CHAPTER 5 FIELD STUDIES

5.1 General

After the development of the computer program, the application of these alternative modes of operation was examined in this text on a case-study basis. To accomplish the objectives of the study, field studies has been conducted in four major opencast coal mines (each having two different sections) of Northern Coalfields Limited (NCL), Singrauli Coalfields. The NCL mines were selected for the study because they are prestigious, huge, mechanized mines that use large-capacity draglines with shovel-dumper combinations to remove overburden. Draglines are used to remove roughly 40% of the overburden. In India, the corporation owns the most draglines. Dragline combinations having different modes of operation in the present study are given in the table below. Field studies were conducted in four different projects, each project has divided into two sections. The dragline and operating parameters of each section are given below in table 5.1.

Table: 5.1 Summary of dragline combinations having different modes of operation in the present study.

S.No.	**Combination (LeD/L+LaD/L)**	**Bench height (m)**	**Cut width (m)**	**Mode of operation**	**Seam thickness (m)**	**Seam gradient (degree)**
1	24/96 + 20/96 (Nighai mine-East section)	27-30	70-80	Horizontal tandem	16	2
2	24/96 + 20/96 (Nighai mine-West section)	27-30	70-80	Horizontal tandem	16	2
3	24/96 + 24/96 (Dhudhichua mine East section)	35	75	Horizontal tandem	16-25	3

4	24/96 + 24/96 (Dhudhichua mine-West section)	33-35	72-75	Horizontal tandem	16-25	3
5	10/70 + 24/96 (Bina mine-east section)	45 m	70	Vertical tandem	12-22	2
6	10/70 + 24/96 (Bina mine-West section)	45 m	70-72	Vertical tandem	12-22	2
7	24/96 + 24/96 (Jayant mine- East section)	32	75-78	Horizontal tandem	14-24	3
8	15/90 + 24/96 (Jayant mine- West section)	30	75	Horizontal tandem	14-24	3

5.2 Brief information about NCL

NCL was formed in 1985 and is a subsidiary of Coal India Limited (CIL), Govt of India and Mini Ratna company since 2007. The Singrauli Coalfield is located between latitudes 23^0 47' & 24^0 12' N, and longitudes 81^0 48' & $82^0$52' E. It is located mainly in Singrauli District of Madhya Pradesh. And a small part of about 80 km^2 is in Sonebhadra District of Uttar Pradesh. It is spread over nearly 2,200 km^2. The coal reserves in the north-eastern part of Singrauli coalfield, covering an area of around 220 km^2, are 9,121 million tonnes, out of which 2,724 million tonnes are proved reserves and the rest is inferred or indicated. Important coal seams in this part of Singrauli coalfield are: Jhingurda (130–162 m thick), Purewa (8–25 m thick) and Turra (12–22 m thick). Due to occurrence of flat, thick, and multiple seams, the area has become of great importance as far as coal and power are concerned. The overburden above the Turra coal seam is removed by dragline for full exposure of co**al.** The location map of the study area mines is shown in figure 5.1.

The area has been chosen because it is the only coalfield in India where the entire coal production is mined by opencast mining. Another unique feature of this region is that the large volume of excavation is carried out by deploying large walking draglines operating in tandem to meet the desired rate of coal exposure and coal extraction. This coalfield has the highest number of draglines in India, mostly working in tandem. The various sizes of draglines ranging from 10 to 24 cubic meter bucket sizes with boom length of 72 to 96 m are being deployed in this region. At present, 23 draglines are in operation in this region.

Near about 90 % of coal produced in India is from opencast mines and the remaining coal is produced from underground mines. Opencast mines deploy large number of heavy earth moving machines like draglines and shovels-dumpers combination to remove overburden and produce coal. Draglines, because of their high production versatility and low cost per unit, are the largest mobile equipment on earth which remains the choice wherever geo-mining condition permits. Out of the 39 draglines operating in India, NCL itself have 22 draglines. In NCL, there are 10 numbers of opencast mines where coal (sub-bituminous coal, i.e., non-coking coal in the range of grades G5 to G-13) is being exploited by shovel-dumper combinations and surface miner. Currently NCL has a fleet of 1239 equipment for production.

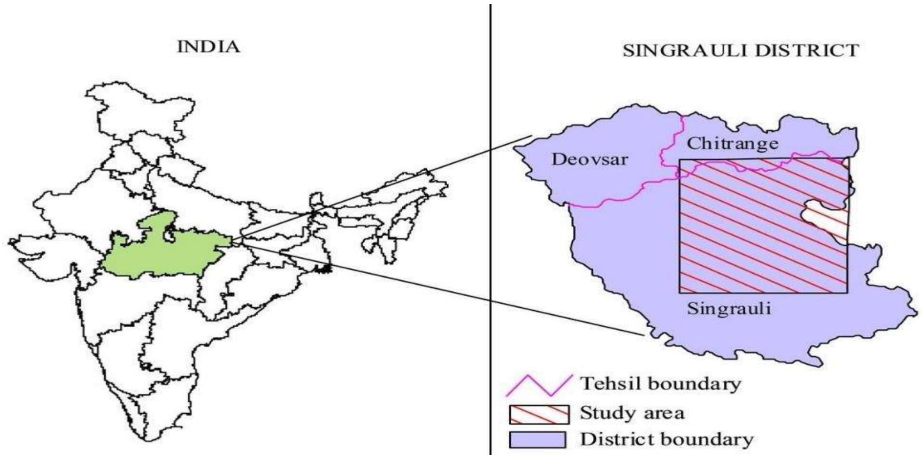

Figure 5.1: Location map of the study area.

