# UNIT 3

# HEAVY EARTH MOVING MACHINERY

## Machines used for different activities

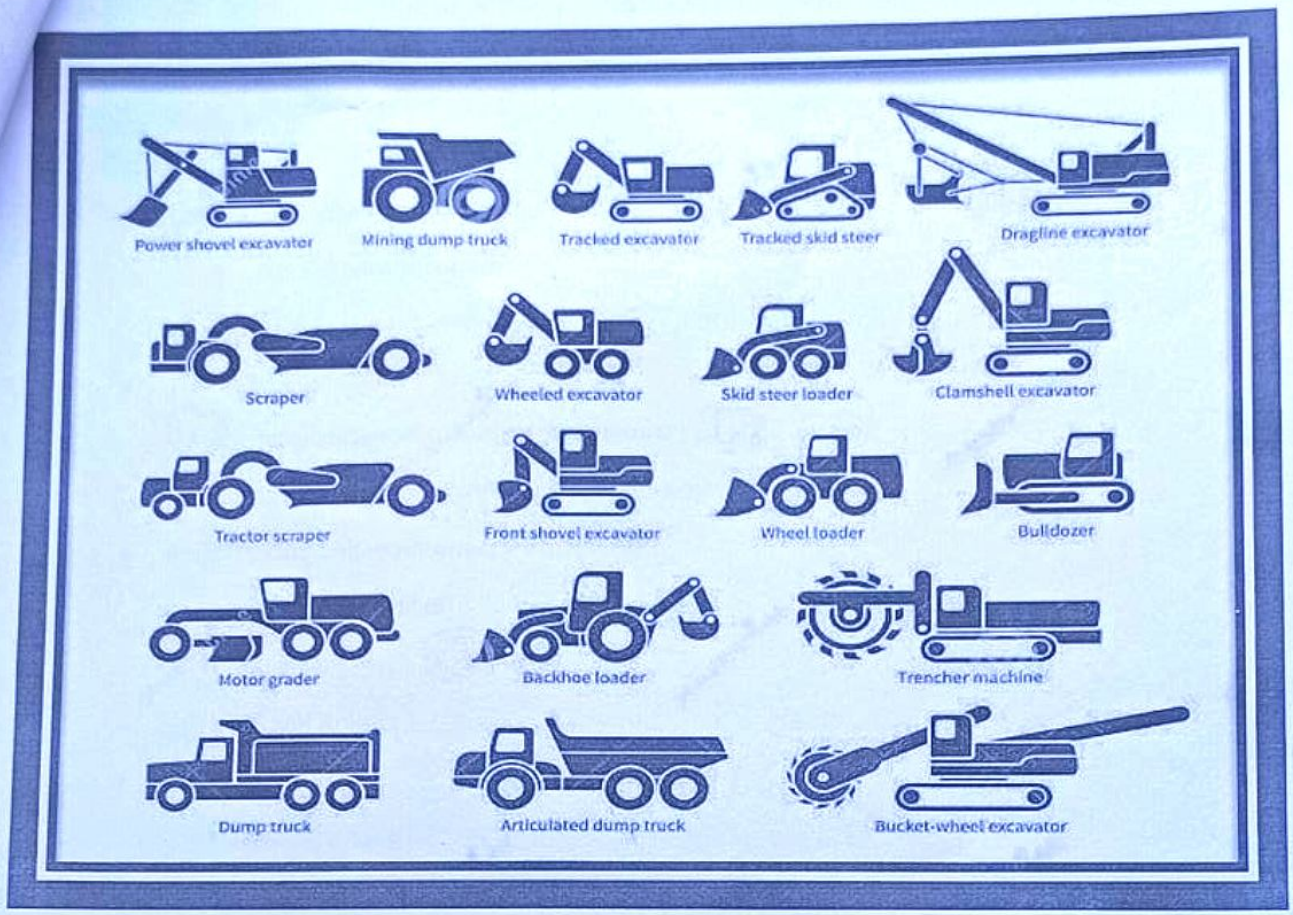
| Activities | Machines used |
|---|---|
| Site clearance and preparation | Scrapers, bull dozers & front-end loaders |
| Drilling | Jack hammer, auger drill, wagon drill, rotary and percussive drill, all hydraulic drills. |
| OB removal | Front end loaders, shovels, draglines, bucket wheel, excavators, surface miners |
| Coal loading | Shovels, front end loaders, hydraulic excavators, surface miners. |
| Transport | Trucks, dumpers, wagons, Reclamation conveyors, Ariel ropeway |
| Reclamation | Dozers, reclaimers, scraper, stackers, spreaders, graders, bridge conveyors, crushers, rippers |

## INTRODUCTION

Heavy Earth Moving Machinery (HEMM) comprise of machines which cut and extract earth, blast rocks, sand and other loose material and then transfer them to a predetermined positions and finally discharge the materials on dumping points through dumpers, belt conveyors, etc. A few machines of this category are also used for road making and maintenance purpose. As a mean of producing mineral wealth, civil construction, road making and irrigation projects.

HEMM are invaluable in realizing the process of production and increasing manifold the productivity of human Laboure.

HEMM are the combination of various mechanisms designed to perform the special type of work mentioned above. The mechanism or the constituents are a prime mover [diesel engine and electrical motors], a power transmission system including clutches, gear boxes chain sprockets, etc., control system and mechanical linkages.




## CLASSIFICATION

Despite their variety they can be classified as follows:

- Excavators
- Transport equipment
- Road making and maintenance equipment
- Drilling equipment

*This can be further classified as shown below*

## Excavator

- Intermittent discharge type equipment
  - Working as pure excavator
    - Shovel
      - ☐ Rope shovel
      - ☐ Hydraulic shovel (Front End Loader, Back-hoe)
    - Dragline

- Working as part excavator and part transport equipment
  - Scraper
  - Pay loader
- Continuous discharge type equipment
  - Bucket wheel excavator
  - Bucket chain conveyor
- Transport equipment
  - Intermittent discharge type [dumper]
  - Continuous discharge type [belt conveyor]
- Road making and maintenance equipment
  - Dozer/Bull dozer
  - Grader
  - Road Roller
- Drilling machine
  - Diesel driven
  - Electrically driven
  - Cranes/Tire mounter

## USES

HEMM are used today in multipurpose activities such as

| SURFACE MINING PROJECTS | IRRIGATION PROJECT |
|---|---|
| STEEL INDUSTRY | AGRICULTURE FIELDS & Other areas |

- They are also used in cities and towns to clean and handle garbage heaps, construct tube railways, etc. But 90% or more of the equipment is used in surface mining projects to excavate and transport minerals like coals, lignite, iron ore, copper ore, bauxite, limestone, etc.

