Quantification of Benefits of Technology Roadmap for Coal Sectors

Volume- I

Part-B

Table of Contents

Disclaimer

Quantification of Benefits of Technology Roadmap for Coal Sector is a document prepared based on the information available in public domain and input provided by various stakeholders.

It is a document for coal companies for information purpose to adopt new technologies and quantification has been done for the purpose of getting actual no. of applications feasible in today's scenario.

The content in this report do not comprises any technical, legal & professional advice. Coal companies should consult technical & financial advice before implementing any of the Technology proposed and should do cost benefits analysis.

Ministry of Coal does not own responsibility for any loss. Further Ministry is not liable to any claims. Users are strongly advised to take firm decisions based on their own analysis.

Feedback for further improvement and updating the content as well as design in publication is solicited and would be appreciated. It is requested to send your valuable suggestions to socrc.moc@nic.in.

1. Introduction

The importance of Coal for country like India is incomparable in present scenario. Thermal power plants meet almost 72 percent of electricity demand. As per the mission of Ministry of Coal "to augment production through Government companies as well as captive mining route by adopting state-of-the-art and clean coal technologies with a view to improve productivity, safety, quality and ecology". Technology-enabled transformation calls for a break from ingrained habits, and a change in mindsets, behaviours, and capabilities. Coal companies must realize that tech-enabled transformation is a journey unique to every company and mine. There will be hundreds of ideas, improvements, and use cases. Some of these can be done now; others will unfold as a company's capabilities and technical architecture develop.

It's already been decade since the world's leading mining companies began to use fully autonomous haul trucks, but they haven't stopped there. However, in terms of advancement in technology Indian Coal mining companies even Coal India Ltd. is still shrugging to implement 4th generation technologies. Further as per Atmanirbhar Bharat country needs to reduce the dependency on imports & fulfil the growing energy consumption by increasing domestic production as demand is increasing due to factors such as expanding economy, rising population, moreover the improvement of quality of life.

Since scenarios regarding workforce, environment are changing around the world, the new technologies only can make the difference for business to being more successful. Therefore, Ministry of coal prepared technology roadmap for coal sector to increase the level of technology in coal mines, in which India is lagging. Document also gave the tentative timelines for adoption. Technologies suggested in Roadmap—particularly artificial intelligence (AI) and machine learning, automation and robotics, mobile digital, the Industrial Internet of Things, and drones etc.—can help the coal industry meet challenges such as low productivity, equipment underutilization, low coal recovery etc. It may also help reduce the industry's environmental footprint, move workers out of harm's way, turn uneconomical reserves economical, and make work less repetitive and less strenuous.

Therefore, Indian coal companies must commit to transforming their existing technologies to nurture innovation & embrace change. Quantification of benefit of Technology Roadmap to coal sector is document prepared for the purpose of getting actual no of applications applicable in today's scenario and their cost benefits. However, all the figures given the document are tentative and taken for the reference purpose only.

2. Opencast Mining

2.1. Alternative fuel Technology

2.1.1. Use of LNG in HEMM:

Qualitative Benefits

- Non-toxic and non-corrosive, resulting in less pollution.
- Higher energy density and no theft and adulteration.
- Produce lower Particulate Matter (PM) than Diesel engines, since LNG does not contain aromatic compounds such as benzene and contains less dissolved impurities (e.g., Sulphur compounds) than diesel does.
- Eco-friendly and safe fuel as compared to Diesel.

Quantitative Benefits:

- LNG engines emit almost 17% lower CO2 than Diesel engine.
- A typical comparison of TTW CO2 Emission for 49 Tonner Vehicle on LNG Dual fuel Engine (1.91 kg/km) is 8.7% lower than Diesel Engine (2.09 kg/Km).
- Well to wheel GHG emissions from LNG engines are on average 12% lower than diesel engines
- Approximately 25-40 % cheaper than Diesel.
- The retrofitting cost of LNG kit can be recovered within 2.5 years by saving of fuel as per the IOCL report.

Applications:

- If trial is successful then industry wide application.

Limitations:

- Only burns if it comes in contact with oxygen in concentrations of 5 to 15%
- Natural gas is lighter than air, in case of leakage, it disperses.

2.1.2. Use of Hydrogen:

Anglo American's a first of its kind, the monster mining vehicle is being piloted in Limpopo, South Africa, at the firm's Mogalakwena platinum mine. the truck will be hybrid, with a hydrogen fuel cell providing roughly half of the power and a battery pack the other half.

Qualitative Benefits:

- Cleaner air, less noise and lower maintenance costs.

Quantitative Benefits:

- One kilogram of hydrogen has the general energy equivalence of roughly 3 kg, or 1 gal., of diesel fuel.
- So, compared to diesel or natural gas, hydrogen will be able to power a vehicle the same distance using less fuel.
- Emits water vapour and it has the potential to reduce on-site diesel emissions by up to 80%.

Applications:

- Long term vision, If successful then industry wide application.

Limitations:

- Hydrogen does not exist on its own so needs to be extracted from water via electrolysis or separated from carbon fossil fuels.
- Storage and transportation of hydrogen is more complex than that required for fossil fuels.
- Hydrogen is a highly flammable fuel source, which brings understandable safety concerns.

2.2. In-pit crushing & conveying:

Qualitative Benefits:

- Economical in high-capacity opencast mines where reasonable lead distance, lifts are involved & improved safety due to decreased mobile vehicle usage
- Reduced spare part, maintenance requirements & bad weather downtime.
- Ideally suited to new operations or an expansion, rather than steady state operation.
- Capex neutral compared to trucks when taking into account replacement schedule and operating expenditure is less.

Comparison of different in-pit crushing system:

IPCC Crushing Options	**Fully Mobile**	**Semi Mobile**	**Fixed**
Throughput	<10,000 t/h	<12,000 t/h	<12,000 t/h
Truck Quantity	None	Low	Intermediate
Crusher Type	Sizer, Jaw/double roll crusher	Any	Any
Unit Crushing Cost	Higher	Intermediate	Lower

Type	Specification
Fixed	High Capacity Typical Gyratory/Jaw Crusher Rarely Relocated Commonly Associated With Transport Tunnel
Semi-Fixed	High Capacity Typical Gyratory/Jaw Crusher Relocated Every 3-5 Years Commonly Associated With Transport Tunnel Or Wide Truck Ramp
Relocatable	Medium Capacity Typical Twin Roll Crusher Or Sizer Relocated Every 6-18 Months Multiple Crushing Station With Conveyor Ramp And Conveyor Distribution Point Not Common In Deep Hard Rock Mine
Movable	Medium-Low Capacity Typical Twin Roll Crusher Or Sizer Relocated As Required To Follow Shovel Commonly Feeds Onto Bench Conveyor Or Conveyor Bridge Multiple Crushing Station With Conveyor Ramp And Conveyor Distribution Point To Date, No Application In Large Scale, Hard Rock Mine

Quantitative Benefits:

- Greenhouse gas emissions reduction up to 25% & noise level reduction of up to 35%. Dust emission reduction of up to 40%
- Reduced manpower requirements up to 40 – 60%.
- The trucks consume 60% of available mechanical energy to carry their dead weight; only 40% energy is used to carry the payload. But for belt conveyors, 10% to 20% energy is required to carry the belt while carrying the material in plane or uphill direction and rest 80% to 90% energy is utilized to carry the material, Conveyors carrying material downhill may generate energy.
- The dump trucks can negotiate maximum gradient up to 1 in 16 for long hauls whereas the conveyors can run effectively up to a gradient of 1 in 4.
- The energy cost to transport same payload over same distance or for lifting same vertical height is more in case of dumper than in case of conveyor. To transport 100 te of payload over a distance of 5 kms, the dump truck will need about 40 lit. of diesel (Rs.3200/-), whereas the belt conveyor will use about 60 Kwh (Rs.360/-).
- Mine life, up to 50-60 years of operation - need at least four years to pay back capital and +10 is ideal.

Applications:

- IPCC currently deployed in 1 Mine of ECL & shall be introduced in 1 mine of BCCL & 2 mines of SECL (Chhal OCM & Manikpur OCM).
- Further, In Pit Conveying system is operational at 2 mines of SECL and future deployment is planned in 7 mines (1.

Kusmunda OCP 2. Baroud OCP 3. Porda- Chimtapani 4. Madannagar 5. Durgapur 6. Pelma 7. Rampur- Batura)

Limitations:

- The initial cost of system is normally higher than that of the truck haulage system.
- The mining operation is completely dependent on availability of the conveyors. This availability is over 95% but a shutdown of one belt can stop the entire production.
- Relocation of the crusher and extension of the conveyor is expensive and requires a shutdown of the mining operation for a period from 2-3 days.

2.3. Ripper Technology:

Qualitative Benefits:

- Higher safety, less disturbance of the surroundings (noise / dust). Better performance due to the small percentage of fines.
- Useful for softer rock and low volume excavation in areas where blasting is not permitted due to proximity of villages and other infrastructures like dam, road, rail track etc
- More precision for the separation of rock layers. Wear resistance and nearly maintenance free.
- Complete elimination of drilling and blasting, elimination of ground vibration and dust development.
- Easier mine management. Higher productivity as compared to primary breaker. Elimination of secondary breaking.
- Environment friendly and easy operation.
- Due to recurring shortage of explosives these machines are due to make bid inroads into the operations of CIL.

Quantitative Benefits

- At places, the cost is as low as Rs 40 /Cu.M due to higher productivity whereas comparative cost in drilling blasting is about Rs 55/Cu.M.
- As per CMPDIL cost study this technology can save around 3 percent as compared to drilling blasting. Cost study has been attached in ***Annexure- 1.***

Applications:

- Currently being deployed contractually in 3 mines and shall be introduced in 1 more mine of CIL.

Limitations:

- May not be effective in hard rocks and massive formations (unfractured formations)

- Limited cut depth of around 1m is likely to affect the productivity of loading equipment.
- May not be suitable for managing fast advancement requiring bulk excavation volumes.

2.4. HEMM size upgradation:

Qualitative Benefits:

- Less specific fuel and other resources consumption.
- Less pollution, dusts etc.
- Bulk handling
- Increase safety because of less number of exposed people.
- Higher productivity.
- Higher capacity of Shovel with matching size dumper may be envisaged depending on the suitability in respect of volume of OB/Coal excavation, presence of no of Coal Seams/Partings which will result in reduced traffic density in the mine and thus enhancing safety of the mine.

Quantitative Benefits:

- Ideally, in case of Dumpers, the 100 Te size is known to be most cost effective.

Applications:

- Applications in large opencast mines.

Limitations:

- High initial capital required.
- High spares cost.
- Higher fuel requirement.
- Competent operators and maintenance crews
- Reduction of flexibility.

2.5. Dozer Rippers:

Qualitative Benefits:

- Increased productivity: Reduces idle time as it is continuous process and also eliminates shifting of machine as in case of blasting. Minimised ground vibration
- Safety: Eliminates chances of fly rocks & Misfires. Noise & Dust reduction
- Product Size: Blasting sometimes result in oversize boulders which may require secondary blasting which is costly affair.
- Quality Control: In blasting there is a chance of dilution.
- Environmentally Friendly: Ripper provides as pollution free environment to work.
- Most suitable where there exist thick built-up area and population.
- Useful for soft strata for initial mine life.

Quantitative Benefits

- Cost Economics: Ripping doesn't involve involvement of various machineries as in drilling blasting thereby making the process economical.

Applications:

- Already 42 departmental machines are in operation and 50 more are being envisaged wherever feasible.

Limitations:

- Initial capital cost is higher
- Maintenance team to be bigger.
- Highly experienced skilled operator is prime necessary for operation so it takes long time to make a dozer operator.
- As operators have different skills & ideas so to maintain bench height and floor level close supervision is necessary
- Output of dozer to the demand of production is very slow in mines.

3. Underground Coal Mining

3.1. Longwall Mining:

Qualitative Benefits:

- Lower operating cost, easier to supervise.
- Higher safety as it can works under weak roofs.
- Ventilation system is very simple.
- Large reserve & uniform deposit are mined by Longwall mining.
- Simple layout allowing high recovery of coal even in thick seams.

Quantitative Benefits

- High recovery (Over 75%).
- Deposit can be extracted from panels of coal that can extend 3 km through the coal seam.
- Allows panel lengths of 3 Kms and widths upto 250 Mtrs.
- Highly cost effective; internationally cost of extraction is ¼th cost in OC mines.

Applications:

- Currently two Longwall faces are in operation in CIL and two are in pipeline. Another 4 are in conceptual stage that shall be worked through MDO mode.

Limitations:

- The first is that it requires a very substantial capital investment to purchase the highly specialized equipment to create a longwall section.
- The development time is significant.
- Subsidence is a substantial risk.
- Zero selectivity once mining commences on the panel.
- Overall flexibility is low.

3.2. Continuous Miner

Qualitative Benefits:

- No drilling blasting required.
- Increase in productivity, safety.
- Most amenable to application in Indian condition.

