कोल इण्डिया
Coal India

cmpdi
A Mini Ratna Company

ISSN 0970-7204

खनन विज्ञान
minetech

खण्ड 40, अंक 2
अप्रैल–जून 2019

Volume 40, No. 2
April-June 2019

ISSN 0970-7204
खनन विज्ञान
minetech

विषय सूची
Contents

खण्ड 40, अंक 2, 2019
Volume 40, No. 2
April -June, 2019

Utilization of Coal mines overburden dumps for Harnessing Solar Energy and Excogitate Economic, Social and Carbon Trade-off

Manoj Kumar[1], Sangeeta[2]

ABSTRACT

This paper discusses the pros and cons of substituting solar power system as alternative land use (ALU) vis a vis other land use (OLU) in post-mine closure scenario in one of the coalmines in Jharkhand and its impact on the neighboring community and environment based on the triple bottom-line framework.

The data under study area for its pre-mining and post-mining phase is collected and its land use is assessed. Based on the assessment, a new land use for solar power system is included and subsequently its effect on Economy, Society and Environment is analyzed and quantified. This paper proposes a new land use over 20 ha on one of the external overburden dumps on non forest land of the study area. It includes a mix of Solar Photo Voltaic System (10 MW) on the top, plantation over other reclaimed area and other usage of land to reduce the net GHG emission of the system without compromising any of the statutory provisions of the mine closure guidelines (2013). This system will generate approximately 6624 MWh/yr resulting in a revenue generation of Rs. 4.30 crores/yr with an estimated net reduction of 7114 tons of CO_{2e} / yr. The electricity so generated will benefit about 6049 households i.e. 9.33 % of the present household in its vicinity, covering a population of approximately 30,000 persons. This study will strengthen the energy plan of the coal company and will help achieve its long-term plan of energy diversification.

Keyword: *Solar, Coal, Closure, Carbon Trade-off, GHG*

INTRODUCTION

Demand for energy and associated services, to meet social and economic development and improve human welfare and health is increasing. The society requires energy to meet basic human needs (e.g., lighting, cooking, space comfort, mobility and communication) and to serve productive processes. Global use of fossil fuels (coal oil and gas) has increased to dominate energy supply, leading to a rapid growth in carbon dioxide (CO_2) emissions. Greenhouse gas (GHG) emissions resulting from the provision of energy services has contributed significantly to the historic

[1] *Manager (M), E&F Deptt, CCL, Email : mkpatna69@gmail.com,* [2] *Sr Mgr(Env),(E&F), CCL, Ranchi.*

increase in atmospheric GHG concentrations. Recent data confirm that consumption of fossil fuels accounts for the majority of global anthropogenic GHG emissions. Implications of past emissions for future warming were discussed by Group I of Intergovernmental Panel on Climate Change(IPCC) in its 48th Session of the Intergovernmental Panel on Climate Change at Incheon, Republic of Korea held on 1st – 6th Oct' 2018. In subsection A2.2, A3.3 countries like Australia, Germany, Chile, Canada, UK, US Angola, Norway, Saudi Arabia put forward the concept of reaching and sustaining net-zero CO_2 emissions and declining net non-CO_2 radiative forcing so that net anthropogenic global emissions must equal zero to halt to global warming.

Entire World is in search of pathways that limit warming to 1.5°C. Harnessing solar energy can be very useful in combating global warming. Solar Radiation Management (SRM) measures are being thought off as one of the alternatives. This was also the burning issue at IPCC-48 (Group III). Energy mix is required in the share of renewables particularly solar energy. It has an enormous potential to mitigate climate change and can provide wide benefits. (IPCC-15) It will contribute to social and economic development, energy access and a secure energy supply, thereby, reducing negative impacts on the environment and health. It is imperative that coal mines must adopt system transition especially with transition in regional land use. The change in mine closure activity can achieve this objective.

Coal Mining is a site-specific activity that disturbs the land environment by changing natural pattern of land by creating void and dumps of overburden. While granting Environmental Clearance (EC) to a project, pre and post mining land use are provided in the EC letter issued to a project. The post mining land-use of mines is usually limited to use of dump and backfilled area for plantation and remaining void area as water reservoir.

For Coal and Lignite mine, a guideline was formulated dated 07.01.2013 for preparation of Mine Closure Plan by Ministry of Coal. The guideline promotes to create a self-sustained ecosystem. This focuses mainly on the sustainable land management at the project site.

Sustainable land management in mine closure process can be a helping tool in land-intensive mitigation options on the Sustainable development goals (SDGs). Involvement of scenarios in Bio-energy with carbon capture and storage (BECCS) and agriculture, forestry, and other land use (AFOLU) levels in 1.5°C pathways are one of the focused area , where only few studies are made at present. Countries like Switzerland, EU, Norway, China along with India are also of this opine. (C3.2 of IPCC-48).

Over 120 researchers working with the Inter-Governmental Panel on Climate Change (IPCC), also indicate that the rising adoption of renewable energies could lead to cumulative greenhouse gas savings equivalent to 220 to 560 Giga-tons of carbon dioxide (GtC02eq) between 2010 and 2050. Close to 80 percent of the world's energy supply could be met by renewables by mid-century if backed by the right enabling public policies. Draft National Energy Policy formulated by NITI Aayog envisages that, while in 2012 coal power stations has a share of 65 % and Solar CSP & PV has a meager share of 0.002 % in Electricity Generation in India, by 2040 the share of Coal power stations will fall to 41.5 % and share of Solar CSP & PV will rise to 14.12 %.

INDIAN SCENARIO FOR MINE CLOSURE

The Central Government vide Notification No. GSR 329 (E) dated 10.04.2003 and No. GSR 330 (E) dated 10.04.2003 amended the Mineral Concession Rules, 1960 and Mineral Conservation and Development Rules, 1988 respectively.

The view amendments specify that all the existing mining lessees are required to submit the "Progressive Mine Closure Plan" along with prescribed financial sureties within 180 days from date of notification. Further, the mining lessee is required to submit "Final Mine Closure Plan" one year prior to the proposed closure of the mine. In the notification it has been enunciated that the "Progressive

Closure Plan" and "Final Closure Plan" should be as per the guidelines issued by the Indian Bureau of Mines.

For Coal and Lignite mine, a guideline was formulated dated 27.8.2009 for preparation of Mine Closure Plan by Ministry of Coal, Govt. of India, New Delhi. The same was amended on 11.1.2012, 25.4.2012. Finally on 07.01.2013, the amended guideline came into focus that supersedes all the previous guideline.

The Mine Closure Guideline incorporated several important features such as incorporation/Approval of MCP in project Report/ Mining Plan for new and existing mines and opening of Escrow Account prior to obtaining permission for opening a mine from Coal Controller (Fig -2).

STUDY AREA

The study of this paper has been limited to an existing coal-mining project situated in East bokaro Coalfield , Dist. Bokaro, Jharkhand.(Fig.- 1)

As per census data 2011, 76 villages with approximately 64835 households falls within 10 km radius of the mine lease area. (Table -1).

Table-1: Household Survey

Total Population	Avg_HH_Size (Persons)	No of Households
3,47,298	5	64,835

Fig.-1 : Location of the Study Area

Although Power supply for domestic/agricultural purposes is available in more than 95% villages, but, is not available for commercial purpose in about 50 % of the villages. In addition, despite the villages being connected with Electric lines, power supply is intermittently as is the case with all rural areas of the state particularly in summer season.

OBJECTIVE

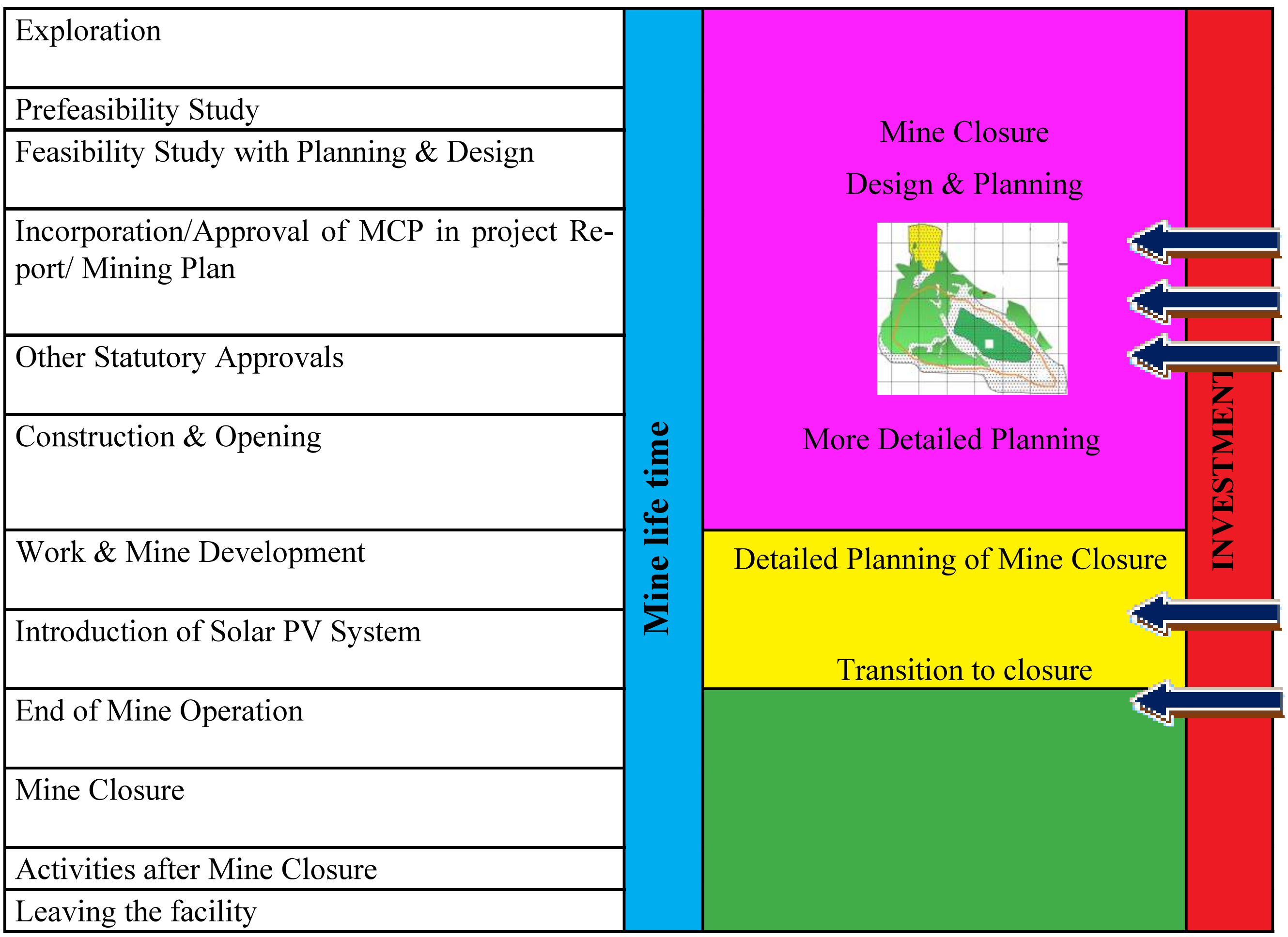
The main objective of the paper is to examine the Economic, Social and Carbon Trade-off of Solar photovoltaic system in the post-mining land use. In addition, carving alternate land use plan for post-mining scenario for a mining complex situated in East Bokaro Coalfield of Bokaro District, Jharkhand.

MATERIAL & METHODOLOGY

The methodology of study includes developing of alternate land use scenario (ALU) over the original land use (OLU) being practiced by the mine managers while preparing mine closure plan (MCP) based on MCP guideline issued my Ministry of Coal (MoC), Government of India (GoI). This implies of installation of Solar PV power plant in the intermediate mining process after mine has developed and started producing coal (Fig. 2). In this study, the solar PV power plant is proposed to be introduced in 3rd year and to be constructed and installed over overburden dump placed on non-forest land.

DATA COLLECTION

The land use data collected from public do-



Source- Mineral intelligence capacity analysis pp 3/12

Fig.-2: Mine Closure Activity

main. The pre and post-mining land use are given at Table-2. The percentage share of different land use is shown at Fig.-3.

The solar PV plant is proposed over the non forest land and over one of the overburden dump covers about 20 Ha. 11.5 Ha for solar plates and rest for other activities. The landuse lay out is shown at Fig.-4.

Apart from the land use, the mine closure activities proposed and the %of the total mine cost breakup of the activities are given in Table-3.

DESIGN & LOCATION OF SOLAR POWER SYSTEM IN STUDY AREA

The facility data location for the study area (Karo, Bokaro, elevation 323 m) is about 82 km from the Climate data location (Ranchi, elevation 453m, heating design temp=11.9°C, cooling design temperature=33.3°C, earth temperature amplitude= 19°C). It falls in vey hot and humid climate zone (Fig.- 5). The solar path at the facility location is shown at Fig.- 6.

It requires 4 acre / MW. Introduction of 10 MW of solar photovoltaic system will require 49.4 acres. 40 acres for construction and instyallation of PV system and 9.5 acres for road and maintenance activity.

Assuming there is no shading effect and fixed tilt plane. Collectors plane orientation with tilt = 23 degree and azimuth as 0 degree. The system has only one array. For 10 MW photovoltaic system, plant size is to be 10,000 kWp.

SELECTION OF PV MODULE

PV module selected for this model is Trina Solar make with module size : 275 W, Short ckt current (Isc) = 9.26 A, maximum power point (Impp) = 8.76 A, temperature coefficient of 4.6 mA/°C, open ckt voltage(VoC) = 38.7°C and voltage at maximum power point (Vmpp) = 31.40 V. We get lower value as per rated capacity.

SELECTION OF INVERTER

SMA, string inverter, 1000kw Sunny central choosen for this design. A total of 8 inverter is required with operating voltage of 596 – 900 V and input maximum voltage of 1000 V each. This combination will make 8000 kWac of gloval inverter poer against 10 MW of installed power with a temperature coefficient of – 0.38%.

Table 2 : Land use of Study Area

During Mining	Area (Ha)	Post-mining	Area (Ha)	
			OLU	**ALU**
Quarry	295.75	Plantation on backfilled area	160.54	160.54
		Void Filled with Water	135.21	135.21
External OB dump	95.24	Plantation on External Dump	95.24	75.25
		Solar PV Plant	0.00	20.00
Infrastructures	45.08	Public Use	45.08	45.08
Road/Vacant Land	85.25	Road in public use	4.40	4.40
		Green belt	27.5	27.5
		Undisturbed land	53.35	53.35
Residential colony	5.00	Residential Colony	5.00	5.00
Conveyer Belt	26.52	company use	26.52	26.52
	552.84		552.84	552.82

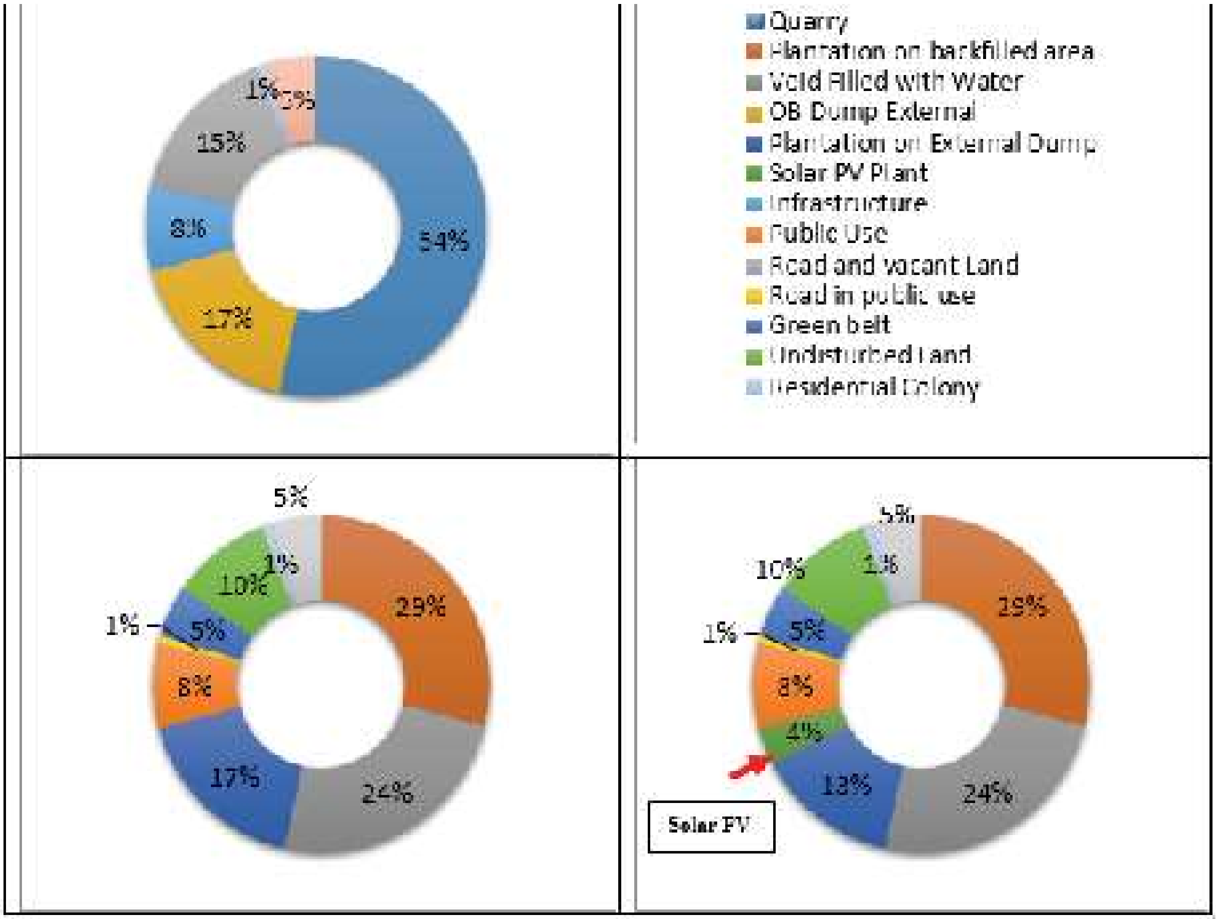


Fig.-3 : Land use

(Top left : During Mining, Bottom left : Post mining as per proposed MCP (OLU), Bottom Right : Post mining – Alternative)(ALU)

Table-3: Mine Closure Activity

S No	ACTIVITY	% OF TOTAL MINE CLOSURE COST
1	Dismantling of Structures	3.17
2	Permanent Fencing of mine void and other dangerous area	1.5
3	Grading of highwall slopes	1.77
4	OB Dump Reclamation	89.06
5	Landscaping	0.3
6	Plantation	0.72
7	Monitoring of parameters for three years	0.42
8	Entrepreneurship Development	0.26
9	Miscellaneous and other mitigative measures	2
10	Manpower cost for supervision	0.8
	TOTAL	100

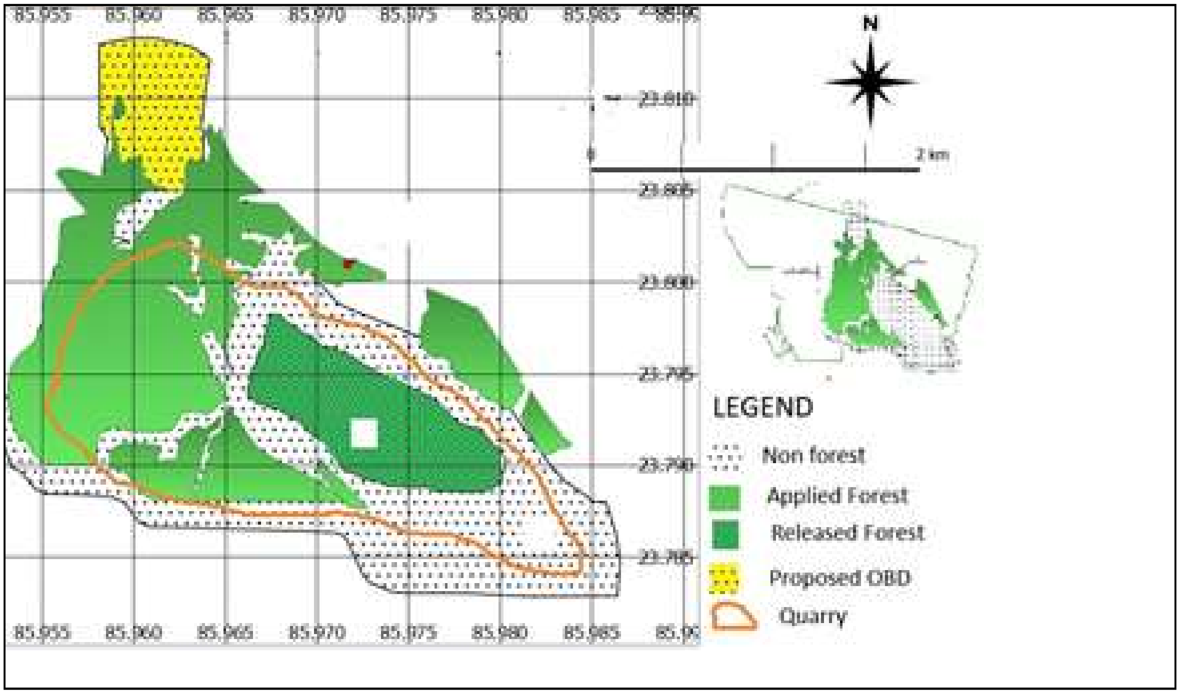


Fig.- 4 : Land use layout for ALU

DESIGN OF ARRAY

The array to formulate with 23 no. of module in series and 1581 strings in parallel with a total of 36363 number of module covering an area of 59519 m^2. The plane irradiance comes out to 100 W/m^2. Impp (STC) = 13908 A, Isx (STC)=14640 A at an operating condition of Vmpp(60°C) = 620 V, Vmpp(20°C)=737 V, VoC(-10°C) = 968V. This array will work on maximum operating power of 9024 kW at 1000 W/m^2 and 50°C. Array nominal power at STC will be 10000 KWp.

Different lossess in this model includes PV Array loss (Array soiling lossess, thermal loss, Ohmic loss, Module Quality loss, module mismatch loss,string mismatch loss) and Auxiliaries loss.

EFFECT ON ECONOMICS

The study area is an opencast coalmine. As per provisions of guidelines of MCP 2013, an escrow fund provisioning to be made for a minimum amount of Rs. 3317 Lakhs @ of Rs. 6 lakhs/ha and assuming no rise in wholesale price index. Considering life of mine to be 20 years, an annual corpus of 166 lakh and in total 5505 to be deposited up to the end of life of mine (Fig.-8). There is investment of Rs. 50.5 crores for the solar PV plant in 3rd – 5th yr (Fig -7).

Economic benefit from attaining the solar PV project its payback period i.e. after 8th year up to end of life is about 30 crores @ Rs.4.3 crores/yr from 14th year to 20th year (Table -4 & Fig. -7).

ALU will result into increased reimbursement opportunity before 25th year, the year up to which claim for reimbursement is to be made is to the tune of Rs. 10 crores over Rs.5.9 crores in original land use scenario (Table -3 and Fig.- 8).

