APPLICATION OF RIPPER-DOZER COMBINATION IN SURFACE MINES: ITS APPLICABILITY AND PERFORMANCE STUDY

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR IN TECHNOLOGY

IN

MINING ENGINEERING

BY

RAJAT KUMAR SAHU

108MN010

DEPARTMENT OF MINING ENGINEERING

NATIONAL INSTITUTE OF TECHNOLGY

ROURKELA-769008

2012

APPLICATION OF RIPPER-DOZER COMBINATION IN SURFACE MINES: ITS APPLICABILITY AND PERFORMANCE STUDY

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR IN TECHNOLOGY

IN

MINING ENGINEERING

BY

RAJAT KUMAR SAHU

108MN010

Under the guidance of

PROF. H.K.NAIK

DEPARTMENT OF MINING ENGINEERING

NATIONAL INSTITUTE OF TECHNOLGY

ROURKELA-769008

2012

NATIONAL INSTITUTE OF TECHNOLGY

ROURKELA

CERTIFICATE

This is to certify that the thesis entitled **"APPLICATION OF RIPPER-DOZER COMBINATION IN SURFACE MINES: ITS APPLICABILITY AND PERFORMANCE STUDY"** submitted by **Sri Rajat Kumar Sahu** in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

Date :

Prof. H.K.NAIK
Dept. of Mining Engineering
National Institute of Technology
Rourkela – 769008

ACKNOWLEDGEMENT

First and foremost, I express my profound gratitude and indebtedness to **Prof. H.K.Naik** , Department of Mining Engineering for allowing me to carry on the present topic **“Application of ripper-dozer combination in surface mines: its applicability and performance study”** and his able guidance and pain taking effort in improving my understanding in this project.

Assemblage of this nature could never have been attempted without the reference to and inspiration from the works of others whose details are mentioned in the reference section. I acknowledge my indebtedness to all of them.

At last, my sincere thanks to all my friends who have patiently extended all sorts of helps for accomplishing this assignment.

Date : **RAJAT KUMAR SAHU**

CONTENTS

ABSTRACT

The surface mining of rocks and coal requires drilling and blasting operation for loosening the strata. In drilling and blasting a lot of dust, gases, ground vibrations, cracks and noise are produced. This concludes that these operations are not eco -friendly. Also they involve many types of machinery to complete the job. Blast free mining is the need of the hour to conserve the environment. Different studies and experiments have come up with developments like Ripper dozer and Surface miner. Ripper is mainly used to excavate the overburden. These involve less number of machinery. But before deploying rippers in mines, proper rippability assessment of the strata should be done. There are different parameters on which rippability of rocks depend on. Relationships are made between the parameters and productivity of rippers. Considering all these parameters rippers are introduced in mines.

LIST OF FIGURES

LIST OF TABLES

Chapter 01

INTRODUCTION

1.1 Background :

Archaeological studies say that mining was done during in prehistoric times in stone age. Great progress was made in the field of mining when the concept of black powder reached far west, probably from China in the late middle ages. This was replaced by dynamite and gradually shifted to ammonium nitrate fuel blasting agents and slurries. Proper breakage of rocks require correct hole placement and blasting order.

Development in drilling techniques was accompanied by developments in loading and excavation techniques. Now-a-days deposits at greater depth have been attacked by surface mining methods. The share of opencast methods has gone upto 70% of world's total mineral production.

The surface mining of hard rocks and ore demands drilling and blasting. But these techniques have many adverse effects on environment. So today's eco-conscious world demands introduction of improved technology for blast free, safe and eco-friendly mining.

Ripper with dozer can be an appropriate answer to the present trend blast free eco-friendly mining. It results in minimized use of explosives for very hard strata.

1.2 Objective:

The basic objective is to study the applicability and performance of ripper-dozer combination in both coal and metal opencast mines and suggest some recent developments.

1.3 Research technique:

I. Extensive literature review has been done to identify the parameters affecting the performance of ripper-dozer. The role of these parameters and how they are affecting are established in this study.

II. Two case studies have been done to study the performance of ripper dozer. Cases of *Panchpatmali Bauxite mines, NALCO, Damanjodi* and *Talabira-1 coal OCP, HINDALCO,* Talabira have been studied.

III. Recent developments in the field of ripping and dozing have been mentioned in this report.

Chapter 02

LITERATURE REVIEW

2.0 Background:

Ripping with dozers came into existence in late 1950s and have become popular method of excavating soil and rock. Mostly it is used to excavate overburden. Ripping is method of loosening rocks using steel tynes attached to the rear of bulldozers. These tynes are lowered into the ground which displaces the soil or blocks of rocks as the whole unit moves forward.

Ripping is usually economic than drilling and blasting. But as the ripping becomes harder drilling and blasting becomes cheaper. The problems of noise and dust pollution by the fly rock and the ground vibration in blasting area has caused serious concern to the environmentalist and the laws as in different countries have laid down strict limits for them. With the evolution of high power rippers this has been made possible and as it stand today ripper dozer while taking care of environment and safety have become competitor to drilling and blasting even in term of cost. The ripper has a long recorded history as it was the first means for fragmenting the rock in situ. The evolution of rippers can be dated back to 312 B.C when a wheel mounted plough drawn by oxen was used for building the Roman Appian way the rippers drawn by tractors with about 75 H.P with the passage of time developments have undergone several technological developments and today we have the heaviest ripper weighing about 92965 kg being pulled by the 770 H.P tractor.

2.1 Reasons to select ripping:

Ripping is considered due to various reasons as stated below:

- **Increased productivity:** In ripping process there is continuous work going on. This reduces idle time. It also eliminates shifting of machines which present in blasting operation.
- **Minimized ground vibration:** Drilling and blasting operation includes large ground vibration which affect nearby inhabitation and creates cracks on ground and structures. Ripping and dozing minimizes ground vibration.
- **Safety:** There are chances of generation of fly rocks during blasting. Also chances of misfires are more in blasting operation. Ripping eliminates the chances of generation of fly rocks and misfires, thereby increasing safety of life and properties.
- **Noise and dust reduction:** Drilling and blasting creates a lot of noise and dust which is eliminated by use of rippers.
- **Product size:** Blasting sometimes result in oversize boulders which may require secondary blasting which is a costly affair. But selection of right kind of ripper results in right size of material.
- **Slope stability:** blasting may result in slope failure. But ripping provides better safety and slope stability.
- **Quality control:** In blasting there are chances of dilution of ore. But in ripping operator can easily distinguish between ore and waste. Ripping is helpful in selecting mining.
- **Cost economics:** Ripping doesn’t involve involvement of various machineries as in drilling and blasting thereby making the process economical.
- **Environmental friendly:** Ripper provides a pollution free environment to work.

2.2 Rippability assessment- A review

Selection of ripper depends on degree of rippability of rock. There is lot of factors on which degree of rippability depends on. Many researchers have suggested many factors. Following is table showing various factors proposed by different researchers.

FACTORS RESEARCHERS	Field Seismic Velocity (m/s)	Fracture Index	Point Load Index	Rock Hardness	Rock Weathering	Joint spacing	Joint continuity	Joint gauge	Dip and Strike Orientation
Atkinson (1971)	√								
J.M.Weaver (1975)	√			√	√	√	√	√	√
Kristen (1982)	√				√	√		√	
Singh R N, Denby B and Egretli I (1987)	√				√				
Hardy J Smith (1986)				√	√	√	√	√	√
Franklin, Broch and Walton (1971)		√	√						

Table 2.1 Factors suggested by different researchers (*Subhrakanta Samal et al*.)

Various factors on which degree of rippability of rock depends on:

- Nature of formation of the rock: Igneous & metamorphic rocks are difficult to rip in absence of substantial fractures or weak planes while sedimentary rocks are more amenable to ripping due to presence of clear planes of stratification.
- Brittleness and crystalline structure of rock.
- Degree of stratification and lamination of rock.
- Well defined fracture plane.
- Moisture content: presence of moisture reduces the shear strength of rock and makes it suitable for ripping.
- Geological disturbances like faults, joints, fractures and planes of weakness.

- Grain size: coarser the grain-size more it is suitable for ripping.
- Degree of consolidation of rock.
- Physico-mechanical properties of rocks like compressive strength tensile strength, shear strength rocks having higher compressive strength require high power ripper for breaking them.
- Specific energy (*Basarir H., et al, 2004*).

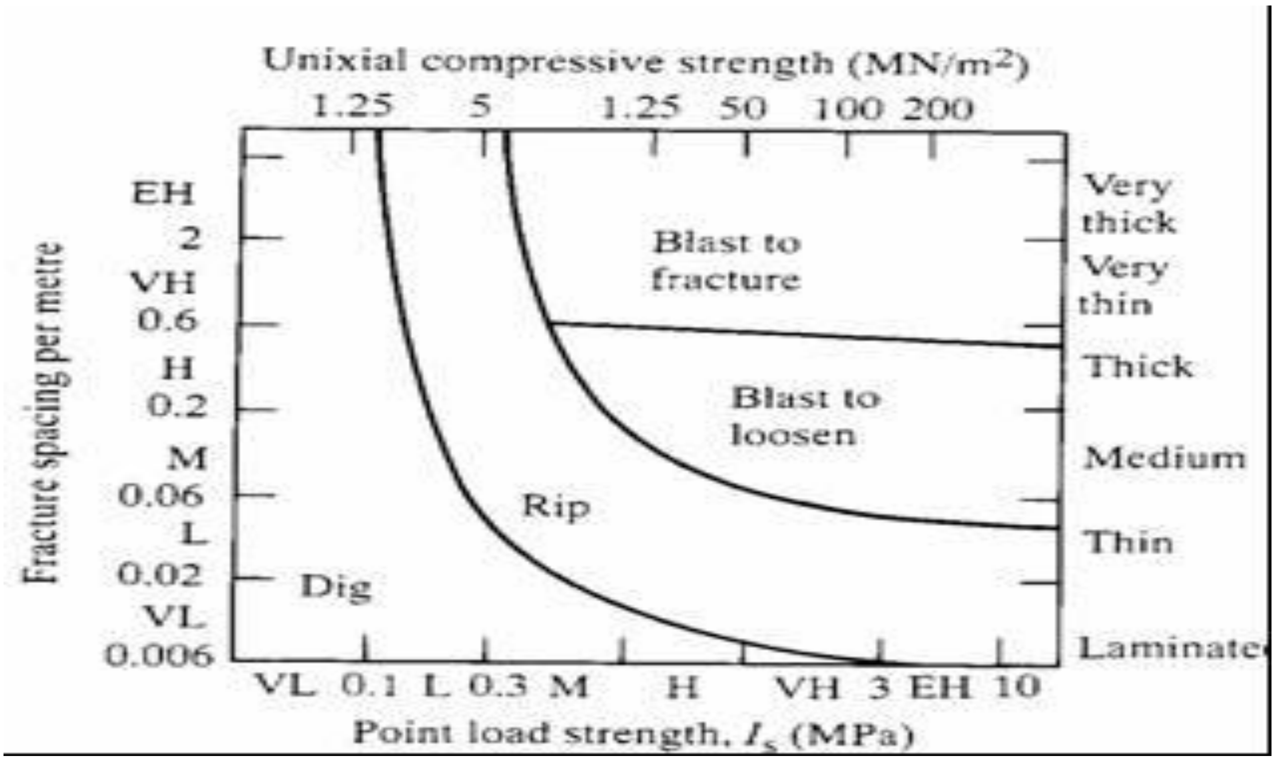


Fig.2.1 Different excavation techniques considering various types of strata.

