.

WHO, estimates that,

- Some 80% of Air pollution related premature deaths are due to heart diseases stroke etc.
  - 14% Chronic Obstructive Pulmonary diseases or Acute Lower respiratory tract infection.
  - 6% deaths due to Lung Cancer.
2. Most of the mining operations like drilling blasting transportation and material handling produce dust. High levels of dust increase respiratory diseases while gaseous emissions contribute towards Global warming besides causing health hazards to exposed population.

Dust is loosely applied term for solid particles predominantly larger than colloidal and capable of temporary

suspension in atmosphere depending on biological properties, the dust can be classified as;-

- a) Fibrogenic Dust:- Mineral dust capable of causing an increase in the connective tissue of lung with permanent alteration of the lung structure. The increase may be nodular or irregular:- Dusts are Silica, Asbestos and Coal Dust etc.
  - b) Nuisance Dust:- The dust is neither toxic nor fibrogenic but when inhaled in large quantity can impair functioning of respiratory system like; Kaolin, Barium sulphate etc.
  - c) Toxic Dust:- Dust in having acute or chronic harmful effects on specific organs including and beyond respiratory tract like : Lead and Manganese compounds
  - d) Respirable Dust: - It is the fraction of total dust which passes through a particle size having impact of respiratory system.
3. Occupational Lung diseases caused by breathing dusts fumes, gases or vapours in a place where a patient works

OLD Depends upon the physical properties of inhaled substances size of the substances etc.



Dust size 10 -20  $\mu\text{m}$  deposit in nose and upper airway

Smaller particles 5 - 10  $\mu\text{m}$  deposit in Trachea, Bronchus

Particles less than 5  $\mu\text{m}$  reach the alveoli or air sac

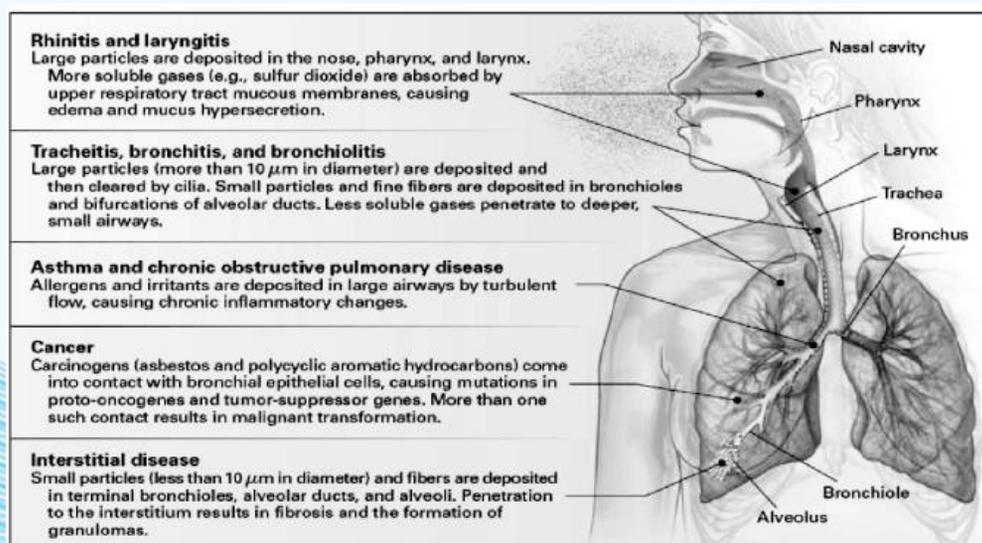
Health hazards are aggravated due to following factors;

- Older age group with reduced CVS & Resp. function
- Poor Health status
- Poor Nutritional status
- Immunological status
- Genetic Factors
- Pathological State: Stress, Anxiety and Chronic Diseases

**4. Dust & its Health Hazards**

Type of Dust	Main Health Impact	Target Organ	Notifiable Occupational Diseases
Free Crystalline Silica	Silicosis (Lung fibrosis) COPD, Lung Cancer	Lungs	Yes
Coal Dust	Coal workers Pneumoconiosis, Restrictive lung disease, Heart Failure	Lungs Branchiate & Alveoli	Yes
Asbestos	Asbestosis, Lung cancer	Lungs	Yes
Manganese	Parkinsonism	Nervous System	Yes
Cotton Dust	Byssinosis, C.O.P.D	Lungs	Yes
Sugarcane Dust	Bagassosis	Lungs	Yes
Chromium Dust	Lung cancer, Bronchial asthma, C.O.P.D, Kidney problems, Dermatitis, Chrome Ulcers	Lungs, Kidney, Skin	Yes
Bauxite Dust	Pneumoconiosis, Lung Cancer	Respiratory system	Yes
Iron Dust	Siderosis, Lung Cancer	Respiratory System	Yes
Occupational Asthma	Due to immunological Problems		No
Lead Dust	Systemic Intoxication, Blood, CNS problems, Gastric problems	Circulatory system, Respiratory problem, CNS	Yes

**5. Occupational Respiratory Diseases (Size, location, Outcome)**





## 6. Common Occupational Lungs disease in Indian is silicosis

Prevalence of silicosis in India	Prevalence
Silicosis in Mica mines -	6.2 – 34%
Silicosis in Slate Pencil Workers -	54.6%
Silicosis in lead & zinc miners -	30.4%
Silicosis in Unorganized sector -	25% in stone Miners
-	12% in Quarry Workers
-	16.7% in glass workers
-	15.1% in ceramic workers

Source : National Institute of Health & Family Welfare, Govt. India

## 7. Diagnosis of Occupational Lungs Diseases

- i) History of dust exposure
- ii) Clinical Evaluation of patient
- iii) Lung Function Test
- iv) Chest X-Ray PA view
- v) Sputum for AFB if required
- vi) CT Scan / MRI

## 8. Occupational Lung Cancers

The international Agency for Research on Cancer (IARC) has categorised certain substances being human respiratory carcinogens;

### Individual Agents

- Asbestos and it's compound
- Arsenic & its Compound
- Beryllium and its compound
- Cadmium and its Compound
- Chromium-vi(Hexavallant) Compound
- Nickel Compounds
- Mustard Gas
- Asbestos with fibres
- Bis (chloro-methyle) Ether.



## 9. Sign & Symptoms of the Disease

- ✓ Dry cough
- ✓ Dyspnoea (breathing difficulty)
- ✓ Fatigue
- ✓ Tachypnoea
- ✓ Fever
- ✓ Loss of appetite
- ✓ Weight loss
- ✓ In severe cases
  - compensatory emphysema
  - Complication of Tuberculosis (Silico-tuberculosis)
  - Cor pulmonale (heart failure)
- ✓ Pneumonoultramicroscopicsilicovolcanoconiosis,

## 10. **There is no cure for Occupational Lung Disease. Prevention is the only solution.** **Prevention for Occupational Lung Disease**

### ➤ **Primordial prevention**

- Removal of exposure e.g. stopping Toxic dust at source of exposure, substituting toxic chemical with safer material

### ➤ **Primary prevention**

- Controlling dust at source to reduce worker exposure e.g. local exhaust ventilation, process enclosure, wet technique etc

### ➤ **Secondary prevention**

- Early detection of the symptomatic disease and prompt intervention e.g. screening by Chest X-ray, Lung function tests, clinical evaluation of the patient etc.

### ➤ **Tertiary prevention**

- Diagnosis, treatment, appropriate placement, compensation and rehabilitation once the disease has occurred

## 11. Challenges & Suggestions

### ➤ **Unavailability of medical surveillance data in soft copy and lack of monitoring and analysis;**

- Central nodal agency for surveillance data analysis from soft copy of all sectors
- Development and strengthening of epidemiological research facilities
- **Lack of awareness among employers, trade unions, workers and other stakeholders**
  - Awareness campaigns and wide publicity
- **Lack of coordination among stake holders for elimination of silicosis and other occupational diseases**
  - Inter-sectoral co-ordination between Ministry of Labour, Mines, Factories, Health, State Government authorities, trade unions, NGOs and other stakeholders



## Importance of Structural Integrity study for Buildings in Mining Premises

Kanhei Sahoo

Civil Engineering Department of any organisation plays a crucial role in mining operations by providing essential infrastructure support. We are consistently applying modern construction methods and new technologies to enhance productivity. Simultaneously, we must prioritize periodic maintenance through integrity study to ensure future sustainability and prevent structural failures.



To mitigate risks, structural integrity studies are executed through periodic physical inspections. These inspections identify cracks, corrosion, and spalled RCC. Furthermore, concrete and steel structures are tested based on their criticality. Common Non-Destructive Testing (NDT) methods for concrete include the Ultrasonic Pulse Velocity Test,

Rebound Hammer Test, Cover Meter Test, and Half-cell Potentiometer Test. For steel structural members, Ultrasonic Thickness Testing, Hardness Testing, and Dye Penetration Testing are conducted.

**Environmental Impact and Ground Stability:** In a mining environment, buildings are subjected to unique stressors that urban structures rarely face. Constant vibrations from heavy machinery, ground movement due to excavation, and the impact of blasting can compromise a building's foundation and load-bearing capacity over time. A comprehensive structural integrity study takes these environmental factors into account, ensuring that administrative buildings, workshops, and processing plants remain stable despite the volatile geological conditions surrounding them.

**Risk Mitigation:** Beyond physical safety, maintaining structural integrity is a key component of operational risk management. Investing in regular NDT and visual inspections prevents costly emergency repairs and unscheduled downtime that can halt production. Documented structural audits provide an essential paper trail of safety compliance, demonstrating a proactive approach to worker protection and asset management that aligns with global best practices in industrial safety.

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*Asst. Manager Civil & Project,  
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Tata Steel Ltd.*



## Deck Charging-Based Blast Optimization for Sustainable Resource Extraction at Baphlimali Bauxite Mines

\*Mr Srikanta Hota and

\*\*Ms Manisha Kumari

### Abstract

The Baphlimali Bauxite Mines, operated by Utkal International Ltd. (Hindalco), faced significant operational challenges stemming from the hard and compact lateritic overburden, which resulted in the production of oversized boulders during blasting operations. This paper presents the implementation and optimization of a deck charging technique utilizing recycled plastic water bottles as inert spacers within explosive columns. The primary objective was to improve rock fragmentation, minimize ground vibration, and enhance the overall sustainability of resource extraction. The methodology involved a detailed blast design, specific procedures for bottle integration, and adherence to safety guidelines. Results demonstrated a notable reduction in explosive consumption (approximately 3-4 kg per hole), leading to substantial cost savings and a decreased carbon footprint. Field observations confirmed improved fragmentation, reduced secondary blasting, enhanced loading and hauling efficiency, and increased safety. While initial implementation required additional resources for training and bottle handling, the long-term operational and

environmental benefits underscore the efficacy of this innovative and cost-effective approach for sustainable mining in hard lateritic formations.

**Keywords:** Deck Charging, Blast Optimization, Bauxite Mining, Sustainable Extraction, Fragmentation, Plastic Bottles, Hindalco, Baphlimali Mines.

### 1. Introduction

India is endowed with rich mineral resources, with approximately 56% concentrated in Odisha, and a significant 85% of Odisha's resources found in the Koraput, Rayagada, and Kalahandi districts. The Baphlimali Bauxite Mine, a captive mine of Utkal International Ltd. (Hindalco), is situated between the Rayagada and Kalahandi districts. The total lease area spans 1,388.74 hectares, including a plateau area of 968 hectares, with an estimated bauxite resource of about 200 million tonnes (MTe).

The Baphlimali bauxite deposit is characterized as a blanket type, featuring an average overburden of 10-12 meters of hard laterite, overlying a bauxite layer of variable thickness (10 to 12 meters). The removal of both overburden and ore necessitates drilling and blasting

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operations to loosen the material for subsequent excavation. These operations are critical in open-cast mining, directly impacting downstream productivity and cost.

The mine operates with a bench height of 6 meters, with the first and second benches primarily composed of hard laterite. Initial blasting operations frequently resulted in a significant number of large boulders due to the hard and compact nature of the lateritic material. These oversized fragments created several operational challenges:

- Difficulty in excavation and loading, leading to increased equipment cycle times.
- Increased secondary blasting requirements, resulting in higher production costs and delays.
- Reduced efficiency of loading and hauling equipment due to irregular fragment sizes.
- Increased wear and tear on loading tools and crushers.
- Safety concerns for workers during secondary breaking operations.

To address these challenges and improve fragmentation quality, the mine introduced a novel approach involving deck charging using recycled plastic water bottles as spacers within the explosive column. This paper details the methodology, results, and benefits of this blast optimization technique.

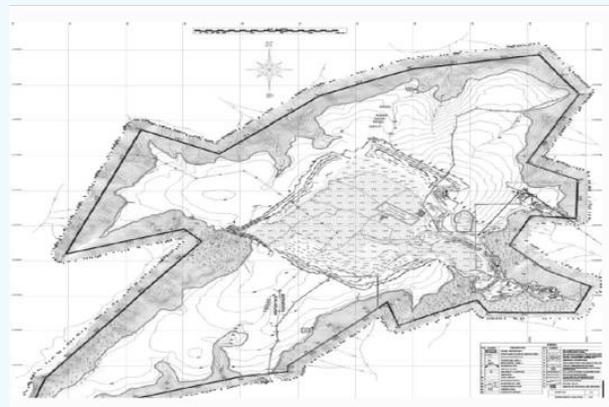
## 2. Literature Review

Deck charging is a well-established modern blasting practice aimed at optimizing

explosive distribution within a blast hole. Its primary goals include achieving desired fragmentation, minimizing ground vibration, and reducing explosive consumption. The influence of deck charging on fragmentation, throw, and vibration control has been extensively studied.

According to DGMS Circular (Tech) No. 7 of 1997, deck charging procedures must be executed with careful attention to stemming and initiation sequences to ensure safety. Studies conducted by Orica and IOCL have highlighted that air decking, a form of deck charging, can improve explosive energy utilization by 20–30%. Bottle decking is presented as a cost-effective adaptation of air decking, where PET bottles act as inert spacers to maintain column separation without collapsing under the pressure of stemming material. This allows for a more even distribution of explosive energy throughout the blast hole.

## 3. Methodology (Solution Adopted)



Part plan showing the location of the blasts and vibration monitoring



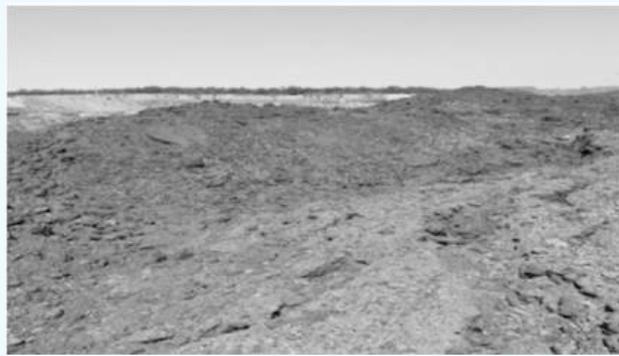
The adopted solution centered on implementing deck charging with empty, used plastic water bottles serving as inert spacers within the explosive column. This method extends the effective explosive column length and ensures a more uniform energy distribution.

**3.1. Principle of Deck Charging with Bottles** In this method, empty used plastic water bottles are strategically placed at intervals along the column of explosives inside the blast hole. These bottles act as

inert spacers, creating small gaps within the charge column. This arrangement avoids the need for multiple decks or additional stemming material to divide the charge. The bottles facilitate a smoother transmission of explosive energy from the bottom to the top of the blast hole, enhancing overall blast performance. Figure 1 visually distinguishes between direct charging and a deck-charged portion, while Figure 2 illustrates the general process flow within a blast hole.



Before Bottle decking



After Bottle Decking

Figure 1: Illustration of Direct Charging vs. Deck Charging Portion in a Blast



FIGURE 2: Process Flow Diagram of a Deck-Charged Blast Hole.

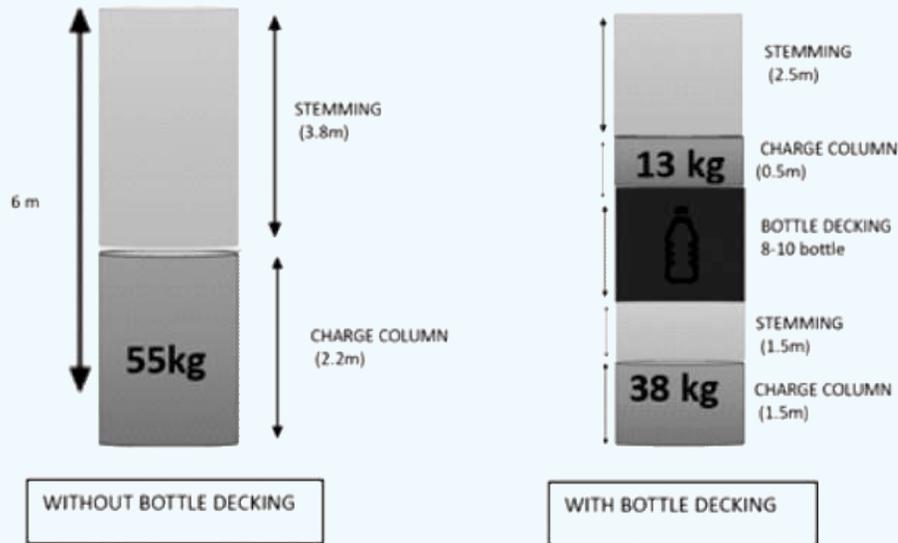


**3.2. Blast Design Parameters** The optimized blast design parameters implemented at Baphlimali Bauxite Mines are detailed in Table 1.

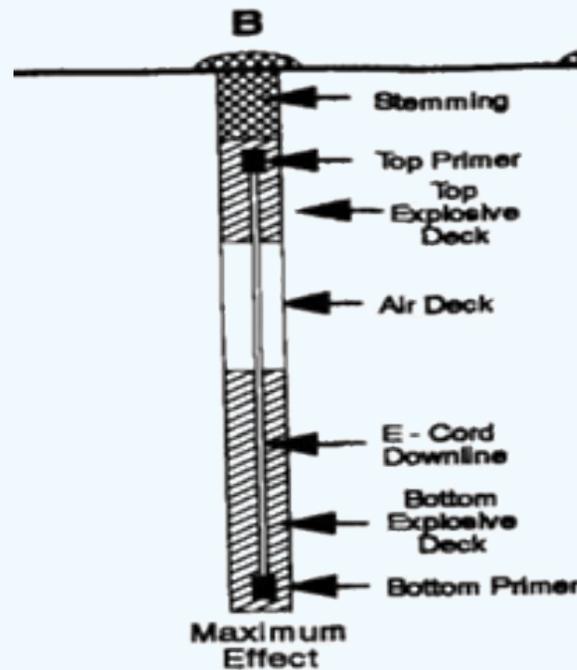
**Table 1: Optimized Blast Design Parameters**

Parameter	Value
Hole diameter	160 mm
Hole depth	5.0 m
Total number of holes	30 - 40
Number of rows	2 to 3
Burden	3.0 - 3.25 m
Spacing	3.5 - 3.75 m
Drilling pattern	Staggered
Top stemming column	3.5 - 3.7 m
Explosive charge per hole	40.00 - 55.00 kg
Maximum charge per delay	40.00 - 55.00 kg
Total explosive charge	1200.00 - 2200.00 kg
Firing Pattern	Diagonal
Inter Hole Delay	17 ms / 25 ms
Inter Row Delay	42 ms / 67 ms

A comparison of charge loading "Without Decking" and "With Decking" is shown in Figure 3, illustrating a reduction from 55 kg to 38 kg per hole with the introduction of 8-10 bottles. Figure 4 provides a detailed schematic of the deck charging components within a blast hole, highlighting the placement of air deck, primers, and explosive decks.

