# CHAPTER 3

## TYPES OF CONSTRUCTION EQUIPMENTS AND PRODUCTIVITY

**By Ins. Abdi K.**



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# Construction Equipment

## Introduction

### Classification of Construction Equipment

- Generally equipment types can be classified into ***Productive*** and ***Support equipments***.
  1. ***Productive equipment*** are those units that alone or in combination lead to an end product which can be recognized as a unit for payment;
     - Include pavers, haulers, loaders, rollers etc.
  2. ***Support equipment*** are those equipments which are required for operations related to the placement of construction such as movement of personnel and materials, and activities that influence the placement of environment.
     - Include represented hoists, lighting sets, vibrators, scaffolds as typical support equipment's

## Classification of Construction Equipment

- the two major classifications of equipments largely based on the ***type of works*** involved are covered.

### I. Construction Equipment

- ***Earth works equipment:*** Bulldozers, Shovels, Clamshells and Draglines, Loaders, Graders, Scrappers, Rollers, Drills, Grouting pumps, Pile driving and Hammers.
- ***Hauling and Hoisting equipment -*** Tractors, Normal and Dump trucks, Scrapers, Hoists, Conveyors and Cranes.
- ***Compaction and stabilization equipment***- Compactors
- ***Foundation Equipment*** - Pile Driving Equipments
- ***Pumping Equipment*** - Pumps, Hoses, Pipes, and Compressors.
- ***Concreting equipment -*** Mixers, Vibrators
- ***Tunnelling equipment -*** TBM
- ***Drilling and blasting equipment***

# Construction Equipment

## Introduction

## Classification of Construction Equipment

### II. Construction Plants

- Aggregate production plants,
  - Crushers, Screens, Conveyors, and Feeders.
- Asphalt mixing plant and
  - Aggregate Batchers, Bitumen Emulsifier, and Mixers.
- Concrete Batching Plants and
  - Feeders, Mixers and Silos.





## Earth Work Equipment

- **Definition:** -Earth work ***is a process of moving soil or rock from one location to the other and processing it***, so that it meets construction requirements of location, elevation, density, moisture content, etc.
- ***Activity involved*** in this ***process*** included ***excavating, loading, hauling, placing (dumping and spreading, compacting, grading, and finishing.***

# Construction Equipment

## Earth Work Equipment

- Earth work includes:
  - Site preparation, excavation, loading, hauling
  - Embankment construction,
  - Backfilling, dredging,
  - Preparing base course,
  - Sub-base and sub-grade,
  - Compaction, road surfacing
- All the above works involve the use of a large number of highly efficient and versatile equipment.

## Earth Work Equipment

- Earth work equipments are broadly classified into ***earth moving, compaction, grading*** and ***hauling equipment***.

### *Earth Work*

- ***Definition***:- Earth work is a ***process of moving soil or rock from one location to the other and processing it***, so that it meets construction requirements of location, elevation, density, moisture content, etc.
- The ***proper selection*** of these equipment and the ***length of time*** they will have to be used are an essential part of the estimator's work.

# General Soil Characteristics

There are ***three principal conditions or states*** in which earth material may exist: **bank, loose, and compacted**. The meanings of these terms are as follows:

- ***Bank State -*** *This is the state when the material is in its natural state i.e. before* disturbance. Often referred to as ‘’in – place’’ or “in situ.’’

**Unit- Bank cubic meter [$Bm^3$]**

- ***Loose State -*** *This is the state after the material is excavated or disturbed.*

**Unit- Loose cubic meter [$Lm^3$]**

- ***Compacted State -*** *This is the state after the material is compacted.*

**Unit- Compact cubic meter [$Cm^3$]**

# Relationships between the three states

## Swell

- *A soil increases in volume when it is excavated because the soil grains are loosened during excavation and air fills* the ***void spaces created***. As a result, a unit volume of soil in the bank condition ***will occupy more than one unit volume*** after excavation. This phenomenon is called swell.

$$\text{Swell (\%)} = \left( \frac{{}^{weight}/_{bank\ volume}}{{}^{weight}/_{loose\ volune}} - 1 \right) x\ 100$$

**Problem Example**

*1)Find the swell of a soil that weighs 2800 lb/cu yd (1661 kg/m$^3$) in its natural state and 2000 lb/cu yd (1186 kg/m$^3$) after excavation?*

# Cont....

***Solution:***

$$Swell = \left( \frac{2800}{2000} - 1 \right) x\ 100 = 40\%$$

**or**

$$Swell = \left( \frac{1661}{1186} - 1 \right) x\ 100 = 40\%$$

***That is, 1 bank of cubic yard (meter) of material will expand to 1.4 loose cubic yards (meters) after excavation.***

# Cont....

## Shrinkage

***When a soil is compacted, some of the air is forced out of the soil's void spaces.*** As a result, ***the soil will occupy less volume that it did under either the bank or loose conditions***. This phenomenon, which is the reverse of the swell phenomenon, is called shrinkage. The value of shrinkage can be determined as follows:

$$\text{Shrinkage (\%)} = \left(1 - \frac{weight/_{bank\ volume}}{weight/_{compacted\ volune}}\right) x\ 100$$

## Problem Example

*1)Find the shrinkage of a soil that weighs 2800 lg/cu yd. (1661 kg/m$^3$) in its natural state and 3,500 lb./cu yd. (2077 kg/m$^3$) after compaction?*

# Cont....

***Solution:***

$$\boldsymbol{Shrinkage = \left(1 - \frac{2800}{3500}\right) x\ 100 = 20\%}$$

**Or**

$$\boldsymbol{Shrinkage = \left(1 - \frac{1661}{2077}\right) x\ 100 = 20\%}$$

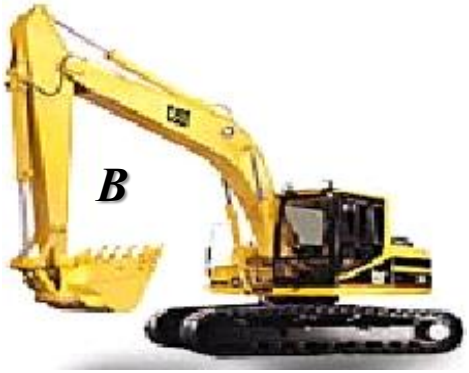
***Hence 1 bank cubic yard (meter) of material will shrink to 0.80 compacted cubic yard (meter) as a result of compaction***

# Construction Equipment and Productivity

## Earth Work Equipment



- Excavators
- Loaders
- Shovels
- Clamshells
- Draglines
- Scrapers
- Dumpers
- Dozers
- Graders
- Rollers



B

A



C



D

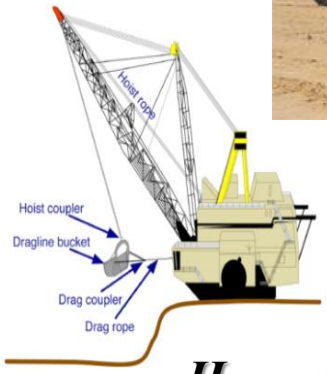


E



Animation Factory
MEMBERS ONLY

F




H



G




I




J

# Construction Equipment

## Earth Work Equipment

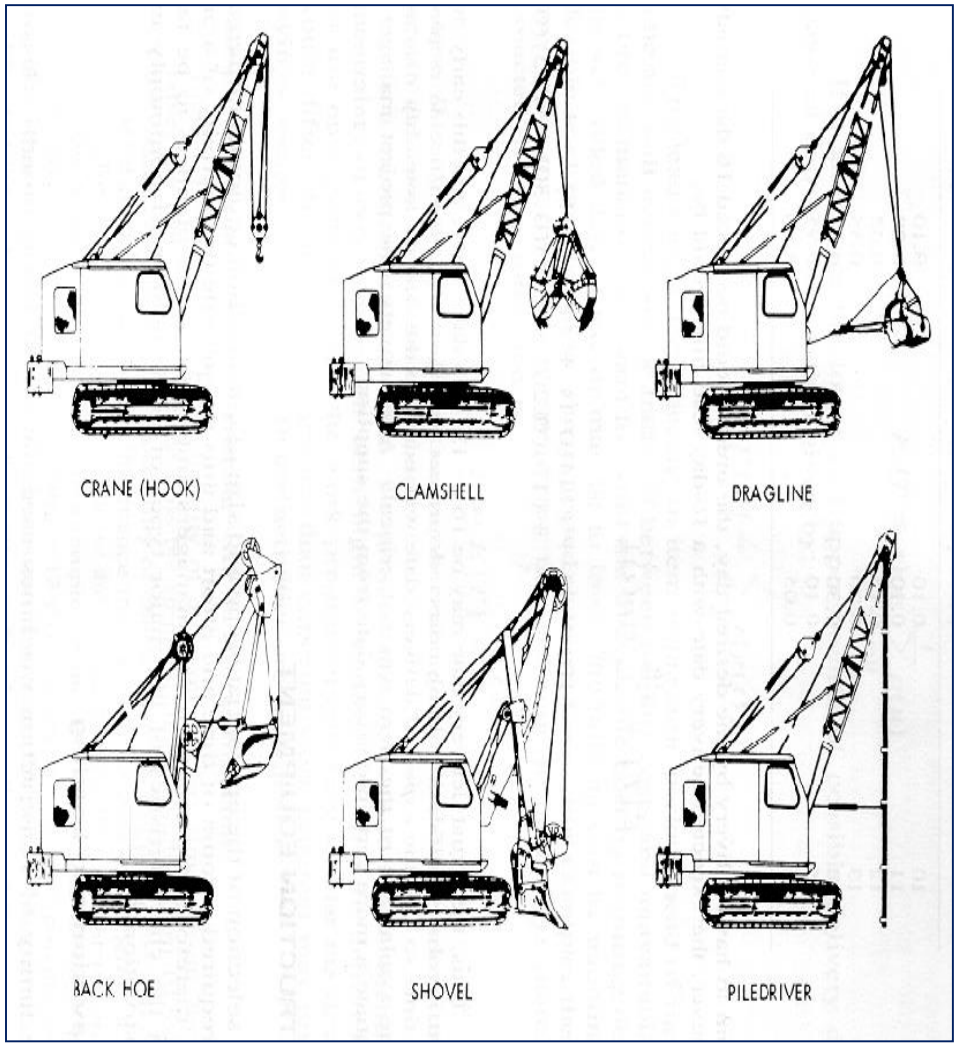
| Kinds of Work | Equipments |
|---|---|
| Clearing | Bulldozer, Rakedozer, Backhoe, Chipper |
| Excavating | Shovel (Backhoe, Dragline, Clamshell)<br>Bulldozer, Ripper, Rock breaker |
| Loading | Wheel Loader, Track Loader<br>Loading shovel (Front shovel) |
| Excavating / Loading | Power shovel (Backhoe, Dragline, Clamshell)<br>BWE(Bucket Wheel Excavator) |
| Excavating / Hauling | Bulldozer, Scrapedozer, Scraper |
| Hauling | Dump truck ( Rigid, Articulated), Wagon, Conveyer<br>Clowler dump |
| Spreading / Grading | Bulldozer, Wheel dozer, Motor grader |
| Compacting. | Tire roller, Steel roller, Vibration roller, Tamping roller, Vibration compactor, Tamper, Bulldozer |
| Trenching | Trencher, Backhoe |
| Maintaining macadam road | Motor grader |
| Slant finishing | Backhoe, Motor grader |
| Rock Braking | Drill, Breaker, Spliter |

# Construction Equipment

## Earth Work Equipment

### *Crane Shovel Family*

- Common Features
- ***Mounting***
  - Crawlers/Tracks
  - Wheels
  - Tracks
- ***Superstructure or control room***
- ***Front end attachment***



# Construction Equipment



## Earth Work Equipment

## Crane Shovel Family

## A. Face Shovel

- Face shovel is an equipment used mainly in quarries, pits and on construction sites to excavate and load blasted rock.
- These equipments are more effective for excavations above the ***wheel or grade level.***
- The basic parts of a power shovel include the mounting, cab, boom, dipper stick, dipper (bucket), and hoist line.
- ***Optimum depth of cut***: is that depth which produces the greatest output and at which the dipper comes up with full load without undue crowding.
  - The depth varies with the class of soil and the size of the dipper.

# Construction Equipment

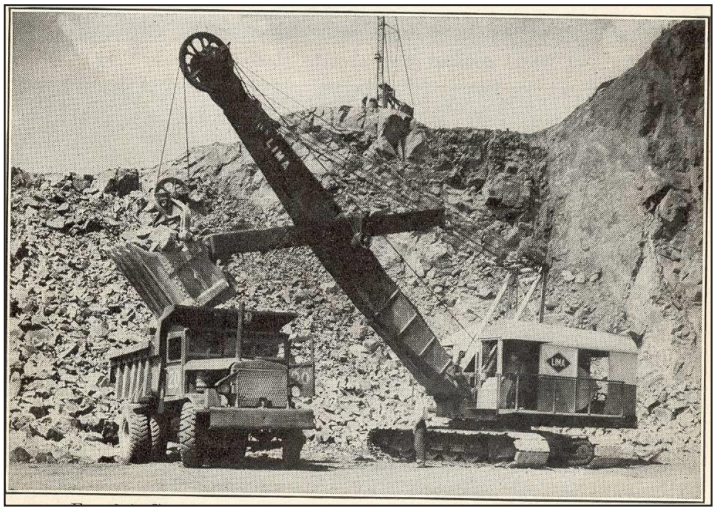


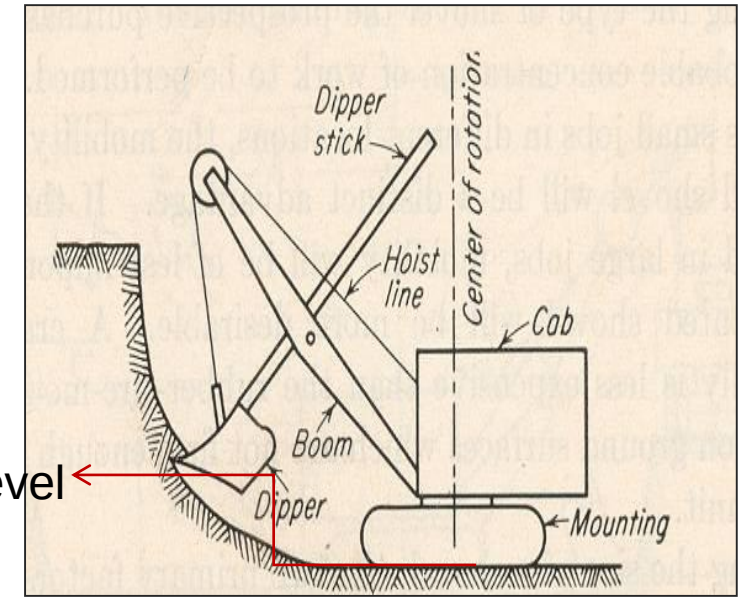
## Earth Work Equipment

## Crane Shovel Family

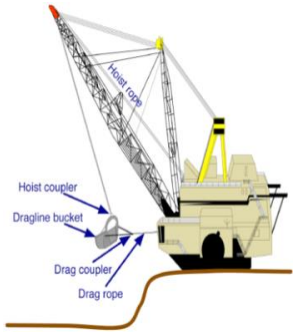
## A. Face Shovel

- The output of a shovel is affected by numerous factors, including the following:
  - Class of material,
  - depth of cut,
  - angle of swing,
  - job conditions,
  - management conditions,
  - size of hauling units,
  - skill of operator and
  - physical condition of the shovel.





# Construction Equipment




## Earth Work Equipment

### Crane Shovel Family

### B. Drag Line

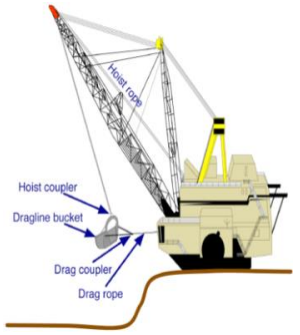
- Draglines are used to excavate earth and load it into hauling units, such as trucks or tractors-pulled wagons, or deposit it into levees, dams and spoil banks near the pits from which it was excavated.
- These equipment are more efficient for excavation below the grade level and have the longest reach of all shovel equipment.
- A dragline can be used for dragging out sediments and is efficient for under water construction.
- These equipment are weak while excavating hard materials and have a lesser productivity than a face shovels.