## Where opencast is to be used

- Flat and mild gradient and at shallow depth
- Stripping ratio viable
- Thick or multiple seam at close spacing
- Area free of pollution or built up structure

# SHOVEL & Hydraulic shovel

A shovel is an equipment which excavates the rock or ore by digging from its operating base to upwards (stripping shovel in this case) and dump it either on a dumper or railway wagon or over the spoil dump for backfilling after swing itself within its limit. It is a highly productive machine and capable to handle all types of ores.

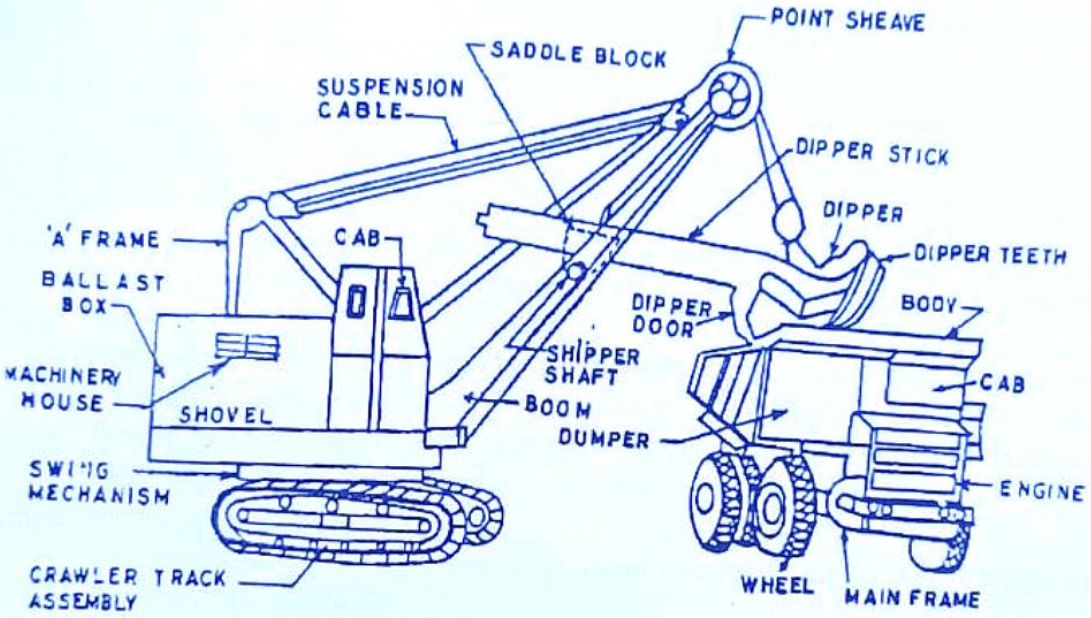



**Fig.** A Generalised Schematic Line Diagram of a Shovel and Dumper. Shovel is Loading on to the Dumper.

Shovel is used overburden removal in the contour mining in the hilly terrain, overburden removal in open pit mining system excavation in the face and loading onto trucks, bunker or railway wagon, removal of top soil, construction of access roads and haul roads, opening up a mine by a box cut system, etc. A flat or mild gradient dry competent floor is a very good operating condition for a dipper shovel.

The design of the shovel is such that only it's minimum mechanical parts (very nominal in weight, compare to the total weight) like the dipper stick, bucket etc. play important role in digging operation. The perfect motion of the dipper sticks to reach and leave the face after loading facilitates will shorten cycle of operation. The bucket which is mounted with sharp teeth cut the rock or mineral body and break them with the help of pressure provided by the hoist and crowd actions.

Efficiency of larger size shovels are much higher particularly during excavation of heavily blasted overburden rocks or coal. During operation assistance may be required either by a bulldozer or a front-end loader together and muck piling of scattered rocks or ore. This will assist shovel to maneuver nicely near to the face and also effectively load them into the bucket.

## Selection of Shovel

*Selection of a shovel is basically done by considering the factors like*

- Requirement of daily production,
- Type and quality of the material to be excavated,
- Total coal or ore reserve, geotechnical parameters of mineral body or overburden rock. In the geotechnical parameter the thickness, compressive strength, tensile strength, shear strength, abrasiveness, dip, etc. of mineral body. coal and also overburden rocks are very important besides Stratigraphy condition, ground stability presence of contiguous seam, intrusion of hard bands, presence of fault, folds and other geological disturbances, ground water condition, etc.
- Bucket fill factor-larger shovel dig better than the smaller one.
- Swell factor,
- Working cycle time,
- Weight and maximum lump size of the materials to be excavated,
- Height of the bench and height of the cut (a shovel can dig material in a bench of height more than 55m).
- Whether the shovel is to be worked out in the overburden or mineral benches which are to be excavated directly.
- Whether it is to be used for production or casting overburden or for reclamation purposes,
- Requirement of working clearance by a particular type and size of shovel,
- Number of faces are to be worked,
- Nature of terrain, depth of the mine to be worked, size of the box cut, size of the area where shovel will operate etc.
- Capacity of the haulage equipment,

Operating parameters like digging height, digging radius, dumping height, dumping radius, etc. High capacity shovels have larger digging height and radius and also they have larger dumping radius, bucket size and capacity (generally for excavation of ore bucket capacity below 15m^3 with a height of bench ranging from 5m to 18m are selected. For over casting bucket capacity of a shovel generally more than 15m^3).

- Over all dimensions-rear end clearance, angle of boom inclination, height of the excavator and height of the excavator cabin,
- Availability of electric power supply,
- Working gradient -maximum gradient may be up to 12° depending upon the type of shovels. Heavier shovel necessitates milder gradient (6 degree to 7º). Speed of the shovel increases with the decrease in gradient,
- Drainage condition
- Ground pressure - due to the bucket filling with digging, swinging of the shovel and unloading of materials, average ground pressure may increase 15-20 times. The maximum ground pressure should not exceed the carrying capacity of the ground floor. Ground pressure should be within 1.5 kg/cm^2 for softer floor condition and 4kg/cm^2 for other rock condition,
- Equipment availability particularly indigenously made,
- Climatic condition and drainage system,

- Reliability of the machine,
- Capital cost of the equipment,
- Operating and maintenance cost,
- Availability of the spare parts,
- Facility of after sales service

## During selection of a shovel the following points are also to be considered in depth

1. The power shovel is somewhat flexible in its operation,
2. Since cost of the shovel is very high, it must be selected for a fairly long-life project,
3. Due to its poor mobility, a power shovel is confined to operating nearly to a smaller area of coverage. So, the selection of a single shovel for a widely spread areas of the mine is to be ruled out.
4. Consideration must be given during planning of an adequate electrical power distribution system during selection of electrical shovel,
5. Due to ease of operation of a shovel, its output does not hamper due to operator's fatigue,
6. The power shovel has excellent digging capability due to its own weight, traction and It can give high production,
7. It can handle all types of materials, including large blocky materials.
8. Operating conditions are fairly rigid,
9. It may require supporting equipment for waste disposal
10. high-powered crowd and hoist motion. Out to crawler mounting, the power shovel has a distinct advantage over the tired mounted loading equipment,
11. Construction of shovel is rugged with the use of electric motors and sophisticated electric and hydraulic controls. The reliability and the efficiency of the shovel is exceptionally high.