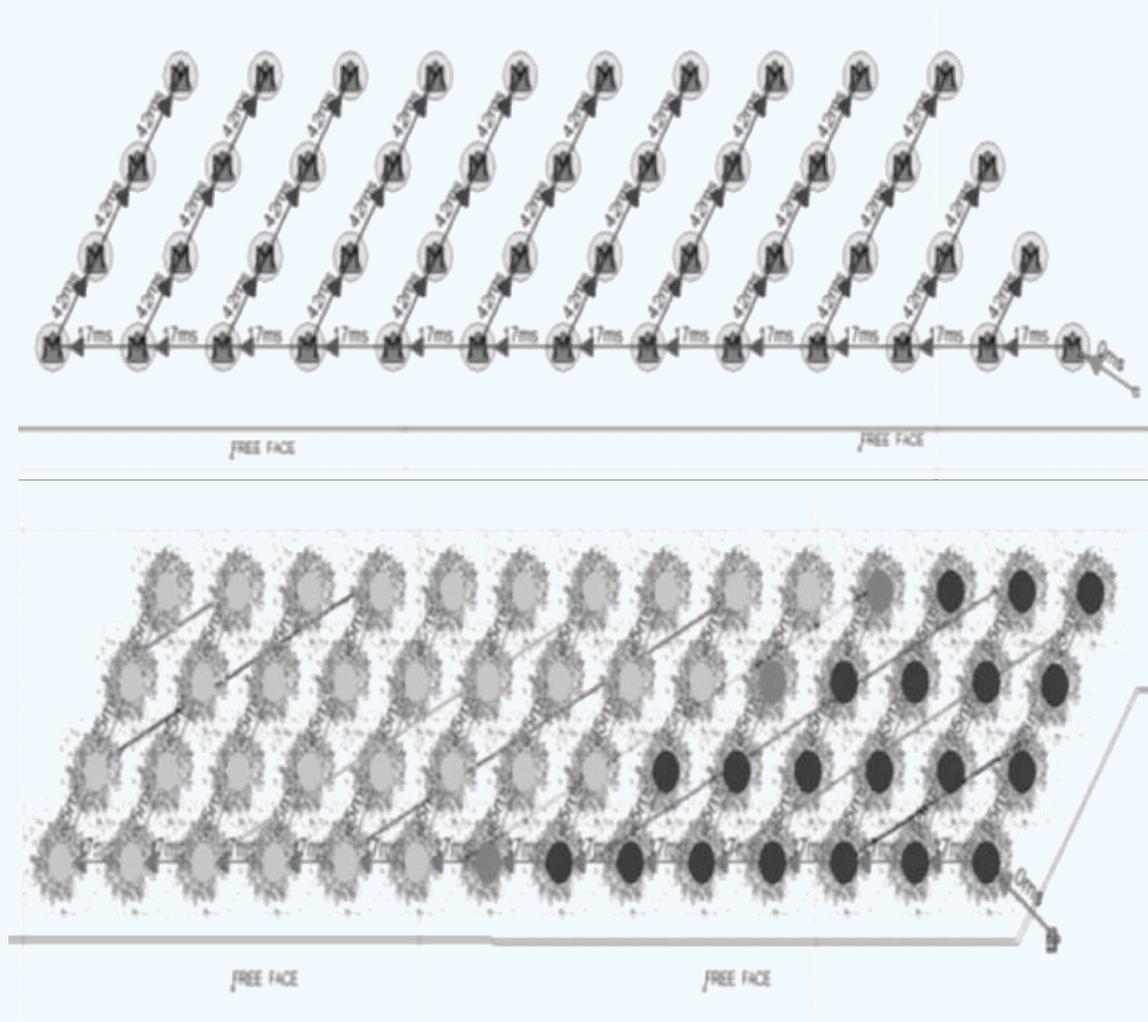


**FIGURE 3: Comparison of Explosive Charge Per Hole Without and With Decking.**  
 Cost Calculation: Saved Explosive 33- 30.6 te = 2.4te ; Cost of explosive = Rs. 98/kg; Saving = Rs 2,35,000



**Figure 4: Schematic Diagram of Deck Charging Components in a Blast Hole**

**3.3. Firing Patterns and Initiation Systems** For enhanced control over ground vibration, diagonal firing patterns were employed. Inter-hole delays of 17 ms and 25 ms, and inter-row delays of 42 ms and 67 ms were utilized (Figure 5). Both electronic detonators and non-electric (shock-tube) initiation systems were implemented for in-hole explosive initiation and surface hole-to-hole initiation. Electronic detonators were particularly recommended near sensitive structures for precise vibration control.



**Figure 5: Diagonal Firing Pattern with Inter-Hole and Inter-Row Delays**

**3.4. Deck Charging Procedure** The following step-by-step procedure was adopted for implementing deck charging in the field (Figure 6):

1. Load the bottom explosive deck to the design length.
2. Insert an empty PET (Polyethylene Terephthalate) bottle (with the cap tightened) at the prescribed position, stabilizing it with a loading rod.
3. Load the upper explosive deck above the bottle.
4. Install the detonator/primer and stem the hole in layers, tamping per design specifications.
5. Mark the hole as "decked" and record the hole ID, depths, bottle type, and initials of the supervisor.



**Figure 6: On-field Implementation of Bottle Deck Charging**

**3.5. Safety and Compliance** Adherence to safety protocols and DGMS (Directorate General of Mines Safety) guidelines was paramount:

- Deck separation material (plastic bottles) must be non-reactive and non-combustible.
- Proper marking and record-keeping of decked holes are mandatory.
- Decked blasting operations must be supervised by a competent blaster.
- In case of misfires, standard misfire handling procedures must be followed.
- Only used plastic water bottles were permitted to prevent the generation of extra noxious gases and contribute to pollution control by consuming plastic waste.
- Uniform-sized bottles with intact caps were used to ensure consistent voids and prevent explosive material from entering the bottles, thereby maintaining proper voids and minimizing explosive consumption.

#### **4. Results and Discussion**

The implementation of deck charging with plastic bottles at Baphlimali Bauxite Mines yielded significant operational and economic benefits, demonstrating its effectiveness as a sustainable blasting practice.



#### 4.1. Explosive Consumption and Cost Savings

A key outcome was the substantial reduction in explosive consumption. For an assumed 100,000 tonnes of material in overburden (OB), the comparison of explosive usage is presented in Table 2.

**Table 2: Explosive Consumption for 100,000 Tonnes OB Material (Approx. 600 Holes)**

Method	Explosive Charge per Hole	Total Explosive Consumption
Without Bottle Decking	55 kg	33 tonnes
With Bottle Decking	50 kg	30.6 tonnes

The saved explosive quantity for this scenario was 2.4 tonnes (33 - 30.6 te). At an average cost of Rs. 75/kg, this translates to a saving of Rs. 1,80,000 for 100,000 tonnes of material.

Table 3 provides data from a broader mine implementation, showing explosive savings over a larger number of blasted holes.

**Table 3: Mine-wide Implementation: Saving in Explosive**

SI No	No. of Holes Blasted	No. of Holes Deck-Charging	Saving/Hole (kg)	Saving in Explosive (kg)	Cost of Explosive/kg (Rs.)	Saving (Rs.)
1	11715	2040	24	8160	99.80	793068.8

This data confirms significant explosive savings across a large-scale application, amounting to approximately 8.16 tonnes of explosives.

**4.2. Operational Efficiency and Sustainability** The project also demonstrated notable improvements in operational efficiency and sustainability metrics.

**Table 4: Saving of Diesel in Rock Breaker Operations**

SI No	Rock Breaker (Before Deck)	Rock Breaker (After Deck)	Difference (hr)	HSD Savings (Liters)	HSD Rate/Liter (Rs.)	Savings in HSD (Rs.)
Total	79	53	26	468	96	44928

Table 4 shows a reduction in rock breaker operating hours, leading to diesel savings and associated cost benefits. The reduction in secondary breaking due to improved fragmentation directly contributed to this efficiency.



Furthermore, the initiative contributed to a reduction in the mine's carbon footprint, as detailed in Table 5.

**Table 5: Carbon Footprint Reduction Due to Deck Charging**

Saving of Explosives (MT)	Carbon Footprints/ Mt of Explosives	Total Carbon Footprints in Explosives (kg)	Saving of HSD (MT)	Total Carbon Footprints/ Liter of HSD	Total Carbon Footprints/ Liter of HSD	G. Total Carbon Footprints Reduced (kg)
8.16	2.95	24.072	468	2.63	1230.84	1254.912

The total benefits from the project, including explosive savings, HSD savings, and carbon footprint reduction (converted to monetary equivalent where applicable), amounted to **INR 8,47,902.00**. This demonstrates a holistic approach to sustainable mining, where efficiency gains directly translate into environmental benefits.

**4.3. Field Observations and Benefits** Field observations after implementing bottle deck charging highlighted several key advantages:

- **Improved fragmentation and uniformity:** The technique produced finer, more uniform fragments, significantly reducing the number of oversized boulders.
- **Reduced ground vibrations:** Controlled energy release and optimized blast patterns led to lower ground vibrations, enhancing safety and minimizing environmental impact.
- **Cost savings:** Approximately 10-12% lower explosive consumption was achieved while maintaining effective fragmentation.
- **Improved powder factor (PF):** Explosive consumption was reduced by 3-4 kg per hole without compromising fragmentation. This was achieved by improving energy transmission and distribution.
- **Fewer secondary blasting and manual breaking operations:** The reduced occurrence of oversized fragments minimized the need for re-drilling and re-blasting, saving time and resources.
- **Improved loading and hauling productivity:** More consistent fragment sizes improved shovel/truck loading rates and reduced cycle times.
- **Reduced equipment wears and maintenance:** Smaller, more uniform fragments reduced stress and wear on loading, hauling, and crushing equipment.
- **Enhanced safety and environmental outcomes:** Less secondary breaking and controlled energy release reduced personnel exposure to hazards and lowered fly rock.
- **No safety incidents:** Compliance with DGMS standards ensured a safe



operational environment throughout the implementation period.

## 5. Challenges and Practical Considerations

Despite the significant benefits, the implementation of bottle deck charging presented some initial challenges:

- **Additional personnel:** More personnel were required to insert bottles into each blast hole, slightly increasing the time and labour involved in charging operations.
- **Handling and verification:** The process of placing bottles as spacers demanded careful handling and verification to ensure proper placement, which initially slowed down the charging process.
- **Training requirements:** Special training was necessary for workmen to ensure correct methods of bottle addition and overall blast execution.
- **Initial delays:** Operators and the blasting crew required time to adapt to the new methodology, leading to minor delays during the early stages of implementation.
- **Collection of used water bottles:** A logistical challenge involved establishing a consistent and reliable supply chain for collecting and preparing used plastic water bottles for blasting operations.

## 6. Conclusion

The introduction of bottle deck charging at Baphlimali Bauxite Mines, while initially requiring additional manpower, time, and coordination, has demonstrably delivered

substantial benefits that far outweigh these challenges. The technique has proven effective in achieving improved rock fragmentation, a significant reduction in oversized boulders, and an enhanced powder factor. These improvements directly contribute to better operational efficiency and considerable cost savings. The controlled and uniform energy distribution facilitated by bottle decking has improved overall safety by reducing secondary blasting needs and minimizing oversized boulders, which pose hazards during excavation and loading. Over time, with proper planning and standardization, the process has become streamlined, effective, and safer. Overall, the adoption of bottle deck charging represents a practical, efficient, and safer solution for optimizing blasting in hard lateritic formations, aligning with sustainable resource extraction principles.

## 7. Future Recommendations

To further optimize and expand the benefits of this technique, the following recommendations are proposed:

- **Conduct field trials with different bottle sizes:** Investigate the impact of varying bottle dimensions on fragmentation and energy distribution to fine-tune the method.
- **Integrate blast design simulations using ShotPlus:** Utilize specialized software like ShotPlus to model and predict the outcomes of different deck charging configurations, further optimizing blast parameters.



- **Continuous monitoring of blast performance and vibration:** Establish a robust monitoring program to collect ongoing data on fragmentation, ground vibration, and other key performance indicators to ensure sustained optimization and identify areas for further improvement.

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#### Acknowledgements

The authors wish to express their sincere gratitude to M/s Hindalco (Utkal International Ltd.) for their invaluable support, resources, and permission to conduct and publish this research at the Baphlimali Bauxite Mines. Our appreciation also extends to the entire team at Baphlimali Bauxite Mines, particularly the mining operations, blasting, and safety departments, whose dedication and cooperation were instrumental in the successful implementation and data collection for this project. Special thanks are due to the mine management for their encouragement and visionary approach towards sustainable mining practices. We also acknowledge the efforts of all personnel involved in the collection and

handling of recycled plastic bottles, which was crucial to this innovative initiative. Their collective contributions made this work possible.

#### Disclaimer

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## Implementation of Vehicle Safety Management System in Ghoraburhani Sagasahi Iron Ore Mines (AMNS INDIA)

Danveer

### Introduction:

The main purpose of developing a Vehicle Safety Management System mobile application for Heavy Earth Moving Machinery (HEMM) in mines is to enhance safety, streamline monitoring and reporting processes, and mitigate potential risks associated with these large and powerful machines. It can generate real-time alerts when any parameter exceeds safe limits, helping operators and supervisors respond swiftly to potential dangers. The app sends notifications to operators, maintenance teams, and supervisors when scheduled maintenance or safety inspections are due, reducing the risk of equipment failure. The app generates automated safety reports, reducing paperwork and the risk of errors. Supervisors, safety officers, and managers can access safety data and alerts remotely, providing them with better oversight of HEMM operations.

### Approaches, Target Set, Measured & Achieved:

Developing a fully automated and digital platform for ensuring safety checking and generating reports in PDF and Excel formats is a significant step in improving safety compliance, reducing paperwork,

and enhancing efficiency. Here's how the system aligns with your objectives:

**a. Automated Safety Checking:** The system provides a digital checklist that inspectors must complete during safety checks. It includes built-in validation checks to ensure that all required safety fitments and braking system checks are performed as per DGMS guidelines.

**b. Report Generation:** After the safety check, the system automatically generates reports in both PDF and Excel formats, including all relevant data and photographs. This significantly reduces the time and effort required for manual report creation.

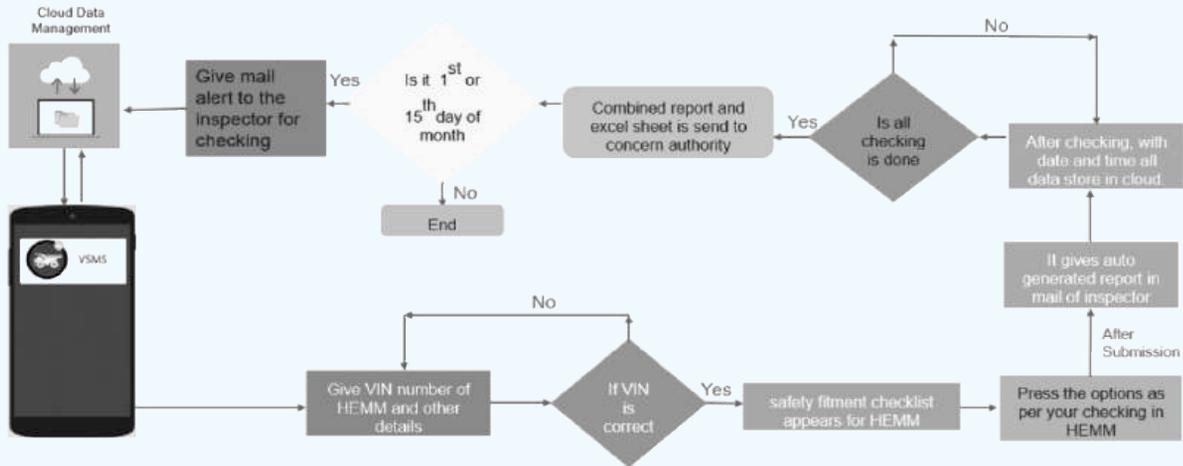
**c. Report Sharing:** The system automates the distribution of generated reports to the concerned persons, ensuring that they receive the information within the stipulated time. Email alerts can be sent to relevant parties with the attached reports.

**d. Data Storage:** All safety check reports, and historical data are stored in a secure digital platform that is accessible from anywhere and at any time. This allows for easy retrieval of past records, simplifying compliance monitoring and audits.



**e. Scheduled Safety Checks:** The system sends automated email alerts to the inspector two days before the scheduled safety check, ensuring they are prepared and aware of their responsibilities.

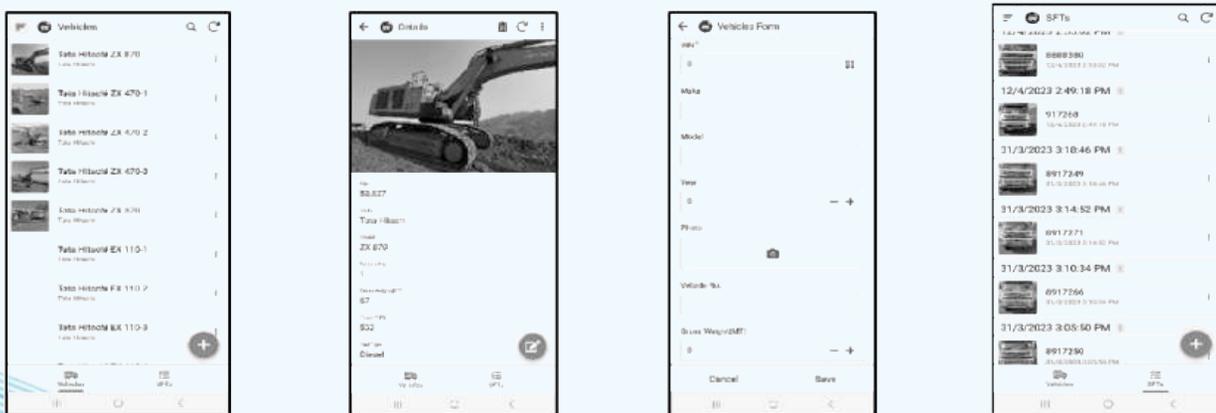
**Process Flow Diagram:**



**Software Building:**

Kotlin is an expressive and concise programming language that reduces common code errors and easily integrates into VSMS apps. To build this app, we started with Kotlin to take advantage of its best-in-class features. When building new Android development tools and content, such as Jetpack libraries, samples, documentation, and training content, we will design them with Kotlin users in mind while continuing to provide support for using APIs from the Java programming language.