Table 2.2 Excavation characteristics based on rock strength and hardness. (*Rock excavation techniques, MnE-415 course notes, university of Arizona mining and geological engineering.*)

Rock hardness description	*Identification criteria*	*Unconfined compression strength* (MPa)	*Seismic wave velocity* (m/s)	*Excavation characteristics*
Very soft rock	Material crumbles under firm blows with sharp end of geological pick; can be peeled with a knife; too hard to cut a triaxial sample by hand. SPT will refuse. Pieces up to 3 cm thick can be broken by finger pressure.	1.7–3.0	450–1200	Easy ripping
Soft rock	Can just be scraped with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of the pick point; has dull sound under hammer.	3.0–10.0	1200–1500	Hard ripping
Hard rock	Cannot be scraped with a knife; hand specimen can be broken with pick with a single firm blow; rock rings under hammer.	10.0–20.0	1500–1850	Very hard ripping
Very hard rock	Hand specimen breaks with pick after more than one blow; rock rings under hammer.	20.0–70.0	1850–2150	Extremely hard ripping or blasting
Extremely hard rock	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.	>70.0	>2150	Blasting

Table 2.3. Excavation characteristics based on joint spacing (*Rock excavation techniques, MnE-415 course notes, university of Arizona mining and geological engineering*.)

Joint spacing description	*Spacing of joints (mm)*	*Rock mass grading*	*Excavation characteristics*
Very close	<50	Crushed/shattered	Easy ripping
Close	50–300	Fractured	Hard ripping
Moderately close	300–1000	Block/seamy	Very hard ripping
Wide	1000–3000	Massive	Extremely hard ripping and blasting
Very wide	>3000	Solid/sound	Blasting

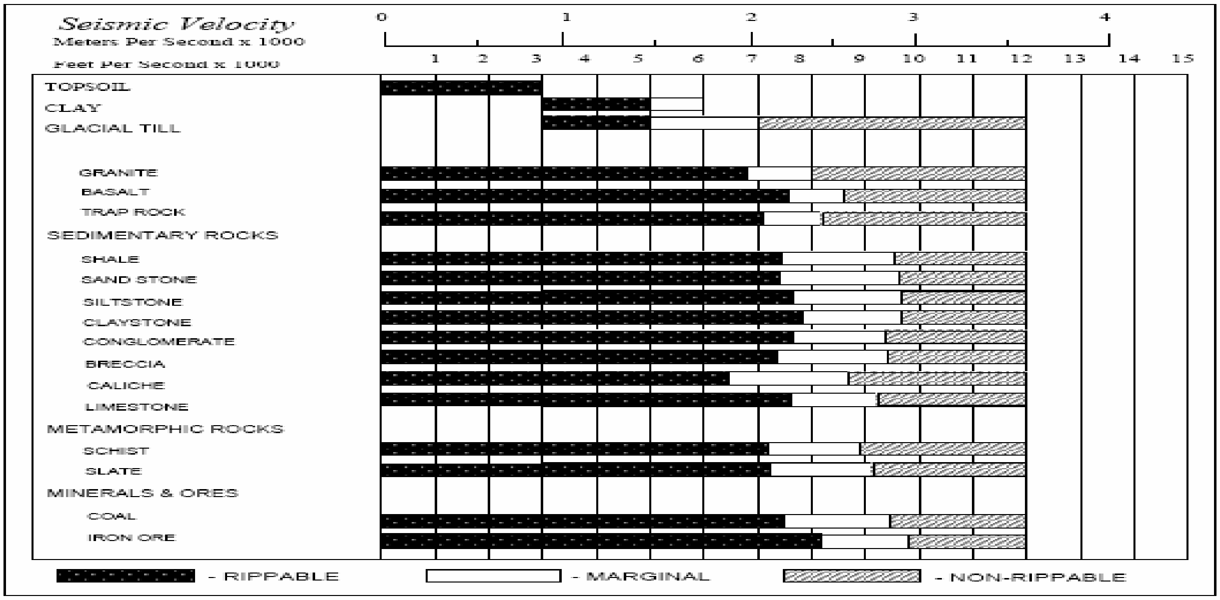


Fig.2.2. Seismic velocities in relation to ripping (*Source: Caterpillar,2008*).

2.3 Determining rippablity

Rippability can be determined in two methods:

i) Direct methods

ii) Indirect methods

2.3.1 Direct method:

It includes direct field trials at the site with available equipment. The ripper performance is determined based on hourly production rate, Q_h in m^3/hr, which is either determined by volume by weight, volume by cross sectioning, and volume by length method (Basarir and Karpuz, 2004). Hourly production depends on ripper horsepower and in-situ rock properties.

Volume by length method: Hourly production is calculated as follows:

Hourly production rate, $\mathbf{Q_h = Q_c \times 60 \times E / t}$

Where, Q_c – Production per cycle, m^3/hour (on bank volume)

E – Operator's efficiency

t – Cycle time, minutes

During direct ripping runs the operator's efficiency, ripping length (L), ripping depth (D), ripping width (W), ripping time (t_r) and maneuvering time (t_m) are recorded.

One cycle production can be determined as follows:

One cycle production, $\mathbf{Q_c = A \times L}$

Where , Q_c – Per cycle production in m^3

A – Cross sectional area, m^2

L – Ripping length, m

Cross sectional area can be calculated by considering following triangular cross section cut by ripper on the ground.

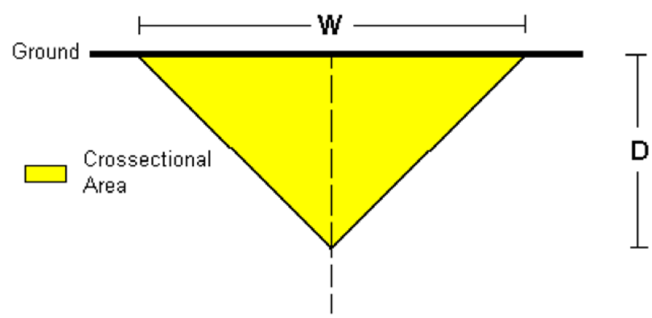


Fig.2.3 Triangular cross section cut

Cross sectional area, $\mathbf{A = DW/2}$

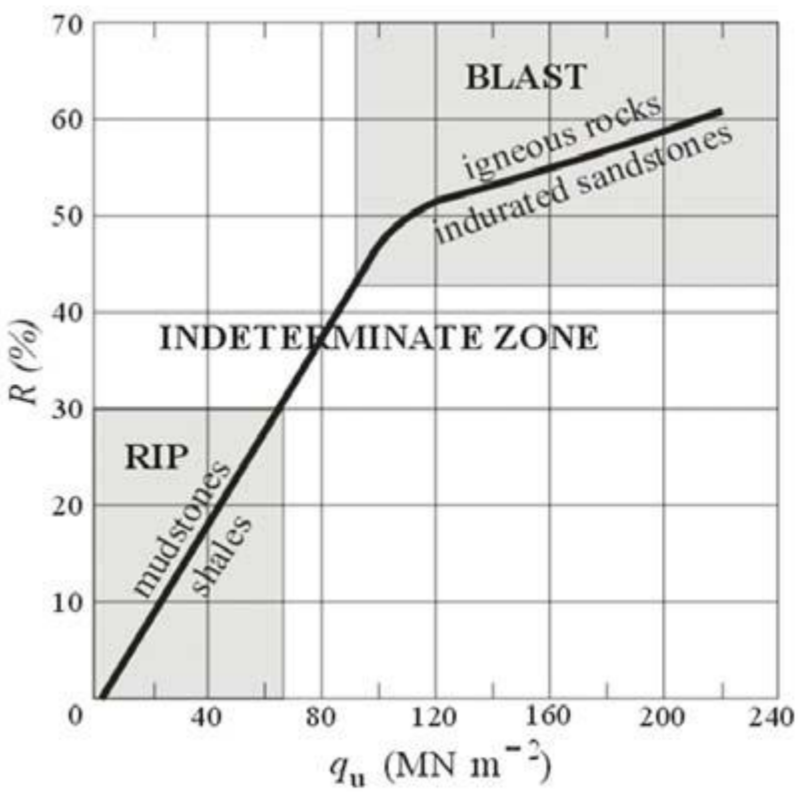
Where, D – ripping depth, m

W – ripping width, m

Substituting all these values we can get hourly production.

2.3.2 Indirect methods:

These methods utilize the material properties and rock mass. They are divided into 'graphical', 'seismic' and 'graphical' methods (Basarir H, et al). Graphical method is used during planning stage of major work. Figure 2.2 and 2.4 shows performance of ripper based on various material properties and seismic velocity of the strata.



Source (*McLean & Gribble, 1985)*

Fig.2.4 Excavability based on Rebound no.(R) and compressive strength(q_u)

Seismic wave analysis:

The seismic wave analysis is based on the principle of propagation of sound waves through different sections of rock. It is known that sound waves travel sub-surface material at different velocities, depending upon the degree of consolidation of the material. Poorly consolidated materials with low seismic velocity are easily rippable than highly consolidated material with high seismic velocity.

The seismic velocity analysis is accomplished by use of ***Refraction seismograph***. The equipment includes a source of sound or shock wave, a receiver, an electric counter, and a set of cables.