NCL mines are divided into two basins, the Moher sub-basin and Singrauli Main basin. Currently, all NCL's coal mining operations are centered on the Moher Sub-basin through ten different opencast mines. The master plan of the Moher basin is shown in figure 5.2.

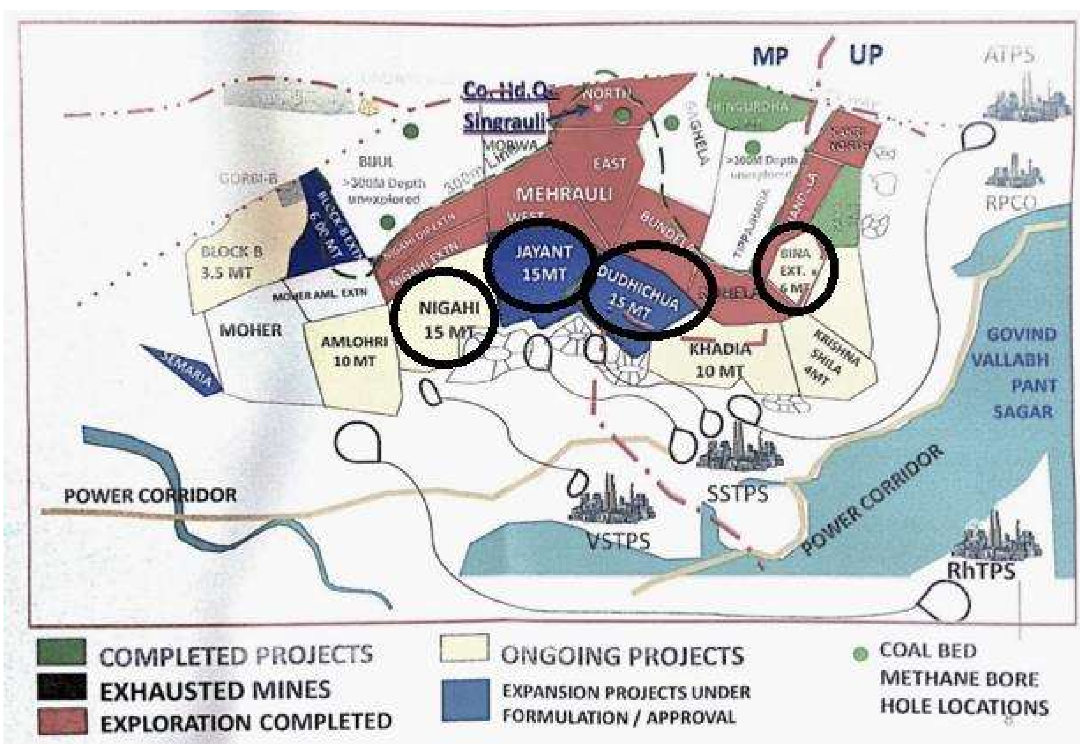

Figure 5.2: Master plan of Moher basin showing study areas in black circles.

Coal production from NCL in last 5 years and target for upcoming years (in

MT) is shown in figure 5.3.

Figure 5.3: Coal production from NCL in last 5 years and target for upcoming years (in MT)

In NCL, coal and overburden are mined by the following methods of opencast mining:

(i) Shovel Dumper System- It is used for coal production and overburden removal.

(ii) Dragline System- It is used for overburden removal.

(iii) Surface Miner-It is used for mining sized coal (-100 mm size) through blast free mining.

(iv)Advanced Blasting System: In NCL, electronic detonator system is being used for controlled blasting in all major opencast mines to ensure proper fragmentation and minimum ground vibration, especially near villages and townships.

Since its inception, NCL has adopted modernization of its equipment and other infrastructure. The equipment population in NCL is as given below:

HEMM	Dragline	Shovels	Dumpers	Surface Miners	Other auxiliary equipment	Total equipment

Population	23	113	550	8	545	1239

The general, geological and mining details of the opencast mining projects of NCL mines where the studies were conducted are discussed below one by one.

5.3 Nighai project

5.3.1 General information about Nighai project

Nigahi Project is a large, mechanized opencast mine situated in Singrauli district of Madhya Pradesh. Nigahi project is located in the Moher sub-basin of Singrauli Coalfield between latitude 24°06’3.29” & 24°11’16.37” north and longitude 82°35’28.23” & 82°39’50.12” east and shares boundary with Jayant and Amlohri projects on the east and west respectively.

5.3.2 Mineable reserves(MR),overburden(OBR), and stripping ratio(SR)

The seam-wise break-up of balance mineable reserves, parting-wise overburden volume and average stripping ratio as of 01.04.2021 within the sanctioned boundary of Nigahi OCP is given below.

Table 5.2: Mineable reserves(MR),overburden(OBR), and stripping ratio(SR)

Particulars	**East Section**	**West Section**	**Total**
Mineable reserves (Mt)			
Purewa seam	103.74	25.52	129.26
Turra seam	71.91	41.38	113.29
Total coal	175.65	66.90	242.55
Volume of OBR (Mm^3)			
OB above Purewa seam	369.66	240.76	610.42
Parting between Purewa & Turra seam	232.87	110.14	343.01

Total OBR	602.53	350.90	953.43
Average stripping ratio (m^3/t)	3.43	5.25	3.93

Figure 5.4: Cross-sectional view of Nigahi mine.

5.3.3 Quarry parameters

The Quarry Parameters of Nigahi OCP are given in the table below.

Table 5.4: Quarry Parameters of Nigahi OCP.

Sl.No.	Particulars	Unit	Value
1	Length of quarry along Turra seam floor	Km	3.50
2	Width of quarry on Turra seam floor	Km	3.40
3	Depth of quarry	m	250.0

5.3.4 Details of major HEMM equipment deployed in the project

The mine deploys the following heavy earth-moving machinery for operations involved in the excavation of overburden, coal, and other auxiliary operations.