Quantitative Benefits:

- Can mine seam thickness of 1.8 to 5m.
- High productivity machine (OMS upto 8 Te/Manshift in India and has scope for improvement)
- Productivity Comparison:

Machine	**Tentative Productivity**
SIDE DISCHARGE LOADER	110 tonnes per day (For a 5-heading district having 3 SDLs)
LOAD HAUL	200 tonnes per day

DUMPER	(For a 5-heading district having 3 LHDs)
CONTINUOUS MINER	1,200 TPD (for low height CM), 1700- 2,000 TPD (for standard height CM) (Depending on the seam thickness)
POWERED SUPPORT LONGWALL	3,280 tonnes per day onwards

Applications:

- Currently 21 set of CMs are in operation and another 50 are in pipeline.
- At ECL, Continuous Miner combined with Shuttle Car (7 sets) had been deployed at Jhanjra, Sarpi, Kumardih-B UG and Khottadih UG projects and is running successfully.
- At SECL, Continuous Miner (CM) at UG mines like Kurja-Sheetaldhara mine, Kapildhara mine, Churcha UG mine, Vijay West UG mine, Haldibari UG mine, Khairaha UG mine, Vindhya UG mine & Bangwar UG mine are in operation. Further future identified mines are Rani Atari UG mine, Rajgamar UG mine, Shivpur Block of Churcha UG mine, Gayatri UG mine

Limitations:

- In the event of a breakdown on continuous miner, the production from the section ceases completely.
- High proportion of the spares have been imported.
- Stone intrusions within the seam can have an adverse effect on production rates and on the machine itself.
- Frequent moves of the continuous miner may be necessary where systematic support is required. This can considerably reduce the time available for production.
- Spillage left by the continuous miner necessitates the use of hand labour or additional mechanized equipment for clean-up operations

3.3. Highwall Mining:

Qualitative Benefits:

- Can be used where coal is blocked in batter of existing opencast mines and which have reached their final limit due to uneconomic stripping ratio or due to local constraints.
- Less manpower required.
- Stacking Push beams saves space. Can be quickly relocated mine to mine.
- Less capital required than underground.
- Operation of machine can be phased without overlapping existing open cut operation.
- Converts idle mine to productive centre and has wide applicability in India

Quantitative Benefits:

- Penetration 300 metres.
- Up to 40% recovery, subject to coal compression resistance, Overburden load, Seam heights/Pillar stability.

Applications:

- Currently 5 Nos of Highwall mines are under various stages of implementation in CIL. In the first phase it has been decided to identify and deploy Highwall mining in at least 40 mines that are likely to be taken up on top priority.
- At ECL, Highwall Mining is proposed to be introduced in Nimcha and Sripur Colliery. Contract agreement has been signed already.
- At SECL, Successfully commissioned in April, 2011 at Sharda mine of Sohagpur area. Another New Project viz. Batura Highwall is under implementation.

Limitations:

- Stability of web-pillars & sustainability of roof have to be established by scientific investigations.

4. Transportation

4.1. Transportation of Men in Underground Mines

4.1.1. Chair Lift Man Riding System:

Qualitative Benefits:

- Brings down the travelling time and fatigue of miners working in underground.
- Increase in productivity, reduction in fatigue and improved safety.

Quantitative Benefits

- E.g. for a distance of 2 km average travel time taken by person is 30 min or more. However, by chair lift system having speed of 3m/s average time taken is 11 min.
- A saving of 40 min/ person/shift which increase OMS as well as production.
- E.g. A underground mine having production of 900TPD and per shift production 300T. If we take 7hrs as working hrs then per hour production is 42.85 T. With increase in working time of 40 min total production per shift increase to 328T.
- The special design of the chair suspension in conjunction with the clamping ring ensures safe travel over sections with a maximum gradient of 45 degrees.

Applications:

- Parasea, Nimcha, Bansra, Shyamsundarpur & Chinakuri Mine III (Chairlift system in each mine) has been operation in ECL. Further expected to be commissioned in two more mines viz. Nimcha & Bansra, respectively (2nd set Chairlift System in each mine).
- At BCCL 3 no of chairlift man riding system is currently functional at 2 mines.
- At WCL, Chairlift man riding system is operational in 12 mines and planned in 3 mines.
- At SECL, 17 nos of Man riding systems (14 mines) are currently functional and 6 man riding systems (in 5 mines) are being planned.

Details	***Mine & Nos***
Present Deployment	1. Churcha UG- 03 2. Nawapara UG -02 3. Kurja UG- 01 4. Kapildhara UG-01 5. Bagdewa UG-01 6. Singhali UG-01 7. Shivani UG-01 8 Behraband UG-01

	9. Pinoura UG-01 10. Jhilimili UG-01 11. Bangwar UG-01 12. Jhiria UG-01 13. Rajendra UG-01 14.Katkona 1&2 UG -01.
Future Planning	1. Khairaha UG-02 2. Gayatri UG-01 3. Katkona 1& 2-01 4. Haldibari -01 5. 5 no seam R-6 mine NCPH colliery-01

- At MCL, following mines having present deployment:

Mine	***Man Riding System***
Orient Mine no. 2 –	1. Hauler (900m length) 2. Chair lift (2000m length) 3. Chair lift (900m length)
Orient Mine no. 3	Chair lift (1350m length)
Hirakhand Bundia Mines	Chair lift (1500m length)
Nandira Colliery	Chair lift (700m length)

Limitations:

- Ensuring reliability and durability of nodes and aggregates of transport.
- Ensuring safety in the operation of transport.
- Ensuring the safety of load.

Statutory Provisions:

- **Coal Mines Regulations reg no. 71**. Outlets from a mine: (3) (b) where the incline is more than one kilometre in length (one way) or the travel by persons is arduous, a suitable man-riding system approved in writing by the Chief Inspector shall be provided for persons to access and egress from the workings of the mine.
- **Coal Mines Regulations reg no. 93.** Travelling roadways: (6) In case the travelling distance from the incline or adit mouth or pit bottom exceeds one kilometre or the travelling is arduous, the owner, agent and manager shall provide suitable man-riding arrangement as approved by the Chief Inspector, within one year from the date of coming into force of these regulations.

4.2. Transportation of Material in Underground Mines

4.2.1. Conveyors for underground:

Qualitative Benefits:

- Belt conveyor is more time and effort saving so it saves the costs. Inbuilt high factor of safety & efficiency.
- A continuous supply of material & Low operating cost than haulage transportation system.
- Conveyors run continuously with minimal overall downtime outside of regularly scheduled maintenance requirements.
- Conveyors make overall trip shorter and safer than haulage system and has wide ranges of applicability. Produces little or no dust
- Very competitive long range operational cost as compared to haulage transport. Conveyors are basic necessity for high-capacity high productivity mine.

Quantitative Benefits

- Can convey coal uphill against gradient up to about 1 in 4.5.
- Requires 1/3rd of manpower needed for haulage mining.

Applications:

Company	***Present Deployment (Nos)***	***Future Planning (Nos)***
BCCL	02	NIL
ECL	73	05
WCL	22	11
SECL	48	NIL
MCL	03	NIL

Limitations:

- Regular maintenance of Conveyor System.
- Continuous monitoring of the conveyor transportation process
- Choosing a rational transportation route.
- Stability inculcation of in seam workings.
- Mine Economics.

4.2.2. Free Steered Vehicle & Multi Utility Vehicle:

Qualitative Benefits:

- Do not emit exhaust gases (in battery operated), they reduce cooling and ventilation requirements. Cut greenhouse gas (GHG) emissions.
- Reduce maintenance costs, and improve working conditions.
- Increased power/torque through entire battery charge cycle.
- Reduce travel time of man and material. Thus, increase in working time which further increase in productivity.

Quantitative Benefits

- Saving of time results in increase of OMS.

Applications:

Free Steered Vehicle:

Company	***Present Deployment (Nos)***	***Future Planning (Nos)***
ECL	03 (Jhanjra Mine)	05
WCL	-	12 in 2 Mines
SECL	-	01 (Ketki Mine)
CCL	01(Churi Mine)	-

Multi Utility Vehicle:

Company	***Present Deployment (Nos)***	***Future Pla nning (Nos)***
ECL	05	05
WCL	-	18 in 2 Mines
SECL	-	01 (Ketki Mine)
MCL	Truck mounted Man lifter -14 nos.	1. Truck mounted Man lifter: Supply order issued - 05 nos. Future requirement – 04 nos. 2. Truck mounted Lighting Towers – 12 nos.

Limitations:

- Risks to pedestrians from FSVs
- Risk of collisions.
- Persons appointed to be in charge of FSV roadways should be given special training in safe FSV operation and required roadway standards.

4.3. Transportation of Material in Opencast Mines

4.3.1. High angle Conveyors for Opencast

Qualitative Benefits:

- Density wise suitable for all type of coal/material. Due to high depth conventional conveyors will not work. In that case high angle conveyors benefit the system.
- Improves economics of the mine, also traffic friendly, eco-friendly. Energy saving system.

Quantitative Benefits

- Belt capable of carrying load up to 70 degree or more in opencast mines.
- Application of Steep Angle Conveyor in Deep Opencast Coal Mine (A Case Study) has been attached in ***Annexure-2*** done by CMPDI.
- It has been concluded that for mine of 15 Mty and depth of quarry 140 to 266m Steep Angle Conveyors along with in pit conveyors has reduced the 60T coal body dumpers by 87 nos. This has also reduced capital expenditure by about Rs.25 crores and cost of production by about Rs.78 per tonne.

Applications:

- 2 projects reports prepared by CMPDI have kept the provision of High angle conveyors.

Limitations:

- Capital costs
- Maintenance Costs

4.3.2. First Mile connectivity:

Qualitative Benefits:

- Replace the existing road transport between pitheads and despatch points and switch over to a seamless mechanised coal transport through conveyor belts which is a covered system for movement of coal reducing the dust pollution.
- Easing the load on road networks, saving on diesel costs, cleaner environment and stoppage of possible pilferage.
- Another advantage is quicker computer aided loading of wagons.
- Improved computer aided loading time will bring down the wagon idling. Wagon cycle time will be reduced by a few hours increasing wagon availability.

Quantitative Benefits:

- The 49 projects under both the phases will have a total of 506.5 million tonnes per annum capacity.

Applications:

- 35 projects were announced under the first phase of the initiative, 14 projects were identified under the second phase.
- Phase-II will have 14 projects (CCL will have 5, ECL 7, MCL 1, SECL 1).

Limitations:

- Capital costs
- Maintenance Costs

4.3.3. Autonomous Trucks

Qualitative Benefits:

- Wireless communication system.
- Navigation and obstacle detection sensors
- Local on-board sensor data processing hardware for accelerator.
- Steering and braking of trucks, controller hardware for coordination of these movement actions
- GPS system to detect real-time location of truck
- Software system for local and supervisory control.

Quantitative Benefits

- The initial reports from the mines using autonomous trucks announced that the mine productivity has been increased by 15-20 percent compared to the manual truck operations.
- Substantial reduction in tire and fuel consumption per ton of production and employee cost.
- Trucks can operate with almost 90 percent availability in their first years where it is almost 80 percent for manual trucks.

Figure: Expected benefits of Autonomous trucks

Applications:

- Long term vision, industry wide applications.

Limitations:

- High Capital costs
- Efficient training required.

4.3.4. Electric Vehicle Charging Station.

Qualitative Benefits:

- Battery electric vehicles (BEV) are electric vehicles that use exclusively chemical energy stored in rechargeable battery packs, with no secondary source of propulsion.
- Cut their overall Co_2 emissions and mitigate the risks of diesel-powered vehicles on the health and wellbeing of their employees.
- Both hydrogen fuel cells and BEVs offer two possible long-term solutions. However, with hydrogen technology still to get off the ground, BEVs offer the best solution.
- It not only save high costs on ventilation and cooling but also improve worker health and generate a fraction of noise of traditional diesel-powered machines.

Quantitative Benefits:

- In underground mines on average, the switch to a fully electric mobile fleet results in a 40% to 50% reduction in ventilation demands.

Application:

- May be introduced for group of mines.

Limitations:

- Cost economics
- Time taken for charging.

4.3.5. Pipe conveyors:

Qualitative Benefits:

- Spillage free transportation of material is obtained due to the enclosed belt. Material build-up on idlers is reduced, decreasing maintenance, as no material is spilled during transit.
- Pipe conveyors fit into narrow areas and save space in congested areas. This is possible due to a circular belt profile, allowing the gantry width to be reduced.
- Can negotiate tight horizontal and vertical curves because the material is enclosed within the pipe and cross belt slip is reduced by the idler configuration.
- Greater rate of elevation is obtained due to the increased contact between belt and material. Has better belt edge damage control, due to improved belt training.
- Promotes environment safety, prevent possible coal pilferage and reduce diesel cost.

Quantitative Benefits:

- Currently installed pipe conveyor at WCL, has the capacity to transport 500 tonnes of coal per hour.