**VSMS Interface:**





### Results:

A thorough examination of current practices and concerns. To address the difficulties, we chose to use automation and digitalization. As per our requirements, we approached many outside providers to automate and digitize the process. A feasibility analysis was performed between the costing and the requirement. To tackle the difficulties within 30 days, it was decided to create a mobile application called VSMS by ourselves using programming. We ensured 100% statutory compliance by performing safety tests every two weeks.

### Conclusion:

- We ensured 100 % statutory compliance by doing the safety checks in each fortnightly.
- Fully digitalized and automated platform by which we capture & share the reports of safety fitment checks automatically.
- Auto-alerting to inspector to do safety check well before schedule time so that chance of lapses is minimized.
- We get the detail history report of each equipment as & when required.
- Safety checking time reduced to 3 minutes per HEMM from 8 minutes per HEMM, thus save time and paperwork due to avoiding of manual and paper-based system.

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## Electroencephalography (EEG) -Based Fatigue Monitoring system (DSI-7) in Mining Industry.

(Synopsis: DSI-7 EEG-Based fatigue monitoring is an advanced safety system that detects operator fatigue by analysing brain activity and provides early warning to prevent accidents in mining operations.)

Pushendra Singh Rao

**Abstract:** Fatigue is a state commonly caused by overworked, which seriously affects daily work and life. How to detect mental fatigue has always been a hot spot for researchers to explore.

To address this critical risk, EEG-based fatigue monitoring systems, such as the DSI-7, are emerging as advanced and reliable safety solutions.

Electroencephalogram (EEG) is considered one of the most accurate and objective indicators.

### 1.0 Importance of Fatigue Monitoring in Mining

In every industrial operation, it's indeed important to monitor the alertness levels of drivers and heavy equipment operators.

Fatigued operators harm themselves and others around them.

These limit production and cause damage and wear - and - tear to vehicles and other machinery.

Worldwide open-pit mining and transportation businesses have adopted fatigue-monitoring technologies, understanding the advantages of utilizing technology to address the problem of restlessness.

*(Area Manager)*

*Bamebari Iron and Manganese Mine, Tata Steel limited*

There have been a variety of techniques employed to potentially minimize fatigue-related accidents in mining areas, ranging from vibrating chairs to randomized warnings to machines that recognize eye movement employing camera systems or by embedded electroencephalography (EEG) sensing.

### 1.1 What is Driver fatigue

Driver fatigue (drowsy driving) is a state of physical and mental exhaustion that reduces driver's ability to operate a vehicle safely.



It impairs alertness, concentration, reaction time and hazard perception, increasing accident risk.



Fatigue leads to reduced productivity, equipment damage, injuries, and fatalities in mining operations.

Indirect impacts include higher absenteeism, low morale, increased turnover, and operation losses.

## 1.2 Importance of Fatigue Monitoring in Mining

**a. Fatal Accidents:** Early detection of driver fatigue reduces collision, rollover, and run over incidents involving HEMM and dumpers

**b. Enhances Operational Safety:** Maintains Operators alertness in long shift, night duties, and monotonous haul road conditions.

**c. Improves Productivity & Equipment Life:** Alert operators ensure smoother machine handling, fewer errors, and reduced maintenance costs.

**d. Supports Regulatory Compliance & safety:** Strengthens safety management systems and demonstrates proactive risk control in mining operations.

## 2.0 EEG (Electroencephalography)

EEG based fatigue systems are highly effective for early fatigue detection because they measure direct brain activity rather than external symptoms.

**a. Direct measurement of brain activity:** EEG captures real-time neural signals (e.g., increase in theta waves and decrease in alpha activity) that change before visible signs like yawning or eye closure appear.

**b. Pre-behavioural detection:** Unlike camera-based systems that detect fatigue

after behavioural signs (PERCLOS, head nodding), EEG identifies cognitive fatigue at the neurophysiological level, enabling earlier intervention.

**c. Objective and reliable:** EEG provides quantifiable biomarkers of mental workload, drowsiness, and reduced alertness, minimizing false alarms caused by lighting, dust, or facial obstructions.

**d. Suitable for high-risk industries:** In environments like mining, transport, or steel plants, EEG-based systems help detect microsleep risk and reduced vigilance before operators take control of critical equipment.

### 2.1. DSI7 EEG System:

A portable, wireless 7-channel EEG system that measures real time brain activity. Uses dry or semi-dry sensors for quick setup and field applicability.

### 2.2. How It Detects Fatigue (Basic Working of DSI-7 EEG Fatigue Monitoring System)

The DSI-7 system works by continuously monitoring the brain activity of an operator using a wearable EEG headset.

The operator wears a lightweight EEG headset with dry sensors.

The headset captures electrical signals generated by the brain (EEG signals).





These signals are transmitted to a monitoring unit or software system.

The system analyses brain wave patterns in real time.

If fatigue or drowsiness is detected, alerts are generated in the form of alarms, vibration, or warning messages. This enables early intervention before an unsafe condition leads to an accident.

### Pre-Shift Fatigue Screening (Practical Implementation of EE for Dumper Operator)

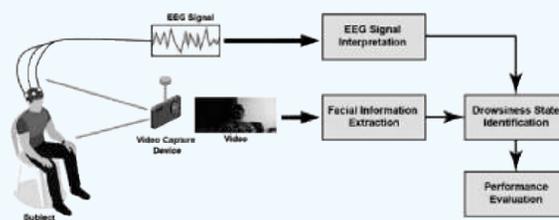
- Step 1: 4-5-minute EEG baseline recording before shift start.
- Step 2: Identify operators with high fatigue index before vehicle allocation. System categorizes operator: **Fit / Borderline/Unfit**.
- Step 3: Only 'Fit' operators allowed to take dumper.
- Step 4: During operation, existing DFMS continues real-time monitoring.
- Prevent high-risk operators from starting critical shift.

### Mid-Shift Risk Assessment

- Quick EEG assessment during scheduled breaks.
- Compare with baseline to detect cognitive decline.
- Recommend rest rotation if fatigue threshold crossed

### 3.0 Why electroencephalography (EEG) based fatigue monitoring systems are perfect for miners?

- Direct measurement of fatigue from the brain, not indirect signs
- Early detection, even before microsleep occurs
- Works in dusty, low-light and vibrating mining environments
- Not affected by helmet, goggles, or facial covering
- Difficult to manipulate or bypass, ensuring reliability
- These features make EEG-based systems particularly suitable for dumper operators, shovel operators, dozer drivers, and control room personnel.



EEG recording

Realtime analysis

Adaptive feedback

Brain training





## Automation Integration for Electrical Safety

Sitesh Kr. Rout

### Summary: -

The integration of automation into electrical systems has shifted the safety paradigm from reactive (responding to failures) to proactive (preventing them). By leveraging IoT sensors, high-speed processing, and remote operation, industries are drastically reducing the "human-in-the-loop" risks associated with high-voltage environments.

### The Core Pillars of Automated Safety: -

#### 1. Real-Time Data & Predictive Analytics

Modern automation platforms utilize Distributed Control Systems (DCS) to monitor electrical health. Unlike manual checks, these systems provide:

- Continuous Thermal Monitoring: Infrared sensors detect "hot spots" in busbars before they melt or combust.
- Transient Analysis: Identifying micro-surges that indicate insulation breakdown.

#### 2. High-Speed Fault Mitigation

In an electrical fault, every microsecond counts.

- Arc Flash Mitigation: Automated light-sensing relays can trigger a "quenching" system or trip a breaker in under 50ms. This keeps the incident energy below the threshold of fatal injury.
- Intelligent Reclosers: Automated systems can distinguish between a temporary fault (like a tree branch touching a line) and a permanent one, preventing unnecessary and dangerous manual resets.

#### Removing the Human from the "Danger Zone": -

The most significant safety intervention is the physical separation of the operator from the equipment.

Manual Process	Automation
Manual Racking	Remote motorized racking
Visual Inspection	Drone/Robot IR Scanning
Manual LOTO	Digital Interlocking system



ROBOTIC MAINTENANCE



DRONE THERMAL INSPECTION



DIGITAL INTERLOCK SYSTEM

### **Future Outlook: AI and Machine Learning: -**

The next frontier involves Machine Learning (ML) models that can predict a "Mean Time To Failure" (MTTF) for specific components. By treating electrical safety as a data problem, we move toward a "Zero-Incident" workplace where the system shuts itself down safely before a human even realizes there is a risk.

### **Conclusion: -**

Automation in electrical safety is no longer a luxury—it is a necessity for modern infrastructure. By reducing response times and removing personnel from high-energy boundaries, automation provides a level of precision and reliability that human intervention simply cannot match.



## Beyond Blame: Latent Conditions, Active Failures, and Systemic Resilience in Safety Management - A Swiss Cheese Model

Aniket Kumar

Abstract:

This article explores James Reason's seminal "Swiss Cheese Model" of accident causation, emphasizing the critical distinction between active failures and latent conditions. It posits that incidents arise from the convergence of immediate human errors (active failures) and dormant systemic weaknesses (latent conditions). By shifting focus from individual blame to systemic vulnerabilities, the model advocates for proactive identification and mitigation of latent conditions, fostering organizational resilience. Strategies for building robust safety systems through layered defenses, thorough incident learning, and a just culture are discussed, highlighting the paradigm shift required for effective modern safety management.

Keywords:

Swiss Cheese Model, Active failures, Latent conditions, Systemic resilience, Safety management, Accident causation, Human factors.

### 1. Introduction

In the intricate and often high-stakes environment of modern industrial operations, ensuring safety transcends simplistic notions of individual responsibility. The landscape of accident

investigation has been profoundly reshaped by Professor James Reason's "Swiss Cheese Model" of accident causation, which offers a robust framework for understanding how complex systems fail (Reason, 1990,). This model moves the discourse "beyond blame," advocating for a systemic examination of vulnerabilities rather than solely attributing incidents to individual error.

### 2. The Core Tenets: Active Failures and Latent Conditions

At the heart of Reason's influential model lies a crucial distinction between two primary types of failures that contribute to adverse events: active failures and latent conditions. Understanding this dichotomy is paramount for developing comprehensive accident prevention strategies and building inherently safer systems.

#### 2.1. Active Failures: The Immediate Triggers

Active failures represent the unsafe acts committed by individuals directly involved in operational processes—often termed the "sharp end" of the system. These are typically observable, immediate precursors to an incident, manifesting as momentary lapses, slips, mistakes, or procedural violations. Examples of active



failures include an operator failing to adhere to a lockout-tagout procedure, a driver exceeding a designated speed limit, or a team member overlooking a critical safety check. While these actions are the direct catalysts for an incident, the Swiss Cheese Model emphasizes that they rarely occur in isolation.

## 2.2. Latent Conditions: The Dormant Systemic Weaknesses

More pervasive and often more challenging to identify are **latent conditions**. These are hidden flaws or inherent weaknesses embedded within an organization's systems, processes, and culture that lie dormant long before an incident occurs. Unlike active failures, which are immediate, latent conditions are "resident pathogens" within the system, setting the stage for future failures (Reason, 1990). They are typically rooted in decisions made at higher organizational levels, including design, management, and policy formulation. These conditions can predispose individuals to make errors or allow active failures to escalate.

Latent conditions encompass a broad spectrum of organizational and operational deficiencies:

- **Organizational Factors:** Inadequate safety culture, insufficient resource allocation (e.g., staffing, maintenance budgets), intense production pressures that compromise safety, flawed management decisions regarding safety investments, or poor communication channels.
- **Supervisory Factors:** Lax supervision, failure to address known unsafe practices, or leadership behaviors that implicitly condone shortcuts.
- **Preconditions for Unsafe Acts:** Poorly designed equipment, lack of proper maintenance, ambiguous or overly complex procedures, inadequate training programs, ergonomic issues, or environmental stressors (e.g., excessive noise, extreme temperatures) that induce fatigue or reduce situational awareness.

These latent conditions are conceptualized as the pre-existing "holes" in the defensive layers of the Swiss Cheese Model. They do not cause harm directly but significantly increase the probability of an incident when combined with active failures.

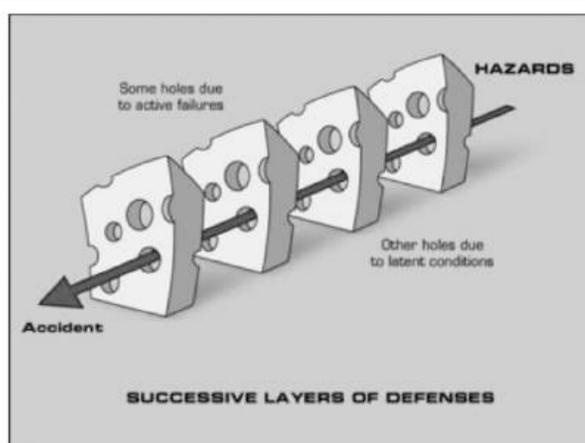
## 3. The Confluence: When Holes Align

The Swiss Cheese Model illustrates that an accident or adverse event occurs when active failures align with one or more latent conditions, creating an unimpeded path for a hazard to reach a target. Each "slice of cheese" within the model represents a defensive barrier or safeguard—be it a policy, procedure, training program, or technological control—designed to prevent harm. The "holes" in these slices represent inherent weaknesses, failures, or bypasses within these defenses.

An incident materializes when these holes, across multiple layers of defense, momentarily align, allowing the hazardous trajectory to propagate unimpeded to the operational outcome (Reason, 1990). For instance, a mechanical malfunction (an



active failure, perhaps stemming from inadequate preventive maintenance—a latent condition) might be exacerbated if the emergency shut-off system is poorly designed or inaccessible (another latent condition related to engineering controls). An operator's delayed reaction (an active failure, potentially influenced by insufficient training—a latent condition) could then lead to a severe incident. This scenario exemplifies the unfortunate and often complex interplay between systemic vulnerabilities and immediate human actions.



**Swiss Cheese Model**

#### 4. Cultivating Systemic Resilience: A Proactive Paradigm

Moving beyond a "person approach," which often focuses on individual culpability, the Swiss Cheese Model champions a "system approach" to safety. This paradigm shift redirects investigative and preventative efforts from individual mistakes to the underlying systemic factors that permit errors and incidents.

Building systemic resilience, therefore, requires a multi-faceted and proactive strategy:

1. **Proactive Identification and Mitigation of Latent Conditions:** Regularly conducting comprehensive audits, rigorous hazard identification programs, detailed risk assessments, and proactive process safety analyses are crucial. The goal is to uncover and rectify dormant systemic weaknesses before they contribute to an incident (Kumar, 2026).
2. **Reinforcing and Diversifying Defensive Layers:** Implementing multiple, independent, and robust layers of defense is essential. The more effective the barriers and the smaller the "holes" within each, the greater the system's inherent resilience. This includes engineering controls, administrative procedures, comprehensive training, stringent personal protective equipment (PPE) requirements, and effective supervisory oversight.
3. **Comprehensive Learning from Incidents and Near Misses:** Incident investigations must extend beyond surface-level causes to thoroughly uncover all contributing latent conditions. Learning from near misses is particularly valuable, as it offers opportunities for corrective action and system improvement without the burden of actual harm.
4. **Fostering a Just Culture:** Establishing an organizational culture where employees



feel safe reporting errors, concerns, and potential hazards without fear of unjust blame or reprisal. A just culture recognizes that while individuals are accountable for their actions, errors often occur within a broader systemic context that management is responsible for improving (Reason, 1997). This environment facilitates open communication and continuous organizational learning.

## 5. Conclusion

The Swiss Cheese Model provides an indispensable conceptual framework for understanding accident causation in complex systems. By distinguishing between active failures and latent conditions, it guides safety professionals toward a more profound and effective approach to accident prevention. The focus shifts from merely reacting to individual

errors to proactively identifying and mitigating systemic vulnerabilities. Embracing this model enables organizations to build more resilient safety systems, ultimately enhancing operational safety, safeguarding personnel, and fostering a culture of continuous improvement that transcends the limitations of a blame-oriented perspective.

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## A Case Study for Slope Stability Analysis of Mine & Waste Dumps of Patabeda Iron Mines.

Shri Baivab Mahalik

### ABSTRACT:

Slope in open cast mines undergoes many considerations like loose soil slopes, low rock mass strength, water pressure, high water table, pore pressure within the soil, steepness of slopes, fractures etc. For improving the stability of slopes, we adopt various stability analyzing techniques such as by using Limit Equilibrium, Finite Element Method (FEM), or Numerical Modelling to predict the slope failure. By determining and interpreting certain parameters like Physico-Mechanical properties, Factor of Safety (FOS) with Ultimate Pit slope angle, we can design the plan for maintaining the slope stability.

### INTRODUCTION:

In today's mining landscape, opencast methods dominate in mineral extraction due to their high production share, operational flexibility, short development timelines, and rapid returns. Although they demand careful overburden storage amid scarce land area, it is important to ensure optimized layouts, dump designs, and slope stability for maximizing ore recovery and minimizing the risks like production losses, extra costs, and landslides in vulnerable areas. This study assesses the excavation impacts on stabilized dumps and new benches at Patabeda Iron Mines of

MGM Minerals Ltd. in Sundargarh District, Odisha.

### OBJECTIVE:

The Objective of scientific study are as follows:-

- 1) Visit to Patabeda Iron mines and collection of samples.
- 3) Lab experiments to be carried out to determine various physico-mechanical parameters of the sample brought from the mine and dump.
- 4) Determination of factor of safety from various geotechnical & physico-mechanical data of existing mine and OB Dumps.
- 5) Determination of Factor of safety of year wise working profile.
- 6). Interpretation of FOS with ultimate dump slope angle.



*Assistant Manager (Mines)*  
Patabeda Iron Mines, M/s MGM Minerals Ltd.



**Fig-1 & 2 (Field Observation) FIELD VISIT & OBSERVATIONS:**

A field visit to Patabeda Iron Mines, confirmed existing mining with proper bench heights, bench widths, and slope angles. In-situ Schmidt Hammer testing across benches revealed high rock strength, while joints, fractures and folding are managed by engineers through dressing and maximal slopes. Rock samples of Haematite, Laterite, Shale, BHJ, and BHQ were collected from the mine and dumps. No bench water leakage occurs as the water table lies below the hill profile in this hilly terrain. The rainwater drains via channels and natural slopes. Mine management

plans interim distancing and full dump relocation as per future plans, while samples of dump/rock were collected for lab tests and modeling. The mine and the dump show strong stability from prior shaping/terracing.