EFFECT ON SOCIETY

From the assessment of societal benefit of the mine closure practice in ALU scenario it was

Table-4 : Economic benefit for ALU

Year	14th	15th	16th	17th	18th	19th	20th	Total
Amount in Rs Lakhs	430	430	430	430	430	430	430	3010

found that the society leaving in an around the study area will be benefitted by Rs. 4.3 crores / year after the end of activity of mine i.e. after 20th year in the name of profit earned by the project (Table-6). This is because the PV power plant, which was installed by the mine management, will be in control of the society and has 10 more years of its life.

Considering the norms for an average household consumption/month as 90 unit, a total of 6049 house hold will be getting clean electricity from the already installed by the mine management of the study area (Table-7).

EFFECT ON ENVIRONMENT

Rehabilitation process in ALU Scenario of the mine closure process after end of mining process in 20th year will result into 7114.4 tons of CO_{2e} per annum ie 0.7 lakh tons of CO_{2e} for the remaining life of the PV system and 1.8 lakh tons for whole life, which is 25 years (Fig.-9). This GHG reduction is equivalent to 634 Ha (=654.3-20) ha or 1567.5 Acre (1616.9-49.5) of plantation which would have absorbed the GHG.

RESULTS & INTERPRETATION

On comparing OLU & ALU it may be observed that ALU is a much better option and have effect on environment, Social and economic tradeoff. ALU scenario would restrict 0.18 Million tons of CO_{2e} @ 7114.4 tons of CO_{2e} per annum which is equivalent to 634 Ha of forest absorbing CO_2. Rehabilitation process will further benefit about thirty thousand population covering 9.33% of the household in the nearby community by providing clean energy to the tune of 6624.0537 MWh/year. Economic benefit may include Rs. 4.3 crores of revenue per year amounting to Rs. 30 crores for the mine management and Rs. 43 crores towards the communities after the closure of mine activities. This would facilitate the mine management to fund the corpus for escrow fund from 12th year itself amounting to Rs. 30 crores. ALU Scenario will result in increased reimbursement opportunity by Rs.10 crores over Rs.5.9 crores as of in OLU Scenario.

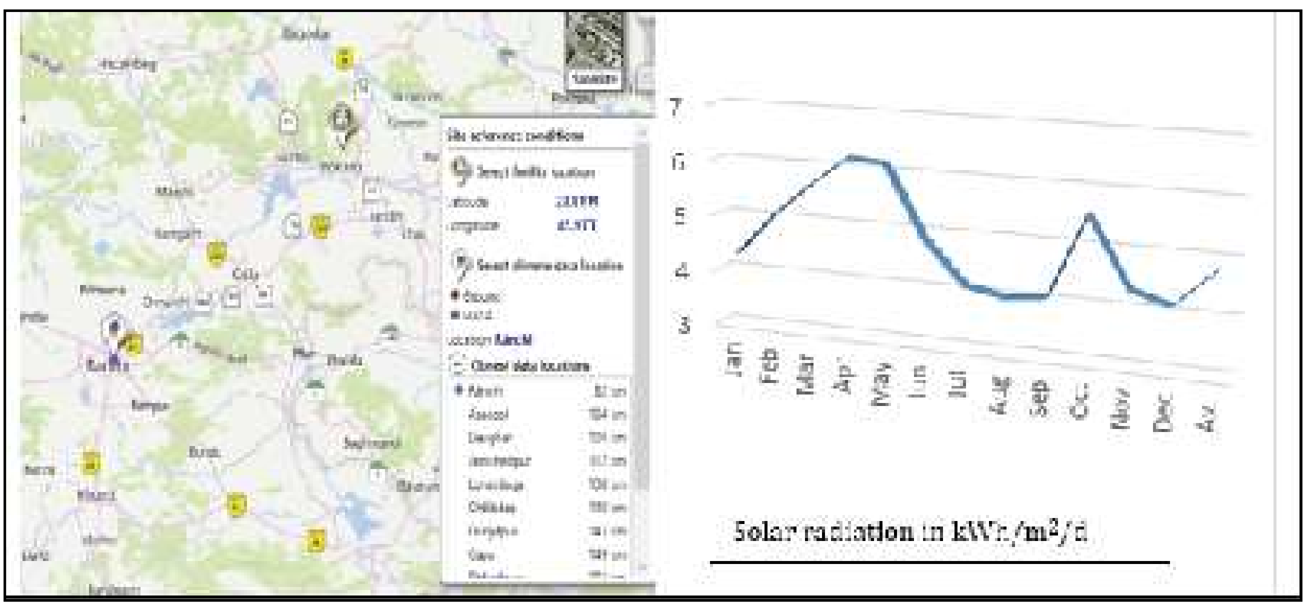


Fig-5: Site Reference Condition

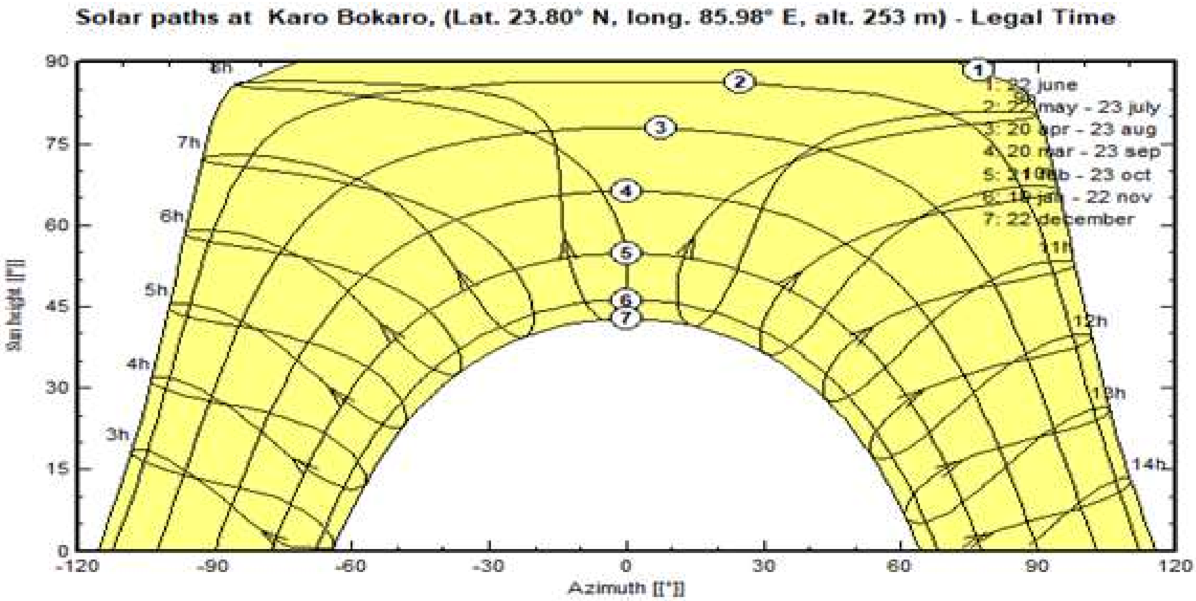


Fig.-6 : Solar path at facility data location

Table-5: Reimbursement Opportunity

Year	Reimbursement			Year	Reimbursement land use scenario			Year	Reimbursement land use scenario		Diff.
	OLU	ALU	Diff.		OLU	ALU	Diff.		OLU	ALU	
1st	0	0	0	8th	30	178	148	17th	31	33	2
2nd	0	0	0	9th	30	335	305	18th	31	33	2
3rd	0	0	0	10th	30	557	547	19th	29	31	2
4th	0	0	0	11th	30	32	2	20th	27	29	2
5th	0	0	0	12th	32	32	0	21st	25	27	2
5th	26	26	0	13th	34	34	0	22nd	26	28	2
7th	26	26	0	14th	34	34	0	23rd	26	28	2
				15th	33	35	2	24th	27	29	2
				16th	33	35	2	25th	31	33	2

Note:All figures in lakh, OLU Land use , ALU- Alternative Land use

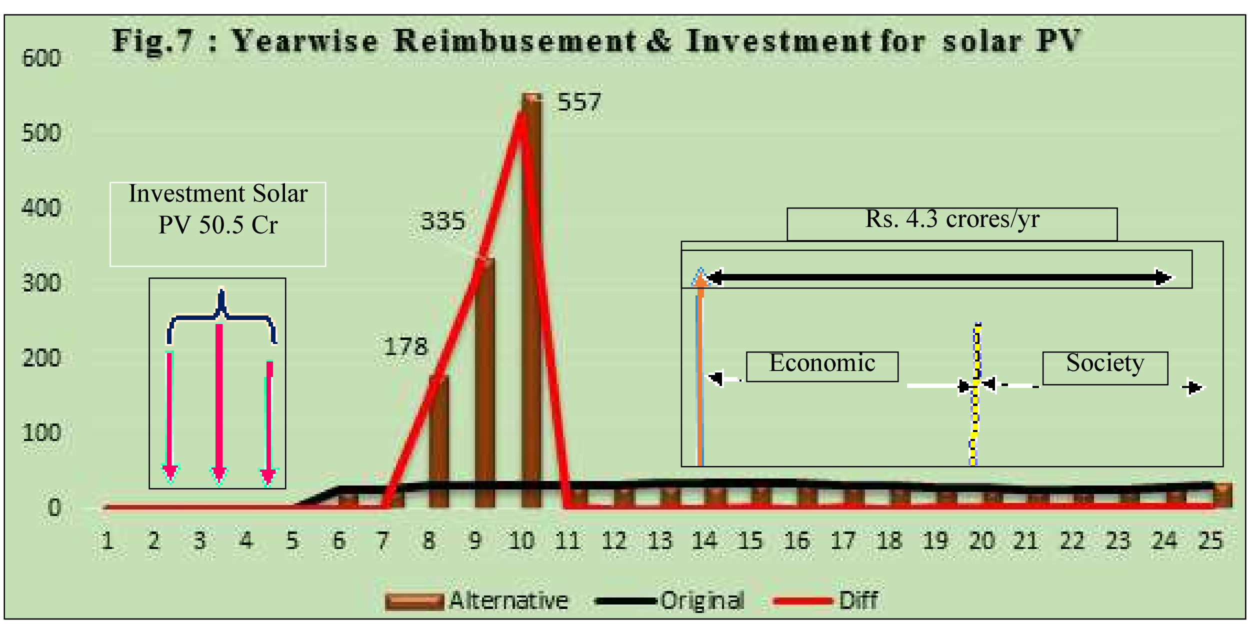


Fig.7 : Yearwise Reimbusement & Investment for solar PV

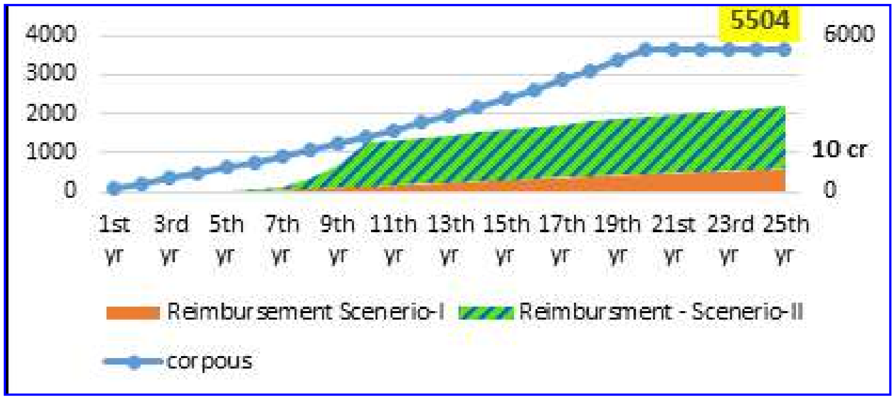


Fig-8: Reimbursement Opportunity

Table-6 : Benefits from solar PV Plant

Year	21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th	Total
Amount in Rs. lakhs	430	430	430	430	430	430	430	430	430	430	4300

Table -7 : Expected Societal benefits to the nearby population

Sl. No.	Description	Quantity	Unit
1	Avg Household Consumption/Month	90.00	KWh
2	Avg Household Consumption/Day	3.00	KWh
3	Electricity exported to grid/yr	6624.0537	MWh
4	Electricity Generation/day	18148	KWh
5	Total Household	64.835.00	Nos.
6	Total Household accommodated	6049	
7	% Of accommodation	9.33%	
8	No of Population benefitted	30246	

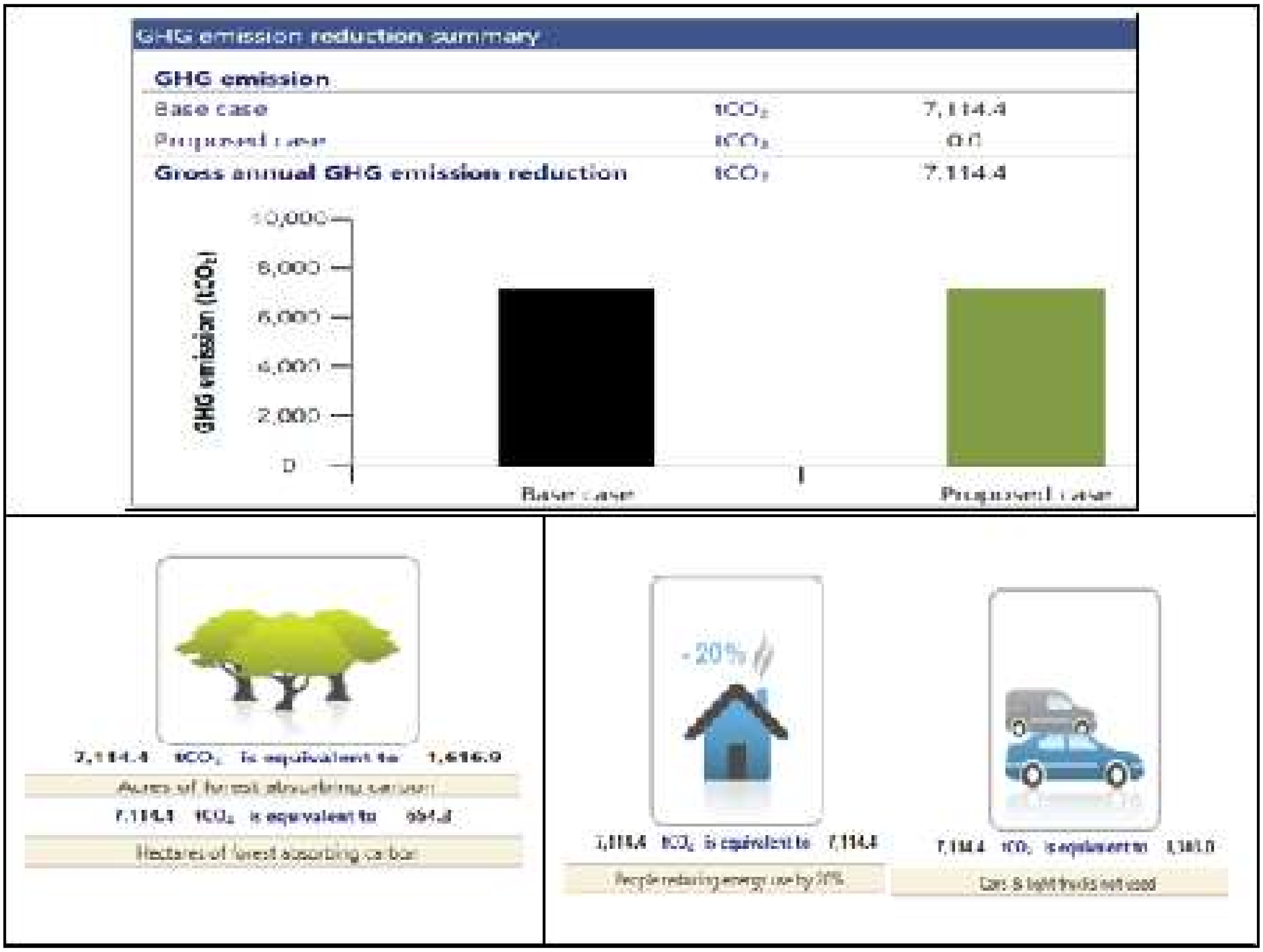


Fig.-9 : Annual GHG emission Reduction

IMPROVEMENT POSSIBILITY AND CHALLENGES

- The performance is directly proportional to different losses thereby reducing the losses; improvement in performance may be visible.
- Length of wire from inverter to injection point to be kept minimum.
- Length of wire between inverter to injection point ie from output of inverter to grid to be minimum. If length is more than facility of voltage step up is required.
- Module to be procured from the reputed supplier and must be readily available in the market for quality assurance.
- Transformer to be chosen for minimum transformer loss.
- Not expose the module to sun for long as performance degrade.
- Mismatch in string and module to be avoided.
- Incident angle modifier to be used.
- Module output be ensured more than 80% at the end of 25th year.
- Use different mode of tilt angle for different seasons / different time of day for better result keeping in mind the cost of operation part.
- While choosing technology and design of plant, project cost and land requirement to be considered.
- Number of inverter to be kept minimum for reduction in cost on inverter. However, for large inverter, its carrying to site and terrain of the area where to be installed are to be considered while designing the plant.
- As deposition of dust in India is more compared to other country, i.e. soiling loss is greater at Indian condition, so this loss is to be considered.
- Collection loss and system loss are to be

considered.

- The availability of electricity grid near the solar installation is an essential component, which needs to be provided by the concerned agencies.
- MOU/Agreements If required, need to be entered into among the beneficiaries / DISCOMs/ Distribution Licensees and the other involved parties.

CONCLUSION

Alternate land use plan for post-mining scenario for a mining complex situated in East Bokaro Coalfield of Bokaro District, Jharkhand has an edge over the original landuse being considered in the preparation of MCP. ALU is a much better option and it has beneficial effect on environment, Social and economic tradeoff. This study will help the researchers in deriving the energy systems under pathways limiting global warming to 1.5°C with limited overshoot (C4.2 IPCC-48). Societal and systems transitions and transformations in the MCP will help in limiting global warming to 1.5°C and provides a powerful tool to mine managers in resolving problems being faced in reimbursement of fund since targets to be achieved in progressive mine closure is not explicitly provided. ALU option have a positive impact on job creation also and can contribute to a more secure energy supply, although with some specific challenges. Improvement is possible in terms of technology & design of plants.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the all person for extending online and offline support for arriving at the objectives of this study. The views presented by authors are solely their interpretation. This paper is the extract of the presentation made by authors in 2nd International Conference on Business, Economics & Sustainable Development (ICBESD 2019) January 17-18, 2019 TERI School of Advanced Studies , New Delhi.

REFERENCES

- *Central Electricity Regulatory Commission, New Delhi (2016); "Determination of Benchmark Capital Cost Norm for Solar PV power projects and Solar Thermal power projects applicable during FY 2016-17"; Petition No. 17/ SM/2015; Date of Order: 23rd March 2016; pp. 1-31.*
- *Compendium Of Gazette Notifications, Office Memoranda Under Environment Impact Assessment Notification, 2006, MoEF&CC, Nov-2014, pp. 389-398.*
- *DEFRA. 2013, "Government GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors" (July 2013); Department for Environment, Food and Rural Affairs, London, pp 27-40 (www.gov.uk/defra).*
- *Edenhofe O, Madruga R P & Sokona Y (2012) "Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN)"; Summary for Policymakers A Report of Working Group III of the IPCC, ISBN 978-92-9169-131-9, pp. 1-246.*
- *Factsheet Mine closure process (overview of different phases and actions), Mineral intelligence capacity analysis pp 1-13. (http://data.geus.dk/MICASheets Editor/ document/25a37283-051e-423a-bf7d-c2dcb0596d44.*
- *Garcia D H (2008); "Overview Of International Mine Closure Guidelines" 3rd International Professional Geology Conference, Flagstaff, Arizona, USA, September 20-24, 2008.*
- *Jharkhand State Electricity Regulatory Commission (2018); "Order on Annual Performance Review for FY 2016-17 and Determination of Revised ARR and Tariff for the FY 2017-18 & FY 2018-19 for Jharkhand Bijli Vitran Nigam Limited (JBVNL)"; Ranchi 27.04.2018, pp. 24 of 210.*
- *IPCC, 1997. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual (3). Chapter 4: Agriculture. Intergovernmental Panel on Climate Change. Paris, France.*
- *Kumar M, Sangeeta and Thakur R (2018); "Off-*

Road Emission Factor For Side Discharge Loader & Load Haul And Dump Machines"; GENIUS ISSN : 2279-0489; vol VI, Issue-II, Part-II, Feb-Jul-2018, PP-50-63

- *Kumar Manoj et al. (2018); "Offsetting of electricity consumption by installation of rooftop solar panels : an opportunity in coal mining area", abridged proceedings of seminar volume : Technological Advancement and emerging mining methods, 24-25 Aug. 2018, pp.42.*
- *Kumar Manoj, Sangeeta, Thakur R & Das A K (2018); "Harnessing Solar Energy by Utilizing Rooftop Space of mining complex in coal mining area of Ramgarh District, Jharkhand", International Conference on Environmental Challenges and Sustainability"; 31st Oct- 2nd Nov 2018; pp. 221.*
- *MoC circular No.55011-01-2009-CPAM dated 07.01.2013 on "Guidelines for preparation of mine closure plan-Reg"; pp 1-12.*
- *MoC circular No. 55011-01-2009-CPAM dtd. 27.08.09 on "Guidelines for preparation of mine closure plan-Reg"; pp 1-12.*
- *Prno J. (2013). An analysis of factors leading to the establishment of a social license to operate in the mining industry. Resources Policy, Volume 38, Issue 4, p. 577-590.*
- *Sellers R & Vogel P (2015); "Guidelines for Preparing Mine Closure Plans, May 2015"; DMP & EPA; Government of Western Australia; pp. 1-100.*
- *United Nations Environment Programme, United Nations Development Programme, Organization for Security and Co-operation in Europe, and North Atlantic Treaty Organization (2005). Mining for Closure, Policies and Guidelines for Sustainable Mining Practice and Closure of Mines; pp. 97(ISBN: 82-7701-037-0)*
- *https://coal.nic.in/content/guidelines-preparation-mine-closure-plan-3.*
- *https://Moef.gov.in*

NOTICE TO THE AUTHORS

As per the decision taken, the payment of honorarium to the authors whom articles are published in this magazine through multi -city cheques has been stopped. In future, it will be done through NEFT/RTGS only.

As such authors are requested to submit the following details alongwith their articles :

Name of a/c holder-
Name of bank-
Bank account no-
IFSC Code-
Mobile no/e-mail id-

Authors are also requested to send only unpublished articles for publication in 'Minetech'.

Single Lift Thick Seam PSLW Operation in India and Crossing a Fault in Such Operation

*M. P. Dikshit**

SYNOPSIS

After nationalization of Indian Coal Mining Industry, there was attempt to extract moderate seams using powered support Longwall (PSLW) with heavy duty equipment to boost u/g production.

The first trial for such thick seam single lift (4.5m) extraction was at Kottadih Project (ECL) in July 1994 using 2×2340 KN (2×468Te.) Shield type French supports.

Subsequent extraction of thick single lift extraction with 2×11000KN (2×1100Te) Shield type Chinese supports at Jhanjra Project was Commissioned in Aug'2016.

The unique operation of single lift (5.5m) extraction at R-VI seam, Jhanjra is continuing successfully improving the mine economics. The PSLW equipment had to cross a down throw normal fault of 4.0m during operation. With the experience of panel-1, where the equipment was to be shifted to new installation chamber, 2nd Panel operation continued without such shifting but scientifically planning the fault crossing along with coal wining operation.