Applications:

Company	*Present Deployment (Nos)*	*Future Planning (Nos)*
WCL	6km long modern Pipe Conveyor System for direct transport of coal from Bhatadi OC coal mine to Chandrapur Super Thermal Power Station (CSTPS) has been introduced.	1 no. pipe conveyor to be deployed in Nagpur Area covering 4 Opencast mines (Inder- Kamptee OC, Gondegaon-Ghatrohan OC, Singhori OC & Bhanegaon OC) dedicated to Khaparkheda & Koradi Thermal Power Plants.
MCL	Presently 4 nos of Pipe Conveyors are under construction at three FMC Projects as given below. 1.Hingula – 3.76 KM long 2.Bhubaneswari Phase-I- 2.2Km long 3.Lakhanpur Phase-I- 2.15km long 4.Bhubaneswari Phase-II-750mtrs long	Provisions of Pipe Conveyors have been kept in CHPs of upcoming mines as per requirement.

Limitations:

- Higher energy consumption due to the higher drag of the closed belt.
- More belt width for the same mass flow as compared to conventional conveyors.
- Sensitive against overload and oversize.
- More difficult repair and dismantling of the belt.
- The facility requires more frequent maintenance and safety checks.
- Backed-up heat in the closed belt when conveying hot bulk material.

5. Information technology/IoT/Artificial Intelligence:

5.1. OITDS

Qualitative Benefits:

- Improvement in operational efficiency of the mine by virtue of online, real-time monitoring and dynamic control of movement of Dumpers and operation of Shovels, to get optimum utilization of Dumper-Shovel combination curtailing undue idleness of these machines.
- Better communication between the equipment and the Control Station and offers real time, online continual documentation of all reports related to operation.
- Monitoring performance of individual machine and operator. Reduction in idling of Shovels
- Reduction in queuing of Dumpers. Minimizing time loss in re-allocation of Dumpers in case of Shovel breakdown through automatic reallocation.
- Aiding in Safety measures thereby improving the quality of life. Ensuring transparency in information sharing.
- Making vital information available online through IVRS. Ease in monitoring and coordination. Effective management of operator's performance data.

Quantitative Benefits

- Coal India's major production comes from opencast mines. Equipment utilization in opencast mines is considerably low (on an average, 36% for Dumper and 48% for Shovel) which is a cause for concern. Benefits achieved by OITDS in Jayant OC Mine NCL is attached in ***Annexure 3.***

Applications:

Company	***Present Deployment (Nos)***	***Future Planning (Nos)***
NCL	1 Mine (Jayant)	-
ECL	1 Mine	-
BCCL	-	1 Mine
SECL	3 Mines (Gevra, Dipka and Kusmunda OCMs)	3 Mines (Gevra, Dipka and Kusmunda with enhanced capacity and updated features)
MCL	3 Mines	NIL

Limitations:

- Full potential of technology is yet to be explored.

5.2. Dumper Truck Volume/ Weight Analyzer

Qualitative Benefits:

- Detection of overloading and uneven loading to avoid fleet damage and increased maintenance cycles.
- Detection of under loading to avoid suboptimal fleet utilization and enable operator behaviour improvement.

Quantitative Benefits:

- Underloaded trucks can significantly increase overall project costs, and it's not uncommon to see underloading factors as high as 20%.

Applications:

- May be introduced in large open cast mines.

5.3. Mine Monitoring system:

Qualitative Benefits:

- RFID based Automatic boom barriers are to be installed at all the entry and exit points of Mines and Railway Sidings
- Only authorized vehicles/tippers can enter/exit into the mine premises which eliminate the possibility of any coal pilferage and helps to regulate vehicle traffic.
- Weighbridges automate calculation of vehicle tare weight and laden weight, update databases at remote servers and transmit this data to the destination weighbridge for verification of trip made and delivered coal quantity.
- Live feed CCTV system established at the weighbridges and coal heaps.

Applications:

CCL:

- RFID with CCTV based weighing control and monitoring system for 112 Road Weighbridges has been done by CCL.
- CCL has successfully arranged to bring the live CCTV footage of 112 CCTV Cameras from all Road weighbridges to be centrally monitored at CCL HQ.
- Vehicle Tracking System has also been implemented at M&A area in which 1000 GPS devices have been installed presently. RFID with Boom-barrier based system has also been installed at check-posts in M&A Area.

BCCL:

- RFID Boom Barrier: Total 4 Nos. RFID boom barrier has been installed (Dahibari-2 nos, Kusunda-1 Nos., Patherdih Monet Washery- 1 Nos).

- 14. Road Weighbridges: Total 6 Nos. road weigh bridges has been installed & commissioned after stamping (Barora Area-2 Nos, Block-ii, Lodna area-2 Nos).
- In motion rail weighbridge: 1 No. IMRWB has been installed at Kusunda Area.

ECL:

- Successfully taken a step to implement "Weighbridge Automation System" for all the 105 road weighbridges of ECL with RFID based boom barrier access control system.
- Live feed of CCTV system established at the weighbridges and coal heaps of Rajmahal Area is operational and monitored at CIL level.

MCL:

- Installed still-shot IP cameras at 90 in-motion and static road weighbridges, as well as CCTV Cameras at 112 Weighbridges.

SECL:

- Integrated system of GPS/GPRS, RFID & Boom Barriers installed in all Areas of SECL.

Limitations:

- Costs related with the use of an RFID based boom barrier.

5.4. High Speed cameras:

Qualitative Benefits:

- Blast optimization study. Stemming retention studies--effects of changing stemming type and height and the performance of stemming plugs.
- Face movement studies including front row burden, blowouts, hard toe problems, material trajectory, velocity, and casting range
- Timing studies, including detonator delay time quality, actual blast hole sequence, and blast delay times achieved, effects of timing changes, cut-offs, and misfires
- Environmental studies including fly-rock, air-blast noise from blowouts, vibration from choked blast, back-break, and noxious fumes.
- A high-speed camera can be utilized to evaluate and review many components of a blast such as Stemming Blowouts, Fly Rock, Stemming Containment, Misfires, Gas Venting and Air Blast etc.

Quantitative Benefits:

- It helps in determining the shortcomings in blast which can be addressed in future so that optimum utilization of explosives energy can be obtained and blasting cost can be reduced.
- Even a minute changes can result in huge financial savings in blasting operations.

Applications:

- Currently being used by CMPDIL.

Limitations:

- High visibility required during operation in low visibility difficult to get clear slow motion video
- Transfer of data from camera to storage device takes time hence to capture more than one blast time delay in taking next blast firing.
- Safe distance to operate the high speed camera from blasting sites with clear view of sites sometimes difficult to find.

5.5. Simulator Based Training:

Qualitative Benefits:

- Improving the safety of miners.

Quantitative Benefits:

- Boosting productivity:
  - ✓ Use of simulators allows trainee operators to get the most efficiency out of their vehicles. By continuously being monitored and recorded during the training process, operator's faults and inefficiencies can be improved through review and analysis.
- Cost savings:
  - ✓ Simulators enable operators to be better trained and prepared leading to fewer accidents.
  - ✓ This means less maintenance to equipment and less downtime to repair broken machinery.
  - ✓ Furthermore, the wear and tear on machinery is diminished as operating costs such as fuel are eliminated.

Applications:

- 871 HEMM operators have been given simulator based training by BCCL in 2020-21.
- Procurement of Multi-dimensional HEMM Simulators for training is in CCL's future initiatives.
- SDL simulator model has been developed in Bankola Area, ECL
- 15 excavator operators of MCL were imparted training on simulators at Tata Hitachi Training Centers at Kharagpur &

Dharwad factories. Further, MCL has initiated procurement action for 02 Simulators.

Limitations:

- Simulation is not always able to completely re-create real-life situations.
- Simulators can be very expensive and require constant updates and maintenance.
- Not every situation can be included.
- Staffs needs to be trained on how to use the software and/or hardware and this takes up time and costs money.
- No real consequences for mistakes may result in trainers under performing and not being fully engaged in the training,

Statutory Provisions

- *DGMS (Tech) Circular No. 04 Date 08-04-2011,* ***Training for operators in Heavy Earth Moving Machinery using Simulator****: It is recommended that all mining companies having opencast working and use heavy earth moving equipment shall install simulator training for operators. In respect of small mechanized mine, the matter may be taken up by the group vocational training centres create common facility in infrastructure for simulator training. It is recommended that in the interest of safety, all mining companies shall initiate necessary action to provide simulator training for operators in heavy earth mining equipment.*

5.6. Online Coal Ash, Moisture & GCV Analyzer for Coal Mines, Washeries & Power Plants.:

Qualitative Benefits:

- Brings down the sampling analysis time to zero.
- Increase in productivity, quality and environmental safety (no radiation).
- Improved quality of the final product as a result of the rejection of the off grade materials, reduce off-grade product penalties.
- Reduce energy consumption due to stable raw batches after prompt ore sorting and dosage of mix components.

Quantitative Benefits:

- Current process consists of sample collection, sample transportation, sample preparation, sample testing. Example sample is collected from the conveyor or mines directly and sent to a laboratory for preparation and testing. This entire process takes 48 hours for the results to be published. Laser Based Coal Analysers reduce sampling time by providing real-time online analysis thereby providing real-time qualitative analysis of coal.

- Technoeconomic Study between LIBS based Coal Analyzers with other Radiation Source based Technologies and traditional LAB sampling method has been attached in ***Annexure-4.***

Applications:

- At Tata Steel Sinter Plant is currently under execution.
- Two installations are currently functional in CHP of South Korea thermal power plants.
- Six units installations are currently functional in CHP of Canadian coal mines.
- Four units installations are currently functional in CHP of Spanish coal mines.
- Six units installations are currently functional in Sinter plants of Russia.
- Ten units installations are currently functional in Sinter plants of Ukraine.

6. Safety

Persons working in the mining industry are exposed to risk of health and safety because of inherent hazards. The work environment in mines is highly dynamic in nature and may change abruptly. The risks to the safety and health of employees due to the unknown and unforeseen hazards pose challenges for occupational safety and health professionals. This further requires comprehensive surveillance at workplaces and newer strategies for prevention of accidents in mines. The accident graph over last few decades has shown a flattening trend and the traditional approach towards safety is not yielding the desired results.

Accident in mines cause not only cause bodily injury or fatal but various other cost involved to the organisation:

- Loss of production
- Loss of Manpower
- Damage to equipment
- **Example:** If we take an example of opencast mine having production of 20000TPD. Accident occurs due to dump failure causing fatal accident of 5 persons. Then no of man-days lost due to accident= 5*264=1320
- Further if complete damage to the equipment happens (say hydraulic shovel 12m3) then cost of equipment = 15.24 cr (2019 price)
- Also if production closes for 3days due to workmen resistance, inquires by DGMS etc then loss of production= 60000t(G12 Coal)
- Then revenue loss= 60000*1369=8.21 cr
- Tentative compensation to 5 workmen = 5*15 Lakh= 75 Lakh

6.1. Sensor based Personal Protective Equipment (PPE)

Qualitative Benefits:

- Provide better safety and long-term cost savings through the active prevention of health issues and tragic situations
- Wearable technologies that improve work performance and reduce error, along with products that send this information to systems that can monitor and improve the work environment.
- Protection from invisible risks - PPE with gas, dust, sound, smoke and temperature sensors can monitor both the external environment and the user, alerting them in time about hazardous environments and alerting supervisors if workers are in unsafe conditions.
- Locating system - tracking systems that are attached to every smartphone connected to network can enable the identification of the location of each miner.

- Real-time data analytics - this would enable an immediate alert to a worker if he enters a potentially hazardous zone or somehow risks his safety.
- Smart communication systems - The interconnected sensors and smartphones could provide fast and effective communication in loud or low-visual environments.
- Smartphone app alerts - sensors connected to apps can send crucial alerts about emergency situations and also auto send emergency rescue messages.
- Improve performance and reduce error - smart PPE improves productivity through connectivity, live updates and remote communication that can save lives and actively prevent workplace accidents.
- Smart health - monitor workers' heart rates and physical work overload.

Quantitative Benefits:

- Reduce indirect cost involved due to injury to persons.

Applications:

- Industry wide applications.

Statutory Provisions

- Regulation 104 of CMR 2017: Safety Management Plan: (2) The owner, agent and manager of every mine, after consulting the safety committee of the mine and Internal Safety Organisation, shall determine all measures necessary to (d) in so far as the risk remains, (i) provide for **personal protective equipment.**

- Regulation 242 of CMR 2017: **Supply of other personal protective equipment.**– (1) Where it appears to the Regional Inspector or the Chief Inspector that any person or class of persons employed in a mine is exposed to undue hazard by reason of the nature of his employment, he may, by a general or special order in writing, require the owner, agent or manager of the mine to supply to such person or class of persons, free of charge, gloves, goggles, shin guards, respirator or such other protective equipment as may be specified in the order.(2) The protective equipment provided under sub-regulation (1) shall be replaced free of charge by the owner, agent or manager whenever it is rendered unserviceable by legitimate use: Provided that in any other event, the replacement shall be made on payment of full cost.(3) If any dispute arises as to the life of any protective equipment, it shall be referred to the Chief Inspector for decision.

- Regulation 244 of CMR 2017. **Obligation of persons provided with personal protective equipment**. – Whenever any person is supplied by the owner, agent or manager of a mine with any personal protective equipment, he shall use the same while doing the work for which he is supplied with such protective equipment.

6.2. Dust suppression (Fog canons/ Mist spray canon):

Qualitative Benefits:

- Reduces visual dust, minimizes water usage and conveyor slippage
- Eliminates excessive moisture content in material Reduces chute blockages.
- Improves housekeeping standards and increases safe work areas during operation

Qualitative Benefits:

- Reduces respirable dust by 80%.