1Table 5.5: HEMM deployed in the project.

Equipment	Make/Model	Capacity/Other Specification	Nos.
Dragline	Russian make (model-W2000)	24/96	2
	Russian make (model- ESH 20/90)	20/90	2
Shovel	P&H mining, HEC, BEML ,Bucyrus	10 Cum.	16
	Komatsu/ PC 2000-8	11.5 Cum.	2
	TYE 20 Cum/ WK20	20	2
Dozer	BEML/ BD 355 /D 355	410HP	25
	Komatsu/ D 475A-5	850HP	3
	Caterpillar /Cat834B	450 HP	1
Drill	Ingersollrand / DMH	310mm	3
	Revathi /RECP 850	310mm	1
	Ingersollrand/ IDM70E	250mm	13
	Revathi /Recp 650	160mm	6
	Ingersollrand /ICM 260	100mm	1
Dumper	Terex / Caterpillar /BEML	120 tons	63
	Caterpillar /BEML/ Komatsu	100 tons	45
	BEMLBH-85-1	85 tons	12
Water Sprinklers	Caterpillar /HM 10-35	28KL	1
	BEML/ WS 70	70KL	5

5.3.5 Method of working

Workings of the mine have been divided into two sections, namely the east section and the west section, with a central haul road located on the floor level of the Purewa seam and on the back filled area. The total strike length of the mine is about 3.5, km and the width of the open cast working is about 3. 4 km. The extraction of coal and removal of OB are being the strip-wise advancing method toward the north. Further, the western section is being worked in two sub-sections with a haul road (mid-entry) on the floor

Turra seam. Turra seam of the eastern section approached by a haul road in the eastern flank on the floor of the seam. Presently, two nos. of 24/96 dragline and two nos. of 20/96 dragline is deployed for the excavation of OB.

About 27 to 30-meter height of OB bench has been provided to each dragline. Balance OB above dragline sitting level is being excavated by shovel-dumper and transported through the eastern and western flank as well as the central haul road. Coal from Turra and Purewa seam is being worked by 10 m^3 shovels in combination with 100T dumpers and transported through west mid-entry in the western section, eastern haul road on the floor of Turra seam & central haul road to different receiving pits of CHP.

Additionally, two surface miners have been deployed in Purewa seams in the eastern section with loading and transportation through contractual means.

The upper OB benches are being worked by 20 m^3 electrical rope shovels in conjunction with 190 T and 205 T rear dumpers. The height of the shovel benches varies from 15-18 m. With two-way traffic along the bench, the width of the working benches varies from 57-63 m, whereas the width of the non-working benches varies from 37-43m. The width of the cut for coal benches has been adopted as 40m. The width of the working bench in the coal seam is 45m. The slope of each bench is about 70° in OB and 80° in coal. The overall running slope in working faces is about 15° - 18° bench height of OB dumps formed by the shovel-dumper system is 30m and, slope of individual benches has been kept at 37°. The overall slope of the dump has been kept about 28°. The system of dragline working in the project is shown in figure 5.5.

Figure 5.5: Dragline working in horizontal tandem at Nighai project.

5.4 Dhudhichua project

5.4.1 General information about Dhudhichua project

Dudhichua opencast project is located on the east of Jayant opencast mine and on the west of Khadia opencast mine in Singrauli coalfield. The project is partly in the district of Singrauli in Madhya Pradesh and partly in the district of Sonebhadra in Uttar Pradesh. The geographic coordinates of the area are bounded by longitude 82°41’3.27”E to 82°40’2.3”E and latitude 24°9’12.23”N to 24°9’20.28”N, whereas the southern latitude of the leasehold boundary is 24°7’19.83”N to 24°10’56.40”N. The area is covered in Survey of India Topo sheet No.63L/12 (RF 1:50000) and special Toposheet No.6 to 9. The terrain of the opencast minefield represents the hilly plateau with steep escarpment facing south with RLs of 375m to 400m with occasional hills rising up to 504 m. The average elevation at the foot of the plateau is 325 m above MSL.

The mine is working in two sections, namely west & east section with an average strike length of 1.7 to 2 km, respectively.

5.4.2 Mineable reserves(MR),overburden(OBR), and stripping ratio(SR)

The total MR is 320.01 Mt, and total OBR is 1482.94 Mm3 with an average stripping ratio of 4.63 m3/t (as of 31.03.2021).

Table 5.7: Details of Mineable reserves (MR), overburden(OBR), and stripping ratio(SR) of Dhudhichua project.

Particulars	**West Section**	**East Section**	**Total**
Mineable coal reserves (Mt)			
Purewa top seam	31.73	25.17	56.90
Purewa bottom seam	54.64	52.63	107.27
Turra seam	94.27	88.66	182.93
Total	180.64	166.46	347.10
Volume of OBR (Mm^3)			
Top OB	380.16	498.79	878.95
Parting between Purewa top and Purewa bottom seams	127.90	145.12	273.02
Parting between Purewa bottom and turra seams	213.25	238.56	451.81
Total	721.31	882.47	1603.78
Average stripping ratio (m^3/t)	3.99	5.30	4.62

5.4.3 Description of coal seams

The mine has three coal seams namely, Purewa Top, Purewa bottom and Turra with overburden and interburden as depicted in the cross-section view in figure 5.6.

Turra Seam

Turra seam represents the most potential and bottom-most workable coal horizon, below Purewa bottom seam. The full thickness of Turra seam including all dirt bands varies from 15.45 m to 25.75 m; the effective thickness variation is from 11.30 m to 24.35 meter.