INTRODUCTION

Thick Coal seams were extracted in lifts in our country where recovery was far below the expectations. As a result, problem of spontaneous heating and incidence of early sealing of working districts were frequently experienced while extracting thick seams.

A Coal seam is termed as thick when it is not convenient to work in single lift and in our country it is usually 4.0m or so. In many cases thick seams extracted in Slices in-conjunction with hydraulic sand stowing in ascending order incurring additional expenditure towards stowing. The main difficulty is suitable support for single lift high seam

* *Professor, Mining Engg Deptt, IIT Kharagpur (W.B.)*

extraction.

Powered support longwall (PSLW) was first commissioned in India at BCCL's Moonidih Project (1978) and subsequently in other Coalfields where all workings were around 3.0m in thickness. The single lift 4.5m Coal extraction was first at Kottadih Project (ECL) from its 5.4m thick R-III/II (Samla) seam in 1994 and then at Jhanjra Project to extract R-VI seam for a thickness of 5.5m. in 2016. All the faces were with shield supports and befitting L/W equipment. At Kottadih the immediate roof was massive sandstone and the support suffered from its inadequacy in the Geo-mining conditions prevailing there.

The Jhanjra Longwall (L/W) is working satisfactorily without much of strata control problems but the 4.5m. down-throw fault at mid panel was a major constraint and was dealt for its safe crossing without stopping coal wining operation in L/W Panel 2.

Such single lift high seam L/W extraction is only possible for development of suitable high capacity powered supports in the glove where both safety and conservation are well attended.

PSLW OPERATION IN THICK SEAM SINGLE LIFT L/W EXTRACTION IN INDIA

There were only two thick seam single lift L/W projects in our country. The salient features of both Kottadih (4.5m) and Jhanjra (5.5m) high seam L/W projects are mentioned in Table-1.

Table-1. Relevant Information on PSLW Operation in Thick Seam Single Lift L/W Extraction

Sl.No	PSLW equipment	Single Lift 4.5 m. extraction (Kottadih)	Single Lift 5.5 m. extraction (Jhanjra)
1.	**Power Support**		
	a. Model	W.S.1.7-2.2/4.7 (Shield type), France	ZY11000/26/56 (Shield type), China
	b.Operating Range	2.2-4.7 m	2.6-5.6 m
	c. Shield travel/stroke	800 mm	800 mm
	d. Width of base frame	1.25 m	1.65 m
	e.No.of Leg	2 (Double Telescope)	2 (Double Telescope)
	f.Dist.Between shield	1.50 m	1.75 m
	g.supportresistance i.At.setting pressure ii. At yield pressure	 3941 KN (32 Mpa) 4926 KN (40 Mpa)	 7916 KN (31.5 MPa) 11000 KN (43.8 Mpa)
	h.Aprox. Support Resistance(Te/m^2)	82 Te/m^2	148 Te./m^2
	Before cutting		
	After cutting	68 Te/m^2	128 Te./m^2
2.	**Shearer**		
	a.Drum dia	2.34 m	2.80 m
	b.Max.cutting ht.	4.5 m	5.5 m
	c.Elec.Motor power (water cooled FLP,1100 V contrating	540 KW/1100 V	1480 KW/3300 V,(2x650 KW cutting , 2x75 KW Haulage, 30 KW pump)
	d.Usual depth of web	800 mm	800 mm

3.	**Armored face conveyor (AFC)**		
	a. Length	150 m	145 m
	b. Capacity	1200 tph	1800 tph
	c. Installed power	2x300KW/1100 V	2x400Kw/3300v
	d. Chain Speed	0.95 m/s	1 m/s
	e.Chain (2. in board)-hyd. tensioning	30 mm x108 mm	34 x 126 mm
	f.Fan (lengh x width x ht) 40 mm Deck plate	1500 mm x 880 mm x286 mm	1750 mm x 900 mm x 308 mm
4.	**Stage Loader**		
	a. Length	45 m	40 m.
	b. Capacity	1200 tph	2000 tph
	c.Chain Speed	0.75 m/sec	1.83 m/sec
	d. Power rating	2x110KW/1100V	315 KW/1100V
5.	**Electrical**		
	TSU (Trans Switch Unit)	3 nos, 1MVA each (6.6 KV/1.1 KV)	7 TSUs – 5 Nos. 6.6 KV/3.3 KV -2nos. 315 KVA
6.	**Gate Belt Conveyer**		
	a. Capacity	1200 tph	1600tph
	b. Belting (PVC)	1200 mm	1200mm
	c. Power Rating	2× 110KW/1100V	2× 280KW, 6.6 KV/1.1 KV
7.	**Ancillaries**		
	a.Power pack	3 nos. Hauhinco (Germany) 320bar/180lpm & 110 KW, stroke 50 mm	3 nos. Chinese 29 Mpa, 250 KW 290bar/flow-400 Lpm.
	b. Crusher	1 nos. on stage loader, 110 KW, Inlet - 850 mm × 850 mm	250KW/1.1 KV Inlet-900mm ×800 mm
	c. Booster Pump	Within 40 m of face 450 lpm (400 lpm -spraying , 50 lpm - motor cooling)	Within 40 m of face, 315 lpm, 45 KW motor.
	D.Misc.	115V – face lighting and communication ckt.	110 V - face lighting and communication ckt.
8.	**L/W Panel Development**	With 4 (Four) sets of drivage equipment. Each set – 1 R/H (Alpine) + 1 LHD (3 Cu. m) +1hyd. roof bolting m/c. Av. drivage-8m. / Day / Set	With 2 sets of drivage equipment. Each set – 1 R/H (Chinese) 160 KW/1.1 KV with bridge conveyer+1Hyd. roof bolter (MYT-150/1320) for roof bolting. Av. drivage-10m. / Day / Set

9.	**Man and material haulages**	a.Man riding - chair lift (2.5 m/s) side bye belt ckt. (Fig. 2) b.Coal evacuation – series of belt (PVC-1200 mm) conveyors - 6.5 km & steel cord belt (1200 mm) at main incline. 2 – Strata bunkers One -500 Te another 1200 Te. capacity. Surface handling by CHP till wagon loading at Rly siding. c.Material input by rope haulage ckt from surface to L/W face.	a)Man riding-Diesel vehicle in u/g. b)Coal evacuation - series of belt (PVC-1200mm) conveyors-3.5 km & steel cord belt (1200 mm) at main incline. U/g bunker – One 800Te, another 500Te presently in use. Coal handling at surface by truck loading from belt discharge to Rly siding. c)Material input earlier by rope haulage ckt, now by Multi Utility Vehicle (MUV) to L/W face.
10.	**Monitoring System**	Continuous monitoring of major surface and u/g installation by APEM (Automatic Programmable Engine Monitors). Installations covered - Main mechanical ventilator, main haulage and all belt conveyor ckt, CHP, Main Pumps, s.stns. (U/G + surface), Man riding system, TSUs, U/G H.P. Stn. (Power pack + compressor),Long wall complex. Information collected by the sensors fed to surface control room which instantly displayed on the screen & recorded for future reference. Remote monitoring for status of equipment at any time and also the mine environmental condition (CO, CH_4, air Quantity) Main mechanical ventilator	No such Remote monitoring system is operating for similar equipment & environmental assessment and recording. All information are collected though telephonic network and CDS system also from surface to all u/g working places/ major installations/office. Mine working with Deg. -1 coal seams, hence automatic environment monitoring is yet to be commissioned.

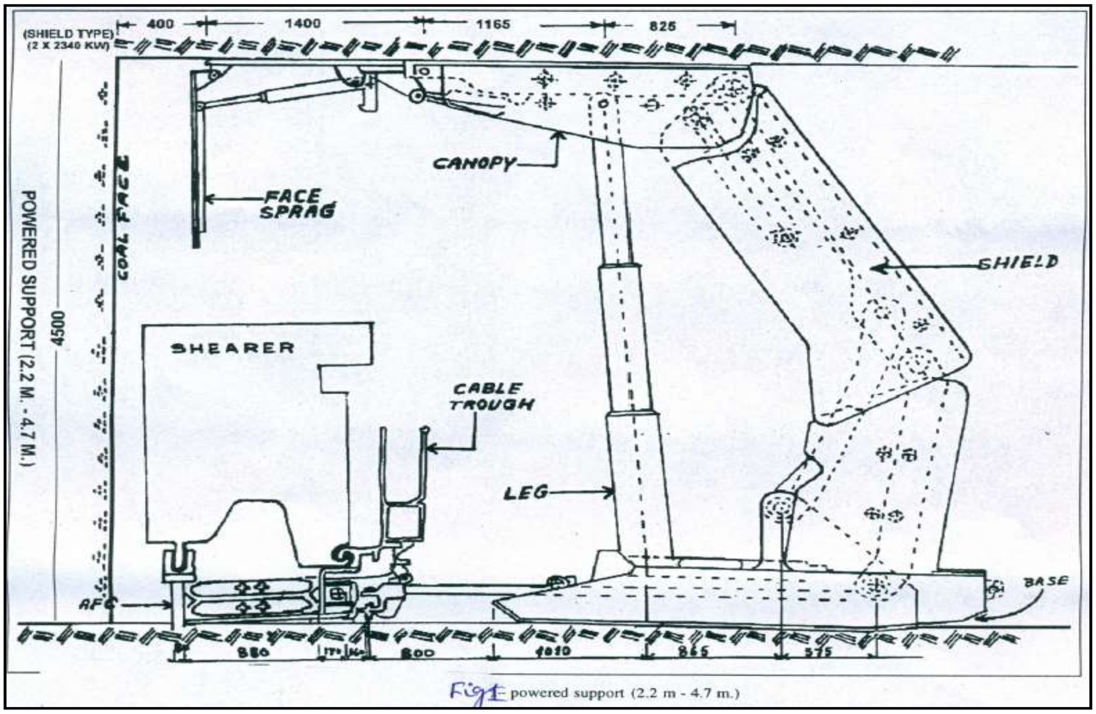


Fig: 1a. P/Support (2.2 m-4.7 m), 2×2340KN (2×468 Te-Capacity) Shield (Canopy 3.39m×1.25m) at Kottadih.

5.Specification for Two-legs shield support		
5.1	Model of Support	ZY11000/26/56
5.2	Support height range	2600 ~ 5600mm
5.3	Support center distance	1750mm
5.4	Support width range	1650~1850mm
5.5	Support yield load @ 43.8Mpa	11000kN
5.6	Setting load @ 31.5Mpa	7916kN
5.7	Support density (f=0.2)	1.34 ~ 1.37Mpa (H=3.5 ~ 5.4m)
5.8	Average pressure against floor	2.98 ~ 3.02MPa
5.9	Hydraulic system pressure	31.5Mpa
5.10	Applicable coal seam dip angle	≤15°
5.11	Operation mode	Manual control
5.12	Weight	Around 35t
5.13	Support dimension for transportation	7760x1650x2600mm (LxWxH)
5.14	Legs	2
	Type	Double telescopic
	Cylinder diameter	400/290mm
	Rod diameter	380/260mm
	Stroke	2945mm
	Setting load @31.5Mpa	3957kN
	Yield load @43.8Mpa	5500kN
5.15	Advancing ram	1
	Cylinder /rod diameter	180/120mm

6

Fig: 1 b. P/support 2×11000KN Shield (Canopy-5.5 m × 1.75 m) at Jhanjra

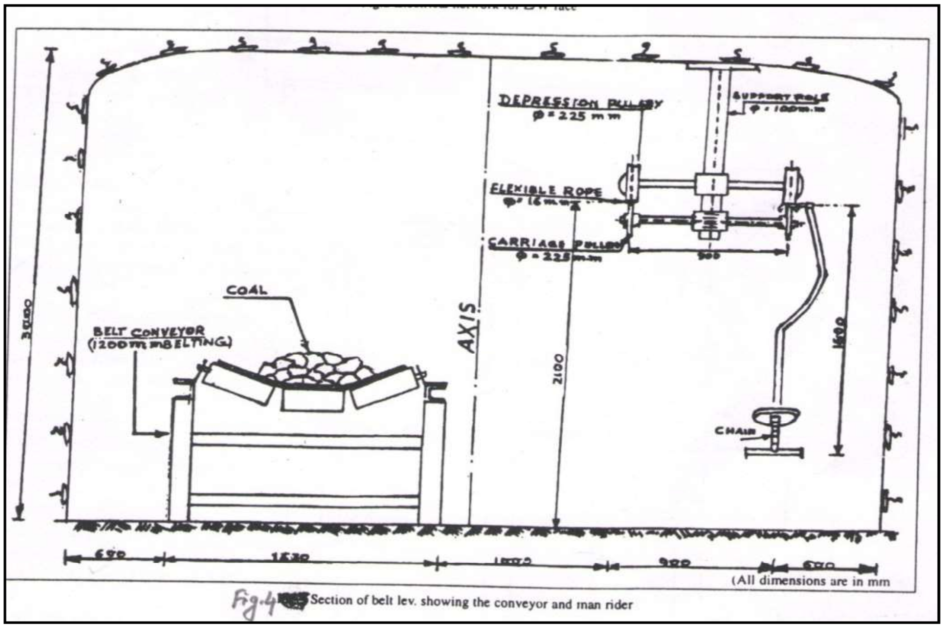


Fig: 2. Section of belt level showing the conveyor and man rider at Kottadih

Table: 2. Panel-wise Operating Parameters and Performance

SL.No	Information	L/W Panel-1	L/W Panel-2	L/W Panel-3	Remark
(a)	Operating tenure	26.7.94 to 6.2.95	5.5.95 to 31.1.96	28.3.96 to 3.4.97	Size of panel subsequently increased.
(b)	Active prodn. period	4.8.94 to 14.2.95 (139 days)	10.5.95 to 15.1.96 (243 days)	5.4.96 to 18.9.96, 20.1.97 to 9.3.97, 25.3.97 to 3.4.97	Panel-3operation considered till 8/9/96 and initial teething period, salvaging duration is eliminated.
(c)	Prodn. for the period (Cl.6)	4.42LT	6.78LT	5.05LT	Total L/W prod. during the period.
(d)	Total coal in the panel	4.60LT (extracted)	6.7LT (extracted)	7.0LT (5.5LT extracted) 5.25LT	
(e)	Maxm. Prodn. in a month	1,16,000 Te	1,05,100 Te	1,10,750 Te	
(f)	Maxm. prod. month TPD	Dec' 94/4300 TPD	Dec' 94/4100 TPD	Aug' 96/ 3700 TPD	
(g)	Maxm. prod.in a day	7,100 Te (28.12.94)	10,120 Te(14.12.95)	6500 Te (29.5.96)	Panel-2 was operated for 22 hrs. on the day for production.
(h)	Panel size	628m×120m	790m×150m	880m×120m	

(i)	L/W system utilization	51%	43%	50% (up to sep.8, 96)	Production time availability in prod. shift excluding 6 hrs. planned stop-page in maintenance shift.
(j)	Maxm. down time of particular equipment in the prod. system	24%	20%	30%	Trunk coal evacuation net-coal haulage.
(k)	Ht. of extraction	4.5m	4.5m	4.5m	
(l)	**OMS**				
	(i) L/W Dist. Max. Minimum	 28.6 8.33	 26.31 7.48	 25.31 7.25	L/W dist. O.M.S (Min) considerably low for the salvaging preparation tenure with wire net laying and one cycle of cutting per day
	(ii) O/All Max. Minimum	 4.60 1.80	 4.30 1.84	 3.50 1.61	In Nov'95 L/W panel-2 stopped for 21 days and panel-3 stopped for 22 days in Sep' 96
(m)	**Cost parameters**				
	(i) E.M.S (Rs.) (ii) Av. cost of prod. (Rs.) (iii) Net sale value (Rs.) (iv) Cost of store/ spare (v) Profit/Loss (+) (-)	257.12 525.89 678.78 Rs. 59.60 Rs. 152.89 (+)Jan'95	294.97 945.14 764.03 93.85 Rs. 181.11 (-) Jan'96	351.11 1005.57 967.15 166.51.97 Rs. 638.42 (+)Sep'96	Av. EMS of project personnel Av. fig. in per Te. basis complied for the operational period of L/W panel

LONGWALL PERFORMANCE

A) At Kottadih Project (4.5 m extraction)

The L/W equipment was first commissioned for production in Panel – 1 in July'94 and subsequently in 2nd & 3rd Panels in the same RIII/I (Samla) seam. The panel-wise performance of the L/W operation is given in Table-2.

B) At Jhanjra Project (5.5m extraction):

- PSLW was commissioned from Aug'16
- Delayed for forestry clearance.
- A unique L/W operation & 1st time in the history of PSLW operation in the country.
- Total no. of support =83(2×1100Te each)
- Face Length – 145, Av. coal prod. 6000TPD
- Max. prod. on a day 8600Te.
- O.M.S (L/W) = 21, O.M.S (mine) = 4.12

Av. CPT – Rs.2740/- (Approx)
Av. Sale Value (CPT) – Rs.2940/- (Approx)
Av. Profit/Loss (CPT) – Rs.200/-(Approx)

The above figures relate to the 1st L/W Panel operated at mine in R-VI seam.

Mine performance achieved in the F.Y 2017-18

Technology	Production (Million Tonne)
L/W	– 1.48
Cont. Miner	– 1.22
R/H	– 0.16
Others (SDL+LHD)	– 0.30
Total	3.16 Mte.

of overlying roof rock rated the roof to be **"cavable with difficulty"** for the existence of 40 to 60m massive hard M.G. to C.G sandstone in the caving height. The RQD of roof rock was around 93% and avg. length of core was 18.6 Cm, av. comp. strength 310 kg/cm2 and modulus of elasticity to the level of 5.94 x 103 to 6.14 x103 Kg/Cm.2 where such sandstone was around 90% in the caving height of the roof.

The operation of successive 3 (Three) L/W panel in the mine helped to gain sufficient strata control information's for equipment operation under similar geo-mining condition.

Table: 3. Month wise L/W Performance in Panel – 2 (R-VI seam)

MONTH	PRODUCTION (Te)	AV. PRODUCTION(Te/Day)
Oct'17 (started on 12th Oct'17)	**63415**	3523
Nov'2017	**151880**	5063
Dec' 2017	**194575**	6486
Jan' 2018	**203455**	6782
Feb' 2018	**205550**	7341
Mar' 2018	**210230**	7008
Apr' 2018	**72800***	

** In April 2018, Fault crossing, so local production some extent affected*

Production Projection for 2018-19 (Jhanjra Project)

L/w + R/H	– 1.70
C.M	– 0.86
LHCM/LCCM	– 0.63
Others (SDL+LHD)	– 0.31
Total	-3.50 Mte.

The mine will have better performance subsequently with higher productivity, less cost/Te. & higher profitability by achieving its annual built up capacity of 3.50 Mte.

OVERLYING STRATA AND SUPPORT BEHAVIOR

A) At Kottadih Project (4.5 m extraction)

PSLW operation greatly depends on characteristics and cavability of overlying strata. At the particular locale the physico- mechanical properties

In fact there was inhibited caving and apparent goaf filling seemed to be satisfactory. But dynamic behavior of upper sandstone roof in the caving height and severe weighting with convergence beyond the characteristic values in all the L/W panels could not be ruled out during operation. Though there was no major air blast till strata control problem was met after a certain area of exposure ranging from 80,000 to 90, 000 sq.m. The strata behavior, weighting on supports, their periodicity, no. of supports attended, bleed pressure etc. during operation of L/W panels are shown in Figs.-3a, b & c. Figure inside the brackets gives the number of supports attained bleed pressure during weighting.

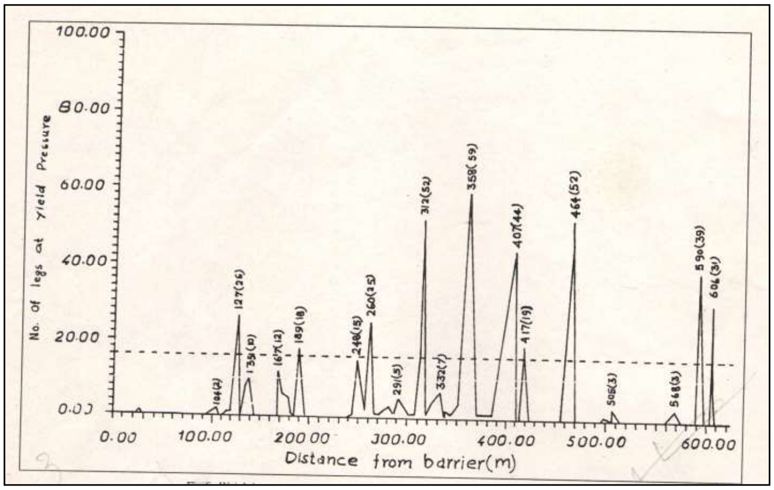


Fig-3a: Weighting on supports at various face positions - Panel-1. Kottadih Project

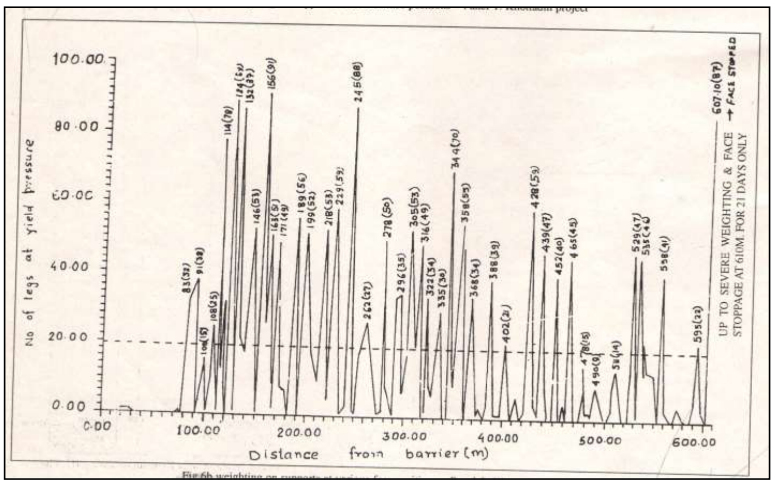


Fig- 3b: Weighting on supports at various face positions - Panel-2. Kottadih Project

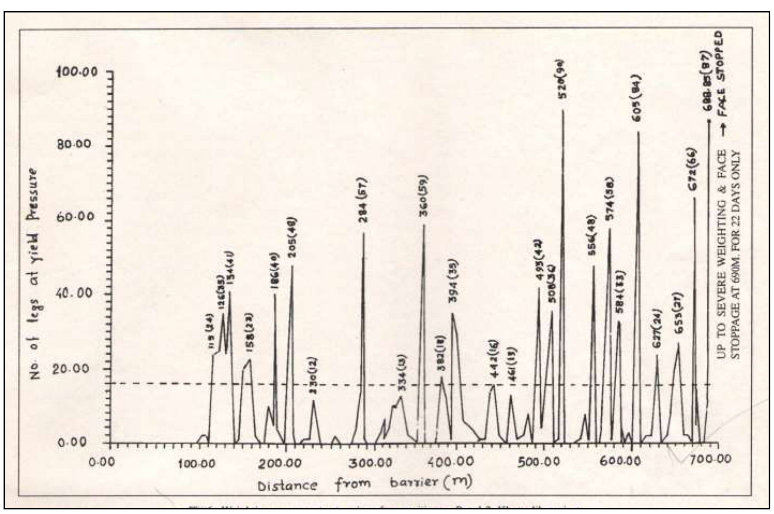


Fig-3c: Weighting on supports at various face positions - Panel-3. Kottadih Project

