University of Gondar

Institute of Technology

Department of HWRE

Construction Equipment and methods

Instructor: Ambelu

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Course Objective and Competences to be acquired

- **The objective of the course is:**
  - **to understand the Selection, Types, Access and Cost utilization of construction Equipments/Plants.**
- **Competencies:**
  - **students are exposed to the utilization of Equipments/Plants as applied to Civil Engineering infrastructure with HWRE to**

Course Content

Chapter one: Introduction

- ✓ Construction Industry
- ✓ Construction Technology and Management
- ✓ Construction Process
- ✓ Why Construction Equipment / Plant Management?
  - ➢ Resource
  - ➢ Equipment Productivity / Efficiency
  - ➢ Equipment Quality
  - ➢ Equipment Mechanization
  - ➢ Choosing Construction Equipment

Course Content

Chapter Two: Construction Equipment and Plant Management

- ✓ Equipment Types and their Productivity

Type	Equipments
✓Earth Work Equipments	*Bulldozers*, *Shovels*, Draglines, *Loaders*, *Graders*, Rippers and Scrappers, *Rollers*, Drills, Blasting, Grouting Pumps, Pile Driving and Hammers.
✓Hauling and Hoisting Equipments	Tractors, Normal and *Dump Trucks*, Hoists, Jacks, Conveyors and *Cranes*.
✓Pumping Equipments	*Pumps*, Hozes, Pipes, and Compressors
✓Asphalt and Concrete work	*Crushers*, *Mixers*, *Vibrators*, Tar Mixing, *Pavers* and Watering.

Course Content

Chapter Two: Construction Equipment and Plant Management

- ✓ **Plant Types and their Productivity**
  - ❑ **Aggregate Production Plants**
  - ❑ **Asphalt Mix Production Plants**
  - ❑ **Concrete Batching Plants**

Course Content

Chapter Three: Construction Equipment/Plant Economics

- ✓ **Equipment/Plant Access & Costs**
  - ❑ **Accessing or Availing Costs (Owning, or Renting, or Leasing Costs),**
  - ❑ **Operation Costs**
  - ❑ **Overhead and Markup Costs**

Course Content

Chapter Four: Construction Equipment/Plant Management in Ethiopia

- ✓ **Historical Perspectives**
- ✓ **Recent Trends**
- ✓ **Useful Organizations / Documents**

Assessment and Evaluation

- **Assessment/Evaluation and Grading Systems:**
- Assignment: 10%
- Quiz/ Presentasion.....20%
- Uniform Exam..... 20%
- Final exam:

CONSTRUCTION EQUIPMENT/PLANT MANAGEMENT

Chapter one: Introduction

Chapter One: Introduction

- Efficient and effective implementation of construction projects require good knowledge of characteristics for and among **resources** (Materials, Money, Manpower and Machineries (the **4 M's**)), activities and stakeholders.
- However; **Human** (Capacity and Capability), **Financial, Physical** (Material, Equipment and Plant), **Institutional** (Management and Production Systems), and **Information** (Access and Availability) resources together with the concepts of availability and utilization of Time and Space could best describe these categories.

Introduction

- This course covers one of these resources: **Physical resource**.
- That is, **Construction Equipment/Plant** was often termed as **Machinery** in most literatures.
- **Equipment Vs. Plant?**
- Equipments (Plants) as resource play a major role in all construction activities.
- Before discussing directly about equipment and plant, it is worthwhile to deal with what a **construction industry** mean and its relevance to the program this course is undertaken.
- This will help to connect the course and the program to its wider context called

Construction Industry

- Construction Industry is an industry which is involved in the planning, execution and evaluation (Monitoring) of all types of civil works.
- Physical infrastructures such as Buildings, Communication and Energy related construction works, Water supply and Sewerage civil works, etc are some of the major projects / programs in the Construction Industry.
- People and machines make it possible
- Processes:
  - Estimating – determining quantity, production and cost
  - Construction – Controlling these during

Construction Industry

- Construction Industry has long been realized as one among the most important enablers for social, economic and political development of countries.
- Specifically this fact is strengthened in the case of least developing countries like Ethiopia.
- This is because on the one hand these projects are inter-sectoral (Table 1.1). 1. Chapter One.doc
- On the other hand the demand of such infrastructures in these countries consume substantial amount of their capital budget (Table 1.2). 1. Chapter One.doc

Construction Industry

- The execution of construction activities may be defined as **economic** and **social activities engaged in producing, assembling, installing** for either new or existing physical infrastructures.
- This indicates that the construction process encompasses an industrial process to account for its name, the **Construction Industry**.
- However, most construction activities involve considerable **on site productions** where the characteristics for industry processes could not apply.
- This will be more applicable in the cases of countries like **Ethiopia** where use of manufacturing construction elements for

Construction Industry

- That is, use of **Labor Intensive** and Construction **On-Site dominated** the way how construction executions are carried out.
- As a result, **Construction Works** can more represent the case of **construction activities** in the case of least developing countries than **Construction Services**.
- In both cases, the need to master the different alternatives of HWRE approaches are useful.
- It is through comparing and evaluating these alternatives based on the contextual realities of such projects that **relevant, efficient, effective and sustainable** choices

Construction Technology and Management

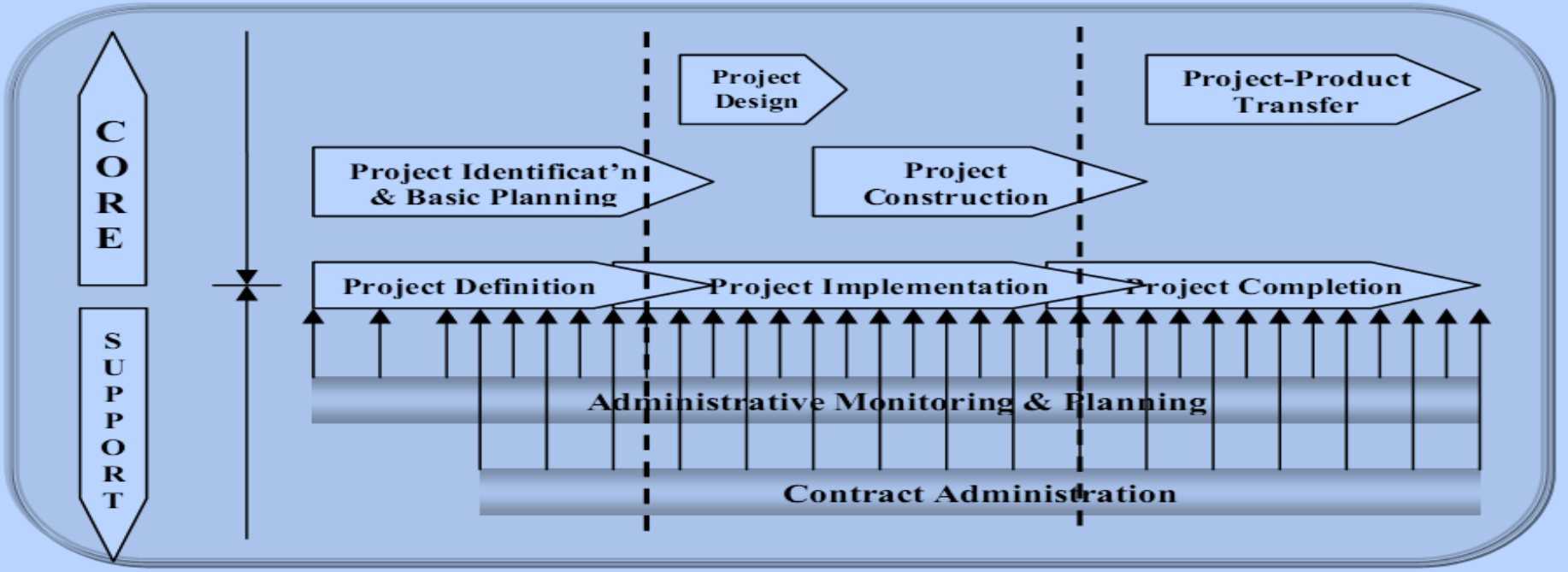
- **Technology** referred to the way how either the materials or the elements or the entire product of any construction works / services is designed and produced.
- **Management** is dealing with the systems how relationships among stakeholders, resources and activities are planned, implemented and monitored for a successful completion of any construction works or activities.
- Therefore the profession **Construction Technology and Management** is a paramount importance to the construction industry because both the demands of the **construction process** (the production or the support processes) can be incorporated in one discipline.

Construction Processes

- Is defined as all processes which guides towards or is a presupposition for the planned construction works or services.
- The construction process as a concept covers **two** main sub processes having different characteristics.
- These sub processes are: **Core processes,** and **Facilitating** or **Supporting processes**.
- Wubishet, 2004 in his dissertation came up with a modified project management process that combined the concept of **project cycle** which is often used in many literatures and the **construction process** using a **three by two matrix** (Figure 1.1).

Construction Processes

- The **horizontal axis** shows the three columns of the matrix based on the three major Project Management phases or cycles called **Project Definition, Project Implementation and Project Completion** Processes.
- Besides, the **vertical axis** shows the two rows of the matrix built upon two major tasks: **Core and Facilitating or Supporting Processes**



Construction Processes

- His argument for such a modification is to acknowledge the need for a two way approach to planning such that planning undertaking during the project definition phase was called **'Basic Planning'** and planning carried out throughout the project life time was termed as **'Administrative Planning'.**
- In his view plan and implementation need to be **integrated** using the 'Administrative Planning Process because Uncertainties could not be fully revealed during the Project Definition phase alone.
- Besides, he included **administrative monitoring** as a continuous process to

Construction Processes

- Therefore **administrative monitoring and planning** processes are important in dealing with uncertainties revealed during project implementations.
- Furthermore, he included **contract administration** process as important in the supporting process
- This is because most construction projects were undertaken with **contractual agreements** and **relationships** and such **uncertainties** will involve **variations** and other **requirement** implications:
  - cost,
  - time, or

Why Construction Equipment / Plant Management?

- There are many reasons why construction equipment or plant management is relevant for the successful completion of a construction project.
- It can generally fall into four major themes called **Resources, Productivity / Efficiency, Quality and Development demand related** issues.

Resource

- A Construction project involves largely Human (Capacity and Capability), Financial, Physical (Material, Equipment and Plant), Institutional (Management and Production Systems), and Information (Access and Availability) resources together with the

Why Construction Equipment / Plant Management?

- **Resource**
  - The integration of technology and management of each individual resource and their combined outcomes are necessary for the successful completion of a construction work or service.
  - For instance, decisions regarding equipment types in use and their skilled manpower are important factors on the performances of construction works or services.
  - Therefore, knowledge and skill on how to effectively use construction

Why Construction Equipment / Plant Management?

- **Resource**
  - In this respect, while **construction technology** deals with how the equipment technology can be **upgraded, skilled manpower** are **trained** to use these equipments and plants and enhancing their **production** processes;
  - **construction management** deals with **selecting types** of equipments such that their combination with other resources yield the **optimum production**.

Productivity / Efficiency in Construction Equipment

- Equipment or Plants are designed **to replace human resources** where repeated activities are mostly applicable to increase productivity or efficiency.
- **Productivity or efficiency** can be defined as **the ratio of output to input.**
- In addition, **time could be saved to decrease the production time** where TVM can contribute to the benefit of a completed project.

Productivity / Efficiency in Construction Equipment

- Each piece of construction equipment is **specifically designed** by manufactures to perform certain mechanical operations.
- To estimate the equipment component of project cost it is necessary to first determine **Equipment productivity**.
- Therefore, construction industry with its technology and management deals with the way how best you can **replace the human labor** with technological advancement to create or upgrade construction equipments or plants together with their usage by skilled manpower for an optimum output, that is **productivity**.

Equipment Quality in Construction Projects

- Use of Construction equipments and plants often give a harmonized and standardized output against **variations of quality** that could be achieved among different skilled manpower.
- Besides, **technological advancement** has brought an enhancement of quality products using such equipments and plants.
- Therefore, use of equipment and plants **increased** the quality of materials, components and the **whole product** of a construction process.

Equipment Mechanization On a Construction Projects

- New technological developments initiated for the purpose of physical infrastructure development through either:
  - gaining recognition of scientific development (technological), or;
  - enhancing human value and living condition demands (social), or;
  - competitive or increasing productivity demands (economical), or;
  - strengthening or acquiring power and resources (political)
- that involves construction equipments could be one reason why we need to consider construction equipment management vital for the discipline construction.

Equipment Mechanization On a Construction Projects

- Ethiopian Construction has traditionally been **labor intensive**
- Most construction did not suit or need mechanization due to:
  - Minimum **cost** specifications
  - Small **size** of works
  - Lack of emphasis on **speed, quality** and **safety**
  - Availability of **cheap labor**
  - Lack of **trained manpower**

Equipment Mechanization On a Construction Projects

Advantages of Mechanization:

- Use of appropriate equipment eliminates human errors and ensures superior quality of work consistently
- Speedy construction avoids time and cost overruns.
- Facility available for usage earlier.
- Certain construction not possible by manual methods

Degree of Mechanization on a Project will Depend on:

Choosing construction equipment and/or plant

- **Equipment costs** rank **second** to **labor costs** in terms of **uncertainty** and in their **effect** on the outcome of anticipated profit for a construction project.
- **Selection of the right piece of equipment**, like the right man for the job, affects field productivity.
- **Productivity** directly influences **profitability**.
- **Using a machine** that does not have enough **capacity** will slow down productivity.
- Using a machine with **too large** capacity might increase productivity to some extent, but will ultimately negatively affect **profitability**, because of the cost of operation of the oversized machine.
- **Pairing machines** with mismatched

Choosing construction equipment and/or plant

- The first equipment selection step involves **matching** the right machine to the work activity.
- The work activity includes **all factors** associated with the specific physical task.
- Each piece of construction equipment is **specifically designed** by the manufacturer to perform certain mechanical operations that accomplish the work activity.
- Mechanical operations are typical for each classification of **earthmoving, excavation, and lifting** equipment.
- For instance, all **front-end loaders** work in the same way.
- They are built to dig at **ground level**, **carry** the load, **hoist** the load, and **dump** the bucket forward.

Choosing construction equipment and/or plant

- To be competitive – **contractor's equipment spread must be competitive** – mechanically and technologically.
- Most often, a piece of equipment does not work as a stand-alone unit. Work in groups.
- **Equipment intensive** operations come with major risks.
- In selection of the most suitable equipment:
  - Equipment must **pay** for it self.
  - Should **earn** more than it costs.
  - Not possible to **own** all types and sizes

Choosing construction equipment and/or plant

- The following basic **relationships** exist for **equipment selection**:
  - As equipment **productivity increases** so does the **initial purchase price, operating**, and **maintenance costs**.
  - As equipment **capacity increases**, so does the **hourly production**.
  - As equipment **productivity increases**, the unit cost for the work decreases.

Choosing construction equipment and/or plant

- Questions to be asked:
  - is project large enough to justify purchasing?
  - Is it possible to dispose of the equipment at reasonable price?
  - Can the equipment currently owned do the job, though not ideal?
  - Ability of the equipment to perform required work
  - Should earn more than it costs
  - Availability of spare parts

Choosing construction equipment and/or plant

- **In order to increase job-site productivity, it is beneficial to select equipment with proper characteristics and a size most suitable for the work conditions at a construction site.**
- **In excavation for building construction, for examples, factors that could affect the selection of excavators include:**

1. **Size of the job**: Larger volumes of excavation will require larger excavators, or smaller excavators in greater number

Choosing construction equipment and/or plant

2. **Activity time constraints**: Shortage of time for excavation may force contractors to increase the size or numbers of equipment for activities related to excavation.

3. **Availability of equipment**: Productivity of excavation activities will diminish if the equipment used to perform them is available but not the most adequate.

4. **Cost of transportation of equipment**: This cost depends on the size of the job, the distance of transportation, and the means of

Choosing construction equipment and/or plant

5. **Type of excavation**: Principal types of excavation in building projects are cut and/or fill, excavation massive, and excavation for the elements of foundation. The most adequate equipment to perform one of these activities is not the most adequate to perform the others.

6. **Soil characteristics**: The type and condition of the soil is important when choosing the most adequate equipment since each piece of equipment has different outputs for different

Choosing construction equipment and/or plant

7. **Geometric characteristics of elements to be excavated**: Functional characteristics of different types of equipment makes such considerations necessary.

8. **Space constraints**: The performance of equipment is influenced by the spatial limitations for the movement of excavators.

9. **Characteristics of haul units**: The size of an excavator will depend on the haul units if there is a constraint on the size and/or number of these

Choosing construction equipment and/or plant

10. Location of dumping areas: The distance between the construction site and dumping areas could be relevant not only for selecting the type and number of haulers, but also the type of excavators.