## Swell factor for commonly found rocks

| S.NO | ROCK | In setu weight Kg/m^3 | Lose weight Kg/m^3 | Swell factor | % Swell |
|---|---|---|---|---|---|
| 1 | Dry earth | 1650 | 1320 | 0.80 | 25 |
| 2 | Wet earth | 1990 | 1590 | 0.80 | 25 |
| 3 | Earth & rock mix | 1470-1770 | 1130-1360 | 0.77 | 30 |
| 4 | Shale or soft rock | 1770 | 1330 | 0.75 | 33 |
| 5 | Well blasted hard rock | 2360 | 1580 | 0.67 | 50 |

| | | | | | |
|---|---|---|---|---|---|
| 6 | Bituminous rock | 1120 | 960 | 0.74 | 35 |

## Some terminology generally used in connection with shovel operation

1. **Swell factor** - It is the ratio of weight of one cubic meter of blasted rock to the weight of one cubic meter of solid rock. Thus, expressed it is less than 1. It indicates the amount of increase in volume of rock mass after blasting. Big boulders due to poor fragmentation create more void causing increased swell factor.
2. **Bucket factor/ fill factor**- Filling ability of the bucket is always less than 1 because entire bucket does not get filled and so there is reduction in struck capacity while filling. It indicates the ratio of volume of material actually held in the bucket to the nominal capacity of the bucket. This factor is determined by field observation. Fill factor is very important parameter which indicate show much material is carried in one pass of the bucket and how many passes are required to fill the dumper of a required capacity.
3. **Swing factor**- Generally cycle time of the shovel is given for swing angle of 90 degree. If swing angle is either more or less than 90 degrees during operation, the cycle time will increase or decrease correspondingly. The factor through which the cycle increases or decreases is called swing factor. This factor is provided by the manufacturer for each shovel.
4. **cycle time** - It is total time taken for digging, loading and hoisting (known as crowding), swinging, dumping in truck and returning for crowding.
5. **Cycle time of dumper** = spotting time + loading time + travel time with loading + discharge time + empty travel time + waiting time for load
6. **Total loading time** = cycle time of shovel x No. of passes to fill dumper.
7. **Effect utilization** = $\frac{actual\ working\ hours\ X\ 100}{total\ shift\ hours}$
8. **Availability factor** = $\frac{shift\ hour - maintainance\ hour - breakdown\ hour}{shift\ hour}$
9. **Utilization factor** = $\frac{shift\ hour - maintainance\ hour - idle\ hour}{shift\ hour}$

## Hydraulic shovel

Hydraulic shovels are slowly replacing the conventional rope shovels. Because of their higher productivity, higher efficiency, higher machine availability, smoother and easier control, possibility of application in both the pushing and pulling forces, efficient, smooth and controlled digging and slumping, faster loading cycle. Possessing fewer parts as compared to a conventional rope shovel, less maintenance cost, low down time. possibility of continuous health monitoring system.

less bulkiness and weight compare to a conventional shovel, ability to selective mining at any desired horizon, ability to dress the high wall (face) etc. hydraulic shovels are gaining much popularity in modem surface mining operation. Some of the hydraulic excavators employs step less control of

traction and its speed which offer simple reversing and operating mechanism with high reduction speed ratio. The machine is also very much reliable in operation. The main operations in a hydraulic excavator are done by the hydraulic pressure.

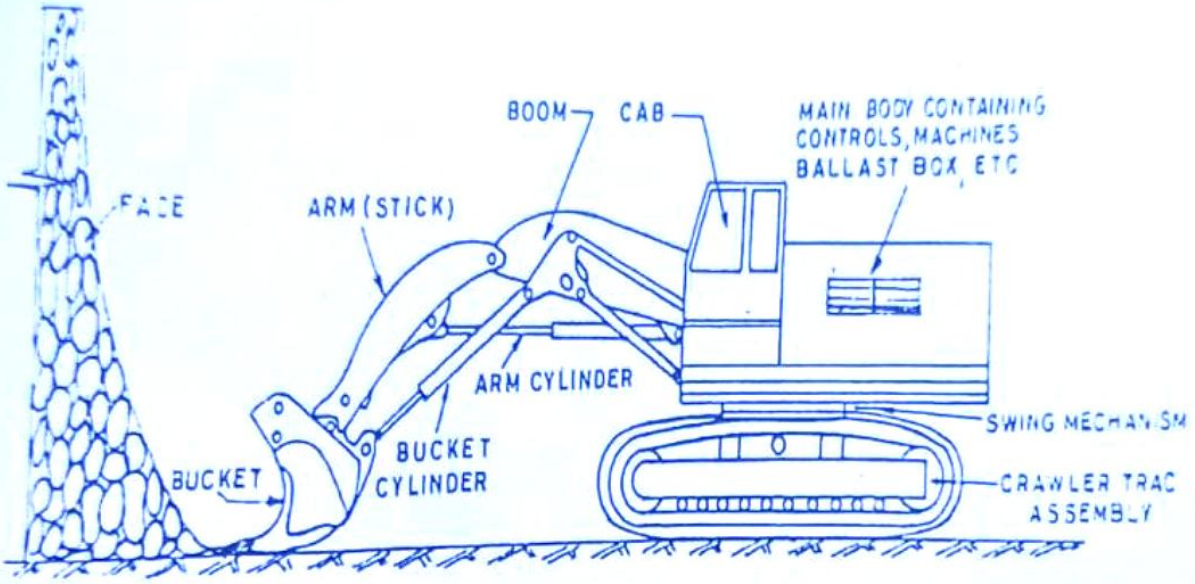



Fig. : A Schematic Line Diagram of a Hydraulic Shovel Under Operation

# Dragline

This machine is used for removing soft or well fragmented material from above a coal seam and dumping it directly or through a rehandling of the removed material on the previously decoaled area of the mine. It is a machine which loads as well as transports and dumps the OB within the mine area from where coal has been extracted. The suitable condition for its use is:

1) Flat deposits, gradients preferably not more than 7degrees to permit back dumping of OB in decoaled area. However, application in steeper gradient is also found, particularly in the erstwhile USSR. The OB is usually dumped on seam floor very near to the coal bench, leaving space sufficient only for water drainage and also to reduce mixing of OB with coal. If coal seam gradient is not flat, the dumped OB will slide towards the coal face particularly in the rainy season and prevent coal extraction, besides being dangerous.