The observation on strata and support behavior, surface subsidence etc.are tabulated below:

Table-4: Strata and Support Behaviour during Longwall Operation

Sl. no.	Operational activities/information.	Longwall panel LW panel 1	LW panel 2	LW panel 3	Remarks
1.	Commissioning of L/W panel	7/94	5/95	3/96	L/W panel-2 commiing delayed for failure of salvaging chamber in panel-1. Fresh chamber to be established.
2.	Total no.of PS &(Av No.of PS reached bleed pressure during weighting)	82(35)	100(47)	83(41)	
3.	Yield & setting pressure of PS (bars)	380 (setting at 84%)	380 (setting at 84%)	400 (setting at 80%)	Support capacity was enhanced around 5% in consultation with manufacturer in Panel-3
4.	Load density at the face.				
	(a) At nominal setting load	69 te/sq m	69 te/sq m	69 te/sq m	
	(b) At nominal yield load				
	(i) Before shearing	82 te/sq m	82 te/sq m	86 te/sq m	
	(ii) After shearing	68 te/sq m	68 te/sq m	72 te/sq m	
5.	Span at 1st weighting	104 m	83 m	115 m	Total retreat from barrier.
6.	Caving periodicity.				
	(a) Av.caving interval	29.5 m	13.45m	23.87m	
	(b) Std deviation	16.73	6.32	11.87	
7.	Abnormality in strata behaviour	Sudden excessive convergence and separation of roof rock at the face			Severe weightings even huge separation of immediate roof and sometimes big boulders on AFC In Panel-1 on two occasions, at 590 m retreat (shield 40 to 59 = 30 m) & at 608 m retreat (shield 20 to 30 = 15 m). Supportd effected in Panel - 2 & 3 were from shield 24 to73 (70 m) and from shield-1 to 60 (80 m) respectively.
	(a) Mxm.convergence on supports during weighting	1.5 m	1.5 m	1.8 m	
	(b) Face retreat	590m & 608m	610 m	688 m	
	(c) Zone of influence	30m & 15m (midface)	70 m (midface)	80 m (from main gate)	
	(d) Maximum convergence at gate road (M/gate)	5mm (20m from face)	4mm (20m from face)	5mm (15m from face)	
8.	MLD developed during severe weighting on supports	65 te/sq m	77 te/sq m	82 te/sq m	Severe weighting with excessive convergence zone subsequently increased from panl-1 to 2&3.
9.	Barriers between the panels	60 m	60 m	30 m	Centre to centre with roadway of about 5m width and excessive spalling in barrier noted in Panel-3 for its inadequate thickness.
10.	+ve set valve operation	-	operative	operative	
11.	Defective legckt/ hyd.leakage at any time.	5%	7%	6%	Leakage of support legs maintained below 10% in all the Panels.
12.	Retreat caused surface effect	590 m	350 m	380 m	Total retreat from barrier.
13.	Av.depth of extraction	200 m	190 m	170 m	Depth of panels subsequently decreased for existence of synclinal fold in the coal seam.
14.	Subsidence :				Subsidence measurement till Sept'96 and further increase is likely in Panel-3
	(a) Angle of draw (Dip/rise - max./min.)	15deg.15'/ 21deg.30'	15deg/24deg	18deg 25'/ 24deg	
	(b) Maximum subsidence	1.50 m	1.644 m	1.40 m	
	(c) Subsidence factor (s/m)	0.34	0.37	0.35	

B) At Jhanjra Project (5.5 m. extraction)

The first such PSLW operation was executed in Aug'16 at Jhanjra Project to extract 5.5m thick coal from R-VI seam using heavy duty Chinese equipment with shield support and continuing now satisfactorily. Overlying strata consisting immediate roof of the seam is shelly sandstone, mostly C.G to F.G and rated as **"cavable with difficulty"** but striations in the formation is helping usual caving of roof during long walling. The RQD of the roof rock is 80%, Av. length of core is 15 Cm, Av. compressive strength – 300Kg/ cm^2 and weighted tensile strength around 48kg / cm^2.

Initially to avoid overhanging of roof and main weighting without difficulty a notch was created behind the power support at the installation chamber by blasting 100 holes, 10m in depth (charge 8/9 Kg/hole). The blasting of the above holes for the said notch was carried out after initial advance of 4m of the L/W face which subsequently helped caving.

During PLSW operation the following strata behavior noted at Jhanjra with 5.5m extraction in R-VI seam.

- Main weighting = 79m.
- Weighting intervals = 15-20m. (Periodic weighting).
- Av. load developed during operation = 90Te. /m^2
- After crossing a fault, Mean load density = 80-85Te. /m^2.
- No leakage in leg Ckt.
  All the above relates to the L/W panel 1 operation in R-VI seam at Jhanjra Project.
- No such strata control problem was met during L/W extraction in Panel-1 and also in the presently operating Panel-2 at the mine.

The 5.5m single lift extraction, first time in the country with highest capacity shield type powered support (2×1100Te) where support resistance was 148 Te./Sq.m-ever used in India.

Only one L/W panel has been completed and 2nd one is continuing hence, after completion of 2/3 panels more information will lead to better understating of the strata and support interaction at the particular mining condition at Jhanjra Mine.

SAFETY PERFORMANCE OF SINGLE LIFT HIGH SEAM PSLW AT JHANJRA PROJECT

After introduction of PSLW for 5.5m. single lift extraction at the mine, the safety statistics got significantly improved also. Though the fatality rate remained 0 (zero) but the serious injuries per 1 Lac manshifts worked reduced to 0.3821 in 2016

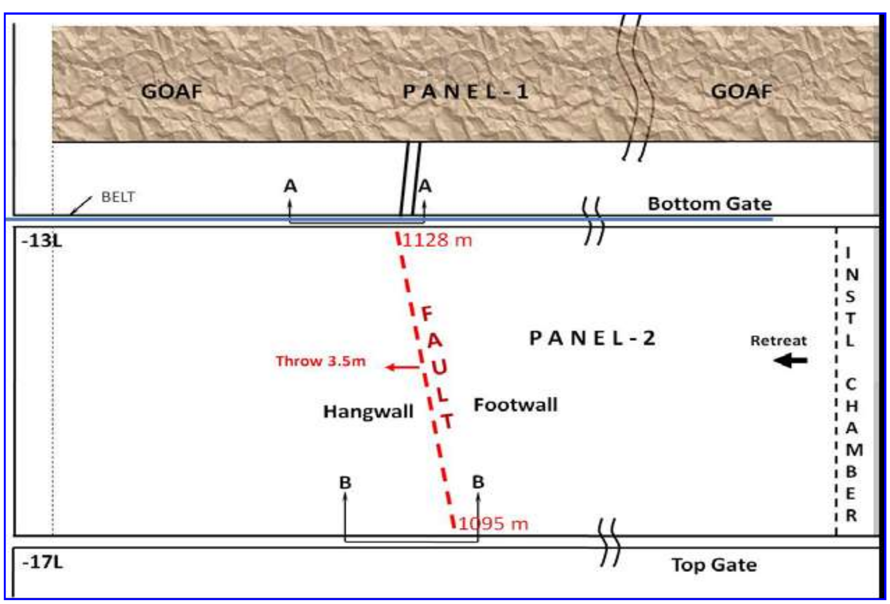


Fig.-4: Longwall Panel-2 and the Position of F0-F0 Fault

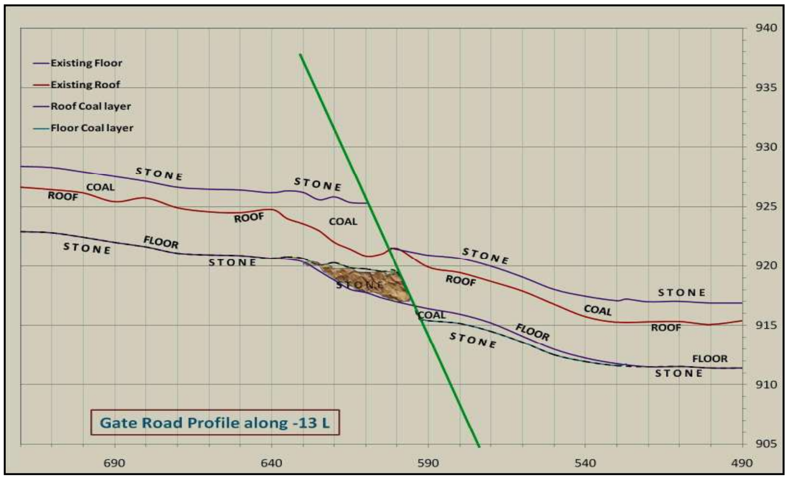


Fig.- 5: Gate Road (Section A-A of Fig.4) and Stone Excavation during Development (-13L main gate)

Fig.-6: Gate Road Section (Section B-B of Fig.4) and Stone Excavation during Development (-17L tail gate)

from 0.5257 in 2015 and that for million tonne coal output had significant reduction and came to 1.455 in 2016 from 2.712 in 2015. The severity Index reduced to 0.3821 in 2016 from 0.5256 in 2015.

The serious injuries per 1 Lac man-shifts worked and that for Mte. of coal output was 0 (Zero) where the severity Index was 0 (Zero) too as there was no serious and fatal accident in the year 2017 at the mine. L/W is safe and successful in India if right capacity/type Power Support is selected suiting to the particular Geo-mining conditions.

Crossing of Fault

The L/W Panel-2 at Jhanjra is operated adjacent to the first L/W panel (Panel-1) already extracted and located on the immediate rise side of Panel-1, in a dip-rise face orientation and retreat towards strike. The average dip of the coal seam is 1 in 16, S48^{0}E direction. The fault (F_0-F_0) was first encountered at one gate and subsequently in the other gate (gate road shown in Fig.-4) of the panel. While negotiating the fault, effective supporting at the gate roads and also at operating longwall was ensured to avoid roof degradation while crossing the disturbed area in the fault zone. The development sections of both main and tail gates at fault sites are shown in Fig.-5 and Fig.-6 respectively.

The Fault

The normal fault having an average down throw of 4.0m was towards out-bye of the panel. The

L/W face was to cross the fault while in operation with stone intrusions and downward displacement of the coal seam at the fault site/area.

As such the working height of coal seam was much reduced in the zone, either ends of the fault as shown in Figs.-5 and 6. The purpose now was for reduction in stone cutting to the minimum for maneuvering thickness of operation of powered supports.

The working thickness of 3.0m at the time of negotiating the fault with PSLW equipment during its operation was possible to cross the fault zone. The height and width of gate roads were around 3.8m and 5.3m.

Negotiating the fault with PSLW operation

The horizon maintained for operation is clearly mentioned in Fig. 7 & 8. The thickness of coal was 4 to 5.5m and that at either side of the fault plane was at 5.0m with a displacement of 4.0m where the fault plane is with an angle of around 58^0, thus the zone including the fault plane will cover around 15 to 20m. The cutting of roof/floor stone was for a maximum of around 1.2m thickness which may decrease to 0.10m in the zone by operating the powered supports at its minimum working range with required minimum hydraulic travel to maintain operational safety.

The stone cutting by shearer at different sub-zones and its exact thickness of cutting in the above quoted fault zone (15 to 20m) was decided at the time of operation at the fault site with due consideration on operational convenience while crossing the fault. However it was convenient to cross the fault continuing coal production with PSLW equipment by proper planning.

The steps taken at Gate Roads while crossing the fault

The following advance actions were taken up at the site before crossing the fault.

(A) Main Gate/Bottom Gate (-13L)

There was cutting of floor stone ranging from 2.5m to 0.3m during development of the gate road. However, longwall extraction was conducted with minimum stone cutting by shearer during long walling and maneuvering of the PSLW equipment in the fault area while negotiating the F0-F0 fault.

1. At the fault plane where it crosses the roof, height of extraction was restricted to as minimum as possible considering respective work-

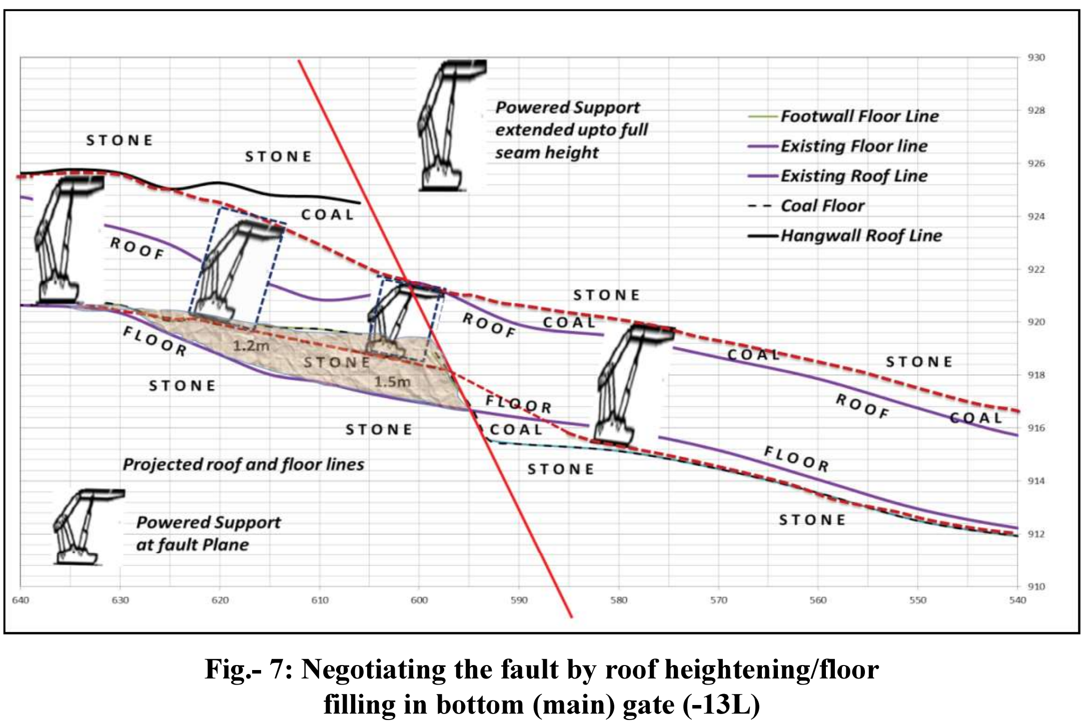


Fig.- 7: Negotiating the fault by roof heightening/floor filling in bottom (main) gate (-13L)

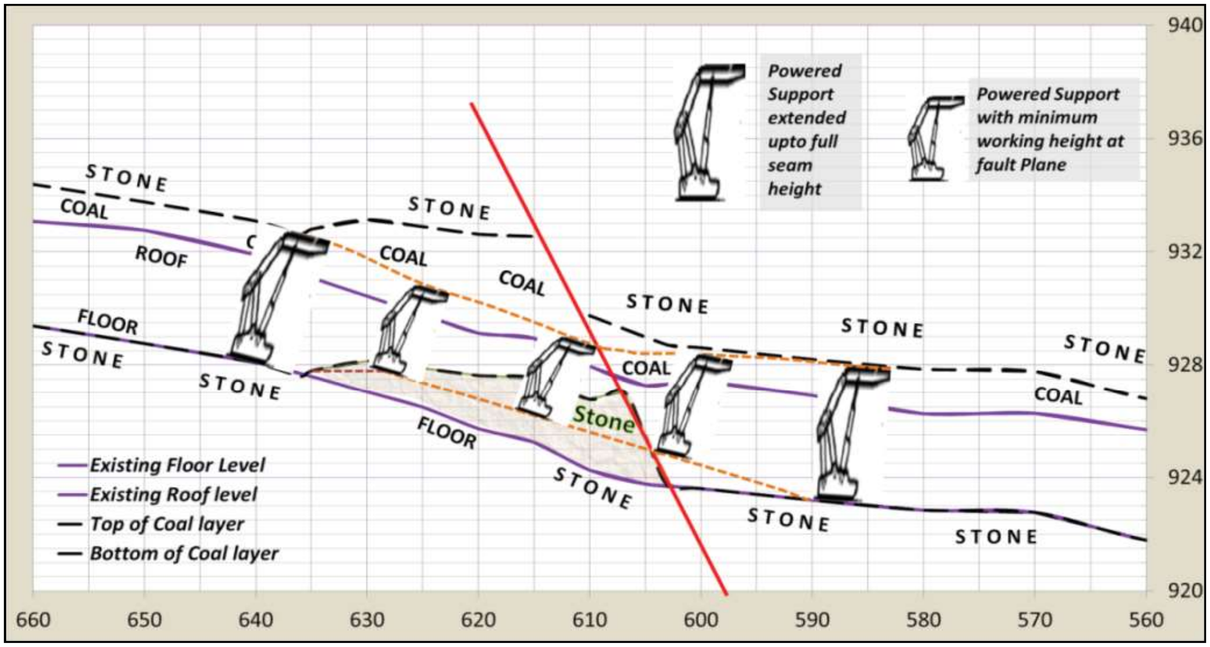


Fig.-8: Negotiating the fault by roof heightening/floor filling in top (tail) gate (-17L)

ability of the support system and preferably not exceeding 3.0m.

2 .The fault zone at main gate (Fig.-9) at a distance of 600m marking, floor lifting/concreting to a thickness of 1.5m was done leaving around 3.0m remaining room height for ventilation etc.(Fig.-5).

3. No further roof coal cutting in the panel was done at the 600m marking (from 7R/13L) mentioned in Fig.-9, i.e. at the fault plane.

4. Immediately after crossing the fault while retreating, i.e. on the out-bye side of 600m marking in the gate road, as mentioned in Points 2 and 3 above, the thickness of coal extraction was increased gradually to full seam thickness available to resume normal operation (Fig.-7).

5. The downward gradient of 1 in 6 was maintained out-bye from the point of 600m marking (Fig. 9) so that PSLW equipment can be placed in the floor of the coal for normal operation while extracting maximum possible roof coal therefrom. The floor lifting/concreting from 600m marking towards out-bye for a distance around 12m was made accordingly with 1 in 6 downward gradient for equipment movement.

6. From the fault plane at above 600m marking as shown in the roadway section (main gate) to a distance around 620m in-bye floor lifting/concreting was done with 1.2m lifting the floor (leaving a free room height of minimum 2.0m).

7. Gradually the AFC was lifted upward at least from15m in-bye of 620m marking by placing packings like hard wood sleepers etc. below it so that the entire PSLW equipment coursed accordingly for the purpose.

8. During longwall retreating from 635m marking, roof coal cutting was continued till 602m marking to maintain at least 3.0m working thickness (Fig.-7).

9. The foregoing exercise was for crossing the fault area along main gate side just to avoid unnecessary stone cutting along floor/roof and maneuvering the equipment without any such operational inconvenience.

(B) Tail Gate/Top Gate (-17L)

The development thickness in the fault area varies from 3.7m to 3.3m. However, at the fault plane where it was at the roof, the development height was 3.5m. The stone cutting was from 3.5m to 0.2m along the gate road in that area.

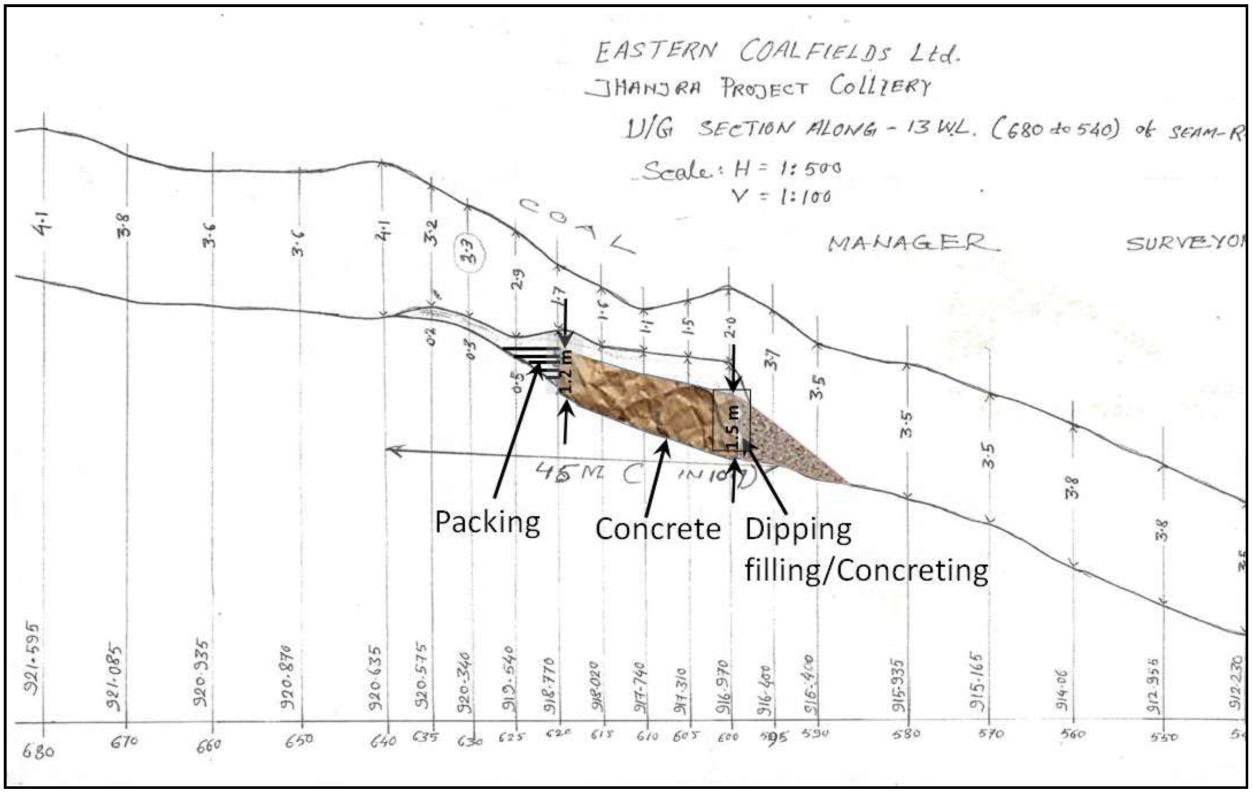


Fig.-9: Roadway section of main gate/bottom gate (-13L) in the fault zone

1. There was a need for filling/concreting along floor in the tail gate (-17L) where the thickness of filling/concreting was varying from 1.5m to 1.0m so as to keep sufficient free room height (min-2m) in the gate road for ventilation etc. after the concreting.

2. The thickness of filling/concreting was 1.5m at the vicinity of fault plane where it contacts the roof at 605m marking (Fig.-10) as per the development section. The thickness of extraction during longwall retreating was maintained at the site of 605m marking (Fig.-10) as minimum as possible preferably not exceeding 3.0m where the fault plane touches the roof.

3.From above 605m marking along roadway a dipping gradient of 1 in 6 or as convenient was ensured for the equipment's safe downward / maneuvering out-bye the fault plane and to place equipment at the original seam floor for usual coal winning by shearer with available full working thickness of the coal there.

4. Such downward dipping floor was prepared by floor filling/concreting from 605m marking at the gate road to around 593m marking at out-bye of the fault plane.