11. Weather and temperature: Rain, snow and severe temperature conditions affect the job-site productivity of labor and equipment.

lesson

1. What type of a good knowledge expected from you for efficient & effective implementation of a construction project?
2. Differentiate construction industry and construction process?
3. Why construction equp’t/plant mgt is important for your field of study?
4. How do you know equp’t productivity?
5. Describe briefly equp’t mechanization on a construction projects?
6. What are the factors that could affect the selection of excavators?

Construction Equipment Management

Chapter Two: Construction Equipments and/or plants

- ✓ Construction Equipments/Plants Management
- ✓ Equipment Types and their Productivity
- ✓ Plant Types and their Productivity

Construction Equipments/Plants Management

- Construction Equipment Management can be referred as the **planning, implementation and monitoring** of construction equipments to:
  - ✓ enhance their **optimum utilization** as a resource,
  - ✓ increase their **efficiency or productivity** of inputs to or products of the construction process,
  - ✓ **harmonize, standardize** and **enhance quality** of their outputs for inputs or as a final product in the construction process; and

Equipment Types

- Equipment types used in a construction project is largely dependent on their:
  - Direct input to unit prices or,
  - Type of work or trades,
  - Scope of work,
  - Mobility,
  - System of control and
  - Availability.

Equipment Types

- **Based on their direct input to unit prices:** ***Productive*** **(units that alone or in combination lead to an end product)** ***Vs Support*** **(which are required for operations related to the placement of construction).**
- **Based on scope of work:** ***equipment intensive*** **(to usage of heavy construction equipments)** ***Vs labor intensive*** **(to usage of light construction equipments).**
- **Based on type of work or trades:** ***Earth Works Equipments, Hauling and Hoisting Equipments, Pumping Equipments and Asphalt and Concrete works***
- **Based on the degree of the Equipments mobility:** ***Stationary Vs Mobile***
- **Based on system of control:** ***manually*** **Vs** ***automatically operated equipments.*** **They can also be** ***mechanically, hydraulically, pneumatically or***

Equipment Types

- For the purpose of this course **Four** major classifications of equipments largely **based on trades of works** involved are covered. These include:
- **Earth Works Equipments**
  - Bulldozers, Shovels, Clamshells and Draglines, Dredgers, Loaders, Graders, Rippers and Scrappers, Rollers, Drills, Blasting, Grouting Pumps, Pile Driving and Hammers.
- **Hauling and Hoisting Equipments**
  - Tractors, Normal and Dump Trucks, Hoists, Jacks, Conveyors and Cranes.
- **Pumping Equipments**
  - Pumps, Hozes, Pipes, and Compressors
- **Asphalt and Concrete works equipments**
  - Crushers, Mixers, Pumping, Vibrators, Tar Mixing, Pavers and Watering.

1. Earthwork Equipments

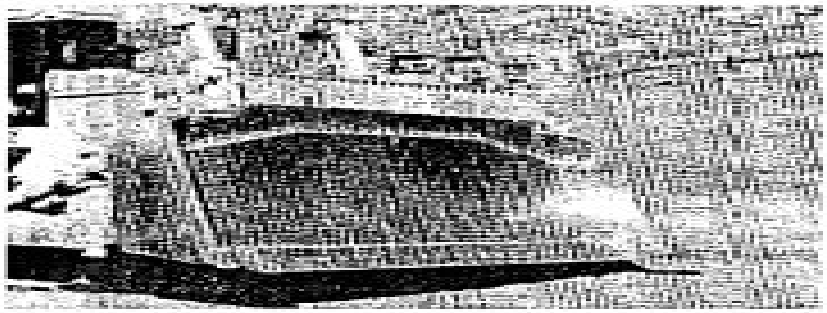
- These equipments are mainly **used to cut, fill, compact, drill and blast earth, rocks and any removable thing.**
- This course covers **Bulldozers, Shovels, Graders, Loaders and Rollers**



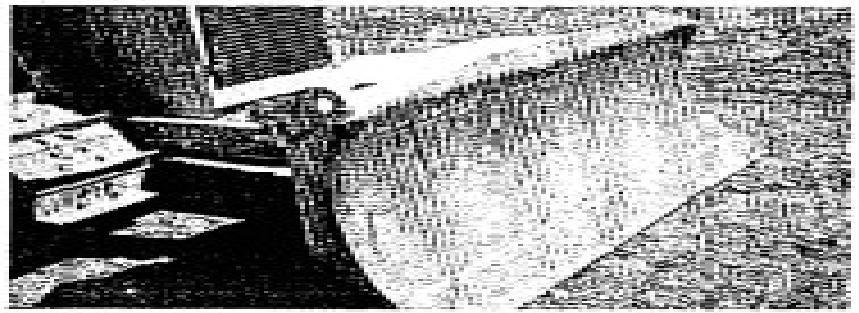
Bulldozers (Dozers): **are tractors power units with low center of gravity (a prerequisite for an effective machine) which possess attached blades.**

Bulldozers (Dozers)

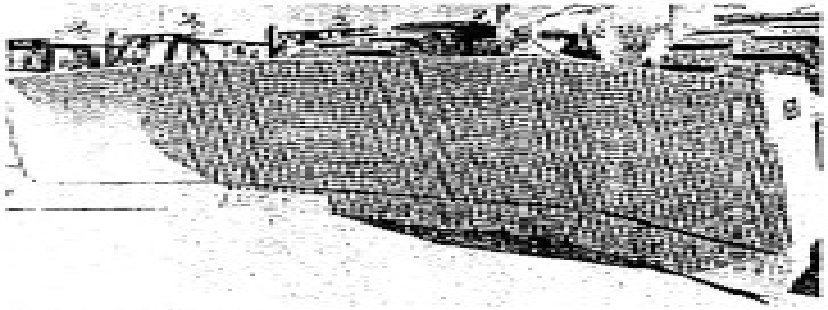
- Basically, a bulldozer possesses **three main parts: a tractor, a blade and a cutting edge**.
- The tractor is the main power which has blade for pushing, shearing, cutting, rolling materials ahead of the dozers.
- Blades are of different types: **Straight, Angle, Universal and Cushion** blades.



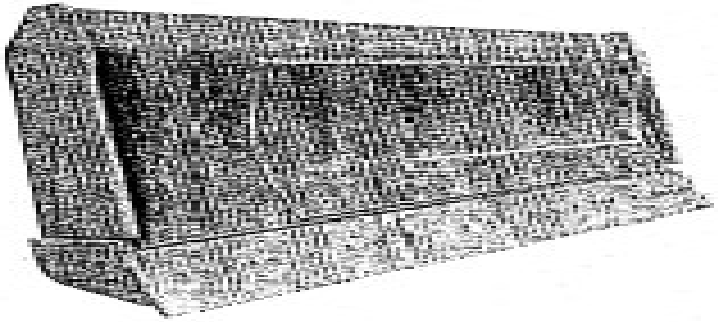
Straight blade



Angle blade



Universal blade



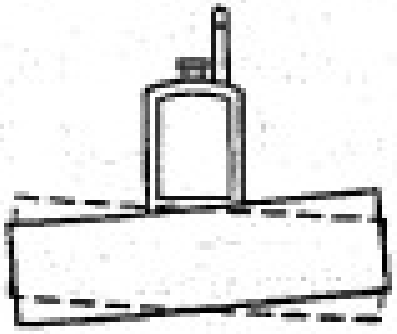
Cushion blade

Bulldozers (Dozers)

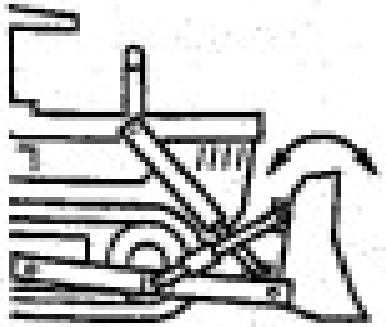
- **Three kinds of movements are possible with the blade; that is, Tilting [1], Pitching [2]and Angling[3].**
  - **Tilting - Tilting the blade is used to break hard materials.**
  - **Pitching - Forward Pitching is used to roll materials forward and Backward Pitching is used to increase depth of cut.**
  - **Angling - this is used to push materials sideways.**
- **See figure Below.**

Bulldozers (Dozers)

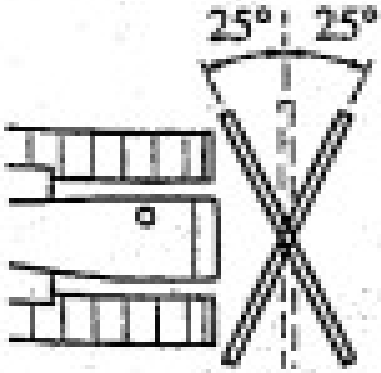
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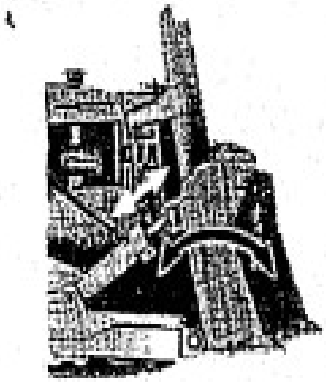


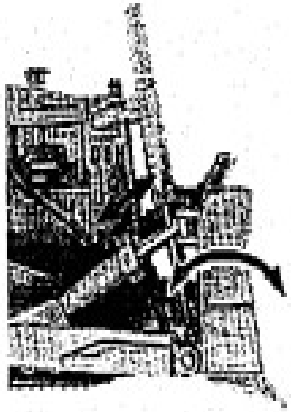
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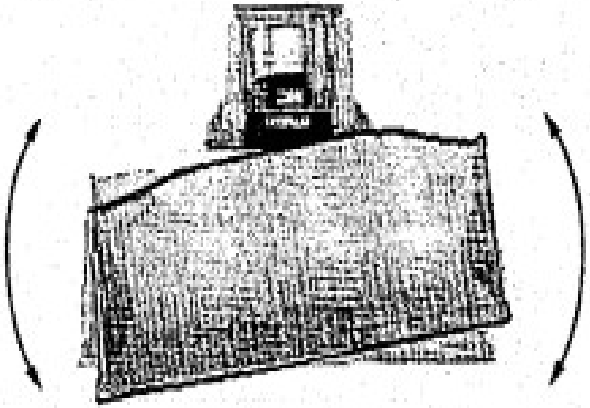
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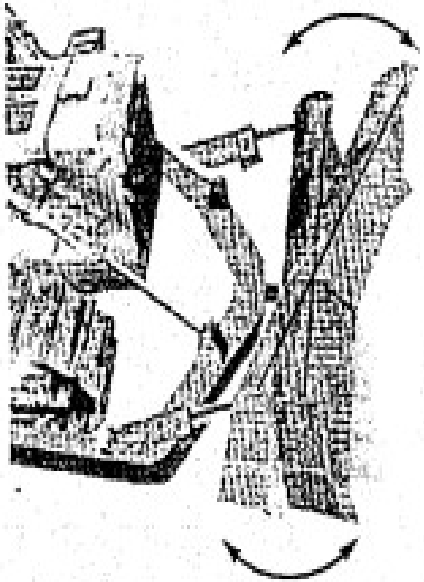




Pitching



Tilting



Angle

Bulldozers (Dozers)

- Factors that affect dozer productivity are **blade type, type and condition of material and cyclic time.**
- Based on their utilization these are





Utilization comparison between *Wheel Dozers* and *Crawler Dozers*

Wheel Dozers	Crawler Dozers
✓Good on concrete and firm and abrasive soils with no sharp edged pieces	✓Can work on variety of soils including sharp edged pieces where fine sand increases running speed
✓Best for level and Downhill works	✓Can serve over almost all terrains
✓Slow or stop operation when wet weather causing soft and slick surfaces	✓Can work on soft ground and over mud-slick surfaces with its special low ground pressures provisions
✓Good for long travel distances	✓Good for short work distances
✓Best in handling loose soils	✓Can handle tight soils
✓Fast return speeds	✓Slow return speeds (almost by





Shovels: **are equipments used for excavating (hard digging) all classes of earth except solid rocks.**

- **It can also be used for loading haul units.**
- **Shovels can be front shovels or back shovels.**
- **Back shovels are often refereed as Back hoes used to dig below its ground level.**
- **While front shovels are used to excavate earth above ground level.**
- **The optimum depth of cut for a back hoe is usually in the range of 30 to 60% of the machines maximum digging depth.**

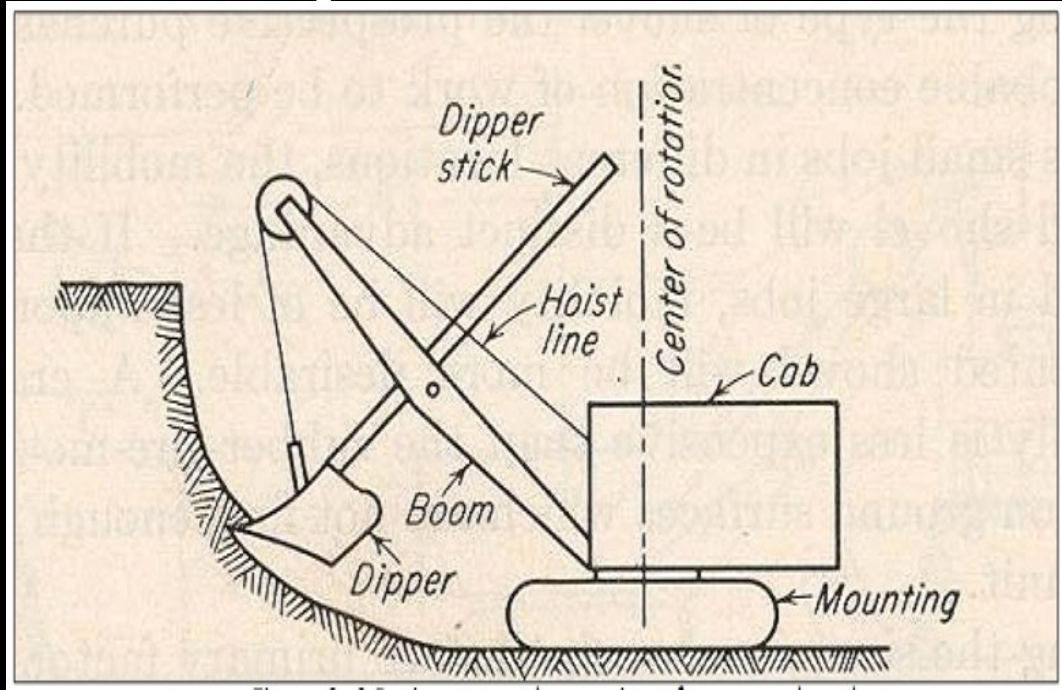
Video: Back hoe/Back Shovel



Shovels

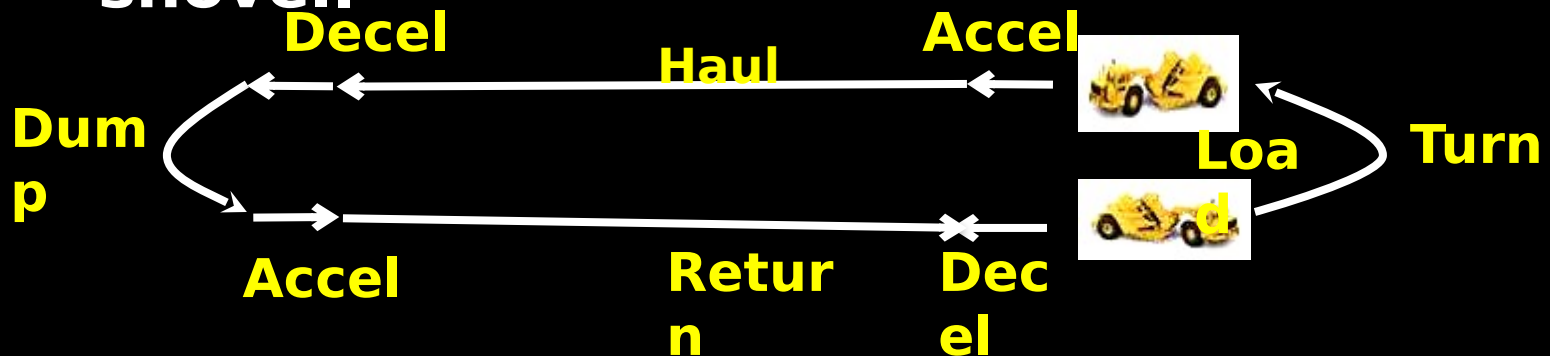
- The basic parts of a shovel include the mounting, the cab, the boom, the stick and the bucket/Dipper.
- Most shovels are crawler mounted and have very slow travel speed.
- Its size is expressed by the size of the





Shovels

- There are four elements in the production (digging – loading) cycle of a front shovel: Dig Earth and Load bucket (7 – 9 sec), Swing with load (4 – 6 sec), Dump Load (2 – 4 sec), and Return swing (4 – 5 sec).
- Travel is limited (average in between 20 bucket loads) to moving into or along the excavation work.
- Back hoes cycle times are approximately 20% longer in duration than a front shovel.