# Construction Equipment

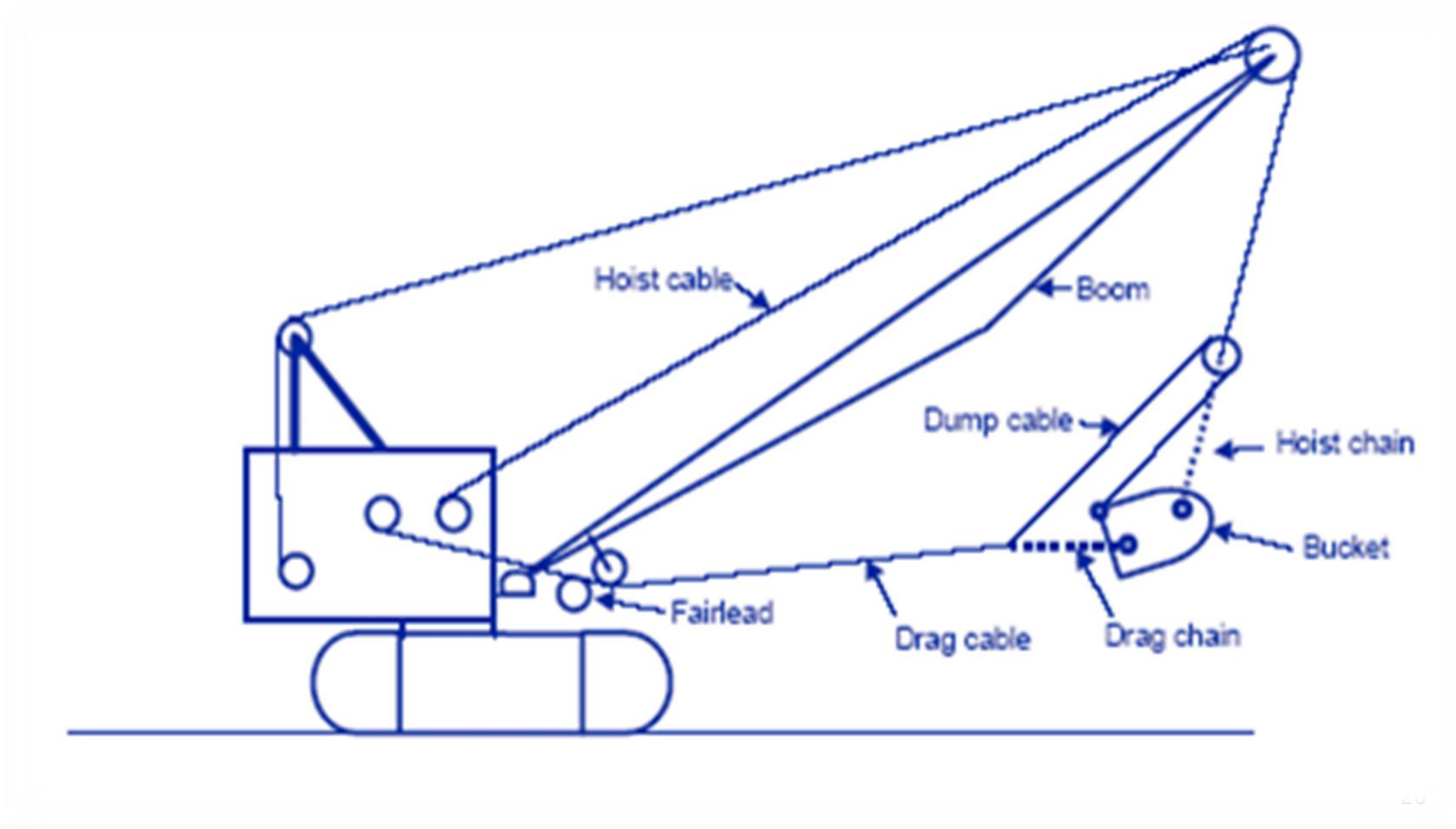
## Earth Work Equipment

## Crane Shovel Family

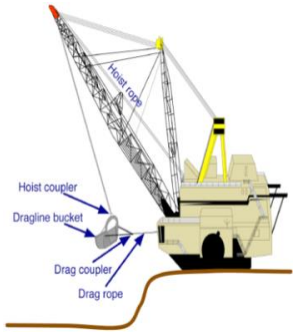
## B. Drag Line




- Basic Components of a drag line



# Construction Equipment




## Earth Work Equipment

## Crane Shovel Family

## B. Drag Line

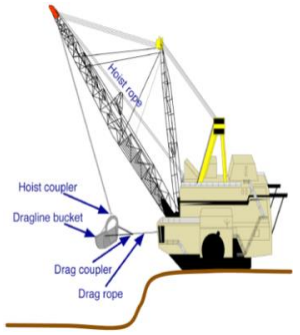
- ***Types of Drag Lines***: Drag lines may be divided into three types:
  - Crawler-mounted
  - Wheel-mounted, self-propelled
  - Truck-mounted
- ***Crawler-mounted draglines*** *can operate* over soft ground conditions that would not support wheel or truck - mounted equipment.
  - The travel speed of a crawler machine is very slow, frequently less than 1 mph,
  - It is necessary to use auxiliary, hauling equipment to transport the unit from one job to another.
- ***Wheel and track-mounted*** units may have travel speeds in excess of 30 mph.

# Construction Equipment

## Earth Work Equipment

## Crane Shovel Family

## B. Drag Line




### *Size of a Drag Line*

- The size of a dragline is indicated by the size of the bucket, expressed in cubic meter (cu m).
- Most draglines may handle more than one size bucket, depending on the length of the boom utilized and the class and weight of the material excavated.
- Since the maximum lifting capacity of a dragline is limited by the force which will tilt the machine over, it is necessary to reduce the size of the bucket when a long boom is used or when the excavated material has a high unit weight.
- In practice, the combined weight of the bucket and its load should not be greater than 75% of the force required to tilt the machine.

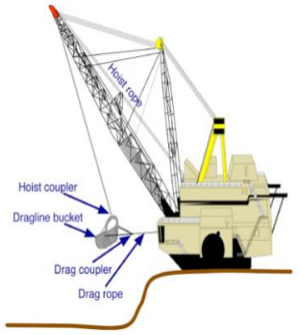
# Construction Equipment

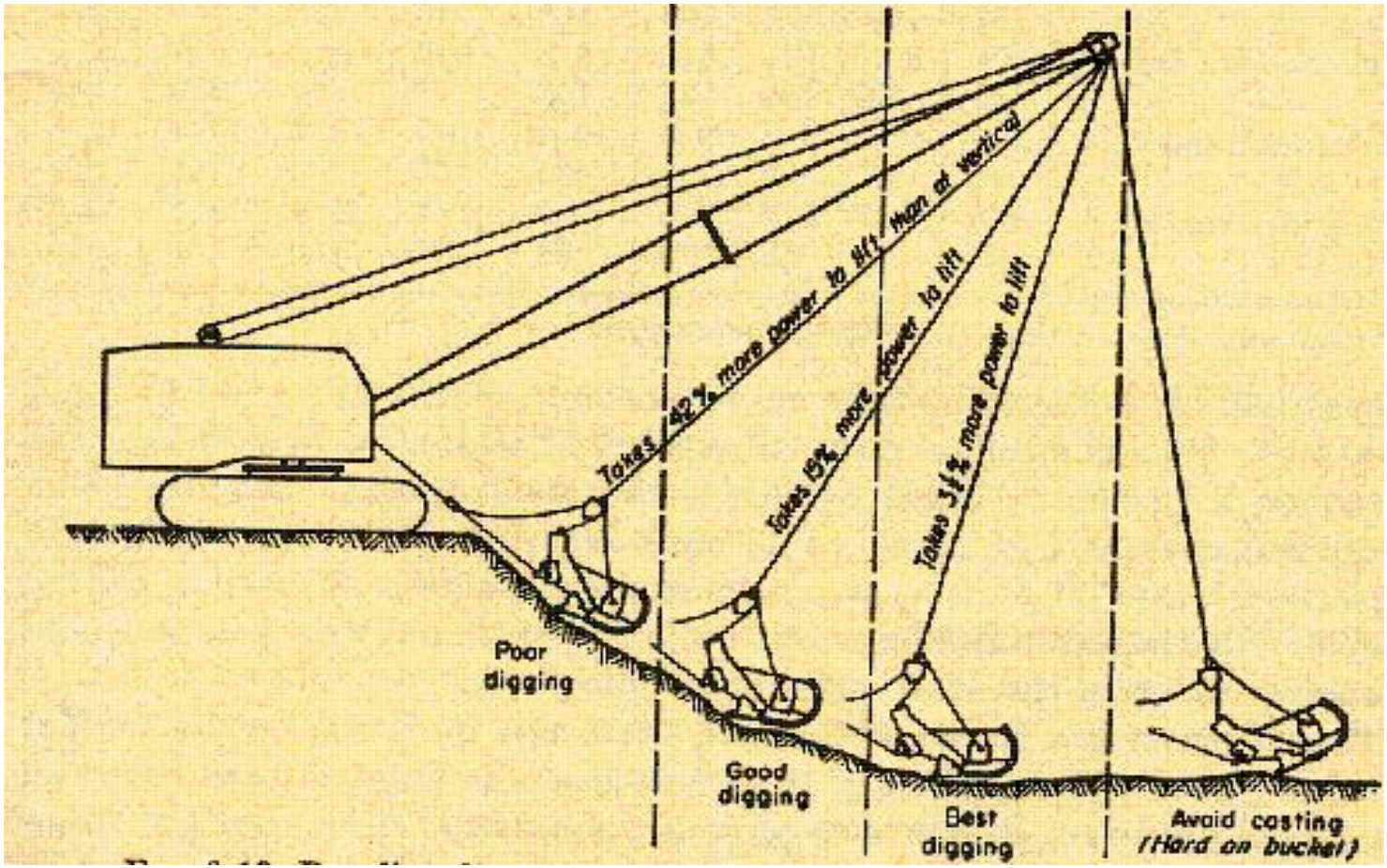
## Earth Work Equipment

## Crane Shovel Family

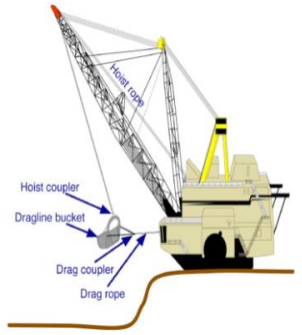
## B. Drag Line

### *Operation of a Drag Line*



# Construction Equipment




## Earth Work Equipment

## Crane Shovel Family

## B. Drag Line

### *Output of drug lines*

- The output of drag lines will vary with the following factors
  - Class of material
  - Depth of cut
  - Angle of swing
  - Size and type of bucket
  - Length of boom
  - Method of disposal, casting, or loading
  - Size of the hauling units, when used
  - Skill of the operator
  - Physical condition of the machine
  - Job conditions



# Construction Equipment



## Earth Work Equipment

## Crane Shovel Family

## C. Clamshells

- Clamshells are used primarily for ***handling loose materials*** such as sand, gravel, crushed stone, coal, etc. and for removing materials from inside cofferdams, pier foundations, sewer manholes, sheet-lined trenches, etc.
- They are specially suited to ***vertically lifting materials*** from one location to another, as in charging hoppers and overhead bins.
- The limits of vertical movements may be relatively large when they are used with long crane booms.
- Clamshell buckets are available in various sizes, and in ***heavy-duty types*** for digging, ***medium-weight types*** for general-purpose work and ***lightweight types*** for rehandling light materials.
-

# Construction Equipment



## Earth Work Equipment

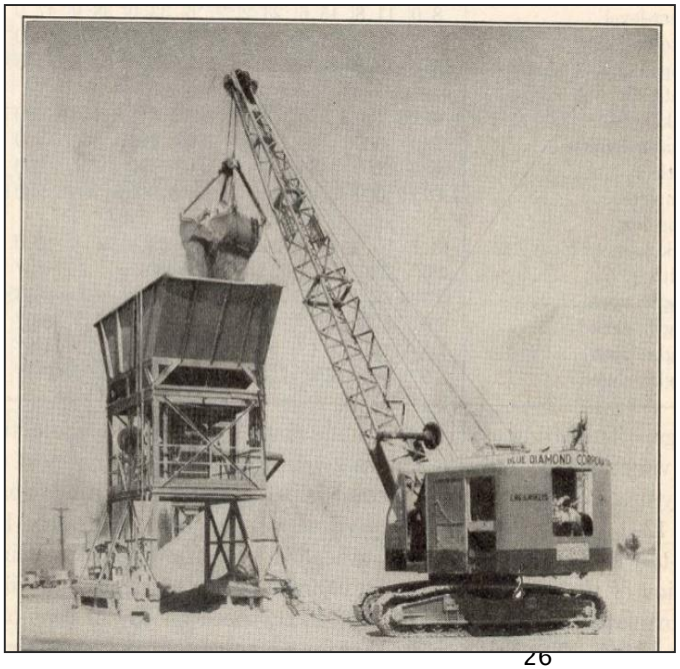
## Crane Shovel Family

## C. Clamshells

- Manufacturers supply buckets either ***with removable teeth*** or ***without teeth***.
- Teeth are used in digging the harder types of materials but are not required when a bucket is used for re-handling purposes.







# Construction Equipment



## Earth Work Equipment

## Crane Shovel Family

## C. Clamshells

- The capacity of a clamshell bucket is usually given in cubic meter.
- The variable factors affecting operations include:
  - The difficulty of loading the bucket,
  - The size load obtainable,
  - The height of lift,
  - The angle of swing,
  - The method of disposing of the load, and
  - The experience of the operator.

# Construction Equipment

## Earth Work Equipment

## Crane Shovel Family

## D. Hoes

- Hoes are used primarily to excavate below the natural surface of the ground on which the machine rests.
- hoe is sometimes referred to by other names, such as ***backhoe*** or ***back shovel***.
- They are adapted to excavating trenches, pits for basements, and general grading work, which requires precise control of depths.
- Because of their rigidity they are superior to draglines in operating on close-range work and dumping into trucks.
- Because of the direct pull on the bucket, backhoes may exert greater tooth pressures than face shovels.
- In storm drain and utility work the hoe can perform the trench excavation and handle the pipe, eliminating a second machine.

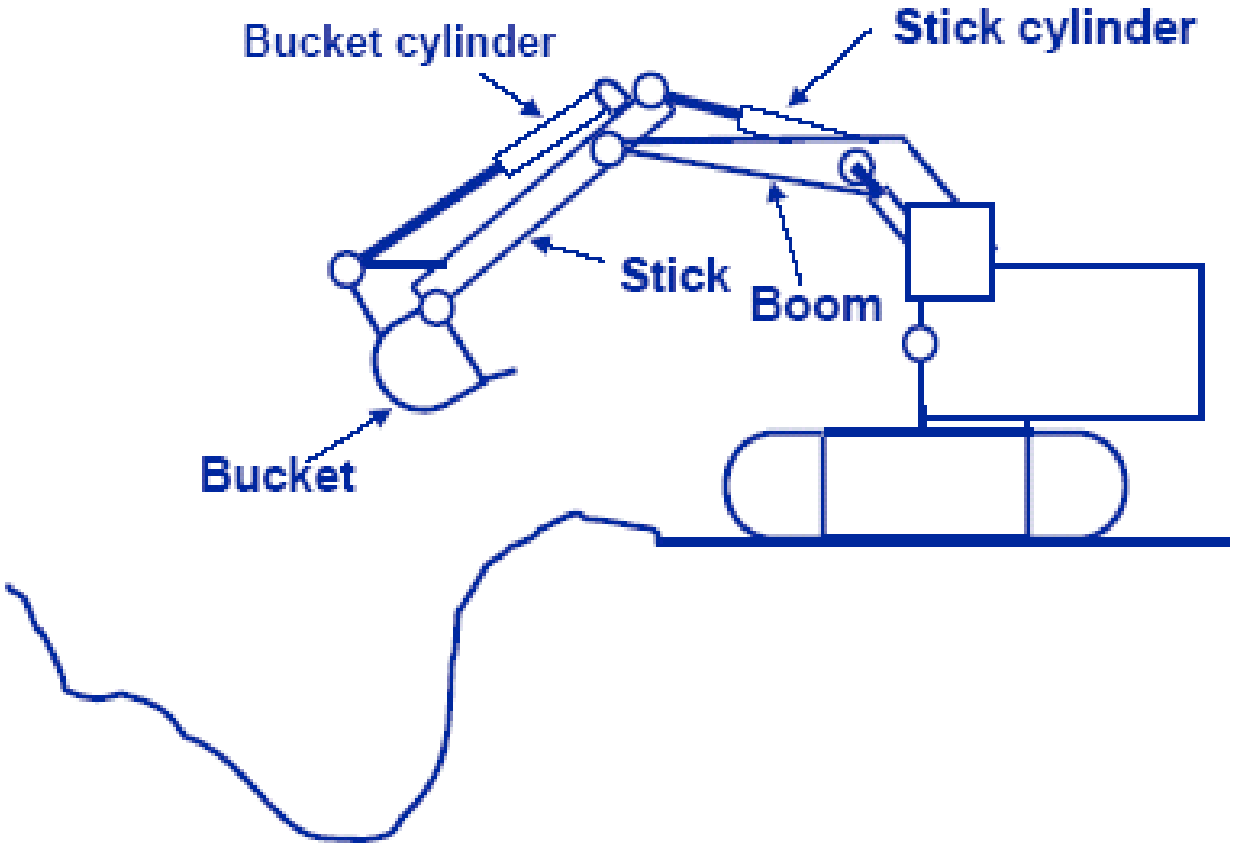
# Construction Equipment

## Earth Work Equipment

## Crane Shovel Family

## D. Hoes

***Basic component of backhoes***



# Construction Equipment

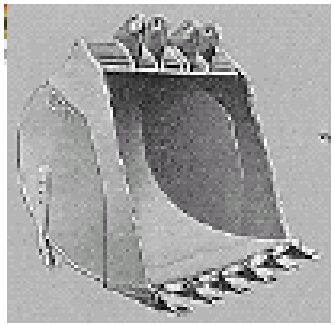
## Earth Work Equipment

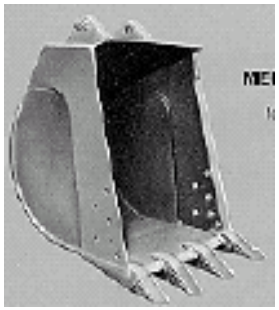
## Crane Shovel Family

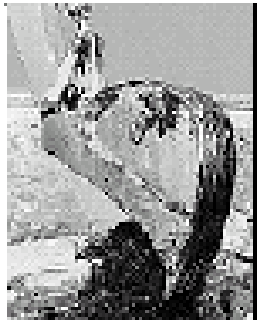
## D. Hoes

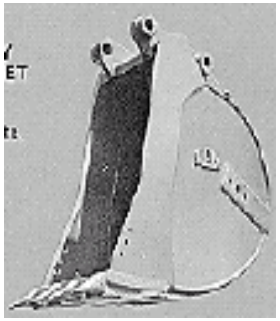
### *Hoe Buckets*

- There are special buckets for everything from light sand to hard rock digging.

