CoTM 6203 Advanced Construction Material & Equipment Management

Lecture 8 – Construction equipment management

Introduction

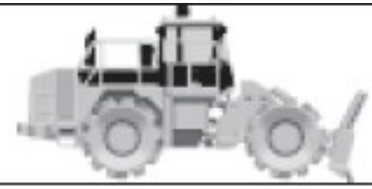
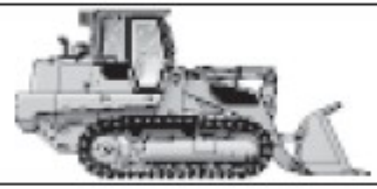
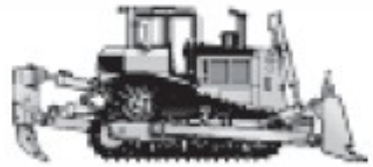
- The purpose of this lecture is to introduce the terminology and basic principles involved in determining the owning and operating costs of construction plant and equipment, analyzing the feasibility of renting or leasing rather than purchasing equipment mainly based on construction economics concept.

Introduction

- Construction equipment come with high price tags.
- While it may be tempting to go for the equipment with low initial price, it is preferable to *opt for standard equipment.*
- Such equipment are manufactured in large numbers by the manufacturers, and their spare parts are easily available, which would ensure minimum downtime. Besides, they can also fetch good salvage money at the time of their disposal.

Earthwork equipment classification

Description	Purpose	Application	Remarks	Capacity
Backhoe	For excavation below the ground (lower elevation)	Cutting of trenches, pits, etc., levelling and loading	Suitable for heavy positive cutting	Struck bucket capacity 0.38 m^3 to 3.25 m^3
Shovel or front shovel	For excavation above its own track or wheel level	For cutting and for loading	Suitable for heavy positive cutting in all types of dry soil	Struck bucket capacity 0.38 m^3 to 3.25 m^3
Dragline	For bulk excavation in loose soils below its own track level	For canals and pits excavation, cutting and desilting of ditches	Suitable for loose soils, marshy land and areas containing water	0.38 m^3 to 3.06 m^3
Clamshell or grab	For deep confined cutting in pits, trenches	Such as shafts, pits, wells	Consists of a hydraulically controlled bucket suspended from a lifting arm	0.38 m^3 to 3.06 m^3
Dozers	For moving earth up to a distance of about 100 m, shallow excavation, and acting as a towing tractor and pusher to scraper machines	Clearing and grubbing sites, excavation of surface earth, and maintaining roads	Can be track-mounted or wheel-mounted	Blade capacity 1.14 m^3 to 6.11 m^3
Roller compactor	For compaction of earth or other materials	Used for large works of highways, canals and airports	Comes in different varieties such as (1) smooth-wheeled roller, (2) vibratory roller, (3) pneumatic-tyred roller, and (4) sheep-foot roller	For (1) 8–10 t (2) 4–17 t (3) 11–25 t (4) 2.5–11.5 t Capacity can be increased by ballasting
Scraper	For site stripping and levelling, loading, hauling and discharging over long distances	Comes in different varieties such as towed scrapers, two-axle scrapers and three-axle scrapers	Best suited for haul distances varying between 150 m and 900 m	Sizes varying from 8 m^3 to 50 m^3
Dumper	For horizontal transportation of materials on and off sites	Suitable for hauling on softer sub-grades. Large-capacity dumpers are used in mines and quarries	Comes in different varieties with front tipping, side tipping, or elevated tipping arrangements	Load capacity of 1 t to about 80 t; 20 t is common for small dumper
Grader	For spreading fill and fine-trimming the sub-grade. Grader performs a follow-up operation to scraping or bulldozing	Grading and finishing the upper surface of the earthen formations and embankments	Graders usually operate in the forward direction	

			
Articulated Trucks	Backhoe Loaders	Compactors	Hydraulic Excavators
			
Motor Graders	Multi Terrain Loaders	Off-highway Tractors	Off-Highway Trucks
			
Paving Equipment	Wheel Excavators	Wheel Loaders	Scrapers
			
Skid Steer Loaders	Track Loaders	Track-type Tractors	Wheel Dozers

Concreting equipment

- Selection of concreting equipment can be complicated and difficult. The decision will involve many issues that have to be analyzed. The following factors mentioned by Alkass *et al.* (1993) are noteworthy:
  - Site characteristics such as boundary conditions, equipment maneuver, provision of temporary roads, noise limitations and other restrictions
  - Equipment availability - local availability of equipment, whether the contractor owns that equipment
  - Continuity of operation
  - Effect of permanent work
  - Weather conditions
  - Temporary works
  - Time restrictions
  - Concrete specifications