Video: *Loader and Dump Truck*

Shovels

- **Optimum depth of cut:** The 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**.
- 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**.

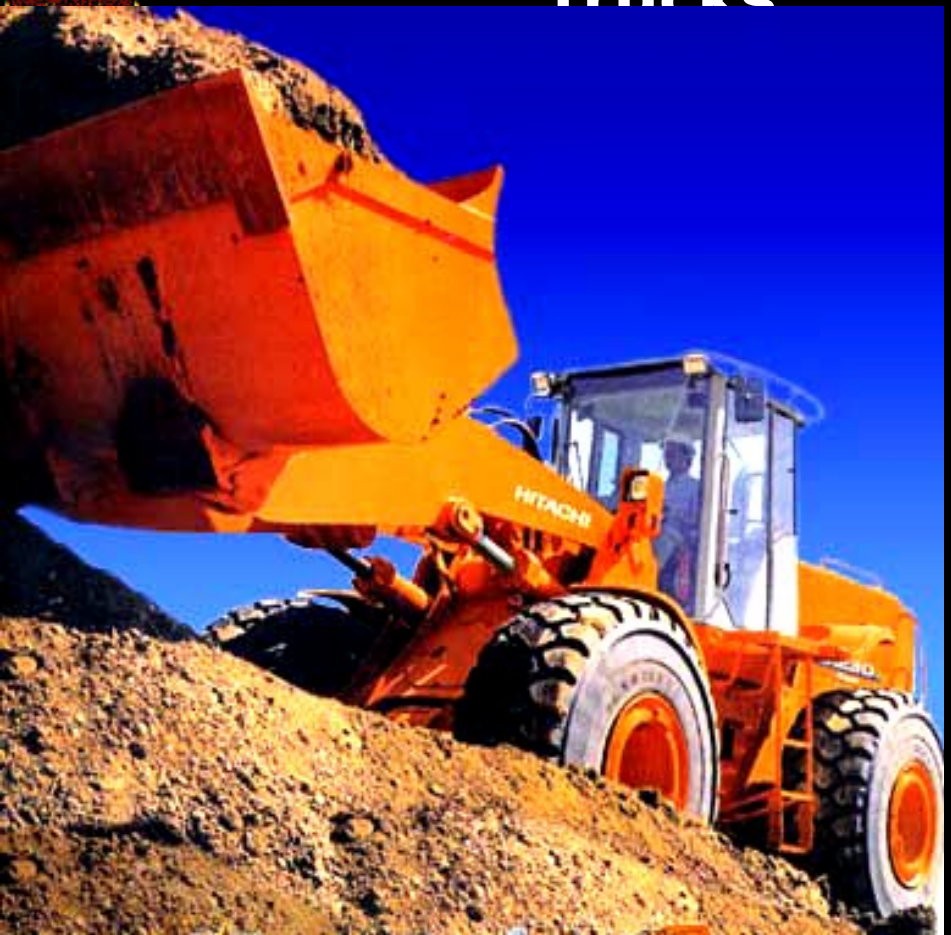
Shovels

Output of Shovels

- As the depth is increased, the output of the hoe will decrease considerably.
- The most effective digging action occurs when the bucket (dipper) stick is at right angles to the boom.
- The greatest output will be obtained if digging is done near the machine, because of the reduced cycle time, and because the material rolls back into the bucket better when the dipper is pulled upward near the machine.

Earthwork Equipments

Loaders: are used both to **excavate** (at or above wheel/track level) and **transport** bulk materials to load trucks





Earthwork Equipments

- They can either be crawler or wheel tractor mounted attached with a shovel type bucket and a forklift.
- They possess up to 40° articulated swing angle both to the right and left.
- Attachments available for the loader include backhoes, crane booms, dozer and blades and forklifts.
- Some models of wheel loaders are designed as a combination of a backhoe and loader and often called backhoe loader.

Earthwork Equipments

Graders: **are multipurpose machines used for finishing, shaping, bank sloping and ditching.**

- **They are also used for mixing, spreading, side casting, leveling, light striping operations, general construction and drift road maintenance.**
- **mary work is cutting and s with the blade often called**



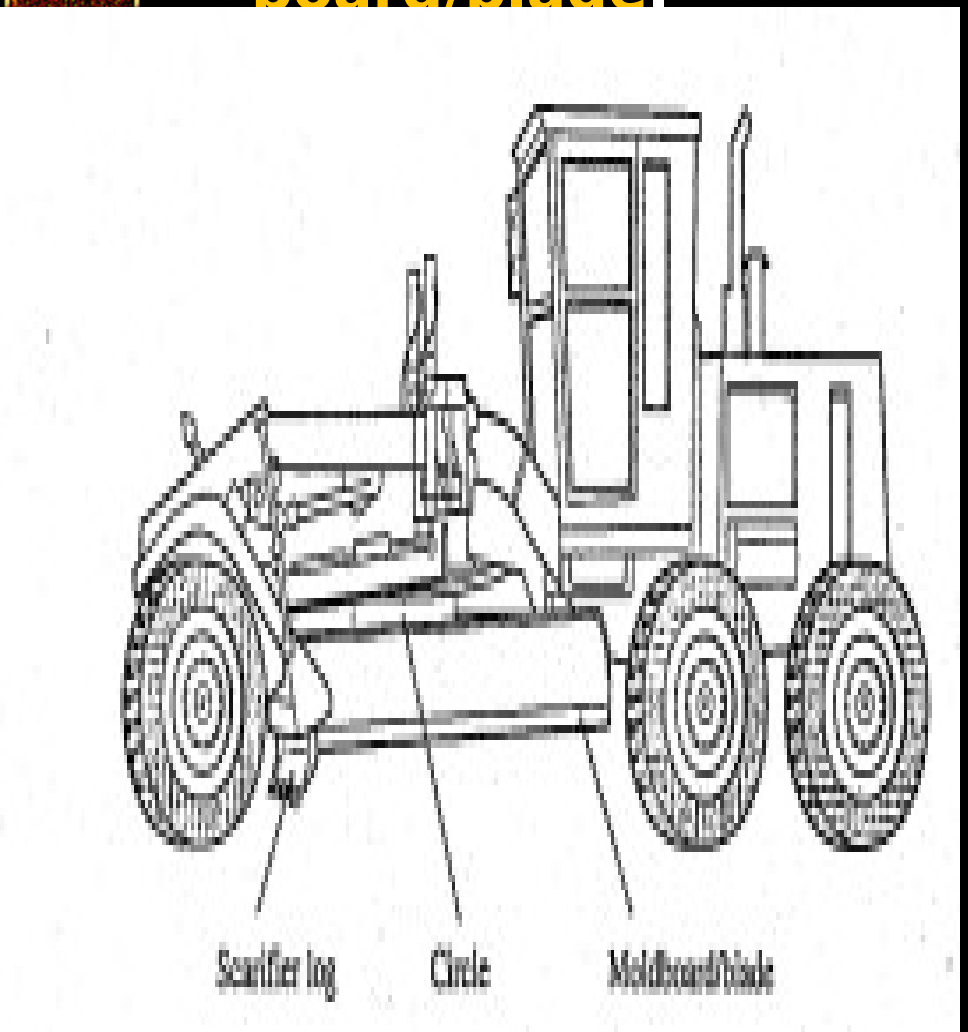
- **It is restricted to make shallow cuts and ditches in a medium hard earth conditions and should not be used for heavy excavation works.**

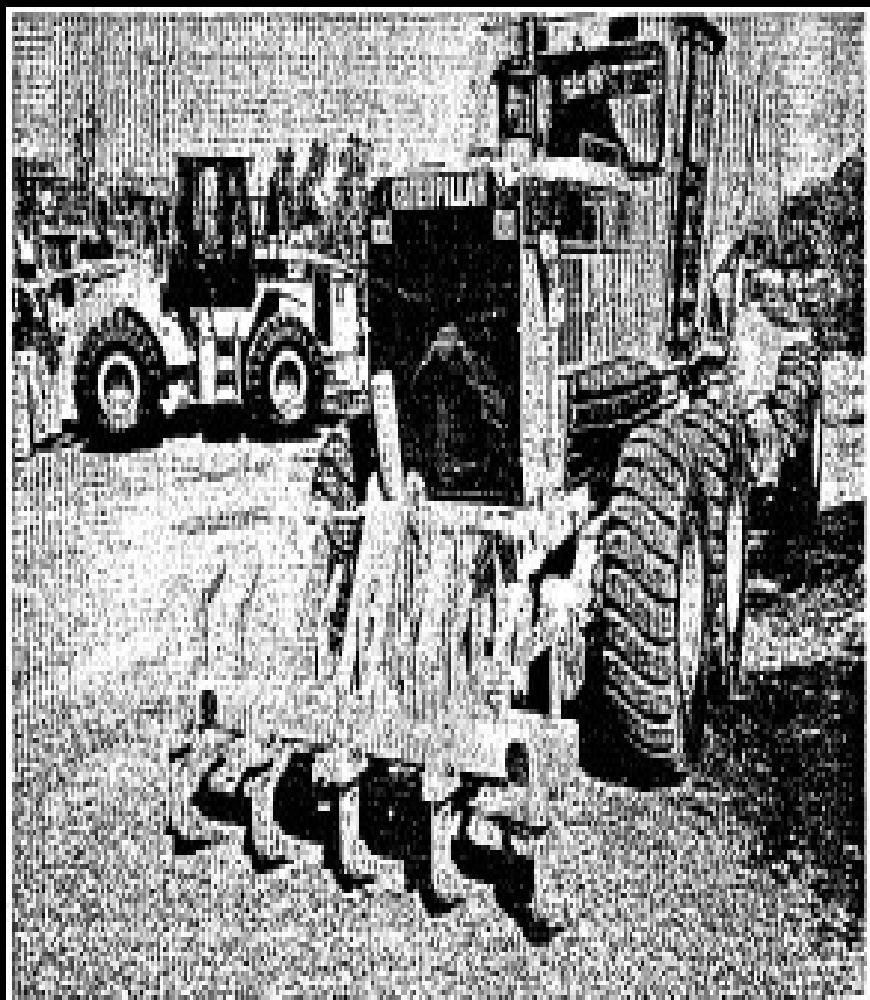
Movie: *Grader*



Grader

- Graders are often mounted with **scarifier**, **light-weight rear mounted rippers** and the **mold board/blade**.





Earthwork Equipments

Rollers: **are used for earth compactions to increase its density.**

- **Plain steel, vibrating, tamping, pneumatic rollers are some examples.**
- **They can be either manually or mechanically or electrically operated.**



Rollers

- The basic forces used in compaction are **static weight, kneading, impact** and **vibration**:
  - **Static weight** – Pressure
  - **Kneading** – manipulation or rearranging
  - **Impact** – sharp blow and
  - **Vibration** - shaking
- The degree of compaction that may be achieved depends on the
  - **properties of soil,**
  - **its moisture content,**
  - **the thickness of the soil and**
  - **method** of compaction.

Rollers

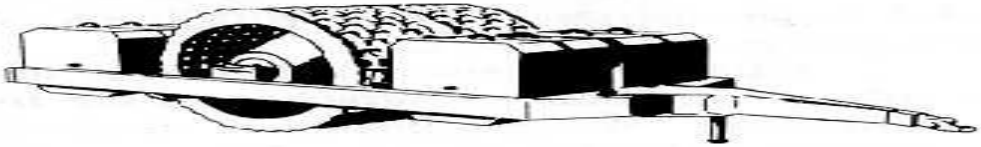
- In addition manually operated vibratory – **plate compactors** are commonly used for consolidating soils and asphalt concrete in locations where large units are not practical.
- Some major types of rollers with different operating characteristics are:
  - **Sheepsfoot Rollers**
  - **Tamping Rollers**
  - **Smooth drum vibratory soil compactors**

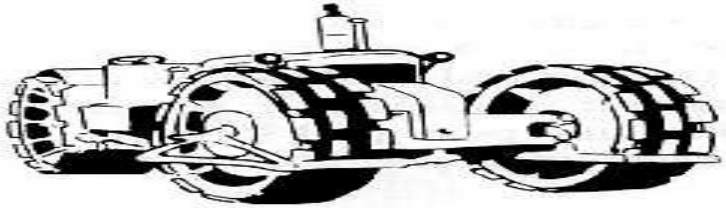
Rollers



TOWED SHEEPSFOOT ROLLER

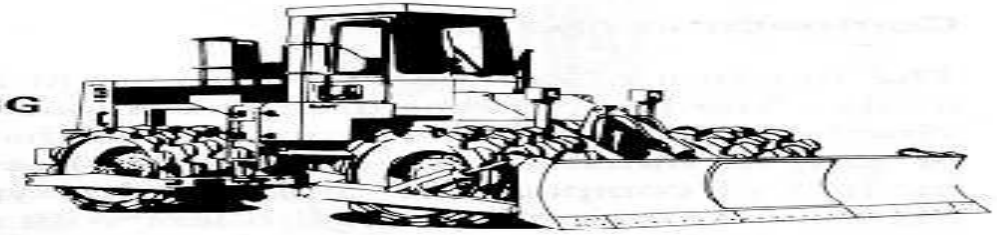
GRID ROLLER

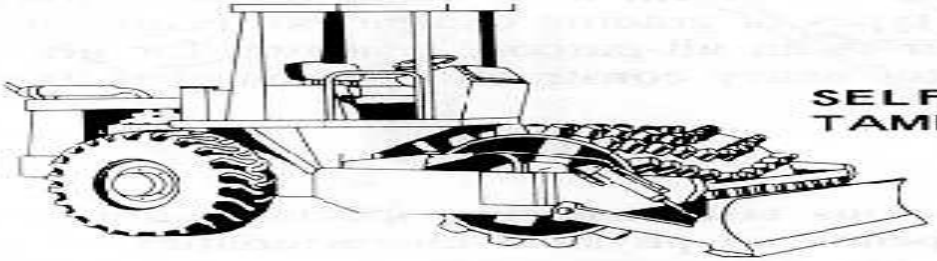




SELF-PROPELLED SEGMENTED STEEL WHEEL ROLLER

SELF-PROPELLED TAMPING FOOT ROLLER





SELF-PROPELLED VIBRATORY TAMPING FOOT ROLLER

Video: Dynamic Compaction

2. Hauling & Hoisting Equipments

- are used **to haul/transport materials** for relatively longer distances.
- This part covers **Dump Truck** hauling Equipment.

Dump Trucks: are hauling equipments with a provision for either rear or bottom or side dumping of their loads operated by either **rigid** or **articulated** frames for dumping.