Purewa bottom seam

Purewa bottom seam is the middle workable coal horizon in the area. The maximum depth of seam occurrence is 240 m. The full thickness of the Purewa bottom seam, including all dirt bands varies from 7.35 to 15.20 m.

The roof of the seam is generally composed of medium to coarse-grained sandstone with occasional shale/clay bands. The immediate floor is also marked by fine to coarse-grained sandstone and, at some places, by grey shale. The seam is highly interbedded in nature. These bands are generally represented by carbonaceous and grey shale.

Purewa top seam

Purewa top seam represents the topmost workable coal horizon in the area. The full thickness of the seam, including all dirt bands, varies from 1.95 m to 10.00 m. The roof of the seam is generally composed of medium to coarse-grained sandstone with occasional shale/clay bands. The immediate floor is also marked by fine to coarse grained sandstone; at places grey shale also constitutes immediate floor. This seam is also interbedded in nature. The dirt bands are generally represented by carbonaceous and grey shale. The amount of dip of coal seams is generally about 2^o to 3^o.

Figure 5.6: Section of seams and partings in mines with their mining strategy in Dhudhichua project.

5.4.4 Details of major HEMM equipment deployed in the project

The mine deploys the following heavy earth-moving machinery for operations involved in excavation of overburden, coal, and other auxiliary operations.

Table 5.8: HEMM deployed in the project.

Sl. No.	HEMM	Size/ Capacity	Number
1	Dragline	24/96	4
2	Shovel	10 cum	13
		20 cum	1
		12 cum	1
3	Dumper	120 tons	33
		100 tons	49
		85 tons	10
4	Drill	311 mm	4
		250 mm	8
		160 mm	7

5	Dozer	320 HP	1
		410HP	14
		590 HP	2
		770 HP	5
		450 HP	3
6	Grader	280 HP	7
		270 HP	1

5.4.5 Method of working and its status

The project has 4 nos. of 24/96 draglines and 14 nos. of $10m^3$ rope shovel in conjunction with 120/85 T rear dumpers for excavation of overburden. Elements of the mining system have been determined in accordance with the parameters of excavation, transport equipment and the parameters of drilling and blasting. The minefield is being developed in two sections namely, western section and eastern section. With due consideration to geo-mining characteristics of the deposit, the mine is proposed to be worked by combined system of mining using dragline and shovel-dumper combination. All the OB of the expansion area will be dumped in internal dump. Coal in both sections is proposed to be extracted by shovels and transported to receiving pits/coal stock yards by 100 T rear dumpers.

The height of the main OB bench over the Turra seam, proposed to side cast by dragline in the previous de-coaled cut, would vary from 33m to 40m. The existing dragline cut width is 75m. The upper OB benches are proposed to be worked by $20m^3$ elect rope shovels working in conjunction with 190-210 T rear dumpers. The width of the cut of the OB shovel benches has been adopted as 20m. The height of the shovel-benches varies from 15-18m. With two-way traffic along the bench, the width of the working benches varies from 57-63m (20m cut width, 12m throw, 21m haul road, 6m for power supply arrangement on alternate benches and 4m safety berm), whereas the width of non-working benches varies from 37-43m. Considering the flat dip (2^o-3^o) of the seams, it is proposed to excavate the OB from advance benches by inclined layers parallel to the seam floor. This eliminates the need to cut new horizons from the side of the seam roof and simplifies water drainage from the benches to the central sump. The thickness of the Turra seam varies from 16m to 20m in most of the area and it is proposed to be worked in two sub-benches by $10m^3$ electrical rope shovel in conjunction with 100 T rear dumpers. The system of draglines working in the project is shown by figure 5.7.

Figure 5.7: Dragline working in horizontal tandem at Dhudhichua project.

5.5 Bina project

5.5.1 General information about Bina project

Bina is the first and largest opencast coal project in Uttar Pradesh. This block is situated on the eastern fringe of the Moher plateau, which is more or less flat with a gentle slope towards the west & south and a strip escapement facing east. The general elevation of the area above MSL varies from 300 meters along the escapement to over 400 meters on the plateau. The feasibility study of the coalfield at the location was prepared by the Central Mine Planning & Design Institute, India (CMPDI), in collaboration with Soviet experts in 1974. The coal produced from the project is linked for power generation at the nearby Anpara Thermal Power Station (1630 MW), Obra TPS (1278 MW) of UPRVUL. The mining operations at the project are conducted by two means viz using company-owned equipment and by privately owned equipment, termed 'outsourced activity'.

5.5.2 Geology and coal reserves

Bina project is situated in Mohr's subbasin. The three coal seams Purewa bottom, Purewa top & Turra seams. Description of coal seams proposed to be worked along with the parting details as of 01.04.2021 is furnished hereunder in table 5.11.

Table 5.11: Geology and coal reserves of Bina project.

Sl. No.	Name of seam	Thickness of coal in meters	Geological reserves in million metric tones	Parting thick ness in meters
1	Turra seam	8 -21	109.44	40-56
2	Purewa bottom	5 -13	70.10	21-50
3	Purewa top seam	3-8	38.66	21-170
	Total		218.20	

5.5.3 Details of major HEMM equipment deployed in the project

The mine deploys the following heavy earth-moving machinery for operations involved in the excavation of overburden, coal, and other auxiliary operations.

Table 5.12: HEMM deployed in the project.