Concreting equipment

Description	Purpose	Capacity	Remarks
Concrete batching and mixing plant	For weighing and mixing large quantity of concrete constituents	20 m^3/h to 250 m^3/h	Comes in different varieties such as stationary and mobile batching plants
Concrete mixers	For mixing small quantities of concrete constituents	Capacity could be up to 200 l/batch for small mixers, and between 200 and 750 l/batch for large mixers	Comes in different varieties such as non-tilting drum type and tilting drum type
Concrete transit mixers	For transporting concrete from batching plant	3 m^3 to 9 m^3	Capacity also depends on the permissible axle load
Concrete pumps, static or portable	For horizontal and vertical transportation of large volumes of concrete in short duration	30 m^3/h for ordinary construction; can be in excess of 120 m^3/h for specialized construction	Direct acting pumps—an output of up to 60 m^3/h through 220 mm delivery pipes. Concrete can be easily pumped up to a distance of 450 m horizontally or 50 m vertically Squeeze pumps—an output of up to 20 m^3/h through 75 mm delivery pipes. Concrete can be easily pumped up to a distance of 90 m horizontally or 30 m vertically

Hoisting equipment

- Hoists are a means of transporting materials or passengers vertically by means of a moving level platform.
- Materials hoists come in basically two forms - static and mobile models.
- The static version consists of a mast or tower with the lift platform either cantilevered from the small section mast or centrally suspended with guides on either side within an enclosing tower.
- Mobile hoists usually do not need tying to the structure unless extension pieces are fitted, in which case they are treated as cantilever hoists.