For performing the survey, all benches are surveyed to measure the compressional wave seismic velocities (P-wave) to aid in the evaluation of the rippability of the sub surface. The instrument called Geode (Make: Geometrics controllers Inc., USA) is used for acquiring the seismic data and the method of profiling is carried out.

Surface wave tomography is an efficient way to obtain images of the group velocity at at a test area, because Rayleigh-wave group velocity depends on frequency. There are separate images for each frequency and at each point in these images the group velocities define dispersion curve which relates group velocity to frequency. Detection and imaging requires a multichannel approach to data acquisition and processing. Integrating Multichannel Analysis of Surface Waves (MASW) method with a Common Mid-Point (CMP) style data acquisition permits the generation of a laterally continuous 2D shear wave velocity field cross section (Park et al., 1999; Xia et al., 1999). Mating MASW with CMP provides a non-invasive method of delineating horizontal and vertical variations in near-surface material properties. ***(M.Ramulu et al., 2012).***

Continuous acquisition of MASW data along linear transects has recently shown great promise in detecting shallow voids and tunnels, mapping the bed rock surface, locating remnants of underground mines and delineating structures (Park et al.,1999). Extending this technology from sporadic sampling to continuous imaging required the incorporation of MASW and CDP (Mayne, 1962). Integrating these technologies result in generation of 2D cross section of the shear wave velocity field. This cross section contains information about horizontal and vertical continuity and physical properties of materials at shallow depths. Seismic reflection surveys are generally designed to image structural and stratigraphic features with a high degree of resolution and accuracy. The surface waves are considered noise.

The seismic wave velocity is recorded in m/s and the tests help in determining the following:

a) Depth to unconsolidated layer such as bed rock gravel or clay
b) Thickness of the intermediate layers assuming each becomes progressively harder
c) Approximate density of each layers degree of consolidation leading to identification of material type
d) Location of faults, fractures and other irregularities in the formation

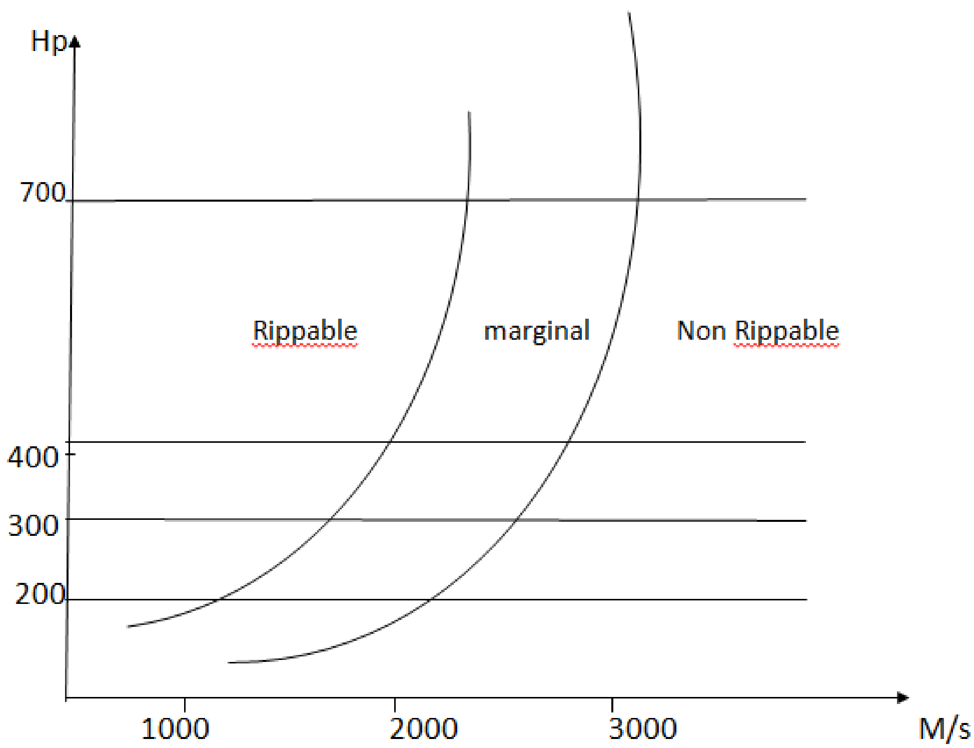


Fig.2.5 Ripping capacities (in term of power and seismic velocity)

2.3.3 Laboratory tests:

Laboratory experiments are done to determine the uniaxial compressive strength (UCS), indirect tensile strength (ITS), unit weight (d), and point load strength index tests (I_{s50}).

Laboratory ripping runs tests is performed on laboratory ripping machines as shown in fig 2.6. This machine simulates working of a single shank ripper with rating 1850 rpm, and cutting speed of 150m/s *(Mohd For Mohd Amin, 2008).*

Specially designed cutting shank is used to make a V-cut in rock samples. The required power is noted down. The result is in terms of specific energy in MJ/m^3. Using the length of the cut (L) in meters, density of material produced, and volume of the material cut in m^3 is calculated. Considering force (F) measured in mega Newtons (MN)

The specific energy (SE) is,

$$\mathbf{SE = FL/V}$$

Fig 2.6 Laboratory ripping machine.

The specific energies can be related to various rock parameters as shown in the table 2.4

Table 2.4. The relationships between rock properties and specific energy (*H Basarir et al, 2008)*

The relationships between rock properties and specific energy

Parameter	Equation	R^2
Uniaxial compressive strength (UCS), MPa	$SE = 0.20UCS + 2.41$	0.81
Indirect tensile strength (UTS), MPa	$SE = 0.77ITS + 3.89$	0.85
Point load strength ($I_{s(50)}$), MPa	$SE = 4.58I_{s(50)} + 3.24$	0.88
Seismic velocity P-wave velocity (SV), m/s	$SE = 0.003SV - 0.052$	0.85
Schmidt hammer hardness value (SHV)	$SE = 0.17SHV + 0.076$	0.79

The relation between specific energy and hourly production of ripper is shown in the following graph.

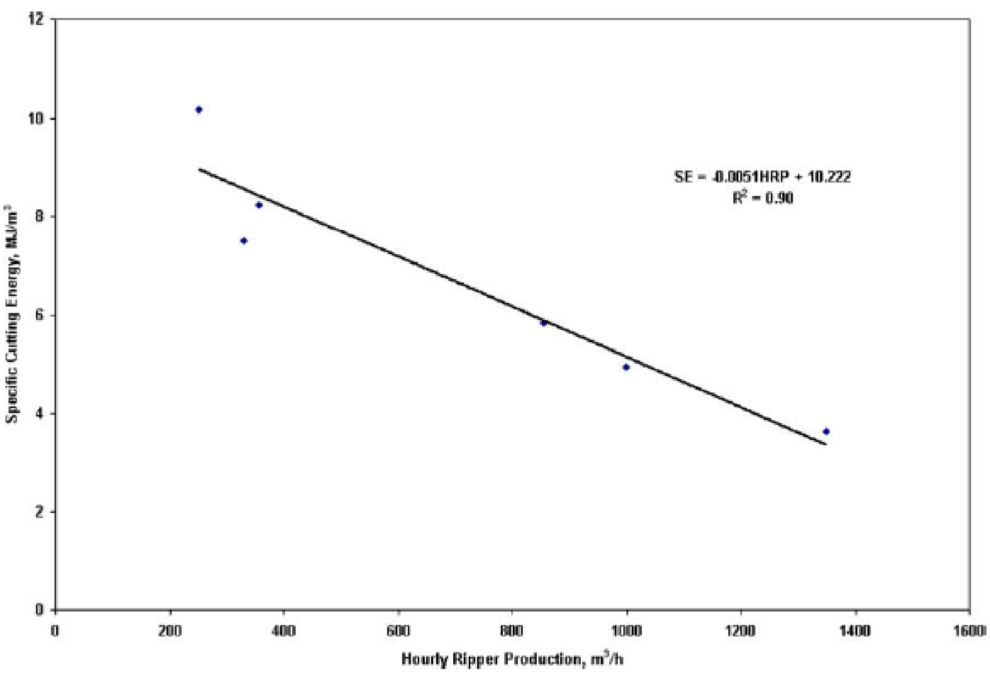


Fig.2.7 Relation between specific energy and hourly production of ripper (*H Basarir et al, 2008)*

2.4 Ripping techniques:

The suitable technique depends on the job conditions. Following factors are to be considered before selecting proper ripping technique.

a) **Ripping speed:** Proper gear and speed plays important role in maximization of ripping production. Generally first gear with a speed of 1-1.5mph gives the economical production with maximum drawbar pull. Excessive speed causes track slippage and rapid undercarriage wear as well as tip wear. Excessive speed heats up the tip thereby decreasing the life of the tip.

Speed in MPH	Drawbar HP
0.5	324.00
1.0	466.00
1.5	510.00
2.0	410.00
2.5	490.00
3.0	480.00
5.0	466.67

Table 2.5 Drawbar pull for consecutive speed *(P K Panda & S K Misra, 1989*)

b) **Ripping depth:** Ripping depth is a function of job condition, material hardness, lamination thickness, and degree of fracturing. Ripping should be done at maximum depth allowable by the ripper. When considerable stratification is encountered it is preferable to rip at partial depth and remove the material in its natural layer rather than to take out a full ripped layer. Where scrapers are used to lift materials to the dumpers it is advisable to rip to a uniform depth eliminating the hard rocks which can lift off the scraper edged from the ground.

c) **Spacing between the passes:** Optimum spacing between the passes helps in maximizing the production. Closer the spacing, smaller is the chunk size. When full penetration occurs, pass spacing of one-half the tractor width allows the track to move over the material just ripped and increasing the crushing of the same.

d) **Ripping direction:** The ripping direction is decided by the job layout. When scrapers are used to remove material ripping should be done in the direction scraper loading in order to increasing the scraper loading efficiency. When vertical laminations or fractures are found on the rock formations ripping is done across the cuts. Downhill ripping is preferred as it takes the advantage of the tractor weight and horsepower.

2.5 Types of Rippers: (P K Panda & S K Misra, 1989)

Following types of ripper dozers are available:

1) Hinge type
2) Parallelogram type
3) Adjustable parallelogram type
4) Adjustable radial type
5) Impact ripper.

1) Hinge type:

In this type the linkage carrying the beam and the shank pivots at the rear end of the ripper. It uses a beam with one or more pockets to hold one to five shanks. Each pocket allows upto five different shank positions to adjust depth and tooth angle to meet various condition. Hinge type provides the advantage of aggressive tooth entry angle but cannot be adjusted for varying rock conditions.