#### **PHYSICO MECHANICAL PROPERTIES:**

Geological cross-sections reveal stratified in-situ formations of Iron Ore, BHJ, BHQ, and Shale – layered with distinct strengths and weathering influencing slope stability – underlying a weaker clay-rich laterite dump material (low cohesion). Representative samples from benches/dump slopes underwent ISRM-standard lab tests at AKS University's Rock Mechanics Laboratory: triaxial compression for rocks (yielding cohesion, elasticity modulus, friction angle) and direct shear for dump. Key physico-mechanical properties (Table-1) serve as inputs for numerical modeling of dump/excavation stability, where accurate parameters like UCS, density, and cohesion are vital to predict responses to loading/excavation, avoiding unsafe designs.

**Table-1: Summary of Physico- Mechanicals Properties of Samples**

Material	Bulk density(kg/m <sup>3</sup> )	Cohesion(kg/cm <sup>2</sup> )	Internal angle of friction (in degrees)
Iron Ore	3230	0.391	35
BHJ	3470	0.257	37
Shale	2310	0.326	26
BHQ	3412	0.257	36
Dump Materials	1654	0.125	29



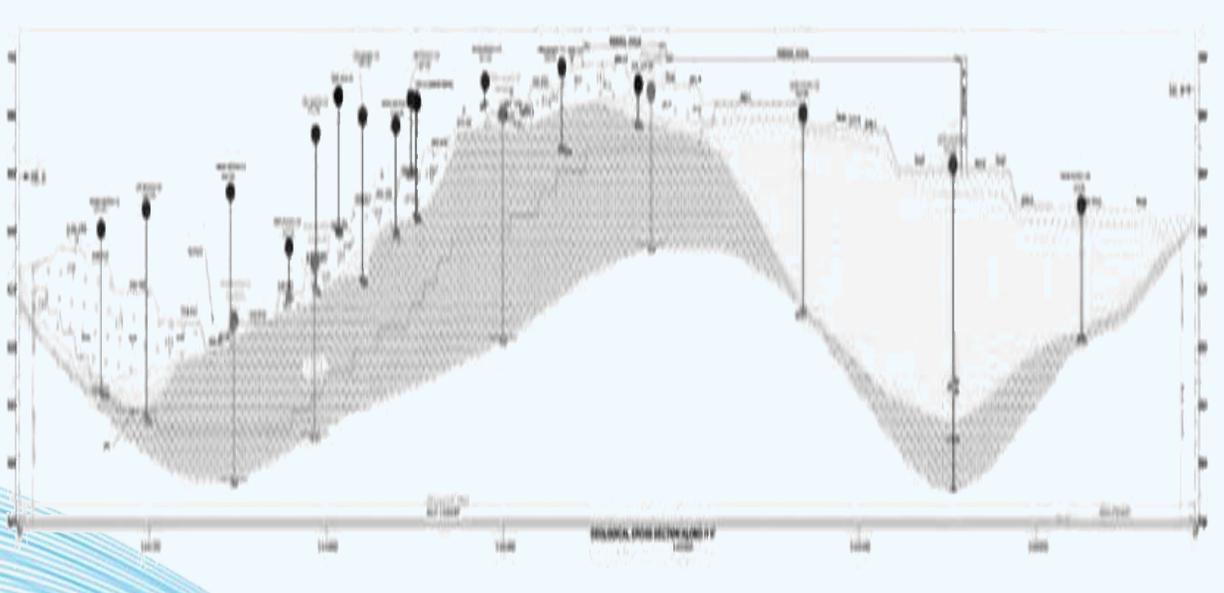
### NUMERICAL MODELLING:

Numerical modeling provides a more suitable approach for evaluating these conditions and predicting the performance of slopes under different excavation and loading scenarios. Numerical Modelling for slope stability includes, Continuum Modelling, ideal for massive/weak/fractured rock masses treated as continuous (using Finite Element/Difference methods like 2D FLAC for time-dependent hydro-mechanical effects, though limited by plane strain assumptions); Discontinuum Modelling, which views slopes as discrete blocks separated by joints/fractures (via Distinct Element Method in UDEC to analyze sliding, toppling, wedge failures, and external factors like blasting/earthquakes); and Hybrid Modelling, combining both for intact/fractured behavior (e.g., FLAC3D/PFC3D to simulate crack

propagation, complex failures, pore pressures, and adaptive re-meshing).

### MINE SLOPE STABILITY ANALYSIS:

Slope stability in Patabeda Iron Mine refers to the steadiness of working face benches or overburden dumps inclined at specific angles to the horizontal, remaining stable when resisting forces like cohesion surpass driving forces such as water presence, seismic activities, and others—otherwise leading to slope failure. Practical assessment relies on geo-technical parameters and sound engineering judgment, with effective slope monitoring programs enabling identification of vulnerable sections, prediction of instabilities, development of control strategies, and safe mining under unstable conditions. For this mine, slope stability analysis was conducted on existing mine benches and the Mine Development Section.



**Fig-3: Geological cross section of the mine.**



**FACTOR OF SAFETY (FOS):**

The Factor of Safety (FOS) is defined as the ratio between the resisting forces and the forces driving slope failure i.e.

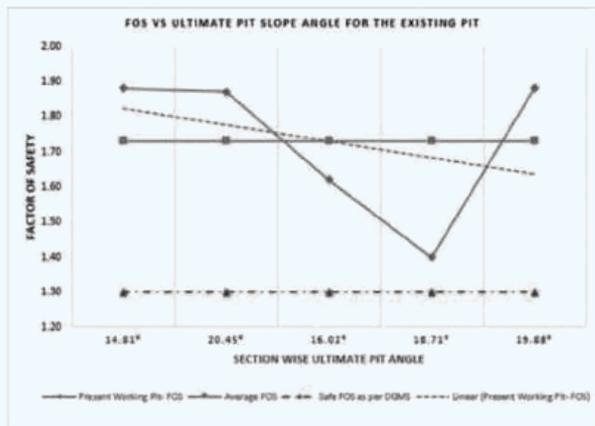
$$[FOS = (\text{Maximum Mobilizable Shear Strength}) / (\text{Mobilized Shear Stress})]$$

**Table-2: Guidelines for Slope stability based on FOS:**

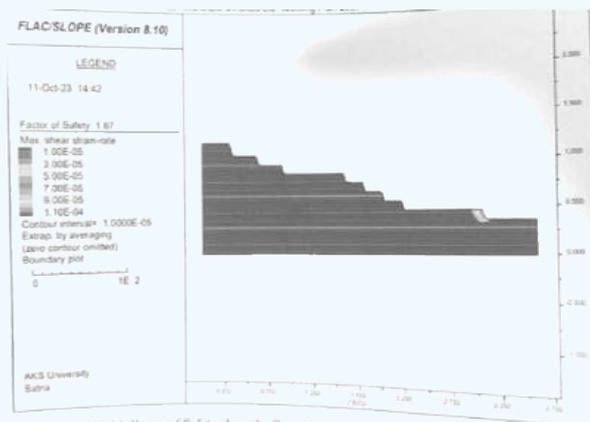
Factor of Safety	Slope Condition
<1.0	Unsafe / Failure Expected
1.0-1.25	Marginal / Uncertain Stability
1.25-1.40	Acceptable for Routine Excavation Work; Questionable for Critical Structures
>1.40	Acceptable for High-Risk Structures such as Dams

The required Factor of safety depends on the consequences of failure. For situations with low probability loads (such as seismic effects or rapid drawdown), an FOS as low as 1.2-1.25 may be acceptable, even for

critical structures. As noted by **Stephen Martel (2002)**, “the Factor of Safety cannot be directly measured in the field and is model dependent, influenced by uncertainties in geology and pore pressure conditions”.



**Fig-4: Comparison between resulted FOS, avg. FOS & Safe Factor of FOS.**



**Fig-5: FOS along the cross section of Mine working.**



### DGMS Guidelines for Factor of Safety (FOS) for Slope and Dump Stability:

The Minimum Factor of Safety (FOS) required depends on whether the slope is working (temporary) or final (permanent).

**Table-3: DGMS Guidelines**

Condition	Minimum FOS Required	References
Working / Operating Benches	$\geq 1.2$	MMR, 1961 - Regulation 106(2) (for systematic benching & safe design)
Final Pit Slopes (permanent slopes)	$\geq 1.3 - 1.5$	DGMS Technical Circular No. 4 of 2007 - "Slope Stability in Opencast Mines"
Slopes in weak / jointed rock or water-bearing zones	Higher FOS recommended. (case-specific)	MMR, 1961 - Regulation 124 (geotechnical study and monitoring requirement)

#### \*Key Stability Considerations:

- Rock mass strength, degree of weathering and joint orientation
- Presence of groundwater and seepage
- Bench geometry: Height, Width, and Overall Slope Angle.

#### Overburden/Waste Dump Stability:

Waste dumps consist of loose, unconsolidated material, therefore require higher safety margins. An identical model of proposed dump is developed in FLAC/Slope, with resulted FOS and Ultimate dump slope angle, which are tabulated below: -

**Table-4: FOS and Ultimate Dump slope angle of Dump.**

Section	Ultimate Dump Slope Angle	Factor of Safety
Dump	27.36°	2.47

**Table-5: Guidelines as per DGMS.**

Type of Dump	Minimum FOS	Required Reference
Active / Working Dumps	$\geq 1.3$	DGMS (Tech) Circular No. 7 of 1991 - "Dump Slope Stability Guidelines"
Permanent / Reclaimed Dumps	$\geq 1.5$	DGMS (Tech) Circular No. 4 of 2007, and DGMS Safety Guidelines on OB Dumps (2016)



**\*Dump Design Requirements:**

- Dumping should be done in layers (lifts) of controlled height.
- Proper surface and toe drainage must be provided to avoid saturation.
- Dumping must avoid steep natural ground slopes without prior geotechnical evaluation.
- Long-term dumps must be compacted and stabilized with vegetation.

**SUMMARY INTERPRETATION:**

**Table-6: Summary**

Area	Recommended FOS	Remarks
Working (temporary) benches	$\geq 1.2$	Acceptable for ongoing excavation
Final pit slopes	1.3 - 1.5	Required for long-term stability
Active OB dumps	$\geq 1.3$	Dump under continuous development
Final stabilized dumps	$\geq 1.5$	Long-term dump stability (post-dumping)

**CONCLUSION:**

With above comparison, it is clear that all the section's Factor of safety is above the minimum required Factor of Safety. The resulted average Factor of Safety of existing bench profile of our mine is 1.73, as comparison to the safe FOS of 1.25 to 1.40 as per guideline of equilibrium of slope. Whereas the Ultimate Pit slope angle of existing pit ranges from 14.81° and 20.45° with average ultimate pit slope angle of 17.97° which is also less than the maximum ultimate slope of angle as stipulated in 106-2(b) permission under MMR 1961.

And With reference to the Table no.4, we conclude that the FOS and the Ultimate Dump slope angle are 2.47 and 27.36° respectively, which clearly indicates that the FOS is more than the stipulated FOS of 1.40 as per guideline of equilibrium of slope tabulated in table no-5 and Ultimate dump slope angle is very minimum to the stipulated maximum ultimate slope angle as prescribed in 106-2(b) permission, under MMR,1961.



# ADVANCED UNDERGROUND VENTILATION

## *Practical Mine Ventilation Engineering in Metal Mines*

**Mr. Badri Narayan Das**

B.Tech in Mining & FMCC (UR)

### ABSTRACT

Every field of industry is using the computers at every production stage. Mining or mineral industry is not an exception. Today, due the great extent of the underground networks and the amount of data involved, we are using computers in solving problems of planning and design & engineering. The solving of a complex ventilation network of a mine cannot be done manually, and usage of a specialized software and advanced IT equipment is a must. By using this specialized software, we can easily calculate & simulate a ventilation network.

Ventilation is the control of air movement, its amount, and direction. Although it contributes nothing directly to the production phase of an operation, the lack of proper ventilation often will cause lower worker efficiency and decreased productivity, increased accident rates, and absenteeism.

### Key Words

Ventilation network model, software Planning, Simulation, Airways.

### 1. INTRODUCTION

Ventilation is a basic part of all underground mine operations. Design of adequate Ventilation network for an underground mine is of utmost importance, although it contributes nothing directly to the production phase of operation, but the lack of proper ventilation often will cause lower worker efficiency and decreased productivity. Ventilation is undertaken in order to bring in fresh-air to the workings and to dilute and remove dust and noxious gases (typically NOX, SO<sub>2</sub>, methane, CO<sub>2</sub> and CO) and to regulate temperature.

As the mine develops and deepens, operating pressure and air volume required to ventilate the mine will increase. Fan performance will be adjusted to meet the changing requirements by changing fan speeds, blade pitch, and the number of fans operating, in addition to erection / construction of stopping / door, regulator, air crossing etc.

### 2. MINE VENTILATION KEY CONCEPTS

- Ventilation system are established to delivering breathable fresh air.



- Controls the temperature & humidity
- Protects the miner by evacuating hazardous gases from the metal mines.
- The effectiveness of mine ventilation ultimately limits the productivity of the Metal mine.
- To maintain the roadways in dry condition.

### 3. AIR FLOWS IN MINES

- Air always flows from a point of higher pressure to lower pressure.
- While planning for ventilation network, we have to consider the shape and size i.e. geometry and extent of mine openings. Ventilation planning also needs to consider other factors which includes considering the amount of heat that will be added up in the course of air flow, the minimum quantity of air supply to every person, the considerable loss due to leakage, the velocity of air to be maintained within permissible limits. The complexity further increases as we need to plan for ventilation according to the method of mining as well as statutory regulations.

#### Types of Air flow into Mines

- InFlow / Down cast
- OutFlow / Up cast

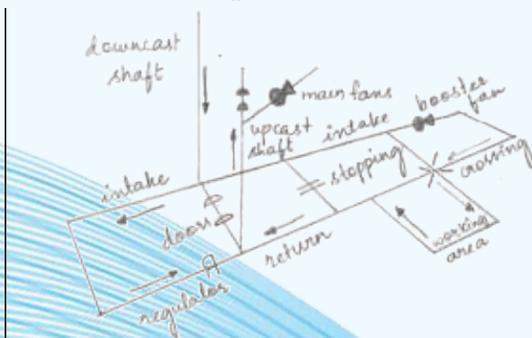


Fig.1 shows the typical layout of a mine ventilation Flow system.

### 4. TYPICAL LAYOUT OF UNDERGROUND MINES

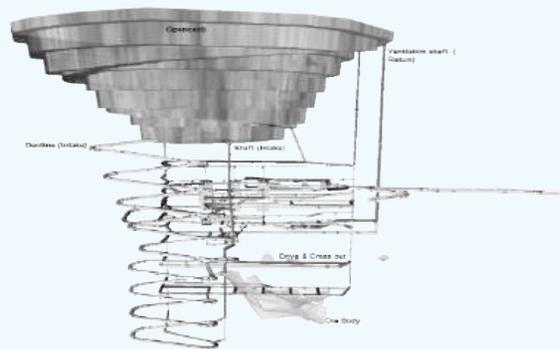


Fig.2 shows the typical layout of Underground Mines.

### 5. A TYPICAL MINE VENTILATION CALCULATION

The quantity of fresh air in a typical Underground metal mine producing @ 1000 TPD is calculated in accordance with the following aspects:

#### I) As per Production -

For every tonnage of daily ore produced, the recommended quantity of air required is 2.5 m<sup>3</sup>/min.

So, for 1000 tonnes, the requirement of air shall be  $1000 \times 2.5 = 2500 \text{ m}^3/\text{min}$ .

#### II) As per Man Power -

The quantity of air required per person employed in largest shift is 6 m<sup>3</sup>/min.

Assuming overall O.M.S of 5 Tonnes per man shift, the requirement of manpower shall be 67.

So, quantity of air required for ventilation purpose shall be  $(67) \times 6 = 402 \text{ m}^3/\text{min}$

#### III) Permissible concentration of noxious gases from Machinery -



There are no regulations at present for metalliferous mines regarding the minimum quantity of air to be delivered for dilution of exhaust gases of diesel equipment, but good practice is to provide approx. 4.2cum/min of air per KW for good ventilation in underground.

For achieving required production and development targets, following diesel

operated machinery shall be deployed and the total Power of equipment will be:

Based on the above three conditions, the maximum air requirement is 8637 Cum/min.

So, it is required to design the ventilation network of such mine with a capacity of say, 9000 cum/min.

Equipment	Capacity	Numbers	Power (KW)	Total (KW)	Usage (%)	Total KW	Ventilation (cum/min)
LHD	4 CuM	2	186	186	100	372	1562.4
LHD	2 CuM	1	79	79	100	79	332
LPDT	15 T	1	148	148	100	148	622
LPDT	25 T	4	261	522	100	1044	4384.8
Drill Jumbo	Single Boom	2	65	65	50	66	277.2
Service Utility Vehicle	Multipurpose	2	79	158	50	79	332
<b>Total</b>				<b>1158</b>		<b>1047</b>	<b>7510.4</b>
Considering 15% leakage							1126.56
<b>Grand Total</b>							<b>8637</b>

## 6. INSTALLATION OF MAIN FAN

Mining ventilation fans used to supply adequate oxygen for the workforce, dilute and exhaust dangerous gasses in the underground mine.

Mines Ventilation fan are categories as main fan/ Surface fan / Underground fan,

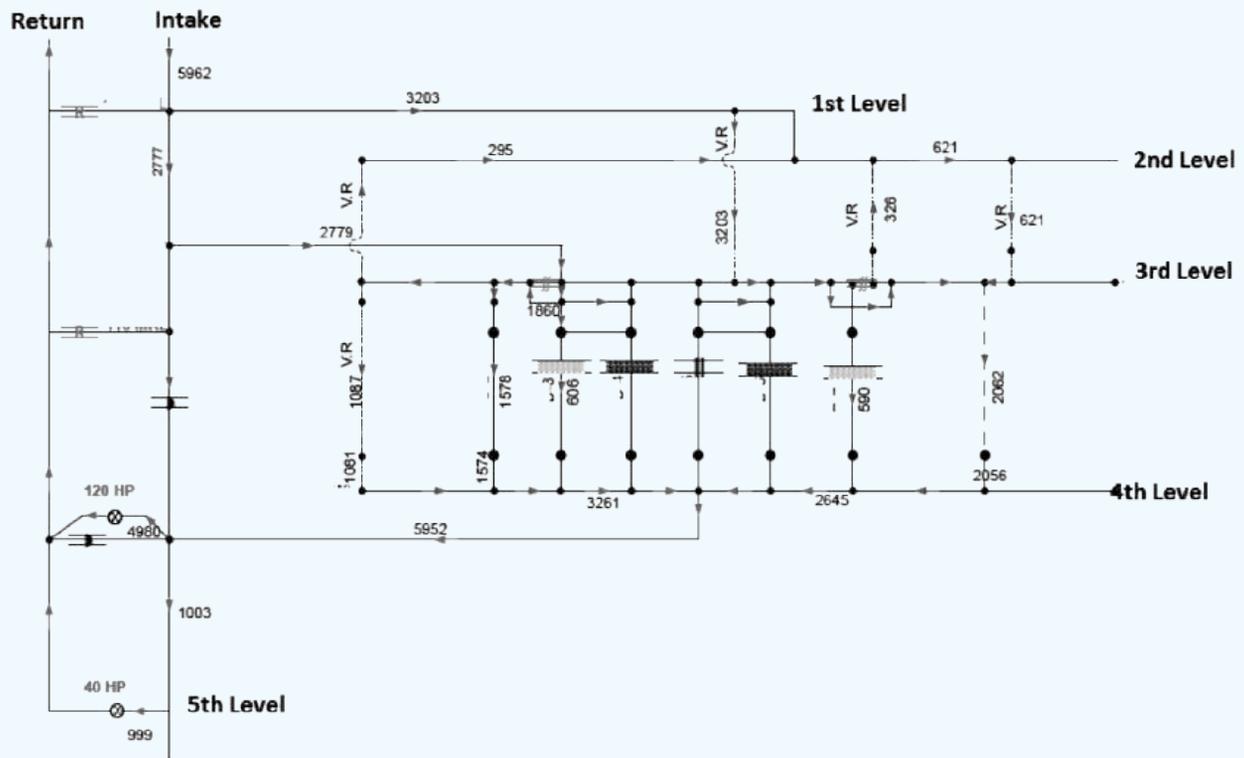
Booster fans and Auxiliary mine ventilation fan.