2) Strike length of the property should be preferably 1.5 to 2 km and more so that a dragline is not required to be frequently shifted from one end to another and its idle marching time reduced.

3) A hilly property may not be suitable for use of dragline. Such an area is to be made flat first before the dragline can be used. There after the dragline should have a uniform workload.

4) Thick seams, say of thickness more than 25m are not suitable for dragline mining. If a coal thickness is to be worked in more than two benches, and the OB has to be back dumped clear of the bottom coal, a dragline is required to have a large boom length. Such a dragline will be

extremely costly due to the engineering problems involved in the design and manufacture of such long boom machines. Alternatively large quantities of OB have to be rehandled to expose coal, which is also a costly proposition.

5) The property should be rather free from geological disturbances. A dragline system works with rigid operational geometry and frequent changes in this geometry to suit geological disturbed deposits, may be difficult to implement without heavy loss of efficiency.

6) The property should be large enough ensuring a life of about 25 years, or more, so that impact of heavy capital investment can be diluted.

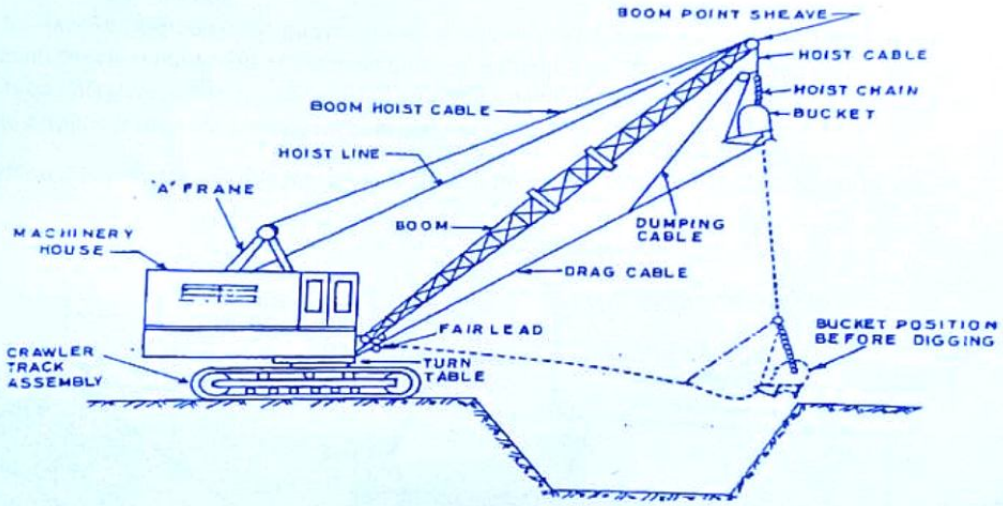



Fig A Generalised Schematic Line Diagram of a Dragline Under Operation

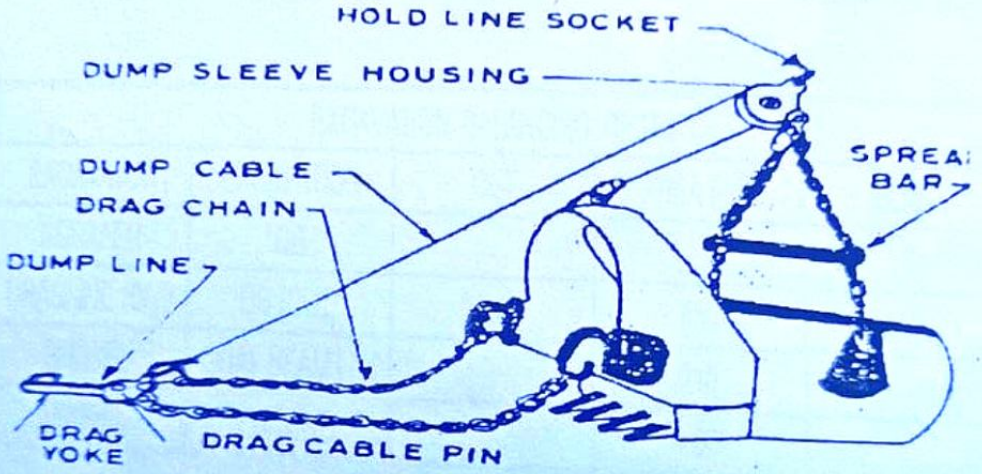



**Fig. : Dragline Bucket.**

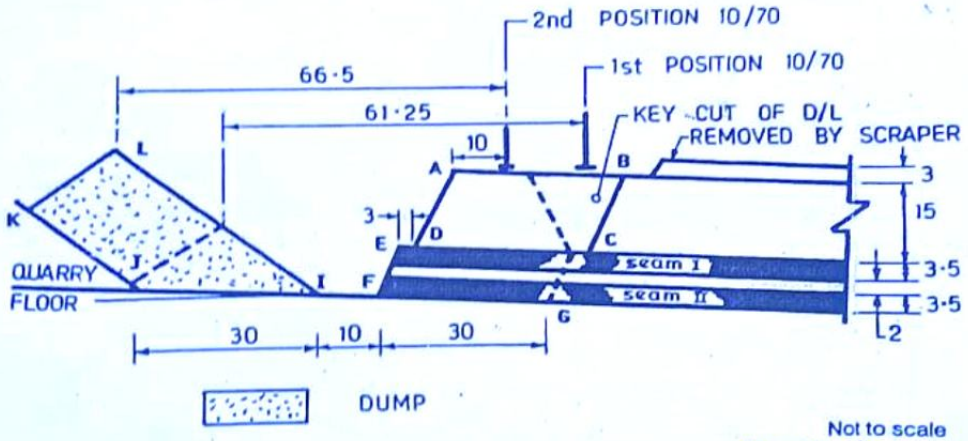
## Common methods used in dragline application are as follow:

I. Simple casting method with or without rehandling.
II. Extended bench method
III. Horse shoe method
IV. Tandem dragline working i.e. two dragline working together, one dealing with part of the material dumped by the other.

## Simple casting method

This is the simplest method of dragline working. In this method, a dragline is sited on the solid strata of the main bench, removes OB of the main bench and dumps it in the decoaled area of the previous cut. Only one dragline is used for OB removal on either side of the main sump of the mine. Sometimes only one dragline is used for working on both sides of the sump.