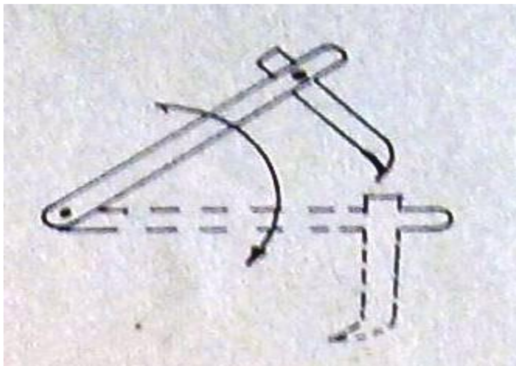


Fig.2.8 Hinge type ripper (P K Panda & S K Misra, 1989).

2) Parallelogram type:

Here the linkage maintains the same tip ground angle regardless of tooth depth, hence excellent penetration characteristics. Single shank rippers are used specially for hard ripping where greater ripping depth is required. The clearance between the tracks and the shanks is more in cseof parallelogram type than hinge type. The ripper is in raised position which helps the operator to see the tip damage or loss thereby avoiding damage to the shank from ripping.

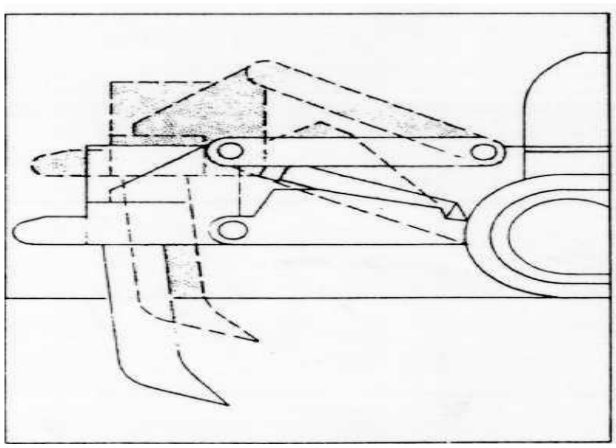


Fig. 2.9 Parallelogram type ripper

3) Adjustable parallelogram type

This shares the features of hinge type and parallelogram type. It can vary the tip angle beyond vertical for improved penetration and can be hydraulically adjusted while ripping to provide the optimum ripping angle.

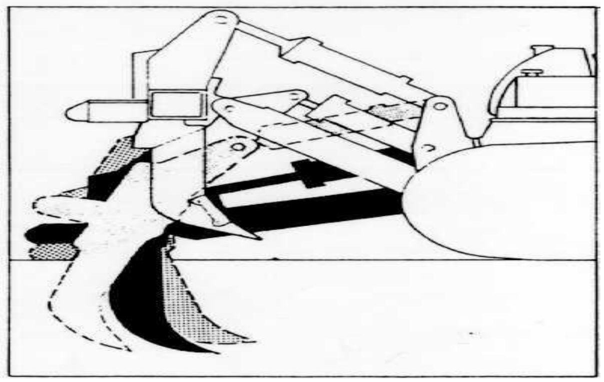


Fig. 2.10 Adjustable parallelogram type

4) Adjustable radial type

It combines the features of hinge type with the shank angles from high angles. It provides more aggressive shank penetration angle at start and optimum angle for advancement through material.

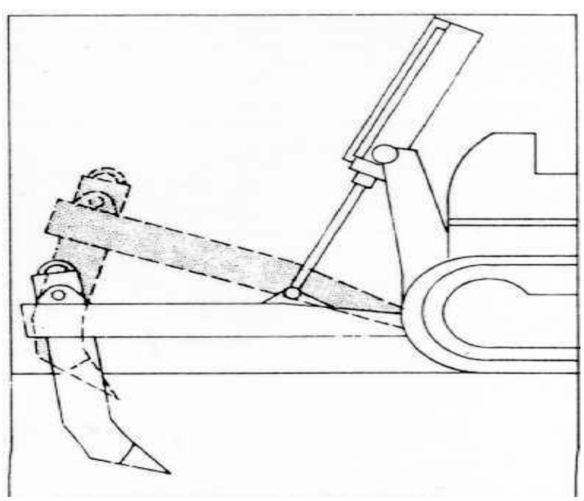


Fig.2.11 Adjustable radial type.

5) Impact type

Generally the drawbar force is limited by tractor engine horse power, power train, weight and traction. In impact type engine power is converted to hydraulic power for operating an impact which is then transferred to shank. This result in fracturing of rock thus increasing penetration, reducing drawbar pull requirement and expanding range of rippable rock. With this type ripper it is now possible to rip rocks having seismic velocity for 3000m/s.

2.6 Ripping mechanism

In the process of ripping, the ripper tip is lowered in to the ground by means of hydraulic forces which continues till initial bit penetration is achieved. The initial penetration of the tip or tyne is either occurred through the rock mass, defect planes or combination of both as shown in fig 2.12.

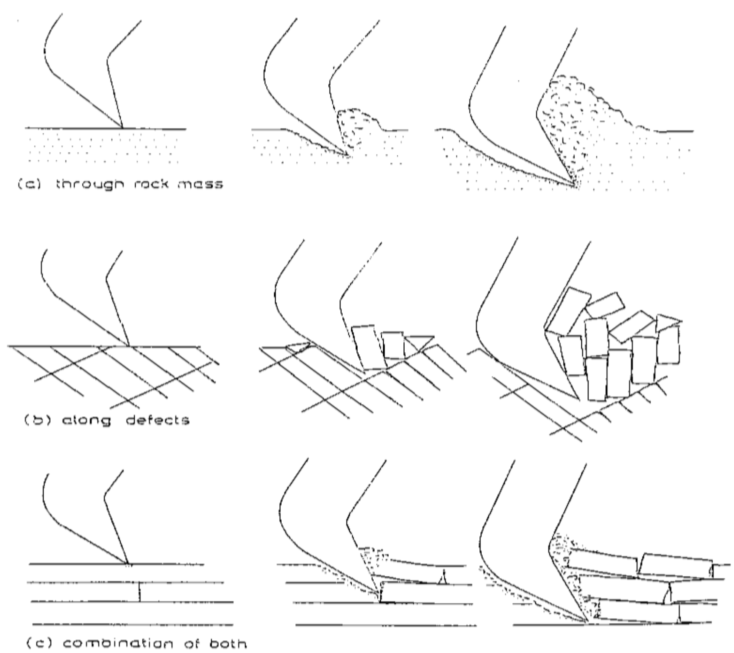


Fig.2.12 Modes of achievement of initial penetration of tyne

When the stress concentration of tip exceeds the compressive strength of the rock it causes shear failure of rock allowing initial tip penetration. As tractor moves the penetration causes tensile failure of rock. In case of jointed rocks the failure takes place due to failure of cohesive force between the structural blocks.

There are basically five mechanisms of ripping (*by Fiona Mac Gregor*) as show in following fig 2.13. These include ploughing, loosening, crushing, tearing, splitting and prying out.

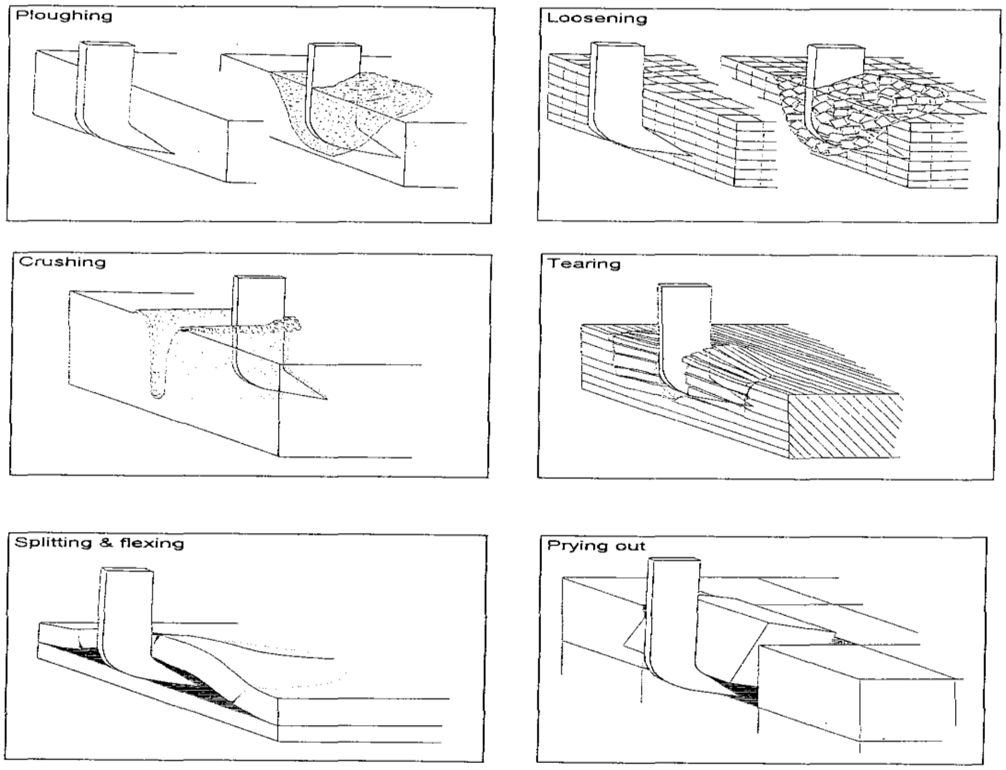


Fig. 2.13 Different ripping mechanisms.

Ripping mechanisms outlined by ***Darcy, 1971***:

i) **Ploughing:** In dense material without bedding planes, a narrow road is plowed , displacing only a small amount of material.

ii) **Crushing:** in case of fractured rocks having small defect spacing (0.1-0.3m) material is easily crushed, disorganized.

iii) **Lifting:** In horizontally stratified rocks, slabs are lifted by ripper causing breaking by traction, bending and shearing.

iv) **Breaking:** Breaking takes place in case of inclined stratified rocks by shearing at the point of the ripper by bending and lateral traction.

2.7 Dozer blade:

Ripper is also available with a pusher blade attachment. The dozer blade or the pusher blade can be raised or lowered through small angles horizontally by rams operated through hydraulic pressure or ropes. The blades are Used to push materials ripped or sand or soft weathered rocks. A dozer can dig upto1.5m below the ground in earth or weathered rock.