### Types of Main Fan installation

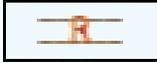
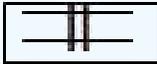
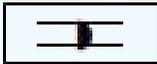
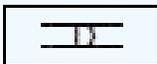
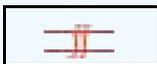
- Surface Installation
- Underground Installation



### Underground Installation



### Legend of the above Ventilation Section

-  → Regulator
-  → Concrete Ventilation Stoppings
-  → Doors Closed
-  → Doors Open
-  → Brattice Cloth
-  → Main Ventilation Fan
-  → Waste Rock Filling
-  → Partially Rock Filling

**Fig. 3** Layout of ventilation section for an Underground mine

Ventilation Network at Early Development and initial production Stage can be designed with one Intake and one Return with the main Ventilation Fan installed underground, as shown in **Fig.3**.



## Surface Installation

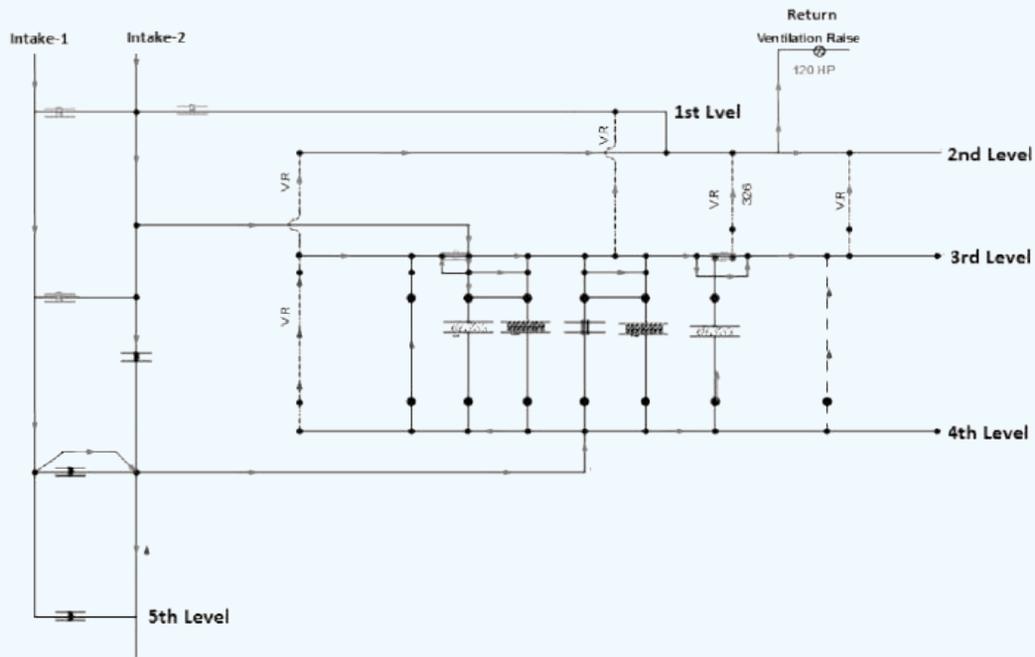


Fig. 4

### Legend of the above Ventilation Section

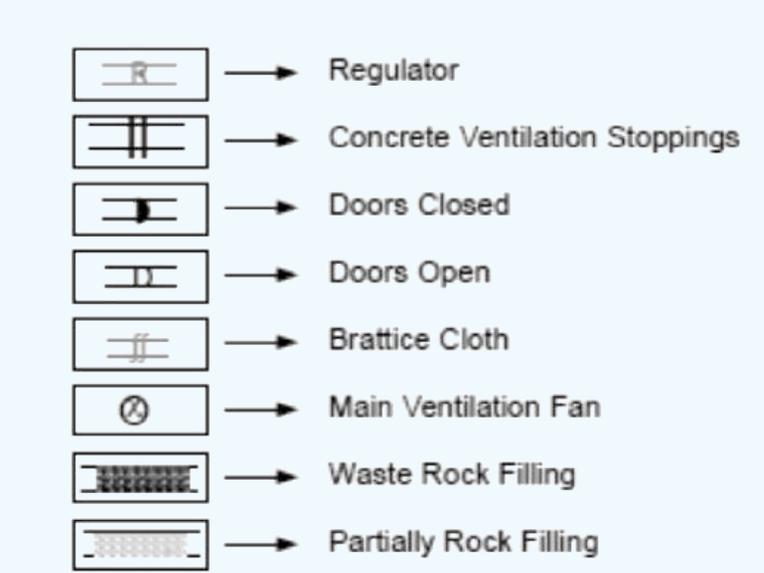


Fig. 4 Layout of ventilation section for an Underground mine

Ventilation Network at Full Production Stage should be planned with a dedicated up-cast return ventilation Shaft/Raise and two intake. This will facilitate to develop two separate network to ventilate two different section of the mine with fresh air. Since the size of the mine will become relatively quite large and single network may become complex and cumbersome, as shown in Fig.4.



## 7. HOW TO DEVELOP A VENTILATION NETWORK USING MODERN AGE SOFTWARE

Mine Ventilation Planning has been made Easy by using various software e.g.

- VENTSIM
- VUMA3D
- MIRARCO
- MagiCAD

The software solves airflow, Quantity of air, re-circulation, stopping, Regulator & Orifice throughout a ventilation circuit.

Planning, Analysis and Modification of ventilation networks has now become

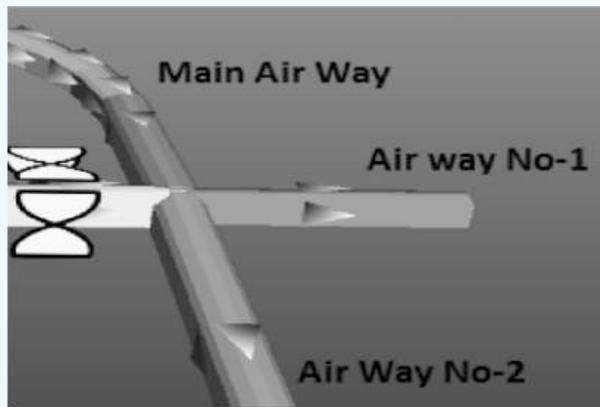
significantly easier than the Traditional method, practiced earlier.

*How the ventilation network is being prepared through VENTSIM software will be discussed and demonstrated hereafter.*

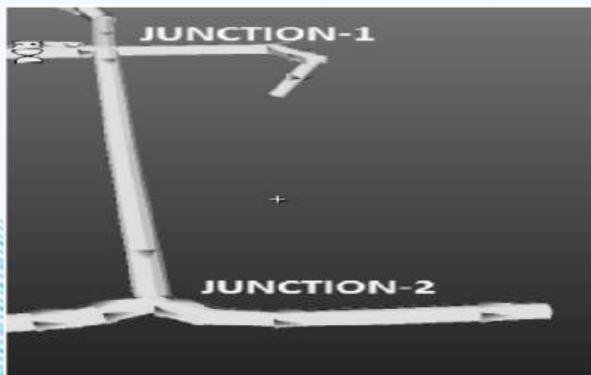
## 8. BASIC CONCEPTS IN VENTILATION NETWORK

A mine generally consists of many airways of various cross-sectional areas, shapes, lengths and interconnected in such a way that it forms a part of a complicated ventilation network with fans installed regularly as per necessity. The following terms are associated with such a ventilation network.

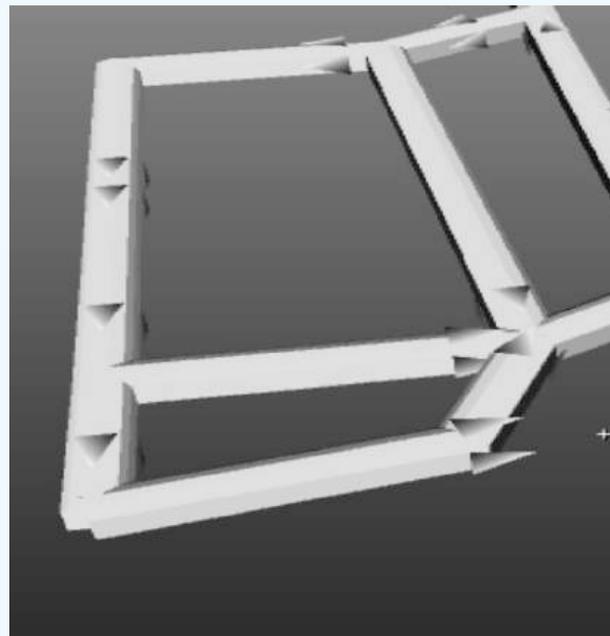
**Junction** - It is a point where 3 or more airways meet



**Branch** - It is an airway between 2 junctions

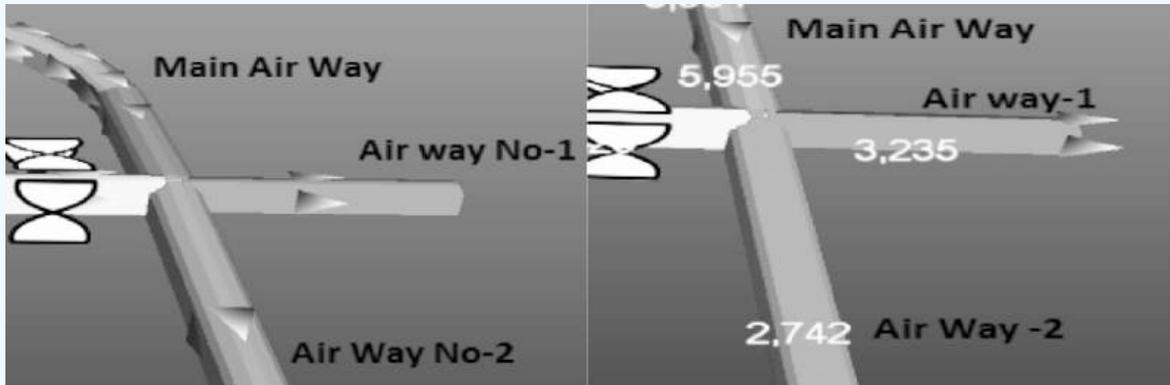


**Mesh** - It is a closed path traverse through a part of the network

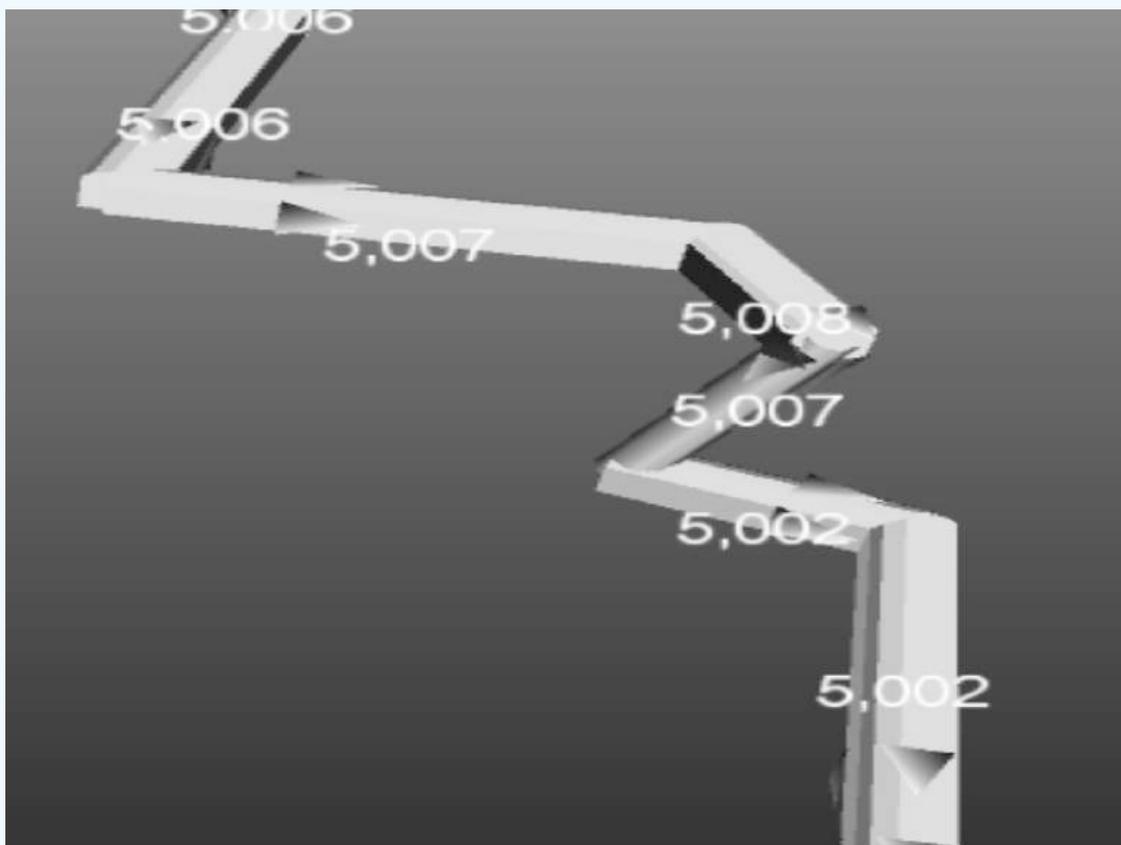




**SPLITTING OF AIRWAYS** - Splitting of airways is the same as parallel connection of airways in which the main intake airway from the shaft/Decline/Incline is splitted into 2, 3 or more airways in order to supply fresh uncontaminated air in each and every level according to the respective quantities needed in these levels.

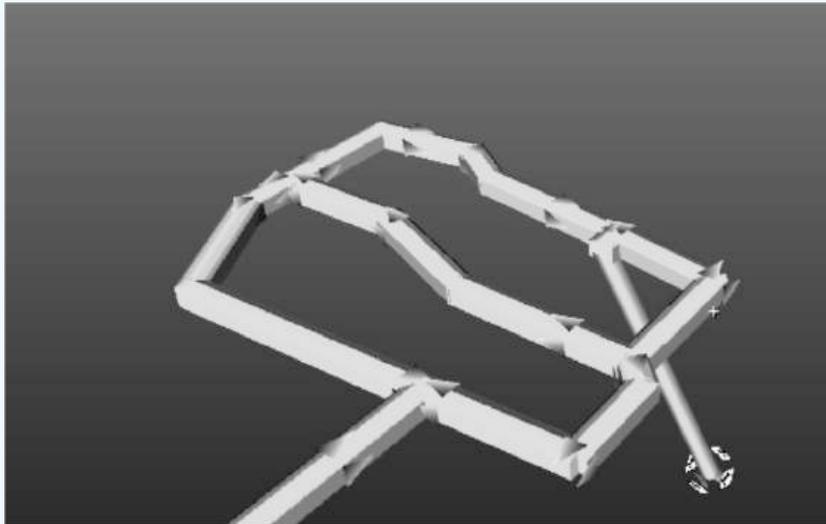


**Airways Connected in Series**





## Airways Connected in Parallel



### 9. BUILDING A NETWORK BY USING VENTSIM

The modeling of the Ventilation Network in VENTSIM is very simple and intuitive.

Before creating a network, the following data base is required.

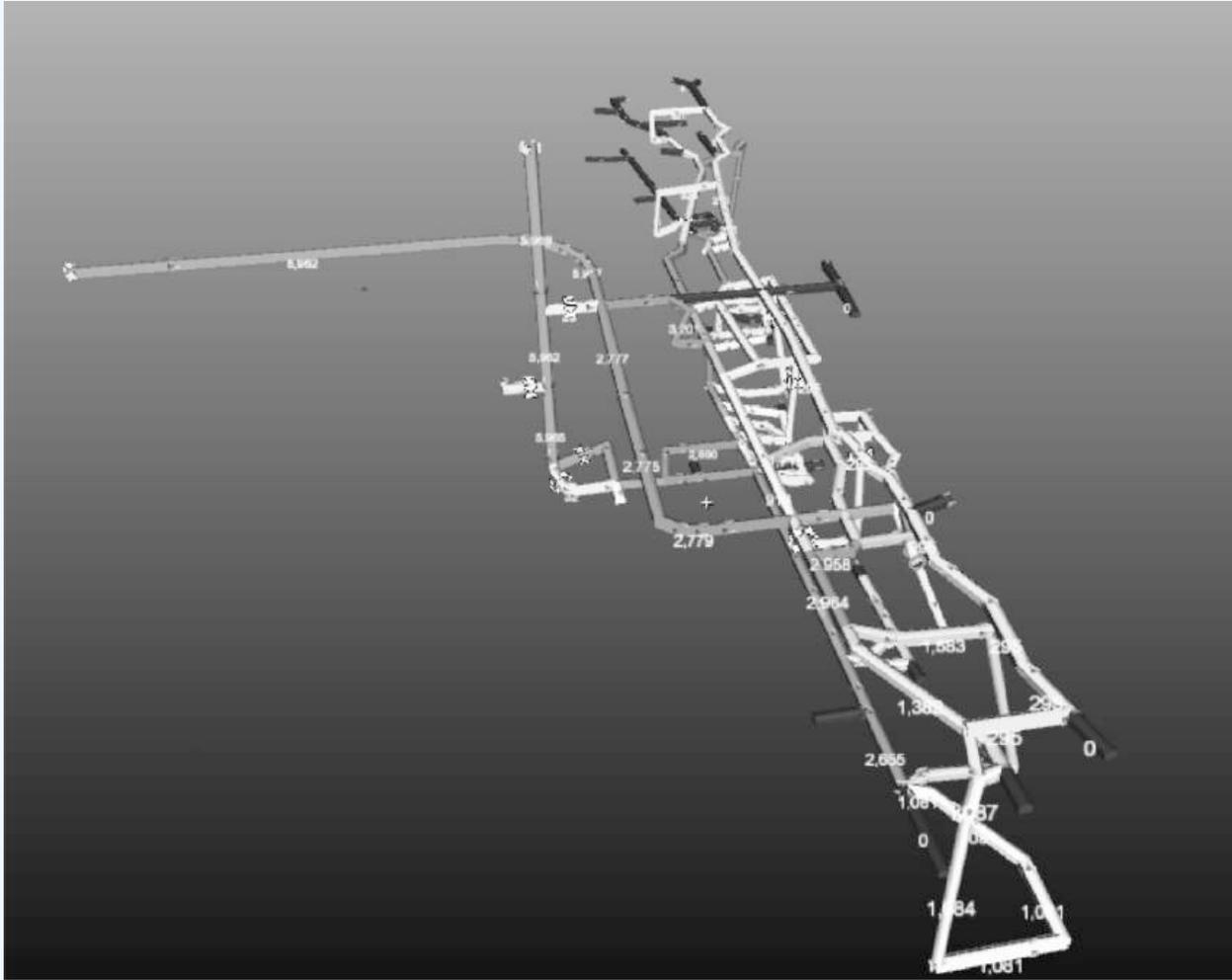
#### Input Data

- Size of entry (Intake, Return, Drives, X-cut & Raise)
- Select Intake & Return
- Length of the entry (Intake, Return, Drives, X-cut & Raise)
- Gradient of the entry (Intake, Return, Drives, X-cut & Raise)
- Air type (Fresh or Exhaust)
- Resistance, Friction factor & Shock loss (May give)
- Co-Ordinate & RL of the entry (Intake, Return, Drives, X-cut & Raise)
- Wet bulb & Dry bulb temperature
- Main fan Capacity ( In terms of Quantity of velocity)
- Location of Main Fan

- Fan characteristic Curve
- Rock type
- Source of Heat
- Quantity of Fuel burn
- Dust concentration
- Emission of Gas

Using the above database in VENTSIM software will give the following **output** in a fraction of second.