- Truck productivity is dependent on **loading, hauling, dumping and returning** productivities

Video: Dump Truck and Loader



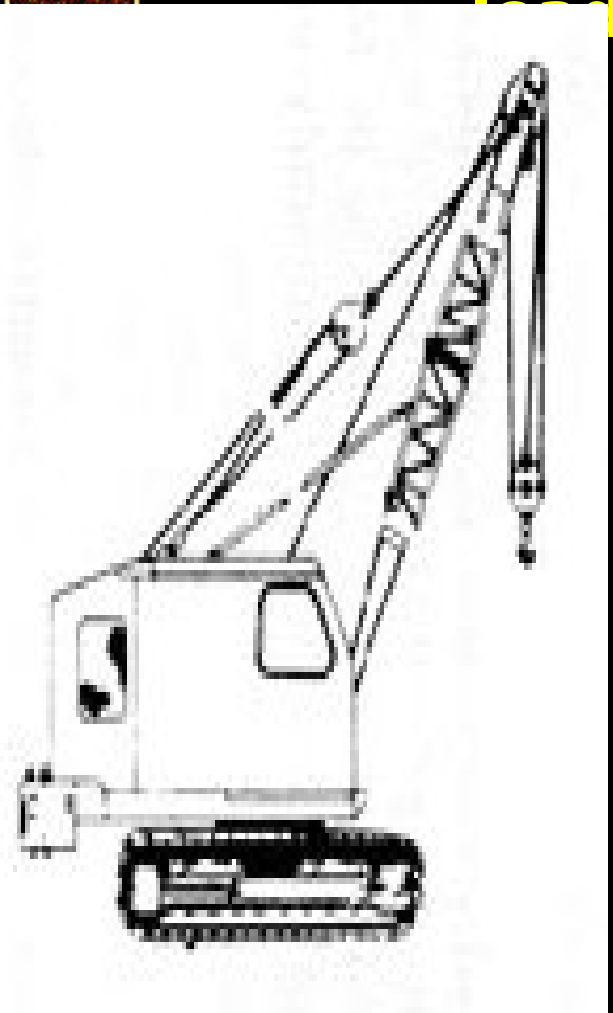
Dump Truck

- The **articulated dump** truck is specifically designed to operate over rough or soft ground which posses a joint with an oscillating ring between the tractor and dump body permit all wheels to maintain contact with the ground at all times.
- In addition, articulated dump trucks can operate on steeper grades of up to **35%**, gate



Hauling & Hoisting Equipments

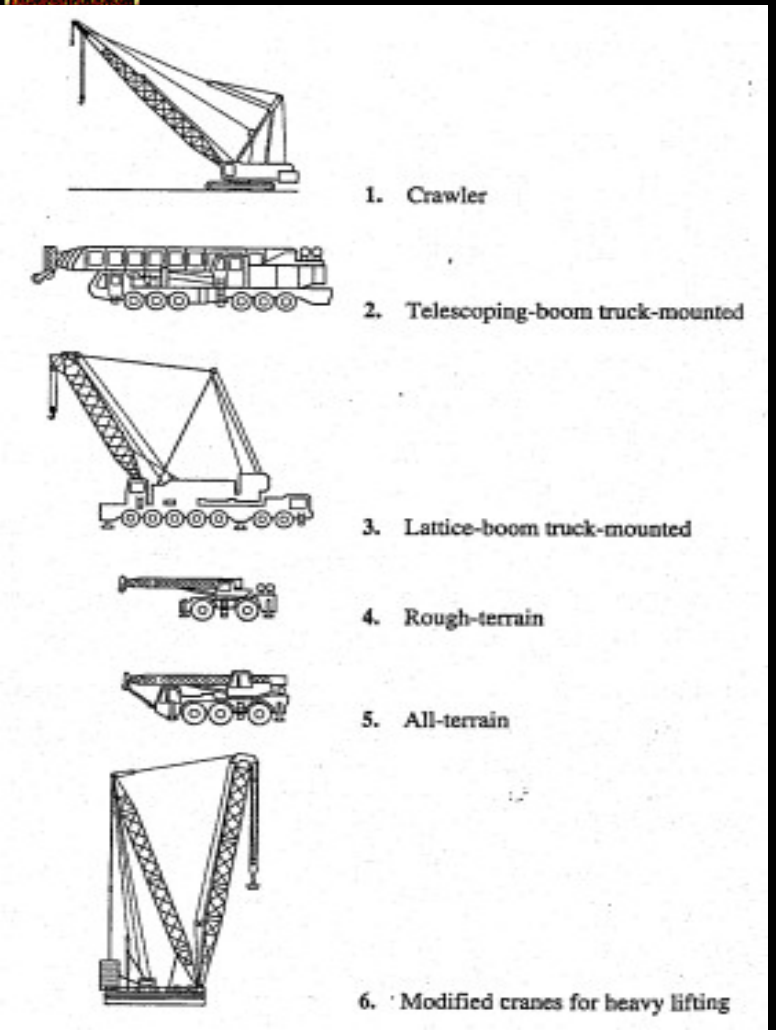
Cranes: **are a broad class of construction equipment used to hoist and place loads.**



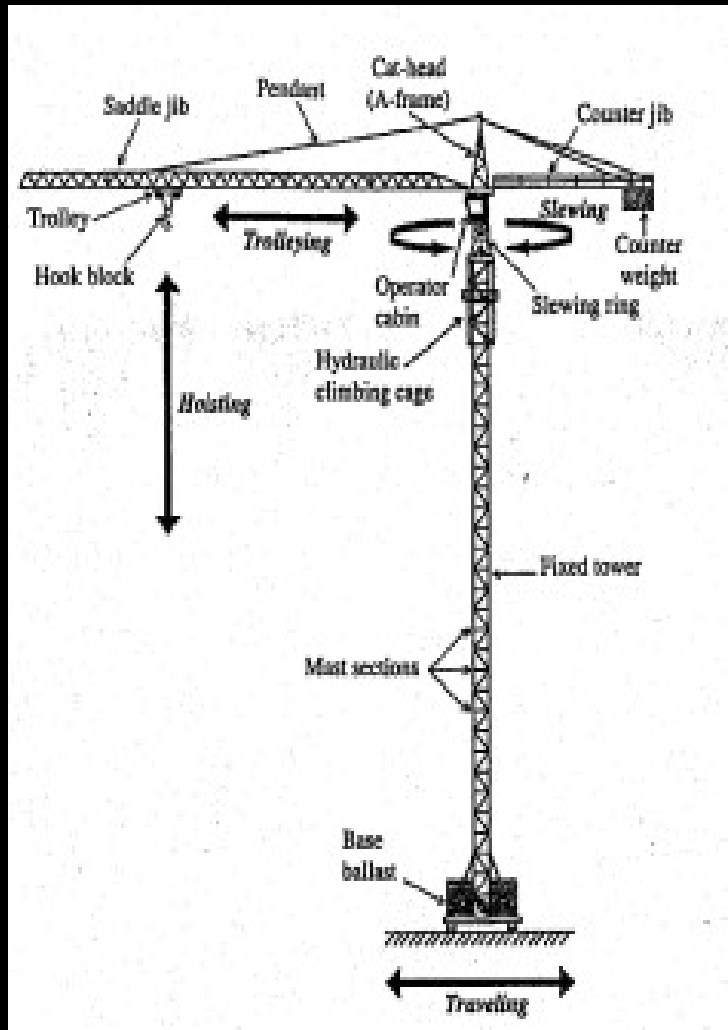
- **Construction cranes are generally two types: mobile and tower cranes.**
- **Its structural strength and tipping moment are the two major factors for its lifting and hoisting capacity.**
- **Tower cranes provide higher lifting height and good working radius while taking up a very limited area but with low lifting capacity and**

Cranes

- **Mobile Crane types, Mobile crane with tower attachment and its nomenclature**







Cranes

- The major factor controlling the load that may be safely lifted by a crane is its operating radius (horizontal distance from the center of rotation to the hook).
- Safety regulations limit maximum crane load to a percentage of the tipping load (load that will cause the crane to actually begin to tip).

3. Concrete & Asphalt Works Equipment

- Concrete works involve six operational activities.
- These are **batching** the materials, **mixing, transporting, placing, consolidating, finishing** and **curing** works.
- Asphalt works are also involved in several operations which require equipments.
- These include **Milling machines** removing an old asphalt pavement, **Sweeper/Brooms** for removing dust, **Hauling trucks**, **Asphalt distributor** for applying primer tack and seal coats, **pavers** and **rollers**.
- For the purpose of this course **mixers, vibrators, pavers** and **compactor** are

Concrete Works Equipment

Mixer:

- Mixing is of three types: Central, Transit and On-Site mixing.
- The central and transit mixing is called the batching.
- Therefore, here only On-Site mixing is covered.

On-Site Mixers: are construction equipments which help to mix the different components of a concrete using a combination of **electro-mechanical** system.

- On-Site Mixers vary in **capacity** and smaller once are fed with their components manually.

On-Site Mixer





Vibrator

- ***Vibrators*** **are used to consolidate concrete because concrete as a heterogeneous mixture of water and solid particles in a stiff condition, it will normally possess a large amount of voids when placed.**
- **These voids will be filled with entrapped air and are not good for the workability of the concrete therefore they need to be out.**
- **One way to get out such entrapped air is by compacting or consolidating concrete using vibrators.**
- **Vibrators can be of internal, surface and form vibrators which are operated by electro – or compressed air and mechanical systems.**

Vibrator

- ***Internal or Spud vibrators:*** **have often a rotary vibrating casing or head that is immersed into the concrete and vibrate the concrete at a high frequency (10,000 – 15,000 vibrations per minutes).**
- **Internal vibrators are best suited for ordinary construction with large sections enabling insertion of the vibrator head one and half times so that its effective radius of action is achieved.**
- **Vibrators are not used to move concrete laterally because they will cause segregation of aggregates hence they need to be inserted as rapidly as possible.**
- **To decrease the effect of Over-Vibration, the**

Vibrator

- ***Surface vibrators:*** **it exert their effects at the top of the concrete surface to consolidate from top to bottom.**
- **These kinds of vibrators are used for thin surfaces like concrete slabs.**
- **They operate in the range of 3000 – 6000 vibrations per minute.**
- ***Form vibrators:*** **are external vibrators attached to the formworks or molds forming the concrete.**
- **There use is associated with large pre fabricated or pre cast construction plants.**

Video: *Vibrator*



Asphalt Works Equipment

Pavers: **can either be Asphalt or Concrete Paving.**

- **Both use Construction equipment called Pavers such as Slip-form pavers whose functions are spreading, vibrating, striking off, consolidating, and finishing pavement ped cross section and m manual work.**



- **It is a speedy and economical way for producing smooth and durable asphalt and**

Asphalt Works Equipment



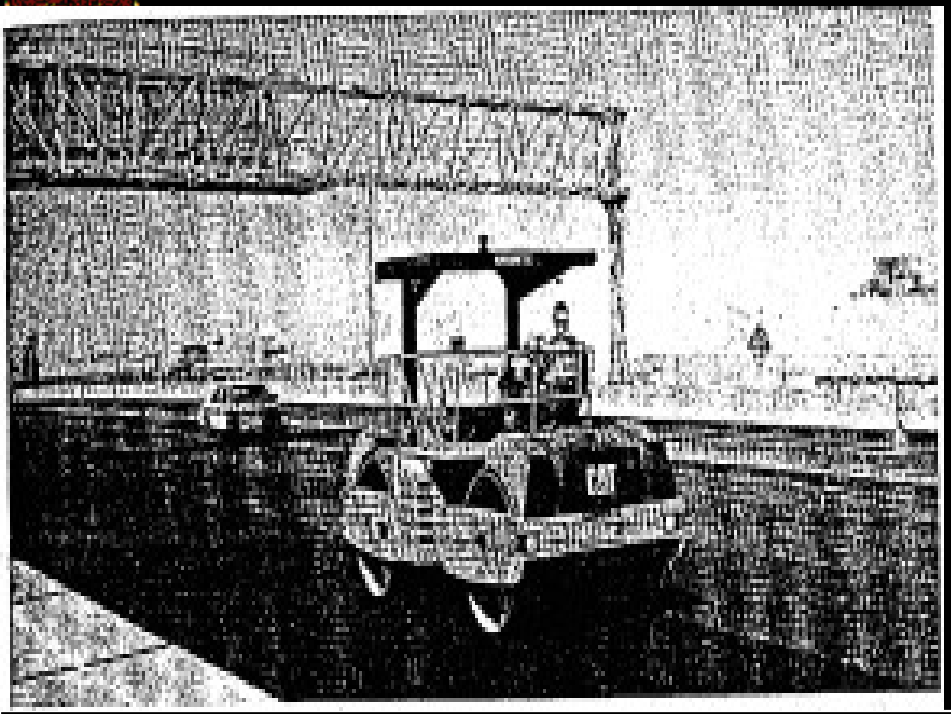
Asphalt in use to resurfacing



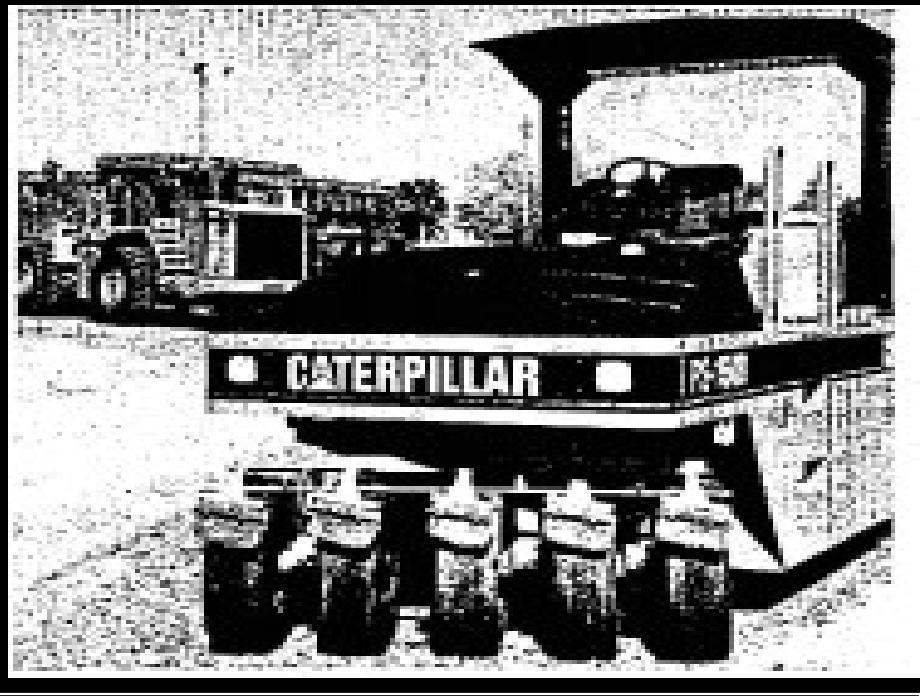
Machine laying asphalt concrete fed from a dump truck

Asphalt Works Equipment

Asphalt Compactor: can either be smooth drum steel wheel and pneumatic tire compactor.



smooth drum steel wheel Asphalt compactor



Pneumatic tire Asphalt compactor

4. Pumping Equipments

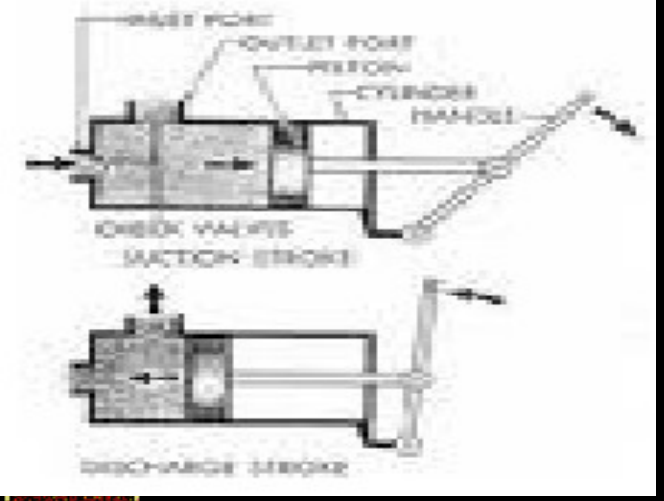
- This includes **Pumps, Hozes, Pipes, and Compressors**.
- Pumps are used extensively on construction projects for such operations as:
  - **Removing** water from pits, tunnels, and other excavations
  - **Dewatering cofferdams**
  - **Furnishing** water for **jetting** and **sluicing**
  - **Furnishing** water for many types of utility services
  - **Lowering the water table** for excava tions

Pumping Equipments

- The factors that should be considered in ***Selecting Pumps*** for construction application includes:
  - **Dependability**
  - **Rate** at which the water must be pumped
  - **Altitude** of the project
  - **Size** of the pipe to be used
  - **Height** of the pump and **lift** from the water surface
  - **Number, sizes** and **types** of **fittings** and **valves** in the pipeline
  - **Availability** of **repair parts**
  - **Simplicity** to permit easy **repairs**
  - **Economic installation** and **operation**
  - **Operating power** requirements

Classification of pumps

- The pumps commonly used on construction projects can be classified as ***Displacement*** and ***Centrifugal.***
- A reciprocating pump operates as the result of the movement of a **piston** inside a cylinder.
- When the piston is moved in ***one direction***, the water ahead of the piston is forced out of the cylinder.
- If water is pumped during a piston movement in one direction only, the pump is classified as **single acting**.
- If a pump contains more than one cylinder, mounted side by side, it is classified as a **duplex for two cylinders, triplex for three**



Displacement Pumps

- Thus, a pump can be classified as a **duplex double-acting** or a **duplex single-acting**.
- The capacity of a reciprocating pump depends essentially on the **speed** at which the pump is operated and is **independent of the head**.
- The maximum head at which a reciprocating pump will deliver water depends on the ***strength*** of the component parts of the pump and the ***power*** available to operate the pump.
- The **capacity** of this type of pump may be varied considerably by varying the **speed** of

Displacement Pumps

- **Advantages**
  - They are able to pump at a *uniform rate against varying heads*.
  - Increasing the *speed* can increase their capacity.
  - They have reasonably high *efficiency* regardless of the head and speed.
  - They are usually self-priming.
- **Disadvantages**
  - Heavy weight and large size for given capacity.
  - Possibility of valve trouble, especially in pumping water containing *abrasive solids*.
  - Danger of *damaging a pump* when operating against a high head.

Centrifugal Pumps

- A centrifugal pump contains a rotation element, called an *"impeller,"* that imparts to water passing through the pump a velocity sufficiently great to cause it to flow from the pump even against considerable pressure.
- A mass of water may possess energy due to its height above a given datum or due to its velocity.
- The former is potential, while the latter is kinetic energy.
- One type of energy can be converted into the other under favorable conditions.
- The kinetic energy imparted to a particle of water as it passes through the impeller is

Centrifugal Pumps

- A centrifugal pump may be equipped with either an open or enclosed impeller.
- Although an enclosed impeller usually has *higher efficiency*, it will *not handle water containing trash* as well as an open impeller.
- The *power* required to operate a centrifugal pump is given by several *equations*.
- The efficiencies of these pumps may be as high as 75%.
- Because of their high efficiency factors, they will *pump a greater volume with lower fuel consumption* as compared to other

Centrifugal Pumps

- A centrifugal pump will pass a spherical solid one-quarter (1/4) the size of the suction opening.
- As an example, a 2-in. pump can pass ½-in.-size solids.
- These pumps can typically pass up to 10% by v



General Introduction and Principles

- **Equipment Productivity:** implies the ***output or efficiency*** of the equipment while it is in operation.
- **Peak Productivity**: - is the ***theoretical productivity*** governed by design limitations only.
- **Actual Productivity**: - is the productivity of an equipment ***after due consideration*** of ***...ors***.

$$Q_a = Q_{th} \times f_1 \times f_2 \times ..$$

- Equipments can be broadly classified into two based on equipment productivity concepts: ***Cyclic*** Operating or ***Continuously*** Operating.