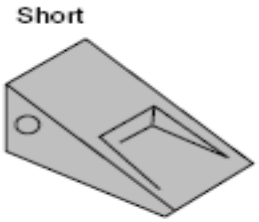


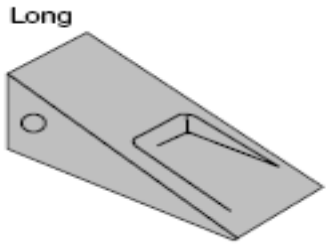


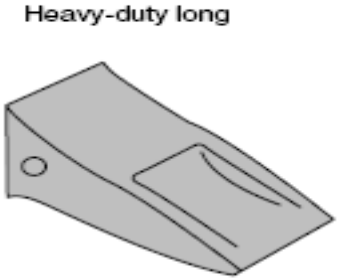


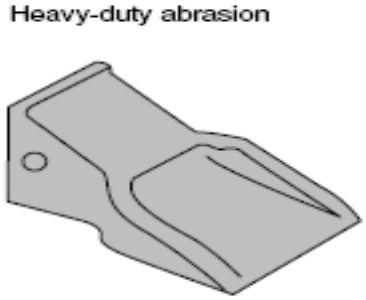


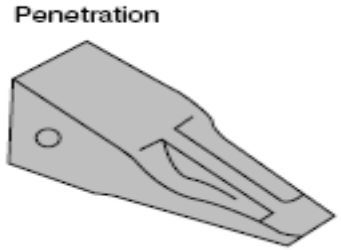
Bucket option




Teeth option

# Construction Equipment

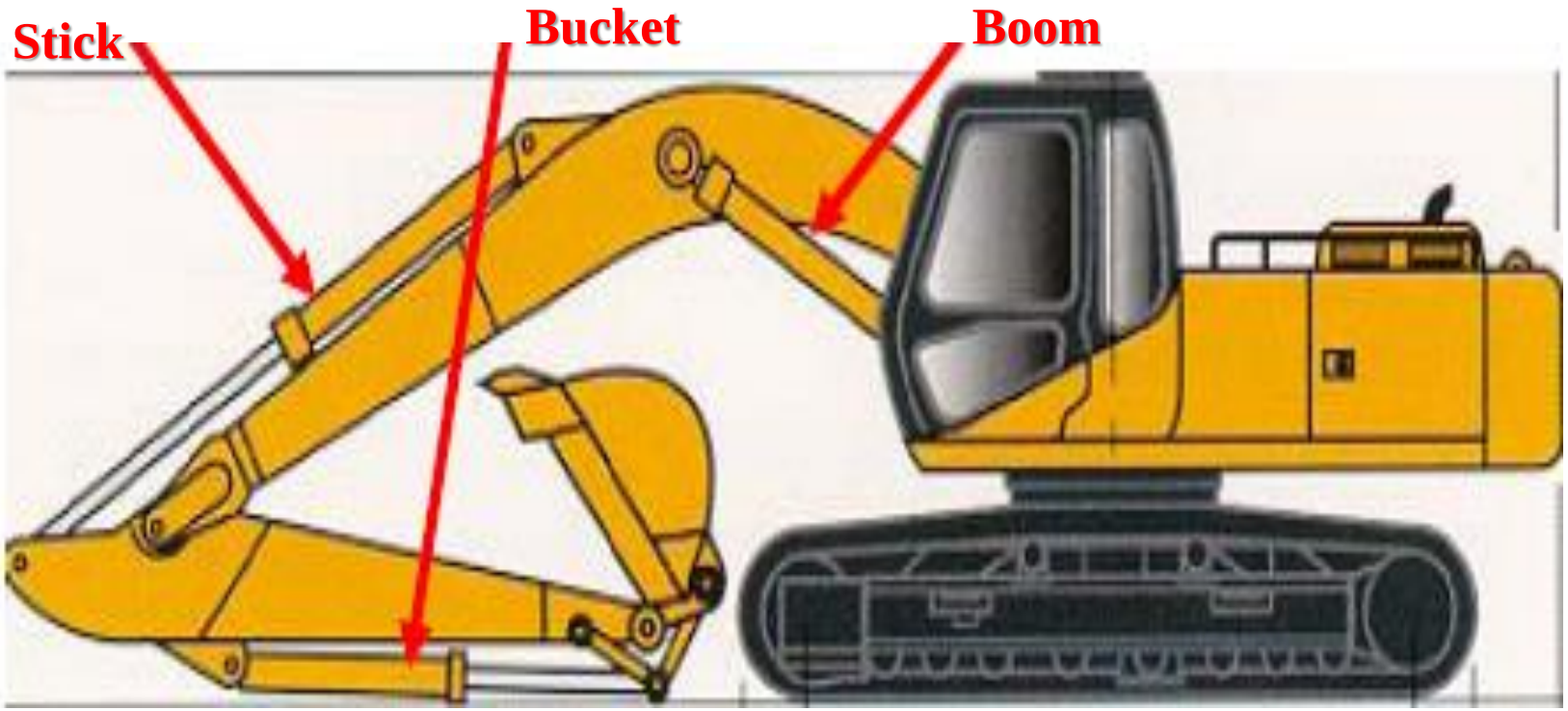
## Earth Work Equipment

## Crane Shovel Family

## D. Hoes

### *Hydraulic Hoes*

- Bucket penetration (break out force) is developed by the ***hydraulic cylinders*** of the ***boom***, ***stick*** and ***bucket***.



# Construction Equipment



## Earth Work Equipment

## Crane Shovel Family

## D. Hoes

### *Hydraulic Hoe Types*

- The hoe can be track or wheel mounted





# Construction Equipment



## Earth Work Equipment

## Crane Shovel Family

## D. Hoes





# Construction Equipment

## Earth Work Equipment

## Crane Shovel Family

## Comparison between the shovel family

Comparison between the shovel family members:

| No. | Parameters of comparison | Face shovel | Dragline | Backhoe | Clamshell |
|---|---|---|---|---|---|
| 1 | Operation in hard soil or rock | Good | Poor | Good | Good |
| 2 | Reach distance b/n machinery and digging point | Small | Longest | Small | Long |
| 3 | Loading efficiency on vehicles | Very good | Fair | Fair | Precise but slow |
| 4 | Digging Level | Mainly above grade level | Below its grade level | Below its grade level | At, above or below grade level |

# Construction Equipment



## Earth Work Equipment

## Heavy Earth moving Equipment

### A. Excavators

- Replaced the cable operated crane shove family
- Excavators are basically digging machines, having the following three main components
  - An ***undercarriage*** to give mobility. This may be crawler track mounted or wheel mounted.
  - A ***superstructure*** with operator's cabin mounted on either a slew ring to traverse through 360° or on a rigid frame.
  - Hydraulically articulated ***boom*** and ***dipper arms with bucket***.
- Excavators are designed to excavate below the ground surface on which the machine rests.
- Good mobility and versatility and excellent for general-purpose work, such as excavating trenches and pits.

# Construction Equipment



## Heavy Earth moving Equipment

## A. Excavators

### *Basic Parts of Excavator*

**Arm**
This part functions same as our lower arm; from the elbow to the wrist.

**Boom**
This part functions like our upper arm; from the shoulder to the elbow.

**The important devices to make the machine move are stored here. They include fuel, oil, an engine, a motor, and other things.**




**Bucket**
This part can be replaced with a drill type, scissors type, or other types.

**Crawler**
The crawler makes it possible for the machine to literally "crawl". It has no problem moving on very rough roads.

# Construction Equipment



## Heavy Earth moving Equipment

### A. Excavators

- Functions of excavators:
  - Excavating – Earthworks
  - Loading Excavated Material
  - Scarification
  - Making of Drains
- Advantages of hydraulic excavators include:
  - Faster cycle time,
  - Higher bucket penetrating force,
  - More precise digging, and easier operator control.
  - Many attachments can be made to increase the versatility of the equipments.

# Construction Equipment



## Heavy Earth moving Equipment

## A. Excavators

### *Types of excavators*

- Excavators are of the following types based on the type of carriers on which they are mounted:
  - I. Crawler mounted excavator
  - II. Truck mounted excavator
  - III. Self propelled excavator
  - IV. Excavators mounted on barge or rail

### *I. Crawler mounted excavator:*

- These excavators are mounted on the crawler system and are very suitable for carrying out large works in rough terrain.

# Construction Equipment



## Heavy Earth moving Equipment

## A. Excavators

### *Types of excavators*

### *I. Crawler mounted excavators:*

- Crawler excavators have the following main characteristics;
  - Can be used for work on soft or wet grounds
  - Can be used on sharp rocks or other advers conditions
  - These can climb steep grades (even up to 4 percent)
  - Requires very less turning space
  - Have very less speed for travelling
  - Can be shifted from one site to another only on trailors



# Construction Equipment



## Heavy Earth moving Equipment

## A. Excavators

### *Types of excavators*

### *II. Truck mounted excavators:*

- These excavators are mounted on truck chassis and has the following main characteristics:
  - High road speed and mobility is the main advantage.
  - Lower stability over sides and hence require counter-weight or outriggers.
  - Require more operating space.
  - Tyres or outriggers give high ground pressure and hence it requires firm and smooth operating locations.
  - Have two engines and two cabs, separately for truck chassis and excavator.



# Heavy Earth moving Equipment

## A. Excavators

### *Types of excavators*

### *III. Self propelled excavators:*

- These excavators are self propelled and has rubber tyres. The main characteristics are:
  - Medium travel speed generally between 10-30 Km per hour.
  - Has one engine and one cab for control by one operator.

### *IV. Excavators on barge or rail:*

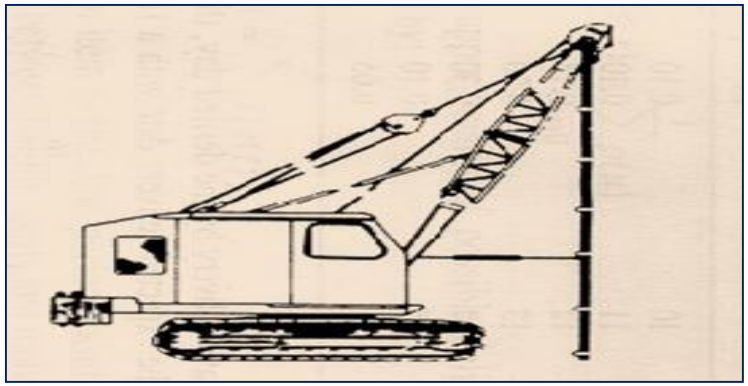
- These excavators are mounted on barge or rail to carry out work of excavation in water or near railway line respectively.

# Construction Equipment

## Heavy Earth moving Equipment

### A. Excavators

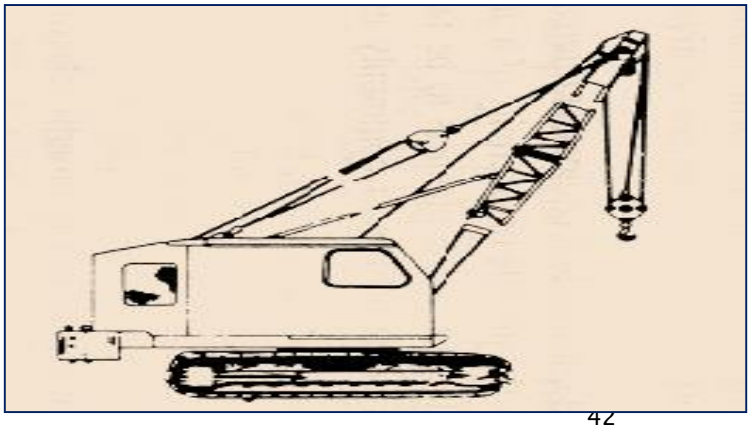
### *Common attachments*



❑ Some common attachments include:

- ***Augers***: Drills holes for poles, posts, soil sampling, and ground improvement
- ***Jack Hammer***: vibratory hammer used to break up concrete and rock.
- ***Bucket Ripper***: The bucket sides and bottom are lined with ripper teeth to break up hard soil or soft rock.
- ***Thumb Bucket***: attached to bucket to provide a hook capacity.





# Production Estimating

Production of hydraulic excavator can be estimated using the equation below and together with ***Tables 3–3 and Table 3–4*** which have been prepared from manufacturer's data.

$$\boldsymbol{Production\ (LCY/h) = C\ x\ S\ x\ V\ x\ B\ x\ E}$$

Where:

*C = cycles / h (Table 3-3)*

*S = swing -depth factor (Table 3-4)*

*V = heaped bucket volume (LCY or LCM)*

*B = bucket fill factor (Table 3-2)*

*E = job efficiency*

**Table 3–2 Bucket fill factors for excavators**

| Material | Bucket Fill Factor |
|---|---|
| Common earth, loam | 0.80—1.10 |
| Sand and gravel | 0.90—1.00 |
| Hard clay | 0.65—0.95 |
| Wet clay | 0.50—0.90 |
| Rock, well-blasted | 0.70—0.90 |
| Rock, poorly blasted | 0.40—0.70 |

**Table 3–3** Standard cycles per hour for hydraulic excavators

| | Machine Size | | | |
|---|---|---|---|---|
| Type of Material | *Wheel Tractor* | *Small Excavator: 1 yd (0.76 m³) or Less* | *Medium Excavator: 1¼–2¼ yd (0.84–1.72 m³)* | *Large Excavator: Over 2¼ yd (1.72 m³)* |
| Soft (sand, gravel, loam) | 170 | 250 | 200 | 150 |
| Average (common earth, soft clay) | 135 | 200 | 160 | 120 |
| Hard (tough clay, rock) | 110 | 160 | 130 | 100 |

**Table 3–4** Swing-depth factor for backhoes

| Depth of Cut (% of Maximum) | Angle of Swing (deg) | | | | | |
|---|---|---|---|---|---|---|
| | *45* | *60* | *75* | *90* | *120* | *180* |
| 30 | 1.33 | 1.26 | 1.21 | 1.15 | 1.08 | 0.95 |
| 50 | 1.28 | 1.21 | 1.16 | 1.10 | 1.03 | 0.91 |
| 70 | 1.16 | 1.10 | 1.05 | 1.00 | 0.94 | 0.83 |
| 90 | 1.04 | 1.00 | 0.95 | 0.90 | 0.85 | 0.75 |

# Example:

1. Find the expected production in loose cubic yards (LCM) per hour of a small hydraulic excavator. Heaped bucket capacity is 3 / 4 cu yd. (0.57 m3). The material is sand and gravel with a bucket fill factor of 0.90. Job efficiency is 50 min/hr. Average depth of cut is 14ft (4.3 m). Maximum depth of cut is 20ft (6.1 m) and average swing is 90?

# CONT…

**Given:**

Material = sand and gravel
Bucket volume ***(V)*** = 0.75 LCY (0.57 LCM)
Bucket fill factor ***(B)*** = 0.95
Job efficiency ***(E)*** = 50/60 = 0.833
Average depth of cut = 14ft (4.3 m)
Maximum depth of cut = 20ft (6.1 m)
Average swing = 90.

**Required:** expected production in loose cubic yards (LCY) & (LCM) per hour

**Solution:**

Cycle output ***(C)*** = 250 cycles/60 min (Table 3 – 3)
Swing-depth factor ***(S)*** = 1.00 (Table 3 – 4) *(14/20 = 70%)*

- $\boldsymbol{Production = C\ x\ S\ x\ V\ x\ B\ x\ E}$

**Production = 250 x 1.00 x 0.75 x 0.95 x 0.833 = 148 LCY/h**

**Production = 250 x 1.00 x 0.57 x 0.95 x 0.833 = 113 LCM/h**

# Construction Equipment



## Heavy Earth moving Equipment

### B. Loaders

- A bucket is attached to the arms and capable of being raised, lowered, and dumped through mechanical or hydraulic controls.
- The loaders having bucket in the front, known as "***front end loaders***" are very common.
- The loaders are versatile, self propelled equipment mounted either on crawler or wheel-type running gear.
- These are equipments used primarily:
  - To load excavated materials to a hauling unit,
  - Excavate soft to medium materials,
  - Loading hoppers,
  - Stockpiling materials,
  - Backfilling ditches, and
  - Moving concrete and other construction materials.

# Construction Equipment



## Heavy Earth moving Equipment

## B. Loaders

### *Basic Parts of a loader*

**Bucket**
Wheel loaders hold a lot of stuff on this part and load it on dump trucks. A bucket can be replaced with differently shaped equipment just like a hydraulic excavator.

This is where the driver's seat is. Some types have a roof only, and others have a room like this one.




**Tires**
There are a lot of different types of tires, depending on what kind of sites and surfaces they will be used.

# Construction Equipment



## Heavy Earth moving Equipment

## B. Loaders

### *Types of Loaders*

- Loaders are of the following two types:
  - Crawler loaders
  - Wheel Loaders



# Construction Equipment



## Heavy Earth moving Equipment

## B. Loaders

### *Types of Loaders*

### *I. Crawler loaders*

- Crawler track types are generally preferred for digging and loading jobs where ground conditions are poor and low pressure characteristics are required.
- They are preferable for applications involving rock and sharp stony ground as there is no possibility of tyre damage.
- These are best employed for short moves between loading and dumping points.
- They should be transported from one site to another after loading on the trailors.