Applications:

Company	***Present Deployment (Nos)***	***Future Planning (Nos)***
ECL	08	02
BCCL	09	15
WCL	20 nos. Trolley mounted & 3 nos. Truck Mounted Fog cannons deployed	69 nos. Trolley mounted & 5 nos. Truck mounted Fog cannons
SECL	09 • Gevra OC, Gevra Area (01) • Kusmunda OC, Kusmunda Area (01) • Dipka OC, Dipka Area (01) • Manikpur OC, Korba Area (02) • Amlai OC Sec B Mine, Sohagpur Area (01) • Amadand OC, J&K Area (01) • Kanchan OC, Johilla Area (01) • Rajnagar OC, Hasdeo Area (01)	12 (in the process of procurement) • 03 Nos. for Gevra OC, Gevra Area • 01 No. for Kusmunda OC, Kusmunda Area • 03 Nos., one each for Vindhya, Umaria & Pali Sub Area of Johilla Area • 05 Nos., one each for Burhar Siding, Sharda HW, Damini UG, Bangwar UG & Rajendra-Khairaha UG of Johilla Area.
MCL	Truck mounted (Mobile) (40	Trolley mounted

	M throw) – 18 nos. Trolley mounted (Static) (100 M throw) – 44 nos.	(Static) (100 M throw) – 69 nos.

Statutory Provisions:

- **Regulation no 46. of CMR2017: Duties of ventilation officer. –** (1) The ventilation officer shall- (a) ensure the observance of all regulations and orders concerning ventilation, spontaneous heating, fire, gas and coal dust including dust suppression and shall advise the manager, if any alteration is required in the ventilation system to ensure adequacy of ventilation in compliance with these regulations or orders; (b) advise the manager on day-to-day problems of ventilation, gas, coal dust, spontaneous heating and fire.
- **Regulation no 143 of CMR 2017: Precaution against dust**. – (1) The owner, agent or manager of every mine shall take such steps as may be necessary for minimising of emissions of dust and for the suppression of dust which enters the air at any workplace belowground or on surface and for ensuring that the exposure of workers to respirable dust is limited to an extent that is reasonably practicable but in any case not exceeding the limits that are harmful to the health of persons.

6.3. Tele-monitoring System (ETMS):

Qualitative Benefits:

- Continuous environmental monitoring with real-time technologies helps provide data that is used to identify trends, make predictions, and establish parameters and trigger levels, which is essential for early warning strategies.
- Improvement of disaster response and preparedness.

Quantitative Benefits:

- Reduce indirect cost involved due accidents by making underground mine environment safely.

Applications:

Company	***Present Deployment (Nos)***	***Future Planning (Nos)***
ECL	01	04
BCCL	03	NIL
WCL	05 (5 Mines)	20 (11 Mines)
SECL	11	06
MCL	03	NIL

Statutory Provisions:

- **Regulation no.170 of CMR 2017: Monitoring devices. -** (1) The Chief Inspector may, if he considers necessary for the safety of persons, require by an order in writing that in any mine or any class of mines belowground, approved environmental monitoring devices to continuously record information regarding environmental conditions, to be installed belowground within such time and subject to such conditions as he may specify therein. (2) The Chief Inspector may, if he considers necessary for the safety of persons, require by a general or special order in writing analysis of mine air samples by gas chromatography or other equivalent technique.

- **7th National Safety conference recommendation no. 1.7:** Necessary facilities for monitoring the environmental parameters should be provided at mines. Facilities of continuous type monitoring should be installed within one year in all degree III gassy coal mines and in other mines having active underground fire or mines having serious problems of heat as identified by mutual discussions between mine management and the Directorate-General of Mines Safety.

- **DGMS Tech Circular no. 4 2017:** Providing environmental monitoring system in belowground coal mines: "all concerned are requested to initiate procurement of approved Environmental Monitoring System immediately for all belowground coal mine workings in third degree gassy seams & fiery coal seams.

6.4. Digital Mine Collision Awareness System:

Qualitative Benefits:

- High integrity proximity detection, 360˚ protection for vehicles, equipment and personnel. GPS tracking and real-time health monitoring surface solution
- Real-time data connectivity and back-to-base reporting. Safety adherence technology. Help reduce vehicle interaction risk, increase safety performance
- Increase production, reduce financial risk & lower ongoing ownership cost.

Quantitative Benefits:

- Reduce indirect costs involved due accidents.

Applications:

- Industry wide application in opencast mines.

Statutory Provisions:

- DGMS (Tech) circular No. O 6 of 2020 Dhanbad dated 27.02.2020: **Minimum Design requirements for various Safety Features to be incorporated for use in Heavy Earth Moving Machinery (HEMM) & Heavy/Light vehicles in Open Cast Mines**. "Arising out of wide, extensive and successful deliberations, a broad consensus was arrived at amongst all stake holders into maintaining the minimum design requirements of such safety features as per the Guidelines enclosed with this Circular. It may please be borne in mind that the enclosed guidelines are only the minimum recommended levels and may be altered from time to time as per evolving needs and that there is no bar on adherence to any higher/superior levels of design and functionality in the interest of safety, It also further be appreciated that adherence to this circular will go a long way in drastically minimizing hazards due to operation of both HEMM and light/heavy vehicles in opencast mines, thus commensurately enhancing safety in mines."

6.5. SAGES (self-advanced goaf edge support):

Qualitative Benefits:

- Keep personal away from the working place. Withdrawal and setting can be done from remote place 30 m away from goaf edge.
- Overall cost of breaker line support will be less with the SAGES as compared to existing supports.
- Provides active roof support ensuring more safety. Persons can work confidently under SGAES.
- Increase in percentage of coal extraction from coal pillars facilitate regular caving of roof strata.
- Eliminate the need for installation of separate strata monitoring and warning indicators at coal faces as they are inbuilt in SAGES.
- Eco friendly system of support which eliminate use of timber chocks and props, saving a huge quantity of trees.

Quantitative Benefits:

- Reduce indirect cost involved due accidents by making underground mine environment safely.

Applications:

- Medium duty 200t capacity remote controlled roof support system in underground coal mines. Implemented in RK-7 min of SCCL.

Statutory Provisions:

- *DGMS Approval: After the successful field trial of SAGES at RK7, mines of Singareni Collieries Companies Limited (SCCL) the Directorate General of Mines Safety (DGMS) has approved for the full scale deployment in underground coal mines. Currently, mining operations are being carried out efficiently with this machine in RK7 mines of SCCL. By embracing SAGES-enabled operations, the Indian mining industry can improve its productivity significantly by improving the % extraction of locked pillars and reduce ground failure fatalities and injuries in the mines. This technology is economic, eco-friendly and safer, and therefore, it can be game-changing for Indian mining industry, if deployed at scale. Experts of the field believe that SAGES will definitely mark a significant shift in the way mining works. The above technology is presently developed at TRL 9 and ready for deployment. The industry collaborator, JBEPL is waiting for the orders from Coal Companies.*

6.6. Slope stability radar

Qualitative Benefits:

- SSR can penetrate dust and fog while optical devices cannot. No requirement for prisms to be placed in the survey area.
- Rapid monitoring of thousands of points rather than single prism locations. Complete coverage of visible surface
- Portable system can be moved into areas of limited access.
- Up to 6km measurement range.
- Competitive cost. Data can be taken into Volumes module.

Quantitative Benefits:

- Reduce indirect cost involved due accidents in opencast mines by dump failures.

Applications:

Company	***Present Deployment (Nos)***	***Future Planning (Nos)***
ECL	NIL	04
WCL	01 (Sasti OCP)	13
SECL	03	03
MCL	NIL	05

Statutory Provisions:

DGMS (Tech.) (S&T) Circular No. 02 Dhanbad, Dated 06.07.2010 reg. **Design, Control and Monitoring of Pit and Dump Slopes in Opencast Mines**: (3) Application of Slope Stability Radar in Monitoring of Slope & Dumps in Opencast Mines: The SSR have been successfully used in some countries with highly variable geotechnical conditions including massive hard rock, intensely

fractured, foliated rocks, weathered rock, coal strata and waste dumps of variable characteristics. Several case studies of the SSR providing improved operational risk management by characterising the slope instability, and providing sufficient warning time prior to failure, have been reported all over the world during last five to eight years.

6.7. CAAQMS

Qualitative Benefits:

Features	Manual AAQMS	CAAQMS
Scalable Real-time Monitoring	Bulky and huge and therefore, its mass installation is not possible	Sensor-based CAAQMS is compact and lightweight to allow for deployment in masses. This feature makes hyperspatial data possible to gather data from all corners of mine.
Data Acquisition	Delayed data collection, transmission, and availability. As it takes travel time & manpower to takes sample and processing at lab, which increases the cost.	Environmental assessment as soon as the sample is collected. This bridges the time-lapse between data acquisition and analytics for speeding up the whole monitoring process.
Measurement Features	AAQMS only monitor limited parameters, like PM, harmful gases like SO2, NO2, CO, CO2, etc	Covers a broader range of parameters including PM, SOx, NOx, CO, CO2, TVOCs, and weather parameters like temperature, humidity, pressure, wind speed & direction, light intensity, UV radiations, noise, rainfall, and floods.
Decision-Making	Data analysis may take up to several days, which delays the decision-making process.	Faster data analytics through CAAQMS allows for on-time pollution monitoring for taking immediate measures to avoid critical situations in the future. It is an essential tool for better compliance enforcement through credible pollution monitoring and reporting practices.

Analytics	Analyzed manually and may account for human error.	Automated data analytics supported by AI technology. It minimizes manual intervention to enhance data accuracy for strengthening the pollution control regime.
Public Awareness	Delayed data acquisition through manual air monitors cannot provide real-time environmental data to the public	Automatic monitors are crucial for providing timely data. With real-time data analytics, the data can be served to the common people in mine areas instantly through integrated public displays, mobile app, web widget, alerts, etc.

Applications:

Company	***Present Deployment (Nos)***	***Future Planning (Nos)***
ECL	04	07
BCCL	NIL	08
WCL	17	11
SECL	09 • Gevra OC, Gevra Area (01) • Kusmunda OC, Kusmunda Area (01) • Dipka OC, Dipka Area (01) • Manikpur OC, Korba Area (01) • Amlai OC Sec B Mine, Sohagpur Area (01) • Bangwar UG, Sohagpur Area (01) • Amadand Bartarai UG, J-K Area (01) • Area GM Office, Johilla Area (01) • Bijuri UG Mine, Hasdeo Area (01)	08 • 01 No. for Gevra OC, Gevra Area • 01 No. for Batura OC, Sohagpur Area • 01 No. for Jagannathpur OC, Bhatgaon Area • 03 nos. for Gare Pelma IV/2&3 Raigarh Area • 01 No. for Bijari OC Raigarh Area • 01 Nos. for Piparia UG, Johilla Area
MCL	12	04

Statutory provisions:

- Currently latest CTO from Odisha & Jharkhand State Pollution Control Boards started mentioning of clauses referring to installation of real time monitoring of Air Quality.
  E.g. In case of Bhubaneswari Mine, MCL the clause no 17 states "Continuous Ambient Air Quality Monitoring Stations (at least 04 nos. keeping in view the cumulative impact of all mines) with data transfer facility to SPCB Server shall be installed in Talcher Area for monitoring of PM1Q, PM2.5. SO_2 and NO_2. The location of CAAQMS shall be finalized in consultation with the Regional Officer, State Pollution Control Board keeping in view the criteria specified for coal mines in Environment (P) Rules, 1986/Standards specified in the consent order."

7. Exploration

7.1. Hydrostatic Drills

Qualitative Benefits:

- Time saving during shifting as Hydrostatic drills takes less time for shifting than mechanical drills which also increases the overall productivity.
- Driller operates with control panel.
- No chuck operation required. Hydraulic foot clamp & hydraulic breakout.
- High wire line winch speed – less time required for removing core.
- Rotation, hoist, winch is hydraulic operated so wear & tear is less.

Quantitative Benefits

- Breakup of meterage drilled by CMPDI for Mechanical & Hydrostatic drills during last 3 years is given in table below

Type of drill/FY	**2018-19**		**2019-20**		**2020-21**	
	No of drill	**Meterage**	**No of drill**	**Meterage**	**No of drill**	**Meterage**
Mechanical drill	45	265781	44	246629	42	236676
Hydrostatic drill	25	233944	26	241843	24	248204
Overall CMPDI	70	499725	70	488472	66	484880

- If we take the example of year 2020-21 per drill meterage drilled by Mechanical Drill is 5635.14 m and by Hydrostatic Drill is 10342.83 m.
- 42 mechanical drills drilled 48.81% while 24 Hydrostatic drills drilled 51.19%.
- In terms of manpower reduction in cost as no of teams required for 42 Mechanical drills is almost half than 24 Hydrostatic drills.

Applications:

- Already in operation through leading exploration agencies in India.