A. Cyclic Operating Equipments

- These are machines which are intentionally or unintentionally *influenced by their operators*.
- The *theoretical productivity* can be computed

$$Q_a = V_n \times n_o \times \eta$$

Where **Qa** – Actual Productivity

Vn – Volume per cycle

η - Efficiency of the equipment

n_o – number of cycle /Unit Time

$$n_o = \frac{60}{T_o}$$

sually Time in hours)

Where **To** – theoretical cycle

A. Cyclic Operating Equipments

- The term "volume per cycle" should represent *the average volume of material moved per equipment cycle*.
- Thus the nominal capacity of the excavator or hauler unit must be modified by the appropriate fill factor based on the type of materials and the equipment involved.
- The term "number of cycle per hour" must include any appropriate efficiency factors, so that it represents the number of cycles actually achieved (or excepted to be

B. Continuously Operating Equipments

- These *are machines that continuously operate*, like pumps, etc. For these kinds of m

$$Q_a = V_n \times a \times n_o \times 60 \times \eta \quad [m^3/hr]$$

Where **Qa** – Actual Productivity

Vn – Volume per bucket

a - Number of buckets

η - Efficiency of the equipment

n_o – number of cycle /Unit Time (usually Time in hours)

Productivity of Excavation and Earthwork Equipments

General Soil Characteristics

- From the characteristics of soils **traffic ability, load ability** and **volume change** are vital for ear th works. Accordingly,
  - **Trafficability -** property that shows th e ability of soil to support repeated traffic loading
  - **Loadability -** property that tells the e ase or difficulty of excavating and loading
  - **Soil Volume Change -** property that is

Productivity of Excavation and Earthwork Equipments

Soil Volume Change Characteristics

There are **three** principal conditions or states in which earth moving 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]**

Productivity of Excavation and Earthwork Equipments

Soil Volume Change Characteristics

- **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]

Productivity of Excavation and Earthwork Equipments

Relationships between the three states

Swell: - an increase in volume of soil due to excavation

$$Swell\ (\%) = \frac{Loose\ Volume - Bank\ Volume}{Bank\ Volume} x\ 100$$

Shrinkage: - this is a decrease in volume of soil due to compaction

$$Shrinkage\ (\%) = \frac{Bank\ Volume - Compacted\ Volume}{Bank\ Volume} x\ 100$$

Productivity of Excavation and Earthwork Equipments

Relationships between the three states

- ✓ In performing earthmoving calculations, it is important to convert all material ***volumes' to common unit of measure***.
- ✓ Although the ***bank cubic meter*** **BCM** is most commonly used for this purpose, any of the three volume units may be used.

Productivity of Excavation and Earthwork Equipments

Relationships between the three states

- ✓ A **pay load** is the volume unit specified as the basis for payment in an earth moving contract.
- ✓ It is usually the bank volume.
- ✓ The factor used to convert **loose volume to bank** is called the ***load factor*** and the factor converting **bank to compacted** volume is called **the *shrinkage factor.***

Productivity of Excavation and Earthwork Equipments

Relationships between the three states

Load and Shrinkage Factors: -

Load factor: - is the ratio of bank volume to loose volume.

fL (load factor) =VB/VL

$$fL = \frac{1}{1 + swell}$$

Shrinkage factor: - is the ratio of compacted volume to bank volume.

fS (shrinkage factor) = VC/VB
= [1- shrinkage]

Productivity of Excavation and Earthwork Equipments

Factors affecting selection of Excavation and Earthwork Equipments include:

1. **Output of excavators**: The size and characteristics of the excavators selected will determine the output volume excavated per day.
2. **Distance to dump site**: Sometimes part of the excavated materials may be piled up in a corner at the job-site for use as backfill.
3. **Probable average speed**: The average speed of the haulers to and from the dumping site will determine the cycle time for each hauling trip.
4. **Volume of excavated materials**: The volume of excavated materials including the part to be piled up should be hauled away as soon as possible.
5. **Spatial and weight constraints**: The size and weight of the haulers must be feasible at the job site and over the route from the construction site to the dumping area.

Productivity of Shovel Family

- The **actual productivity** of the shovel family is ***dependent on the actual volume per cycle and the cycle time***.
- Thus, to compute the actual productivity one should be able to make a good estimate of the ***actual bucket capacity*** (which depends on the soil characteristics) and the ***cycle time***.
- The actual productivity can be computed as:

$$Q_a = V_h x\, n_o x \eta$$

Productivity of Shovel Family

- To utilize this Equation for estimating the production of shovel family or an excavator, it is necessary to know ***the volume of material actually contained in one bucket load***.
- The methods by which **excavator bucket and dozer blade capacity** are rated are given in Table below.

Machine	Rated Bucket Capacity
• Backhoe and shovel ✓ Cable ✓ Hydraulic	– Struck Volume – Heaped Volume at 1:1 angle of repose
• Clamshell	– Plate line or water line volume
• Dragline	– 90% of struck volume
• Loader	– Heaped volume at 2:1 angle of repose

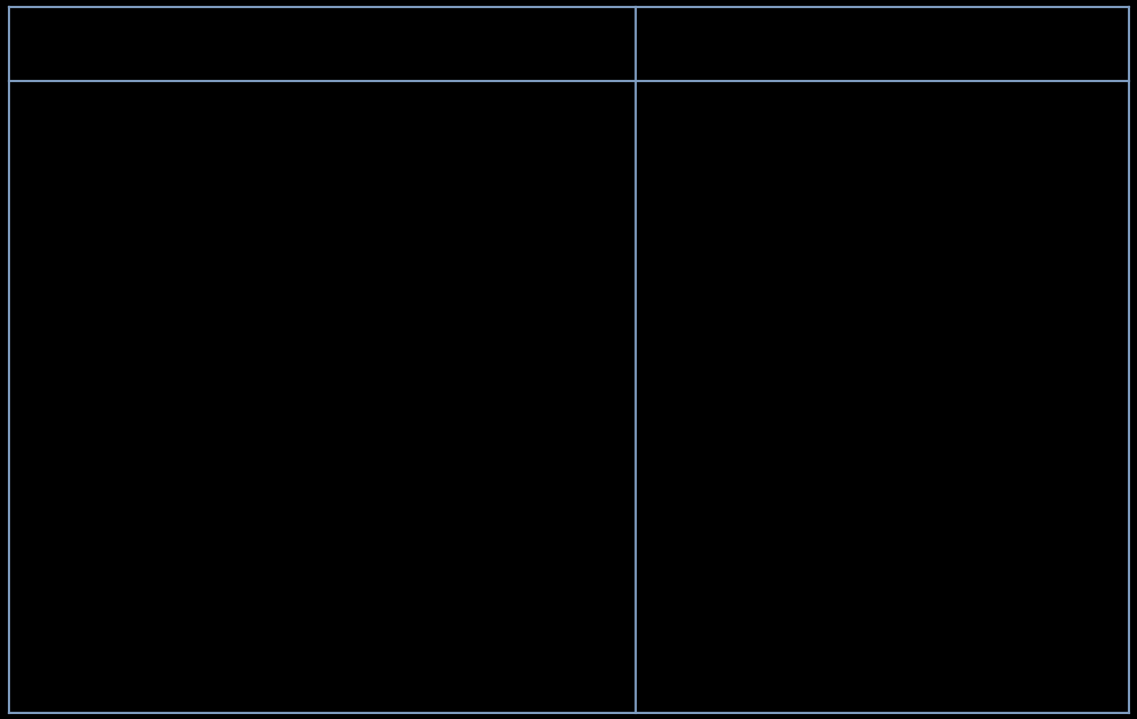
Productivity of Shovel Family

- **Plate line capacity** is the bucket volume contained within the bucket when following the outline of the bucket sides.
- **Struck capacity** is the bucket capacity when the load is struck off flush with the bucket sides.
- **Water line capacity** assumes a level of material flush with **the lowest edge of the bucket** (i.e., the material level corresponds to the water level that would result if the bucket were filled with water).
- **Heaped volume** is the maximum volume that can be placed in the bucket without spillage based on **a specified angle of**

Productivity of Shovel Family

- Since **bucket ratings** for the **cable shovel, dragline, and cable backhoe** are based on ***struck volume***, it is often assumed that the heaping of the buckets will compensate for the swell of the soil.
- That is, a 5m^3 bucket would be assumed to actually hold 5 bank m^3 of material.
- A better estimate of the volume of material in one bucket load will be obtained if the nominal bucket volume is multiplied by a **bucket fill factor or bucket efficiency factor.**
- Suggested values of bucket fill factor for common soils are given in Table below.

Productivity of Shovel Family



- The most accurate estimate of bucket load is obtained by multiplying the heaped bucket volume (loose measure) by the bucket fill factor.
- If desired; the bucket load may be converted to bank volume by multiplying its loose volume by the soil's load factor.

Productivity of Shovel Family

- Production of a hydraulic excavator may be estimated by using Equation below together with Tables below, which have been prepared from manufacturers' data

$$Q_a = V_n x n_o x S x B x \eta$$

Where Qa – Actual Productivity (m3/hr)

Vn – heaped bucket volume

no – Cycles per hour (Table 3)

S – Swing depth factor (Table 4)

B – Bucket fill factor (Table 2)

η – Job efficiency

2. Chapter Two.doc

Productivity of Shovel Family

Example 1:

- Estimate the actual bucket load in bank cubic meters for a loader bucket whose heaped capacity is 3.82m3. The soil's bucket fill factor is 0.90 and its load factor is 0.80.

Solution

Bucket load = Bucket Volume x B.F. F x fL

= 3.82 Lm3 x 0.90 x 0.80

= 2.75 Bm3

Productivity of Shovel Family

- It should be noted that a ***cycle time*** is the sum of **fixed cycle time and variable cycle time**.
- **Variable time** represents those components of cycle time related with travel time.
- **Fixed time** represents those components of cycle time other than travel time.
- **Fixed Cycle time** represents the time required to maneuver, change gears, start loading, and dump.
- **Variable Cycle time** is the time required to excavate and travel to load and travel to return to original position after loading.

Productivity of Shovel Family

Example 2:

- Find the expected production in loose cubic meter (LCM) per hour of a small hydraulic excavator. Heaped bucket capacity is 0.57 m3. The material is sand and gravel with a bucket fill factor of 0.95. Job efficiency is 50 min/h. Average depth of cut is 4.3m. Maximum depth of cut is 6.1m and average swing is 90.

Solution

- Cycles per hour = 250 Cycles / 60 min (Table 3)
- Swing Depth Factor S= 1.05 (Table 5)
- Bucket Fill Factor B= 0.95
- Bucket Volume = 0.57 Lm3
- Job Efficiency = 50/60 = 0.833
- Qa = 0.57 m3 x 250 cycles / hr x 1.05 x 0.95 x 0.833

$$Q_a = V_n x n_o x S x B x \eta$$

Productivity of Dozers

- The basic earth moving production equation 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 severa

$$\text{Blade Load}\,(Lm^3) = 0.375 x H(m)\, x W(m) x L(m)$$

- ***Blade volume*** can be computed by using

Productivity of Dozers

Example 3:

- **A power shit crawler tractor has a rated blade capacity of 7.65 Lm3. The dozer is excavating a loose common earth and pushing it a distance of 80 m. Maximum reverse speed in third range is 8 km/hr and dozing speed is 4.0 km/hr. The fixed time for a power shift transmission is 0.05 min. Estimate the production of the dozer is the job efficiency is 55 min/hr and load factor is 0.90.**

Solution: -

- **Cycle Time = Fixed Cycle Time + Variable Cycle Time**
- **Fixed Cycle Time = 0.05 min**
- **Variable Time = Dozing Time + Return Time**
- **Dozing Time = Dozing Distance / Speed = 80 m / (4 km/hr * 16.7 m/min) = 1.20 min**
- **Return Time = Return Distance / Speed = 80 m / (8 km/hr * 16.7 m/min) = 0.60 min**
- **Cycle Time = 1.20 + 0.60 +0.05 min = 1.85 min**
- **no (No of cycle per hour) = 60/1.85 = 32.43**
- **Qa = 7.65 Lm3 x 32.43 cycles / hr x 55/60 x 0.90 = 204.69 Bm3/hr ≈ 205 Bm3 / hr**

Productivity of Graders

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

$$\text{Time (hr)} = \left[\sum \frac{\text{Number of pass x Section Length(km)}}{\text{Average Speed for Section(km /hr)}} \right] x \frac{1}{\text{Efficiency}}$$

- **Average speed depends on the operator skill, machine characteristics, and job condition.**

Productivity of Graders

- Typical grader speeds for various types of operations are given in Table 7.

Operation	Speed (km/hr)
Bank Sloping	4.0
Ditching	4.0 – 6.4
Finishing	6.5 – 14.5
Grading and road maintenance	6.4 – 9.7
Mixing	14.5 – 32.2
Snow Removal	19.3 – 32.3
Spreading	9.7 – 14.5

Productivity of Graders

Example 4:

- A 25 km gravel load requires reshaping and leveling. It is estimated that six passes of a motor grader will be required.
- Based on the operator skill, machine characteristics, and job condition, estimates indicated two passes at 7 km/hr, two passes at 8 km/hr and two passes at 10 km/hr.
- If the job efficiency is 0.80, **how many grader hours will be required for this job**?

Solution:

$$\text{Time (hr)} = \left[\sum \frac{\text{Number of pass} \times \text{Section Length(km)}}{\text{Average Speed for Section(km/hr)}}\right] \times \frac{1}{\text{Efficiency}}$$

$$\text{Time (hr)} = \left[\sum \left(\frac{2\times25}{7}\right) + \left(\frac{2\times25}{8}\right) + \left(\frac{2\times25}{10}\right)\right] \times \frac{1}{0.80} = 23.0\text{hrs}$$

Compactor Productivity

- Equation below may be used to calculate compactor production **based on compactor speed, lift thickness, and effective width of comp**

$$\text{Production} \quad [\text{Cm}^3/\text{h}] = \frac{10 \times W \times S \times L}{P} \times \eta$$

Where P = number of passes required

W = width compacted per pass (m)

S = Compactor Speed (km/hr)

L = compacted lift thickness (cm)

Productivity of Loaders/Haulers

- Loader production can be estimated as the product of average bucket 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* (less than 5 m for track loaders).
- The important aspect is determining the actual travel time.
- Travel times shall be determined from manufacturer's performance curves.
- **As you would expect, travel time will depend on the vehicle's weight and power, the condition of the haul road, the grades**

Productivity of Haulers

- In calculating the time required for a haul unit to make one complete cycle, it is customary to break the cycle down into fixed and variable components.