- Suitable path
- Suitable location of Main & Auxiliary ventilation fan
- Fan Optimisation
- Split of air movement
- Air Quantity in each location
- Air Velocity in each location
- Direction of air flow
- Low & high concentration of air flow
- Re circulation of air
- Requirement of regulator
- Requirement of Stoppings
- Requirement of Door
- Crossing
- Simulated Resistance
- Suitable location for Connection of level



## 10. BENEFITS BY USING VENTILATION SOFTWARE

- Instant decision can be taken
- Instant report generation
- Save time
- Save Manpower
- Increased Operational Effectiveness
- Increase Safety
- Improve engineering efficiency
- Reduce appliance (Fans, doors, regulators, ducting, etc.)

- Reduce Maintenance cost
- Reduce energy cost
- Reduce Mining cost

## 11. CONCLUSION

The design of ventilation network & VENTSIM software is most widely used and it has been found that designing a complicated network in very deep mine, regular monitoring of the actual results and thereafter any modification, if required, can easily be carried out very quickly with minimum manpower.



## Loose Scaling in Underground Mines

Binod Kumar Choudhary

### Introduction

Loose scaling is a critical ground control practice in underground mining, aimed at ensuring the safety of workers and the stability of excavations. It involves the identification and removal of loose, fractured, or unstable rock from the backs (roof), ribs (walls), and faces of underground openings. Failure to perform effective scaling is a leading contributor to rockfall incidents, which remain one of the most serious hazards in underground mines.

### What Is Loose Scaling?

Loose scaling is the deliberate removal of rock that is no longer securely attached to the surrounding rock mass. Such rock may appear intact but can detach unexpectedly due to gravity, blasting vibrations, stress redistribution, or weathering. Scaling is typically performed using hand-held scaling bars, mechanized scaling equipment, or a combination of both, depending on ground conditions and mines design.

### Causes of Loose Rock in Underground Mines

Loose rock can develop for several reasons, including:

- 1. Blasting Effects:** Poor blast design or excessive explosive energy can fracture

the surrounding rock, creating unstable slabs and wedges.

- 2. Geological Discontinuities:** Faults, joints, bedding planes, and foliation can weaken rock mass cohesion, increasing the likelihood of detachment.
- 3. Stress Redistribution:** Mining activities alter in-situ stresses, potentially causing rock deformation, spalling, or slabbing.
- 4. Weathering and Water Ingress:** Moisture can weaken rock strength over time, especially in clay-rich or highly fractured formations.
- 5. Vibration and Equipment Movement:** Repeated vibration from machinery or nearby blasts may dislodge previously stable rock.

### Importance of Loose Scaling

Loose scaling plays a vital role in underground mine safety and productivity:

- Prevention of Rockfall Accidents:** Removing loose rock significantly reduces the risk of injury or fatality from falling material.
- Protection of Equipment and Infrastructure:** Rockfalls can damage machinery, ground support systems, and ventilation controls.
- Improved Working Conditions:** Clean, stable excavations enhance visibility, access, and overall operational efficiency.

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*Manager Mining (GVTO),  
M/s IMFA Ltd, Kaliapani*



- **Regulatory Compliance:** Most mining regulations require regular inspection and scaling of underground openings.

### Methods of Loose Scaling

1. **Manual Scaling:** Manual scaling is commonly performed using steel scaling bars of varying lengths.

#### Advantages:

- High level of control
- Effective in tight or irregular spaces
- Low equipment cost

#### Limitations:

- Exposes workers to close-proximity hazards
- Physically demanding
- Less effective for large or high backs

2. **Mechanized Scaling:** Mechanized scalers use hydraulic booms fitted with scaling tools to remove loose rock from a safe distance.

#### Advantages:

- Improved worker safety
- Greater reach and productivity
- Suitable for large openings

#### Limitations:

- Higher capital and maintenance costs
- Requires trained operators
- Limited access in narrow headings

### Safe Loose Scaling Practices

To ensure effective and safe scaling, the following best practices should be followed:

- **Conduct Thorough Inspections:** Inspect the ground conditions before, during, and after scaling. Look for cracks, drummy sounds, or visible separations.

- **Scale from a Safe Position:** Always stand under supported ground and scale from the perimeter toward the centre.

- **Use Appropriate Tools and PPE:** Proper scaling bars, hard hats, eye protection, gloves, and steel-toe boots are essential.

- **Maintain Clear Communication:** Ensure nearby workers are aware of scaling activities and keep the area barricaded if necessary.

- **Never Scale Unsupported Ground Alone:** Scaling should be done with supervision and in accordance with mines procedures.

### Integration with Ground Support

Loose scaling does not replace ground support but complements it. Scaling should always be performed before installing rock bolts, mesh, or shotcrete. Even after support installation, ongoing scaling may be required as ground conditions change. Regular re-scaling is especially important in high-stress or weak rock environments.

### Training and Competency

Loose scaling is a fundamental component of underground mine safety and ground control. Effective loose scaling depends mainly on proper worker training and experience. Workers must know how to identify loose or unstable rock and understand the safest way to remove it. With good training, they can use scaling tools correctly, follow safe work procedures, and recognize dangerous ground conditions early. Experienced and well-trained workers help reduce rockfall risks and make underground workplaces safer for everyone.



## Health & Safety is priority, Mining is prosperity

**Ranajit Mahakud**

The Golden Rule of The eaRTh: Why SafeTy  
is The BedRock of MineRal PRoSPeriTy

Mining is often called the "mother of all industries." From the smartphone in your pocket to the steel in our skyscrapers, every advancement of modern civilization begins with a shovel in the ground. However, the true value of a mine is not measured in tonnes of ore or carats of gemstones; it is measured in the well-being of the people who extract them.

The theme "Health & Safety is Priority; Mining is Prosperity" is not a choice between two paths—it is a single, unified vision. In the modern industrial landscape, we have learned a vital lesson: A safe mine is a productive mine.

When health and safety are treated as the highest priority, the results are felt far beyond the balance sheet:

- **Operational Excellence:** Rigorous safety protocols naturally lead to disciplined, efficient workflows and reduced downtime.
- **Human Capital:** Prosperity is built by people. Protecting the health of miners ensures that the industry's most valuable asset—skilled experience—is preserved.
- **Social License:** For mining to bring true prosperity to a nation, it must hold the

trust of the community. That trust is earned through an unshakeable commitment to "Zero Harm."

Prosperity through mining requires more than just extracting wealth; it requires the "Wealth of Health." This means implementing the Hierarchy of Controls to mitigate risks before they reach the worker.

By moving from simple Personal Protective Equipment (PPE) toward elimination and substitution of hazards, we ensure that every miner returns home in the same condition they arrived. This is the hallmark of a world-class operation.

**" A mine that does not protect its people cannot protect its future."**

Conclusion: The Legacy of Responsibility

As we look toward the future, the definition of "Prosperity" is evolving. It no longer refers solely to financial gain, but to the sustainable development of our resources and our people. By making Health and Safety our non-negotiable priority, we don't just extract minerals; we build a legacy of resilience.

Let us commit to a future where our mineral wealth is a testament to our human worth. When safety is the standard, prosperity is the result.

**" Prosperity is Built on the Foundation of Protection."**

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*Manager (Mechanical)  
Kasia Iron & Dolomite Mines  
Jindal Steel Limited*



## Health & Safety is Priority, Mining is Prosperity – A Mechanical Engineer's View from Kaisa Mines

**Rama Chandra Mohanty**

As a Mechanical Engineer (JSP) at Kaisa Mines, I maintain the machinery that powers our prosperity – hydraulic system, Electrical systems & types of maintenance. In this rugged industry, health and safety isn't optional; it's the engineering blueprint for sustainable success. At Kaisa, we prove daily that prioritizing safety through mechanical innovation turns risks into rewards

My role puts me at the heart of operations. I involve in preventive maintenance on our fleet of all dumpers, using vibration analysis to predict failures before they endanger lives. Last month, my retrofit of emergency shut-off valves on dumper prevented a potential injury, saving the day and keeping production on track. These aren't heroics – they're standard at Kaisa, where safety metrics guide every bolt tightened.

Engineering Safety into Prosperity

We engineer excellence with proven strategies:

- Predictive maintenance: Take SOS & Health test on Every PM.
- Failure analysis report: To find the root cause of every Breakdown.
- Regular audits: I lead quarterly inspections, integrating
- Innovation push: Best Kaizen will be rewarded on every month.
- Safety: Zero Harm target & safety observations platform for all associated employees.

Health and safety is our priority because mining is our prosperity. At Kaisa Mines, mechanical engineering doesn't just build machines; it builds futures. Let's keep innovating: safety safe, operate smart, and prosper together.

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*Mechanical Engineer  
JSP, Kaisa Mines*



## Anti-Tilt Devices in Dumpers and Raised Dump Body Interlock Systems

Rohit Kr Sinha

### Ensuring safety in off-road haulage operations

Dumpers/Tippers are essential machines in construction, mining, and bulk material handling. Their function is simply to transport and unload loose materials. However, this simplicity hides a major hazard: rollovers and uncontrolled tipping during dumping.

To prevent this, modern safety designs integrate anti-tilt devices and raised dump body interlock systems. These systems protect personnel, equipment, and the work site.

#### 1. The Risk: Tipping and Instability

Dumpers operate on uneven, sloped, or soft ground and carry high centres of gravity when loaded. Major risks include:

- Side tilt rollovers – especially on uneven ground or during sharp turns with body raised.
- Forward/backward instability – loading too much at once or poor brake traction.
- Uncontrolled dump body movement – due to hydraulic failure or operator error.

These lead to injuries, fatalities, and equipment loss.

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*Area Manager Maintenance,  
Manganese Group of Mines,  
Tata Steel Ltd*

#### 2. What is an Anti-Tilt Device?

An anti-tilt device is a safety system designed to detect and prevent tipping of the dumper while the dump body is raised. This system typically involves:

##### a) Sensors

- Inclinometers/tilt sensors mounted on the chassis measure the angle of the machine relative to level ground.
- Body position sensors to detect how high the dump body is raised.

##### b) Control Logic

A safety control module compares tilt angle and dump body height. If the dumper exceeds a predefined safe angle while the body is raised, the system will intervene.

##### c) Actuation

When unsafe conditions are detected:

- Hydraulic lock-out or restriction is activated.
- Dump body movement is limited or stopped.
- Audible/visual alarms alert the operator.

The objective is to prevent further body raising and reduce rollover risk.



### Anti Tilt Device Interlocking in Tipper

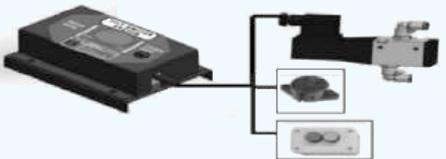


Set Safety Limit - 5°  
Tipping Success



Set Safety Limit - 5°  
Tipping Failure

**Circuit Diagram :**



#### Working & Features

- Prevent Vehicle Toppling and Tipping System (Cylinder) damage under heavy side loads
- Prevent damage to tipping body & hinges and Ensure safe tipping operation.
- Cautions unsafe conditions for tipping operations.
- Dual axis angle measurement (±7°) Digital output and Quick response Robust design.
- Plug & Play installation and configurable set limit.
- Audio indication to alert the driver.

**Note:** Audio indication is ON when the vehicle angle is more than set point 5 degree during tipping to alert the Driver and at 7 degree stop the hydraulic operation.

### 3. What is a Raised Dump Body Interlock System?

A raised dump body interlock system is a broader safety mechanism that limits vehicle motion and operations when the dump body is elevated. Key functions include:

- a) Gear/Speed Interlock
  - When the dump body is above a safe height, the system can prevent shifting into high gears or forward motion beyond slow travel.
- b) Steering Lock or Limited Steering
  - To reduce risk, steering may be limited when the body is raised.
- c) Hydraulic Lock-Out
  - Prevents lowering or raising the body if certain safety conditions aren't met (e.g., machine not stopped, parking brake not engaged).
- d) Engine Power Reduction
  - Limits engine torque to avoid sudden movements.

### 4. How These Systems Work Together

The anti-tilt device focuses on machine stability, while the raised dump body interlock focuses on safe operational mode. Together, they:

1. Monitor machine orientation
2. Detect unsafe body positions
3. Restrict controls that might worsen instability

4. Alert the operator

5. Require corrective action before resuming normal operation.

### 5. Why These Systems Matter

#### a) Prevent Fatal Accidents

Statistics from mining and construction sectors show a high percentage of mobile equipment fatalities involve rollovers and uncontrolled dumping.

#### b) Reduce Equipment Damage

A rollover can destroy the chassis, body, hydraulic system, and attachments – costing hundreds of thousands of dollars.

### Conclusion

Anti-tilt devices and raised dump body interlock systems are critical safeguards in modern dumpers used across mining, construction, and heavy industries.

They:

- ✓ Detect dangerous conditions
- ✓ Prevent unsafe dump operations
- ✓ Restrict motion when risks are high
- ✓ Alert operators to take corrective action

When combined with training, maintenance, and proper operating procedures, these systems significantly reduce accidents, extend equipment life, and protect workers on site.



## Advanced Vibration Management and Drone-Enabled Blast Monitoring at Katamati Iron Mines

Chetan Agrawal

Katamati Iron Mines (KTM) – particularly Pit-1, Pit-2, and Pit-4 – operate in a zone of heightened environmental and social sensitivity due to their proximity to Tata Steel's residential and administrative establishments. Given this unique context, **blast-induced ground vibration and air overpressure** constitute critical operational risks requiring continuous oversight. Effective control of these parameters is essential not only for compliance with statutory norms but also for maintaining stakeholder trust and ensuring uninterrupted mining operations.

Recognising these requirements, **Orica**, in partnership with **Tata Steel Limited**, has deployed the **Advanced Vibration Management (AVM)** program at Katamati Iron Mines. This initiative marks a shift from traditional reactive blast monitoring to a fully **data-driven, predictive, and performance-oriented** approach. AVM integrates vibration modelling, real-time field monitoring, and advanced post-blast analytics into a single, cohesive framework capable of predicting blast outcomes with high reliability.

### **Advanced Vibration Management (AVM): A Predictive Approach**

The AVM system supports improved blast design through accurate prediction of vibration levels based on site-specific geological conditions, explosive characteristics, charge distribution, burden, spacing, and timing patterns. By utilising historical vibration datasets and real-time monitoring inputs, AVM enables engineers to evaluate multiple design scenarios and select optimal configurations that keep vibration within **DGMS-prescribed limits** and Tata Steel's internal standards.

At Pit-2 and Pit-4, the deployment of AVM has markedly strengthened **vibration governance**. The system produces detailed and auditable datasets, facilitating traceability of blast parameters and providing advanced analytical insights. These outputs support regulatory compliance, reduce uncertainties in blast planning, and help mitigate potential structural risks to nearby sensitive facilities such as the Training Centre and administrative offices. The availability of validated data also empowers the mine to address stakeholder concerns and regulatory inquiries with greater confidence and transparency.

### **Operational Benefits and Performance Improvements**

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*(Sr. Area Manager) & Mandeep Gill (Sr. Manager)*



The application of AVM has delivered tangible improvements in blasting performance at Katamati Iron Mines. Optimised charge distribution, controlled initiation timing, and precise energy management have resulted in:

- Improved fragmentation quality, enhancing downstream load-haul-dump and crushing efficiency.
- Elimination of fly rock incidents in AVM-controlled blasts
- More consistent blast outcomes, reducing operational unpredictability.
- Safer operations with reduced exposure to blast-related hazards
- Better control over air overpressure and vibration amplitude, even in sensitive zones

These performance gains contribute directly to operational excellence, improved productivity, and a safer work environment. The ability to reliably manage vibration levels also supports the mine's long-term sustainability and regulatory compliance strategy.

### Integration of Drone-Based Monitoring

To complement AVM and further strengthen blast assessment capability, Katamati Iron Mines has incorporated **drone-based aerial photography and videography** into routine blasting practices. High-resolution drone surveys—conducted both before and after blasting—provide a robust and objective

visual record of blast performance. Key applications include:

- Assessment of fly-rock dispersion and confirmation of safe blast execution
- Precise mapping of muck-pile distribution, geometry, and throw distance.
- Visual evaluation of fragmentation patterns
- Identification of blast-induced ground effects
- Support for incident investigation and root-cause analysis

Drone footage provides a level of coverage, accuracy, and repeatability that is not possible through manual observation alone. This enhances transparency, strengthens documentation quality, and supports compliance with internal and regulatory audit requirements.