***The method is extremely suitable for single thin seam mining or for two thin seams close together.***




Not to scale
Dimensions in metre

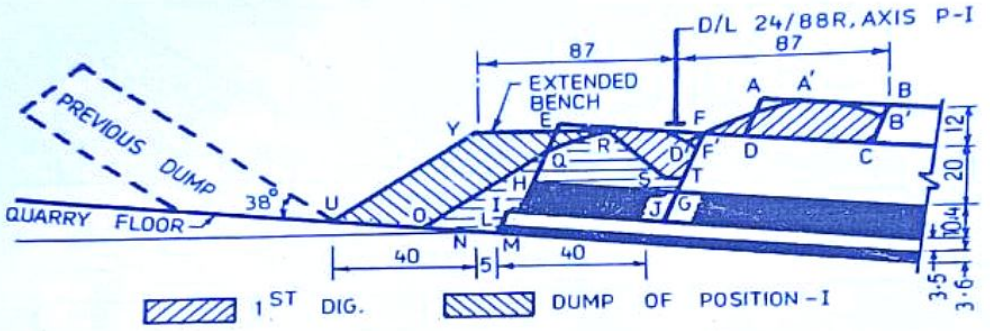
| EXCAVATION BALANCING CHART | | | | |
|---|---|---|---|---|
| EXCAVATOR | EXCAVATION | CUT | AREA ($m^2$) | DUMP |
| SCRAPER | OB | | | |
| DRAGLINE 10/70 | OB (CUT) | ABCD | 450 | IJKL |
| SHOVEL | COAL SEAM I & I | | 210 | |
| SHOVEL | PARTING | | 60 | |

**Figure : Simple sidecasting by dragline.**

## Extended bench method

In this method, a dragline bench is extended by dumping (and dozing) a part of the OB removed by dragline so that same dragline can be sited in a second position on the dumped and dozed OB. This enables the distance between the first and the second position of the dragline to be more compared to what was possible in the simple casting method. This increase in distance the capabilities of the dragline to dump OB further away in the decoaled area.

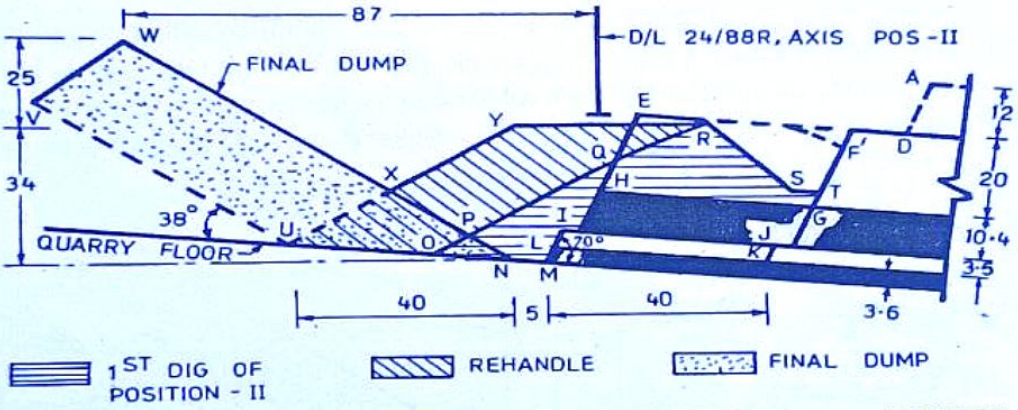
***The method is suitable for exposing relatively thicker seam.***




B'A'D' – BLASTED PROFILE OF ABCD
F'RQO – BLASTED PROFILE OF EFGH

**POSITION – I**

| S. No. | D/L POSITION | EXCAVATING | CUT | AREA $m^2$ (SOLID) | DUMP |
|---|---|---|---|---|---|
| 1 | P-I | Ist. DIG | D'A'B'CFF'RSTF | 480 + 192 | YRQOU |




PARTING IJKL WILL BE REMOVED BY ELECTRIC HYDRAULIC SHOVEL

**POSITION–II**

| D/L POSITION | EXCAVATING | CUT | AREA $m^2$ (SOLID) | DUMP | |
|---|---|---|---|---|---|
| P–II | R.H. 1st. DIG | YRPX PQRSTGHILMN | 474 + 47 (10 % EXTRA) + 608 | UVWX | % RH = $\frac{521}{1280} \times 100 = 41\ \%$ |

**Figure : Extended Bench method for dragline.**

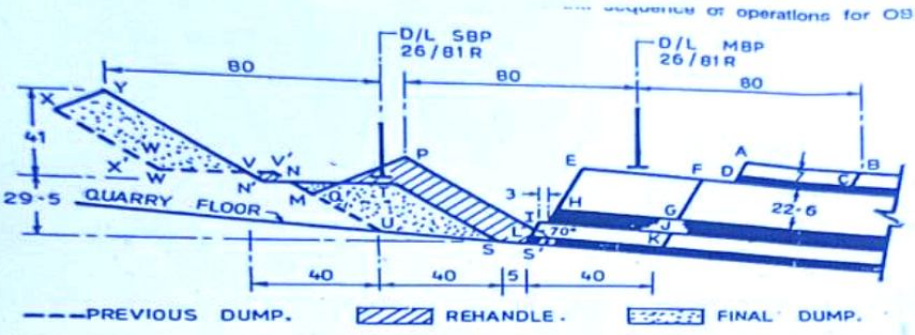
Not to scale
Dimensions in metre .

## Horse shoe method

In this method, a dragline is brought to spoil dump area after it has done its work from the dragline bench in first position. The spoil dump is specially prepared for the purpose by dozing it for giving a

suitable site to dragline for its second position. The distance between the first and the second position of a dragline now is more than that what has been possible with simple casting and extended bench methods.

***Consequently, rehandling capability of a dragline further increases and seams up to about 25m thick (i.e. a thickness that can be tackled by forming a minimum of two extraction benches) can be conveniently exposed by this method.***



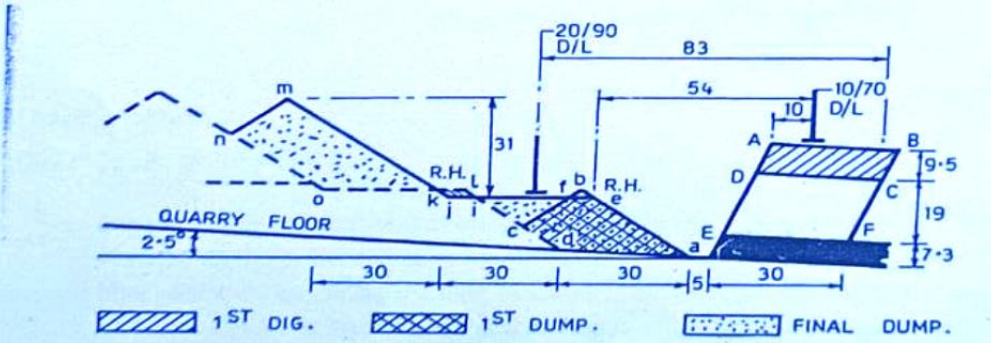

| D/L | OPERATIONAL POSITION | EXCAVATION | CUT (SOLID) | AREA $m^2$ (SOLID) | DUMP |
|---|---|---|---|---|---|
| 26 M/81 R | MAIN BENCH POSITION (MBP) | 1st. DIG | ABCD EFGH | 280 + 904 | MPQRIS'SU |
| | SPOIL BENCH POSITION (SBP) | 1st. DIG | IJKL | 332 | |
| | | REHANDLE | QPIS'ST + VV'NN' | 513 + 17 + 152 | MNO VWW'X'XY |