There are different types of blades to suit different types of work, but most commonly used are ***straight, universal*** and ***semi-universal***. The straight blade comprises of mold board slanting forward and concave in the front. It has a removable cutting edge at the bottom. The universal blade has large wings on either side of central section. The semi-universal has features in between the above two and short wings. The straight blade has higher capability of better penetration and handling of heavier material. The universal blade is suited for larger loads pushed over long distances. The wings prevent the spillage of materials. The semi-universal blade provides improved load retention capability and better penetration in tighter ground as compared to universal blade.

Output of dozer :

$$\mathbf{Q = 60Cs\mu/t}$$

Where, Q- output in m^3/h

C – dozer blade capacity

s – swell factor

μ - production efficiency

t – cycle efficiency

Chapter 03

SELECTION OF RIPPER- DOZER

There are various factors affecting the selection if rippers. However the seismic wave velocity and productivity affects much. Also the specific energy plays an important role. Various studies have been taking place. Relationship between specific energies, seismic wave velocity and productivity has been established by various researchers.

Table 3.1. General relationship between ease of ripping and producivity (*by Fiona Mac Gregor)*

PRODUCTIVITY (m^3/hr)	EASE OF RIPPING
0 - 250	Very difficult
250 - 750	Difficult
750 - 1500	Medium
1500 - 3000	Easy
3000 - 7000	Very easy

Following table suggest relationship between the specific energies and productivity of different types of Caterpillar ripper dozers.

Table 3.2 Extended rippability classes of marls (*by H. Basarir & C. Karpuz, 2004*)

Class	Grade	Specific	D8	Dozer	D9	Dozer	D10	Dozer	D11	Dozer
	Grade	Energy	Production, m^3/h	Assessed class	Production, m^3/h	Assessed class	Production, m^3/h	Assessed class	Production, m^3/h	Assessed class
1	0–20	<3.75	>1300	Very easy	>1500	Very easy[a]	>6000	Very easy[a]	>10000	Very easy[a]
2	20–55	3.75–5.25	900–1300	Easy	1000–1500	Easy	4300–6000	Very easy[a]	7000–10000	Very easy[a]
3	55–70	5.25–7.00	400–900	Moderate	450–1000	Moderate	1900–4300	Very easy[a]	3000–7000	Very easy[a]
4	70–85	7.00–9.00	250–400	Difficult	285–450	Difficult	1200–1900	Easy	2000–3000	Very easy[a]
5	85–95	>9.00	<250	Very difficult[b]	<285	Very difficult[b]	<600	Difficult	<800	Easy
6	95–100	–	0	Blast	0	Blast	<150	Very difficult[b]	<250	Difficult

[a] For these cases, there is point in using D10 or D11 type dozer, since even D8 type dozer will work in these site with high efficiency.
[b] In these sites, there in no need to use D8, D9 or D10 type dozers, since both type will results in too low production.

Table 3.3 Typical specifications of various rippers from the Caterpillar Company.

Ripper types	Production for Seismic velocity <1500 m/s (bm^3/h)	Production for Seismic velocity <2000 m/s (bm^3/h)	Power rating (kW)
D8R	900	500	250
D9R	1075	550	343
D10R	1450	800	522
D11R	1650	900	634

Apart from seismic velocity, specific energy and productivity of ripper, other parameters can be used to refine the selection of ripper. For this proper rippability assessment need to be done which can be possible in the ways discussed in the literature review section.

Chapter 04

FIELD STUDY 1: PACHPATMALI BAUXITE MINES, NALCO

4.1 Introduction:

Panchpatmali bauxite mines of national Aluminium Company Limited with a production of 4.8 Million tonnes of bauxite 1.6 Million tonnes of over burden with high capacity rippers has been chosen as economic alternative to drilling and blasting. The bauxite deposits of Precambrian age where the ore has been formed through a process of weathering and lateralization of the parent rock (khondalites). The over burden is composed of hard ferruginous laterite extending in thickness from 0 to 3.5 m with an layer extending in thickness in an irregular manner from 10 to 35m with an average thickness of 14mts.The average OB ratio is 1:0.3 over entire deposit.

The seismic wave velocity studies of different formation conducted by NGRI Hyderabad reveals that vary from 1100m/s to 2600 m/s and 80% of deposit falls within the velocity range of 1100 - 1300 m/s 15% of the deposit falls within 1300 to 1800 m/s to 2600m/s and above. The study of seismic wave velocities in the various formations of Panchpatmali deposit demonstrated the amenability of the deposit for efficient and economic application of production ripping and enabled the designers to select out of the available rippers suitable equipment sizes for rock fragmentation in the mine.

4.2 Location

The Panchpatmali bauxite mine in the Koraput District of Orissa exploits the largest single bauxite deposit in India having a reserve of 317 million tones of bauxite with a production capacity of 4.8 million tones pre year. It is located 40 Kms from the Koraput District Head quater on the national haighway NH-43 (connecting Raipur & Vizag). The Panchapatmali Hill spans for a length of 21 Kms in NE-SW directions, bounded by latitudes $18^0$46’ & 18^0 north & longitude 82^0 57’ and 83^0 04’ east. The deposit constitutes the top of the Panchpatmali hill the bauxite is confined between the elevations of 1154m &1366m above the mean sea level in the three different blocks namely North, Central and South blocks, extending over an area of 16 sq.kms. The central block has been further divided into Sector-I and Sector –II.

4.3 Relief of the terrain

Panchpatmali hill forms a part of the Eastern Ghats range in general this area represents deserted hill topography. Small hillocks and mounds are inter-spaced with narrow and deep valleys. Panchpatmali is distinctly marked within this hilly terrain both in the field and in topo sheet because of its height and extensive flat plateau land conspicuously this hill is continuous and undisseccted compared to the adjoining hills of smaller dimensions.

Flat to gently rolling plateau top on Panchpatmali hill extends for a length of 21 km In NE-SW direction. Few water sources cut the plateau width and flow to irregular laid out narrow steep valleys and escarpments at the hill slopes. The width of plateau varies from more than 2000 meters to less than 100 meters with an average of 800 meters. The area is 16.8 sq. km.

The highest point on Panchpatmali stands at an elevation of 1336.7 meters above mean sea level and 450 meters above the adjoining plains. The mean reduced level of plateau edge is around 1280 meters. It has steep escarpments for 10 meters to 50 meters on all the thereafter the slope is gentle.

4.4 Geology of the area

The geological, structural and Lithological characteristics of Panchapatmali bauxite deposit and secondary areas are same as other Eastern Ghats deposit. Bauxite bearing laterite capping which occurs as a blanket cover over whole of Panchpatmali hill is formed in situ by weathering and lateralization of khondalites the parent rock which lies below the lateritic formation the main geological features are out lined below-

- The rock types of the area belong to Khondalites and Chanockite series of the Eastern Ghats and are of Precambrian age khondalites generally form high and liner ridges while charnockites occur on lower slopes of the hills or the valleys.
- Khondolites are granitic gneisses with quartz feldspar garnet, sillimanite corundum opaque ore minerals limonite and graphite as the major mineral constitutes. Charnockites of all types i.e. acidic, basic and intermediate types are observed in the area. Khondolites with weak planes of line foliations cleavages joints etc. are more weathered and altered compared to charnockites.

- Relatively low mineralization thickness (13.3 m) on the whole compared to the admissible bench height up to 12m.
- Irregular mineralization thickness, generally between 8.5m and 18m sometimes more than 20m particularly varying by a possible 5m over about 10m.
- Small amount of sterile overburden averaging 3m in thickness, or only 18.4% of the total thickness to be mined.
- Simple relief with slopes generally less than 10% although steeper over 2/5 of the of the deposit area.
- Very irregular contact between ore and bottom due to the relief and more especially to the irregularities in the mineralization thickness and overburden.

4.5 Mining method

Considering the deposit characteristic of Panchpatamali bauxite deposit "Trench Mining Method" has been adopted for scientific extraction of Bauxite ore. This is a simple modification of the conventional bench method of mining. This method drive for operating a number of slightly absently trenches with staggered faces and floor at increasingly lower level form a service road & normally advancing parallel to the longer axis of the plateau. The width exceeding 40 m & different floor levels between adjacent trenches not exceeding 4 m.

The trench mining method of operation adopted in Panchpatmali Bauxite mine can be classified into three basic phases.

<u>1) Excavation of overburden</u>

Overburden on the top of the mineralized Zone average (3m thick) comprising top soil and laterite are mined in two stages. Top soil is directly excavated and loaded will ahead of laterite & kept separately for using in plantation in reclaimed area. The laterite is mined on a single bench, ahead of bauxite maintaining a lead of 75m. The low ratio of overburden to ore & the relative softness of the rock handled to excavation or rocks breakage by ripping. Blasting is used in addition to ripping in the harder formation rock breakage. After blasting or ripping the OB is handled wheel loader & dozer to clean the mineralized top. The laterite overburden is loaded into

50/55 ton dumper by means of wheel loader. Then the dumpers carry the overburden to a dumping area, where the Bauxite has already been mined out for reclamation.

2) Excavation of bauxite

The bauxite mining at present is carried out in two stages top bench mining & Bottom bauxite mining. The top benches are excavated by drilling & blasting with average bench height of 8 m Holes of 150 mm dia. drilled by DTH drill are Charged with indo–boost , indo-gel & blasted to loosen the ore. The blasted mineral is loaded by the 8.7 m^3 wheel loader into 50/55 ton dumpers which carry it to the crusher. The bottom bench bauxite is mined selectively by using back hoe for complete bauxite excavation. Both overburden & bauxite face advances in a number of parallel trenches of varying width & levels.

The bauxite ore is crushed to 150mm size by a double roll toothed crusher & then transported to Alumina plant through a single flight long distance cable belt conveyor system of 14.6 km Length.

The trench method of mining has the following advantages-

- Mining faces are separated, inter chargeable, are numerous & can be worked concurrently for effective grade control of ROM feed.
- Adaptability to geological disturbances on the deposit resulting in lower loss & dilution factors.
- Convenient work site dimensions permit concentration of mining equipment & minimized travel time.

3) Reclamation of mined out area

Reclamation of mined out area is a concurrent process with ore mining in the trench mining method. Once complete bauxite excavation is done the area is released for back filling by the over burden consisting of fertile soil and laterite mined separately. First laterite is filled and leveled then a thin layer of soil is covered on the top of it for plantation activities. Sumps and reservoirs' are also planned within this reclaimed area for collecting rain & surface runoff water from mining areas which is allowed to the valleys after due sedimentation/ setting of mud.