# Construction Equipment



## Heavy Earth moving Equipment

## B. Loaders

### *Types of Loaders*

### *II. Wheel loaders*

- As a result of the development of more capable power trains (axel and tires), there was a steady trend towards wheel loaders at the expense of crawlers.
- Wheel loaders are generally ***four wheel drive***. However, for handling light jobs on good ground conditions ***two-wheel drive*** varients are also used.
- ***Four wheel drive loaders*** are generally used for ***construction jobs***, whereas, ***two wheel drive loaders*** are used for ***bulk handling*** of coal, cement, fertilizer etc.

# Construction Equipment



## Heavy Earth moving Equipment

## B. Loaders

### *II. Wheel loaders*

- From manoeuvrability point of view, wheel loaders are of
  - A. Articulated type (Pivot steer)
  - B. Rigid frame- two wheel steer or all wheel steer.

### *A. Articulated type of loaders*

- They are hinged in the middle of the front and rear axels.
- Due to their ***operational characteristics*** and capability of ***working in limited space*** and ***short turning radius***, resulting higher speed of work, they have become popular.
- The articulation permits the loader to pivot 30-45 degree either side of the center.

# Construction Equipment



## Heavy Earth moving Equipment

## B. Loaders

### *II. Wheel loaders*

### *A. Articulated type of loaders*

- Some advantage of articulated type of loaders are:
  - Quick manoeuvring and thereby easier spotting of loads
  - Less rolling resistance on turns
  - Better mobility on soft surface
  - Give better performance and high productivity.

### *B. Rigid frame type loaders*

- These are comparatively cheaper than articulated frame type of loaders.
- Manoeuvring back and forth before dumping is required in most cases.
- Rigid frame loaders are of two types, namely two wheel steer and all wheel steer.

# Construction Equipment

## Heavy Earth moving Equipment



## B. Loaders

### *II. Wheel loaders*

☐ Some models of wheel loaders are designed as a combination of a backhoe and loader and often called ***backhoe loader***.



# Construction Equipment



## Heavy Earth moving Equipment

## B. Loaders

### *Backhoe loader features*

- ❑Very common piece of equipment
- ❑Many subcontractors own/lease
- ❑Very versatile
- ❑Easily transported
- ❑"Low" maintenance costs
- ❑Operator "friendly"
- ❑Easily rented



# Construction Equipment



## Heavy Earth moving Equipment

## B. Loaders

### *Operations*

- Loaders are used to carry out the following main operations;

### *A. Loading*

- Loading operation is the main operation performed by the loaders.
- Loading consists of scooping, lifting, turning and dumping materials such as sand, gravel, and crushed materials from stockpiles, bank or construction site into the hauling units.

### *B. Hauling*

- Wheel loaders are excellent for moving loose materials over short distances to dump into hauling units, hoppers, conveyors, bins, or any other place of work in the construction site.

# Construction Equipment



## Heavy Earth moving Equipment

## B. Loaders

### *Operations*

### *C. Excavating*

- Crawler loaders and heavy duty wheel loaders are excellent for many excavation jobs.
- These loaders can excavate as well as lift the excavated material and dump it into trucks or on the stockpiles

### *D. Clearing*

- Loaders can scoop up and load the debris of demolished buildings into hauling units.
- Loaders are the first equipment to prepare the site for building and construction operations; and also the last equipment in order to backfill, spread, level and top with selected good soil.

# Construction Equipment



## Heavy Earth moving Equipment

## B. Loaders

### *Attachments*

- The following are main attachments which can be fitted to a wheel loader

***a) Back filling attachment***

- Back filling can be done with the bucket of this attachment when used with the loader.

***b) Forklift attachment***

- An industrial forklift when attached with the loader gives more stability, more tractive power and greater clearance than the normal.

***c) Sweeping attachment***

- A sweeping attachment can be fitted to a wheel loader for general cleaning of roads and parking areas in the industries.

# Construction Equipment



## Heavy Earth moving Equipment

## B. Loaders

### *Attachments*

- The following are main attachments which can be fitted to a wheel loader

### *d) Multi purpose bucket*

- A multi purpose or four-in-one bucket can be used as a dozer, scraper, clamshell and a general purpose loading.

### *e) Ripper-scarifier a attachment*

- These are mounted on the rear of the loader to loosen hard surfaces.

### *f) Miscellaneous other attachments*

- A large number of attachments for specialized jobs are also available for fitting to the loaders. Some of these are pipe laying attachments, pole handling attachments, boom for loader crane set up.

# Estimating Loader Production

- Loader production may be estimated as the product of average bucket load multiplied by cycles per hour. Basic cycle time for a loader includes the time required for loading, dumping, making four reversals of direction, and travelling a minimum distance (15ft or less for track loaders). Table 4 – 6 presents typical values of basic cycle time for wheel and track loaders. While manufacturers' performance curves should be used whenever possible, typical travel time curves for wheel loaders are presented in Figure 4 – 15.

$$\textbf{Production} = \textbf{bucket load volume } x \ \frac{\textbf{job efficiency}}{\textbf{cycle time}}$$

Where:

**Cycle time** = basic cycle time (table 4 – 6) + travel time (figure 4 – 15)

**Bucket load volume** = bucket load x bucket fill factor

**Table 4–6** Basic loader cycle time

| Loading Conditions | Basic Cycle Time (min) | |
|---|---|---|
| | *Articulated Wheel Loader* | *Track Loader* |
| Loose materials | 0.35 | 0.30 |
| Average material | 0.50 | 0.35 |
| Hard materials | 0.65 | 0.45 |

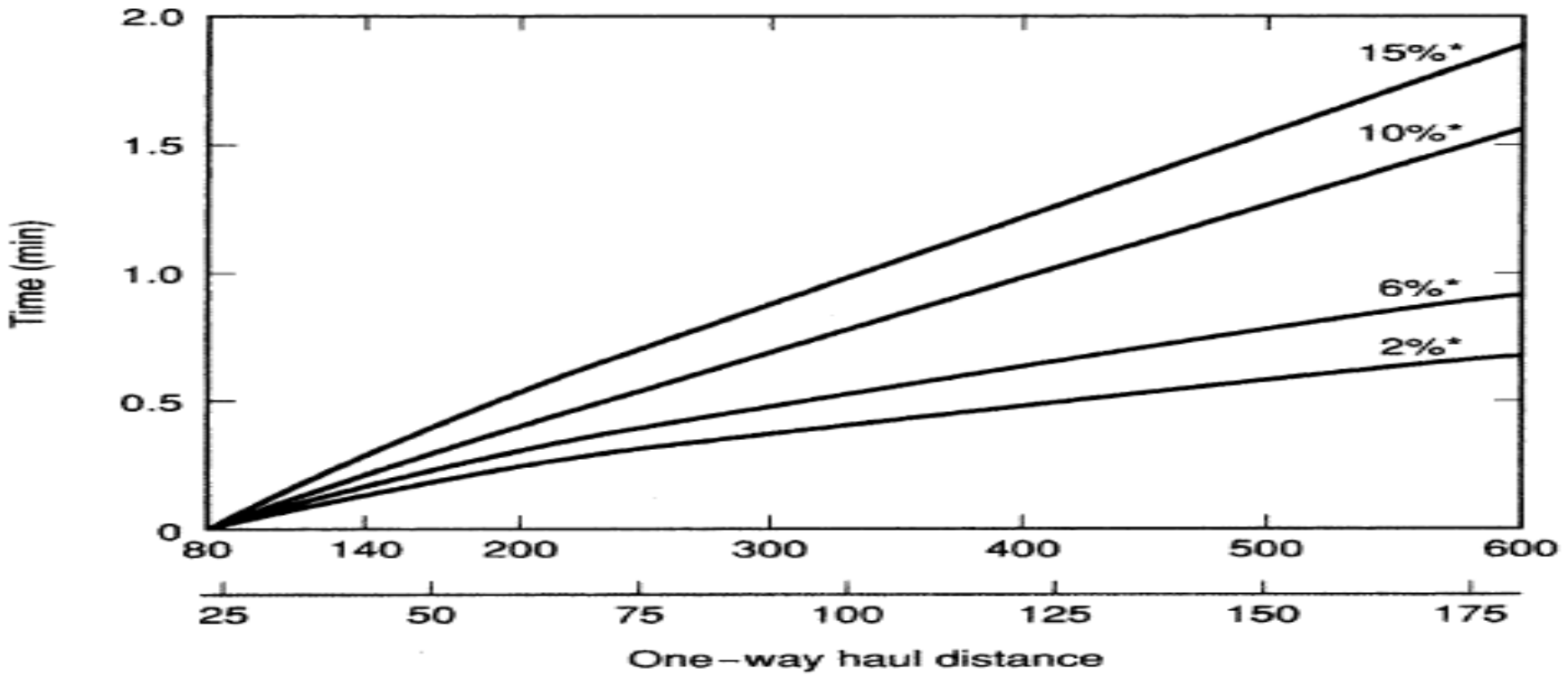



**Figure 4–15** Travel time, wheel loader (haul + return).

# EXAMPLE:

1. Estimate the hourly production in loose volume (LCY and LCM) of a 3 ½ -yd (2.68 $m^3$) wheel loader excavating sand and gravel (average material) from a pit and moving it to a stock file. The average haul distance is 200 ft (62 m), the effective grade is 6%, the bucket fill factor is 1.00, and job efficiency is 50 min/hr.

***Given:***

wheel loader

type of soil = sand and gravel (average material)

*Bucket load* = 3 ½ -yd (2.68 $m^3$)

Average haul distance = 200 ft (62 m)

Effective grade = 6%

Bucket fill factor = 1.00

***Job efficiency*** = 50 min/hr

***Required:*** *hourly production in loose volume (LCY and LCM)*

# Solution

**Bucket load volume** = bucket load x bucket fill factor

***Bucket load volume*** = 3.5 x 1.00 = 3.5 LCY (2.68 LCM)

Basic cycle time = 0.50 min ***(Table 4 – 6)***

Travel time = 0.30 ***(Figure 4 – 15)***

**Cycle time** = basic cycle time (table 4 – 6) + travel time

***Cycle time*** = 0.50 + 0.30 = 0.80 min

$$\boldsymbol{Production = bucket\ load\ volume\ x\ \frac{job\ efficiency}{cycle\ time}}$$

$$\boldsymbol{Production = 3.5\ \frac{50}{0.80} = 219\ LCY/h}$$

or

$$\boldsymbol{Production = 2.68\ \frac{50}{0.80} = 168\ LCM/h}$$

# Construction Equipment



## Heavy Earth moving Equipment

### C. Dozers

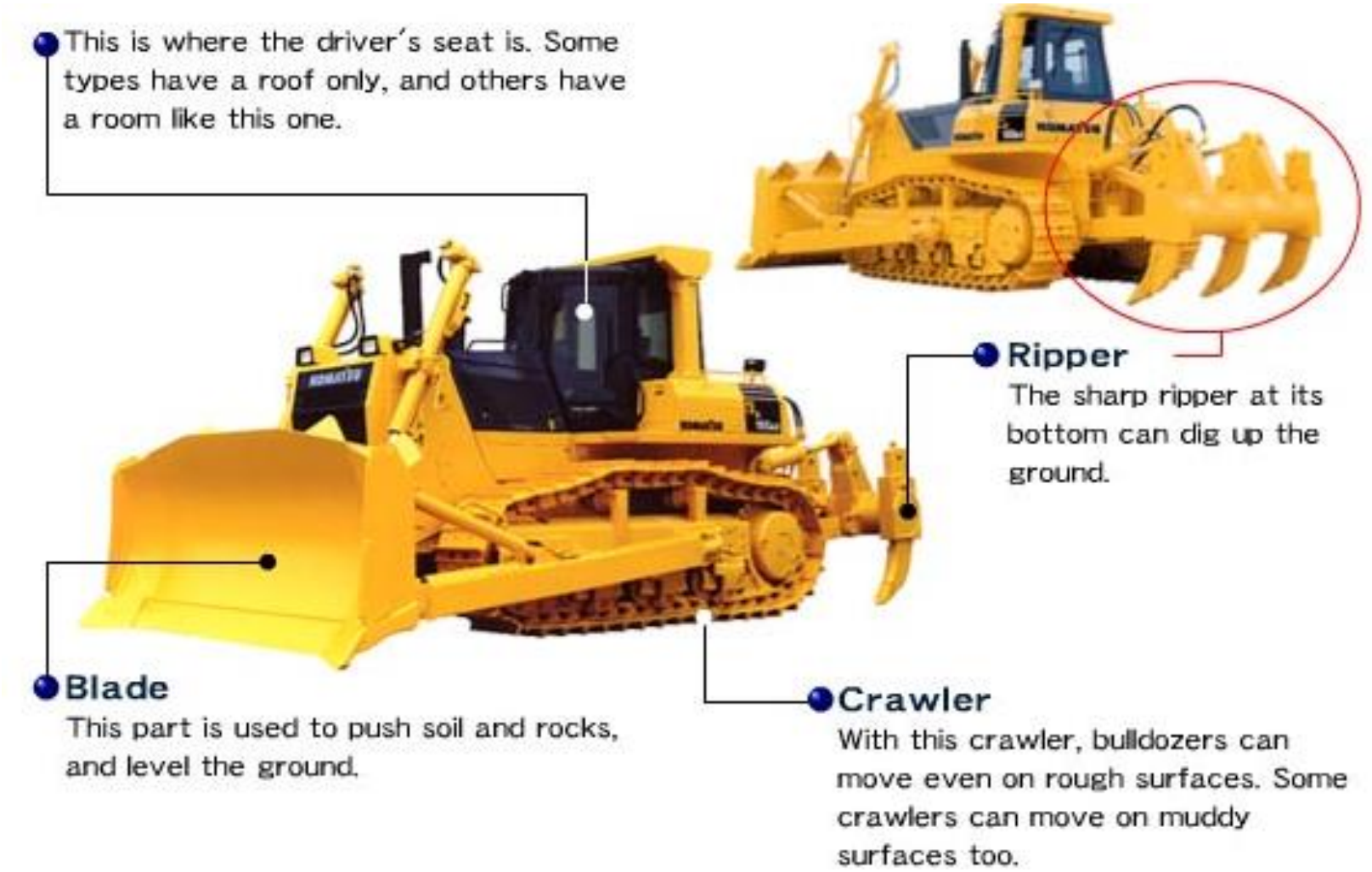
- Dozers are machines designed primarily for ***cutting*** and ***pushing*** the material over relatively short distance.
- They consist of a tractor equipped with a ***front–mounted earthmoving blade*** controlled by ***hydraulic cylinders*** to vary the depth of cut.
- A dozer moves earth by lowering the blade and cutting until a full blade load of materials is obtained. It then pushes the material across the ground surface to the required location.
- Rear mounted hydraulic ***scarifiers*** and ***rippers*** can be fitted to loosen hard material prior to dozing.

# Construction Equipment



## Heavy Earth moving Equipment

## C. Dozers



# CONT...

- The bulldozer is a versatile machine. It can be used for:-
  - moving earth over distances up to 100 m, clearing and grabbing sites.
  - stripping top unwanted soil,
  - Excavating to a shallow depth,
  - pushing scrapers,
  - spreading soil for leveling areas,
  - stripping bare soft rock, and maintaining roads.

# Construction Equipment



## Heavy Earth moving Equipment

## C. Dozers

### *Application of Dozers*

☐ The following are the main dozer application

- ***Clearing land*** of timber and stumps,
- ***Opening up pilot roads*** through mountains and rocky terrain,
- ***Moving earth*** for the haul distances up to approximately 100m,
- ***Helping load*** tractor-pulled scrapers,
- ***Spreading*** earth fills,
- ***Backfilling*** trenches,
- ***Side hill cuts***
- ***Clearing*** construction sites of derbies, and
- ***Maintaining*** haul roads.

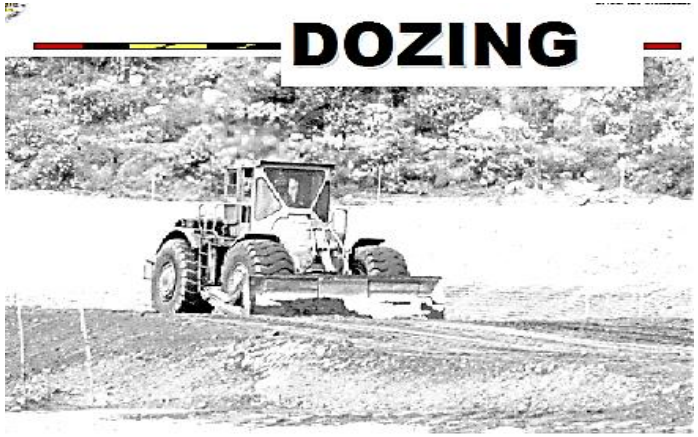
# Construction Equipment



## Heavy Earth moving Equipment

## C. Dozers

### *Application of Dozers*




Pushing material





*Moving earth*



*Helping scrappers*

# Construction Equipment



## Heavy Earth moving Equipment

## C. Dozers

### *Application of Dozers*



# Construction Equipment



## Heavy Earth moving Equipment

## C. Dozers

### *Dozer Blades*

- A heavy blade of ***slightly concave profile*** is attached in the front of the tractor.
- The blades has a ***replaceable cutting edge***, which wears out with the use of the blade.
- The dozer blades are available in sizes from ***2m to 7.5m wide*** and ***0.8m to 1.5m height***.
- Dozer blades are of the following types:

A. ***U-Blade***: Used for moving ***big loads*** over ***longer distances***; curved shape and side and top extensions reduce the spillage of loose material; best suited for ***lighter materials***.