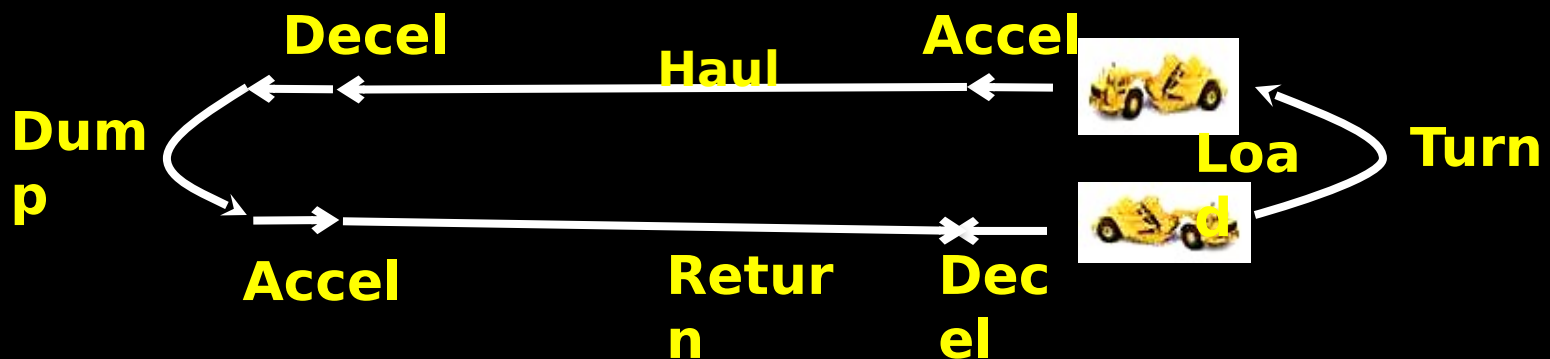
  Cycle time = Fixed time + Variable time

- **Fixed time** represents those components of cycle time other than travel time.
- Fixed time can usually be closely estimated for a particular type of operation.
- **Variable time** represents the travel time required for a unit to haul material to the unloading site and return.
- In this section methods for calculating a vehicle's **resistance to movement**, its

Cycle capacity

- The cycle capacity *C* of a piece of equipment is defined as the number of output units per cycle of operation under standard work conditions.
- The cycle time *T* refers to units of time per cycle of operation.
- The standard production rate *R* of a piece of construction equipment is defined as the number of output units per unit time.

$$R = \frac{C}{T} \quad or \quad T = \frac{C}{R}$$



Daily standard production rate of excavator



- The daily standard production rate P_e of an excavator can be obtained by multiplying its standard production rate R_e by the number of operating hours H_e per day.

$$P_e = R_e H_e \quad or \quad P_e = \frac{C_e H_e}{T_e}$$

Daily standard production rate of a hauler



- In determining the daily standard production rate of a hauler, it is necessary to determine first the cycle time from the distance ***D*** to a dump site and the average speed ***S*** of the hauler.
- Then the travel time for the round trip is given by:

$$T_t = \frac{2D}{S}$$

Daily standard production rate of a hauler

- The **loading time (To)** is related to the cycle time of the excavator T_e and the relative capacities C_h and C_e of the hauler and the excavator respectively.
- In the standard case:

$$T_o = T_e \frac{C_h}{C_e}$$

Daily standard production rate of a hauler

- Let T_t be the **travel time** for the round trip to the dump site, T_o be the **loading time** and T_d be the **dumping time.**
- For a given **dumping time** T_d, the **cycle time** T_h of the hauler is given by:

= Roun + Loading time (Td).

$$T_h = \frac{2D}{S} + T_e \frac{C_h}{C_e} + T_d$$

Daily standard production rate of a hauler

- The daily standard production rate P_h of a hauler can be obtained by multiplying its standard production rate R_h by the number of operating hours H_h per day.

$$P_h = R_h H_h = \frac{C_h H_h}{T_h}$$

Number of haulers required

- Then the approximate number of haulers required to dispose of the excavated materials is given by:

$$N_h = \frac{wP_e}{P_h}$$

- **w** denote the swell factor of the soil
- **wPe** denotes the daily volume of loose excavated materials
- **Pe** denote excavation volume.

Actual Equipment productivities

- Equipment productivities at job sites are influenced by **actual work conditions** and a **variety of inefficiencies** and **work stoppages**.
- If the conditions that lower the standard production rate are denoted by ***n*** factors F_1, F_2, ..., F_n, each of which is smaller than 1, then the actual equipment productivity ***R'*** at the job site can be related to the standard production rate ***R*** as follows:

$$R' = RF_1F_2F_3 \dots F_n$$

Actual cycle time

- The cycle time ***T'*** at the job site will be increased by these factors, reflecting actual work conditions.
- If only these factors are involved, ***T'*** is related to the standard:

$$T' = \frac{T}{F_1 F_2 F_3 \ldots F_n}$$

Example 1: Daily standard production rate of a power shovel



- A power shovel with a dipper of one cubic yard capacity has a standard operating cycle time of 30 seconds.
- Find the daily standard production rate of the shovel.
- For C_e = 1 cu. yd. (1 cubic yard = 0.764 cubic meter), T_e = 30 sec. and H_e = 8 hours, the daily stan

$$P_e = \frac{C_e H_e}{T_e} = \frac{(0.764\ \mathrm{m}^3)(8hr)\left(3600\ {}^{sec}/_{hr}\right)}{30\ sec} = 733.44m^3$$

- In practice, of course, this standard rate would be modified to reflect various production inefficiencies.

Example 2: Daily standard production rate of a dump truck



- A dump truck with a capacity of 6 cubic yards (4.587 m^3) is used to dispose of excavated materials at a dump site 4 miles away.
- The average speed of the dump truck is 30 mph and the dumping time is 30 seconds.
- Find the daily standard production rate of the truck.
- If a fleet of dump trucks of this capacity is used to dispose of the excavated materials in Example 1.1 for 8 hours per day.
- Determine the number of trucks needed daily, assuming a swell factor of 1.1 for the

Example 2: Daily standard production rate of a dump truck



- The daily standard production rate of a dump truck can be obtained by using Equations above:

$$T_t = \frac{2D}{S} = \frac{2(4mi)\left(3600\frac{sec}{hr}\right)}{\left(30\frac{mi}{hr}\right)} = 960\,sec$$

$$T_o = (30sec)\frac{(6\,yd^3)}{(1yd^3)} = 180\,sec$$

$$T_h = 960 + 180 + 30 = 1,170\,sec$$

- Hence, the hourly production rate is:

$$P_h = \frac{C_h H_h}{T_h} = \frac{(4.587m^3)(8hr)(3600\,sec/hr)}{1,170\,sec} = 112.91\,m^3$$

- Finally, the number of trucks required is:

$$N_h = \frac{wP_e}{P_h}$$

$$N_h = \frac{1.1 * 733.44\,m^3}{112.91m^3} = 7.1$$

- implying that 8 trucks should be used.

Example 3: Job site productivity of a power shovel



- A power shovel with a dipper of one cubic yard capacity (in Example 3.1) has a standard production rate of 960 cubic yards (733.44 m^3) for an 8-hour day.
- Determine the job site productivity and the actual cycle time of this shovel under the work conditions at the site that affects its productivity as shown below:

Work Conditions at the Site
Factors

- **Bulk composition**

0.954

- **Soil properties and water content**

0.983

Example 3: Job site productivity of a power shovel



- **Using the above Equation, the job site productivity of the power shovel per day is given by:**

$$P'_e = P_e F_1 F_2 F_3 \ldots F_n$$

$$P'_e = 733.44X0.954X0.983X0.8X0.7 = 385.17\,m^3$$

- **The actual cycle time can be determined as foll**

$$T' = \frac{T}{F_1 F_2 F_3 \ldots F_n} = \frac{30\,sec}{0.954X0.983X0.8X0.7} = 57\,sec$$

Example 4: Job site productivity of a dump truck



- **A dump truck with a capacity of 6 cubic yards (in Example 1.2) is used to dispose of excavated materials.**
- **The distance from the dump site is 4 miles and the average speed of the dump truck is 30 mph.**
- **The job site productivity of the power shovel per day (in Example 1.3) is 385.17 cubic meters, which will be modified by a swell factor of 1.1.**
- **The only factors affecting the job site productivity of the dump truck in addition to those affecting the power shovel are 0.80 for equipment idle time and 0.70 for management efficiency.**
- **Determine the job site productivity of the dump truck.**

Solutions:



- The **actual cycle time T'h** of the dump truck can be obtained by summing the actual times for traveling, loading and dumping:

$$T'_t = \frac{2D}{SF_1F_2} = \frac{2(4mi)\left(3600\frac{sec}{hr}\right)}{\left(30\frac{mi}{hr}\right)(0.8)(0.7)} = 1,714\ sec$$

$$T'_o = \frac{T'_t C_h}{F_1F_2C_e} = \left[\frac{(57\ sec)}{(0.8)(0.7)}\right]\left[\frac{6\ yd^3}{1yd^3}\right] = 611\ sec$$

$$T'_d = \frac{T_d}{F_1F_2} = \left[\frac{(30\ sec)}{(0.8)(0.7)}\right] = 54\ sec$$

- Hence, **the actual cycle time** is:

$$T'_h = T'_t + T'_o + T'_d = 1,714 + 611 + 54 = 2,379\ sec$$

- The **jobsite productivity P'h** of the dump truck per day is:

$$P'_h = \frac{C_h H_h}{T'_h} = \frac{(4.587m^3)(8hr)(3600\ sec/hr)}{2,379\ sec} = 55.53\ \mathrm{m}^3$$

- The **number of trucks** needed dail

$$N'_h = \frac{wP'_e}{P'_h} = \frac{1.1 * 385.17\ m^3}{55.53m^3} = 7.6$$

Equipment Productivity

- Some other factor that can affect the output/productivity of equipments **resistance to movement** include Rolling Resistance, Grading Resistance, Coefficient of Traction, Drawbar Pull and Rim Pull.
- **Rolling Resistance (R^2)**: sometimes referred as wheel or track resistance.
- It is associated with the **condition of surfaces** and the **types of wheeled tires, their treads** and the **pressure** they exert on the surface.
- Results from: **friction + force required to shear through or ride over the supporting surface**

Rolling Resistance

- R^2 is expressed **in Kg of tractive pull** which is required to pull a ton load over a level surface for a good tire condition and their values are estimated (Table 2.3) for various types of wheels and surface conditions in Kg / ton of gross load for earth moving construction equipments.
- That is;

$$R^2 = R^2 \text{ factor} * W \text{ including load}$$

- If soil is stable and well compacted and well maintained by a grader, and if the moisture content is kept near optimum - possible to provide a road surface with RR as low as for concrete or asphalt.

Rolling Resistance factors in Kg / ton for different conditions

Surface Type	Steel Tire	Crawler Track	Rubber Tires	
			High Pressure	Low Pressure
Concrete	18	25	15	20
Asphalt	22 – 30	27 – 30	18 - 29	22 - 27
Compacted Earth Road	27 – 30	27 - 35	18 - 25	22 - 30
Loose Earth	45 – 67	36 - 50	45 - 60	40 - 45
Sand & Gravel	125 – 145	72 - 90	110 - 130	100 – 120
Muddy	160 – 180	90 - 110	135 - 180	125 - 150

s

tractive effort required to keep it moving at a uniform speed is 15*50=750.

Rolling Resistance

- To determine RR of a road - tow the vehicle along a level section at uniform speed. The tow cable should be equipped with a dynamometer or some device to determine tension.

  R = P / W R= Rolling resistance, kg/ton

  P= Total tension in tow cable, kg

  W= Gross wt. of vehicle, tons

- If **tire penetration** is known, an approximate RR value for a wheeled vehicle can be calculated by:

RR = 2% of GVW + 0.6% of GVW per cm of

Grading Resistance

Grading Resistance (GR): is the force opposing movement when the equipment is against a frictionless slope which acts against the total weight including its load.

- This is dependent on the physical property of the traveling surface irrespective to the type of equipment or the condition or type of road.
- That is;

GR = W including load * G%/10 ..... for slopes less than 10^0

- For each 1% grade - increase required in tractive effort is 10 kg/ton

Grading Resistance

- For each 1% grade - increase required in tractive effort is 10 kg/ton.
- W is a 1-ton wt.

F=10 kg/ton* G%

- This formula is valid for a G up to about 10 %, that is, the small angle assumption ($\sin \alpha \approx \tan \alpha$).
- RR may be equated to an equivalent gradient:

(RR expressed in kg/ton) / (10 kg/ton) = G %

- **Total Resistance = RR** (expressed as an equivalent gradient) **+ Grade Resistance**
- Total resistance can be expressed as an **effective grade**.

Grading Resistance

Example 5:

- A wheel tractor-scraper weighing 91 tons is being operated on a haul road with a tire penetration of 5 cm.
- What is the total resistance in kg and effective grade where

  (a) the scraper is ascending a slope of 5% and

  (b) the scraper is descending a slope of 5%?
- **Solution: [Quiz]**

Grading Resistance

Solution:

A) Ascending 5 % Slope (Slope = + 5 %)

Rolling Resistance (kg/t) = 20 + (6 x cm penetration)

= 20 + 6 x 5 = 50 kg/t

= 50 kg/t x 91 t = 4,550 kg

Grade Resistance (kg) = 91 t x 1,000 kg/t x 0.05 = 4, 550 kg

Total Resistance = 4, 550 kg + 4, 550 kg = 9,100 kg

Effective Grade = 5 + 50/10 = 10 %

B) Descending 5 % Slope (Slope = - 5 %)

Rolling Resistance (kg/t) = 4,550 kg

Grade Resistance = 91 t x 1,000 kg/t x - 0.05 = - 4, 550 kg

Equipment Productivity

- **Coefficient of Traction (T Coef):** is a factor by which the total weight on the drive wheels or tracks (Won gear) should be multiplied to determine the maximum possible tractive force (F tractive) between the wheels or tracks and the surface just before slipping will occur. That is;

  F Tractive = T Coef * Won gear

- As a result, the power that can be developed at the interface between running gear and the road surface is often limited by traction.
- The factors controlling the tractive force are the weight on the powered gear, the characteristics of the running gear and

Equipment Productivity

Drawbar Pull (DP in KN): is a pull that a tractor can exert on a load that is being towed by it.

- It is the total pulling effort of an engine minus the pull required to move the tractor over the level surface.
- If the tractor is hauled on an upgrade its drawbar pull reduces by 9.81 Kg for each ton of weight of the tractor including its load for 1% of slope.

Rim Pull (RP in KN): is a tractive/pulling force between the rubber tires of driving wheels and the surface on which they travel.

- For track machines – force that is available at the drawbar
- For a wheel machine – force developed at

Drawbar and Rim Pull in KN for different gear speeds

Gear	Drawbar Pull		Rim Pull	
	Speed (Km/hr)	DP (KN)	Speed (Km/hr)	RP (KN)
1st	2.7	155	5.1	63
2nd	3.5	120	11	26.4
3rd	4.4	77	20	16
4th	5.6	62	34	9
5th	7.1	45	54	5.9
6th	11.2	25		

Construction Plant Types and their Productivity

- Construction plants are industries where parts of construction elements or processed materials are produced.
- Construction plants can be classified as:
- Cement Based Production plants such as Concrete Batching Plant, Concrete Blocks, Tiles and Pipes Production Plant, and Concrete Structures Pre-manufacturing Plant;
- Stone Based Production Plants such as Masonry Blocks Quarrying Plant, Selected Materials, Scoria and Pumice Quarrying Plant, Gravel Quarrying and Crushing Plant, and Marble, Granite, etc Quarrying and Production Plant;

Plant Types

- **Metal and Wood Based Production Plants** such as Stairs and Accessories Production Plant, Door and Window Frames Production Plant, Steel and Wooden Structures and Accessories Production Plant, Gutters, Flashing and Cladding Production Plant, Form and False Works Production Plant, and Other Metal and Wood Ceiling, Floors and Walls Finishing Production Plant;
- **Clay Based Production Plants** such as Brick Production Plant, and Roof Tiles Production Plant;
- **Ceramics Based Production Plants** such as Sanitary Appliances and Accessories Production Plant, and Floor and Wall

Plant Types

- **Plastics Based Production Plants** such as Floor, Ceiling and Wall Finishes Production Plant, and Electrical and Sanitary Appliances and Conduits Production Plants.
- Construction Plants **bring in the manufacturing industry characteristic** and **allow on shelf purchases of most components the construction works**.
- As a result of these ***two*** rationalizations of construction executions, the construction industry will:
  - **Minimize labor intensive** construction works, that is reduces human labor;
  - **Minimize construction works on site**, that is promote manufacturing and assembling construction system;

Plant Types

- **Improve efficiency** and working environment of construction works;
- **Enhance** Environment, Health and Safety Requirements;
- **Improve Technology** of Construction Works;
- **Large scale** of operation is possible;
- **Promote** Uniformity, Standardization and Improvement;

- Plant types discussed in this section are plants for ***aggregate production***, **asphalt mix production** and **concrete batching**.

Aggregate Production Plants



- Aggregates are **used for concrete and Asphalt or Asphalt Concrete pavement works**.
- Since such materials **require quarries where abundant row materials exist,** their production requires a ***special place than the construction site***.