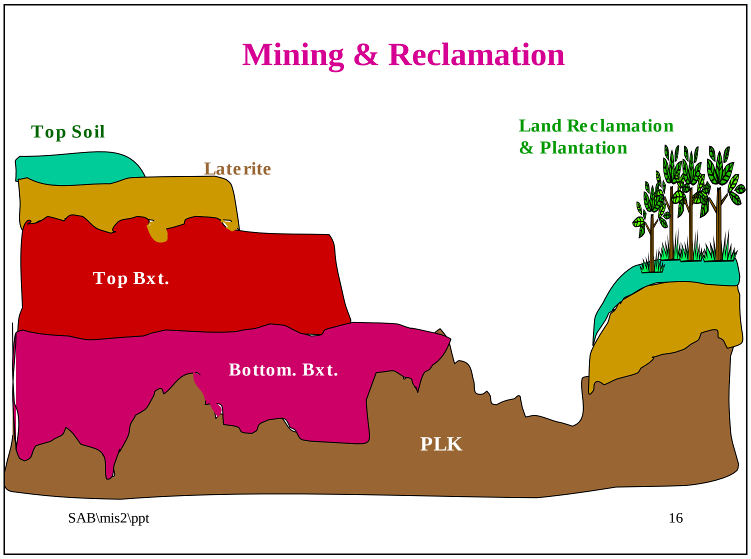


Fig 4.1 Panchpatmali bauxite mines Mining and reclamation.

4.6 Drilling and blasting operation

The existing practice of Drilling & Blasting has been adopted since the inception of the mine with lot of efforts, leading to optimum use of explosive energy. The non-rainy days and non-watery holes use ANFO. ANFO is mixed by imported Mixing and delivering truck of very high capacity. Cartridge and/or Cast booster is predominantly used as booster. In dry holes, cartridge column charge is used with cartridge booster. The support system to store explosives, explosive vans to carry explosives and accessories are quite systematic and observe all statutory provisions as is laid in Indian Explosives Rules & Metalliferrous Mines regulation.

Major drawbacks:

1) **Use and Storage of explosive-** After naxal attack in the mines crores of money has been invested not only for the security of the employees but more in Storage and transportation of Explosive. It is very challenge for the C.I.S.F. Jawan to maintain security in the magazine where explosive is stored. Recent times using explosive for mining operation

not only unsafe for the life of security force but also not advisable for economical point of view.

2) **Fragmentation-** Generation of oversize boulders in blasting which cause jamming, shear pin and downtime of crusher so necessitates of secondary breaking, first option secondary blasting which is not done so rock breaker is the next option for handling over size boulder. Sorting the oversize boulder while loading by wheel loader then breaking in to required size by rock breaker need extra machine as well as manpower which cause loss of working hour as well as unsafe to handle and un-productivity one.
3) **Steep mining-** Where the angle of dip of the bauxite deposit is more than 25^0 mainly valley side it is not easy for drilling so dozer or loader is deployed for preparation of platform for drilling and also to make the blasting face vertical for better output which is uneconomical. Where the angle of dip is very steep drilling & blasting impossible so need for ripper dozer operation
4) **Ground vibration-** one of the troublesome and controversial issues facing is that blast induced ground vibration with general trend towards large blasting in mines, increased population and spread of urban near to the mining site ground vibration problem complain have risen manifolds so blasting near to structural building and valley site villages is avoided
5) **Impact on environment-** Panchpatmali bauxite mines comes under forest region; bird and wild animal of different species are found in this place. Heavy noise and ground vibration scares away the animal and birds inhabiting the area it also harmful for human beings as well.

<u>Minor drawbacks-</u>

1) In the process of rock blasting lot of dust as well as high level of noise is produced which is harmful for the men.
2) Blasting results in back break and overhangs which are dangerous for equipment operating there.
3) Since men and machineries need to be shifted from the danger zone before blasting a lot of idle time is inevitable.
4) Fly of rock after blasting needs to be cleaned at the face before loading which further increase idle time of equipment.

5) Failure of blasting, misfire, blown out directly effect to the production as well as productivity.
6) The operator is unable to distinguish between ore and waste in blasted face near to non-ore zone which affects the quality of the ROM.
7) Blasting in rain and dense fog is not possible for the safety point of view.
8) Extra qualified personnel for drilling as well as blasting is needed for safe operation
9) Bucket fill factor for blasted material is less than dozing material
10) More power is required for loader for loading blasted material than dozed material
11) The top Bauxite in Panchpatmali Bauxite Mines contains non-ore as intrusion which will make quality control very difficult in blasting
12) The contact zone of overburden and bauxite is very undulating by blasting not possible to control

4.7 Selection for blast free mining system

Year before last the mine faced a serious threat to the life and property. Armed extremist groups attacked the mine and the explosive storage ware house (called 'magazine'). In the post, PCRA had approached the Central government about the possible solutions to get rid of explosives used in drilling and blasting operations in the mine. A number of literatures on the 'blast free mining' technique currently in use globally was also studied. National geophysical Research Laboratory, Hyderabad had done seismic wave velocity study for Nalco Bauxite deposit and had revealed that this S. Wave velocity varies from 1100 m/s to2600 m/s, and some 80% of the deposit was within the velocity range of 1100-1300m/s with the rest within 1800-2600 m/s and above. Their study had revealed that 60% of the bauxite deposit is amenable for ripping. Over last 25 years of experience, Nalco had been doing considerable amount of ripping. Ripper dozer mining can be the best alternative option to totally eliminate drilling & blasting operation.

4.7.1 Different Studies done for selection of ripper dozer machine at Panchpatmali bauxite mines

In order to assess the economical process of rock fragmentation at Panchpatmali various tests were carried out which include the following:

1) Laboratory determination of seismic wave velocity in both laterite as well as bauxite by NGRI Hyderabad
2) Field determination of seismic wave velocity in both laterite and bauxite by NGRI Hyderabad
3) Study of physico-mechanical properties of both laterite and bauxite by IIT, Kharagpur.

Table 4.1 The results of the seismic velocity by NGRI Hyderabad (*S. Samal et al*)

No of species	Laterite	bauxite	khondalite
80%	1100m/s	1300m/s	1400m/s
90%	1500m/s	1500m/s	1500m/s
95%	1800m/s	1700m/s	1700m/s
100%	2600m/s	2200m/s	1900m/s

Table 4.2 The physico-mechanical properties of various types of rock at Panchpatmali bauxite mines study by IIT Kharagpur *(S. Samal et al*)

Rock property	**laterite**	**Vesicular bauxite**	**Massive bauxite**	**Soft bauxite**	**khondalite**
Dry density (kg/m^3)	2.0	1.85	2.1	1.8	1.9
Moisture Content (%)	2.0	2.2	2.5	2.5	7.0
Compressive Strength (kg/cm^2)	140+/- 70	92+/- 31	144+/- 87	85+/- 35	32+/- 36
Tensile strength(kg/cm^2)	26+/_ 13	18+/- 4	25+/- 6	16+/- 3	15+/- 4

The test results indicated that both bauxite & laterite at Panchpatmali were amenable to ripping. A techno-economic analysis was carried out for selecting the appropriate method of ripping or blasting for rock fragmentation.

4.8 Specification of KOMATSU D-475A ripper dozer: (*KOMATSU D475A-5E0 manual*)

Komatsu D-475A ripper dozer is employed. Following are the specification of ripper.

Engine

Model . . . . Komatsu SAA12V140E-3

Type . . . . 4-cycle, water-cooled, direct injection

Aspiration . . . . Turbocharged, air-to-air after cooled

Number of cylinders 12

Bore x stroke . . . . **140 mm x 165 mm** 5.51" x 6.50"

Piston displacement . . . . **30.48 ltr** 1,860 in3

Governor . . . . All-speed, electronic

Horsepower

SAE J1995 . . . . Gross **671kW** 899 HP

ISO 9249/SAE J 1349* . . . . Net **664kW** 890 HP

Rated rpm. 2000rpm

Fan drive type . . . . Hydraulic

Lubrication system

Method . . . . Gear pump, force lubrication

Filter . . . . Full-flow and bypass combined

*Net horsepower at the maximum speed of

Radiator cooling fan . . . . **641 kW** 860HP

Transmission

Komatsu TORQFLOW transmission consists of a water-cooled, 3-element, 1-stage, 1-phase torque converter with lockup clutch and a planetary gear, multiple-disc clutch transmission which is hydraulically-actuated and force-lubricated for optimum heat dissipation. Gearshift lock lever and neutral safety switch prevent accidental starts.

Final drive

Double-reduction final drive of spur and planetary gear sets to increase tractive effort and reduce gear tooth stresses for long final drive life. Segmented sprocket teeth are bolt-on for easy replacement

Fig.4.2 Komatsu D-475A ripper dozer

Steering system

PCCS lever, joystick-controlled, wet multiple-disc steering clutches are spring-loaded and hydraulically released. Wet multiple-disc steering brakes are spring-actuated, hydraulically released, and require no adjustment. Steering clutches and brakes are interconnected for easy, responsive steering.

Minimum turning radius . . . . **4.6 m** 15'

Operating weight

Tractor weight . . . . **83590 kg** 184,290 lb Including steel cab, rated capacity of lubricant, coolant, full fuel tank, operator, and standard equipment.

Operating weight . . . . **108390 kg** 238,960lbIncluding strengthened Semi-U tilt dozer, giant ripper, steel cab, ROPS, operator, standard equipment, rated capacity of lubricant, coolant, and full fuel tank.

Ground pressure . . . . **166 kPa** 1.69 kg/cm2 24.0 psi A **2770 mm**

Coolant & lubricant capacities

Coolant . . . . **210 ltr** 55.5 U.S.gal

Engine . . . . **121 ltr** 32.0 U.S. gal

Torque converter, transmission, bevel gear, and steering system . . . . **210 ltr** 55.5 U.S. gal

Final drive (each side) . . . . **75 ltr** 19.8 U.S.gal

Undercarriage

Suspension . . . . Oscillating equalizer bar and pivot shaft

Track roller frame. . . . . . . Cylindrical, high-tensile-strength steel construction

Rollers and idlers. . . . . Lubricated track rollers K-Bogie Undercarriage

Lubricated track rollers are resiliently mounted to the track frame with a bogie suspension system whose oscillating motion is cushioned by rubber pads.