Limitations:

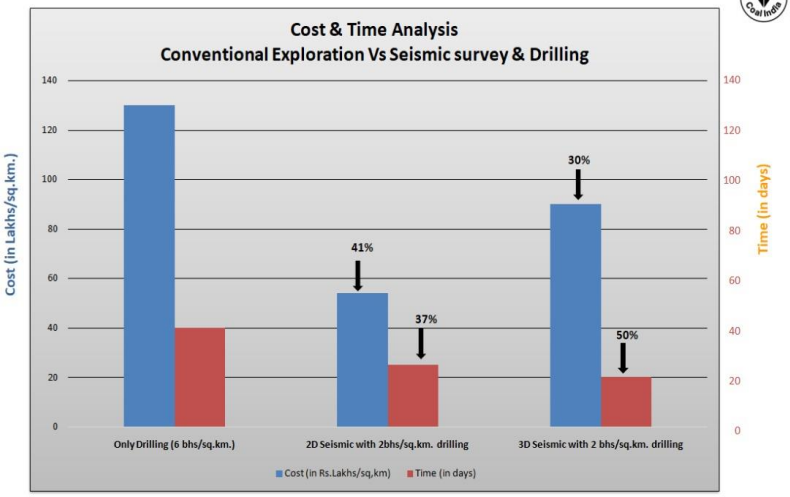
- More fuel consumptions compared to mechanical rigs.

7.2. Geo-physical Survey:

Qualitative Benefits:

- Enhance the speed of exploration by reducing no. of boreholes to explore the area.

Quantitative Benefits



- 2D seismic having 41% reduction in cost and 37% reduction in time. Further 3D seismic 30% reduction in cost and 50 percent reduction in time.

Applications:

- Vast use of 2D/3D seismic survey for both Promotional and Detailed exploration for which implementation has already been started.
- CMPDI has completed data acquisition in 5 blocks out of 10 blocks.

8. Survey

8.1. Drones

Qualitative Benefits:

- Volumetric measurement of Overburden Removal
- Monitoring of plantations/afforestation for assessment of their survival and growth.
- Mine closure monitoring
- Thermal mapping of mine fire zones.
- Security of mine and coal stockyard.
- Inspection of components/ installation at inaccessible areas.
- Settlement mapping for issue related to land acquisition.
- Blasting monitoring in OCPs.
- Haul road monitoring by drones helps accounting of haul fleet and safe conditions will ensure savings in fuel costs and higher productivity of workers.
- Generation of digital terrain models for mine operational planning.
- Changes between two surveys can be tracked and highlighted automatically.

Quantitative Benefits

- Almost 2X reduction in total survey time.
- Capturing data with a drone is 2 times faster than with traditional land-based methods. One can easily collect the data at required frequency.
- 100 percent safe operation: Drones allow you to survey parts of the mine or quarry that are normally difficult to access with traditional surveying equipment. This eliminates the hazards employees typically face while walking through dangerous zones, navigating active sites or climbing onto stockpiles. All this without disrupting the flow of operations and movement of machinery.

Applications:

- CMPDIL has procured drones for surveying and mapping applications. The first drone has been supplied in December, 2020 equipped with state-of-art LiDAR optical and thermal sensors and second drone was supplied in March, 2021.
- CMPDI has also outsourced various applications for verification of their efficacy in mining activities.

Work(s) undertaken by in-house Drones:

a) Surveying of 595 sites in Jharia Coalfields, BCCL
b) Surveying of 4 blocks in Talcher CF, MCL.
c) Surveying of Internal/External Dumps in 80 Sq. Kms. area in NCL.

Works Completed in outsourcing mode:

a) Data acquisition by Drone based sensors for various applications in Northern Coalfields Limited. Applications covered under this project are:
   - Blasting Monitoring in Dudhichua OCP
   - Vegetation Cover Mapping in Nigahi OCP
   - Inspection of inaccessible areas (HEMMs, CHP, Silo etc.)
   - Settlement mapping of expansion areas in Jayant Dudhichua OCPs

b) Data acquisition by Drone based sensors for various applications in South Eastern Coalfields Limited. Applications covered under this project are:
   - Air Quality Measurement in Dipka & Gevra OCPs.
   - Plantation Height Assessment in Gevra OCP.
   - Settlement mapping of expansion areas in Gevra OCP

Annexure-1: Cost Benefit Analysis of Ripper Technology

COST STUDY BY CMPDI, Dhanbad

N/8+ Annexure -II

Many mines of BCCL are in close proximity to habitation. To avoid any damage to existing infrastructure and loss of life innovative technologies are needed. This proposal puts forward an idea of using Vibro Ripper in one such patch of BCCL which combines rock breaking and ripping action avoiding conventional blasting.

A comparative annual cost analysis for OB only has been done based on data provided in this proposal and existing CMPDI norms. Cost analysis for coal could not be carried out because of unavailability of productivity data of Vibro-Ripper for coal in the file. However, cost for coal is also expected to follow same trend as for OB. The study is based on assumption that one number of drill 100-160 mm is used for drilling followed by blasting and this operation of drilling and blasting will be replaced by Vibro Ripper attachment to the hydraulic excavator. Rest operation will remain same in both the methods that is loading by shovel into dump trucks and further hauling. Summarised result of the cost analysis has been tabulated below and details has been attached as annexure (to this note):

(Amount in Rs. Lakh)

Sl. No.	Particulars	Vibro-Ripper	Drilling and Blasting
1	Salary and Wages	35.55	86.90
2	Stores	186.44	172.43
3	Miscellaneous Expenses	6.25	5.13
4	Interest on Working capital	11.03	12.78
	Total Cash cost	239.27	277.24
5	Interest on Loan	32.34	17.88
6	Depreciation	32.14	18.83
	Total	303.75	313.95

From the analysis it can be seen that **cost is comparable for both the methods.**

As Vibro Ripper is not being used in any coal mines of Coal India Limited, **Vibro Ripper along with matching hydraulic excavator may only be deployed on experimental basis by outsourcing mode in any mine where conventional blasting and controlled blasting is not possible due to proximity of habitation. This will help in extraction of coal which would be otherwise locked.** Proper study of geo mechanical data of the mine in which it is intended to be deployed should be carried out before finalising specification of Vibro Ripper by BCCL. Experience certificate of working in mine of similar geo mechanical conditions should also be asked for.

It is also pertinent to mention here few more points:

1. As per clause 5.4.4 of CIL purchase manual, vetting from CMPDIL is required only when there is variation in HEMM specification or HEMM itself for any sanctioned project or project to be sanctioned. This file does not fall under this category. (with reference to noting on page no. N2)
2. As per CIL purchase manual clause 5.2.1, purpose of new requirement is classified as under:
   a) *New projects / schemes for increasing production.*
   b) *For expansion of existing production unit.*

16/10/18

c) *For welfare, safety, community etc. schemes.*

d) *For R&D.*

e) *For advance action for P&M for projects likely to be approved.*

Moreover Project Reports / Feasibility Report / Schemes etc. should be approved at appropriate level.

As per reply of Project Officer, Rajapur OCP there is no such sanctioned project / scheme available for the mentioned area. Hence, this proposal falls under no such category.

3. Proposal should not be based on presentation made by a single manufacturer and proper survey should have been done for other manufacturer of vibro-ripper for opencast mining. CMPDIL does not endorse procurement or hiring of Vibro Ripper of any particular make. CMPDIL only proposes size / capacity of equipment in Project Reports and does not propose for procurement of equipment of any particular manufacturer.

4. Attachments of the file should be properly numbered before being sent to CMPDIL.

(Hemant Kumar Chauhan) 9/10/18

HoD (Mkt./Env.) 09.10.18

R.D., RI-II 09/10/18

GM (P&P), BCCL

Application of Steep Angle Conveyor in Deep Opencast Coal Mine (A Case Study)

Devendra Pratap Singh
Chief Manager (Mining),
OC Division, CMPDI,
Ranchi, 834031, India.
singh.dp@coalindia.in

Asit Kumar Roy
Chief Manager (Excv.),
OC Division, CMPDI,
Ranchi, 834031, India.
asit.roy@coalindia.in

Abstract - In India, over 90% of the total coal production is achieved through opencast mining which requires huge quantity of OB removal and mining of coal from the quarry and subsequent transport to the surface. We know that the transport cost is one of the major components in the total cost of production and as the depth of mine increases, along with quantity of material to be transported increases the transport cost rises exponentially. Thus the economics of the mine greatly depends on the economics of the transport system used. Moreover, there is huge inflationary pressure with the fuel costs on the rise.

With the increase in depth of opencast coal mines and for steep quarry batter slope, Steep Angle Conveyor is a solution for transporting coal from quarry floor to surface with better economy and productivity. It is also an eco-friendly, traffic-friendly and space & energy saving solution.

Due to high initial depth and steep quarry batter slope, it is difficult to install conventional conveyor in one Non-CIL opencast project. Therefore, it has been decided for implementation of Steep Angle Conveyor. Economic analysis of Steep Angle Conveyor system vs Dumper system reflects that the capital requirement & cost of production per tonne for Steep Angle Conveyors along with in-pit conveyors and requirement of 60T coal body dumpers have reduced.

Keywords: Steep Angle Conveyor

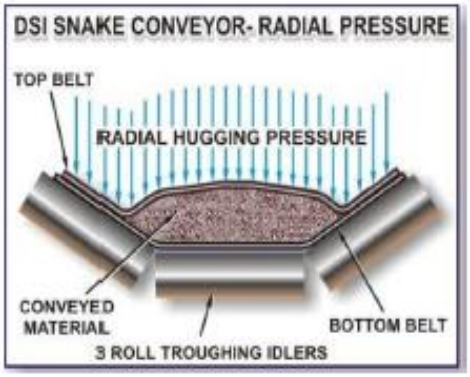
I. INTRODUCTION

At present, there are two main alternatives proposed for the transport system, e.g. (i) truck system and (ii) conventional belt conveyor system. In Indian context, truck based transport system has been a favourite tool for the transportation of OB and coal. However, there is an increasing pressure to restrict the movement of Trucks from environmental point of view, as outlined while issuing Environmental Clearance by MOEF.

Conventional belt conveyors offer a most economical method for transporting bulk materials at recommended inclination angles up to 14 degrees for most common materials. Internal friction development and the induced dynamics of the moving conveyor belt, limit the conveying angle. Conveying angles beyond the angle of internal friction can be achieved by a cover belt which, when pressed against the material, will create a hugging-action to prevent sliding at the contact surface.

Sandwich Belt Conveyors are so named due to the manner in which the material is 'Sandwiched' between two belts before it is inclined at angles up to 70 degrees. Material is 'hugged' by the belts throughout the inclined section to ensure that it does not slide back down the incline, even if the conveyor trips.

A Sandwich Belt Conveyor (Steep Angle Conveyor) consists of two endless belt conveyors that share a common load carrying path. The top and bottom belts are independently driven and tensioned. Along the carrying path, the top and bottom belts are alternately supported against closely spaced troughing idlers. Radial pressure due to belt tension and the curving profile continuously hugs the material that is sandwiched between the two belts. Internal friction is developed and bulk material can be conveyed at any high angle up to 70 degrees or even more.



II. OBJECTIVE

The objective of implementation of Steep Angle Conveying system in conjunction with Surface Miner/In-pit crushing in Indian geo-mining condition is to make coal transportation in opencast coal mines more economic, highly productive, eco-friendly, traffic-friendly and space & energy saving.

III. FACTORS GOVERNING STEEP ANGLE CONVEYOR STRUCTURE

Following are major factors governing a Steep Angle Conveyor structure for conveying material in a mine:

- Whether the dip of the seam permits internal dumping
- Rate of advance of coal face and internal dump
- Rate of deepening the pit
- Whether a dump truck can pass underneath
- Ease of maintenance in a pit environment
- Mine safety, blasting parameters, fire, slope stability, material rolling back etc.
- Dependability to handle large quantities, breakdown analysis/unscheduled maintenance.

IV. STRUCTURAL DESIGNS OF STEEP ANGLE CONVEYOR

After detailed deliberations and discussions with manufacturers of Steep Angle Conveyor, two types of structural designs are approved for a feasible application in a mine.

SINGLE RUN SYSTEM

A single run system as shown in the drawing is suggested for a mine with Steeply to moderately dipping seams. In steeply dipping seams, as there is no inetrnal dumping, Steep Angle Conveyor can be installed at one suitable position and modules can be added to compensate for the depth.

The first position of Steep Angle Conveyor can be at a depth of 90m to 100m to reduce truck fleet. Individual cases must be studied in details to arrive at exact depth. If internal dumping is proposed in a moderately dipping seam, the structure can be shifted to a new location and the shifting period can be scheduled accordingly. Advance preparation at new site will certainly bring down this period significantly.

For coal production, rate should not be less than 4 to 5 Mtpa to justify investment on Steep Angle Conveyor. Life of mine after Steep Angle Conveyor installation should not be less than 18 years.