Aggregate Production Plants

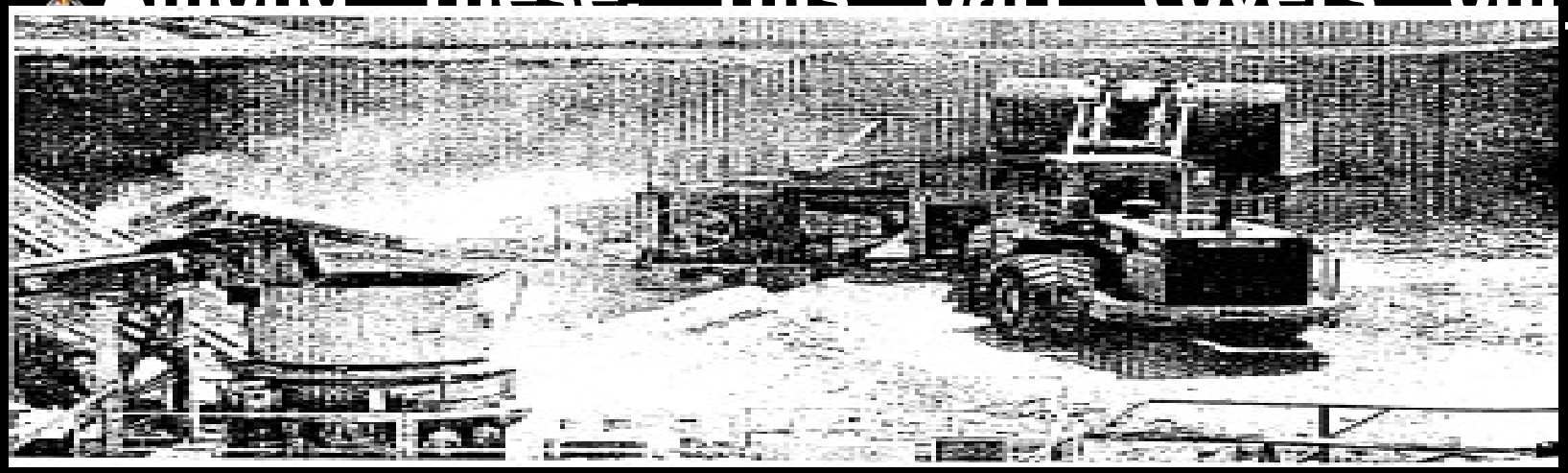


Generally it involves ***five functions:***

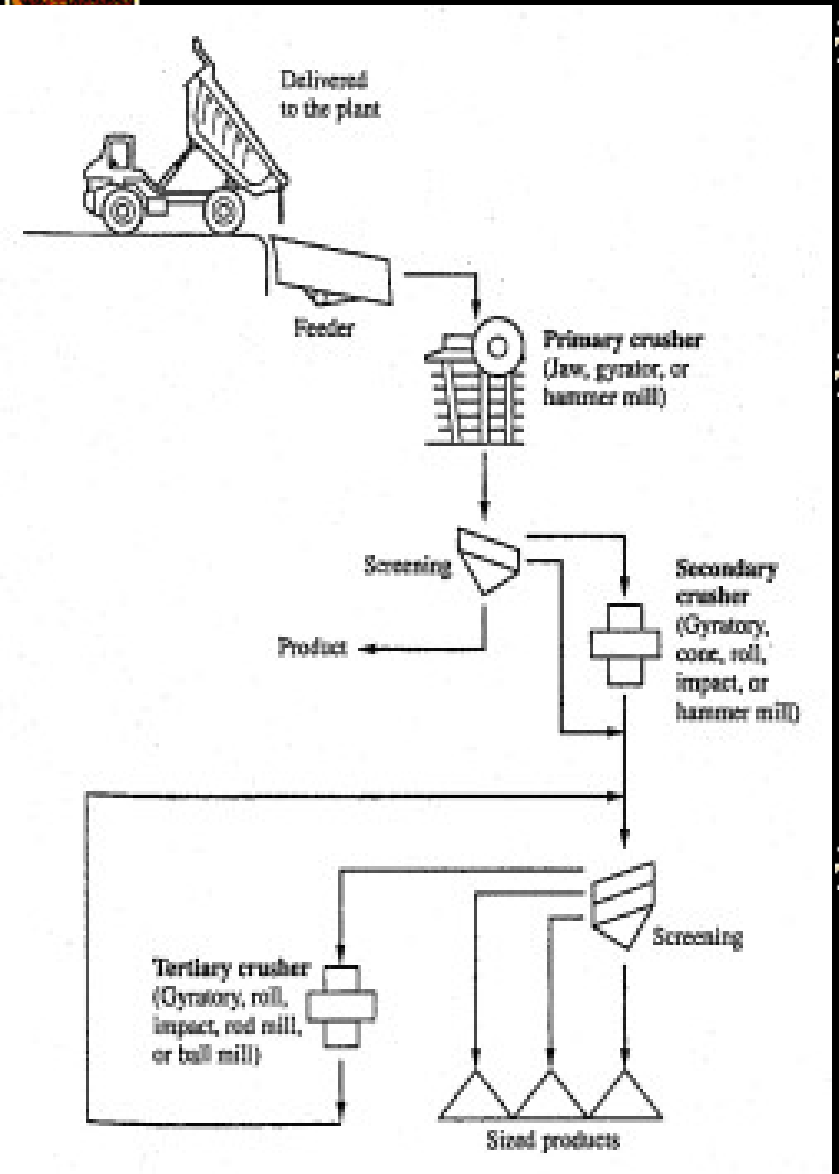
- ✓ Selecting appropriate ***site*** and its organization
- ✓ Producing different particle sizes - ***Crushing***
- ✓ Separating or Screening into the different sizes ***(particle size ranges)***
- ✓ ***Washing*** to eliminate undesirable materials, and

Aggregate Production Plants

- In order to carry out these functions, aggregate plants use the following construction equipments: ***Drilling and Blasting equipments, Crushers, Revolving or Vibrating Screen box, Log Washers, Dozers, Shovels, Loaders and Trucks.***
- Among these, this part covers only



Aggregate Crushers



- **Crushing requires several iterations to reach to the intended particular sizes.**
- ***If a single step with a large amount of energy is applied, excessive fines are generated which results into much wastages.***
- **As a result, crushing plants use step production to produce the required size**

Aggregate Crushers

- Jaw, Gyratory, Roll, Impact, and Specialty Crusher types are used for producing aggregates in different number of iterations
- Jaw crushers and True Gyrators are typically employed as *primary units because of their large energy storing fly wheels and high mechanical advantage.*
- Representative productivity (capacity in ton per hour) for gyratory crushers can be obtained from table in the handout.
- Roll, Impact and other types of Gyrator crushers are used *for secondary and tertiary* applications.

Aggregate Crushers

- The *capacity of* roll crushers *vary with the type of stone, size of fed stone with their feeding rate, required finished particle size, width of rolls and their rotation speed.*
- Representative capacities of roll crushers are given on table of your handout.
- The capacity of Compression (Jaw, Gyratory and Roll crushers) and Impact crushers will increase if the stone feed is at a uniform rate.
- Different types of crushers use different number of iterations to produce different reduction ratio ranges (Table on your

Aggregate Crushers

- In selecting crushers, the following five factors can be considered:
  - ✓ Crushed stone type
  - ✓ Required plant capacity
  - ✓ Maximum feed stone size
  - ✓ Feeding method, and
  - ✓ Required product size.

Asphalt Mix Production Plants

Asphalt Mix Production Plants: ***Hot mixed asphalt*** **is produced at a central plant and transported to the paving site with trucks.**

- **There are two kinds of asphalt plants; Batch and/or Drum plants.**
- **Batch plants use individual batches to proportionally mix liquid asphalt and aggregates;**
- **Drum plants uses both the aggregate drying and the mixing functions in combination in a single drum.**
- **Asphalt plants carry out uniform blending, heating and mixing the necessary materials in order to produce asphalt or asphalt**

Asphalt Mix Production Plants

- The most important issue with regard to asphalt plants are their air emissions concentrated to a particular area such that their environmental impact could be kept to a minimum level.
- Drum plants are newer in technology and are more recommended- which covered in this course.
- The primary components of a drum mix asphalt plant are:
  - ✓ Cold feed system
  - ✓ Asphalt handling system
  - ✓ Drying and Mixing drum
  - ✓ Dust collector and

Asphalt Mix Production Plants

- **Cold feed systems** consist of three to six open bins where the different size of aggregates is fed to the drying drum.
- **The asphalt handling system** is used to store in a heated tank separately which is ready to be pumped into the mixing drum.
- The **mixing** is then performed within the drum and the final mix is discharged directly into the storage silo for subsequent dispatches into transporting trucks.
- To avoid air pollution, asphalt plants are equipped with dust **collector systems.**

Asphalt Mix Production Plants

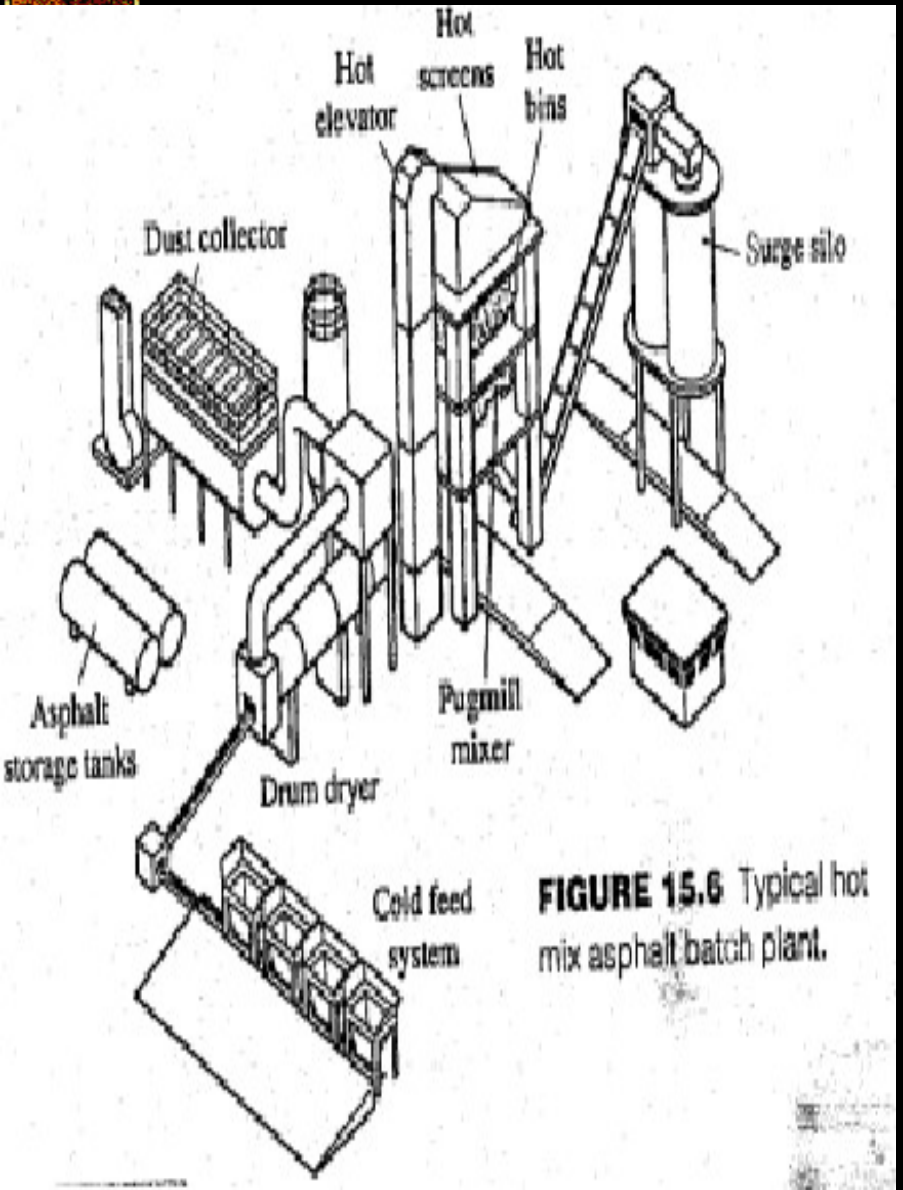
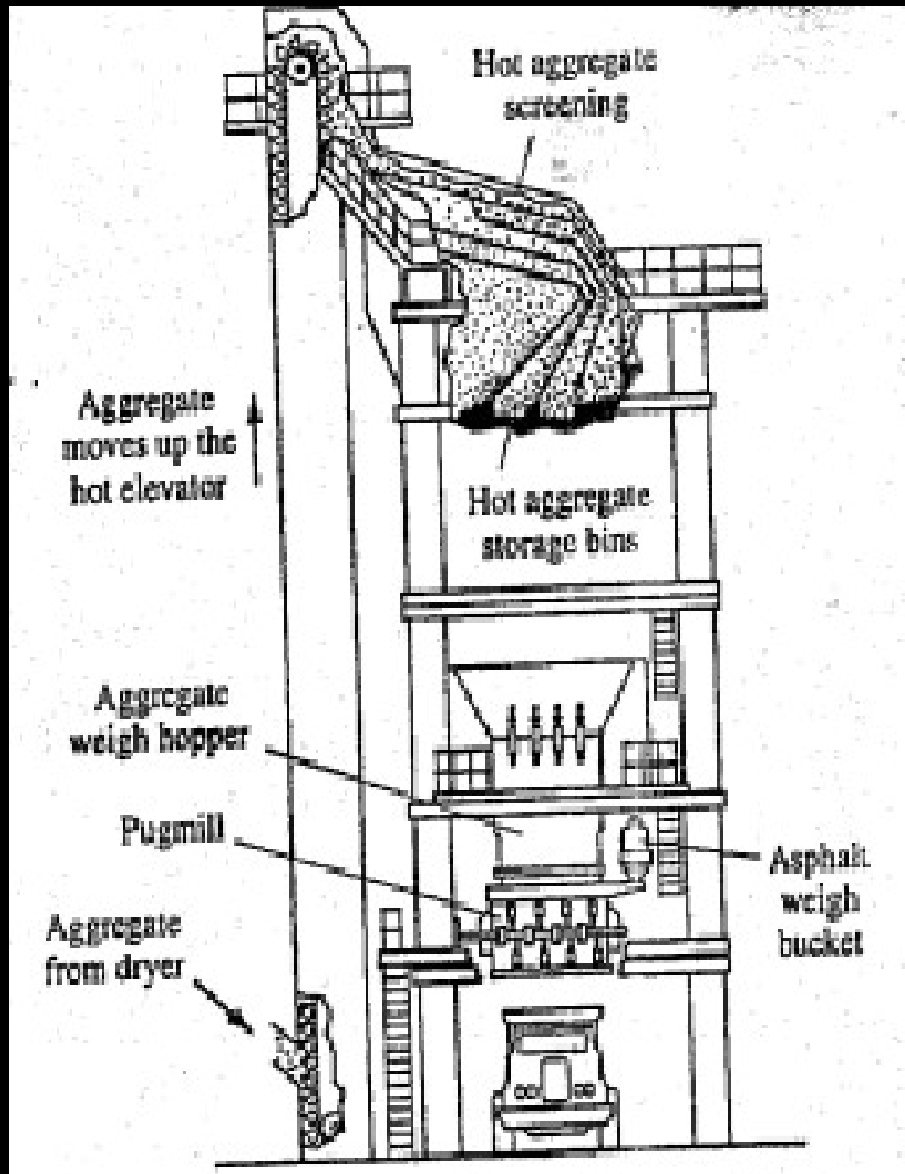


FIGURE 15.6 Typical hot mix asphalt batch plant.