Not to scale
Dimensions in metre

**Figure : Horse shoe method for dragline.**

## Tandem dragline working

In this method, a minimum of two draglines are put in tandem operation using any of the above methods. Though, theoretically, it is possible to use more than two draglines in tandem, in practice, it rarely done. Normally, the second dragline is either sited on the extended bench or on the spoil dump.




D/L 10/70 IS 150-200 m AHEAD OF D/L 20/90.

Not to scale
Dimensions in metre

| DRAGLINE | CUT | DUMP | AREA $m^2$ (SOLID) |
|---|---|---|---|
| 10/70 | A B C D | a b c d | 285.0 |
| 20/90 | C D E F (DIG) | k m n o f c i | 570.0 |
| | I J K I (R.H.) | | 9.6 |
| | e b f (R.H.) | | 1.0 |

**Figure 8.4 : Draglines working in tandem.**

## The dragline has following demerits also

1. If the blasted rocks are of large lump, the bucket is filled insufficiently and the bucket and drag rope wear rapidly.
2. Used for softer rock formation.
3. Production cost is more as compared to the powered shovel.
4. Its efficiency is less as compared to a power shovel.
5. Lesser spotting ability.
6. Lesser output than the powered shovel.

# Surface miner

Surface miners are, of recent origin, in opencast coal mining. They find their **FRONT CRAWLE** application in projects where drilling and blasting is prohibited or where selective mining of mineral seams are intended to be introduced.

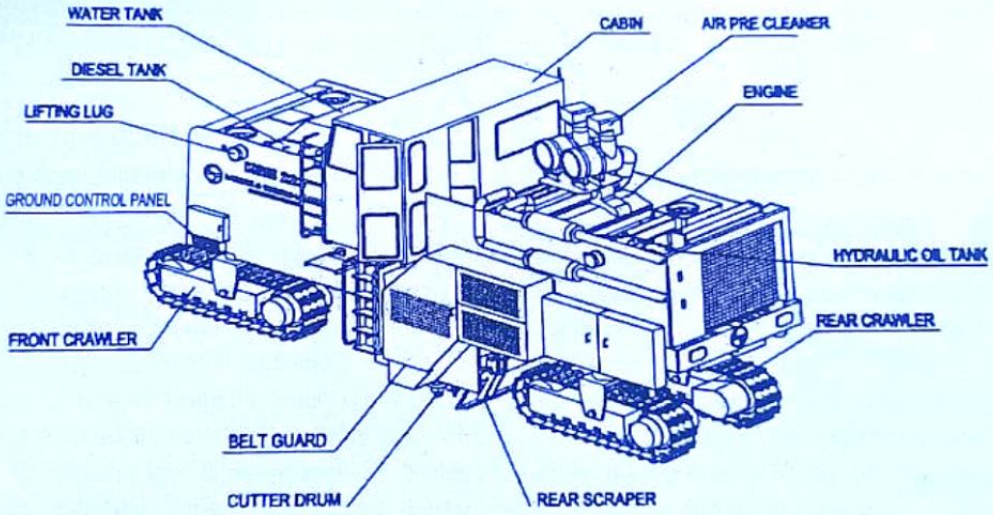



**Fig. Construction Features of Surface Miner**

## Loading option

*Direct Loading onto Trucks*

One of the main characteristics of the surface miners is their ability to load the cut material directly onto trucks. Depending on the machine type, surface miners are designed either as front loading or rear loading machine. Following Loading Options are Available with Modern Surface Miners Direct loading into trucks and indirect loading i.e. first ground dumping and then rehandling into transport vehicles. Front loading, Rear loading, windrowing and side casting can be done as per convenience.

*Direct Truck Loading*

Direct truck loading is affected through an inbuilt discharge conveyor. Here no ground dumping is done. In this process, the performance is affected by availability of trucks and size of cut material and

operational efficiency of discharge conveyor. The conveyor can be slewed to right and left and the height is adjustable. The weight of the conveyor is balanced by a counter weight. The surface miner's operator has direct visual contact with the truck as he may slew his seat to right or left.

## Indirect Loading

In side casting mode, surface miner cuts the material and a stockpile is built by dumping the material on one side by slewing the conveyor. Depending on the slewing angle of the conveyor, upto 3 to 5 adjacent cuts can be dumped on top of each other. The material can easily be reloaded with a FE loader.

### Bull dozer

Bull dozer is considered as one of the earliest excavating machines in surface mining. It is both an excavator as well as an important auxiliary machine. It is so versatile that, it is very difficult to conceive any modern opencast coal mine without bull dozer. Bull dozer essentially is a crawler mounted or wheeled tractor fitted with a blade. It is capable of extracting and moving and stockpiling rock for a short distance. Depending on the capacity of tractor, it can be classified as extra heavy duty (over 300 HP) heavy duty (150300 HP) medium duty (100-150 HP) and light duty (20-80 HP) dozer.

## Selection of Blade for Bull Dozer

**Bull dozer blades are heavy metal plates fitted in front of a tractor. Bull dozer blades may be of three types**

1. A straight blade ("S- Blade") which is short and has no lateral curve and no side wings. This type of blades is used for fine grading. Straight blade performs at its best when used for land clearing, terracing, ditching, stump removal and straight dozing more particularly it is equipped with tilt cylinder.
2. Universal blade ("U-blade"). It is tall and curved having very large side wings to carry more material. U-blade is an angled blade which can be converted into three different positions by rotating it on different angles. U-blades are used for digging loose material and large dumps.
3. S-U Combination blade which is shorter, has less curvature and shorter side wings. This type of blades is used for pushing large rock stockpile.