Equipment	Make	Capacity/	Numbers

		Specification	
	Ramson & Rapier	24 cum.	2
Dragline	Russian	10 cum.	2
	HEC	10 cum.	4
Electric Rope Shovel	Russian	10 cum.	1
	HEC	10 cum.	4
Hydraulic Shovel	BEML	5.5 cum.	1
	BEML	85T	5
	BEML	100T	14
	Caterpillar	100T	18
Hydraulic Shovel	Kamatsu/L&T	100T	11
	BEML	410HP	16
Dozer	Kamatsu	850HP	1
	Revathi	250mm	4
Drill (electric)	Atlas Copco	250mm	1

5.5.4 Method of working

The elements of the mining system have been determined in accordance with the parameters of excavation and transport equipment and the parameters of drilling and lasting. Generally, the mine is worked in two sections separated by central haul road-north & south sections. The length of north and south flanks are 1.10 km and 1.22 km, respectively having a total length of 2.32 km .each section is worked by combination of two draglines i.e., 10/70 and 24/96. The length of the south & north-cut is m and 1200 m, respectively. Corridor in sitting level at both sides is 18m and at no coal side at roof level is 10m. Dragline is deployed in parting overlying the lowermost Turra seam for its exposure. The OB benches above the dragline bench are excavated by shovel- dumper system (Deptt & HOE). Parting between Turra and Purewa bottom seams is being taken by draglines through separate bench blasting. Transportation through main central haul road on Turra seam floor to receiving pit of existing CHP cum deshaling plant.

In general, the draglines are operated in vertical tandem methods. The height of the main bench over Turra seam, mined by dragline, varies from 42m to 55m. The dragline cut width is 70m. For OB removal between Purewa bottom and Purewa top seams, $10m^3$ electric rope shovel in conjunction with hydraulic shovel and 100 T, dumpers are being used. The shovel dumper bench width is 60 to 70 meter, and 13m height is in standard practice. The width of the cut for shovel benches has been adopted as 70m for shovels. The maximum height of the shovel benches is 15m for electric rope shovel and 10m for hydraulic shovel. Coal winning is being done by pay loader in conjunction with 100 T, rear dumpers. Turra is being worked in three benches. Height of benches varies from 6m to 8m. Bands of thickness more than 1m above the seam are being separated by dragline.

Drilling and blasting involves 250 mm dia. drills for OD and 160 mm dia. drills for coal benches. Explosives used are SMS/SME and charged at 65kg per meter and 95kg per meter depending on the hole dia. The system of dragline working in the project is shown by figure 5.8.

Figure 5.8: Dragline working in vertical tandem at Bina project.

5.6 Jayant project

5.6.1 General information about Jayant project

Jayant project is located in the Singrauli Coalfields in the State of Madhya Pradesh and a small area of 80 sq km in the extreme north-east lies in the district of Sonebhadra of Uttar Pradesh. in India. Geographically the area lies between latitudes $24^{o}6'45''$ and $24^{o}11'15''$ and longitudes $82^{o}36'40''$ and $82^{o}41'15''$. The Project is situated on a high plateau ranging from 300 m to 500 m above the MSL (mean sea level) .The coal is non-coking type and the grade is of C, D and E type**.** The amount of dip is generally about 2^{o} to 3^{o}. The overburden is 90% medium and coarse grained sandstone. The rocks of the Jayant project belong to the Gondwana formation having Barakar measures rocks coal.

5.6.2 Summary of coal reserve, OB estimate, and other vital parameters.

These are described below through table 5.14.

Table 5.14: Summary of coal reserve, OB estimate, and other vital parameters.

Sl. No.	Particulars	Value
1.	Coal Produced up to 2020-21	402.76 MT
2.	OB Removal up to 2020-21	1106.42 MCum

3.	Total Mineable Reserve (As on 01.04.21)	223.77 MT
4.	Total Volume of OB (remaining as of 01.04.21)	712.43 MCum
5.	Present depth of the Mine	150m
6.	Av Stripping Ratio	2.99
7.	Life of the mine	13 Years (as on 01.04.2021)
8.	Present Strike length	4.8 KM
9.	Executives (As on 01.04.2021)	180 (including 07 females)
10.	Non-executives (As on 01.04.2021)	Monthly rated: 390
		Daily rated: 1345
		Apprentices: 68

5.6.3 Description of coal seams

Turra seam

Turra seam represents the most potential and bottom-most workable coal horizon. The seam occurs at a depth range (roof) of 106 to 249 m. The stratigraphic thickness, i.e. including all dirt bands varies from 13.90 to 23.61 m, whereas effective thickness, i.e. excluding dirt bands of 1 m and above in thickness, ranges from 11.90 to 21.65m.

Purewa bottom seam

The Purewa bottom seam overlies Turra seam after a parting of 46.61 to 66.40 m. The seam occurs at a depth range (roof) of 39 to 227 m. The stratigraphic and effective thickness of the seam varies from 8.69 to 18.54 m and from 3.40 to 15.17 m, respectively. The seam is highly interbedded in nature. The maximum cumulative number and thickness of dirt bands less than 1 m in thickness is 9 and 2.11 m, respectively.

Purewa top seam

Purewa top seam represents the topmost workable coal horizon in the area. The seam in crops in the central part and occurs at a depth range (roof) of 16.40 to 204.90 m. The stratigraphic, as well as effective thicknesses of the full seam, vary between 4 m and 13.07 m. This seam is interbedded in nature. The full seam contains 0 to 5 combustible and 0 to 6 non-combustible dirt bands of less than 1 m thickness with a maximum cumulative thickness of 1.38 m and 1.79 m, respectively.