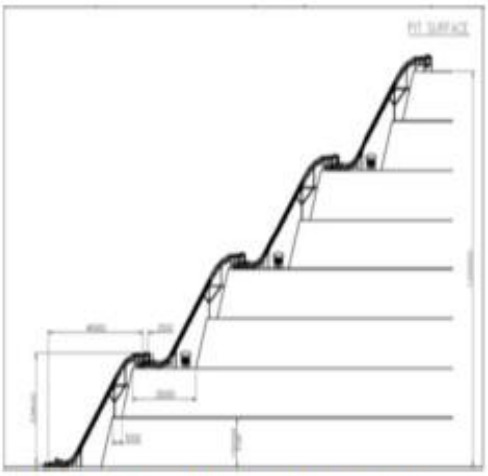
A dumper can pass underneath this structure and staircase is provided alongside Steep Angle Conveyor for maintenance personnels. A hydraulic lift can also be used for maintenance purposes.

It has also been noted that the system is quite robust and with proper maintenance and care it can provide sufficient dependebility to handle large production. The system is equiped with latest sensing system, overlaod protection system, fire sensors to avoid any untoward incidence resulting in unscheduled production loss. A shield is provided to protect vulnerable parts of the structure from fly rocks. Sufficent distance is also maintained from active face.

MODULAR SYSTEM

A modular system is suitable for the mines where frequent shifting is required with advancing internal dump benches. Every unit or module is self-sufficient and can be taken to a new site very quickly. The mode of transport can be crawler mounted at both ends, or

Sandwich Conveyor in a deep Pit



Modular Sandwich Conveyor in a deep Pit

skid mounted to be pushed or pulled by a Dozer. Another popular design to render mobility is by removable crawler pads that can shift multiple units resulting in less investment on crawlers.

Modules can be time phased and are added to compensate for the growing depth of the pit.

Structural changes are possible where these modules can give sufficient clearance to a Truck passing underneath. This is especially important while internal dumping for OB Trucks plying within a closed circuit.

Inherent problem with design shown above is of shifting as support trestles are provided on alternate benches. This can be obviated by a cantilever design made possible by structural engineering.

Another added advantage of modular system of Steep Angle Conveyor is the enhanced dependability. Extra modules with a little additional cost can be fast replaced in the event of unscheduled break down. Certain modifications are required at the place on the bench to accommodate hoppers and tail endings.

It is understood that the Steep Angle Conveyor system will further evolve over time as more experience is gained in working with it. Indigenous practices for operations, shifting, and maintenance, will develop to greater adoptability. Many structural changes are envisaged while implementation phase of Steep Angle Conveyor as new insight emerge.

V. APPLICABILITY

Coal with a lump size of preferably < 200 mm and evenly distributed for effective sandwiching and to avoid material falling back within the sandwich region.

Density-wise suitable for all types of coal and for medium density OB.

Normal Temperature is recommended for the belt and moisture may cause reduction in frictional force while sandwiching.

The best suitable position for Steep Angle Conveyor is along the side batter. Coal can be brought to the bottom most seam floor for 30 to 50 meters parting and for greater parting thickness, a separate unit can be planned for upper seams.

VI. JUSTIFICATION FOR APPLICATION OF STEEP ANGLE CONVEYOR SYSTEM IN THE PROPOSED OCP

- Due to high initial depth & steep quarry batter, it is difficult to install conventional conveyor.
- It improves economy of the mine.
- It is a highly productive system.
- It is an eco-friendly system.
- It is a traffic-friendly system.
- It is a space saving system.
- It is an energy saving system.
- It is a solution for transporting coal from quarry floor to surface at higher depth.

VII. PROPOSED QUARRY PARAMETERS

Sl. No.	Particulars	Unit	Value	
			Min	Max
1	Quarry Area			
	Along floor(Total)	ha	1028.31	
	Along surface(Total)	ha	1620.31	
2	External dump area	ha	1447.50	
3	Strike length	m		
	Floor		3200	4500
	Surface		4000	5500
4	Dip-Rise length	m		
	Floor		1800	3500
	Surface		2500	4200
5	Depth of Quarry	m	140	266
6	Extractable Reserves	Mt	427.86	
7	Overburden to be removed	Mcum	2804.11	
8	Stripping Ratio (Average)	cum/t	6.55	
9	Annual production	Mty	15.00	
10	Life of proposed quarry including construction	Years	34	
11	Quarry perimeter Total	m	190450.00	

VIII. MAJOR HEMM PROVISIONS

MAJOR EQUIPMENT	Size	Proposed Maximum No.
Electric Rope Shovel	42cum	7
Rear Dumper	240T	110
Diesel Hyd. Shovel	10-12cum	17
Rear Dumper	100 T	158
Surface Miner	100t Class (Wt.)	4
FEL	10-12cum	6
Rear Dumper (Coal Body)	60T	40
Crawler Dozer	850-860hp	4
Crawler Dozer with Ripper Attachment	850-860hp	2
Crawler Dozer	410hp	24
Wheel Dozer	460-500hp	3
Drill (RBH) Electric	311mm	7
Drill (RBH) Diesel	160mm	17
Steep Angle Conveyor		3

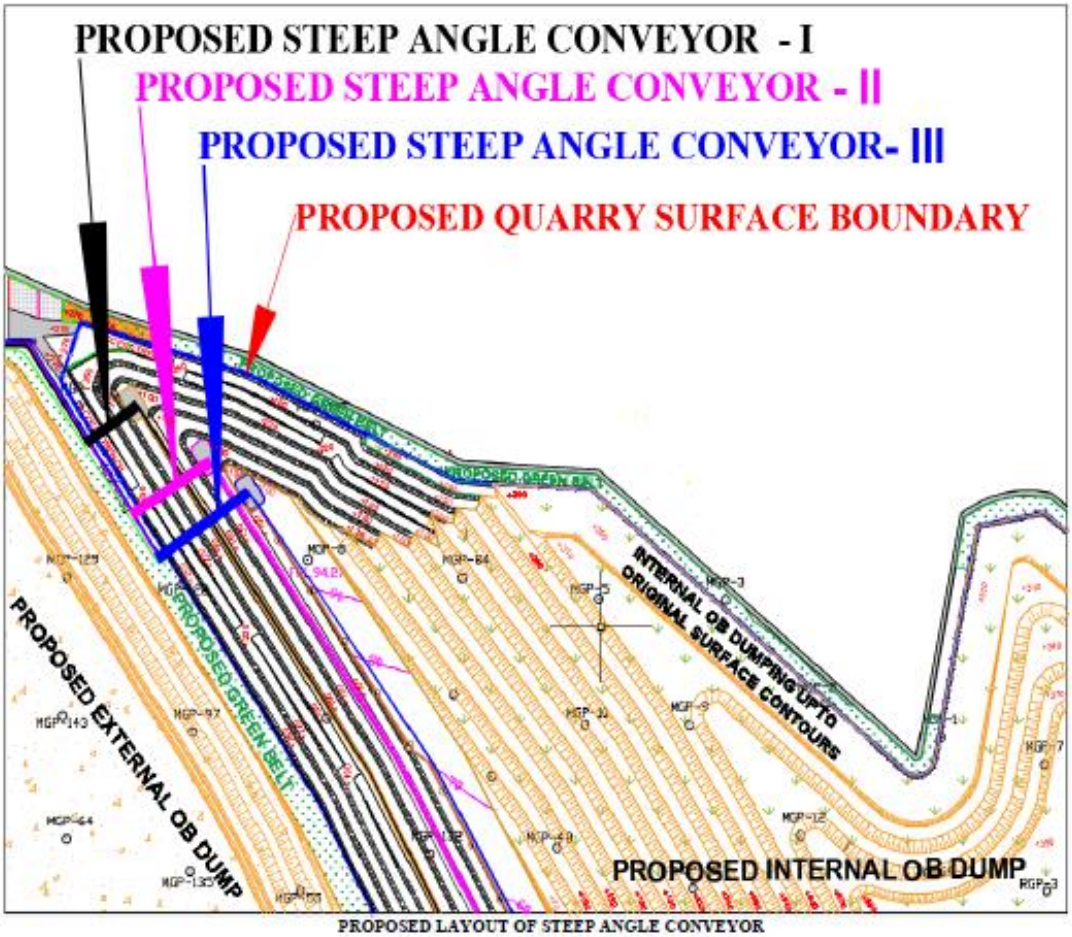
IX. PROPOSED STEEP ANGLE CONVEYOR SYSTEM & LAYOUT

The proposed Project Report for Non-CIL OCP has been prepared for the production of 15Mty of ROM coal from OCP. Coal production has been proposed by surface miner (-100 mm size) as such the crushing is not required for conveying of coal by conveyors. Coal cut by surface miner (-100 mm size) will be loaded on to 60T coal body dumpers through 10-12cum Front End Loaders. 60T coal body dumpers will feed the coal to conventional belt conveyors laid along the Western quarry batter.

The mining condition in proposed OCP is not suitable for conventional conveying system for transportation of coal from quarry floor to surface. Coal from three different coal horizons (top coal horizon, middle coal horizon & bottom coal horizon) conveyed by three conventional belt conveyors laid along the Western quarry batter will be lifted through three corresponding Steep Angle Conveyors from three different coal horizons to surface. Three separate receiving arrangements have been envisaged at three different coal horizons of the quarry for receiving coal from dumpers.

The Run-Off-Mine (ROM) coal produced by surface miner (-100 mm size) from the quarry shall be received into receiving pits by means of 60T coal body rear discharge dumpers at three different coal horizons / floor of the major seams of the quarry and conveyed up to surface by means of high angle conveyors. Receiving pit hoppers at seam floors have been provided with sufficient capacity to accommodate payload of two dumpers at a time. These receiving pits at different floor will be made as per mine advancement. The ROM coal from receiving hoppers at quarry floor will be reclaimed through feeders and collected by short belt conveyor and further it will be collected by the respective Steep Angle Conveyor (1 to 3) which will carry the coal up to surface.

Coal produced in seams IX & X will be collected at coal horizon-1 and fed to surface through Steep Angle Conveyor-1 of 1500TPH nominal capacity. Coal produced in seams VII & VIII will be collected at coal horizon-2 and fed to surface through Steep Angle Conveyor-2 of 1500TPH nominal capacity. Similarly, Coal produced in seam V & VI will be collected at coal horizon-3 (quarry floor) and fed to surface through Steep Angle Conveyor-3 of 2000TPH nominal capacity. This arrangement of coal receiving and feeding to Steep Angle Conveyor have been provided at all the three coal horizons / level for each Steep Angle Conveyor. The coal from three different Steep Angle Conveyors will be collected by three different conventional conveyors at surface. It will be finally fed to ground bunkers through series of conventional conveyors at surface.