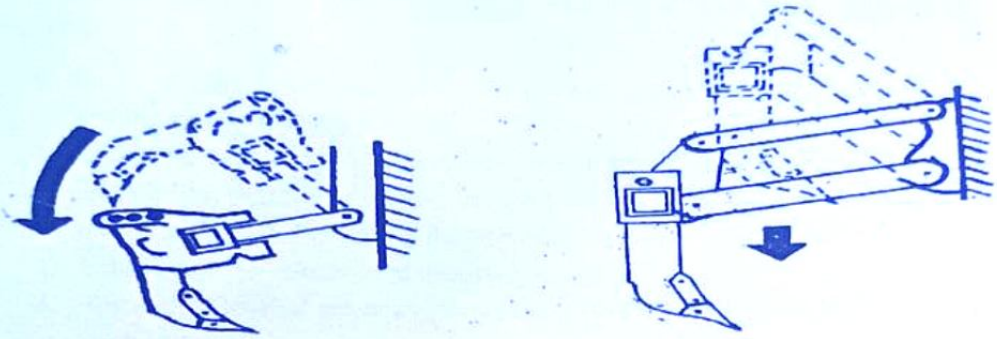
## Bull dozer with ripper attachment

*Ripping of rocks by bull dozer ripper combination*

Mechanical loosening of rock can be affected by trailed or tractor mounted rippers. The mass of tractor (dozer) is made use to ensure penetration of working members of ripper. The depth of ripping done with the trailed member of ripper is usually Ripper may have up to five teeth with solid or composite tips. Single tooth ripper is used for weathered rocks, while dense rocks require multi-teeth ripper. The depth of penetration is varied by means of hydraulic control system. Low or medium jointed weathered rocks are ripped

**Fig. Dozer with Single Shank Ripper**

with teeth having straight uprights. Brittle or heavily jointed rocks are ripped with teeth of intricate shape.



Hinged Type (A) Parallelogram Type (B)
Fig. Ripper Attachment with Dozer

Geometrical parameters of the working member of a ripper include the following particulars: -

a) Cutting angle
b) Tip edge angle
c) Clearance angle
d) Tooth thickness and length
e) Tooth spacing.

Cutting force of ripper depends on ripping angle. for weathered rock optimal ripping angle is 30-45°. An increase of ripping angle from 40° to 60° doubles the resistance. A decrease of ripping angle below 30° also increases resistance to ripping. As the ripper moves, the rock is broken in a trapezium shaped boundary. Loosening ability of rock is specified by the possible penetration of ripper tooth into the loosened rock and depends upon rock strength and its joints. Rock is loosened by ripper by carrying parallel passes and distance between adjacent passes are set dependent upon required lump size and loosening depth. Depth of effective ripping is less than depth of penetration of tooth into the ground. Cross passes are created to get better lump size. Rip ability also depends on the pattern of jointing of rock.

## Bucket wheel excavator

It is suitable for long range stripping of soft overburden rocks at a considerably lower cost although the machine is costly having lower flexibility. The machine is nicely applicable in the following conditions:

1. Hard and tough well fragmented blasted rock with no or less boulders, having consistency of uniform ground and bank condition.
2. Since it has a wide radius of excavation (around 40m to 90m) with high and deep cut, the width of the bench floor exposes more reserve and create huge amount of space for the mobile equipment. The slope of the pit is also very stable.
3. It can be used for selective and thin seam mining.
4. For easy disposal of ore or overburden to a considerable distance above or below of its working level.
5. It is very highly efficient excavator for lignite, soft aluminum, etc.
6. For reclaimination of land.

## Applicability

The bucket wheel excavator are used where soft, unconsolidated overburden exists which does not require preparation. They can be also used after blasting and pre-preparation. Strara with less than 10 MPa compressive strength are better suited for working with BWE.

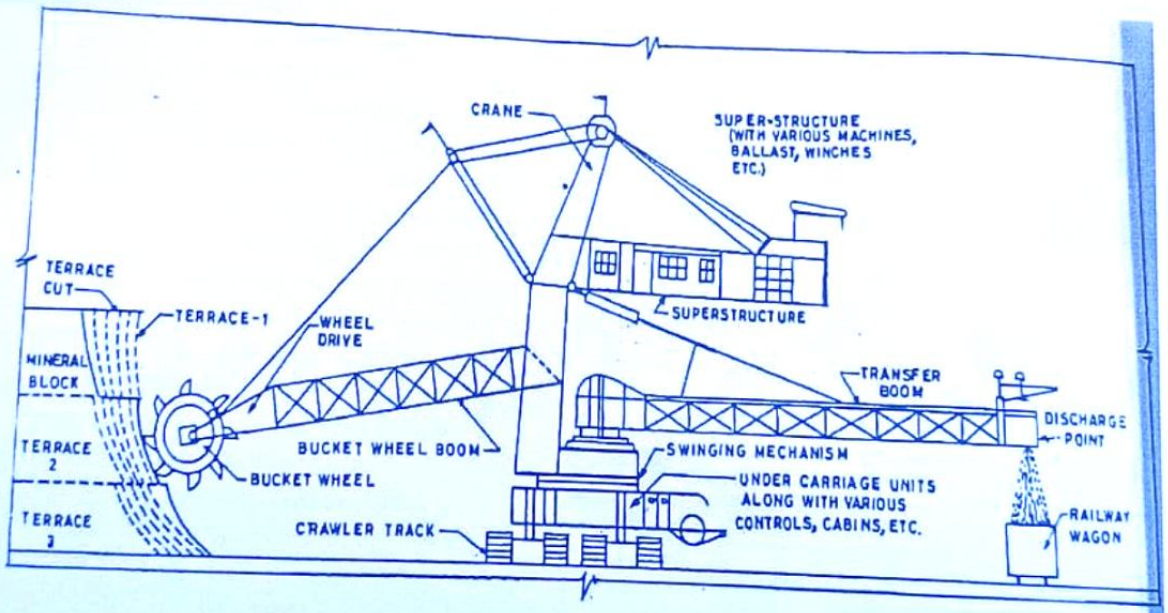



Fig. A Generalised Schematic line Diagram of a Bucket Wheel Excavator under Operation

## Construction of Mining Truck/Dumper

Modern dump trucks used in coal mines are very flexible and sturdy in use. There are many manufacturers who manufacture various capacities of dump trucks which differ in constructional details. Almost all dump trucks have following components.

1. Body,
2. Engine,
3. Drive system
4. Hydraulic system,
5. Tyres and Rims,
6. Operator's cabin

## Factors Governing Selection of Dumpers

With so many types of dumpers available in the market, it is very difficult to make a choice. Selection of dumpers of right kind requires skill and expertise with sound knowledge of financial analysis and decision making. Factors given below, require careful and systematic evaluation to come to a right choice.