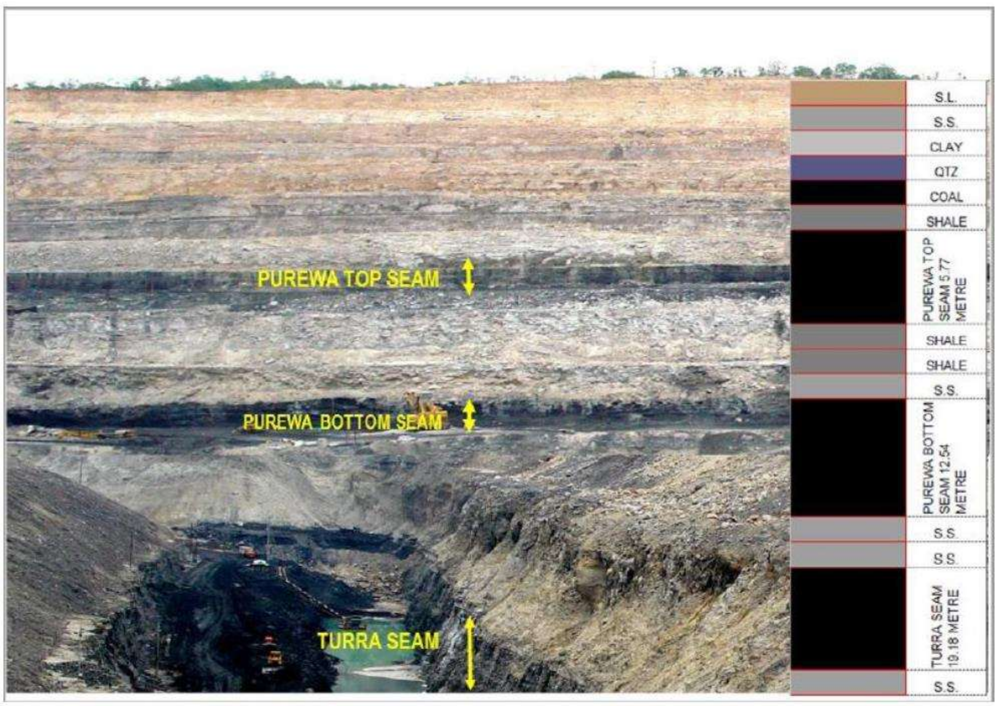

Figure 5.9: Overall view of the different coal deposition and overburden at Jayant opencast project.

5.6.4 Mineable reserves(MR),overburden(OBR), and stripping ratio(SR)

The section-wise MR, OBR& Av.SR is given in the table below.

Table 5.15: Section-wise, MR, OBR & Av. SR.

Particulars	**West Section**	**East Section**	**Total**

Mineable Coal Reserves (Mt)			
Purewa Top Seam	31.55	28.42	59.97
Purewa Bottom Seam	61.00	43.93	104.93
Turra Seam	100.94	74.02	174.96
Total	193.49	146.37	339.86
Volume of OBR (Mm^3)			
Top OB	259.59	117.03	376.62
Parting between Purewa Top and Purewa Bottom seams	84.13	93.88	178.01
Parting between Purewa Bottom and Turra seam	270.05	192.84	462.89
Total	613.77	403.75	1017.52
Average Stripping Ratio (m^3/t)	3.17	2.76	2.99

5.6.5 Details of major HEMM equipment deployed in the project

The mine deploys the following heavy earth-moving machinery for operations involved in the excavation of overburden, coal, and other auxiliary operations.

Table 5.16: HEMM deployed in the project.

Equipment	Make/Model	Capacity/Other Specification	Nos.
Dragline	Ransome & Rapier	24/96	3
	Russian make (model- ESH)	15/90	1
Shovel	P&H mining, HEC	10 Cum.	9
	BEML, Bucyrus	11.5 Cum.	2
	WK20	20 cum	2
Dozer	Kamatsu	890 HP	4
	BEML/ Caterpillar	770 HP	1
	Kamatsu	410 HP	16

	Wheel dozer	-	2
Drill	Ingersollrand	310 mm	1
	Ingersollrand	250 mm	13
	Revati	160 mm	7
	Revati	100 mm	1
Dumper	Caterpillar	190 tons	15
	BEML	120 tons	4
	Caterpillar /BEML	100 tons	60
	Komatsu	85 tons	1
Water Sprinklers	BEML/ WS 70	70 KL	6
	BEML	28 KL	12
Graders	-	280 HP	06
Surface Miner	-	Drum width 4M	02

5.6.6 Method of working

The method of work adopted at Jayant project is dragline-cum-shovel-dumper combination mining. Two flanks, namely east and west are, operating in the length of 2.2 km and 2.2 km, respectively with a total length of 4.4 km. The coal seams are dipping north and the sump is located at the intersection point of both flanks. An average of 80 meter width is taken in the dragline cut with an average working height 27 meters, and the rest of the parting, i.e. 28-30 meters is taken by shovel-dumper combination by an outsourcing agency. There are two draglines, 15/90 and 24/96 in west side and two nos. 24/96 draglines are in the eastern side. Draglines are operated in horizontal tandem method, as per the balancing diagram proposed by CMPDIL. There are two mid-entries, i.e. east and west mid-entry, apart from central entry to mine out Turra seam. These entries facilitate the draglines to operate continuously without idling while taking the new seating in the next cut. Also, the lead of dumpers reduces with the provision of mid-entries.

Shovel and dumper combination are deployed for Turra, Purewa top and bottom coal seam and all OB benches beyond the dragline benches. In the Shovel-dumper combination 40 meter width and 15-meter height is taken as a standard practice. Part of OB removal in the mine has been outsourced. 2 nos. of surface miner are deployed at Purewa bottom seam in west section, and coal transportation from surface miner face is being done by an outsourcing agency.

The normal drilling pattern for the dragline bench is 10x12 meters with 259/311 mm dia. drills and for Shovel-dumper combination, the pattern is 9x11 meters with 259 mm dia. drills. The explosives used are SMS and SME with charging 65 to 95 kg/meter depending upon the bench condition, hole dia. and drilling pattern. The use of e-det (electronic detonators) has been introduced at Jayant, recently on account of its effectiveness in controlling ground vibration along with facilitating better fragmentation. The system of dragline working in the project is shown by figure 5.10.