# Construction Equipment



## Heavy Earth moving Equipment

## C. Dozers

### *Dozer Blades*

B. ***Straight Blade***: Used primarily for ***shallow surface removal***, land clearing; designed to push dirt for short distances, versatile, lightweight and maneuverable, handles a wide range of materials.

C. ***Angle Blade***: It is designed to move material towards the sides of a cut, backfilling or cutting ditches, and sustainably reduces the amount of maneuvering.

D. ***C (cushion Blade)***: Used primarily with scrapers for "on the go" push loading; can be used for lighter excavation and other general tasks.

E. ***Land fill Blade***: These blades are specially designed to handie refuse and/or fill material.

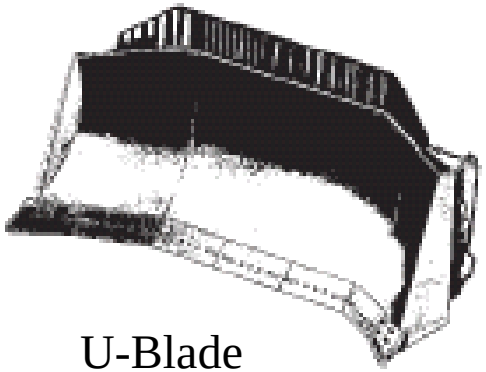
# Construction Equipment



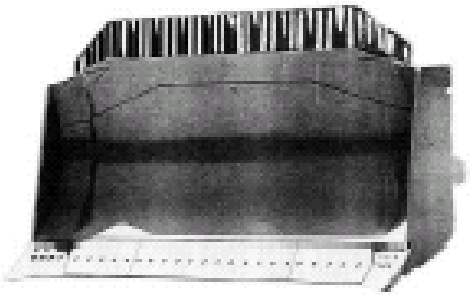
## Heavy Earth moving Equipment

## C. Dozers

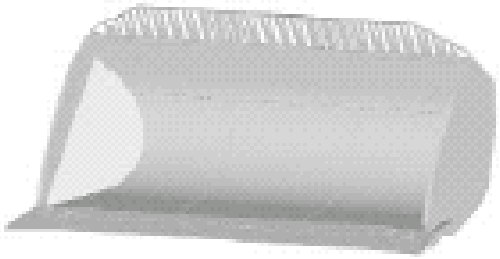
### *Dozer Blades*



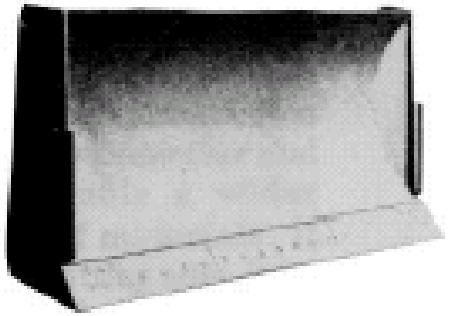
U-Blade



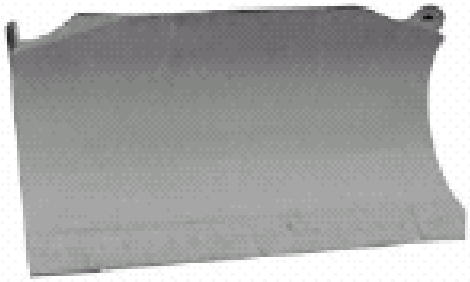
SU-Blade



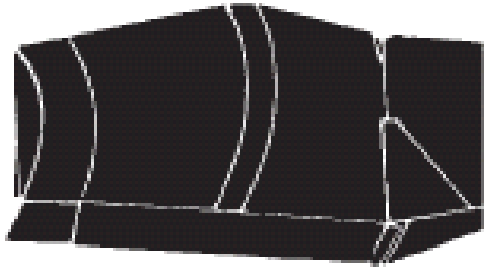
Carry Dozer “CD” Blade



Straight “S” Blade



Power Angle &
Tilt Blade



Variable Radius
“VR” Blade

# Construction Equipment



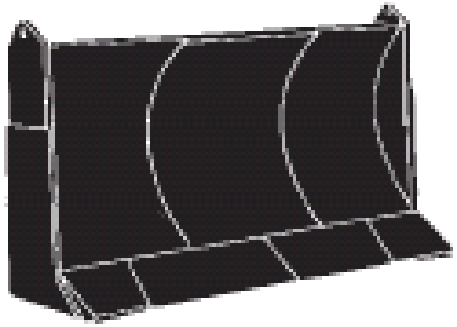
## Heavy Earth moving Equipment

## C. Dozers

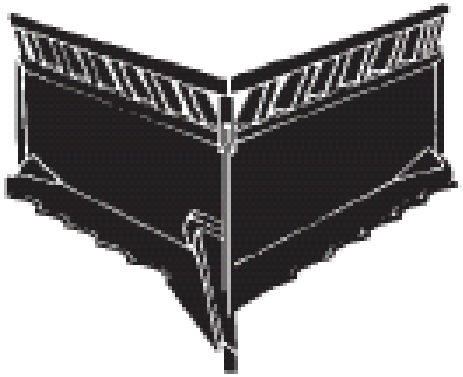
### *Dozer Blades*



Angle “A”-Blade



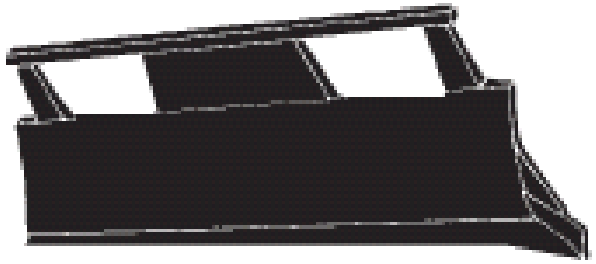
Cushion “C”-Blade



V-Tree cutter -Blade



Rakes



K/G -Blade

# Construction Equipment



## Heavy Earth moving Equipment

## C. Dozers

### *Blade adjustments*



**Tilting**



**Angle adjustment**

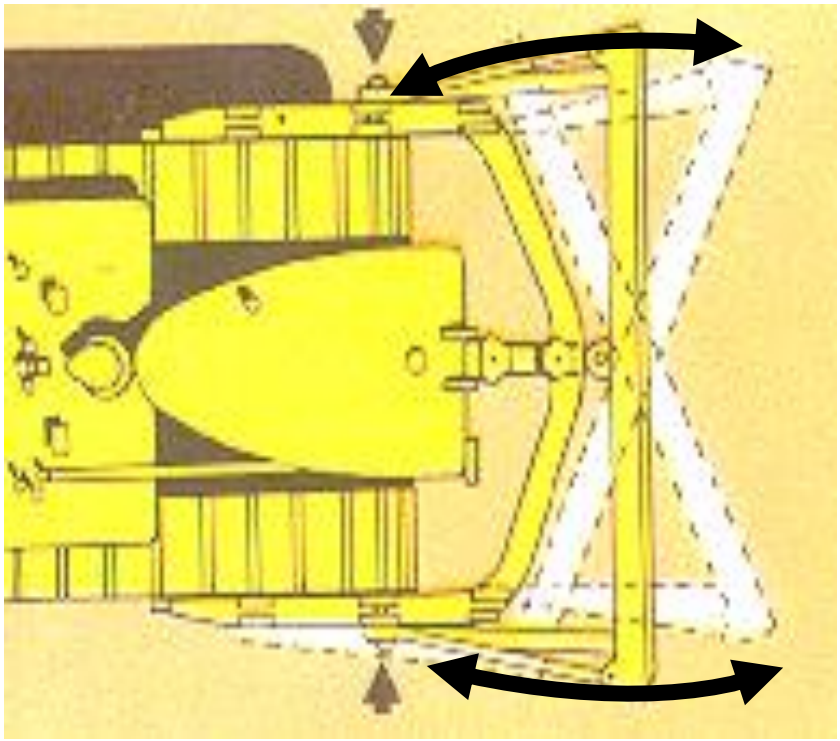
# Construction Equipment



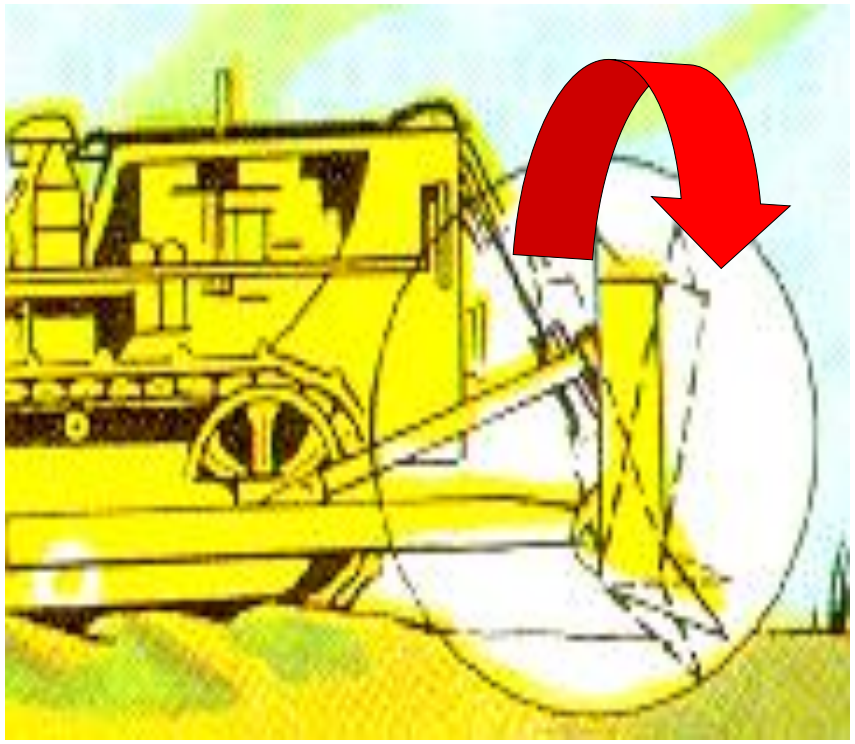
## Heavy Earth moving Equipment

## C. Dozers

### *Blade adjustments*



**Angle adjustment (Top View)**



**Pitch adjustment**



## Heavy Earth moving Equipment

### C. Dozers

***Dozer Blades and Material Evaluation***

- Besides job requirement, several other consideration determine choice of attachment.
- ***Moisture content***, ***particle size***, and ***number of voids*** are the more important characteristics influencing dozing performance.

a) ***Moisture content***: If the moisture content increases above the optimum, material becomes heavy and will thus have a ***negative effect on dozing performance***.

b) ***Particle size***: Large particles resist penetration more than smaller ones, requiring more dozing power.
   - Materials consisting of ***irregularly*** and ***sharp-edged*** particles are more difficult to doze than material composed of ***round-edged*** particles



## Heavy Earth moving Equipment

## C. Dozers

### *Dozer Blades and Material Evaluation*

c) ***Voids***: Relatively dense materials with few voids contain large numbers of individual particles in close contact with each other . Because of this more force is required to break up this tightly bonded material.



# Construction Equipment



## Heavy Earth moving Equipment

## C. Dozers

### *Rippers*

- Crawler-tractor, mounted with ripper is finding increasing use in construction, mining and quarrying.
- ***Characteristic of material*** to be ripped influence the selection of ***ripper type***; ***number of shanks*** required, ***ripping speed*** and ***amount of ripper penetration***.

### *Types of Rippers*

A. ***Fixed multiple-shank ripper***: used for comparatively simple ripping operations.

B. ***Variable multiple-shank ripper***: These are used where there are many boulders, or where the quality of rock is not consistent.

# Construction Equipment



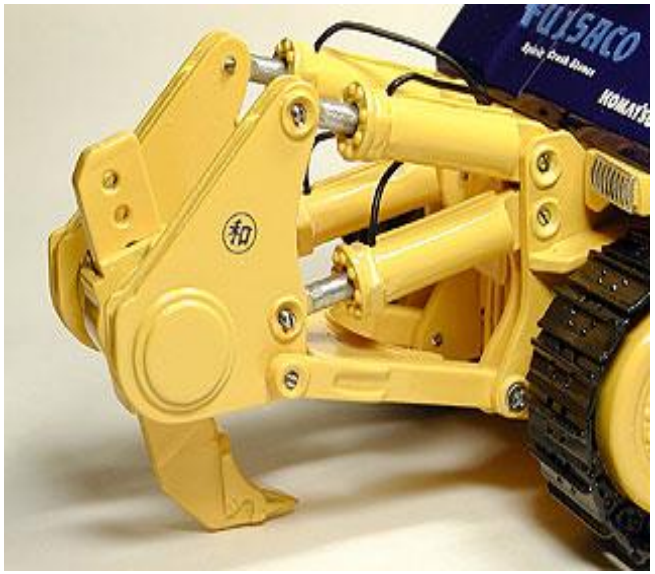
## Heavy Earth moving Equipment

## C. Dozers

### *Types of Rippers*

C. ***Fixed giant ripper***: has only one single powerful shank, but is not common as compared to variable giant rippers.

D. ***Variable giant ripper***: has a single powerful shank . The angle of this ripper can be changed according to the ground requirements.






# Construction Equipment

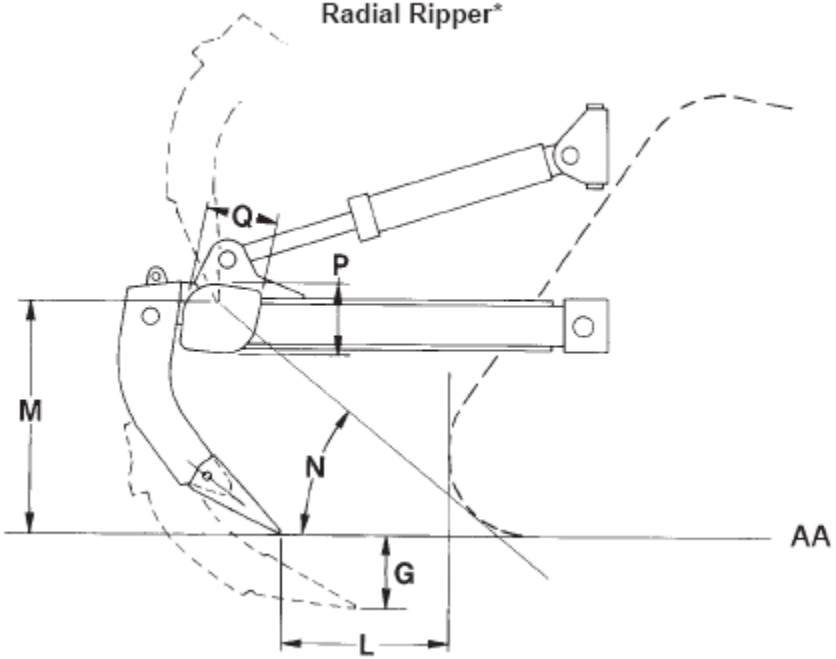


## Heavy Earth moving Equipment

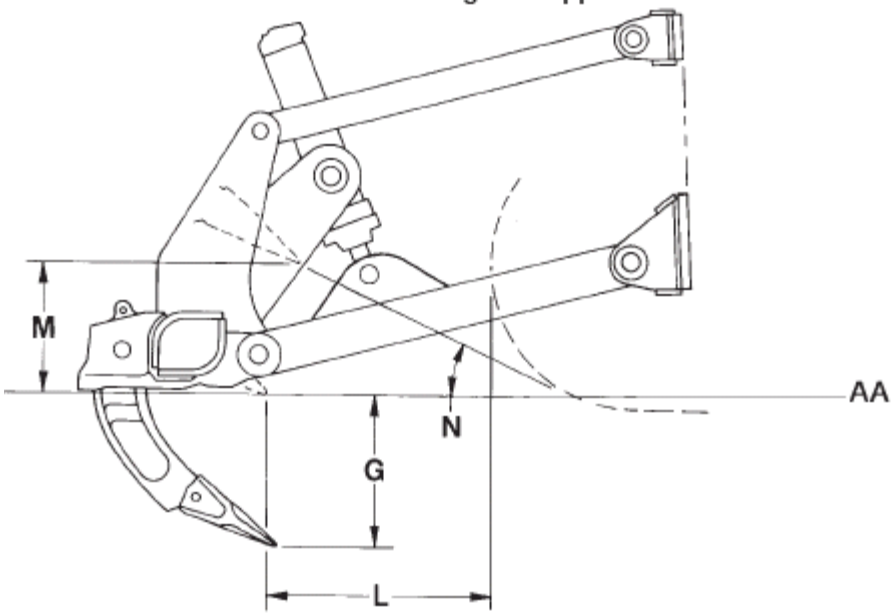
## C. Dozers

### *Types of Rippers*

Radial Ripper*




Fixed Parallelogram Ripper





## Heavy Earth moving Equipment

## C. Dozers

### *Ripping Efficiency*

- In order to achieve ***high ripping efficiency***, following suggestion should be considered.
  1) When material is not broken, loosen the surface in one direction, then cross-ripping should be adopted.
  2) If material is soft, use more than one shank ripper.
  3) Ripping should be done downhill.
  4) Avoid reversing when shank is in the ground.
  5) When both dozing and ripping operations are required to be done, it should rip going out and doze on the way in.
  6) For hard material, use shorter tips, and for ordinary work use longest and sharpest point.