PROPOSED LAYOUT OF STEEP ANGLE CONVEYOR

X. ECONOMIC ANALYSIS OF STEEP ANGLE CONVEYOR SYSTEM VS DUMPER SYSTEM

TABLE-I STEEP ANGLE CONVEYOR SYSTEM TECHNICAL & FINANCIAL DATA

Base date: December 2017

Year	Top Level							Middle Level							Bottom Level						
	HAC length (m)	Production from Top Belt (Mt)	HAC Structure Cost (1500 TPH) (Rs. Lakhs)	Conv. Conveyor Length (m)	Conventional Conveyor Structure Cost (Rs.84000 /m)	HAC Belt Cost (Rs. Lakh)	Conv. Belt Cost (Rs. Lakh)	HAC length (m)	Production from Middle Belt (Mt)	HAC Structure Cost (1500 TPH) (Rs. Lakhs)	Conv. Conveyor Length (m)	Conventional Conveyor Structure Cost (Rs.84000 /m)	HAC Belt Cost (Rs. Lakh)	Conv. Belt Cost (Rs. Lakhs)	HAC length (m)	Production from Bottom Belt (Mt)	HAC Structure Cost (2000 TPH) (Rs. Lakhs)	Conv. Conveyor Length (m)	Conv. Coveyor Structure Cost (Rs.8600 0/m)	HAC Belt Cost (Rs. Lakhs)	Conv. Belt Cost (Rs. Lakhs)
P5	210	4.24	1749.5	350.0	279.3	262.4	14.0														
P6	210	4.66	1749.5	350.0	279.3	262.4	14.0	300.0	5.1	2475.2	765.0	642.6	371.3	32.1							
P7	210	4.66	1749.5	350.0	279.3	262.4	14.0	300.0	5.1	2475.2	765.0	642.6	371.3	32.1							
P8	210	4.66	1749.5	350.0	279.3	262.4	14.0	300.0	5.1	2475.2	765.0	642.6	371.3	32.1							
P9	210	4.66	1749.5	1000.0	798.0	262.4	39.9	300.0	5.1	2475.2	765.0	642.6	371.3	32.1	355.0	5.2	4352.0	770.0	662.2	652.8	33.1
P10	210	4.66	1749.5	1000.0	798.0	262.4	39.9	300.0	5.1	2475.2	1500.0	1260.0	371.3	63.0	355.0	5.2	4352.0	770.0	662.2	652.8	33.1
P11	210	4.66	1749.5	1000.0	798.0	262.4	39.9	300.0	5.1	2475.2	1500.0	1260.0	371.3	63.0	355.0	5.2	4352.0	770.0	662.2	652.8	33.1
P12	210	4.61	1749.5	1000.0	798.0	262.4	39.9	300.0	5.0	2475.2	1500.0	1260.0	371.3	63.0	355.0	5.4	4352.0	770.0	662.2	652.8	33.1
P13	210	3.61	1749.5	1000.0	798.0	262.4	39.9	300.0	3.9	2475.2	1500.0	1260.0	371.3	63.0	355.0	7.5	4352.0	1500.0	1290.0	652.8	64.5
P14	210	3.61	1749.5	1700.0	1356.6	262.4	67.8	300.0	3.9	2475.2	1500.0	1260.0	371.3	63.0	355.0	7.5	4352.0	1500.0	1290.0	652.8	64.5
P15	210	3.61	1749.5	1700.0	1356.6	262.4	67.8	300.0	3.9	2475.2	2200.0	1848.0	371.3	92.4	355.0	7.5	4352.0	1500.0	1290.0	652.8	64.5
P16	210	3.61	1749.5	1700.0	1356.6	262.4	67.8	300.0	3.9	2475.2	2200.0	1848.0	371.3	92.4	355.0	7.5	4352.0	1500.0	1290.0	652.8	64.5
P17	210	3.62	1749.5	1700.0	1356.6	262.4	67.8	300.0	3.7	2475.2	2200.0	1848.0	371.3	92.4	355.0	7.7	4352.0	1500.0	1290.0	652.8	64.5
P18	210	3.62	1749.5	1700.0	1356.6	262.4	67.8	300.0	3.6	2475.2	2200.0	1848.0	371.3	92.4	355.0	7.8	4352.0	2200.0	1892.0	652.8	94.6
P19	210	3.62	1749.5	2400.0	1915.2	262.4	95.8	300.0	3.6	2475.2	2200.0	1848.0	371.3	92.4	355.0	7.8	4352.0	2200.0	1892.0	652.8	94.6
P20	210	3.62	1749.5	2400.0	1915.2	262.4	95.8	300.0	3.6	2475.2	2900.0	2436.0	371.3	121.8	355.0	7.8	4352.0	2200.0	1892.0	652.8	94.6
P21	210	3.60	1749.5	2400.0	1915.2	262.4	95.8	300.0	3.6	2475.2	2900.0	2436.0	371.3	121.8	355.0	7.8	4352.0	2200.0	1892.0	652.8	94.6
P22	210	3.05	1749.5	2400.0	1915.2	262.4	95.8	300.0	3.2	2475.2	2900.0	2436.0	371.3	121.8	355.0	8.8	4352.0	2200.0	1892.0	652.8	94.6
P23	210	3.05	1749.5	2400.0	1915.2	262.4	95.8	300.0	3.2	2475.2	2900.0	2436.0	371.3	121.8	355.0	8.8	4352.0	2900.0	2494.0	652.8	124.7
P24	210	3.05	1749.5	3100.0	2473.8	262.4	123.7	300.0	3.2	2475.2	2900.0	2436.0	371.3	121.8	355.0	8.8	4352.0	2900.0	2494.0	652.8	124.7
P25	210	3.05	1749.5	3100.0	2473.8	262.4	123.7	300.0	3.2	2475.2	2900.0	2436.0	371.3	121.8	355.0	8.8	4352.0	2900.0	2494.0	652.8	124.7
P26	210	3.05	1749.5	3100.0	2473.8	262.4	123.7	300.0	3.2	2475.2	3700.0	3108.0	371.3	155.4	355.0	8.8	4352.0	2900.0	2494.0	652.8	124.7
P27	210	3.05	1749.5	3100.0	2473.8	262.4	123.7	300.0	3.2	2475.2	3700.0	3108.0	371.3	155.4	355.0	8.8	4352.0	2900.0	2494.0	652.8	124.7
P28	210	3.05	1749.5	3100.0	2473.8	262.4	123.7	300.0	3.2	2475.2	3700.0	3108.0	371.3	155.4	355.0	8.8	4352.0	3600.0	3096.0	652.8	154.8
P29	210	3.05	1749.5	3800.0	3032.4	262.4	151.6	300.0	3.2	2475.2	3700.0	3108.0	371.3	155.4	355.0	8.8	4352.0	3600.0	3096.0	652.8	154.8
P30	210	3.05	1749.5	3800.0	3032.4	262.4	151.6	300.0	3.2	2475.2	3700.0	3108.0	371.3	155.4	355.0	8.8	4352.0	3600.0	3096.0	652.8	154.8
P31	210	3.05	1749.5	3800.0	3032.4	262.4	151.6	300.0	3.2	2475.2	3700.0	3108.0	371.3	155.4	355.0	8.8	4352.0	3600.0	3096.0	652.8	154.8
P32	210	0.70	1749.5	3800.0	3032.4	262.4	151.6	300.0	0.7	2475.2	3700.0	3108.0	371.3	155.4	355.0	2.0	4352.0	3600.0	3096.0	652.8	154.8

TABLE-II STEEP ANGLE CONVEYOR SYSTEM TECHNICAL & FINANCIAL DATA

Base date: December 2017 **(Rs. Lakhs)**

Year	Total							Manpower			
								Cat-6		Cat-3	
	HAC Cost (Rs. Lakhs)	Conventional Conveyor Structure Cost (Rs. Lakh)	HAC Belt Cost (Rs. Lakh)	Conv. Belt Cost (Rs. Lakh)	HAC / Conv. Conveyor Life (Yrs)	HAC Belt Life (Yrs)	Conv. Belt Life (Yrs)	(No.)	(Salary & Wages)	(No.)	(Salary & Wages)
P5	1749.50	279.30	262.43	13.97	18	9	3	18	132.30	32	216.0
P6	4224.70	921.90	633.71	46.10	18	9	3	34	249.90	54	364.5
P7	4224.70	921.90	633.71	46.10	18	9	3	34	249.90	54	364.5
P8	4224.70	921.90	633.71	46.10	18	9	3	34	249.90	54	364.5
P9	8576.70	2102.80	1286.51	105.14	18	9	3	50	367.50	80	540.0
P10	8576.70	2720.20	1286.51	136.01	18	9	3	50	367.50	80	540.0
P11	8576.70	2720.20	1286.51	136.01	18	9	3	50	367.50	80	540.0
P12	8576.70	2720.20	1286.51	136.01	18	9	3	50	367.50	80	540.0
P13	8576.70	3348.00	1286.51	167.40	18	9	3	50	367.50	80	540.0
P14	8576.70	3906.60	1286.51	195.33	18	9	3	50	367.50	80	540.0
P15	8576.70	4494.60	1286.51	224.73	18	9	3	50	367.50	80	540.0
P16	8576.70	4494.60	1286.51	224.73	18	9	3	50	367.50	80	540.0
P17	8576.70	4494.60	1286.51	224.73	18	9	3	50	367.50	80	540.0
P18	8576.70	5096.60	1286.51	254.83	18	9	3	50	367.50	80	540.0
P19	8576.70	5655.20	1286.51	282.76	18	9	3	50	367.50	80	540.0
P20	8576.70	6243.20	1286.51	312.16	18	9	3	50	367.50	80	540.0
P21	8576.70	6243.20	1286.51	312.16	18	9	3	50	367.50	80	540.0
P22	8576.70	6243.20	1286.51	312.16	18	9	3	50	367.50	80	540.0
P23	8576.70	6845.20	1286.51	342.26	18	9	3	50	367.50	80	540.0
P24	8576.70	7403.80	1286.51	370.19	18	9	3	50	367.50	80	540.0
P25	8576.70	7403.80	1286.51	370.19	18	9	3	50	367.50	80	540.0
P26	8576.70	8075.80	1286.51	403.79	18	9	3	50	367.50	80	540.0
P27	8576.70	8075.80	1286.51	403.79	18	9	3	50	367.50	80	540.0
P28	8576.70	8677.80	1286.51	433.89	18	9	3	50	367.50	80	540.0
P29	8576.70	9236.40	1286.51	461.82	18	9	3	50	367.50	80	540.0
P30	8576.70	9236.40	1286.51	461.82	18	9	3	50	367.50	80	540.0
P31	8576.70	9236.40	1286.51	461.82	18	9	3	50	367.50	80	540.0
P32	8576.70	9236.40	1286.51	461.82	18	9	3	50	367.50	80	540.0

TABLE-III STEEP ANGLE CONVEYOR SYSTEM OPERATING COST

Base date: December 2017 (Rs. Lakhs)

Year	Salaries & Wages	Stores Cost	Power cost	Misc. Cost	Interest on Working Capital	Total Cash Cost	Depre-ciation	**Total Operating Cost**	**Production (Mt)**
P5	348.30	52.11	433.15	53.20	21.92	908.68	146.52	**1055.20**	**4.24**
P6	614.40	131.75	1085.20	127.78	42.24	2001.37	371.70	**2373.07**	**9.76**
P7	614.40	131.75	1085.20	127.78	42.24	2001.37	371.70	**2373.07**	**9.76**
P8	614.40	131.75	1085.20	127.78	42.24	2001.37	371.70	**2373.07**	**9.76**
P9	907.50	286.53	2668.75	255.40	70.06	4188.23	771.30	**4959.53**	**15.00**
P10	907.50	302.64	2808.47	268.53	71.47	4358.60	815.89	**5174.49**	**15.00**
P11	907.50	302.64	2808.47	268.53	71.47	4358.60	815.89	**5174.49**	**15.00**
P12	907.50	302.64	2808.47	268.53	71.47	4358.60	815.89	**5174.49**	**15.00**
P13	907.50	318.94	2948.20	281.87	72.90	4529.41	861.23	**5390.64**	**15.00**
P14	907.50	333.93	3087.92	293.75	74.20	4697.31	901.57	**5598.88**	**15.00**
P15	907.50	349.48	3227.65	306.25	75.56	4866.44	944.04	**5810.48**	**15.00**
P16	907.50	349.48	3227.65	306.25	75.56	4866.44	944.04	**5810.48**	**15.00**
P17	907.50	349.48	3227.65	306.25	75.56	4866.44	944.04	**5810.48**	**15.00**
P18	907.50	365.30	3367.37	319.05	76.94	5036.16	987.52	**6023.68**	**15.00**
P19	907.50	380.29	3507.10	330.93	78.24	5204.05	1027.86	**6231.91**	**15.00**
P20	907.50	395.84	3646.82	343.43	79.59	5373.18	1070.33	**6443.51**	**15.00**
P21	907.50	395.84	3646.82	343.43	79.59	5373.18	1070.33	**6443.51**	**15.00**
P22	907.50	395.84	3646.82	343.43	79.59	5373.18	1070.33	**6443.51**	**15.00**
P23	907.50	411.65	3786.55	356.23	80.98	5542.91	1113.80	**6656.71**	**15.00**
P24	907.50	426.64	3926.27	368.11	82.28	5710.80	1154.15	**6864.95**	**15.00**
P25	907.50	426.64	3926.27	368.11	82.28	5710.80	1154.15	**6864.95**	**15.00**
P26	907.50	443.78	4066.00	382.40	83.79	5883.47	1202.68	**7086.15**	**15.00**
P27	907.50	443.78	4066.00	382.40	83.79	5883.47	1202.68	**7086.15**	**15.00**
P28	907.50	459.60	4205.72	395.20	85.18	6053.20	1246.16	**7299.35**	**15.00**
P29	907.50	474.59	4345.45	407.08	86.48	6221.09	1286.50	**7507.59**	**15.00**
P30	907.50	474.59	4345.45	407.08	86.48	6221.09	1286.50	**7507.59**	**15.00**
P31	907.50	474.59	4345.45	407.08	86.48	6221.09	1286.50	**7507.59**	**15.00**
P32	907.50	474.59	4345.45	407.08	86.48	6221.09	1286.50	7507.59	3.46
		DESIRED OPERATING COST BASED ON WEIGHTED AVERAGE						**35.10**	
		DESIRED OPERATING COST BASED ON SIMPLE AVERAGE						**42.03**	