### A Closed-Loop Feedback System for Continuous Improvement

The true strength of the AVM-drone integration lies in its ability to create a **closed-loop blast optimisation cycle**. By correlating:

- AVM-predicted vibration
- Real-time monitoring data
- Drone-derived visual insights
- Actual blast parameters

engineers can achieve a deeper understanding of blast behaviour and energy distribution. This feedback



framework enables incremental refinement of blast designs, reduction of fly-rock risk, and improved control over fragmentation and muck-pile formation. With each blast, the system becomes more accurate and responsive, reinforcing a culture of **continuous improvement**.

#### **Strategic Importance and Way Forward**

Given the proximity of sensitive infrastructure and communities, the strategic importance of Katamati Iron Mines cannot be overstated. The adoption of Advanced Vibration Management, combined with drone-based monitoring, represents a **critical risk-mitigation and**

**performance-enhancement strategy** for the mine. This integrated approach aligns closely with:

- Tata Steel's commitment to operational excellence.
- Regulatory assurance and environmental stewardship.
- Responsible mining and social licence to operate.
- Data-driven decision-making and digital transformation in mining.

Continued utilisation and expansion of AVM and drone technologies will strengthen blast predictability, elevate safety standards, and reinforce Tata Steel's leadership in modern, sustainable mining practices.



# DIGITAL BLASTING REVOLUTION AT BAPHLIMALI BAUXITE MINE

Miss Manisha Kumari

*Transforming Safety, Precision, and Productivity Through Orica's Integrated Digital Blasting Ecosystem*

**Utkal Alumina International Limited - Baphlimali Bauxite Mine (BBM), Odisha,** has undertaken a groundbreaking technological shift by adopting Orica's advanced digital blasting platforms. This transition marks a significant milestone in enhancing safety, accuracy, and operational efficiency in large-scale bauxite mining.

*"Digital blasting has transformed how we plan, execute, and analyse every blast – improving safety, efficiency, and predictability."*

## Abstract

Digital blasting technology is reshaping the future of mining operations by replacing manual, experience-driven processes with precise, data-centric workflows. This paper highlights BBM's successful implementation of Orica's digital blasting suite—ShotPlus, BlastIQ Mobile, and BlastIQ Insights—and examines how the mine has achieved improved blast outcomes, enhanced safety, and robust traceability. The article also outlines challenges, solutions, and measurable operational benefits.

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*Mining Engineer,  
Mr Karan Mahato, Mining Engineer*

## Keywords

Digital Blasting, ShotPlus, BlastIQ, Mining Technology, Blast Optimization, Hindalco, Bauxite Mining, Orica, GPS Drilling, Fragmentation Improvement

## 1. Introduction

In modern mining, drilling and blasting remain the foundation for efficient excavation. Traditionally, these activities rely heavily on operator experience, manual processes, and paper-based documentation. Such an approach often leads to variability in blasting outcomes, increased safety risks, and challenges in maintaining accurate records.

To overcome these limitations, **BBM has embraced a digital blasting ecosystem**, becoming one of the leading mines in Odisha to adopt complete digital integration from design to analysis.

The shift from conventional to digital blasting not only enhances precision but also drives continuous improvement through real-time data and historical analytics.

## 2. Why Digital Blasting?

Mining operations at BBM identified the following drivers for adopting digital systems:



- **Reduced dependence on operator experience**
- **Minimization of blast-related errors**, such as oversized fragments and inconsistent fragmentation
- **Lower vibration, misfires, and flyrock incidents**
- **Enhanced traceability**, documentation, and auditing capability
- **Standardization of drilling, charging, and stemming practices**

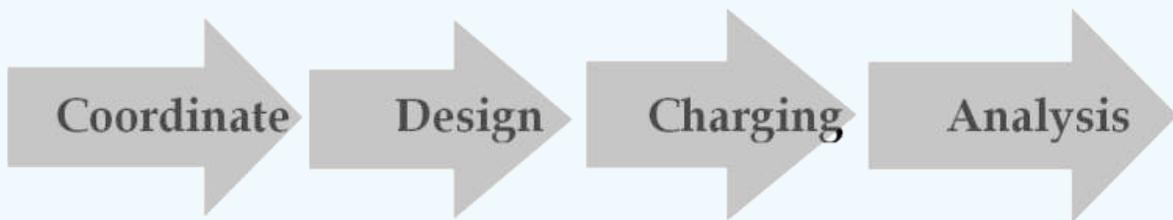
Digital tools ensure each blast follows an optimized plan, is executed with precision, and generates analyzable data for future improvements.

### 3. Conventional vs. Digital: A Comparative Overview

Parameter	Conventional Method	Orica Digital Solution
<b>Blast Design</b>	Manual layouts	3D optimized ShotPlus design
<b>Drill Accuracy</b>	Manual pegging	GPS-guided drilling
<b>Explosive QA/QC</b>	Experience-based	Digital logging through BlastIQ
<b>Delays &amp; Stemming</b>	Inconsistent	Standardized and trackable
<b>Documentation</b>	Paper-based logs	Cloud-based centralized database

The transition clearly demonstrates a shift from reactive, manual processes to proactive, data-driven execution.

### 4. The Digital Blasting Workflow

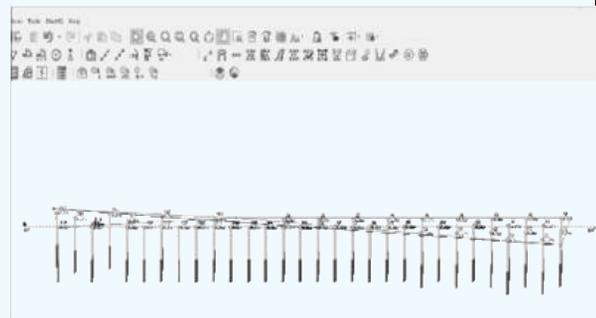


#### Step 1: Field Coordinate Capture

- Patch coordinates recorded via Handy GPS/DGPS for high accuracy

#### Step 2: Blast Design (Shot Plus)

- Optimized 3D design: burden, spacing, charge, delays
- Drilling strictly follows finalized design



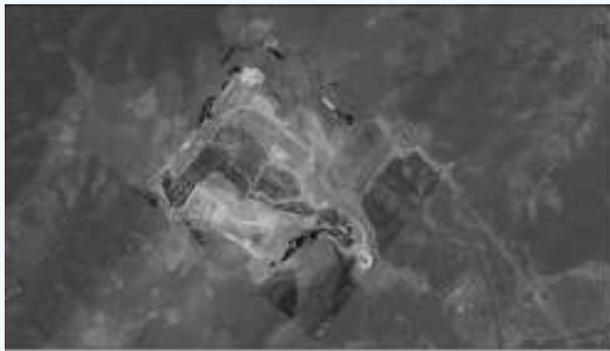


### Step 3: On-Field Charging (BlastIQ Tablets)

- Real-time hole-wise explosive loading tracking
- Immediate QA/QC of stemming and charge

### Step 4: Post-Blast Analysis (BlastIQ Insights)

- Evaluates fragmentation, powder factor, energy distribution
- Historical data used for trend analysis and improvement



## 5. Key Benefits of Orica's Digital Blasting Software

### A. Enhanced Safety

- Accurate drilling and charging minimize flyrock, ground vibration, and misfires
- Operators spend less time near explosives
- Digital hole tracking prevents incorrect loading

### B. Higher Efficiency & Productivity

- Optimized fragmentation boosts excavation and loading rates
- Reduced oversize results in lower secondary breaking costs
- Better powder factor management reduces explosive consumption

### C. Superior Digital Control & Traceability

- Standardized templates and workflows
- Cloud-linked records ensure transparency
- Data-driven continuous improvement across patches

## 6. Challenges and Practical Solutions

### Challenge:

High blasting frequency and limited manpower led to difficulties in file handling, data management, and workload distribution.

### Solution:

Training ground-level staff on Orica's digital tools improved operational efficiency and empowered operators to handle digital tasks confidently.



*“Empowering operators with digital tools has reduced errors and boosted safety awareness.”*

### **7. Conclusion**

The successful deployment of Orica's digital blasting technology at Baphlimali Bauxite Mine demonstrates that digitalization is far more than a technological upgrade—it is an operational transformation. Enhanced safety, improved fragmentation, reduced variability, and

data-backed decision-making are now integral to BBM's blasting cycle.

*“The transformation isn't just digital – it's a leap in safety, efficiency, and operational excellence.”*

BBM has set a strong benchmark for the mining industry, showcasing how digital integration can drive performance, sustainability, and reliability.



## SAFTEY ARTICLE

### Operator Ranking & Analytics Model (ORAM)

A Data Driven Framework for Enhanced Mining Safety and Operational Excellence

OMQ Division, Tata Steel Limited

Sibasankar Mishra

#### ABSTRACT

*This paper presents the Operator Ranking & Analytics Model (ORAM), a comprehensive data driven framework designed to transform mining operations through intelligent operator assessment, predictive analytics, and enhanced safety protocols. ORAM addresses critical gaps in conventional operator evaluation systems by leveraging Vehicle Health Monitoring System (VHMS) and Fleet Management System (FMS) data to create transparent, unbiased performance metrics. The dual engine architecture comprising Behavioural (ORAM-B) and Mechanical (ORAM-M) modules enables proactive equipment monitoring, intelligent resource allocation, and continuous skill development. Implementation at Tata Steel's iron ore operations demonstrates 10-15% improvement in operator efficiency, 3-5% fuel savings, and significant reduction in safety incidents through predictive maintenance and behavioural optimization.*

**Keywords:** Mining Safety, Operator Analytics, Predictive Maintenance, Fleet Management, Machine Learning, Behavioural Analytics

#### 1. INTRODUCTION

Mining operations worldwide face persistent challenges in operator performance evaluation and equipment health management. Traditional assessment methodologies rely

predominantly on attendance records and subjective experience-based judgment, creating significant gaps in operational safety and efficiency optimization. At Tata Steel's Katamati and Noamundi iron ore mines, the Vehicle Health Monitoring System (VHMS) and Fleet Management System (FMS) generate millions of data points daily, yet this wealth of information remains largely underutilized for proactive decision making.

The absence of standardized evaluation frameworks creates operational inefficiencies where identical equipment operated on the same routes exhibits 30-40% productivity variance. Fuel consumption patterns and breakdown occurrences remain untracked at the operator level, preventing targeted intervention and skill development. ORAM addresses these systemic challenges through a unified analytical framework that transforms raw operational data into actionable safety and performance insights.

#### 2. PROBLEM ANALYSIS AND SAFETY IMPLICATIONS

Current state analysis reveals three critical safety and operational concerns requiring systematic intervention:



**2.1 Unstructured Evaluation Systems**

Manual, attendance-based operator assessment provides no mechanism for identifying unsafe driving behaviors, excessive equipment stress, or inefficient operational patterns. Without objective metrics, operators exhibiting potentially hazardous practices such as aggressive acceleration, improper braking, or excessive idle times remain undetected until equipment failure or safety incidents occur.

**2.2 Underutilized Monitoring Systems**

VHMS and FMS technologies capture comprehensive vehicle telemetry including engine parameters, fuel consumption, geo location, and operational timestamps. However, siloed data management and reactive maintenance protocols prevent

proactive identification of emerging equipment issues. Critical insights on fuel consumption patterns, cycle time anomalies, and component stress remain hidden within unused datasets.

**2.3 Operational Impact on Safety**

Inconsistent operator performance directly correlates with increased safety risks. Route specific challenges, equipment limitations, and environmental factors are not systematically factored into deployment decisions, leading to suboptimal operator equipment route combinations that elevate accident probability and equipment wear.

**3. ORAM SOLUTION ARCHITECTURE**

ORAM employs a dual engine architecture integrating behavioral and mechanical analytics to deliver comprehensive operational intelligence:

ORAM B (Behavioral System)	ORAM M (Mechanical System)
<ul style="list-style-type: none"> <li>• Operator Skill Profiling &amp; Benchmarking</li> <li>• Data Driven Allocation Decision Support</li> <li>• Operational Efficiency &amp; Productivity Metrics</li> <li>• Route Normalized Performance Scoring</li> </ul>	<ul style="list-style-type: none"> <li>• Proactive Equipment Health Monitoring</li> <li>• Granular Trip Level Visual Analytics</li> <li>• Predictive Maintenance Diagnostics</li> <li>• Geospatial Detailed Haul road Mapping</li> </ul>

Table 1: ORAM Dual Engine Module Components

**4. MACHINE LEARNING DERIVED SAFETY METRICS**

ORAM employs advanced machine learning algorithms to derive weighted performance metrics that directly correlate

with safety outcomes. The model analyses operator controllable factors while normalizing for external variables such as route difficulty, equipment type, and material characteristics.



Performance Parameter	Weight	Safety Correlation
Productive Time Ratio (PTR)	31.83%	Minimizes fatigue related incidents
Hauling Speed Optimization	13.45%	Reduces collision risk
Route Normalized Performance	13.00%	Accounts for terrain hazards
TKPH Compliance	11.82%	Prevents tire related failures
Stop Time Management	11.52%	Reduces congestion hazards

Table 2: ML Derived Performance Weights and Safety Correlations

## 5. SAFETY OUTCOMES AND OPERATIONAL IMPACT

Implementation of ORAM at Tata Steel's iron ore operations has yielded measurable improvements across multiple safety and efficiency dimensions:

### KEY PERFORMANCE IMPROVEMENTS

- 10-15% improvement in operator efficiency through data driven skill development.
- 3-5% reduction in fuel consumption via behavioural optimization and route intelligence
- 5-10% increase in material movement through predictive allocation
- Significant reduction in unplanned equipment downtime through VHMS analytics
- Enhanced safety compliance through transparent accountability mechanisms

## 6. CONCLUSION

ORAM represents a paradigm shift in mining operator management, transitioning from reactive, subjective assessment to proactive, data driven intelligence. By integrating behavioural analytics with mechanical diagnostics, the framework creates a comprehensive safety ecosystem that benefits operators, equipment, and organizational objectives. The transparent leaderboard system promotes positive behavioural change while the predictive maintenance capabilities extend equipment life and prevent safety critical failures.

Future development phases will incorporate real time in cabin alert systems, advanced haul road segment analysis with satellite imagery integration, and expanded VHMS parameter integration for tire health and payload optimization. ORAM's scalable architecture positions it for deployment across Tata Steel's raw material operations, establishing new benchmarks for mining safety and operational excellence.



## सुरक्षा नारे (Safety Slogans)

सुजीत कुमार एक्का

### मुख्य संदेश

- ध्यान में रखो एक ही बात, अपना सुरक्षा अपने हाथ.
- सुरक्षा से अपना नाता जोड़ो, दुर्घटनाओं से अपना मुँह मोड़ो.
- लापरवाही से अपना जान ना गवाए, सुरक्षा को अपनाएं.
- खतरों को दूर भगाएं, सुरक्षा को गले लगाए.

### सावधानी और सतर्कता

- सावधानी हटी, दुर्घटना घाटी.
- सुरक्षित जीवन का यही अर्थ है, सुरक्षा के बिना सब व्यर्थ है.
- एक भूल करे नुकसान, छिने खुशियाँ और मुस्कान.
- जरा संभाल के करो काम, कहीं ना हो जाए जीवन की शाम.
- काम करते समय ना करो बात, नहीं तो दुर्घटनाओं से होगी मुलाकात.
- जरा देख कर रखो कदम, ज़िंदगी नहीं मिलती हर दम.

### नियम और जिम्मेदारी

- सुरक्षा से जो नाता तोड़ेगा, वह एक दिन दुनिया छोड़ेगा.
- खुद के जीवन को अगर है बढ़ाना, हमेशा सुरक्षा नियमों को अपनाना.
- काम के बाद काम के साथ, आपकी सुरक्षा आपके हाथ.
- नसीब समझ कर छोड़ो मत, सुरक्षा नियम को तोड़ो मत.
- लगाओ काम पर सुरक्षा का पहरा, फिर ले जाओ घर मुस्कुराता चेहरा.
- अपने कार्य की हरदम करो समीक्षा, सुरक्षा से काम करने पर प्रबल होगी इच्छा.
- हर कार्य के पहले जानो, सुरक्षा के हर मापदंड को पहचानो.

### सार्वभौमिक संदेश

- सुरक्षित ढंग से काम हो, सारे सपने साकार हो.
- सुरक्षा से बगावत, दुर्घटना को दावत.
- काम से अगर नज़र हटेगी, तो भाई ज़रूर दुर्घटना घटेगी.
- कश्मीर हो या कन्याकुमारी, काम में सुरक्षा है बहुत ज़रूरी.
- यह इतिहास गवाह है, बिना सुरक्षा तबाही है

सीनियर इलेक्ट्रीशियन

लांजीबेरना लाइमस्टोन एंड डोलोमाइट माइंस, डालमिया सीमेंट



## प्रगति का आधार : सुरक्षा और व्यापार

रनाजित महाकुद्

खनन से ही जुड़ा हुआ है, देश का हर अरमान, धरती की इन गहराइयों में, छिपा हुआ वरदान।