Extreme Service Track Shoes Lubricated tracks. Unique seals prevent entry of foreign abrasives into pin to bushing clearances to provide extended service life. Track tension is easily adjusted with grease gun.

Number of shoes (each side) . . . 41

Grouser height:

Single grouser . . . . **105 mm** 4.1"

Shoe width (standard) . . . . **710 mm** 28"

Ground contact area **64240 cm2** 9,957 in2

Ground pressure (Tractor) . . . . . **128 kPa** 1.30 kg/ cm^2 at 18.5 psi

Number of track rollers 8

Number of carrier rollers 2

Hydraulic system

Closed-center load sensing system (CLSS) designed for precise and responsive control, and for efficient simultaneous operation.

Hydraulic control units:

All spool valves externally mounted beside the hydraulic tank.

Plunger type hydraulic pump with capacity (discharge flow) of **542 Ltr/min** 143 U.S. gal/min at rated engine rpm.

Relief valve setting . . . . **27.5 MPa** 280 kg/cm2 3,980 psi

Control valves:

Spool control valves for Semi-U tilt dozer and Full-U tilt dozer

Positions: Blade lifts . . . . Raise, hold, lower, and floats

Blade tilts. . . . . Right, hold, and left

Spool control valves for variable digging angle multi-shank ripper and giant ripper.

Positions: Ripper lifts . . . . Raise, hold, and lower

Rippers tilt. . . . . Increase, hold, and decrease

Hydraulic cylinders . . . . Double-acting, piston

Hydraulic oil capacity (additional volume):

Semi-U tilt dozer . . . . **180 ltr** 48 U.S. gal

U tilt dozer . . . . **180 ltr** 48 U.S. gal

Ripper equipment (additional volume):

Giant ripper . . . . **130 ltr** 34 U.S. gal

Multi-shank ripper . . . . **130 ltr** 34 U.S. gal

Following Types of dozer used in Panchpatmali bauxite mines

1) BEML D-355---------------------------------3Nos.
2) BEML D-475----------------------------------1No
3) Komatsu D-375----------------------------2Nos
4) Komatsu D-475-----------------------------2Nos

4.9 Cost calculation:

4.9.1 Cost calculation for Drilling and blasting per tonne.

Quantitative information--

Drilling per day—(average)--560mt, 280mt per shift, 3 drills with 3 operators, effective working hour is 4 hours in a shift, for one drill interest—Rs. 4417.8469,Depreciation –Rs. 6126.25 ,R & M cost—Rs.5416.667.

Table 4.3 Cost calculation for drilling per MT

Particulars	***UoM***				
Drilling per day	mt	560			
particulars	***UoM***	***Quantity***	***Rate/unit***	***Value-Rs***	***Per unit***
Material cost	@2%			654	1.17
HSD	litre	1200	Rs45/lit	54000	96.42
Conversion cost					
Labour cost				9000	16.07
Depreciation				18379	32.82
R&M cost@10%				16250	29.02
ADMN Overhead				9168	16.37
Interest				13254	23.67
Total cost/mt					**215.54**

Table 4.4 Cost of blasting per T (tonne) with gel explosive

Particulars	***UoM***	***Quantity***	***Rate/unit***	***Value (Rs)***	***Per unit(Rs)***
Material generated	Mt	560			
	T	1200			
Material cost					
Explosive	kg	9000	32	288000	24
HSD for explosive Van	litre	60	45	2700	0.25
Conversion cost					
Labor cost				9000	0.75
Depreciation				4241	0.35
R&M @10%				3750	0.32
Admn OH@10%				25409	2.12
Interest				3059	5.46
Total cost					**33.90**

Explosive consumption in one hole------114 kg

Drilling cost for one hole -------------------Rs 1725

Quantity generated --------------------------200

Drilling cost per MT---------------------------8.65

Total cost Drilling & blasting per MT-----33.90+8.65= **Rs 42.55 per T**

Shovel is used to excavate and load the blasted material onto dumpers. So the shovel operation and maintenance costs = Rs. 12.42 per T.

Final cost = Rs(42.55 + 12.42) = Rs. 54.97 per T ………………………..(1)

4.9.2 Cost calculation for ripper dozer per T (tonne)

Material generated-7200T

Executive working hours in a day--8

Two dozers operating in one shift

Diesel consumption-2000lit,

Labor cost Rs -6000 per day

<u>Table 4.5 Ripping cost per T (tonne)</u>

Particulars	**unit**	**quantity**			
Material generated	T	7200			
Particulars	**UoM**	**Quantity**	**Rate/unit**	**value**	**Per unit**
A) Material cost					
consumbles@2% of R&M				6545	.91
HSD	Litre	2000	Rs 45/lit	90000	12.5
B) Conversion cost					
Laborers cost				6000	.833
Depreciation				61263	8.51
Repair& maintenance cost @10% residual cost				32725	4.55
Admn.overhead@10%				22053	3.06
Interest on capital				44178	6.14
Total cost/per MT					36.503

In order to load the material loader is required.

So the owning and operating cost of loader = Rs. 14.92 per T.

Therefore total cost of ripping and dozing = Rs 51.423 per T ……………………..(2)

4.10 Dozing operation

Different tests and cost calculation for ripping & dozing in both laterite and bauxite was done then after techno- economic analysis carried out for selecting the appropriate method for ripping was found. Considering ripping:-

For removal of over burden

The thickness of overburden is very less about 3mts ripping & dozing appeared to be the right choice compared to drilling blasting due to following reasons

- Drilling productivity in over burden is less due to shifting the machine for each hole for 3mts drilling. Experience has showed that nearly 20% time is wasted for shifting
- Due to Low thickness powder factor in blasting is high in overburden
- Pile formed after blasting is not suitable for handling properly by wheel loaders
- Low moisture give rise to huge amount of silica rich dust which creates health hazards
- Thickness of laterite is not uniform so by blasting operation totally removal laterite is not possible without ripping & dozing

Removal of over burden is carried out by two method blasting as well as ripping but in loose area where ripping is easily possible ripper dozer is deployed but for hard weathered lateritic over burden blasting is the best option till now. Highly sloping areas where drilling is not possible then ripper dozer of higher HP such as Komatsu 475-A is deployed. Cross ripping practices advisably where ripping is only done not dozing for loosen the in situ

Bauxite excavation

Average thickness of the bauxite deposit is 14mts but varies from 4mts to 40mts. During the test and observation it is found that heterogeneous bauxite formations occurring over 30% of the initial of mining area where iron percentage varies widely across the bauxite profile where drilling blasting is necessary but after that deposit is very weak so ripping is economical. Various ripping techniques which is employed in the mines as follow

- Close spaced ripping is employed where the mineral deposit very hard massive and ferruginous to avoid big boulders due to degree of fracture

- Cross ripping with dozing involves ripping an area with series of longitudinal passes and then covering the same area while ripping in a transverse direction then dozing the area to make pile this is done when extremely hard surfaces
- Only Cross ripping is done where there is no requirement of dozing the material to make pile for loading by wheel loader .it is only possible in very loose deposit.

4.11 Drawbacks of ripper dozer mining

1. Initial capital cost is higher
2. Maintenance team be bigger .In some case without spare parts dozer is kept out of production months and more
3. Highly experienced skilled operator is prime necessary for operation so it takes long time to make a dozer operator.
4. As operators have different skills & ideas so to maintain bench height and floor level close supervision is necessary
5. Output very low in hard weathered laterite & ferruginous bauxite area
6. Output of dozer to the demand of production is very slow in mines

4.12 Conclusion:

Experience gained in production ripping at NALCO’s bauxite mines has conclusively established ripping as an economically viable alternative to drilling and blasting and can be safely resorted to where ever the rock characteristics are favorable and the suitable equipment available within the country, production by ripping is gaining wider acceptance the world over mainly due to the techno- economic considerations due to need lesser manpower capital investment and uninterrupted work cycle this alternative for rock breaking is become popular and economical.

Chapter 05

FIELD STUDY 2: TALABIRA- 1 COAL MINE, OCP, HINDALCO

5.1 Introduction:

The interest to begin coal mining under safest environment condition lead to the birth of Talabira-1 mining operation- the first blast free coal mine in India and fist captive coal minng in Odisha through ripper dozer and surface miner. Talabira-1 mine is situated in Sambalpur District of Odisha. It is operated by HINDALCO. The excavated coal goes to Hirakud for captive power generation. Mining operation is accomplished by Ripper dozer and continuos surface miner. No crushing unit and coal handling plant are required due to deployment of surface miner. Overburden removal and coal winning is directly handled by HINDALCO whereas loading and transportation of overburden and coal has been handled by the contractor AVIAN OVERSEAS Pvt. Ltd. Continuous surface miner produces coals of desired size below 150mm suitable for using in the power plant and improves quality by selective removing the dirt band. This is selective mining. Then the coal is transported to the destination by tippers.

5.2 Geo-mining condition:

Talabira-1 constitutes the south eastern end of Ib valley coalfield. The area allocated is 2.60 sq.km and HINDALCO lease area is 1.70 sq.km the remaining belongs to the forest department and to the department of water resources. The mine is located near to the water reservoir of Hirakud dam. The south eastern tongue of the coalfield is affected by three major faults (N-S, NW-SE, NE-SW) in which the NE-SW fault separate block from the Rampur Colliery. The rock exposures of the Talabira-1 belong to Karharbari and Barakar formations. The three correlated splits of Ib seam represent the Karharbari formation. The Barakar formation on the other hand, contains five correlatable horizons of top and four splits of Rampur bottom seam. The Rampur top seam is the youngest and the thickest seam.