1. Technical Parameters
    a. Dump trucks must match the system i.e., Loading unit
    b. Specifications must correspond to high performance like ratio of pay load to net vehicle load and ratio of fly wheel power to gross vehicle weight.
    c. Cycle performance and terrain of movement.
    d. Status of dumping and haul road
    e. Ease of operation including operator's visibility
    f. Safety features and their operation
    g. Ease of maintenance
    h. Physical availability of trucks
    i. Life of dump truck
    j. Availability of skilled manpower for operation and maintenance
    k. Previous experience with the vehicle
    l. Credibility of the supplier
    m. Availability of spares and their lead time
    n. Performance of the vehicle in varying weather conditions
    o. Performance with respect to tyre availability.
    p. Safety certification by DGMS
2. Commercial Parameters
    a. Productivity of dumpers
    b. Operating cost
    c. Total Cost per cum.
    d. Lead time for delivery
    e. Cost of vehicle including insurance, freight and commissioning charges
    f. Warranty
    g. Quantum of initial spares and services provided by the supplier

In order to arrive at the most economic choice for the vehicle all direct and indirect costs should be evaluated and cash flow at net present value (N.P.V.) should be calculated for comparison. Following "capacities" are often referred to in case of a dump truck.

- Struck Capacity: It is volume of material when it is filled to the top but no material above the sides.
- Heaped Capacity: It is maximum volume of material that dumper can handle when material is heaped above sides. While struck capacity is constant for any unit, heaped capacity is variable and is function of material properties and geometry of dumper body.
- Rated Capacity: It is in terms of weight and is the load that machine can carry. Most machines are designed to carry a particular weight rather than volume. Volume of material handled will depend on density of the material. For a given machine, maximum weight that the machine will carry is fixed dependent upon strength of its component.

## Specifications of Dumpers Commonly Used in India

The most commonly used dumper in Indian opencast mines is RD 35.

## Specification of BH 35 Dump Truck (BEML)

Max. Pay load - 32000kg, Capacity (heaped) -22.5 m

## Off-Road Dump Truck

*Advantages of dumper/ off road truck are as follows*

1. It is self-contained and independent of power source,
2. It is flexible, easily maneuverable and has mutually independent performance.
3. Since it is off highway truck there are less regulatory requirements regarding construction of haul roads.
4. It requires simpler traffic rules, concentrated working is possible,
5. If dumping area is, for any reason, jammed, traffic can be diverted to another area without much difficulties thus excavator production does not suffer. Similarly, if excavator is under breakdown dumpers can be diverted for loading to another excavator, thus maintaining dumper performance.
6. Dumper/truck transport can be successfully adapted to varying open pit profile.
7. It is most suited for selective mining and for mining of fiery area

*Disadvantages*

1. Truck consumes high quantity of petroleum energy, supply and price of which are always uncertain because of global reasons.
2. It requires very specialized repair and maintenance. Very elaborate workshop facilities are required.
3. It is affected by extreme weather conditions.
4. Operator's skill affects its performance,
5. In case of very deep mines having steep gradient haul road of proper grade may not be possible to plan.

## Most Common Combinations of Transport Systems

*Shovel- Truck Combination*

This combination is selected based on the following considerations:

- When haul distance is small (say within 3 km to 4 km)
- When gradient is little bit steeper (best gradient for truck is below 6° however it can negotiate even 12").
- When size of the ore or overburden rocks are blocky in nature which makes the shovel more suitable as compared to another loader.
- When work is not very much extensive (or patch work), for selective mining and when concentration of work and flexibility of operation is desirable.
- When availability of the access room is very limited and the topography is not suitable for other transport system.
- When requirement of production is from very low to very high (i.e., the production is very much flexible) and life of the mine is short too long.
- When height of the bench is such that shovel is best suitable in that condition as compared to another loader. With this combination both production and productivity of the shovel increase.
- When it is desirable to not to purchase varieties of equipment to reduce the complexity of maintenance and spare parts management. The same combination can effectively be used for removal of overburden rock, soil and ore.
- When it is planned that the quarry will be deep below 200 m and less amount of construction work is to be done. This is because it can negotiate more amount of gradient, less bending radius around 16m to 20 m and require very less amount of surface top alignment. It also reduces much of excavation work and haulage distance; which ultimately reduces the time of construction and lower down the cost.

### Shovel:

For a single pass it takes nearly 2 minutes 30 second to 3 minutes time to complete a cycle of operation. It is always desirable that a dumper shall be filled up within 3-5 passes. Hence capacity of a dumper shall be selected accordingly to match the system.

Dumper:

In surface mining operation, it is desirable to maintain the speed of the dumpers in between 16-25 km/hr. taking all aspects of normal delays, if the average speed of the dumper is 20 km/hr, the maximum time to complete a cycle by a dumper will be as follows:

| Distance of travel (Km) | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Cycle time (minute) | 15 | 20 | 25 | 30 |

Minimum production per day by a few dumpers (travelling speed 20 Km/Hour)

| Travel distance (KM) | Minimum production($m^3$) | | | |
|---|---|---|---|---|
| Capacity of dumper (Tonne) | 1 | 2 | 3 | 4 |
| 8(Tipping Truck) | 60 | 45 | 35 | 30 |
| 15 | 150 | 120 | 90 | 75 |
| 25 | 250 | 190 | 150 | 125 |
| 35 | 400 | 300 | 240 | 200 |
| 50 | 500 | 375 | 300 | 250 |
| 85 | 800 | 600 | 480 | 400 |
| 120 | 1000 | 750 | 600 | 500 |

Following are productivity norms adopted by coal India (average condition) (Dumper productivity in Meum/Year) Lead of travel (One way)

| S.N. | Rope shovel dumper combination | 1 km | 1.5 Km | 2 Km | 2.5 Km | 3 Km | 3.5 Km |
|---|---|---|---|---|---|---|---|
| 1 | RD Mech 35T+ 4.6 cum | 0.1352 | 0.1133 | 0.1133 | 0.0916 | 0.0829 | 0.0762 |
| 2 | RD Mech 50T+ 4.6 cum | 0.1688 | 0.1472 | 0.1270 | 0.1165 | 0.1057 | 0.0974 |
| 3 | RD Mech 35T+ 5 cum | 0.1472 | 0.1233 | 0.1091 | 0.0998 | 0.0902 | 0.0829 |
| 4 | RD Mech 50T+ 5 cum | 0.1833 | 0.1549 | 0.1378 | 0.1264 | 0.1148 | 0.1057 |
| 5 | RD Mech 85T+ 10 cum | 0.3242 | 0.2726 | 0.2417 | 0.2213 | 0.2004 | 0.1844 |
| 6 | RD Mech 120T+ 10 cum | 0.5013 | 0.4288 | 0.3835 | 0.3524 | 0.3214 | 0.2972 |
| 7 | RD Mech 170T+ 20 cum | 0.7584 | 0.6398 | 0.5671 | 0.5181 | 0.4696 | 0.4322 |