# Construction Equipment



## Heavy Earth moving Equipment

### C. Dozers

***Crawler Vs Tyre Tractors***



***A. Crawler Mounted tractors***



***B. Wheel Mounted tractors***

# Construction Equipment



## Heavy Earth moving Equipment

## C. Dozers

### *Crawler Vs Tyre Tractors*

- Each type of tractor has certain advantages in certain conditions.
- ***Advantages of crawler mounted tractors:***

1) More tractive effort, hence can also operate on loose or muddy soil.
2) In absence of tyres, can easily operate in rocky conditions.
3) Where maintenance of haul roads is difficult, it can easily travel, especially in rough terrain.
4) Crawler tractors are more compact and powerful and hence can handle difficult jobs as well.
5) Greater floatation because of the lower pressure under the trucks.

# Construction Equipment



## Heavy Earth moving Equipment

## C. Dozers

### *Crawler Vs Tyre Tractors*

❑ ***Advantages of wheel mounted tractors***:

1) Can travel at higher speeds during operations and also from one job to the other.
2) Ease in operation. Operator feels less fatigue.
3) Can travel on paved roads without damaging them.
4) Can travel long distances at its own power, whereas crawler mounted needs trailors.
5) When work is spread over long area, these are found to be producing more output.
6) Operation, maintenance and repair costs are less in wheeled tractor as compared to crawler tractors.

# Estimating Dozer Production

- The basic earth moving production equation ( **Production = Volume per cycle x cycles per hour)** may be applied in estimating dozer production. This method requires an estimate of the average blade load and the dozer cycle time.
- There are several methods available for estimating average blade load, including the blade manufacturer's capacity rating, previous experience under similar conditions, and actual measurement of several typical loads.

# CONT...

- A suggested method for calculating blade volume by measuring blade load is as follows:
  - Doze a full blade load, then lift the blade while moving forward on a level surface until an even pile is formed.
  - Measure the width of the pile *(W)* perpendicular to the blade and in line with the inside of each track or wheel. Average the two measurements.
  - Measure the height *(H)* of the pile in a similar manner.
  - Measure the length (L) of the pile parallel to the blade.

## CONT...

- Calculate blade volume using the following equation:
  - **Blade load (LCY) = 0.0139 x H (ft.) x W (ft.) x L (ft.)**
  - **Blade load (LCM) = 0.375 x H (m) x W (m) x L (m)**

***Total dozer cycle time*** - is the sum of its fixed cycle time and variable cycle time.

***Total cycle Time = Fixed cycle time + Dozing time + return time***

***Fixed cycle time*** - represents the time required to maneuver, change gears, start loading, and *dump*.

$$\boldsymbol{Dozing\ time = \frac{distance}{dozing\ speed}}$$

$$\boldsymbol{Return\ time = \frac{distance}{reverse\ speed}}$$

$$\boldsymbol{Production = blade\ capacity\ x\ \frac{job\ efficiency}{total\ cycle\ time}}$$

## CONT...

*Variable cycle time* – is the time required to doze and return. Since the distance is relatively short, usually returns in reverse gear. Table 4-5 provides typical operating speeds for dozing and return. Some manufacturers provide dozer production estimating charts for their equipment

**Table 4–4** Typical dozer fixed cycle times

| Operating Conditions | Time (min) |
|---|---|
| Power-shift transmission | 0.05 |
| Direct-drive transmission | 0.10 |
| Hard digging | 0.15 |

**Table 4–5** Typical dozer operating speeds

| Operating Conditions | Speeds |
|---|---|
| Dozing | |
| Hard materials, haul 100 ft (30 m) or less | 1.5 mi/h (2.4 km/h) |
| Hard materials, haul over 100 ft (30 m) | 2.0 mi/h (3.2 km/h) |
| Loose materials, haul 100 ft (30 m) or less | 2.0 mi/h (3.2 km/h) |
| Loose materials, haul over 100 ft (30 m) | 2.5 mi/h (4.0 km/h) |
| Return | |
| 100 ft (30 m) or less | Maximum reverse speed in second range (power shift) or reverse speed in gear used for dozing (direct drive) |
| Over 100 ft (30 m) | Maximum reverse speed in third range (power shift) or highest reverse speed (direct drive) |

# Example:

A power-shift crawler tractor has a rated blade capacity of 10 LCY (7.65LCM). The dozer is excavating loose common earth and pushing it a distance of 200 ft. (61 m). Maximum reverse speed in third range is 5 mi/h (8 km/h). Estimate the production of the dozer if job efficiency is 50 min/h.

## SOLUTION

Dozer blade capacity = 10 LCY (7.65LCM)
Type of soil = loose common earth
Distance = 200 ft (61 m)
Reverse speed = 5 mi/h (8 km/h)
Dozer job efficiency = 50 min/h.

***Required:*** Estimate the production of the dozer

***Solution:***

***Fixed cycle time*** = 0.05 ***min*** (Table 4 – 4)

***Dozing speed*** = 2.5 mi/h (4.0 km/hr.) (Table 4 – 5)

$$\boldsymbol{Dozing\ time = \frac{distance}{dozing\ speed}}$$

$$Dozing\ time = \frac{200ft}{\frac{2.5mi}{hr} x \frac{5250ft}{1mile} x \frac{1hr}{60\ min}}$$

$$Dozing\ time = \frac{200ft}{2.5\ x\ 88} = \boldsymbol{0.91\ min}$$

## CONT…

$$\boldsymbol{Return\ time} = \frac{\boldsymbol{distance}}{\boldsymbol{reverse\ speed}}$$

$$Return\ time = \frac{200ft}{\frac{5mi}{hr}\ x\ \frac{5250ft}{1mile}\ x\ \frac{1hr}{60\ min}}$$

$$Return\ time = \frac{200ft}{5\ x\ 88} = \boldsymbol{0.45\ min}$$

***Total cycle Time = Fixed cycle time + Dozing time + return time***

***Total Cycle time = 0 .05 + 0.91 + 0.45 = 1.41 min***

$$\boldsymbol{Production = blade\ capacity\ x\ \frac{job\ efficiency}{total\ cycle\ time}}$$

$$Production = 10\ x\ \frac{50min/h}{1.41min} = \boldsymbol{355\ LCY/h}$$

Or

$$Production = 7.65\ x\ \frac{50min/h}{1.41min} = \boldsymbol{271\ LCM/h}$$

# Quiz

**2**.A hard digging crawler tractor has a rated blade capacity of 10 LCY (7.65LCM). The dozer is excavating hard common earth and pushing it a distance of 100 ft. (28 m). Maximum reverse speed in second range is 3 mi/h (5 km/h). Estimate the production of the dozer if job efficiency is 70 min/h.

**Table 4–4** Typical dozer fixed cycle times

| Operating Conditions | Time (min) |
|---|---|
| Power-shift transmission | 0.05 |
| Direct-drive transmission | 0.10 |
| Hard digging | 0.15 |

**Table 4–5** Typical dozer operating speeds

| Operating Conditions | Speeds |
|---|---|
| Dozing | |
| Hard materials, haul 100 ft (30 m) or less | 1.5 mi/h (2.4 km/h) |
| Hard materials, haul over 100 ft (30 m) | 2.0 mi/h (3.2 km/h) |
| Loose materials, haul 100 ft (30 m) or less | 2.0 mi/h (3.2 km/h) |
| Loose materials, haul over 100 ft (30 m) | 2.5 mi/h (4.0 km/h) |
| Return | |
| 100 ft (30 m) or less | Maximum reverse speed in second range (power shift) or reverse speed in gear used for dozing (direct drive) |
| Over 100 ft (30 m) | Maximum reverse speed in third range (power shift) or highest reverse speed (direct drive) |

# Construction Equipment

## Heavy Earth moving Equipment

### D. Power Shovels

Used predominately for hard digging above track level and loading haul units.

- Front dump and bottom dump buckets
- Bottom dump - More versatile
  - Greater reach and dump clearance
  - Easier to position for dumping
  - Less spillage
- However heavier than front-dump buckets.
- Limited ability to dig below the track level. Very efficient when digging from track level up to about the height of the shipper shaft.
- Capable of developing a high breakout force.

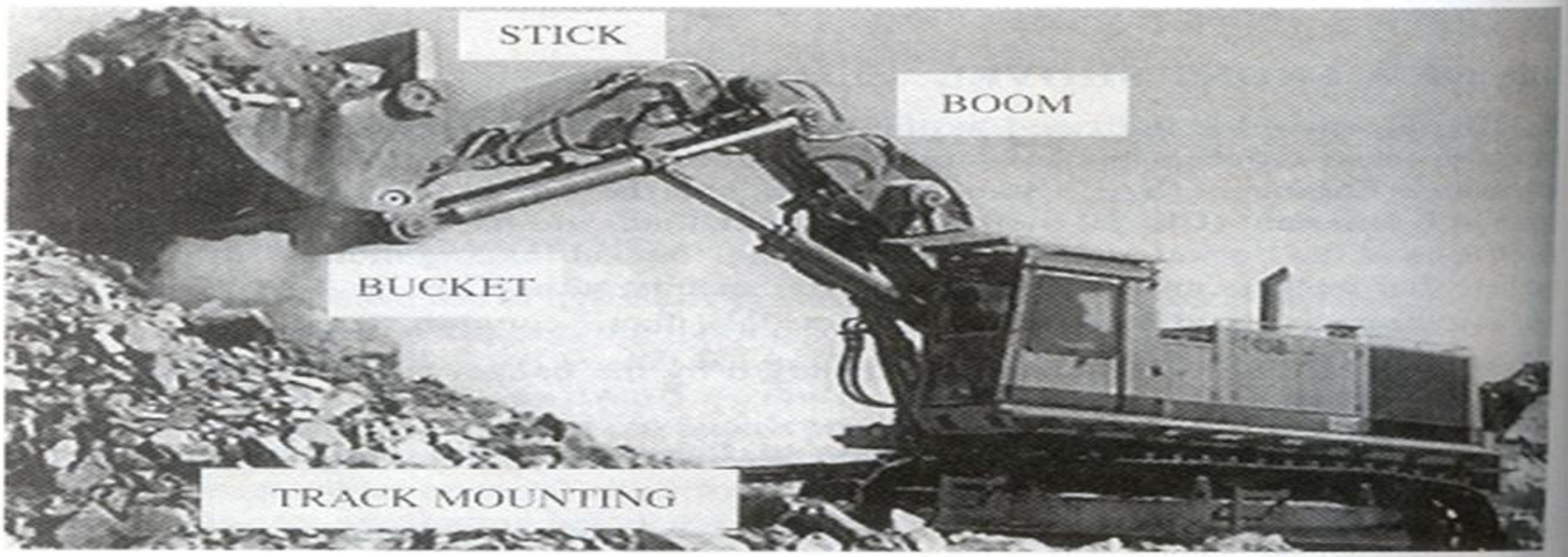
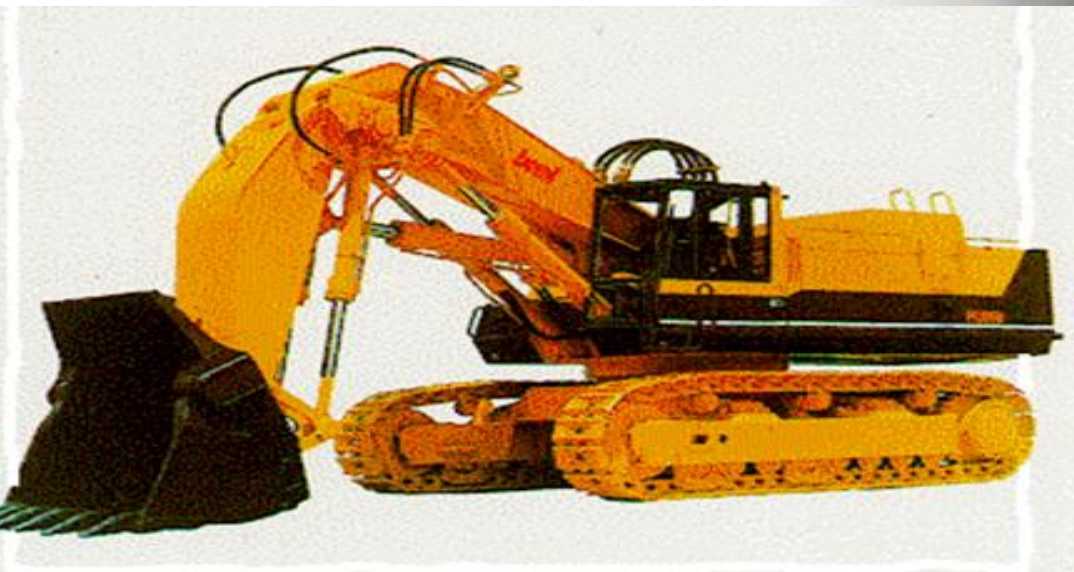



**FIGURE 8-12**
Basic parts of a hydraulic front shovel.



**LOADING SHOVEL**
**FLYWHEEL HORSE POWER: 404 HP**
**OPERATING WEIGHT: 67,000 Kg**
**BUCKET CAPACITY: 3.8M$^3$ ~ 4.5 M$^3$**

# Production Estimating

*Factors affecting the output*

- *Class of material*
- *Depth of cut*
- *Angle of swing*
- *Job conditions*
- *Management conditions*
- *Size of hauling unit*
- *Skill of operator*
- *Physical condition of shove*

Production for hydraulic shovels may be estimated using the equation

$$\boldsymbol{Production\ (LCY/h)\ or\ (LCM/h) = C\ x\ S\ x\ V\ x\ B\ x\ E}$$

Where:

- *C = cycles / h (table 3-6)*
- *S = swing-depth factor (table 3-6)*
- *V= heaped bucket volume (LCY or LCM)*
- *B = bucket fill factpr (table 3-2)*
- *E = job efficiency*

# Cont...

**Table 3–6** Standard cycles per hour for hydraulic shovels

| | Machine Size | | | | | |
|---|---|---|---|---|---|---|
| | *Small Under 5 yd (3.8 $m^3$)* | | *Medium 5–10 yd (3.8–7.6 $m^3$)* | | *Large Over 10 yd (7.6 $m^3$)* | |
| **Material** | **Bottom Dump** | **Front Dump** | **Bottom Dump** | **Front Dump** | **Bottom Dump** | **Front Dump** |
| Soft (sand, gravel, coal) | 190 | 170 | 180 | 160 | 150 | 135 |
| Average (common earth, soft clay, well-blasted rock) | 170 | 150 | 160 | 145 | 145 | 130 |
| Hard (tough clay, poorly blasted rock) | 150 | 135 | 140 | 130 | 135 | 125 |

| | Adjustment for Swing Angle | | | | | |
|---|---|---|---|---|---|---|
| | *Angle of Swing (deg)* | | | | | |
| | **45** | **60** | **75** | **90** | **120** | **180** |
| Adjustment factor | 1.16 | 1.10 | 1.05 | 1.00 | 0.94 | 0.83 |

# Example

Find the expected production in loose cubic yards (LCM) per hour of a 3-yd ($2.3m^3$) small hydraulic shovel equipped with a front-dump bucket. The material is common earth with a bucket fill factor of 1.0. The average angle of swing is 75% and job efficiency is 080.

**Given:**

Bucket volume ***(V)*** = 3.0 LCY (2.3 LCM)
Material = common earth
Bucket fill factor ***(B)*** = 1.0
Average angle of swing = 75%
Job efficiency ***(E)*** = 0.80

# Solution:

Standard cycles ***(C)*** = 150/60 min (Table 3 – 6)

Swing factor ***(S)*** = 1.05 (Table 3 – 6) `

$$\boldsymbol{Production\ (LCY/h)\ or\ (LCM/h) = C\ x\ S\ x\ V\ x\ B\ x\ E}$$

**Production** = 150 x 1.05 x 3.0 x 1.0 x 0.80 = 378 LCY/h

= 150 x 1.05 x 2.3 x 1.0 x 0.80 = 290 LCM/h



# Heavy Earth moving Equipment

## E. Scrapers

- Scrapers are capable of ***excavating***, ***hauling***, and ***dumping*** material ***over medium- to long-haul distances.***
- The scrapers are designed to ***dig***, ***load***, ***haul***, ***dump*** and ***spread*** and sometimes called as ***carry all***.

### *Types of scrapers*

- The scrappers are of three types:

### *I. Towed scrapers:*

- They are provided with either cable or hydraulic control.
- They are becoming obsolete.
- When coupled to a suitably powered crawler tractor, they can operate in extremely adverse conditions.
- Travel at ***slower speed*** and can be used for short hauls only.

# Construction Equipment



## Heavy Earth moving Equipment

## E. Scrapers

### *Types of scrapers*

### *II. Self propelled or motorized or conventional scrapers:*

- Generally manufactured in ranges from ***10-20*** cubic meters.
- Needs push loading by a crawler mounted or wheeled tractor.
- Have ***more hauling speed*** and hence are suitable for long distance hauling .

### *III. Self loading or elevating scrapers:*

- The problem of loading by a pusher is overcome by these type of scrappers.
- These are twin engine scrappers and can work completely independently of all other plants.
- Pay loads are restricted because of the additional weight of the loading elevator and its drive system.