Figure 5.10: Dragline working in horizontal tandem at Jayant project.

5.7 Data collection from field study

For production calculations, the cycle time must be accurately estimated. For the study, data like cycle time, number of cycles, hourly or daily production, working, and breakdown time etc. data were collected from the dragline monitoring system (DMS) of the dragline of the mine as well as from the mine(s) office. Before a dragline productivity analysis can be performed, volumetric and swing angle information for the simulated mining strips must first be combined with additional data from a dragline performance analysis and time study. The time study results can also be used to determine the relationship between the elements of a dragline cycle time. Dragline swing and hoist information and walking and other delay times can be obtained either from performance curves provided by the equipment manufacturers or from mine site time studies.

5.8 Dragline monitoring system

Complex geological conditions are usually encountered with deeper dragline excavation. In these conditions, the operator should have good control over operating parameters and the machine performance. A dragline monitoring system (DMS) is generally the most excellent tool used to collect data on the machine performance. (Phillips, 1989). The primary objective of a DMS, regardless of its format, is to gather, summarise, process, and report on detailed data automatically. The data and performance analysis are helpful in recognizing and reducing poor practice with optimising critical mining parameters. New dragline stripping method can also validate and evaluate with the DMS (Phillips, 1989.). Figure 5.11 to 5.14 show Leica on-board monitoring system of a dragline model W-2000 at NCL mine with various information. A typical DMS of any kind consists of three main sections (McLean and Baldwin, 1989)

1. On-board display equipment: This computer system is used to record data, process it, and provide digital outputs.

2. Interface equipment: This device establishes a communication channel between the dragline and the mining office's main computer.

3. Mine office computer: The dragline data are received to the office computer. The input data are then compacted and stored. After input data calculations, interpretation, and manipulation, the output data are represented in various tables and graphs. These data can also be used for machine performance analysis, maintenance monitoring, and scheduling.

Figure 5.11: Leica on-board monitoring system of a dragline model W-2000 at NCL mine.

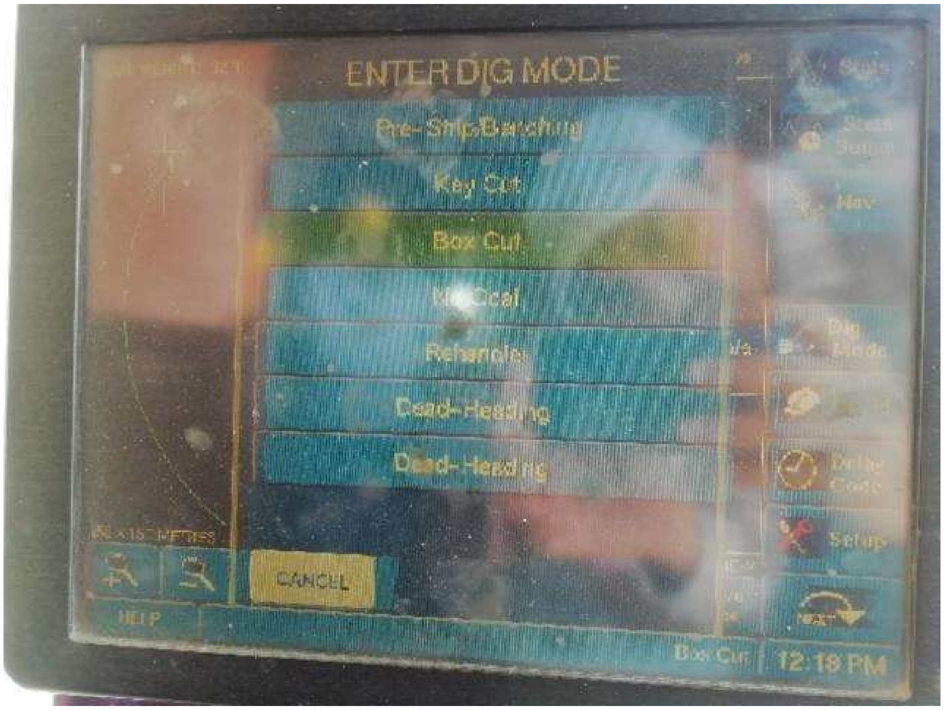

Figure 5.12: Leica dragline monitoring system showing various dig modes.