Table 5.1 Geo-mining condition of Talabira-1 block (*HINDALCO, 2011*)

Name of the seam	Range of depth	Parting in meters	Thickness in meters	Direction of dip	Rate of dip	Nature of overburden
Rampur top	8-54			NW-SE	5^o to 10^o	Top soil/ boulder clay
Rampur bottom-III	6-60	2-5.32	0.44-2.76	NW-SE	5^o to 10^o	Sandstone & shale
Rampur bottom-II	6-66	071-6.15	0.44-3.01	NW-SE	5^o to 10^o	Sandstone & shale
Rampur bottom-I	6-74	0.3-3.42	0.24-5.57	NW-SE	5^o to 10^o	Sandstone & shale
IB-III	18.37-82.71	2.34	0.4-3.83	NW-SE	5^o to 10^o	Sandstone & shale
IB-II	32-92.00	2.66	0.14-2.0	NW-SE	5^o to 10^o	Sandstone & shale
IB-I	36-08		0.25-2.54	NW-SE	5^o to 10^o	Sandstone & shale

5.3 Salient features of Talabira-1 OCP:

- Mining lease area : 170.305 Ha
- Coal bearing area : 89 Ha
- Active mining area : 55 Ha
- Recoverable coal reserve : 23.50 MT (million tonnes)
- Grade of coal : G & F
- Workable seams : 7 no.s
- Use of coal : Captive power
- Avg. stripping ratio : 1.09 m^3/tonne
- Dip of the seam : 5^o-10^o
- Output per manshift : 31.56 tonne
- Thickness range of seams : 0.7m to 44.69m
- Maximum overburden on top seam : 23m
- Maximum depth to be mined : 90m
- Average stripping ratio : 1.25
- Cost of coal : Rs.350 per tonne.
- Gross calorific value : 3250-3600 kcal. (F-G)

5.4 Parameters for overburden (OB) and coal benches:

Table 5.2 Parameters of the Ob and coal benches (*HINDALCO, 2011*)

Parameters	Overburden	Coal
Bench height	7m	7m
Bench width	>=3x(dumper width)	>= 3x(width of tipper)
Bench slope	<= 70^o	<= 70^o

5.5 Selection and use of Ripper dozer in Talabira-1:

Based on the seismic velocity analysis and productivity of ripper types of ripper are selected. Also Talabira-1 is located near water reservoir of Hirakud dam. So it was dangerous to practice drilling and blasting practices near to it. Therefore as directed by DGMS, blast free mining method was adopted for the excavation. Ripper dozers are used to remove the overburden and continuous surface miner is used to excavate the coal. Loaders are used to load the OB and coal to dumpers and tippers.

HINDALCO has deployed two rippers of KOMASU D-475A for OB removal (*year of commencement – July 2003*).

Feature of D-475A ripper used in Talabira-1:

- Number- 2
- Power:- 860 HP (Komatsu D-475A)
- Used mainly for overburden and shale (hard rock)
- Cost:- Rs 4.5 crores.
- Operating Cost:- Rs 20 per te (approx)
- Oil consumption per hour = 120 lt

The specification of the ripper D-475A has been already mentioned in the section 4.8.

5.6 Cost Calculation:

5.6.1 Ripping cost calculation per tonne (T) of OB generated.

Table 5.3 Ripping cost per tonne of OB

Particulars	**unit**	**quantity**			
Material generated	T	7800			
Particulars	**UoM**	**Quantity**	**Rate/unit**	**value**	**Per unit**
A) Material cost					
consumbles@2% of R&M				6500	.833
HSD	Litre	2160	Rs 45/lit	97200	12.46
B) Conversion cost					
Laborers cost				6000	.769
Depreciation				61260	7.854
Repair& maintenance cost @10% residual cost				32500	4.167
Admn.overhead@10%				22000	2.82
Interest on capital				44178	5.66
Total cost per MT					**34.563**

Considering loader for loading the OB onto the dumpers.

Owning and operating costs of loader = Rs.14.92

Total cost of ripping = Rs.49.483 per T …………………..(3)

5.6.2 Drilling and blasting cost per tonne of OB produced.

Drilling cost per meter = Rs.215.54

Hole diameter = 150mm

Hole depth = 7.8m

Drilling cost per hole = Rs.1681

Material generated = 344 T

Drilling cost per T = Rs. 4.88

Blasting operating cost = Rs.38.63 per T

Labor cost = Rs. 0.75 per T

Depreciation cost = Rs.0.35 per T

Repair and maintenance cost = Rs. 0.32 per T

Administration overhead cost = Rs.2.12 perT

Interest = Rs.5.46

Total blasting cost = Rs.47.63 per T

Shovel owning and operating cost = Rs. 12.42 per T.

Total cost incurred in drilling and blasting process = Rs 64.94 per T …………..(4)

5.7 Conclusion:

It is obvious ripping and dozing is economical but this is constrained by various factors.

Also due to location this method was adopted. Talabira 1 mine is located 50 mts away from the Hirakud water reservoir. So it demanded a blast free mining.

For very hard strata ripping becomes expensive. So it can be associated by drilling and blasting.

Chapter 06

RECENT DEVELOPMENTS IN THE FIELD OF RIPPER DOZER.

1. **Remote operation of ripper and dozer: (** ***Remote control technologies Pv.t Ltd, Australia*****)**

Remote Control Technologies is a world leader in remote control systems for dozer applications and the first one to design systems for Caterpillar D5N, D8T, D9H, D10, D10N, D10R, D11N, D11R Series 1,2,3, KOMATSU D475, D572-A2, D575A, D575A-3 & D275AX. RCT is the first one to install remote control for a dozer CAT D11Nin PNG in 1989. In 2006 RCT was the first in the world to remote control a CAT D8T dozer.

Following are the advantages of remote control operation:

- Prevents repetitive stress injuries.
- Maximization of machine utilization.
- Greater overall operator vision.
- Improved ergonomic working condition for operator.
- Less idle time between production cycle.
- More control of critical machine tolerances.
- Hazardous machine tasks can be accomplished safely.

Fig.6.1 Dozer being remotely controlled.

2. Mine APS Dozer (*www.apsmining.com*)

MineAPS Dozer is a GPS+GLONASS machine guidance solution for dozers, enabling faster, safer and more productive operation. High precision GPS+GLONASS guidance allows accurate dozing to plan without the need for rechecking or pegging.

Features:

- Accurately report machine position in 3D relative to digital design.
- Open systems technologies includes MS Windows, SQl, XML, NMEA, Sharepoit services.
- Compact and flexible GPS+GLONASS receivers to balance investment and application.
- Easy to use touch screen operator interface.
- Operator can choose to work to design surface or offsets.
- Support multiple user selectable surfaces in asingle file.
- Onboard system diagnostics.
- Fixed hazard and mobile equipment proximity warnings.
- Optional ripper sensor.
- Optional blade guidance sensor.
- Open communications interface compatible with 3G cellular, 802.11x, mesh and other communication systems.
- Off board and onboard producitn reporting options by machine, area, group or opretor including: volumes, push distances, cycles, rehandle, idle vs push vs ripping, delays, export DTM of ‘as built’ surface.

Benefits of the system:

- Selective mining is possible leading to improved grades.
- Improved safety through fixed hazard and proximity warnings.
- Improved efficiency and reduced errors.
- Achieves results faster with fewer passes.
- Reduce rework caused by over or under cutting or filling.
- Significantly reduce dependence on survey and grade checking.
- Machine based production reporting removes errors and improves timeless and accuracy of management information.

Chapter 07

CONCLUSION

Recent developments in the ripper capabilities have made ripping a viable operation than drilling and blasting. Although blasting can be associated with ripping in some cases, but different studies like initial investment, operating cost, volume produced and cost incurred studies should be done. Now a day in this eco-conscious world there is high need to conserve the environment. Recent scenario of mining industry has to follow lot of laws & regulations of the government and public welfare as well as political parties to run the mines. To save environment, life of wild animal with poor villagers' welfare will be the basic need to fulfill for smooth run of mines. Air pollution, dust, fly rock, ground vibrations from drilling and blasting and handling explosive is very difficult to manage for this time being. There is a high need of blast free mining. Recent studies show that ripping is now possible for iron ore production.

In future there will be further development to apply ripping in majority surface mines and hence will start a revolution of blast free mining.

REFERENCES

i. Amin Mohd For Mohd ; Huei Chan Sook ; Zuhairi Abd. Hamid; Mohd Khairolden Ghani. "Rippability assessment of rock based on specific energy and production rate", 2nd construction industry research achievement international conference (CIRAIC2009). Pp-3-5.

ii. Panda P.K ; Misra S.K . " Ripping an aid to primary mining system a NALCO experience" ,3rd national conference on surface mining , 1989.

iii. Samal Subhrakanta ; Dash Ashish ; Murthy V.M.S.R ; Mohanty P.R. " Ripping –an excavation technique of future promise" , ISM Dhanbad.

iv. Basarir H. ; Karpuz C. ; Tutluoglu L. (2007). " A fuzzy logic based rippability classification system". Template journal.

v. Basarir H. ; Karpuz C. ; Tutluoglu L. (2008). " Specific energy based rippability classification system for coal measure rock" , Journal of terramechanics.

vi. Prof.Mishra G.B, "Surface mining", Bhubaneswar; Geominetech publications, first edition, 2007, chapter 8-"excavation and loading", page- 405-406.

vii. www.rct.net.au ; Remote control solutions for dozer applications., Remote control Technologies Pvt.Ltd.,Kewdale western Australia.

viii. http://www.civil.utm.my/staff/file/116/file/Rippability%20Assessment%20of%20Rock%20Based%20on%20Specific%20Energy%20&%20Production%20Rate.pdf

ix. http://www.saimm.co.za/Journal/v107n12p817.pdf

x. http://www.civil.utm.my/staff/file/116/file/Rippability%20Assessment%20of%20Quartzite%20in%20Kenny%20Hill%20Formation%5B1%5D.pdf

xi. Overburden Side Casting by Blasting-Operating large Opencast Coal Mines in a Cost Effective Way",Partha das sharma

xii. Ramulu M.; Choudhury P.B.; Sangode A.G. and Soni A.K., 2012 “Rippability assessment by refraction seismic survey at an iron ore mine in Karnataka” ,Mining engineers Journal, volume 13, No.10, PP-20-27.

xiii. Komatsu company Handbook edition 30, 2010,pp-IC-14.

xiv. Xia,J., Miller R.D., and Park C.B.,1999, “Estimation of Near surface shear wave velocity by inversion of Rayleigh wave”: Geophysics, pp 64,691-700.

xv. HINDALCO Industries limited, “Annual Mines Safety Fortnight”, 2011-12.

xvi. Atkinson, T.,1970, “Ground Penetration by ripping in open pit mining”, Mining magazine, vol.122, pp 458-468.

xvii. Caterpillar Tractor Company, October 9182, Caterpillar performance Handbook, 13th edition, section 1-10, caterpillar tractor Company, Peoria,IL.

xviii. Fiona MacGregor,PhD, thesis summary-“The Rippability of Rock”, pp-1, 6-8.

xix. University of Arizona , Mining and geological Engineering, “Rock Excavation”, MnE 415-515 : course notes- spring 2006, pp- 235-248.

xx. NALCO Ltd. field study.