# Construction Equipment



## Heavy Earth moving Equipment

## D. Scrapers

### *Types of scrapers*

- Another classification method of scrapers

### *I. Push-loaded (Conventional):*

- Single powered axel
- Tandem powered axels

### *II. Self loading:*

- Push-pull, tandem powered axels
- Elevating
- Auger

# Construction Equipment



## Heavy Earth moving Equipment

## E. Scrapers

### *Types of scrapers*




***Conventional (Push loaded)***

Become uneconomical when

- Haul grades > 5%
- Return grades > 12%

***Tandem powered Twin Engine***

- Good for jobs having adverse grade
- Owning operating costs are about 25% higher



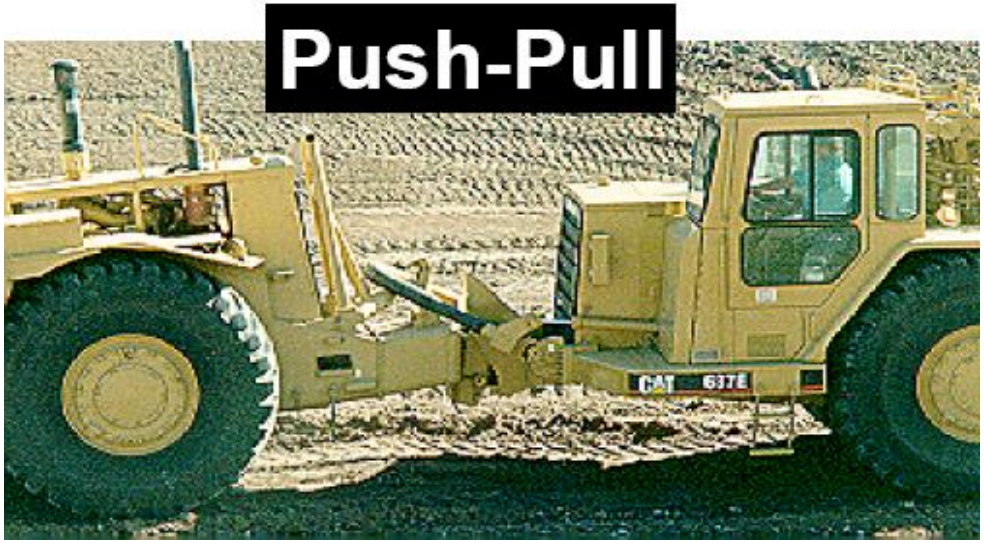
# Construction Equipment

## Heavy Earth moving Equipment



### E. Scrapers

*Types of scrapers*




***Push pull scrapers***

- Can work as a team or operate individually with a pusher.
- Tire wear will increase in rock or abrasive materials.

***Elevating scrapers***

- Good for short hauls and in favourable materials.
- Can work alone in the cut.
- Cost more initially and to operate.



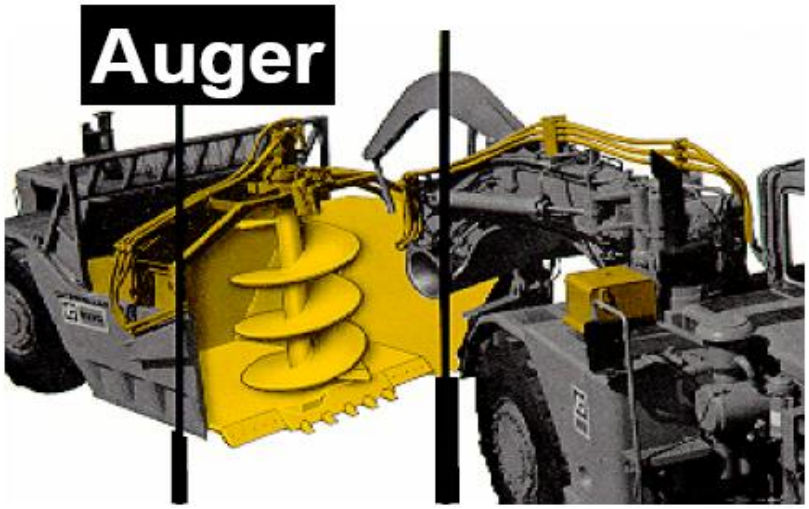
# Construction Equipment

## Heavy Earth moving Equipment



## E. Scrapers

*Types of scrapers*




***Auger Scrapers***

- Can self load in difficult condition, laminated rock or granular material.
- The augers add weight to the scraper during travel and it is more costly to own and operate than the conventional.



# Construction Equipment



## Heavy Earth moving Equipment

## E. Scrapers

## Basic Parts of a scraper

❑ A scraper has the following main parts:

### *i. Bowl*

- The bowl is a pan to hold the scraped dirt
- It is hinged at the rear corners to the rear axle inside the wheels, and is capable of tilting down for digging or ejecting.

### *ii. Cutting edge*

- The bowl has a cutting edge attached to the bottom.
- The cutting edge is lowered into the dirt to make a shallow cut.

### *iii. Apron*

- This is a wall in front of the bowl, which opens and closes to regulate the flow of the earth in and out of the bowl.

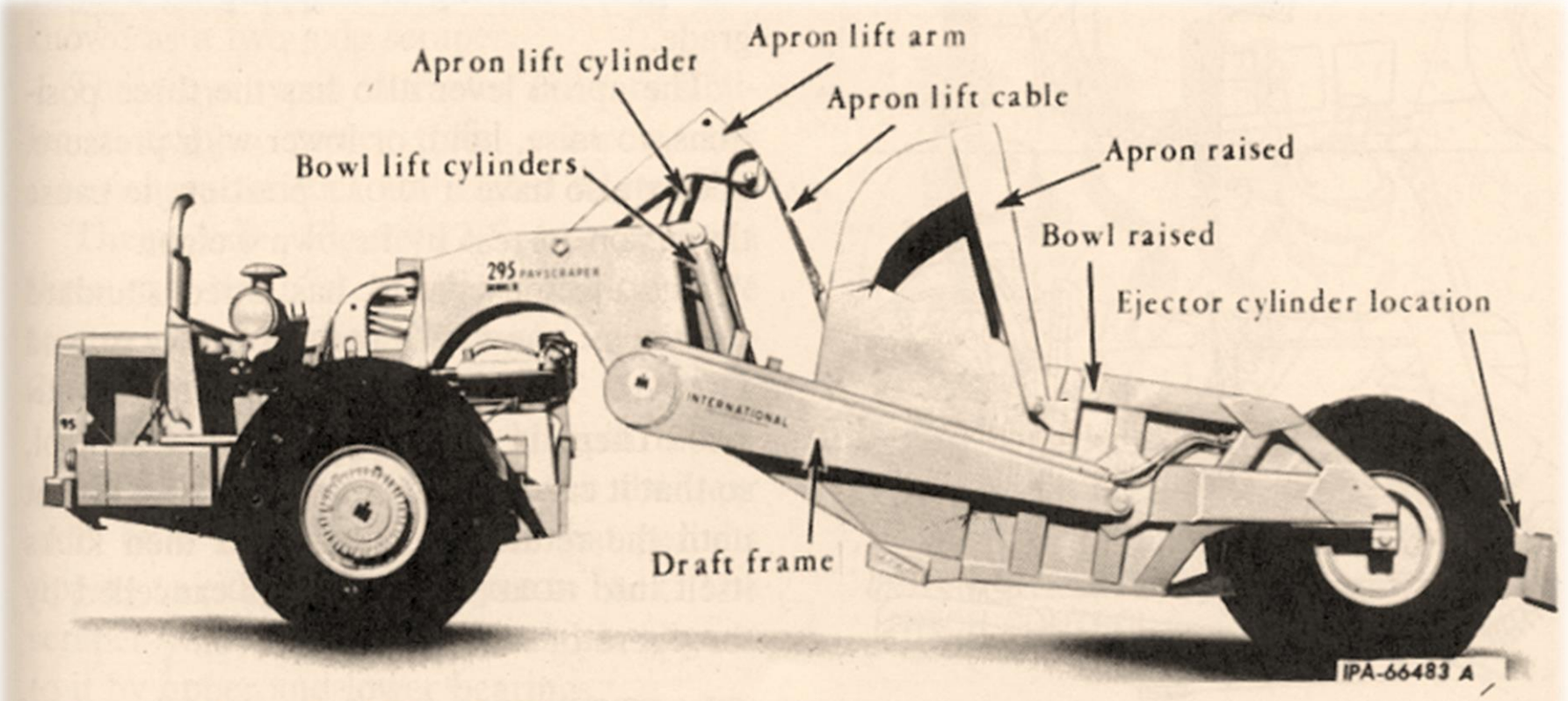
# Construction Equipment



## Heavy Earth moving Equipment

## E. Scrapers

## Basic Parts of a scraper




*Courtesy of International Harvester Company*

Fig. 17-2. Names of scraper parts



## Heavy Earth moving Equipment

## E. Scrapers

## Basic Parts of a scraper

### *iv. Tail gate or ejector*

- These are the rear of the pan which is capable of forward and backward movement inside the bowl





## Heavy Earth moving Equipment

## E. Scrapers

## Operation

- Operation of a scraper is described here under for an earth work:

### i. *Loading or digging*

- The operator moves to the cut with the ejector at the rear and the apron raised approximately to 40 cm.
- The bowl is then lowered to the desired depth of cut, increase engine speed, move forward in first gear keeping optimum depth of cut.
- When the bowl is full, the apron is closed and the bowl is then raised.

### ii. *Transporting*

- The bowl is transported in high gear in raised position to provide sufficient clearance.
- During transporting, apron should be fully closed to prevent loss of material

# Construction Equipment



## Heavy Earth moving Equipment

## E. Scrapers

## Operation

❑ Operation of a scraper is described here under for an earth work:

### *iii. Unloading*

- The bowl should be positioned to spread the material to the desired depth during this operation.
- A partial opening of the apron during the initial unloading will help in even spreading.
- For wet and sticky material, the apron should be raised and lowered repeatedly until the material behind it is loosened and drops out of the bowl.
- Then the ejector is moved forward to push the remaining material out of the bowl at a uniform rate.
- When the dump is complete, the tail gate is fully retracted, the apron dropped and the ‘bowl’ raised to transporting position.

# Construction Equipment



## Heavy Earth moving Equipment

## E. Scrapers

## Operation

- Following are some of the suggestions for ***increasing scraper production***:
  - Construct and maintain smooth haul roads for faster travel.
  - Depth of cut should be according to the type of soil being cut.
  - Use ripper teeth in hard or abrasive materials for easy handling.
  - Where possible, loading be done in down grade
  - To increase the stability of the scraper during travel, carry the bowl as close to the ground as possible.
  - If necessary pre-wetting of the soil is done so that the soil is reasonably moist, as most soils load easily when they are moist.
  - Whenever possible, plan the work to eliminate all avoidable turns.

# Construction Equipment




## Grading Equipment

### F. Graders

- Grading is the process of bringing earth work to the desired ***shape*** and ***elevation*** (grade).
- Motor graders are used for leveling and smoothening the earthwork, spreading and leveling the base course in the construction of roads and air fields.
- Motor graders can be used for the following types of works:
  - Gravel road repairing
  - Road shoulder reshaping, bank cutting and reshaping
  - Ditch filling or digging
  - Levelled or slopped ground finishing
  - Base course spreading and levelling
  - Material mixing, hard surface cutting, snow clearance,
  - Land clearance, frozen top soil and asphalt breaking

# Construction Equipment




## Grading Equipment

## F. Graders

### *Comparison with dozers*

- A grader is restricted to making shallow cuts in medium-hard materials.
- They should not be used for heavy excavations.
- A grader can move small amounts of material but cannot perform dozer-type work because of the structural strength and location of its moldboard.
- Graders can work on slopes as steep as 3:1.
- Grader are capable of progressively cutting ditches to a depth of 3 ft.

# Construction Equipment

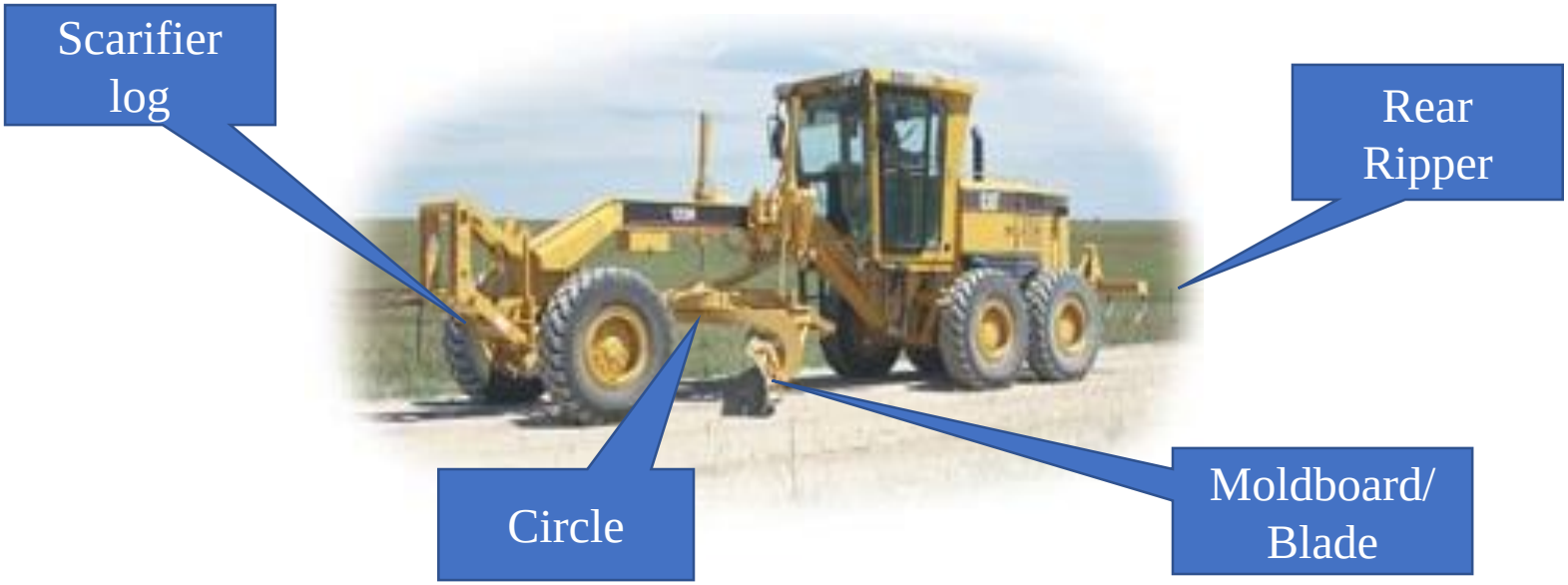



## Grading Equipment

## F. Graders

### *Basic parts of grader*

- The components the grader that actually do the finishing are:
  - ***Blade (Moldboard)***
  - ***Scarifier***
  - ***Rippers***



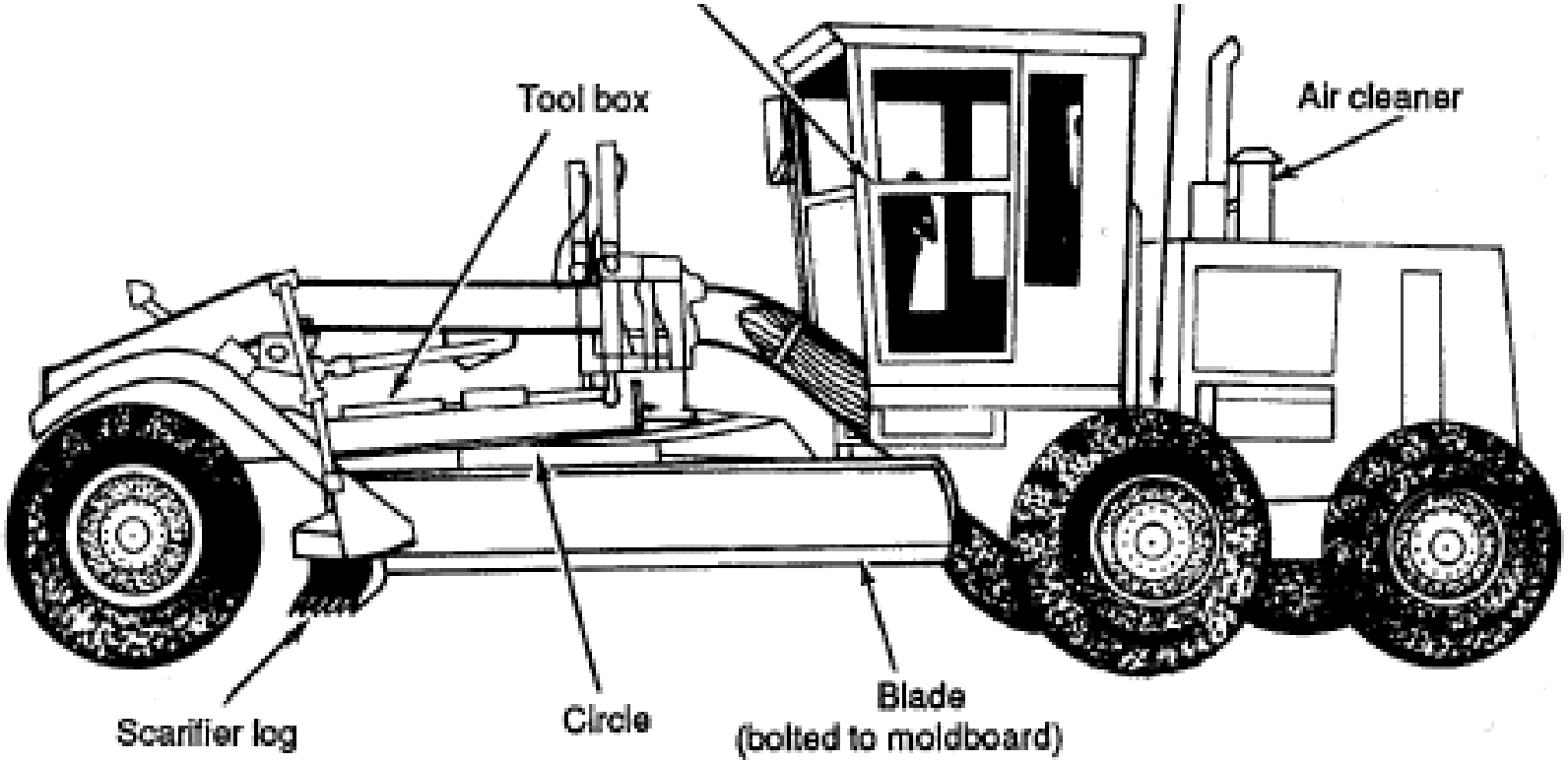
# Construction Equipment




## Grading Equipment

### F. Graders

***Basic parts of grader***



# Construction Equipment




## Grading Equipment

## F. Graders

### *Blade*

- The blade (Mould Board) is the ***main tool*** of the grader.
- It is carried by a ***rotating circle*** and is easily maneuverable to a wide range of cutting positions with the help of hydraulic controls.
- The blade and the circle are mounted on a frame and is supported at the front of the machine by a ball joint.
- The blade can be adjusted to any position with help of levers as indicated below:
  - ***Side shift***: the blade has Blade Sideshift Ram
  - ***Lifting the blade***: The blade can be lifted or lowered by levers operating the two rams.
  - ***Rotating the circle***: A hydraulic motor is provided to rotate the circle and blade. Blade can be rotated either in clockwise or counter clockwise direction.