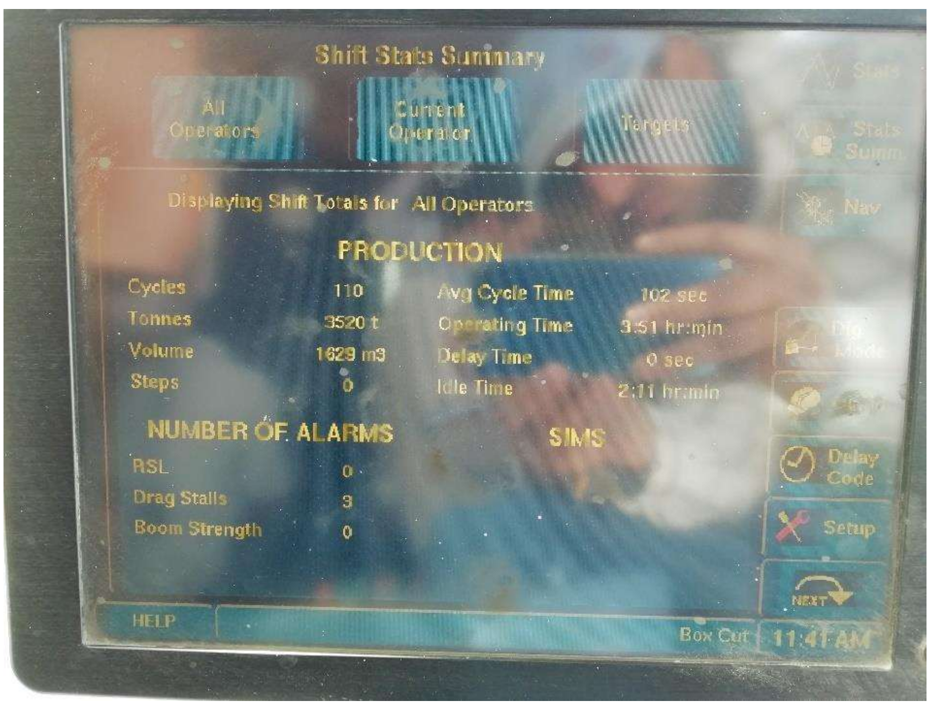

Figure 5.13: Leica dragline monitoring system showing shift stats summary.

Figure 5.14: Leica dragline monitoring system showing cycle time and swing angle information.

Data captured by a dragline monitoring system (DMS) can be used for different purposes including machine performance analysis, scheduling, automated reporting, and maintenance monitoring as well as evaluating the effect of geology and changes in the mode of operation. In this thesis a cycle time study was performed using data from a dragline monitoring system captured over a four-month period. The results of the cycle time study were then used as input in production and productivity calculations.

5.9 Determination of annual production capacity of different draglines

During field study, four different capacities of the draglines were encountered namely 24/96, 20/90, 15/90 and 10/70 respectively.

The amount of overburden removal and coal production are directly proportional to each other. It means productivity of the machine has direct impact on the rate of coal exposure. It should be the aim of planning engineer to adjudge the productivity of the equipment before further operational planning to accomplish meaningful results. This is precisely the reason as to why the average productivity approach has been incorporated in the present study. An estimate of dragline productivity is sensitive to adjustment in six basic parameters which are (i) average cycle time, (ii) availability percentage, (iii) utilization percentage, (iv) availability cum utilization percentage, (v) swell factor, (vi) fill factor, (vii) machine travel and positioning factor. The annual production of various draglines has been assessed considering 3 shifts per day of 8 hours per shift for 365 days per year working schedule basis i.e. 8760 hours (as per CMPDIL). It is pertinent to mention here, that previously annual production of draglines has been assessed considering 6000 working hours per year.

5.9.1 Average cycle time

To evaluate the performance of a dragline of particular bucket capacity and in a particular mode of operation, the cycle of operation and average cycle time must be known. In order to get precise and accurate productivity of a dragline, cycle time analysis has been done for various swing angles keeping in view the mode of operation (tandem operation). The average cycle times of different capacity draglines are tabulated in Table 5.17. From these field data, the average cycle time for 24/96, 20/90, 15/90 and 10/70 dragline were found to be 81.45, 77.95, 71.60 and 69.48 seconds respectively.

Table 5.17: Cycle time of different capacity draglines for various swing angles.

Swing angle (Degree)	**Cycle time for 24/96 (sec.)**	**Cycle time for 20/90 (sec.)**	**Cycle time for 15/90 (sec.)**	**Cycle time for 10/70 (sec.)**
90	70.00	66.5	58.9	58
105	73.84	70.34	64.14	61.4
120	77.68	74.18	67.7	65.8
135	81.50	78	71.5	69.5

150	85.25	81.75	75.6	72.9
165	89.00	85.5	80	78
180	92.90	89.4	83.4	80.8
Average cycle time	81.45	77.95	71.60	69.48

5.9.2 Average annual production of different capacity draglines for various swing angles

The average annual production of the different capacity draglines can be obtained by the formula given below:

$$P_A = \frac{B}{C} \times K \times S \times F \times M \times 3600 \times 8760 m^3 \dots\dots\dots\dots\dots (7.1)$$

where, P_A = Annual production of the dragline (m^3) for solid in-situ rock

B = Bucket capacity of the dragline (m^3)

C = Average cycle time (sec)

K = Availability-cum-utilization factor of dragline

S = Swell factor of the OB (sandstone)

F = Fill factor of the dragline bucket

M = Machine travel and positioning factor. (It depends upon the time required to travel and position the dragline during maneuvering)

Values of these factors are obtained from CMPDIL norms and are given below.

K = 0.7537, S = 0.718, F = 0.934 and M = 0.74

After obtaining the average cycle time for various swing angles, availability cum utilization factor, swell factor, fill factor and machine travel and positioning factor, the average annual production of the different capacity draglines can be obtained by substituting these values in the formula given above. The annual productivity of different draglines calculated by this formula is given in table 5.18.

Table 5.18: Annual productivity of different draglines.

Swing angle (Degrees)	**Dragline 24/96**	**Dragline 20/90**	**Dragline 15/90**	**Dragline 10/70**
90	4.10	3.55	3.10	2.14
105	3.90	3.35	2.86	2.03
120	3.71	3.16	2.72	1.91
135	3.55	3.00	2.58	1.81
150	3.40	2.85	2.45	1.74
165	3.26	2.71	2.33	1.63
180	3.13	2.58	2.24	1.58
Average	3.57	3.02	2.61	1.83

It is obvious from table 7.2 that average annual productivity of the draglines 24/96, 20/90, 15/90 and 10/70 are 3.57, 3.02, 2.61 and 1.83 Mm^3 respectively which are very close to the annual productivity for 135-degree swing angle. Thus, average annual productivity of 24/96, 20/90, 15/90 and 10/70 draglines can be considered to be 3.57, 3.02, 2.61 and 1.83 Mm^3 respectively.