कोयला, लोहा और खनिज ये, देते सुख-सत्कार, खनन ही है खुशहाली,

इसका गौरव है अपार।

किंतु तरक्की की राहों में, भूल न जाना धर्म, सबसे ऊपर मान के चलना,

सुरक्षा का यह कर्म।

नियमों का जब पालन होगा, सुरक्षित हर इक जान, तभी बनेगा सफल और, ऊँचा यह

संस्थान।

हेलमेट, जूते और बेल्ट, हैं जीवन के हथियार, इनको पहन के ही करना, खतरों के पार

प्रहार।

सावधानी जो हटी यहाँ तो, हो सकता नुकसान, सजग रहेंगे हम सभी तो, बढ़ेगा देश

का मान।

समृद्धि की सीढ़ी चढ़ें हम, सुरक्षा के साथ, हाथों में लेकर चलें हम, उन्नति का

विश्वास।

“सुरक्षा ही प्राथमिकता, यही हमारा मित्र, खुशहाल बनेगा खनन से, भारत का हर

तंत्र।



## ସୁରକ୍ଷା ହେଉ ଆମ ଜୀବନ ମନ୍ତ୍ର

## ଖଣି ନିରାପତ୍ତା ସଂଗ୍ରହ କବିତା

କେଶବୀନନ୍ଦ ଘଡ଼େଇ

ସତ୍ୟବ୍ରତ ନାୟକ

ଲୋହ ପାହାଡ଼ର ନିରବ ହୃଦୟେ,  
ଗଜଗଜ ଧ୍ୱନି ଶ୍ରମର ସ୍ୱର  
ମାନବ ଘାତରେ ଲେଖୁଛି ଇତିହାସ,  
ଉନ୍ନତିର ନୂଆ ଅଧ୍ୟାୟ ଭରି ପ୍ରତିଦିନ ନୂଆ ଦୃଶ୍ୟର ଚିତ୍ର ।  
କିନ୍ତୁ —  
ଏକ ମାତ୍ର ଅସାବଧାନ ପଦକ୍ଷେପ,  
ଏକ ମୁହୂର୍ତ୍ତର ଅଲକ୍ଷ୍ୟ ମନ,  
ସ୍ୱପ୍ନକୁ ଭାଙ୍ଗି ଦେଇପାରେ,  
ଆନନ୍ଦକୁ କରିପାରେ ଶୋକର ଜନ୍ମସ୍ଥାନ !  
ତମ୍ଭର ଦୌଡ଼େ ହଲ୍ ରୋଡ଼ ଉପରେ,  
ଢିଲୁ ଧ୍ୱନି କାଟେ ନିରବତା,  
ରୁଷ୍ଟିଂ ପୂର୍ବ ସାଇରେନ୍ ଡାକେ —  
“ସତର୍କ ! ସତର୍କ !” ଦେଉଛି ସଚେତନତା ।  
ହେଲମେଟ୍ ମାତ୍ର ଟୋପି ନୁହେଁ,  
ଏହା ଜୀବନର ରକ୍ଷା କବଚ,  
ସେଫ୍ଟି ବୁଟ୍ କେବଳ ଛୁଟା ନୁହେଁ,  
ପ୍ରତି ପାଦକୁ ରକ୍ଷା କରୁଥିବା ସଚେତନ ସହଚର ।  
ଘରେ ଥାଏ ମା’ର ଆଶାଭରା ଦୃଷ୍ଟି,  
ସନ୍ତାନ ଅପେକ୍ଷା କରେ ହସିଥିବା ମୁହଁ,  
ସଙ୍ଗୀନୀର ପ୍ରାର୍ଥନା ଆକାଶ ଛୁଏ —  
“ସୁସ୍ଥ ଫେରନ୍ତୁ” ସେହି ଏକମାତ୍ର ଅଭିଳାଷ ଥାଏ ହୃଦୟ ମଧ୍ୟରେ  
ଗୁଞ୍ଜି ରହୁଥିବା ସ୍ୱର ।  
ସୁରକ୍ଷା କେବଳ ନିୟମ ନୁହେଁ,  
ନୁହେଁ କାଗଜର ଲେଖା ଶବ୍ଦ,  
ଏହା ହେଉଛି ଜୀବନର ପ୍ରତିଜ୍ଞା,  
ପ୍ରତ୍ୟେକ ଶ୍ରମିକର ପବିତ୍ର ସଙ୍କଳ୍ପ !  
ଆସନ୍ତୁ, ଏହି ଧର୍ମାତ୍ମକ ସେଫ୍ଟି ଡିଏଲ୍ ଅବସରରେ,  
ନେବା ଆମେ ସାମୂହିକ ଶପଥ —  
“ପ୍ରଥମେ ସୁରକ୍ଷା, ପରେ କାମ”  
ଏହି ହେଉ ଆମ ଜୀବନର ସତ୍ୟ ଧର୍ମପଥ !  
ନିରାପଦ ଖଣି - ସୁଖୀ ପରିବାର,  
ସଚେତନ ଶ୍ରମ - ଉନ୍ନତିର ଆଧାର !  
ସାଦର ସମ୍ମାନସହ ।

ମସ୍ତିଷ୍କ ସୁରକ୍ଷା ମସ୍ତିକ କରଇ  
ମସ୍ତିକ ସୁରକ୍ଷା ସିଏ,  
ଶିରସ୍ତାଣ ଅବା ହେଲମେଟ୍ ହୋଇ  
ମସ୍ତିକେ ବିରାଜୁ ଥାଏ ॥  
ସ୍ୱୟଂ ପାଦ ହୀତା ସୁରକ୍ଷିତ ଜୋତା  
ପାଦେ ପାଦେ ରକ୍ଷା କରେ,  
କରରେ ଗ୍ଲୋବ୍ ମାନେ ହସ୍ତବନ୍ଧ  
ଥିଲେ ଦୁର୍ଘଟଣା ତରେ ॥  
ଆଖି ରକ୍ଷା ରାମା ସୁରକ୍ଷା ଚକ୍ଷମା  
ଭୁଲିବାନି ଆମେ ଜମା,  
ଧୂଆଁ ଧୂଳି ଠାରୁ ନିରାପଦେ ଥାଉ  
ଖଣିର ରକ୍ଷା ଗାରିମା ॥  
ଖଣି ନିରାପତ୍ତା ସଂଗ୍ରହରେ ବାଉଁ  
ନିଜ ନିରାପତ୍ତା କଥା  
ବଖାଣିଲୁ ଯାହା ପାଳନ କରିଲେ  
ନଥିବ ବିପଦ ଚିନ୍ତା ॥

କାସିଆ ଆଇରନ୍ ଏଣ୍ଡ ଡୋଲୋମାଇଟ୍ ମାଇନ୍ସ

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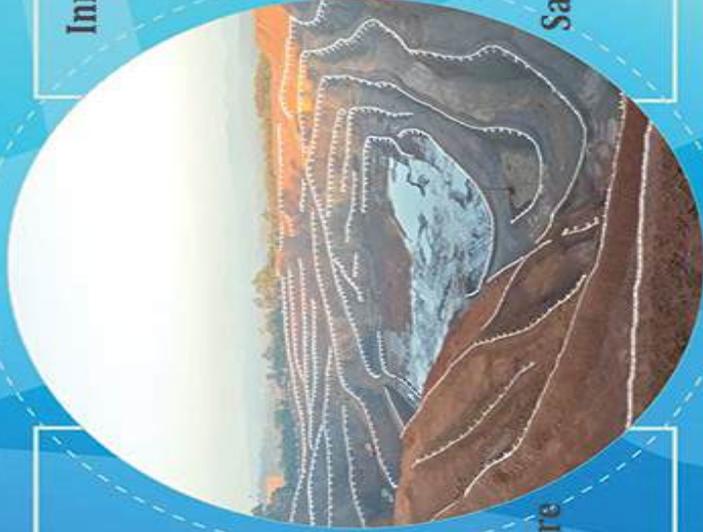
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Dist-Keonjhar, Odisha-758014

**Sponge Iron Plant 2:**

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Dist- Keonjhar, Odisha-758031

**Head Office:**

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**Ferromanganese Plant 1:**

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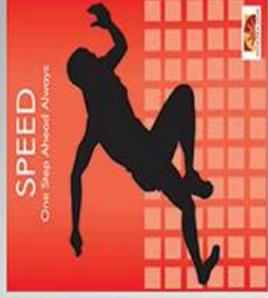
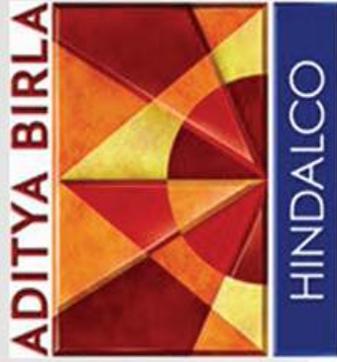
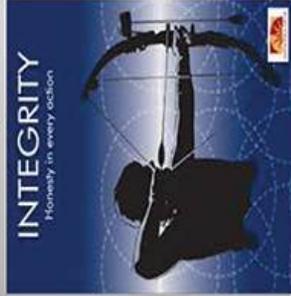
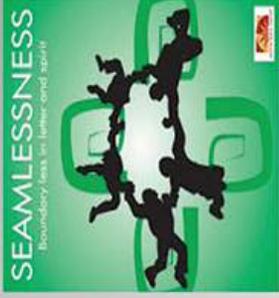
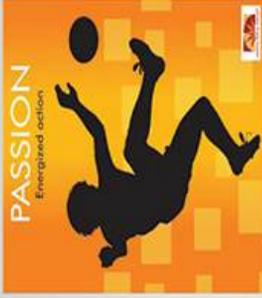
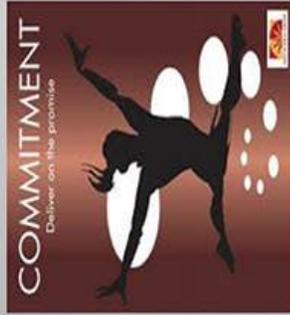
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**Corporate Office:**

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Mail ID-kiplmines2020@gmail.com

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Dist-Keonjhar, Odisha-758014

**Sponge Iron Plant 2:**

At-Kutugaon Po-Chipinda  
Dist- Keonjhar, Odisha-758031

**Head Office:**

Kashvi Mall, 4<sup>th</sup> Floor, Mining Road, Keonjhar  
Mail ID-groupkashvi@gmail.com, Pin-758001

**Siljora-Kalimati Iron & Mn. Mines:**

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**Ferromanganese Plant 1:**

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- Operating single largest coal pit for National Thermal Power Corporation Ltd (NTPC), India (18 MTPA)
- Operating largest Baryte mine in the world for APMDC, India (3 MTPA)
- Thriveni Rebuild Centre (TRC) equipment refurbishment and testing, one of the largest in Asia.
- Integrated Iron ore pellet plant (4MTPA) & Beneficiation plant (4.7MTPA) with underground slurry pipeline of 218Km, one of the largest in India.
- Operating Thermal Coal Mines in Indonesia with an annual production of 4 Million Tons of coal per year.
- Started operation of Gold mines at Jonnagiri

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Regional Office Address

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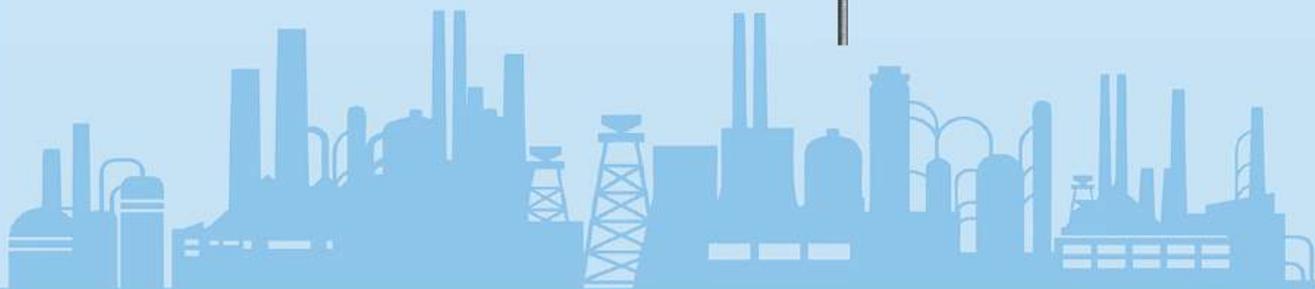
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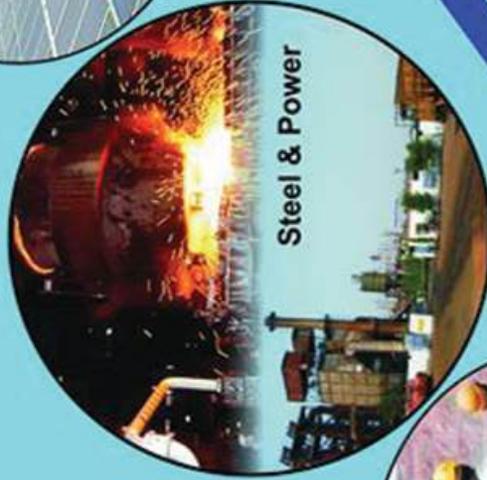
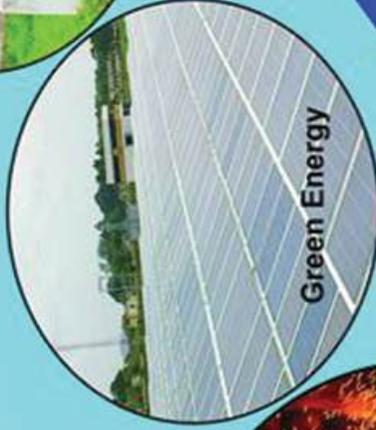
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## ବିପଦଜନକ ଶ୍ରମିକମାନଙ୍କ ପାଇଁ ସୁରକ୍ଷା ସୁବିଧା ।

ପ୍ରତିକ୍ଷେପକ ସ୍ଵାସ୍ଥ୍ୟସେବା ସଂସ୍କୃତିକୁ ପ୍ରୋତ୍ସାହିତ କରନ୍ତୁ ।

- ସମସ୍ତ ଶ୍ରମିକଙ୍କୁ ବାର୍ଷିକ ମାଗଣା ସ୍ଵାସ୍ଥ୍ୟ ପରୀକ୍ଷା କରାଯିବ ।

### ଜାତୀୟମାନଙ୍କ

- କେନ୍ଦ୍ର ସରକାର ଶ୍ରମିକଙ୍କ ଉତ୍ତମ ସୁରକ୍ଷା ପାଇଁ ଜାତୀୟ ମାନଦଣ୍ଡ ପ୍ରସ୍ତୁତି କରିବେ ।

### ଲିଙ୍ଗଗତ ଭେଦଭାବ ନିଷେଧ

- ମହିଳାମାନେ ଭୂତଳ ସମେତ ସମସ୍ତ ପ୍ରତିଷ୍ଠାନରେ କାମ କରିପାରିବେ । ଖଣି, ଭାରୀ ଯନ୍ତ୍ରପାତି ଏବଂ ବିପଦଜନକ କାମ, ଯାହା ସମାନ ଚାକିରି ସୁଯୋଗ ସୁନିଶ୍ଚିତ କରିବ ।

### ଶ୍ରମିକଙ୍କ ସୁରକ୍ଷା ସର୍ବାଧିକ ହେବ ।

- ପ୍ରତ୍ୟେକ କାରଖାନାରେ ଏକ ସୁରକ୍ଷା କମିଟି ଗଠନ କରାଯିବ-ସ୍ଥାନ ସୁରକ୍ଷା ତଦାରଖ ସୁନିଶ୍ଚିତ କରିବା ପାଇଁ ବିପଦଜନକ ରାସାୟନିକ ପଦାର୍ଥର ନିରାପଦ ପରିଚାଳନା ସୁନିଶ୍ଚିତ କରିବା ପାଇଁ ।

ଆମ୍ଭ ନିର୍ଭର ଭାରତ ପାଇଁ ଶ୍ରମ ସଂସ୍କାର ।



# ଚାରୋଟି ଶ୍ରମ ସଂକେତ କାର୍ଯ୍ୟକାରୀ ହେଲା

## ଖଣି ଶ୍ରମିକଙ୍କ ସୁରକ୍ଷାକୁ ଏକ ନୂତନ କବଚ ମିଳିଲା



ଦୁର୍ଘଟଣା କ୍ଷତିପୂରଣ ବ୍ୟବସ୍ଥା -ଘରୁ କର୍ମକ୍ଷେତ୍ରକୁ ଯିବା ସମୟରେ ଦୁର୍ଘଟଣାକୁ ଏବେ ନିୟୁକ୍ତି ସମ୍ପର୍କିତ ବର୍ଗରେ ଅନ୍ତର୍ଭୁକ୍ତ କରାଯାଇଛି ।

ଶ୍ରମିକଙ୍କ ସୁରକ୍ଷା ସର୍ବୋପରି ହେବ - କେନ୍ଦ୍ର ସରକାରଙ୍କ ଦ୍ଵାରା ଅଧିସୂଚିତ ମାନକଗୁଡ଼ିକ କର୍ମକ୍ଷେତ୍ରରେ ବୃତ୍ତିଗତ ସୁରକ୍ଷା ଏବଂ ସାମ୍ବ୍ୟ ଅବସ୍ଥାକୁ ମାନକୀକରଣ କରିବ ।

ଏବେ ସମସ୍ତ ଶ୍ରମିକଙ୍କ ସ୍ଵାସ୍ଥ୍ୟ ସୁରକ୍ଷା ସୁନିଶ୍ଚିତ କରାଯିବ ଏବଂ ସେମାନେ ବାର୍ଷିକ ମାଗଣା ସ୍ଵାସ୍ଥ୍ୟ ପରୀକ୍ଷା ପାଇବେ ।

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ସ୍ଥାୟୀ କର୍ମଚାରୀମାନେ ନିଯୁକ୍ତି କ୍ଷମତା ବୃଦ୍ଧି କରିବେ ଏବଂ ସ୍ଥାୟୀ କର୍ମଚାରୀଙ୍କ ପରି ସାମାଜିକ ସୁରକ୍ଷା, ଆଇନଗତ ସୁରକ୍ଷା ଭଳି ସୁବିଧା ସୁନିଶ୍ଚିତ କରିବେ ।

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ଏହା ରୁକ୍ତିନାମାକୁ ହ୍ରାସ କରିବ ।

ଏହା ଦକ୍ଷତା କର୍ମୀମାନଙ୍କ ପାଇଁ କ୍ୟାରିଅର ସୁଯୋଗ ବୃଦ୍ଧି କରିବ ।



ଆମ୍ଭ ନିର୍ଭର ଭାରତ ପାଇଁ ଶ୍ରମ ସମ୍ମାନ ।

# ଚାରୋଟି ଶ୍ରମ ସଂକେତ କାର୍ଯ୍ୟକାରୀ ହେଲା

## ମହିଳା ଶ୍ରମିକମାନଙ୍କ ପାଇଁ ଲାଭ

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- ମହିଳା ଶ୍ରମିକମାନେ ରାତି ପାଳି ପାାଇବେ ଏବଂ ସମସ୍ତ ପ୍ରକାରର କାମ (ଭୂତଳ ଖଣି, ଭାରୀ ଯନ୍ତ୍ରପାତି ସମେତ) କରିବାର ସୁଯୋଗ ପାଇବେ-ସେମାନଙ୍କର ସମ୍ମତି ଏବଂ ସୁରକ୍ଷା ବ୍ୟବସ୍ଥା ନିଶ୍ଚିତ କରିବା ବାଧ୍ୟତାମୂଳକ ହେବ ।
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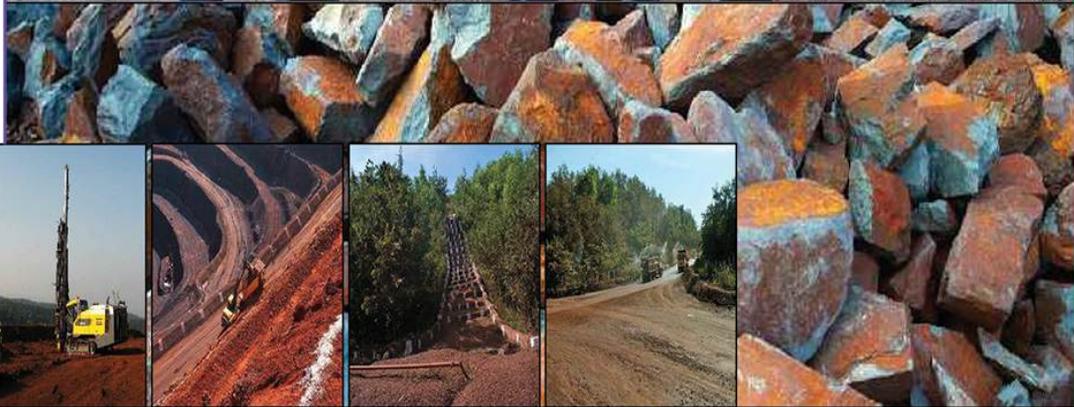
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