# Construction Equipment




## Grading Equipment

## F. Graders

### *Blade*

- ***Adjusting blade cutting angle (Blade pitch)***: The vertical angle of the blade can be adjusted.

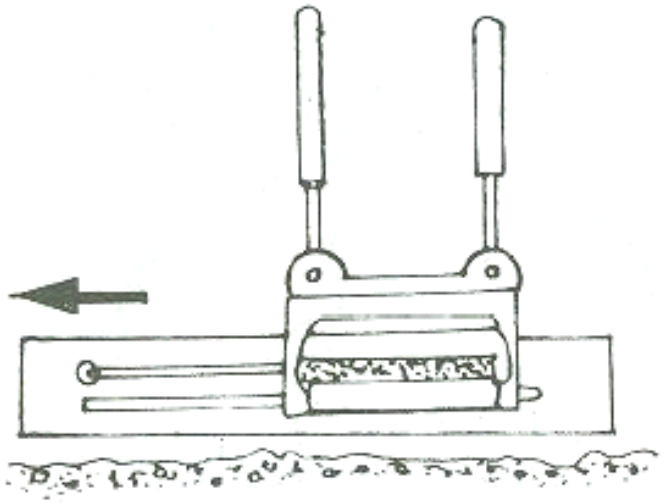


Fig. 4.2. Blade sideshift.

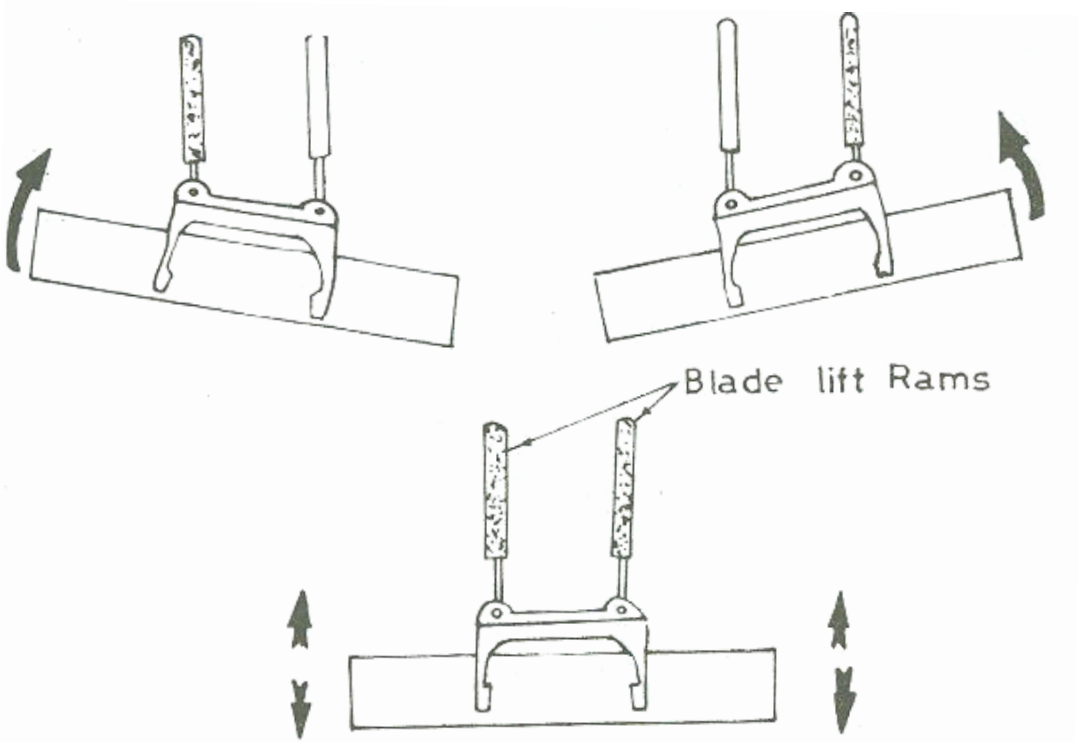



Fig. 4.3. Lifting the blade.

# Construction Equipment

## Grading Equipment

## F. Graders

### *Blade*



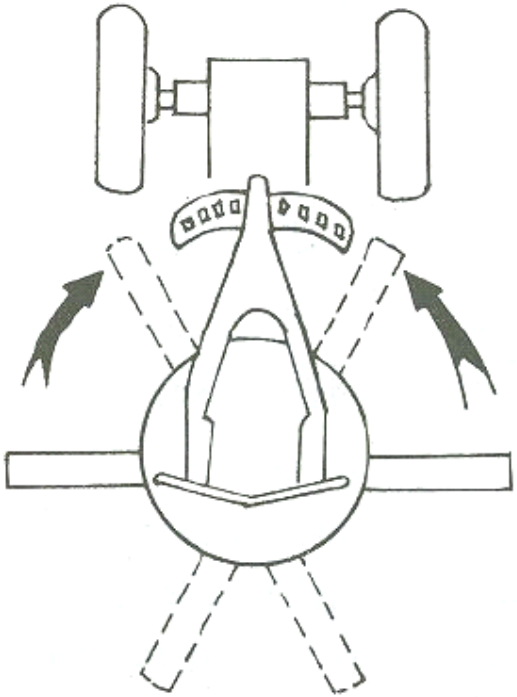
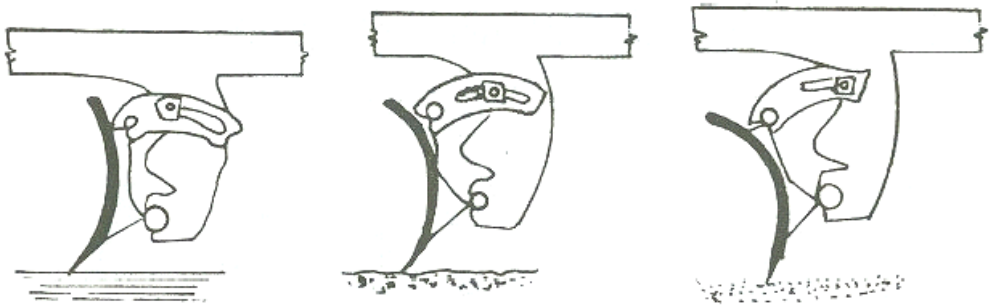
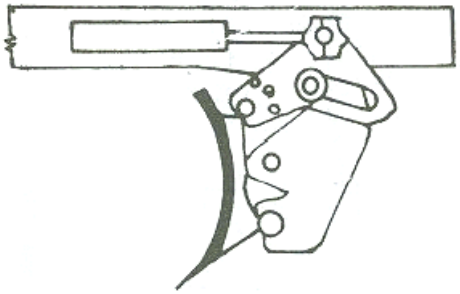



Fig. 4.4. Rotating the Circle.



(a) Manual Adjustment



(b) Hydraulic Adjustment

Fig. 4.5. Blade Cutting Angle.

# Construction Equipment

## Grading Equipment

### F. Graders

***Blade***








***Adjusting blade cutting angle***

# Construction Equipment

## Grading Equipment

## F. Graders

### *Blade*










***Adjusting blade cutting angle***

# Construction Equipment

## Grading Equipment

## Graders

### *Scarifier*




- Scarifier is a special tool attached with the motor grader for loosening the hard soil and has a set teeth mounted on adjustable shanks.
- This attachment digs up hard ground like asphalt, old pavement, frozen surface and hard soil with vegetation and brushes which can not be removed by the blade.
- The teeth are replaceable, and the number of teeth can be varied to suit the ground hardness.
- High strength alloy steel tips can be mounted on the teeth to prevent teeth wear and extend their service for economical performance.

# Construction Equipment

## Grading Equipment

## Graders

### *Scarifier*






# Construction Equipment




## Grading Equipment

## Graders

### *Ripper*

- The ripper is used to break up materials too hard to cut with moldboard blade.
- The depth of cut is controlled by hydraulically operated ripper control lever.
- Type of material to be ripped will determine position of the ripper shank.



# Construction Equipment




## Grading Equipment

## Graders

### *Various Operations*

### *A. Grading:*

- Grading in road construction means flattening and smoothening the road surface and others by the scrapping action of the blade, includes working operation like, ***surface skimming***, ***light duty bulldozing***, ***leveling***, ***spreading*** and ***crowning***.
- A cutting depth of 2 to 3cm is considered to be the best for optimum efficiency. Under no circumstances it should be greater than 5cm.

### *B. Spreading:*

- Gravel together with binding material is spread by the motor grader.
- For spreading the cutting angle is set at 60° nearly.
- Cutting edge of the blade is set above the ground at a distance equal to the depth to which the material is to be spread.

# Construction Equipment




## Grading Equipment

## Graders

### *Various Operations*

### *C. Finishing and Leveling:*

- In final finishing and leveling, surface have to be finished to fine limits.
- In such cases make the finishing pass with the blade only slightly angled and set to skim the surface.

### *D. Ditch Digging:*

- The front end of the blade is tilted down and the rear end is tilted up above the road surface. The front end cuts into the ground.
- This is used to dig drainage ditches and road side ditches.

### *E. Cutting:*

- For the purpose of cutting in soft dirt, set the blade to an angle b/n 40-55 degree, while in hard dirt an angle of 30-45 degree is proper.

# Construction Equipment

## Grading Equipment

## Graders

## *Various Operations*






***Laser Blade controls***




***Ditch Cutting***

# Estimating Grader Production

- Grader production is usually calculated on a linear basis (miles or kilometers completed per hour) for roadway projects and on an area basis (square yards or square meters per hour) for general construction projects.
- The time required to complete a roadway project may be estimated as follows:

$$\boldsymbol{Time\ (h) = \left[\sum \frac{Number\ of\ passes\ x\ Section\ length\ (mi\ or\ km)}{Average\ speed\ for\ section\ (\frac{mi}{h}\ or \frac{km}{h})}\right] x\ \frac{1}{Efficiency}}$$

- Average speed will depend on operator skill, machine characteristics, and job conditions.
- Typical grader speed for various types of operation are given in Table 5 – 6.

**Table 5–6** Typical grader operating speed

| Operation | Speed | |
|---|---|---|
| | *mi/h* | *km/h* |
| Bank sloping | 2.5 | 4.0 |
| Ditching | 2.5–4.0 | 4.0–6.4 |
| Finishing | 4.0–9.0 | 6.5–14.5 |
| Grading and road maintenance | 4.2–6.0 | 6.4–9.7 |
| Mixing | 9.0–20.0 | 14.5–32.2 |
| Snow removal | 12.0–20.0 | 19.3–32.3 |
| Spreading | 6.0–9.0 | 9.7–14.5 |

# Example Problem

Fifteen miles (24.1 km) of gravel road require reshaping and leveling. You estimate that six passes of a motor grader will be required. Based on operator skill, machine characteristics, and job conditions, you estimate two passes at 4 mi/h (6.4 km/h), two passes at 5 mi/h (8.0 km/h), and two passes at 6 mi/h (9.7 km/h). Job efficiency is 0.80, how many grader hours will be required for this job?

Required: productivity of

# Solution:

$$Time\ (h) = \left[\sum \frac{Number\ of\ passes\ x\ Section\ length\ (mi\ or\ km)}{Average\ speed\ for\ section\ (\frac{mi}{h}\ or \frac{km}{h})}\right] x\ \frac{1}{Efficiency}$$

$$Time\ (h) = \left[\sum \frac{2\ x\ 15\ mi}{4.0\ \frac{mi}{h}} + \frac{2\ x\ 15\ mi}{5.0\ \frac{mi}{h}} + \frac{2\ x\ 15\ mil}{6.0\ \frac{mi}{h}}\right] x\ \frac{1}{0.80} = 23.1\ hours$$

**Or**

$$Time\ (h) = \left[\sum \frac{2\ x\ 24.1\ km}{6.4\ \frac{km}{h}} + \frac{2\ x\ 24.1\ km}{8.9\ \frac{km}{h}} + \frac{2\ x\ 24.1\ km}{9.7\ \frac{km}{h}}\right] x\ \frac{1}{0.80} = 23.1\ hours$$

# Quiz-2

1. Eight miles (14.1 km) of gravel road require reshaping and leveling. You estimate that eight passes of a motor grader will be required. Based on operator skill, machine characteristics, and job conditions, you estimate three passes at 6 mi/h (8.4 km/h), two passes at 3 mi/h (6.0 km/h), one passes at 2 mi/h (3.1 km/h) and two passes at 4 mi/h (5.7 km/h). Job efficiency is 0.6, how many grader hours will be required for this job?

Required: productivity of

## G. Trucks

Because hauling or the transportation of excavation is a major earthmoving activity, there are many types of hauling equipment available to the constructor.

- Trucks and wagons are still the most common forms of construction hauling equipment. The heavy-duty rear-dump truck is the most widely used because of its flexibility of use and the ability to move rapidly between sites.

## Trucks used for:-

- hauling on public highways are limited by transportation regulations in their maximum width, gross weight, and axle load. There is a growing trend toward the use of off-highway models that can be larger and heavier and carry payloads up to several hundred tons.

# CONT...









## Determining the Number of Haul Units Needed

The total cycle time for the truck or wagon is the sum of the fixed time (spot, load, maneuver, and dump) and the variable time (haul and return). The fixed time elements of spot, maneuver, and dump may estimated by the use of Table 4 – 9. Loading time can be calculated by the following formula.

$$\textbf{\textit{Load time}} = \frac{\textbf{\textit{Haul unit capacity}}}{\textbf{\textit{Loader production}}\ @100\%\ \textbf{\textit{efficiency}}}$$

$$\textbf{\textit{Load time}} = \textbf{\textit{Number of bucket x excavator cycle time}}$$

**Table 4–9** Spot, maneuver, and dump time for trucks and wagons (min)

| Conditions | Bottom Dump | Rear Dump |
|---|---|---|
| Favorable | 1.1 | 0.5 |
| Average | 1.6 | 1.1 |
| Unfavorable | 2.0 | 2.5 |

## CONT...

- The number of trucks theoretically required to keep a loader fully occupied and thus obtain the full production of the loader can be calculated

$$\textbf{Number of haulers required } (N) = \frac{\textbf{Haul unit cycle time}}{\textbf{Load time}}$$

**Haul cycle time = truck cycle time + load time**

- The expected production in this situation may be calculated by the following formula. In performing this calculation, use the precise value of N, not its integer value.

$$Expected\ production\ (no.units\ less\ than\ N)$$
$$= \frac{Actual\ Number\ of\ units}{N}\ x\ \ Excavator\ production$$

## Example :

**Given** the following information on a shovel/truck operation,

(a) calculate the number of trucks theoretically required and the production of this combination

(b) calculate the expected production if two trucks are removed from the fleet.

- Shovel production at 100% efficiency = 371 BCY/h (283 BCM/h
- Job efficiency = 0.7
- Truck capacity = 20 BCY (15.3 BCM)
- Truck cycle time excluding loading = 0.5h

# Solution:

(a) calculate the number of trucks theoretically required and the production of this combination

$$\boldsymbol{Load\ time} = \frac{\boldsymbol{Haul\ unit\ capacity}}{\boldsymbol{Loader\ production\ @100\%\ efficiency}}$$

$$Load\ time = \frac{20}{371} = 0.054\ h \qquad \text{or}$$

$$\left[Load\ time = \frac{15.3}{283} = 0.054\ h\right]$$

Haul cycle time = *truck cycle time + load time*

$$\boldsymbol{Number\ of\ haulers\ required\ (N)} = \frac{\boldsymbol{Haul\ unit\ cycle\ time}}{\boldsymbol{Load\ time}}$$

$$Number\ of\ trucks\ required = \frac{0.554}{0.054} = 10.3 = 11$$

***Expected shovel production*** = *371 x 0.75 = 278 BCY/h* *or*

*Expected shovel production* = *283 x 0.75 = 212 BCM/h*

(b)calculate the expected production if two trucks are removed from the fleet actual number of units = 9

$$\boldsymbol{Expected\ production\ (actual\ units) =}$$

$$\frac{\boldsymbol{Actual\ Number\ of\ units}}{\boldsymbol{N}}\ \boldsymbol{x\ shovel\ \ production}$$

$$Expected\ production\ (actual\ units) = \frac{\mathbf{9}}{\mathbf{10.3}}\ \boldsymbol{x}\ \mathbf{278} =$$

$$\mathbf{243}\ \boldsymbol{BCY/h} \qquad \mathbf{0r}$$

$$Expected\ production\ (actual\ units = \frac{9}{10.3}\ x\ 212 =$$

$$186\ BCM/h$$