5. To bring the entire equipment (PSLW) on the filled/concrete floor, the gradient from 605m marking to 630m marking was so carried out that the same (concrete) was 1.0m thickness at 630m. It helped possibility of least floor stone cutting by shearer during face retreat in the zone. Also adequate free room height was maintained for ventilation etc. During longwalling, roof coal was cut by shearer to sufficient thickess for easy movement of the equipment at the face in the zone where necessary.

6. The AFC was lifted upward direction gradually by placing packings like hard wood sleepers below it so that the support system, AFC with shearer takes suitable rising tendency well in time at least from 10m in-bye from 630m marking.

7. Roof coal cutting by shearer was encouraged from 635m marking along the gate road (-17L)

so that the filled/concreted portion at floor is possible to have at least 3.5m working height. But the same at the fault plane at 605m marking was not exceeded 3.0m working thickness while retreating. After 600m marking out-bye, extraction was of higher thickness as possible gradually to full seam thickness by roof coal shearing.

tially and gradually towards main gate.

<u>Factor of safety (fos) for retreating l/w block at the fault area</u>

Case 1: On meeting the fault area/zone

On meeting the fault zone at the tail gate area, the width of unsupported zone varies between 23.5m

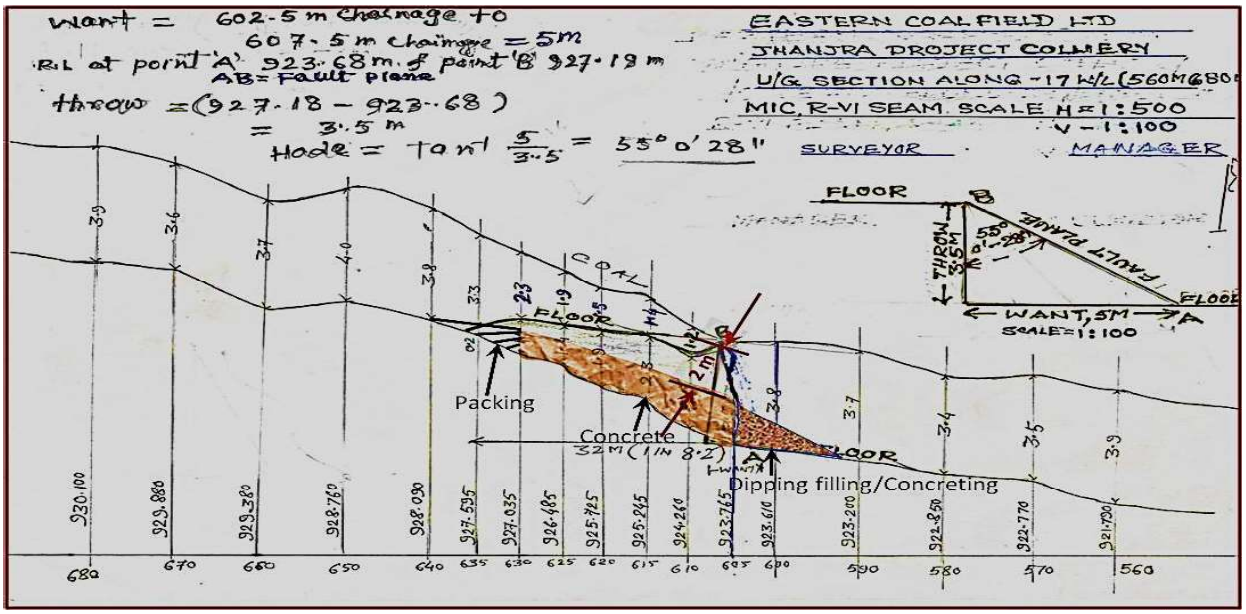


Fig.-10: Roadway section of tail gate/bottom gate/tap gate (-17L) in the fault zone

<u>*Face Orientation*</u>

A steady progress of the face was necessary and the fault plane was not to come in parallel with the line of extraction while retreating the panel to avoid stability problem. In order to have a better stability, the face (L/W) need to be oriented at a suitable angle from tail to main gate where the direction was such that the distance from the face to fault plane at tail gate is less by atleast 20/25m from that at main gate and the fault it gradually crossed in segments while face retreat. The orientation for the face-line during longwall retreating at the fault area was 10^0 to 15^0 with respect to that of fault plane in the L/W panel so the major portion of the face was not to reach the fault plane at a time. The fault was crossed in segment gradually while meeting the face with such orientation.

The L/W face crossed the fault at tail gate ini-

to 25.5m at T/Gate and 53m to 55m at B/Gate depending upon the assumed width of overhang behind the powered supports was varying from 3m to 5m.

Case 2: On meeting the fault plane (at T/Gate)

On meeting the fault zone at the tail gate area, the width of unsupported zone varies between 8m to 10m at T/Gate and 37.5m to 39.5m at M/Gate depending upon the assumed width of overhang behind the powered supports varying from 3m to 5m.

Considering the fact that the fault is at 12^o inclination with the face orientation.The FOS of the L/W block is calculated using two popular scientific approaches and the corresponding values are tabulated in Table -6. The resistance offered by the power support is not consider in both the cases.

Table-6: Factor of Safety (FOS) for retreating L/W block/pillar at the fault area

Portrayal of pillar under consideration	Factor of Safety (FOS)			
	Assuming 3m overhang behind powered supports		Assuming 5m overhang behind powered supports	
	Using Salamon-Munro Formula	Using Sheroery Formula	Using Salamon-Munro Formula	Using Sheroery Formula
Case 1: On meeting the fault area/zone	2.79	2.96	2.65	2.81
Case 2: On meeting the fault plane (at T/Gate)	1.74	1.31	1.60	1.20

Gate supports at the Fault Zone and other measures

Both the gate roads were suitably supported

1. As the fault was associated with disturbed area, the supports were set adequately in the zone of stone cutting for a length of around 25m along both gate roads covering either side of the fault plane where the zone was gradually negotiated for arriving to normal working thickness of the coal seam after the fault.

2. Powered supports were to operate at desired setting pressure by maintaining hydraulic pressure setting of the power pack. Positive set valves were kept in operation while crossing the above zone of around 25m in the fault area.

3. Both face and gate road supports and their monitoring on load development, convergence at face, gate roads were monitored in every shift.

4. At the fault plane, the existing roof bolts at gate roads supports were reinforced for tieing. This includes the additional bolts of atleast 3.0m in length inclined towards out-bye the panel to tie fault planes by 2/3 rows (6 nos. in each row, at 1.0m interval in a row and 0.6 between rows) using cuttable resin grouted bolts (Figs.-10 and 11). Also 3 rows of vertical bolts set at the out-bye of fault plane for site reinforcement.

5. While negotiating the fault area, steady face retreat was desired. The rate of retreat planned at 2.0m/day so that the load concentration do not cause bed separation by front abutment as far as possible. The entire exercise for negotiating the fault was planned such that the fault was crossed by 3 weeks time. But due to hard sandstone progress was slow.

6. Equipment was properly checked and advance maintenance made so that there is least operation time loss and avoidance in stoppage of vital installation in the system thereby minimum downtime of PSLW equipment and out-bye evacuation curcuit too during fault crossing.

7. Additional supports like cogs, hydraulic props, goaf edge supports, others like M.S bar type etc. were kept readily available at the site which were installed whenever needed for the operation depending on site conditions.

8. All the above actions and preparatory measures were thoroughly explained to all concerned point wise as to be conversant for all the activities during fault crossing.

OBSERVATIONS

1. The fault was crossed following the sequence of stone cutting for 31 to 37m length and to maintain minimum working height convenience in equipment operation at the fault zones and least possible stone cutting in fault area.

2. Adequate supporting was done at both top and bottom gates in the zone of stone cutting.

3. For prefractering of hard stone long holes by compressed air drills were made parallel to the face line & blasted with adequate protection of powered support hydraulics. Sometimes secondery blasting of blocks were needed too.

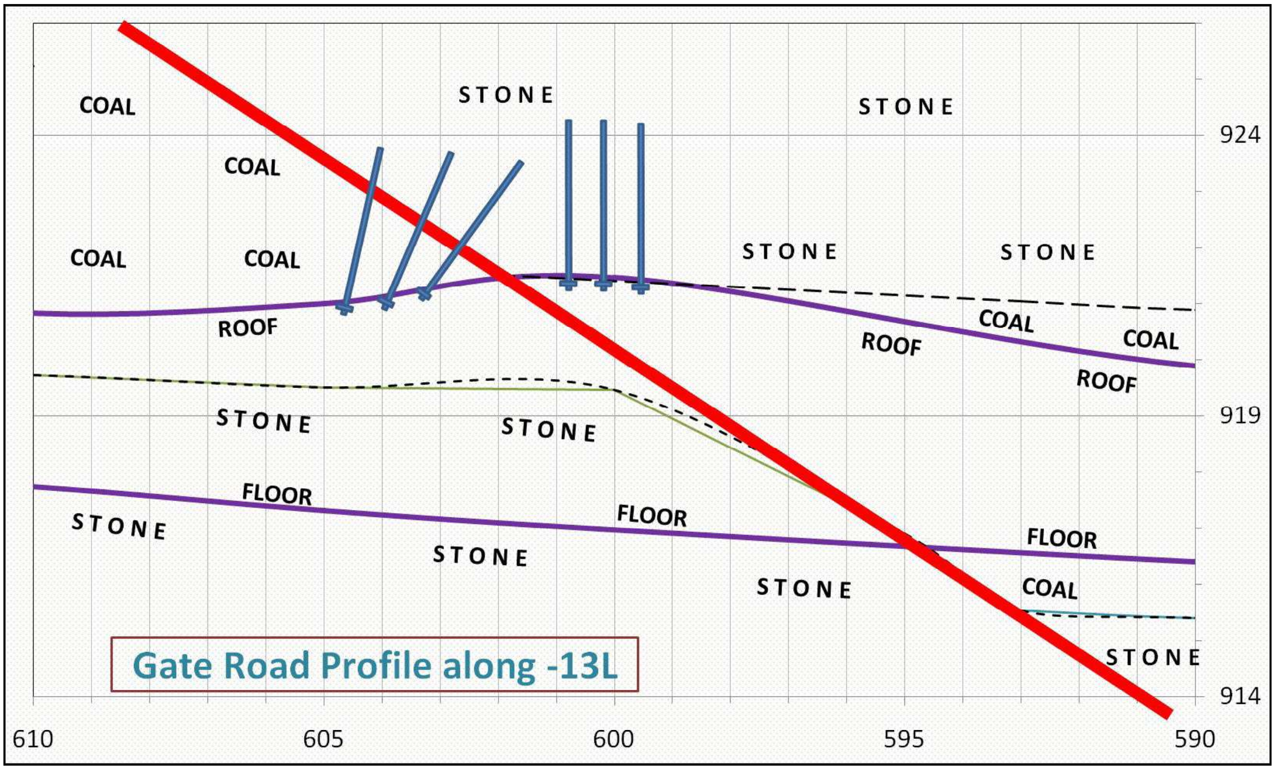


Fig.-11: Bolting reinforcement scheme in main (bottom) gate, -13L

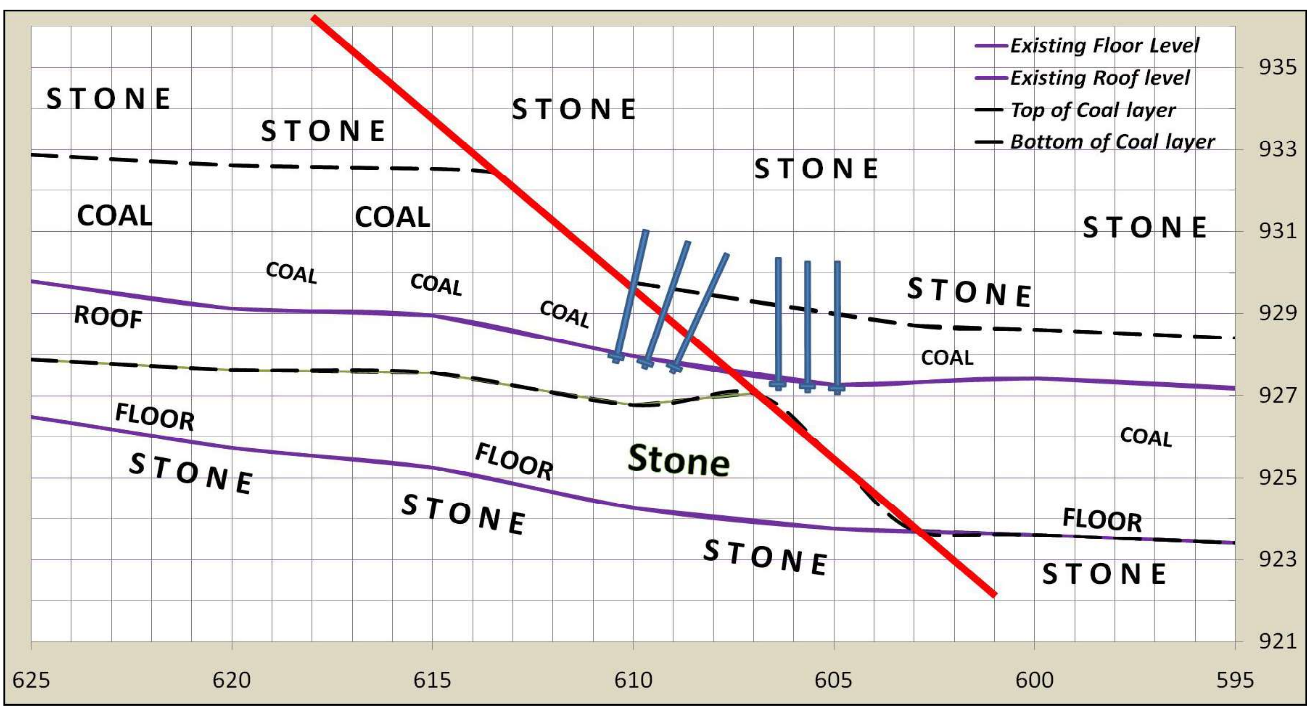


Fig.-12: Bolting reinforcement scheme in tail (top) gate, -17L

4. However, most important was to maintain the horizon properly during shearing at either side of the fault plane so that the supports are able to cross the fault with their minimum working height keeping safe hydraulic travels as reserve to avoid leg closure during weighting if experienced while crossing the fault.

5. Supports at both the gate roads and face needed special attention with reinforcement in gate road supports.

6. As there was hard sandstone and cutting/roof heightening beyond gate development height was limited to as minimum as possible while crossing the fault. The thickness of stone cutting in the fault zone as explained earlier was sometime reduced further where possible.

7. In the zone as marked in Figs.-9 and 10, in order to ensure stability and to maintain proper working horizon with minimum stone cutting and covering maximum coal thickness (in working height) in the fault area was made by concrete flooring of varying thickness 0.2 to 1.5m along floor at both the gate roads in the fault zone.

8. The factor of safety of the retreating L/W block/pillar against fault plane was computed from two sets of calculations which were found at safe level and reasonably acceptable.

9. During actual operation for negotiating the fault, there was need for stone blasting at the face to avoid its hard cutting by sharer and pre-fractured mass was easily possible to be separated/cut by the shearer without major wear & tear.

   The objective to negotiate the fault during coal wining operation was possible fullfiling the procedure as planned.

10. In case, the position of such fault is known in advance, the development of gate roads are to be so planned and oriented at fault area such that development follows seam horizon to avoid stone cutting to the best during longwalling. But in case of Jhanjra it was not known earlier to panel development.

CONCLUSION

Globally PSLW reveals highly successful technological development in thick seam extraction even more than 6.0m in single lift. In India presently operating single lift 5.5m coal extraction with PSLW is a quantum jump and to be steadity persuaded for wider diffision in suitable locales even to extract thickness beyond it. The experience and subsequentat assesment for Kottadih L/W panels highlighted for the requirement of enhanced support resistance (145 Te/m^2) and for inter- panel barrier of 35 m to avoid strata control problem during such thick seam extraction.
At Adriyala mine, SCCL (Telengana State), the experience gained while extracting around 3.6 m coal thickness with 250 m face length is highly encouraging by achieving average production of 8000-9000 TPD.

In our country success of PSLW depends on the following factors.

1. Manpower Selection

   Man being the most important factor for technology transfer and sustainable absorption need to develop culture and attitute with excellent team work in L/W system with suitable longwall cardre.

2. Equipment Selection

   Selection of suitable power support & equipment for particular locale is essential for effective strata control and performance during longwalling.

3. L/W Planning

   "Utilisation Factor" of equipment to be increased with longer panel length & optimising face length so that at least 10-11 month /year the equipment remain in production operation for entire life of the equipment.

4. Indigenous spares development & workshop facility

   Development of indigenous spares as import substitute and full proof workshop facility naer to mine for repair and overhauling of equipment have to be developed. Preventive maintenance and major over hauling of equipment are to be done as per manufacturer's recommendations.

5. Equipment Monitoring

Suitable remote monitoring system at least operation and environmental monitoring at surface control room of the mine is to be incorporated in such high- investment projects with PSLW for early rectification of breakdown/unwanted equipment stoppage etc.

6. On the spot decission by support from higher Authority

On spot decission in many important operationial issues except in major policy decision with support from higher authority is needed for persons at site / project officer.

7. Future strategy

In order to improve u/g coal production there is a need to move ahead for more longwall faces with suitable PSLW equipment for safe and maximum recovery of valuable coal resources particularly at depths from thick seams. Both the important issues – safety and conservations are best attended in longwall mining than any other available mining methods. In addition, our superior quality coals at depths are only possible for mining by adoption of suitable PSLW system.

REFERENCES

1.Prof. Dikshit M.P -"Powered support L/W for safe operation of high seam single lift coal extraction" published in proceedings of "The Principles of modern safety & performance Improvement in mines" Held at Kolkata PP-187-205 June 27-29th 2017 organized by ISM Alumimi Association Kolkata Chapter.

2. Dishit M.P & et al - "The first Longwall experience on single lift 4.5 m extraction in an Indian Coal Mine" published in the Journal of Mines, Metals & Fuels PP 15-25 Spl no. on Foreign collaboration in Mining – Technological aspects Vol. – XLV Nos 1 & 2, Jan – Feb 1997.

Cost Effective Coal Mining from Coal Quality Perspective

*T.H.Mohan Rao**

INTRODUCTION

Coal has been a major contributor in providing energy security to the nation during the past century. 80% of our mining is in coal and the balance 20% is in various metals and minerals such a gold, copper, iron, lead, bauxite, zinc and uranium. India ranks 25th in the world in per capita consumption of coal, while China ranks first. As professed by Dr APJ Abdul Kalam, India needs to increase its coal production and consumption to 2000 million tonnes over the next decade, by removing legal bottlenecks through Parliamentary laws and by following transparent and proactive policies to make **efficient** use of our natural resource.

Coal Mining is an extremely challenging activity that requires a very high degree of commitment from the men who operate the coal mine(s) and is required to be meticulously carried out by ensuring optimum utilization of the machines and as per the laid down Rules and Regulations. As we know, coal is a precious non-renewable fossil fuel that occurs beneath the earth at varying depths, the quality of coal becoming higher with increasing depth. Out of the two widely prevalent methods of mining in the country, viz., the Under Ground and Opencast mining methods, the latter, while contributing to the remarkable rise in coal production the country is witnessing, has simultaneously brought with it large scale woes about the quality of coal that is mined through this method.

THE BIGGER PROBLEM

Out of the above 2 methods of mining, while the UG mining is comparatively more challenging, the OC mining, involving removal of huge overburden, is more prone to coal quality problems in view of the fact that the coal seams occurring in the Indian subcontinent are of the ***drift*** origin, the theory about which postulates that the formation of coal seams took place when the plant matter drifted away from the original location, resulting in rise in contamination by the accumulating extraneous strata due to alternate filling of river basins with earth and plant matter. This phenomenon has ultimately given birth to several layers of seams which are quite thick, in the process the original quality of coal occurring in the Indian Sub-continent, per se, remained low. As against this, the ***Insitu*** Theory, which postulates that the plant matter got buried at the place of its original location, infers that coal formed in other countries under → these circumstances is comparatively of much better quality.

The Drift Theory having thus explained about the general poor quality of our coal, what has added to the woes from the coal quality point of view in our country is the propensity of the mine manager to extract everything he lays his hands on, above the earth and below the earth, with little regard to quality of coal. Since OC Mining has to essentially involve careful and methodical removal of OB

**Sr. Manager (QC), Western Coalfields Ltd (Hqrs), Nagpur (Maharastra)*

above the earth and then systematic segregation of the contaminants while extracting coal below the earth, it is of paramount importance to ensure that both these activities are carried out keeping the issue of quality of coal extracted always under serious consideration. Before proceeding further, it may be appropriate to understand about the conditions that lead to formation of coal, how they influenced the quality of coal, types of coal, coal characteristics and the period of coal formation in the Indian Sub-continent.

WHAT DETERMINES QUALITY OF COAL?

Coal, a secondary rock, is the general name given to the stratified accumulations of carbonaceous material derived from vegetation. The starting point of coal formation is usually peat or some similar accumulation of partially decayed vegetable matter. By a process of compaction and slight heating during burial, peat is converted into the familiar black coal. The original plant matter, degree of decay and weathering before burial, heat, pressure and degree of alteration after burial determine the quality characteristics of coal. In general, it has been shown that transformation of plant debris to coal occurs mainly in two stages..1). Bio-chemical stage or Peat formation stage, which is called the "Humification Process" and 2). Geo-chemical stage or Coal formation stage, which is called the "Coalification Process." More series of stages in the coalification process corresponding to the amount of heating that the rock has undergone are recognized. These are:

Peat Lignite (brown coal) → Sub-bituminous → Bituminous → Sub-anthracite → Anthracite

TYPES OF COALS

According to nature of plant material, coals are divided into 2 types: Humic coals (woody) and Sapropelic coals (non-woody).