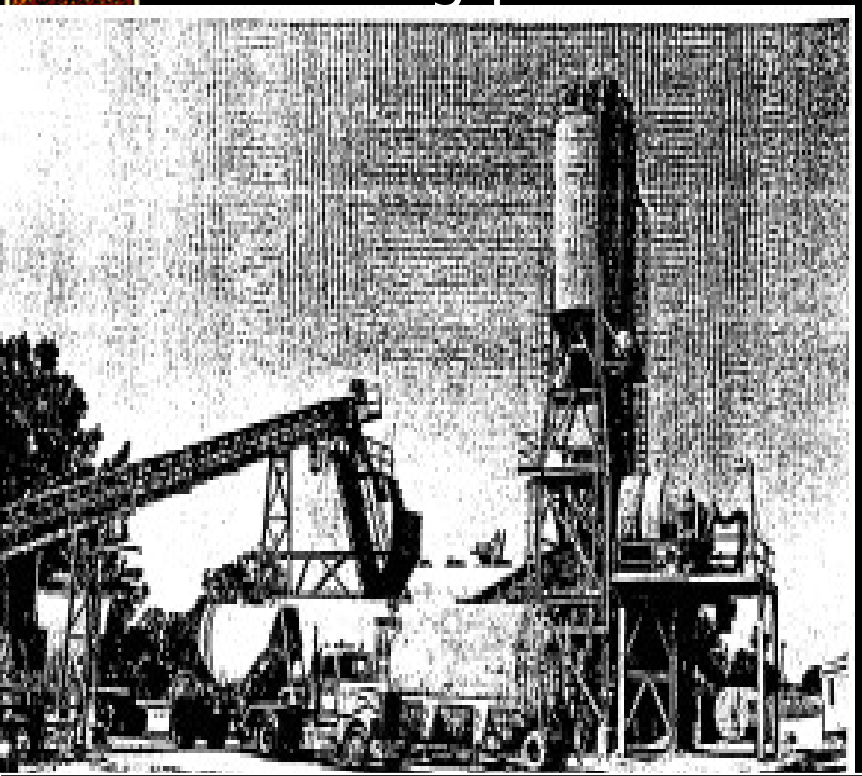
Asphalt Mix Production Plants



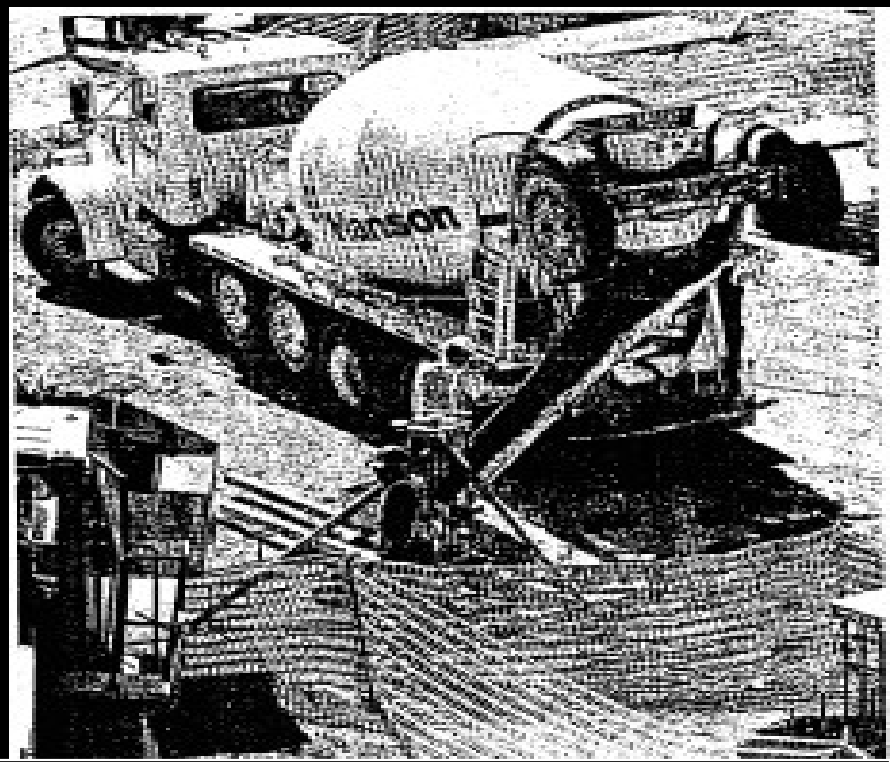


Concrete Mix Production Plants

- Which includes both **Central and transit** mixing plant:



Central mix concrete plant, the mixer drum is seen at the right end of the plant



Transit mix plant (track mixer) placing concrete for cast-in-place work

Plant Types and their Productivity

- For instance, if one aimed to carry out a construction project without considering the *equipment availability, Productivity, accesses and costs and types with their different function* during planning, the cost of the project will be high if the contractor is faced with scarcity of equipments during construction.
- It is very *cost extensive and transportation* of the product does also need special care.
- It can be considered as *a supplying industry where the aggregates, asphalt and concrete mixes are purchased off shelf.*

CONSTRUCTION EQUIPMENT MANAGEMENT

Chapter Three: Construction Equipment/Plant Economics

- ✓ Equipment/Plant Access and
- ✓ Equipment/Plant Costs

Equipment Access

- There are three basic ways of securing construction equipments.
- These are *Buying (direct Ownership), Renting or Leasing.*

1. *Direct Ownership (Buying):* has the advantage of guarantying use and control of equipment whenever demanded but requires continuity of work for it to payback its cost because such equipments are very expensive.

- Beside, their maintenance services require adequate attention.
- If a construction company foresees the use of construction equipment continuously, direct ownership will bring down its competitive cost of bidding to increase the chance of acquiring/winning projects.

Equipment Access

2. ***Rental Services:*** are **short term provisions** of construction equipments from renting organizations for the purpose at hand.

- This is particularly advantageous **if the job is of short duration** and a construction company **do not foresees continuity of similar works.**
- Companies can also use rental services **for testing and selecting construction equipments** before direct ownership.
- Rental charges are ***higher than normal direct ownership expenses*.**
- Besides, there **could be shortage during peak work seasons.**

Equipment Access

- **Responsibility for maintenance** is indicated in the rental contract.
- May use the rent with option to purchase **- if not sure about the future utilization.**
- Renters have to charge extra profit - hence hourly charge will be higher **- if the owner used the equipment extensively.**
- **options:**

  1. Purchase it

  2. Rent it (using a lease agreement)

  3. Rent it with an option to purchase it at a later date.

Equipment Access

- **Purchasing Vs Renting.**
- **Purchase equipment *that will be used frequently*, rent equipment that will *be used only rarely.***
  - **Advantages of purchasing:**

1.Economical if used sufficiently.

2.Available when needed.

3.In better condition if better care and maintenance.

Equipment Access

Disadvantages of owning:

1. **May be more expensive** than renting
2. **Involves substantial investment** of money that may be used for other purposes.
3. **May influence owner to continue using obsolete equipment.**
4. Ownership of equipment **designed primarily for a given type of work** may induce a contractor to continue doing that type of work, though not profitable.
5. Might influence a contractor to continue using the equipment **beyond its economical life**.

Example on purchase and rent

- A small wheel loader has an ownership cost of $ 10.96 per/hr and it can work each year 2400 hrs.
- If you want to employ this machine in your project where the total operation hour is 1000 hr, will it be feasible to rent or buy?
- The rate of rent in local renter is $20 /hr for monthly rent, $ 29/hr for weekly rent and $ 46/hr for Daily rent.
- Annual cost of ownership = 10.96*2400 = $ 26,304

Solutions

- Yearly ownership cost = 10.96$/hr* 2400hr = $26, 304
- Monthly rent cost = 20*176 = $ 3520

Solutions

Rental Duration	Rates ($/hr)	Operating hour breakeven point ($ 26,304/$/hr)	Operating hour breakeven point ($ 3,520/$/hr)	Operating hour breakeven point ($ 1160/$/hr)
Monthly	20	1315	-	-
Weekly	29	907	121	-
Daily	46	572	77	25

- If the Loader will be used for less than 1315 hr but more than 907 hr, the monthly rental should be considered instead of ownership.
- When the project usage is less than 1315 hr but greater than 121 hr, a weekly rental would be appropriate
- In case of very limited usage (less than 25 hr the daily rate is optimal)

Equipment Access

3. ***Lease Services:*** are **long term agreements** for the use of construction equipments.

- This is an **alternative to direct ownership** where the leasing company owns the equipment for the agreed time and the lessee (user) pays the owner to use the equipment.
- Lease contracts clearly state the **responsibility** of the two parties including the management and servicing of the equipments.
- Lease rates are **applied mainly to recover the capital costs** of the equipment for its ***periodic replacement plus overhead and***

Equipment Access

- **Advantage:**
  - Sometimes the lessor provides management and servicing
  - No need to hire mechanics and grease men
  - Can concentrate only on the task of building

Equipment Costs

- The three major issues related to equipment costs are:

1. The Optimum economical Life Time;
2. The optimum way to secure a construction equipment, that is; the cost of either Owning (Capital Cost) or Renting or Leasing of a construction equipment; and
3. The cost of Operation.

- These issues require several *records or information* with regard to evaluation of equipments performances, establishing owning and operating costs, and analyzing their replacements.
- Recent development of the information technology has made this task better and

Equipment Costs

- Generally, Equipment costs are divided into three major parts.
- These are:

1. Accessing or Availing Costs (Owning, or Renting, or Leasing Costs),
2. Operating Costs, and
3. Overhead and Markup Costs.

Equipment Costs

1. Accessing or Availing Costs (Owning, or Renting, or Leasing Costs):

- **Which constitutes: *Cash flows for Purchase expenses, Salvage Value, Tax savings from depreciation, Major repair and Overhauls, Insurance, Interest and Tax Costs, and Storage and Miscellaneous expenses* for construction equipments.**
- **The *purchase expenses* include the price of the equipment, its shipping or other forms of transporting services and necessary custom taxes to own it.**

Equipment Costs

- ***Salvage Value*** **is revenue shown as cash inflow of equipments if they have value at any time of their transfer of ownership or their disposal.**
- **Machines that wear out and posses few secondary uses could be grouped as low salvage value equipments.**
- **On the other hand, there are equipments either gets overhauled to keep their operating conditions or even have multiple service life applications which could be regarded as high salvage value equipments.**
- **There is a possibility also when subsequent brands with new and technologically, economically and socially better products**

Equipment Costs

- **Tax savings from depreciations** can only be applicable if only the company who owns the equipment is profitable.
- There is a possibility to carry over to years where such profitability occurs.
- Depreciation is a legitimate cost of business that recognizes the loss in value of equipment over time.
- Tax saving from Depreciations can then be computed using **Straight line, Declining Balance, Sum of Years digits and Production** methods or **use of Tax code schedules.**

Equipment Costs

- **Major Repairs and Overhauls**
  - are included under ownership cost because they are meant for increasing the service life of equipments.
  - These costs are additional to initial investment costs and shall be considered expenses at the time of their investment to be added on the Book values to be depreciated.
- **Insurance, Interest and Tax costs (IIT Costs):**
  - Insurance costs often ranges from **1–3%** of Average Annual Value (AAV) of equipments which can either be an actual premium paid to insurance companies or a self-insurance

Equipment Costs

- Tax costs refer to those equipment ownership taxes charged by customs offices which are commonly assessed between 2–4.5% of AAV depending on location and property taxes.
- Interest costs are related to either interest payments if the equipments are purchased with loan or loss of interest on the money invested if purchased in cash.
- In this case the borrowing and saving interest rates are applicable respectively.
- Interest costs are computed using the product of interest rates in percentages and AAV.

Equipment Costs

- **Storage and Miscellaneous Expenses Equipments**

- require storage and other miscellaneous costs due to **bad weather,** in between job times and their breakdown for maintenance.
- These demand **storage places** either through self ownership or space rental services and other subsequent utilities together with wages for operators or guards.
- These expenses are combined in an overhead cost of projects which can be estimated as **0–5 %.**

Equipment Costs

2. Operation Costs

- **Typical expenses during equipment operations are Fuel, Oil and Grease (FOG) costs, Normal Repairs and Tire and High Wear Items Replacement Costs. Operators' costs are often considered in Labor costs component of CBSs and are not considered as a part of equipments operation costs.**
- **Either manufacturers' or good service records could be used to estimate hourly FOG expenses of equipments. Besides, routine maintenance, servicing and tires and high wear replacement parts such as blades, bucket teeth, ripper tips, and cutting edges can also be estimated per working hour.**

Equipment Costs

3. Overhead and Markup Costs

- In addition to the direct costs of ownership and operation, general overhead costs constituted Equipment costs.
- These costs are associated with wages of mechanics and supervisory personnel's, clerical and records services, rental and amortization of maintenance facilities.
- A markup or profit margins expressed as percentage of total hourly operating costs is also part of the Equipment costs.

CONSTRUCTION EQUIPMENT MANAGEMENT

Chapter Four:

Construction Equipment/Plant Management in Ethiopia

- ✓ Historical Perspectives
- ✓ Recent Trends
- ✓ Useful Organizations / Documents

Construction Equipment / Plant in Ethiopia

Historical Perspectives

- Construction works, though vary among its types, over development periods replaced use of manpower by equipments and at the same time considerable consumptions such as selected materials, crushed stones (gravels), asphalt and concrete are considered for mass production at a plant level.

Construction Equipment Management in Ethiopia

- It is well known that high rise building works, building works involving prefab components and steel structures form building infrastructures; road, water works

Construction Equipment / Plant in Ethiopia

- In Ethiopia, the first construction equipment was a **steam operated roller** by the then majesty in **1912.**
- This was further introduced by foreign construction companies' involvement in the **road sector since 1934**.
- After Italian invasion, **some rollers and small scale stone crushers** were left for use in the construction industry.
- Further to this, **WB loan was also used to procure construction equipments** which were **operated by foreign skilled operators.**
- When **private contractors started** to flourish before the demise of the imperial regime, they also have received **assistance for their**

Construction Equipment / Plant in Ethiopia

- A training center under the **Ethiopian Road Authority** was established in **1964** which included **equipment operators training as well.**
- This training center remained the only training center for equipment operators so far.
- **Except for enhancing efficiency of equipment operations**, a comprehensive study and management that includes its consideration during planning and its appropriate selection for efficiency and effectiveness has **not been addressed** before the first ***Equipment Management System*** manual by **ERA and Roy Jorgensen Associates of Canada, LTD in 1981.**

Construction Equipment / Plant in Ethiopia

- In order to improve the planning and operation efficiency of Construction Equipments, their outputs using work study methods have been developed in 1983.
- In the building sector also similar document that included the productivity of building construction equipments were also developed.
- After the establishment of BaTCDA in 1987; cost break down including equipment cost estimation and licensing requirements to each grade of contractors for their minimum equipments owning were also one input for equipment management development in

Construction Equipment / Plant in Ethiopia

- **Construction equipments licensing** have been started recently after the establishment of a department under the then **MoWUD/MoCUD** and now **CDSO** of the **MOI.**
- These departments **register equipments and provide plates for them.**
- This has been seen a good service to contractors so that their ability **to get credit and other bank and insurance benefits by using such equipments as collaterals.**

Construction Equipment / Plant in Ethiopia

The problem with regard to construction equipments in Ethiopia are generally that:

- **Most of them are old,**
- **Leasing and Renting possibilities are rare,**
- **They are capital extensive for most contractors in which they could create considerable cash flow problems if unwisely owned for only license upgrading systems**
- **In ability to choose the right equipment for spare part services, and**
- **Lack of skilled equipment operators.**

Construction Equipment / Plant in Ethiopia

Construction Plant Management in Ethiopia

- To my knowledge the development of plant management in Ethiopia is almost nonexistent.
- This is due to the fact that its activities have largely concentrated on **production of selected and different grades of gravel materials.**
- Even these are scattered and established based on **project requirements.**
- **Quarries** providing stones, selected materials such as red and black ashes, and pumice for hollow concrete blocks are **either privately or publicly owned.**

Construction Equipment / Plant in Ethiopia

- Concerning Concrete Batching plant, it is only limited to one company which is owned by **MIDROC** Construction firm.
- There are some organized **gravel production plants largely concentrated in the vicinity of the capital city.**
- I have no knowledge of the existence of **asphalt batching plant in Ethiopia** so far except that there are some **productions in mass** on project bases on large places.
- These were found **only limited to asphalt liquid preparations.**

Construction Equipment / Plant in Ethiopia

- **Prefabrication** methods employed in **1980s** has brought the concept of producing building elements for assembly on site which could possibly be one way to develop the plant management in Ethiopia.
- From the above information, it is obvious that material assessment in the country to show possible **sources for raw materials are not yet well identified and developed.**
- Besides, existing quarries and plants **are not well organized** which indicates that there are problems with construction **related information sources**.
- As a result, **construction plant management in Ethiopia is at its infant stage.**

Construction Equipment / Plant in Ethiopia

- This opens an opportunity to research works on the development of plant management in Ethiopia in General.
- This has to focus first on assessing the existing potentials for plant productions for use in the construction industry and further search and identify possible potentials in order to acknowledge resources capacity and development of plant management.

Construction Equipment / Plant in Ethiopia

Recent Trends

- Both equipment and plant management in Ethiopia are not well organized and faced with higher pressure for their development.
- One contribution was involvement of foreign construction companies and technical assistances with this regard which are vital for skill, technology and knowledge transfer.
- In addition, the development of private construction companies over time together with the government incentive provisions helped to develop their ability to own construction equipments.

Construction Equipment / Plant in Ethiopia

- Recent concerns have forwarded the issue of **rental and leasing possibilities where equipment pools have to be developed.**
- **Proclamation** for such companies developments are already in place.
- However, it **remained a concept so far due to these pools are capital expensive.**
- **International Financing Cooperation** is closely working with both private and public organizations to its developments.
- With regard to **plant management except non integrated developments on the bases of developing mines and construction materials**, to my knowledge there are no coordinated efforts underway for its development.

Construction Equipment / Plant in Ethiopia

Useful and major Organizations for Equipment and Plant Management in Ethiopia are:

- **Ministry of Infrastructure.**
  - **Ethiopian Roads Authority** including Alemgena Training Centre, Regional, Rural Offices for Roads constructions, and the Road Fund
  - **Construction Design and Supervision Office**
- **Ministry of Federal Affairs** including its city / town building and roads offices

Construction Equipment / Plant in Ethiopia

- **Ministry of Capacity Building**; Construction Sector Capacity Building Program
- **Public and Private Contractors.**
- **Equipment Suppliers** such as Ries Engineering, Moenco, Ethio Nipon, Nyala Motors, NMC, Hagbes, Tana Engineering and MIE.
- **International Finance Cooperation.**

Construction Equipment / Plant in Ethiopia

Useful and major documents for Equipment and Plant Management in Ethiopia are:

- **Equipment Management System (1981 and 2002 still draft) by ERA**
- **Construction Management System (1983 and under review) by ERA**
- **Ethiopian Codes for Practice Norms by MoWUD**
- **Technical Specifications by ERA, BaTCODA and MoWUD**
- **Equipment requirement for licensing by CDSO of MOI**
- **Equipment rental rate proposals (1998 – 2004) by MOI**
- **Suppliers' Manuals**



Thank You!!!

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