TABLE-IV DUMPER SYSTEM TECHNICAL & FINANCIAL DATA

Base date: December 2017

Year	Top Level				Middle Level				Bottom Level			
	Lead (km)	Productivity (Mcum/yr)	Production from top Coal Horizon	No. of dumpers	Lead (km)	Productivity (Mcum/yr)	Production from middle Coal Horizon	No. of dumpers	Lead (km)	Productivity (Mcum/yr)	Production from bottom Coal Horizon	No. of Dumpers
P5	2	0.2612	4.24	16.24								
P6	2	0.2612	4.66	17.85	3	0.2188	5.10	23.29				
P7	2	0.2612	4.66	17.85	3	0.2188	5.10	23.29				
P8	2	0.2612	4.66	17.85	3	0.2188	5.10	23.29				
P9	2	0.2612	4.66	17.85	3	0.2188	5.10	23.29	3.75	0.1958	5.24	26.79
P10	2.25	0.2508	4.66	18.59	3.25	0.2106	5.10	24.20	3.75	0.1958	5.24	26.79
P11	2.25	0.2508	4.66	18.59	3.25	0.2106	5.10	24.20	3.75	0.1958	5.24	26.79
P12	2.25	0.2508	4.61	18.38	3.25	0.2106	5.04	23.92	3.75	0.1958	5.35	27.35
P13	2.25	0.2508	3.61	14.41	3.25	0.2106	3.92	18.60	3.75	0.1958	7.47	38.16
P14	2.25	0.2508	3.61	14.41	3.25	0.2106	3.92	18.60	3.75	0.1958	7.47	38.16
P15	2.5	0.2404	3.61	15.03	3.5	0.2023	3.92	19.36	4.25	0.1839	7.47	40.63
P16	2.5	0.2404	3.61	15.03	3.5	0.2023	3.92	19.36	4.25	0.1839	7.47	40.63
P17	2.5	0.2404	3.62	15.05	3.5	0.2023	3.72	18.39	4.25	0.1839	7.66	41.67
P18	2.5	0.2404	3.62	15.06	3.5	0.2023	3.59	17.75	4.25	0.1839	7.79	42.37
P19	2.5	0.2404	3.62	15.06	3.5	0.2023	3.59	17.75	4.25	0.1839	7.79	42.37
P20	3	0.2188	3.62	16.54	3.75	0.1958	3.59	18.34	4.5	0.1785	7.79	43.64
P21	3	0.2188	3.60	16.45	3.75	0.1958	3.58	18.26	4.5	0.1785	7.83	43.84
P22	3	0.2188	3.05	13.94	3.75	0.1958	3.17	16.20	4.5	0.1785	8.78	49.18
P23	3	0.2188	3.05	13.94	3.75	0.1958	3.17	16.20	4.5	0.1785	8.78	49.18
P24	3	0.2188	3.05	13.94	3.75	0.1958	3.17	16.20	4.5	0.1785	8.78	49.18
P25	3.25	0.2106	3.05	14.49	4	0.1892	3.17	16.76	4.75	0.1741	8.78	50.43
P26	3.25	0.2106	3.05	14.49	4	0.1892	3.17	16.76	4.75	0.1741	8.78	50.43
P27	3.25	0.2106	3.05	14.49	4	0.1892	3.17	16.76	4.75	0.1741	8.78	50.43
P28	3.25	0.2106	3.05	14.49	4	0.1892	3.17	16.76	4.75	0.1741	8.78	50.43
P29	3.25	0.2106	3.05	14.49	4	0.1892	3.17	16.76	4.75	0.1741	8.78	50.43
P30	4	0.1892	3.05	16.12	4.75	0.1741	3.17	18.22	5	0.1696	8.78	51.76
P31	4	0.1892	3.05	16.12	4.75	0.1741	3.17	18.22	5	0.1696	8.78	51.76
P32	4	0.1892	0.70	3.72	4.75	0.1741	0.73	4.20	5	0.1696	2.02	11.94

TABLE-V DUMPER SYSTEM TECHNICAL & FINANCIAL DATA

Base date: December 2017 (Rs. Lakhs)

Year	TOTAL			Manpower			
				Gr-B		Cat-3	
	Dumpers	Cost (Rs. Lakhs)	Life of Dumpers (Years)	(No.)	(Salary & Wages)	(No.)	(Salary & Wages)
P5	17.00	4322.25	7	66	532.62	12	81.00
P6	42.00	10678.50	7	162	1307.34	30	202.50
P7	42.00	10678.50	7	162	1307.34	30	202.50
P8	42.00	10678.50	7	162	1307.34	30	202.50
P9	68.00	17289.00	7	263	2122.41	49	330.75
P10	70.00	17797.50	7	270	2178.90	50	337.50
P11	70.00	17797.50	7	270	2178.90	50	337.50
P12	70.00	17797.50	7	270	2178.90	50	337.50
P13	72.00	18306.00	7	278	2243.46	51	344.25
P14	72.00	18306.00	7	278	2243.46	51	344.25
P15	76.00	19323.00	7	293	2364.51	54	364.50
P16	76.00	19323.00	7	293	2364.51	54	364.50
P17	76.00	19323.00	7	293	2364.51	54	364.50
P18	76.00	19323.00	7	293	2364.51	54	364.50
P19	76.00	19323.00	7	293	2364.51	54	364.50
P20	79.00	20085.75	7	305	2461.35	56	378.00
P21	79.00	20085.75	7	305	2461.35	56	378.00
P22	80.00	20340.00	7	310	2501.70	57	384.75
P23	80.00	20340.00	7	310	2501.70	57	384.75
P24	80.00	20340.00	7	310	2501.70	57	384.75
P25	82.00	20848.50	7	317	2558.19	59	398.25
P26	82.00	20848.50	7	317	2558.19	59	398.25
P27	82.00	20848.50	7	317	2558.19	59	398.25
P28	82.00	20848.50	7	317	2558.19	59	398.25
P29	82.00	20848.50	7	317	2558.19	59	398.25
P30	87.00	22119.75	7	336	2711.52	62	418.50
P31	87.00	22119.75	7	336	2711.52	62	418.50
P32	20.00	5085.00	7	78	629.46	14	94.50

894173/2021/O/o HEAD OF OC DIVISION, CMPDI HQ

TABLE-VI DUMPER SYSTEM OPERATING COST

Base date: December 2017 (Rs. Lakhs)

Year	Salaries & wages	Stores Cost	Power cost	Misc. Cost	Interest on Working Capital	Total Cash Cost	Depreciation	Total Operating Cost	Production
P5	613.62	2537.92	0.00	96.79	157.00	3405.34	617.46	**4022.80**	**4.24**
P6	1509.84	6270.16	0.00	238.97	387.58	8406.55	1525.50	**9932.05**	**9.76**
P7	1509.84	6270.16	0.00	238.97	387.58	8406.55	1525.50	**9932.05**	**9.76**
P8	1509.84	6270.16	0.00	238.97	387.58	8406.55	1525.50	**9932.05**	**9.76**
P9	2453.16	10151.69	0.00	387.12	627.95	13619.92	2469.86	**16089.78**	**15.00**
P10	2516.40	10450.27	0.00	398.28	645.97	14010.92	2542.50	**16553.42**	**15.00**
P11	2516.40	10450.27	0.00	398.28	645.97	14010.92	2542.50	**16553.42**	**15.00**
P12	2516.40	10450.27	0.00	398.28	645.97	14010.92	2542.50	**16553.42**	**15.00**
P13	2587.71	10748.85	0.00	409.64	664.40	14410.60	2615.14	**17025.74**	**15.00**
P14	2587.71	10748.85	0.00	409.64	664.40	14410.60	2615.14	**17025.74**	**15.00**
P15	2729.01	11346.01	0.00	432.33	701.19	15208.54	2760.43	**17968.97**	**15.00**
P16	2729.01	11346.01	0.00	432.33	701.19	15208.54	2760.43	**17968.97**	**15.00**
P17	2729.01	11346.01	0.00	432.33	701.19	15208.54	2760.43	**17968.97**	**15.00**
P18	2729.01	11346.01	0.00	432.33	701.19	15208.54	2760.43	**17968.97**	**15.00**
P19	2729.01	11346.01	0.00	432.33	701.19	15208.54	2760.43	**17968.97**	**15.00**
P20	2839.35	11793.88	0.00	449.47	729.00	15811.69	2869.39	**18681.08**	**15.00**
P21	2839.35	11793.88	0.00	449.47	729.00	15811.69	2869.39	**18681.08**	**15.00**
P22	2886.45	11943.17	0.00	455.45	738.78	16023.85	2905.71	**18929.56**	**15.00**
P23	2886.45	11943.17	0.00	455.45	738.78	16023.85	2905.71	**18929.56**	**15.00**
P24	2886.45	11943.17	0.00	455.45	738.78	16023.85	2905.71	**18929.56**	**15.00**
P25	2956.44	12241.75	0.00	466.78	757.14	16422.11	2978.36	**19400.46**	**15.00**
P26	2956.44	12241.75	0.00	466.78	757.14	16422.11	2978.36	**19400.46**	**15.00**
P27	2956.44	12241.75	0.00	466.78	757.14	16422.11	2978.36	**19400.46**	**15.00**
P28	2956.44	12241.75	0.00	466.78	757.14	16422.11	2978.36	**19400.46**	**15.00**
P29	2956.44	12241.75	0.00	466.78	757.14	16422.11	2978.36	**19400.46**	**15.00**
P30	3130.02	12988.19	0.00	495.07	802.98	17416.25	3159.96	**20576.22**	**15.00**
P31	3130.02	12988.19	0.00	495.07	802.98	17416.25	3159.96	**20576.22**	**15.00**
P32	723.96	2985.79	0.00	113.92	184.81	4008.49	726.43	**4734.92**	**3.46**
			DESIRED OPERATING COST BASED ON WEIGHTED AVERAGE					**112.71**	
			DESIRED OPERATING COST BASED ON SIMPLE AVERAGE					**120.56**	

XI. CONCLUSION & RECOMMENDATION

CONCLUSION

From the tables showing operating costs for Steep Angle Conveyor system and Dumper system, it is evident that the Steep Angle Conveyors along with in-pit conveyors has reduced the 60T coal body dumpers by 87 nos. This has also reduced capital expenditure by about Rs.25 crores and cost of production by about Rs.78 per tonne.

In the proposed OCP, due to high initial depth, steep quarry batter and suitable geo-mining conditions, Steep Angle Conveyor has been proved cheaper, more productive, eco-friendly, traffic-friendly and space & energy saving solution for transporting coal from quarry floor to surface.

RECOMMENDATION

Steep Angle Conveyor is a new technology for Indian Coal Industry. For the success of Steep Angle Conveyor system, strict compliance of Project Report provisions, disciplined work culture, scheduled maintenance, condition-based monitoring and adherence to provisions of DGMS guidelines for the safety of men & machineries are highly recommended.

REFERENCES

1. Almond, R.M. and Schwalm, R.J., "In-Pit Movable Crushing/Conveying Systems. American Mining Congress
2. Almond, R.M. and Huss, C., "Open Pit crushing and Conveying Systems", Engineering and Mining journal, June 1982.
3. Barden, K.L., Files, T.I., and Gilewicz, P.J., "Cross-Pit Conveyor and End-Around-Conveyor Continuous Mining Systems" American Mining Congress International Mining Show, Las Vegas, Nevada, October1982.
4. Baer, R.E., "Concepts of Materials Handling Systems and Portability of Crushers in Pits". Procedure Annual Meeting, AIME, Duluth, Minnesota, January 1979.
5. CEMA reference book on bulk material handling by conveyor 2010.
6. R&D Project documentation prepared by Central Mine Planning & Design Institute Limited with assistance from Manufacturers, participating consultants, subsidiary companies and open source (Internet etc.).
7. Resources at www.saimh.co.za (South African Institute of Material Handling)

Annexure 3: Benefits achieved by OITDS in Jayant Mines NCL

Activity	Before OITDS	After OITDS
Attendance, Allocation & Communication to the Operator	• Manual system used to take around 45 minutes. • Communication to the operator over wireless was not possible. • Manual Allocation invited human bias and error.	• Attendance and allocation is done within 25 minutes and is announced over Public Address System. • Both ways Communication to operator over wireless is possible. • Allocation done by computer always on best fit basis.
Dynamic Allocation and effective mine monitoring.	Trip count done manually by trip man. • In case of Shovel breakdown Dumpers were manually reallocated taking much of time. • No monitoring tool was available to view the activities in mines centrally. • Recording of dumper's movement was not possible. • No tool was available to redirect Dumpers to optimised route. • Safety was being monitored manually.	Computer does trip count automatically and accurately. • Dumpers are instantly reallocate in case of Shovel breakdown. • Effective real time mine monitoring system through distributed computer network. • The movement of dumper can be tracked at a later point of time and can be graphically replayed from the stored records at any point of time for analysis purpose. • Optimised route is communicated to operator at the end of each Dumper cycle. • Monitoring of over-speeding, crossing through prohibited zone, fire alarm, SOS message
Vital Sign Monitoring System and	• Health related parameters of Dumpers were not Being communicated to concerned	• Online Monitoring of Health Parameter of Dumpers is being

Maintenance	persons online. • Preventive Maintenance was being done offline manually	done. • Preventive Maintenance Schedules are generated online and gets recorded.

Annexure 4: Technoeconomic comparison between LIBS based Coal Analyzers with other Radiation Source based Technologies and traditional LAB sampling methods.

Techno-Economic Quantitative Analysis

Sr. No.	Item	Laser Based	Radioactive based	Traditional Sampling
1	Initial Capital Cost (in lacs)	600	550	50
2	Supporting Instruments (in lacs)	0	50	0
3	Radioactive License Costs (in lacs)	0	5	5
4	Life (in years)	10	2.5	2
5	Source Disposal Cost (in lacs)	0	50	0
6	Specialized Manpower (nos.)	0	3	30
7	Specialized Manpower Costs (in lacs)	0	15	126
8	Radiation Safety Infrastructure Setup	0	20	5
9	Maintenance Cost (in lacs)	18	24	12
Total Operation Costs for 10 years (in lacs)		708.00	1,215.00	1,645.00

Finding and Conclusions

- LIBS technology reduces operational and maintenance costs by upto 60% over a period of 10 years in comparison to conventional methods.
- LIBS technology provides simultaneous quantitative analysis of all elements including light elements in real time without sampling with industry highest accuracy standards.
- LIBS is safe, does not contain any radiation so absolute safety of plant personnel is ensured and requires no authority certification.
- LIBS is independent of environmental conditions, operates 24x7 with downtime to ensure maximum productivity.
- No humaz errors in sampling and sample preparation procedures.