Humic Coals

The coals occurring in the above six stages in the process of coalification are collectively known as "Humic" coals, which are by far the most important and are mainly formed from the remains of the wood and bark of the original plants. This series shows a progressive increase in maturity and carbon content and progressive decrease in oxygen, hydrogen, moisture and VM during the above coalification process. Humic coals are specifically characterized by low hydrogen content. The percentage of carbon in dry mineral-free coal is called the 'rank' and the coal rank increases with coalification. The individual constituents of coal are known as 'macerals' (derived from the verb 'to macerate'). Macerals are divided into 3 main groups, viz., Vitrinite, Exinite and Inertinite. These 3 macerals are in turn sub-divided into another 3 sub-groups according to detailed character of the mineral, as Vitrite (mainly Vitrinite), Clarite (Vitrinite and Exinite) and Durite (Exinite and Inertinite). These being the micro-constituents present in humic coals, the macro-constituents (of humic coals) consisting of above micro-constituents, are broadly classified into the following 4 macroscopically distinguishable litho-types (rock-types occurring within the coal seams as banded constituents), the presence or absence of which determines the original quality of coal. The distinct characteristics of these four lithotypes are as in Table-1:

The *coalification* process is found to proceed in one direction only (from Peat to Anthracite), hence unidirectional, and is marked by the gradual increase of carbon content and thereby of calorific value of coal. In a shaft or borehole the VM content of coal decreases with increasing depth ***(Hilt's law)*** and indicates that the degree of *coalification* increases with depth. Hilt's law is supported by another observation that the moisture content of lignite/coal in a shaft or borehole decreases proportionately with the depth from the surface, which follows that the oxygen content decreases with depth, which means that the carbon content increases with depth ***(Schurmann's Rule).***

Sapropelic Coals

These coals are derived from sapropels (loose deposits of sedimentary rock rich in hydrocarbons) and non-woody matter as leaves, spores, cuticles, etc., of plants as well as from organic oozes, algae,

Table-1

Vitrain	Clarain	Durain	Fusain
1.Characterized by a brilliant black, glossy luster 2.Doesn't soil hands when touched and is friable 3.Composed primarily of the maceral group, vitrinite 4.Derived from the bark tissue of large plants 5.Occurs in narrow, markedly uniform horizontal bands rarely more than 0.5" thick 6.Formed under drier surface conditions due to prevention of decomposition of the woody plant tissue by stagnant groundwater 7.Presence contributes to significant rise in the quality of coal	1.Characterized by alternating bright and dull black laminae (layers) 2.Brightest layers are composed chiefly of the maceral vitrinite and the dull layers are of other maceral groups exinite and inertinite 3.Exhibits a silky luster less brilliant than that of vitrain 4.Formed under conditions that alternated between those in which durain and vitrain were formed 5.Presence contributes to good rise in the quality of coal	1.Characterized by hard, granular texture 2.Composed of the maceral groups exinite and inertinite and large amounts of inorganic minerals 3.Occurs as thick, lenticular (shaped like a bi-convex lens) bands, usually dull black to dark grey in colour 4.Formed in peat deposits below water level, where inorganic minerals accumulated from sedimentation 5.Presence contributes to significant drop in the quality of coal	1.Characterized by silvery-black layers, only a few milli meters thick and forms a minor fraction of coal seams 2.Extremely soft and crumbles readily into a fine, soot-like powder 3.Composed mainly of fusinite (carbonized woody plant tissue) and semi-fusinite from the maceral inertinite group 4.Closely resembles charcoal in terms of both chemical and physical properties 5.Formed in peat deposits swept by forest fires or some bacterial action that generated intense heat 6.Presence contributes to serious drop in the quality of coal

fungi, etc. These coals contain less carbon than normal coals and are typically massive and unbanded and on distillation, yield petroleum. Hence they may be considered as a more or less transitory stage between true coal and petroleum. These are hydrogen-rich and generally occur at the top of the coal seam and are extremely fine-grained and are characterized by conchoidal (concave lens-shaped) fracture, and dull black, sometimes waxy luster. Rich in liptinites (microscopic organic matter derived from waxy or resinous parts of plants), sapropelic coals have high yields of volatile matter so as to be ignited by a match. There are 2 types of sapropelic coals, viz., 'cannel' coals and 'bohead' coals.

Cannel Coals	Boghead Coals
• rich in spores • formed in lakes and pools, where floating spores transported by wind and water, accumulated in mud mixed with plant debris • formerly known as candle coal because it ignites easily and burns with a bright, smoky flame.	• rich in algae • In addition to algae, these coals may contain fish scales and other fossils, which show that animal substances contributed to the formation of these coals.

PERIOD OF COAL FORMATION IN INDIA

Coals of India belong to two principal geological periods –Gondwana coals of Permian age (formed about 270 million years ago) and Tertiary coals of Eocene to Miocene age (formed about 54 million years ago). At that time, ie., around 270 million years ago, the present day South Africa, South America, Antarctica, Australia, India and Madagascar in East Africa formed a landmass called Gondwana land. Coal formed in Gondwana land is thus known as Gondwana Coal . Gondwana formation is the chief source of coal in India and refers in Indian Geology to a very thick group of distinct fresh water sedimentary rocks widely occurring in the Indian sub-continent and ranging in age from Upper Carboniferous to Lower Cretaceous periods. While the coals of the Gondwana formations account for 99% of the total coal deposits in the country, those of the Tertiary formations account for just 1% of the coal deposits in the country.

GEOLOGICAL SUCCESSION OF STRATA IN WHICH POTENTIALLY WORKABLE COAL SEAMS OCCUR IN INDIA

Coalfields	**Geological System**	**Duration**	**Localities**
Tertiary Coalfields	Miocene to Upper Paleocene (7 to 54 Million years ago)	47 Million Years	Lignites in Kashmir Valley Lignites in Neyveli Lignites in Rajasthan Makum coalfields of Upper Assam
Upper Gondwana Coalfields	Upper Jurassic (135 to 195 Million years ago)	60 Million Years	Satpura Region
Lower Gondwana Coalfields	-Upper Permian (225 to 240 million years ago) -Lower Permian (240 to 280 million years ago)	-15 Million Years -40 Million Years	- Raniganj, Jharia, Bokaro and Karanpura coalfields of the Damodar Valley of West Bengal and Bihar (now Jharkhand) - Mahanadi Valley, Sone Valley, Pench Valley, Prahhita-Godavari Valley and Wardha Valley

GEOLOGICAL TIME SCALE

ERA & Duration in Million Years	**PERIOD/ SYSTEM**	**MILLION YEARS AGO**	**EPOCH**	**Duration (million years)**	**Remarks (Dominant Animals & Plants & Periods of Coal Formation)**
CAINOZOIC (65)	QUARTERNARY	0 to 0.01	HOLOCENE	0.01 (10,000 years)	Man & Modern Plants
	TERTIARY	0.01 to 2.0	PLEISTOCENE	1.99	
		2.0 to 7.0	PLIOCENE	5.0	Mammals, Birds & Flowering plants
		7.0 to 26	MIOCENE	19.0	**Tertiary Coalfields:** Lignites (Brown coals) & Makum Coalfields of Upper Assam...**2nd period of coal formation** Miocene & Oligocene: Mammals, Birds & Flowering Plants Eocene & Paleocene: Mammals & Flowering Plants Cretaceous: Dinosaurs & Elms, Oats and Mapples Jurassic: Dinosaurs & Conifers
		26 to 38	OLIGOCENE	12.0	
		38 to 54	EOCENE	16.0	
		54 to 65	PALEOCENE	11.0	
MESOZOIC (160)	CRETCEOUS	65 to 135	-	70.0	
	JURASSIC	135 to 195	-	60.0	
	TRIASSIC	195 to 225	-	30.0	Dinosaurs, vegetation not abundant

UPPER PALEOZOIC (170)	PERMIAN	225 to 280	-	55.0	**GONDWANA Coalfield**: Coal formation remarkably maximum (chiefly Bituminous and Anthracite).....**1st period of coal formation** Permian :Reptiles & Ferns Carboniferous :Amphbians & Ferns
	CARBONIFEROUS	280-345	-	65.0	
	DEVONIAN	345 to 395	-	50.0	Fish &Early land plants
LOWER PALEOZOIC (205)	SILURIAN	395 to 435	-	40.0	Fresh Water Fish, Graptolites & Early Land Plants.
	ORDOVICIAN	435 to 500	-	65.0	Graptolites & Algae
	CAMBRIAN	500 to 600	-	100.0	Trilobites & Algae
PRE-CAMBRIAN (3900)		600 to 4500	-	3900.0	Protozoa And Unicellular Life ; No Flora

COST-EFFECTIVE COAL MINING FROM COAL QUALITY PERSPECTIVE

Having seen what determines the original quality of coal, it is therefore important to understand that the original quality of coal can only be ensured but can never in any case, be improved, since coal quality, per se, is purely dependant on the inherent chemistry of coal seams and the micro-constituents that are present during the coal formation stages. As such, it's first necessary to realize that coal being a natural product, its quality is already confirmed during its formation stage itself. Therefore, it must be remembered that the natural quality of coal only can, and more importantly, has to be preserved and maintained. This is possible only by ensuring that quality of coal is never allowed to get diluted either by inadvertent or worse, intentional mixing of other associated contaminants with coal, for the sake of quantity. The unfortunate part is, these contaminants also naturally occur within the coal seams as postulated by the drift theory.

Because of the invariable presence of these contaminants in varying degrees, the quality of coal in the country has become largely heterogeneous due to which the quality of different coal seams as also the quality even within the same coal seam is highly inconsistent. Hence, the responsibility of a successful mine manager is to extract coal **WITHOUT** any associated contamination. In order to ensure that the original quality of a coal seam can be sustained, it is therefore mandatory that we first ensure **preservation** AND then, **maintenance** of the natural quality of coal from seam to siding and finally **deliver** coal in its natural quality WITHOUT the associated contamination. In order that this devout responsibility is discharged with a sense of commitment, we need to scrupulously implement the following **4** already known methods, in the sequence listed here, viz.,

1. Extraction of only coal, ie., extracting what is required to be extracted, simultaneously ex-

cluding what is required to be excluded during the mining operations, ie., dutifully and unquestionably excluding bands of at least ½ Mtr and more thickness while extracting coal

2. Careful segregation of contaminants from coal stocks since bands of < ½ Mtr thickness do get included during production stage due to prevailing mining practices
3. Blending of inferior quality coal with superior quality coal, if needed, to arrive at a balance keeping the market demand and statutory requirements in view, and finally
4. Commencement of dispatch of coal free from all contaminants only after reduction to the required size

FACTORS THAT AFFECT & INFLUENCE THE QUALITY OF COAL

Again these already known factors, from which above methods have been derived, are mostly common to all the UG converted OC Mines/OC Mines and a even few UG mines, and can be divided into uncontrollable and controllable categories and our focus must be on compulsory and ruthless implementation of the controllable factors in order to preserve the natural quality of coal, so as to effectively check any grade slippage. Both the Uncontrollable and Controllable factors, in a nutshell, are detailed as tabulated below:

As can be seen above, while the occurrence of the uncontrollable factors is outside our domain, that of the controllable factors is well within our domain and hence needs to be addressed with all seriousness. Both the uncontrollable and controllable factors shown above are drawn from the extensive QC measures & systems framed in WCL.

SYSTEMATIC AND CONTINUOUS IMPLEMENTATION OF QC MEASURES & SYSTEMS

In order to realize the sole objective of pro-

Uncontrollable Factors (Geo-mining and natural)	**Controllable Factors (which can be & therefore must be enforced)**
1.Collapsing of coal along-with sandstone and other contaminants into the sand-filled de-pillared galleries of the UG converted OC Mines due to blasting, resulting in further contamination of the otherwise pure coal 2. Presence of fire in the galleries 3. Blanketing of coal stocks to control fire leading to further contamination of coal 4. Presence of several intermittent thin shale/ stone bands within the coal seams 5. Inconsistent thickness of shale/stone bands 6. Inconsistent thickness of coal seams 7. Occurrence of faults and other geological disturbances in the coal mines 8. Slushy nature of OB, which tends to slip downwards in the absence of proper OB benches, badly affecting the quality of coal	**1. Extraction of coal after exclusion of bands** **2. Compulsory Stone/Shale segregation from mines' stocks if (1) is completely not possible** **3.Segregation of left-over Stones/shale from Sidings' stocks and still carried-over stones/shale from top of loaded wagons/trucks** **4. Loading of wagons under strict supervision (Selective Loading--by deploying at least one supervisor with each payloader)** **5. Regular fire-fighting at coal stocks with high pressure water jets** **6. Non-mixing of fresh coal with contaminated stock** **7. Separate stacking of fresh coal** **8. Compulsory routing of raw coal through CHPs** **9. Sweetening of inferior quality coal with superior quality coal so as to ensure the required balance**

ducing clean coal without any contamination, we **need not** reinvent the wheel. The wheel is already invented and we already have the well established and time-tested QC measures & Systems in place, the implementation of which **needs to be attentively enforced** at 5 stages from Seam to Siding on a **regular basis**, since coal quality maintenance is a continuous feature, which needs to be taken care of 24X7 in order to have a robust financial health of the organization, which as we know and acknowledge, is purely dependent on the quality of coal dispatched rather than the quantity of coal dispatched.

This is where the crucial role of the QC Measures & Systems comes to play. These Measures & Systems, contiguous and the resultant offshoots of the systematic mining practices unfolding in the mining industry in the country, are nothing new! Hence the attempt is to only give the processes a re-look. Let's now briefly recall these again already known measures & systems.

Before Commencement of Extraction of Coal

- Proper OB/Coal benching and cleaning of benches before blasting operations
- Identification and scrupulous exclusion of bands > ½ Mtr thickness
- Quenching of fire on coal face(s), if any

During Mining Operations

- Adoption of proper drilling pattern so as to ensure that contiguous stone/shale bands are meticulously avoided during blasting
- Compulsory selective mining of coal (grade-wise, if possible), ie.,by excluding the already identified bands of > ½ Mtr thickness

After Completion of Mining Operations (At Mines)

- Separate & distinct stacking of coal of different grades, if any
- Separate stacking of clean and contaminated coal and intensive segregation of contaminants
- Prevention of on-set of fire in coal stocks on a continuous basis
- Loading of trucks/tippers under effective supervision while transporting coal to CHPs/ Feeder Breakers for ensuring proper sizing
- Creation of reject yards for stacking contaminants
- Arrangements for disposal of contaminants and proper accounting of the same

Before Transportation to Railway Sidings

- Ensuring that CHPs/FBs are maintained in proper working condition with availability of adequate no. of picks (at least 80%) on the crusher drums at any given point of time
- Reduction of coal to required size before transportation to sidings

At the Railway sidings

- Transportation of properly sized coal with quality conforming to grades declared and free from any contaminants, to sidings
- Non-acceptance of either uncrushed coal, coal mixed with contaminants or coal on fire at sidings
- Intensive segregation of still carried-over stones/shale from siding stocks
- Deployment of supervisors with each pay-loader during loading operations (selective loading)
- Intensive segregation of still carried-over stones/shale from top of loaded wagons
- Erection of boards depicting siding name/ grades' information
- Maintenance of joint inspection registers with consumers' representatives

THE ALL IMPORTANT COST FACTOR

What should be the CTC (Cost to the Company) per ton for supply of coal of a particular grade to a consumer? The cost must be well within the corresponding notified price, so as to ensure that the finances of the organization remain healthy. Here comes the crucial quality factor and the need to deliver coal in conformity with the grades declared since, any grade slippage, even by 1 level, would result in higher cost to the organization. With a view to arrive at the loss an organization would incur in the event of delivery of coal in grades lower than those declared, as an illustration, the coal grades existing and the corresponding notified prices prevailing in WCL have been considered. Existing grades of ROM coal in WCL vary from G8 to G13. Following table shows the loss the company would incur in the event grade slippage is noticed by 1 Gr, 2 Gr, 3 Gr, etc., against the billed grade(s) of ROM coal dispatched from different sidings/dispatch points. Further, in terms of the relevant provisions of the FSAs, in the event the entire consignment is analyzed as 'ungraded', the company is entitled to just 1 Re/Ton irrespective of what the original billed grade was. Following table shall reveal the loss the company would incur in the event of grade slippage against supply of coal in different declared grades.

From Table-A it may be seen that while the loss (cost) to the company would range from Rs. 389/- per Ton to Rs. 1221/- per ton in the event of grade slippage by different levels against supply of coal in the billed grade of G8, the loss would range from Rs. 140/- per ton to Rs. 832/- per ton in the event of grade slippage by different levels against supply of coal in the billed grade of G9, and so on. In the event the entire coal loaded into the whole rake/truck is analyzed as 'ungraded' the company would lose the entire billed value and receive a token price of just Re 1/- per ton, irrespective of the billed grade, as shown in the last column.

In comparison to above, the rake-wise loss the company would incur in the event of grade slippage at the prevailing coal prices, considering that the average quantity of coal loaded into one rake is 4000 Tons, would be very disgusting. The loss in the event of dispatch of ungraded rakes would range from Rs. 70.24 lacs to 39.16 lacs against the billed value of Rs. 70.28 lacs to Rs. 39.20 lacs in respect of G8 to G13 grades respectively. Grade slippage must be restricted at least to the last grade of G17 on the GCV scale, so as to ensure that the company would at least make Rs. 21.44 lacs on each rake loaded, which otherwise would slip to an alarming Rs. 4000/- per rake (@ Re 1/- per ton) if the quality of the coal supplied in a rake is analyzed as ungraded, as shown in Table-B.

CONCLUSION

Any obsession to extract and deliver the product faster, without moving through the processes, would be clearly disastrous. The "Product-before-Process" perspective, rather than the time-tested and global 'Process-before-Product' concept, implies that the processes are under compromise for the sake of a 'quick' product. For every product to take a perfect shape, a clear gestation period, as per the laid down and fixed time frame, is required. Before the product is delivered to the consumer, it has to move through the set processes by which it gets refined and acquires the acceptable format/shape. This is what is known as the "Process-before-Product" concept, ie., taking the product through the mandatory processes before it is delivered to the consumer.

Table-A **(Rs/Ton)**

Grade	Basic ROM Price for Power	Loss incurred by the Co. in the event of grade slippage									
		(-)1 Gr	(-)2 Gr	(-)3 Gr	(-)4 Gr	(-)5 Gr	(-)6 Gr	(-)7Gr	(-)8 Gr	(-) 9 Gr	Un Graded
G8	1757	389	529	612	694	777	860	1049	1153	1221	1756
G9	1368	140	223	305	388	471	660	764	832	....	1367
G10	1228	83	165	248	331	520	624	692	....	....	1227
G11	1145	82	165	248	437	541	609	....	....	....	1144
G12	1063	83	166	355	459	527	....	....	....	....	1062
G13	980	83	272	376	444	....	....	....	....	....	979

Table-B **(Rs lacs per Rake)**

Grade	Billed Value of ROM (Power) for one Rake (Wef 9.1.18)	Loss incurred by the Co. in the event of grade slippage for full coal rake									
		(-)1 Gr	(-)2 Gr	(-)3 Gr	(-)4 Gr	(-)5 Gr	(-)6 Gr	(-)7 Gr	(-)8 Gr	(-)9 Gr	Un Graded
G8	70.28	15.56	21.16	24.48	27.76	31.08	34.40	41.96	46.12	48.84	70.24
G9	54.72	5.60	8.92	12.20	15.52	18.84	26.40	30.56	33.28	....	54.69
G10	49.12	3.32	6.60	9.92	13.24	20.80	24.96	27.68	....	....	49.08
G11	45.80	3.28	6.60	9.92	17.48	21.64	24.36	....	....	....	45.76
G12	42.52	3.32	6.64	14.20	18.36	21.08	....	....	....	....	42.48
G13	39.20	3.32	10.88	15.04	17.76	....	....	....	....	....	39.16
G14	35.88	7.56	11.72	14.44	....	....	....	....	....	....	35.84
G15	28.32	4.16	6.88	....	....	....	....	....	....	....	28.28
G16	24.16	2.72	....	....	....	....	....	....	....	....	24.12
G17	21.44	....	....	....	....	....	....	....	....	....	21.40

On the other hand, acquiring the product 'somehow' and **'now'** (known as instant gratification), ie., through the "Product-before-Process" concept, might appear to give us quick 'results' from the quantity point of view, but ultimately leads to a general sense of non-fulfillment and emptiness in the long run, as anything we acquire this way has no real, lasting value.

So as to realize the objective of unconditional acceptance of our product by the consumer without any reservations whatsoever, which forms the crux of "cost effective coal mining from coal quality perspective", the raw coal needs to be passed through a definite set of processes which are the time-tested and well known "QC Measures & Systems". When coal from a given coal block/colliery is extracted through these processes, ie., with **"due regard"** to quality, as stated in CIL's Mission Statement, the coal so extracted shall bring the right price, resulting in a significantly lower cost to the company, leading to **BOOM** of the enterprise. On the other hand, when coal is extracted with NO regard to quality, the opposite happens and we shall lose heavily on the quality front, resulting in an abnormally higher cost to the company, leading to the DOOM of the enterprise. When the enterprise considers quality as a non-compromising element, everything else shall fall in line and the consumers also shall stand in line for taking our coal. By protecting the interests of the consumers by ensuring value for their money, an enterprise, by default, protects its own interests. Quality of coal therefore is of paramount importance in sustaining the cost-effectiveness of a coal block/colliery, and thus becomes the pivot on which the growth of the organization rests. Therefore there is an urgent and perennial need to consider quality as the sole overriding factor. As long as this doesn't happen, the real growth cannot be brought forth and no time would be lost before the existence of an organization begins to cease!

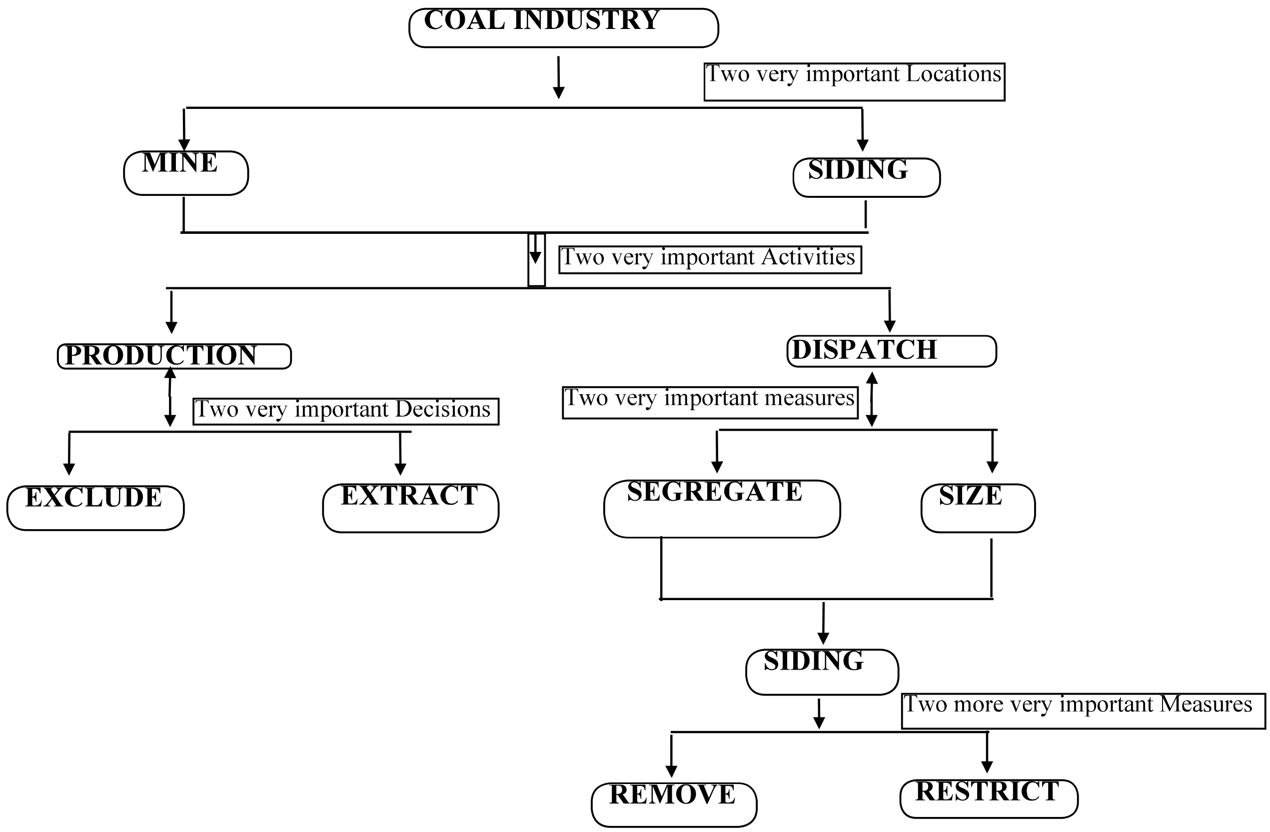
Before I end, as a penultimate finale to this article, let me place before you what Dr APJ has said in his book "The Scientific Indian", about the general poor quality of our coal, the ill effects associated with continued use of poor quality coal, what we need to do to effectively counter the problem, the need for attracting big investments in mining sector and the necessity for bringing in healthy public-private partnerships (PPPs) so as to ensure cost effective and qualitative mining in our country for ultimate national development:

"Naturally occurring coal is not all good compacted carbon. As it is found in the earth, it carries many other particles and materials. Most coal has some ash content as well. The quality of coal varies from mine to mine. On the whole, Indian coal contains more ash than the coal mined in some other countries like Australia. But nowadays, the technology is available to remove many of these extraneous matters from coal. This is good from the point of view of the user as equipment using cleaned-up coal is much safer and more efficient. From the environmental point of view as well, emissions can be better controlled (by using coal free from contaminants). Though climate change activists are against the use of coal, India has to depend on coal for much of its electric power generation and for many factories. However, we cannot use the older technologies which pollute the atmosphere. Fly ash, a by-product of coal, affects the environment in a major way.

In spite of the economic liberalization of 1991 the mining sector has not attracted major investments. This is possibly due to problems in land acquisition, development of infrastructure, transportation systems, social engineering and community development involved in major greenfield site projects. There is a need to relook at the total management solution for attracting investment in new mines. The solution has to lead to the creation of joint venture institutions with the central government, state governments and the private sector as partners. The facilitation for the project through provision of land, infrastructural development, community development, etc. can be done by government agencies whereas the investment in the mine and the associated technological inputs can come from the private sector. In addition, the private sector must have the freedom to run the mine in a cost-effective manner. This may be a long-term solution for our future mining in the country and it will have unique opportunities for both the government and the private sector to work together for national development."

Finally, in the next page the panacea, 2-2/2-2-2 (Double two/Triple two), the essence of the above article is given in a Schematic Diagram in 10 simple words for realization of Mission 0&0, i.e, Zero grade slippage & Zero consumer complaints, which would without doubt lead to "cost-effective coal mining from coal quality perspective", ensuring a clear sustainable growth of an organization, which perhaps sows the seed for ultimate national development as envisioned by Dr APJ, as long as India continues to use coal to safeguard its Energy Security.

2-2/2-2-2 (Double Two/Triplate Two)
Panacea for Realizing Mission 0&0 -Zero Grade Slippage & Zero Consumer Complaints (In 10 Simple words)



EXPLANATION

1. First 2 of Double Two- Coal industry has just 2 very important locations: **Mine & Siding**
2. Second 2 of Double Two-To carry out just 2 very important activities: **Production & Dispatch** of good quality coal
3. First 2 of Triple Two - In order to Produce good quality coal, we need to take just 2 very important decisions: To **Exclude** what is supposed to be excluded and to **Extract** what is supposed to be extracted
4. Second 2 of Triple Two - Similarly, in order to dispatch good quality coal, we need to implement just 2 very Important Measures: To **Segregate** the still carried-over contaminants from coal stocks and then to **Size** the coal to required specifications, by routing through CHP
5. Third 2 of Triple Two - In order to achieve zero grade slippage and to win consumer satisfaction, we need to first completely **Remove** all extraneous matter from Siding (as we do at our homes as we shift) and then to continuously **Restrict** inflow of the same into the siding (as we keep doing at our homes), so that Mission 0&0 (Zero Grade Slippage & Zero Consumer Complaints) can be effectively achieved.

REFERENCES

- *Introduction to the Geology of Coal & Indian Coalfields-By N.L. Sharma, Hon Professor in Geology & K.S.V. Ram, Lecturer in Geology, ISM/Dhanbad...Oriental Publishers*
- *Introduction to Physical Geology-By A.K. Dutta, Distributor: H.R. Dutta, Banushree, Burdwan Compound, Ranchi*
- *The Penguin Dictionary of Geology-By D.G.A. Whitten with J.R.V. Brooks..Penguin Books*
- *A Manifesto for Change-By Dr. APJ Abdul Kalam & V. Ponraj..Harper Collins*
- *The Scientific Indian-By Dr. APJ Abdul Kalam & V. Ponraj..Penguin Books*
- *Extensive QC Measures & Systems Framed & Circulated in WCL*

Coal Mine Surveillance and Management System (Cmsms) & Khanan Prahari Application of Information Technology for Monitoring of Illegal Coal Mining

Rajneesh Kumar[1], Ajay Kumar Singh[2], Anindita Biswas[3]

ABSTRACT

Illegal coal mining activities are a steady problem in India since long. Due to this problem the control over mineral resources gets hampered. In support of addressing illegal coal mining and related hazards a monitoring system **Coal Mine Surveillance & Management System** and associated mobile app **'Khanan Prahari'** have been developed for Coal sector. With the help of these two systems illegal coal mining incidents could be identified and suitable remedial action may be taken to prevent such activities, leading to prevention of loss of national resources.

These Web App and Mobile App have been inaugurated by Hon'ble Minister of Railways and Coal Shri Piyush Goyal on 4th of July, 2018

INTRODUCTION

Coal is the most abundant fossil fuel and one of the primary energy resources of India. It is used by a variety of sectors including power generation, iron and steel production, cement manufacturing and as a liquid fuel. The majority of coal is either utilised in power generation that utilises steam coal or lignite, or iron and steel production that uses coking coal. Coal India Ltd. is the single largest coal producer in the world with an annual production of around 608 Million Tonnes. Illegal mining activities and theft of coal have been going for a long period of time. It not only has adverse effects on environment but also on financial health of the organization. This even can be a threat to local communities also.

Illegal coal mining activities are those which carried out beyond the Leasehold boundaries of coal mines.

Pilferage, rat hole mining etc. carried out by any unauthorized person(s) or entity anywhere in the coalfield region can also be called an illegal coal mining activity.

Keeping in view the problems mentioned above Ministry of Coal decided that there should be a

[1]*HoD (Geomatics),*[2]*Chief Manager (E&M),*[3]*Manager (Geology), Geomatics Divn, CMPDI (HQ),Ranchi*

system through which illegal coal mining can be monitored by using suitable technology so that the action taken remains transparent.

In this direction Geomatics Division, CMPDI (HQ) in association with Bhaskaracharya Institute for Space Applications and Geo-Informatics (BISAG), Gandhinagar has developed a monitoring system named as Coal Mine Surveillance & Management System (CMSMS) and a mobile app 'Khanan Prahari' for identification, reporting and taking remedial actions on illegal coal mining incidents. They are expected to contribute in reducing illegal coal mining incidents to improve the utilization of coal in a better way and improve the safety and living conditions of the public in the coalfield area.

SALIENT FEATURES OF CMSMS

CMSMS can be accessed on https://ncog.gov.in/CMSS/ and 'Khanan Prahari' mobile app is available on Google Play Store/Apple App Store and can be downloaded in Android and IOS mobile.

Fig-1: The login page displayed in CMSMS

The CMSMS uses the basic platform of Ministry of Electronics & Information Technology **(MeitY)** and National Center of Geo-Informatics **(NCoG).** The basic reference for analysing any information is mine lease boundaries. CMSMS incorporates maps of India provided by MeitY on which information up to village level boundaries are available. Geo-referenced Coalfield boundary, Lease boundary and Block boundary are also available as separate layers in the system through the GIS Map visualizer. There are four categories of coal blocks which are CIL Blocks, Non CIL Blocks, SCCL Blocks and Captive Blocks.

CMSMS have two systems for generating information on illegal mining i.e.

i) Through periodic scanning of satellite images at 3 months interval and
ii) Through information provided by Mobile App 'Khanan Prahari'.

'Khanan Prahari' can also be used by the common man and complaints, photos regarding coal pilferage and illegal mining can be uploaded through it. The identity of the informer will be kept secret. The information generated through satellite image scanning and by 'Khanan Prahari' are called reports. The action taken on the reports generated is also shown on the system. Nodal Officers have been identified in each subsidiary to take action on the illegal mining reports generated within the lease boundaries under CIL. Nodal officers of area falling outside CIL lease areas are Director of Mines and Geology of respective states. Any illegal coal mining activity carried out outside CIL lease areas will be reported to them for further remedial actions.

CMPDI carries out Land Reclamation Monitoring of open cast mines of CIL annually, based on the satellite data. These data are also incorporated in CMSMS to know the progressive change in various parameters related to land reclamation, like, biological reclamation, technical reclamation and total area reclaimed etc.

It also provides information on Environmental Clearances (EC) and Forest Clearance (FC) status of various coal mining projects in different subsidiaries of Coal India Limited.

CMSMS will have three types/ levels of access for its various users:

i) **Guest Users:** Only for viewing purposes and information on action taken against the reported cases of illegal mining.
ii) **Administrator:** with right to edit/ modify/ delete/ update relevant information.
iii) **Nodal Officers:** to view and enter action taken information against reported cases.

A Coal Map tab has been provided on the Dashboard which is a GIS Map visualizer. In this section one can select layers of interest and overlay it on digital boundary maps or on satellite images to see the reported incident. The location of illegal mining site reported through mobile app will be shown by Flag Marks.

CMSMS DASHBOARD

After logging in as Guest User or by using the credentials provided by CMPDI for Nodal Officers, the following page appears (Fig-2). The page has four options- 'Dashboard', 'Land Reclamation', 'Coal Map' and 'FAQ'.

On clicking the **'Dashboard'** option (Fig-2), the page shows distribution of coal blocks (Fig -3) and also the overall report of illegal mining received through Khanan Prahari Mobile App as well as by scanning of Satellite Data which is to be done at CMPDI. Under 'Monitoring of Illegal Coal Mining' option, one can see the number of illegal mining incidents reported through mobile app and those detected by scanning. It also shows how many of the incidents that has been reported are found to be genuine and how many are yet to be verified (Fig-4).

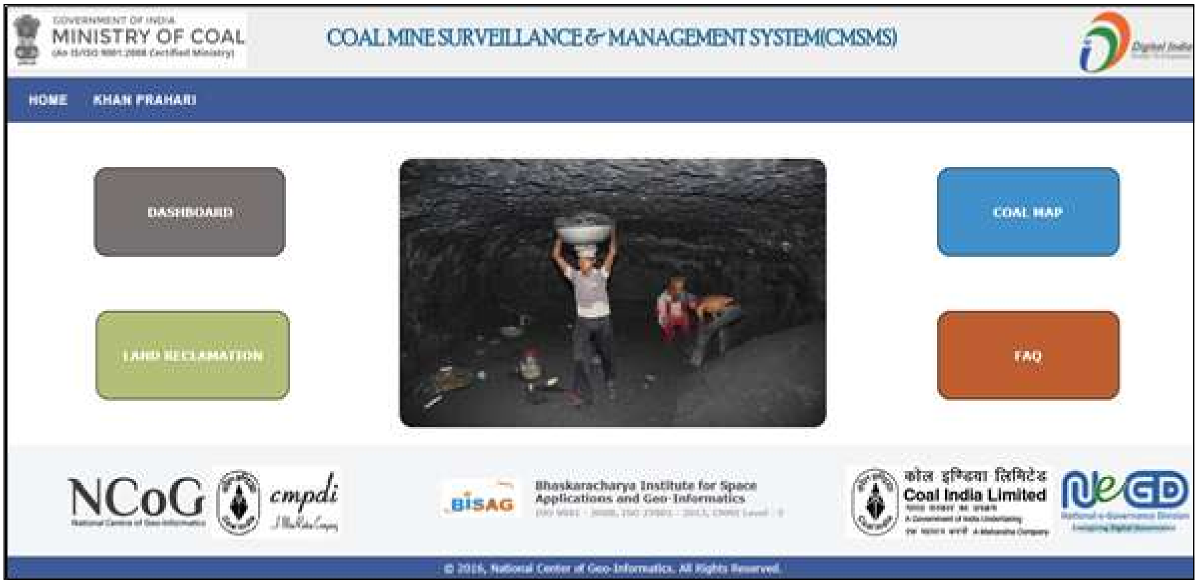


Fig -2: The page displayed immediately after logging in

DISTRIBUTION OF COAL BLOCKS		
Number of Block		
CATEGORY	NUMBER	PERCENTAGE
CIL	454	52.24%
NON CIL	249	28.65%
SCCL	84	9.67%
CAPTIVE	82	9.44%
Total	**869**	**100.00%**

Fig -3: Dashboard showing category-wise distribution of Coal Blocks

MONITORING OF ILLEGAL COAL MINING	
COMPLAINT STATUS MONITORING	NUMBER
Number of complaint generated by Khanan Prahari.	90
Number of complaint generated by Scanning.	0
Number of complaint forwarded to State Nodal Officer.	35
Number of complaint verified by State Nodal Officer	12
Number of complaint forwarded to CIL Nodal Officer	55
Number of complaint verified by CIL Nodal Officer.	53
Number of complaint forwarded to SCCL Nodal Officer.	0
Number of complaint verified by SCCL Nodal Officer.	0
Action Taken on Genuine Complaint.	14

Fig-4: Dashboard showing status of reported Illegal Coal Mining incidents

LAND RECLAMATION

The user may select **'Land Reclamation'** tab to view the land reclamation reports of the last 3 years. On selecting the tab the following page appears (Fig-5):

Land Reclamation reports are available under two categories:

(i) Projects with annual production of more than 5 million cubic meter (Coal + OB) and
(ii) Projects with annual production of less than 5 million cubic meter (Coal + OB).

The user may select any particular year and view the detailed Land Reclamation report of that year.

COAL MAP

The **'Coal Map'** option (top right in Fig 2) allows the user to view various layers under two sections. 'Base Map' provides various boundaries like state boundary, district boundary, taluka and village boundary. River, Rail, and Road are also provided under the base map category. Satellite Map of India is available under 'Other Map Services'.

Under Layers option, Coalfield boundary, Lease boundary and Coal Block boundary are provided. Satellite images of various coalfields are provided under 'Raster Layers'. Selecting Khanan Prahari Data under Mobile App Data will show the flagging of places from where cases of illegal coal mining incidents are reported.

CMSMS DATA FLOW DIAGRAM

The same is shown in Fig-6.

GUIDELINES FOR USING CMSMS

To access the CMSMS System, visit https://ncog.gov.in and navigate to "Coal Mine Surveillance & Management System" tab. The user is directed to the login page of the Surveillance system. There are provisions for three levels of users:

1. Guest User: Any person may log in as "Guest user". No username or password is required. Guest User has only viewing rights and cannot modify any data.
2. Administrator: Administrator can use his credentials to log in and edit/ delete/ modify/ add layers like Block Boundary, Lease Boundary etc.
3. Special Users: Nodal officers of each subsidiary/ State Government can log in using credentials provided by CMPDI. They can view the Khanan Prahari / CMSMS reported incidents and verify the same in the field and give feedback on the reported incident.

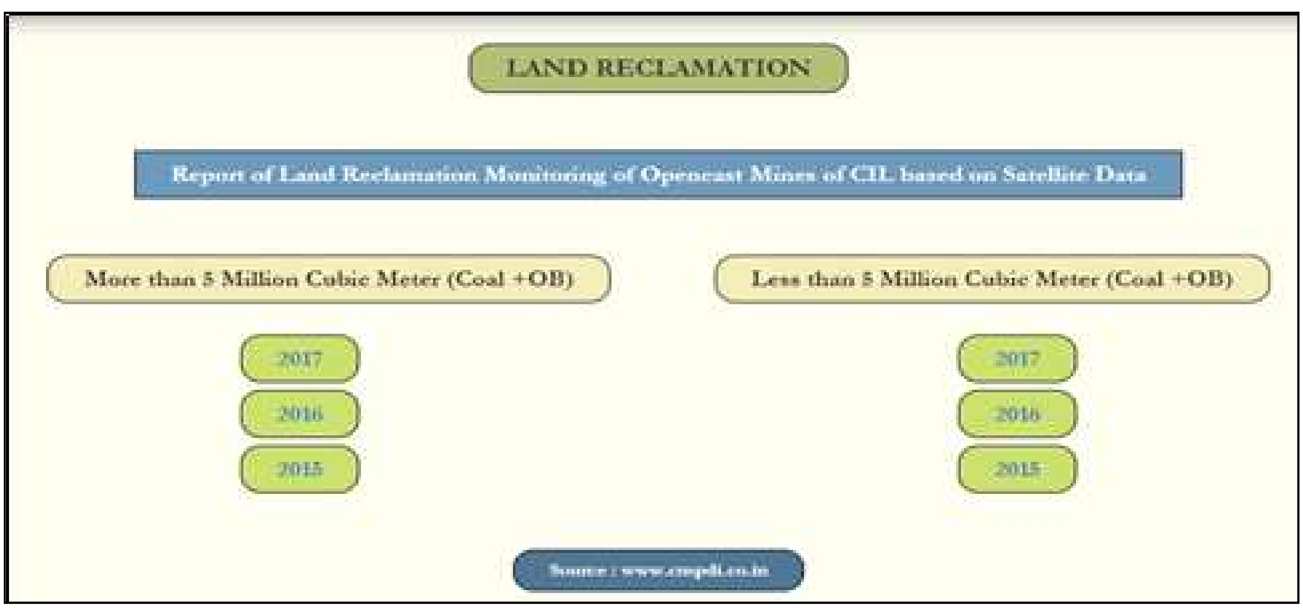


Fig-5: Land Reclamation Page of CMSMS

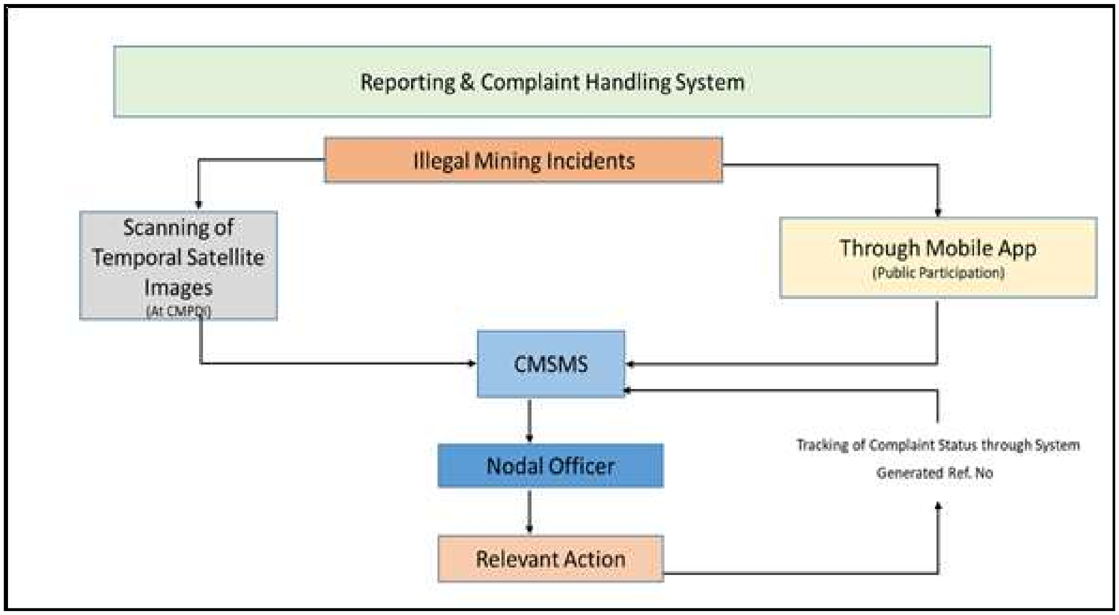


Fig-6: CMSMS Data Flow Diagram

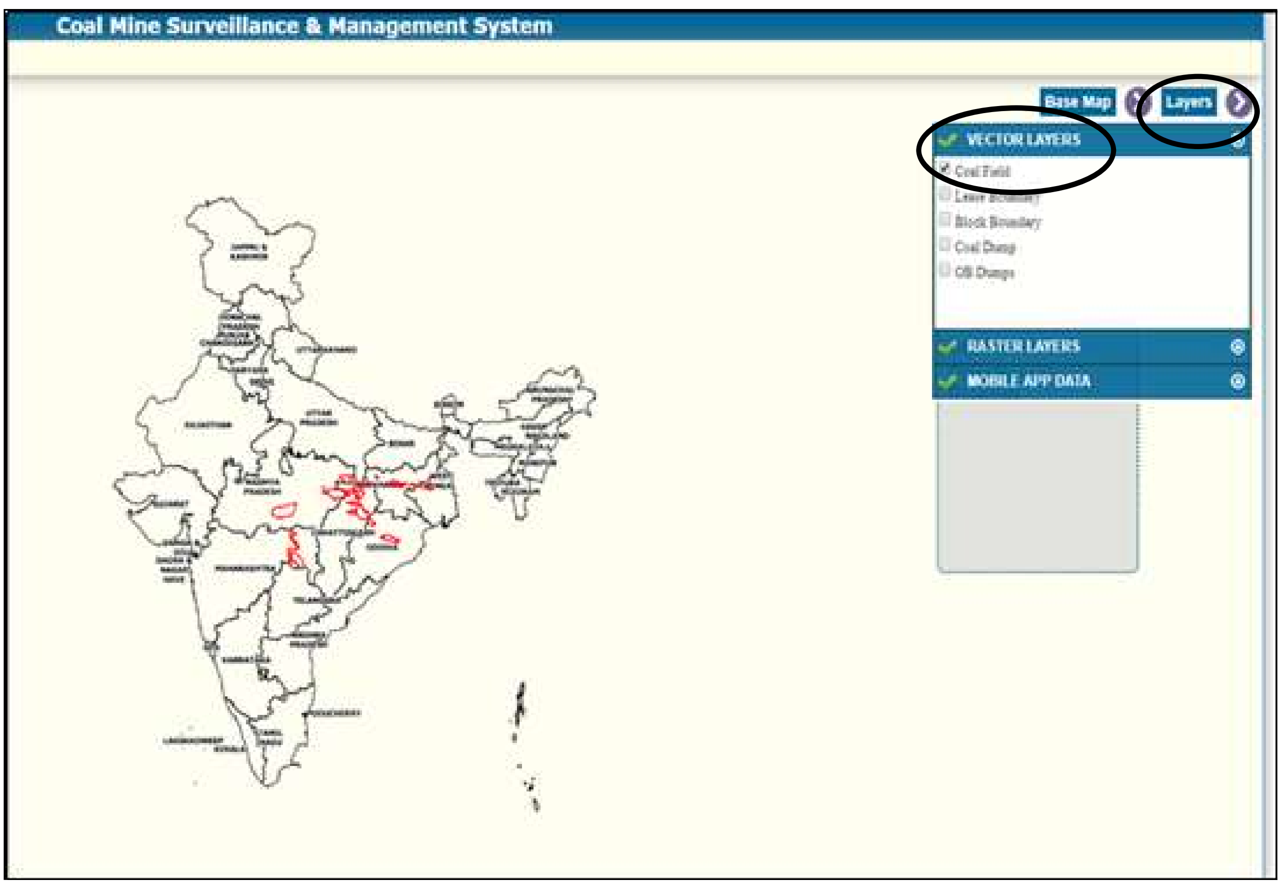


Fig-7: Displaying Coalfield Boundaries on GIS Map Visualizer

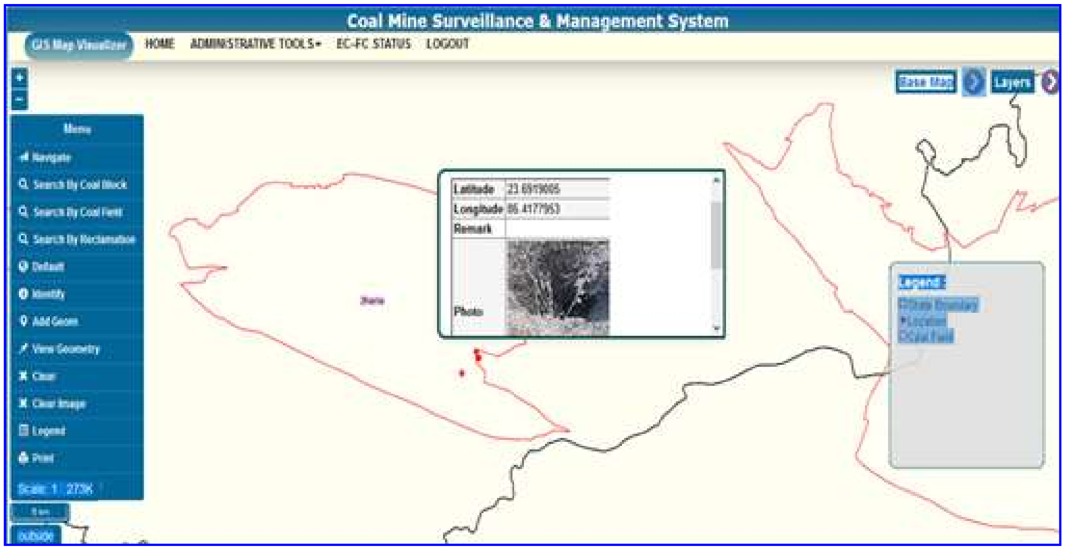


Fig -8: GIS Map Visualizer showing the selected features along with the attributes

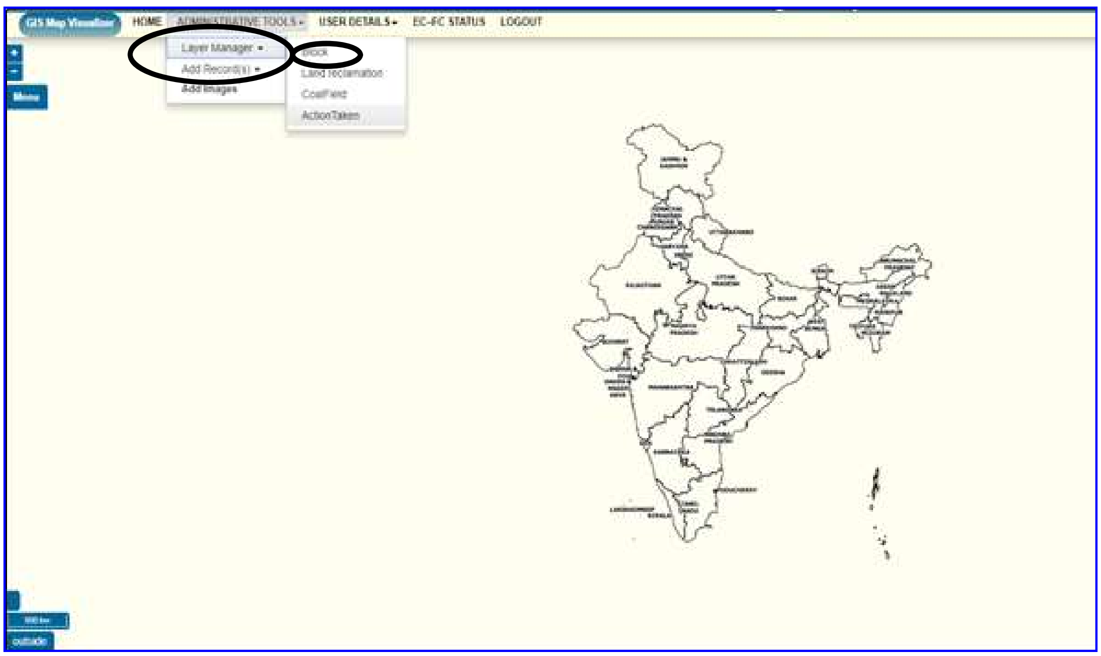
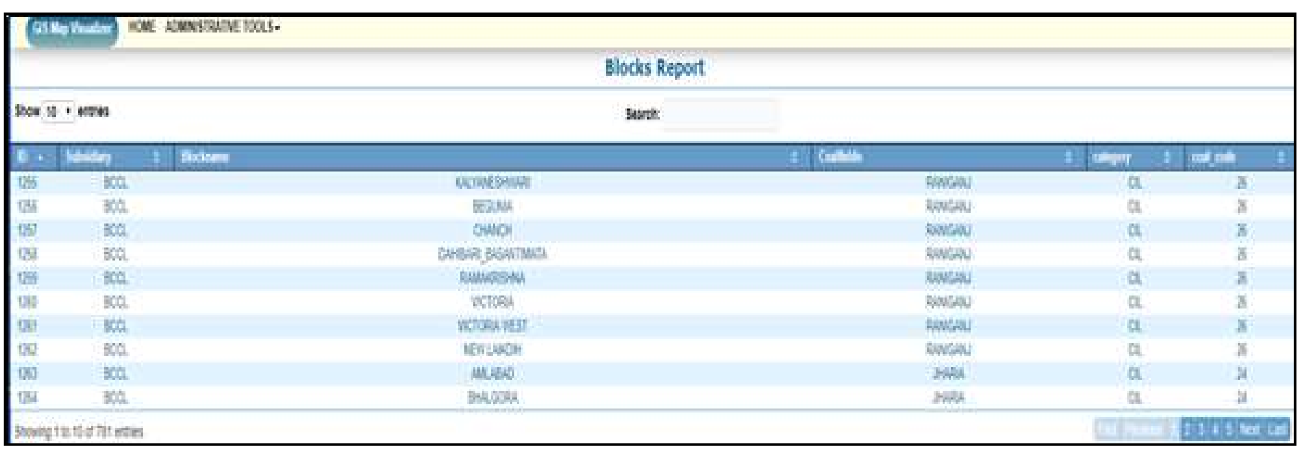


Fig-9: Image showing the options under 'Administrative Tools'


Blocks Report

Show 10 entries Search:

ID	Subsidiary	Blockname	Coalfields	category	coal_code
1255	BCCL	KALYANESHWARI	RANIGANJ	CIL	26
1256	BCCL	BEGUNIA	RANIGANJ	CIL	26
1257	BCCL	CHANCH	RANIGANJ	CIL	26
1258	BCCL	DAHIBARI_BASANTIMATA	RANIGANJ	CIL	26
1259	BCCL	RAMAKRISHNA	RANIGANJ	CIL	26
1260	BCCL	VICTORIA	RANIGANJ	CIL	26
1261	BCCL	VICTORIA WEST	RANIGANJ	CIL	26
1262	BCCL	NEW LAIKDIH	RANIGANJ	CIL	26
1263	BCCL	AMLABAD	JHARIA	CIL	24
1264	BCCL	BHALGORA	JHARIA	CIL	24

Showing 1 to 10 of 781 entries

Fig -10: The Blocks details in a tabular format

VIEWING THE APPLICATION

1. Log in as Guest User or using credentials.
2. Click on the Coal Map option. It displays the map of India on the screen.
3. Various type of information can be seen on the GIS Map Visualizer. To view different layers on GIS Map Visualizer, click on the 'Layers' tab available on top right (Fig 7). It displays 3 subgroups namely: Vector Layers, Raster Layers, Mobile App Data
4. Under the 'Vector Layers' Tab, there are several options like Coalfield, Lease Boundary & Block Boundary. The user may select any of these options to visualize them on the map. A Legend is also displayed describing what each symbol represents in the map (shown in Fig-8)
5. The Raster Layer tab provides option to visualize the satellite images of coalfields. User may select any coalfield and the satellite image of the same will be displayed.
6. Data uploaded through the Mobile App can be visualized by clicking on 'Mobile App Data' and then selecting 'Khanan Prahari Data'.
7. The attributes of the Layers displayed on map get displayed by selecting 'Identify' option under 'Menu' tab provided on left side and then selecting the relevant option.
8. To visualize information in a tabular form, click on 'Administrative Tools' and then to 'Layer Manager'. The user may select any of the options from 'Block', 'Land Reclamation', and 'Coalfield', 'Action Taken' (shown in Fig -9).
9. Selection of the 'Block' option will display the name of the Block, its ID, the subsidiary to which it belongs and other details (shown in Fig -10).
10. The option 'Land Reclamation' will display the Subsidiary name, Coalfield name Project name and other details of projects undertaken for Land Reclamation Monitoring.
11. The 'Coalfield' option displays the name of the Coalfield, the Subsidiary to which it belongs and other details.
12. The 'Action Taken' tab displays the Action Taken Report and other details with respect to report generated whenever an incident is reported/detected (Fig - 11).
13. To view the District, Taluka or Village of any State of India, click on 'Base Map' tab provided on top right and select the relevant option. As shown in Fig - 12, state and district options are selected. The user then needs to zoom in to that

CMSMS REPORT

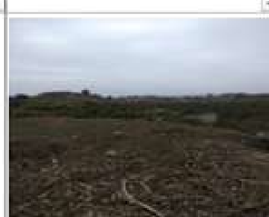
Trigger ID	Date of complaint	Coalfield	Subsidiary	Category of leasehold	Latitude	Longitude	Mode of complaint (Khanan Prahari or Scanning)	Nature of complaint True/False/ Test/Action to be taken	Complainants Remark	Associated uploaded Photograph	NODAL OFFICER Remark
319	16 December 2018	Barddhaman	ECL	CIL	23.5957	87.1402	Khanan Prahari	FALSE	Opportunities of binay chawdhury hospital,mangalpur		Checked at the spot and found nothing to report
320	17 December 2018	Barddhaman	west bengal	NON-CIL	23.6347	87.1184	Khanan Prahari	Yet to be verified	mangal pur near by s.k.s puplic school unlegal mince		Action yet to be taken by Nodal Officer (WB state Nodal officer)
321	17 December 2018	Barddhaman	ECL	CIL	23.6232	87.1283	Khanan Prahari	FALSE			The said place belongs to NH 02 near Bansra area More,where we found no illegal mining. But near area approx 02 km far from there (NH-02 Bansra More Area) some illegal pit mining and some abandoned illegal pits found,regarding this we want to inform you that we had lodged several complaints in local PS Raniganj and Dozering operation there.

Fig -11: The 'Action Taken Report' page of CMSMS

particular state to visualize districts, villages etc. (Fig -13). A legend is also displayed alongside.

14. By clicking on the Road option the user can visualize the road networks of that area.

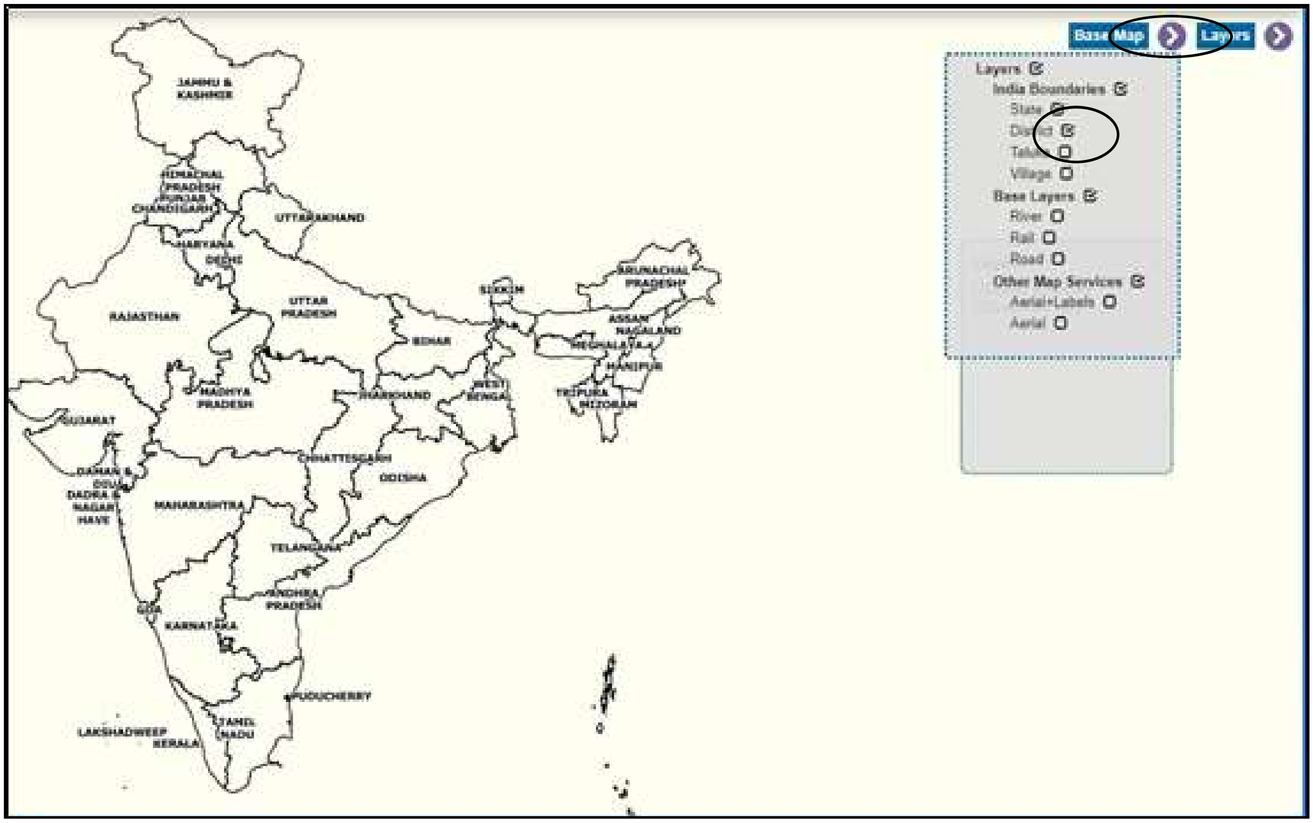


Fig -12: GIS Map Visualizer showing the District and State options under Base Map

Fig-13: Image showing the District and State Boundaries of a region

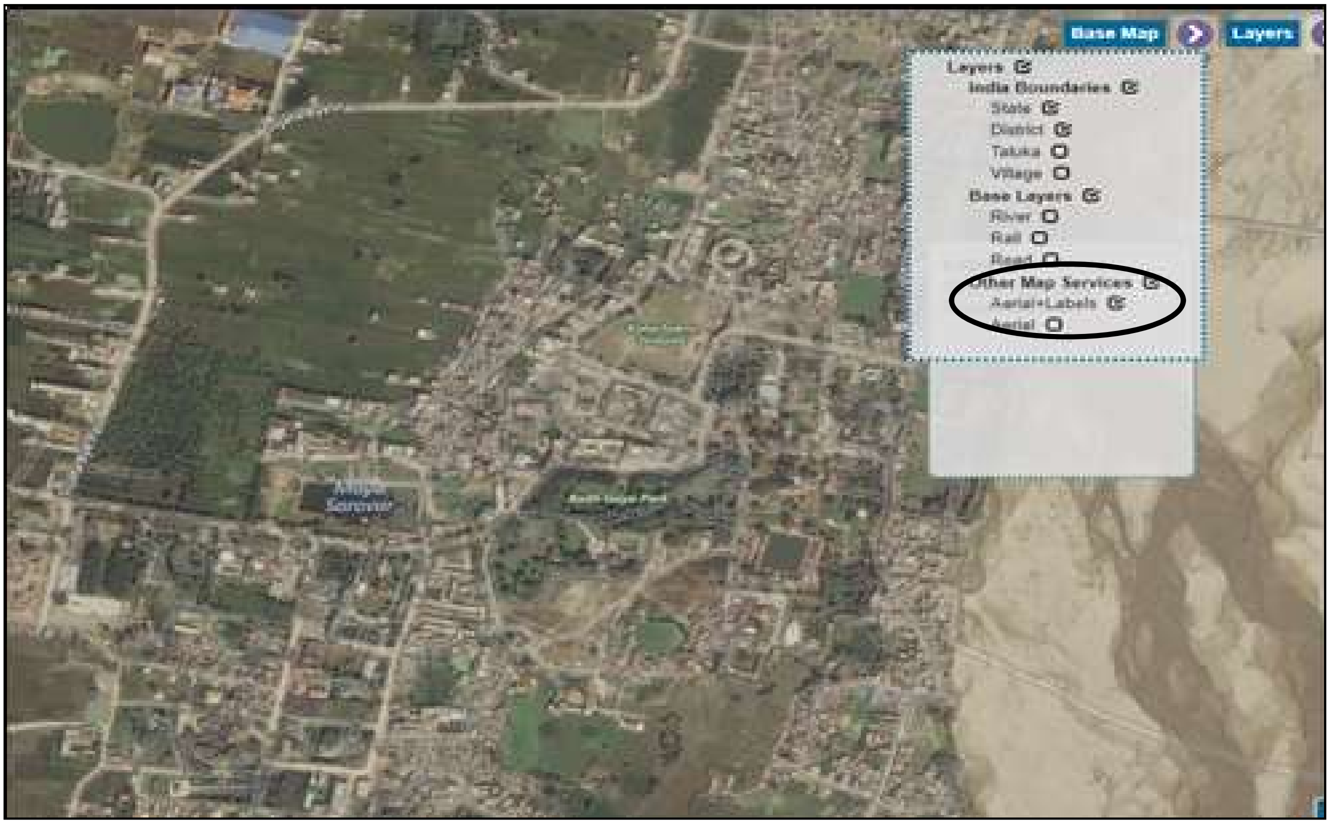


Fig -14: Satellite image along with the place names

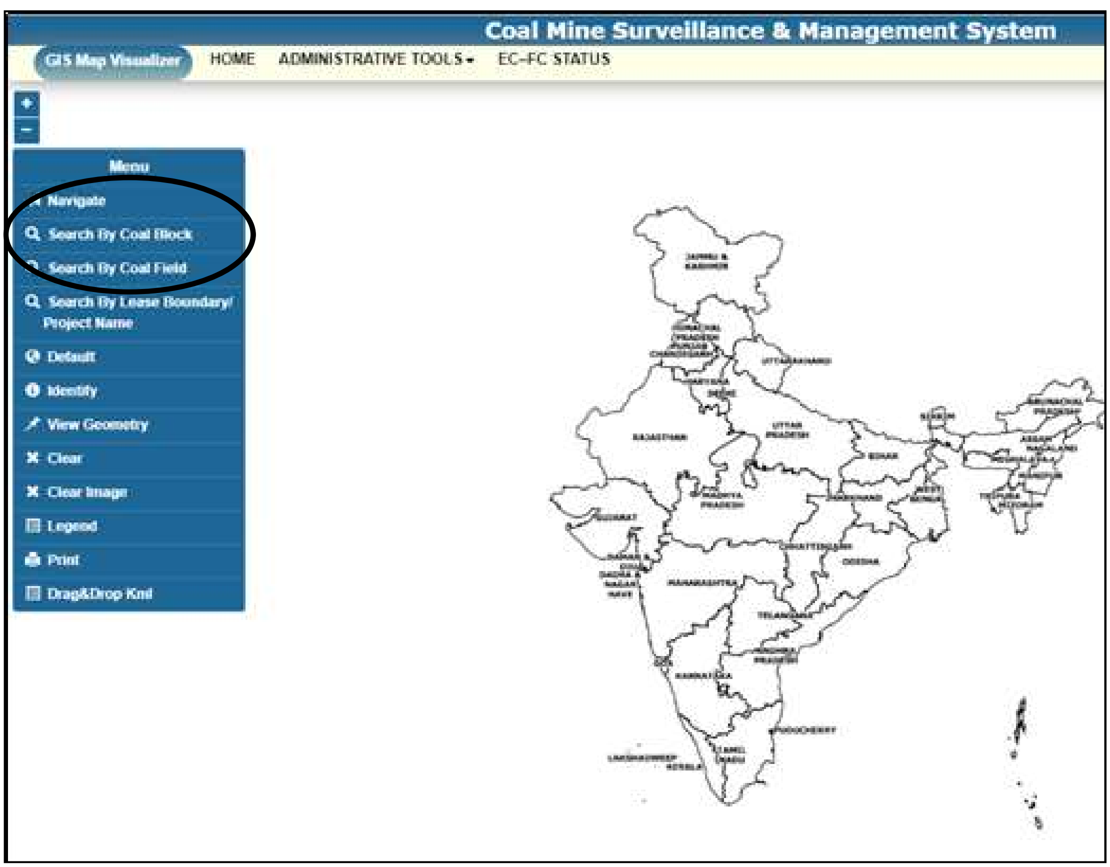


Fig.- 15: Image highlighting the Search options under 'Menu'

Fig-16:Home Page of Khanan Prahari

15.Under Other Map Services, there are two options: Aerial and Aerial + Labels. The Aerial option displays satellite image, while Aerial + Labels displays satellite images together with the names labels (Fig -14).

THE 'MENU' TAB

1.The user may search by names of Coal Block or Coalfield or by Lease Boundary / Project name under 'Menu' tab provided on the left side (shown in Fig 15).

2.The attributes of the Layers displayed on map get displayed by selecting 'Identify' option under 'Menu' tab and then selecting the relevant option.

ROLE OF NODAL OFFICERS

- Nodal Officers have been nominated by competent authority of respective subsidiary companies of CIL to view, verify and take suitable actions on the illegal coal mining reports generated within CIL command area.
- For the areas outside CIL, Director of Mines & Geology of respective States or their representatives have been nominated to function as Nodal Officers for taking suitable action against reported incidents.
- CMPDI will communicate 'User ID' and 'Password' to Nodal Officers for accessing the CMSMS website.

"खनन प्रहरी" - THE MOBILE APP: OPERATIONAL PROCEDURES

It is a Mobile App of Ministry of Coal for Reporting Illegal Coal Mining. It is a tool for reporting any illegal coal mining incident through geotagged photographs as well as textual information by any individual from the place of incidence.

1.Any person willing to report any incident of illegal mining, may do so using the first option 'Complain' at the top of the home page of the app (Fig 16).

2.The complaint page opens (Fig 17). Enter the mobile no. and the complaint details in the Remarks row. Take a picture of the incident site through camera of the Mobile App. GPS enabled devices will instantly record the latitude - longitude of the location.

3.Press the 'Submit' button. The complaint will be submitted to the system for verification. A complaint number will be generated for future reference.

4.The complaint number is unique for each complaint, and can be seen in the system for tracking of the status.

5.To know the current status of the complaint, click on 'Track Your Status' option on the home page of the app (Fig 16). The tracking page is displayed (Fig. 18). Enter the complaint number and submit it. The current status of the complaint will be displayed.

6.Two Map options are provided in the home page: 'Mines Map' and 'Google Map', 'Mines Map' displays the Satellite imagery along with names of places and roads and 'Google Map' shows

Fig-17: The Complain Lodging Page

Fig-18: Complain Tracking Page

the map provided by Google. GPS enabled devices will also show the current location of the device (mobile).

7. The 'FAQ' option provides more information regarding the commonly asked questions about the various terminologies.

BENEFITS OF CMSMS

- CMSMS can prove to be an effective tool for identification, reporting and taking remedial actions on illegal coal mining incidents.
- It is expected to contribute to reducing illegal coal mining incidents and improve the utilization of coal in a better way.
- It will improve the safety and living conditions of the public in the coalfield area.