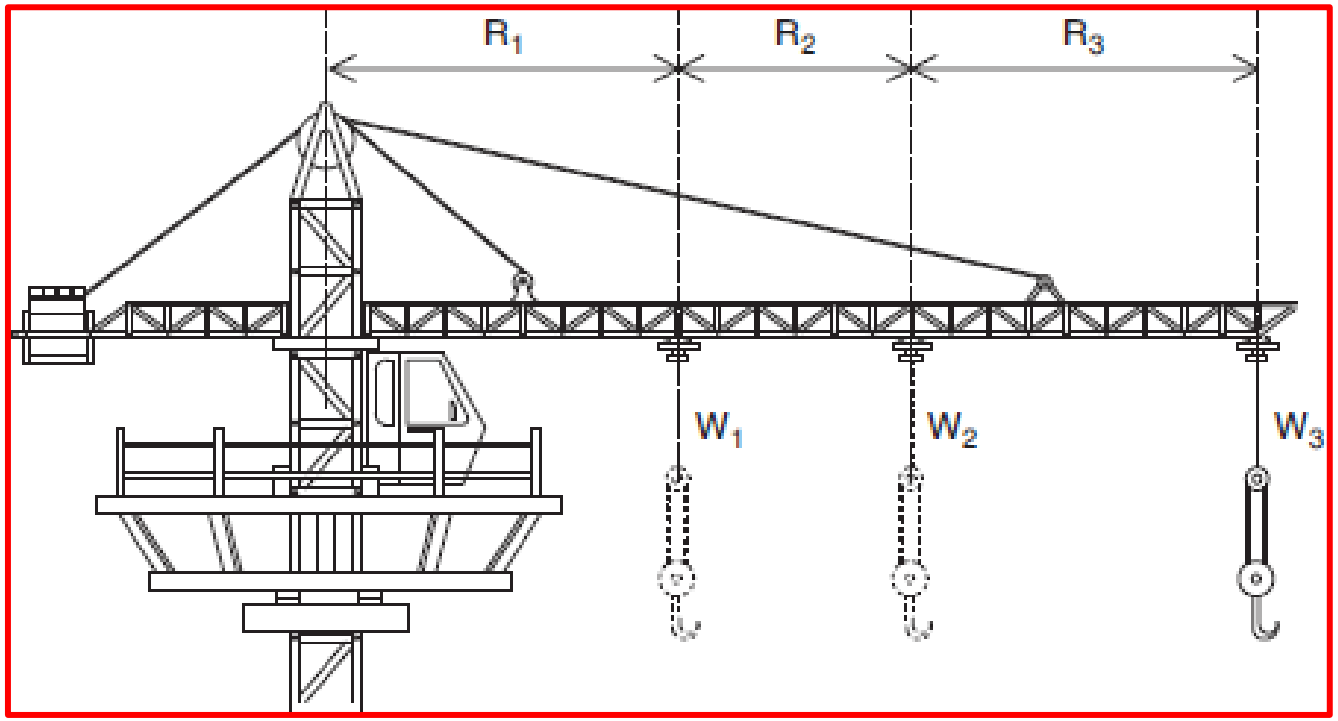
Cranes

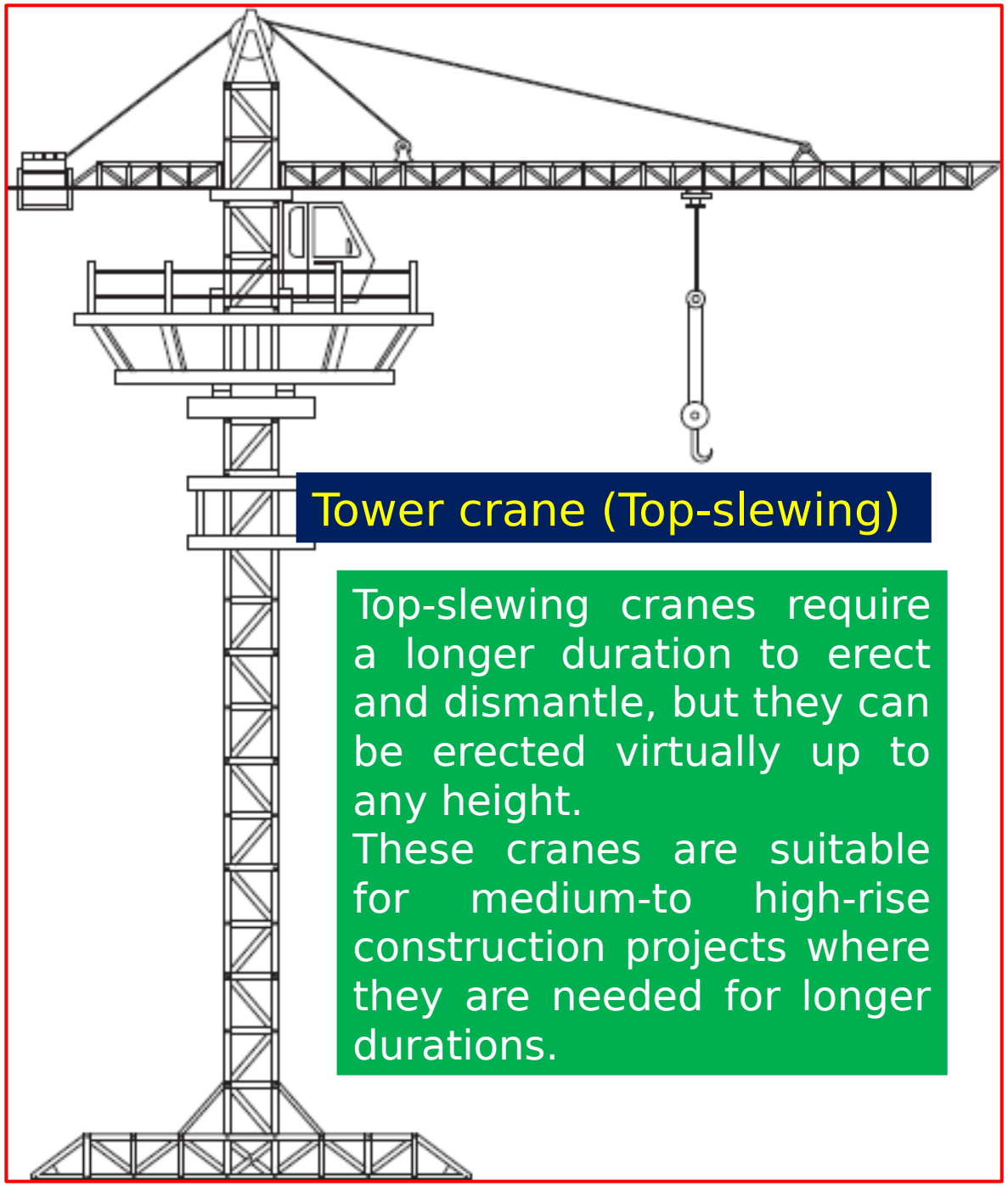
- A crane is a device used for hoisting and placing materials and machinery.
- It is used to facilitate handling of materials such as formwork, reinforcement, pipes and structural steel items.
- The use of cranes has greatly increased in the construction industry due mainly to the need to raise the large and heavy prefabricated components often used in modern structures.
- Cranes are available in different ranges and the choice of a crane is dependent on factors such as the weight of the materials and machineries to be lifted, the overall dimension, the distance to which they are to be placed, and the prevailing site condition.
- Construction cranes can be broadly classified under two major categories - *tower cranes and mobile cranes*.

Tower Crane

- In appearance most of the tower cranes look alike, but they are not of same type.
- Various types of tower cranes are available in the market and it is important to choose the right tower crane for a project.
- The tower cranes offer several advantages over conventional cranes and it is required to be familiar with the different features of the tower crane.
- The manufacturer’s catalogue offers useful advice such as the lifting capacities at different radii.
- Tower cranes are available in different types, sizes and capacities. The lifting capacity is one of the important selection parameters besides length of reach (radius), maximum hook height above ground, and crane positioning.

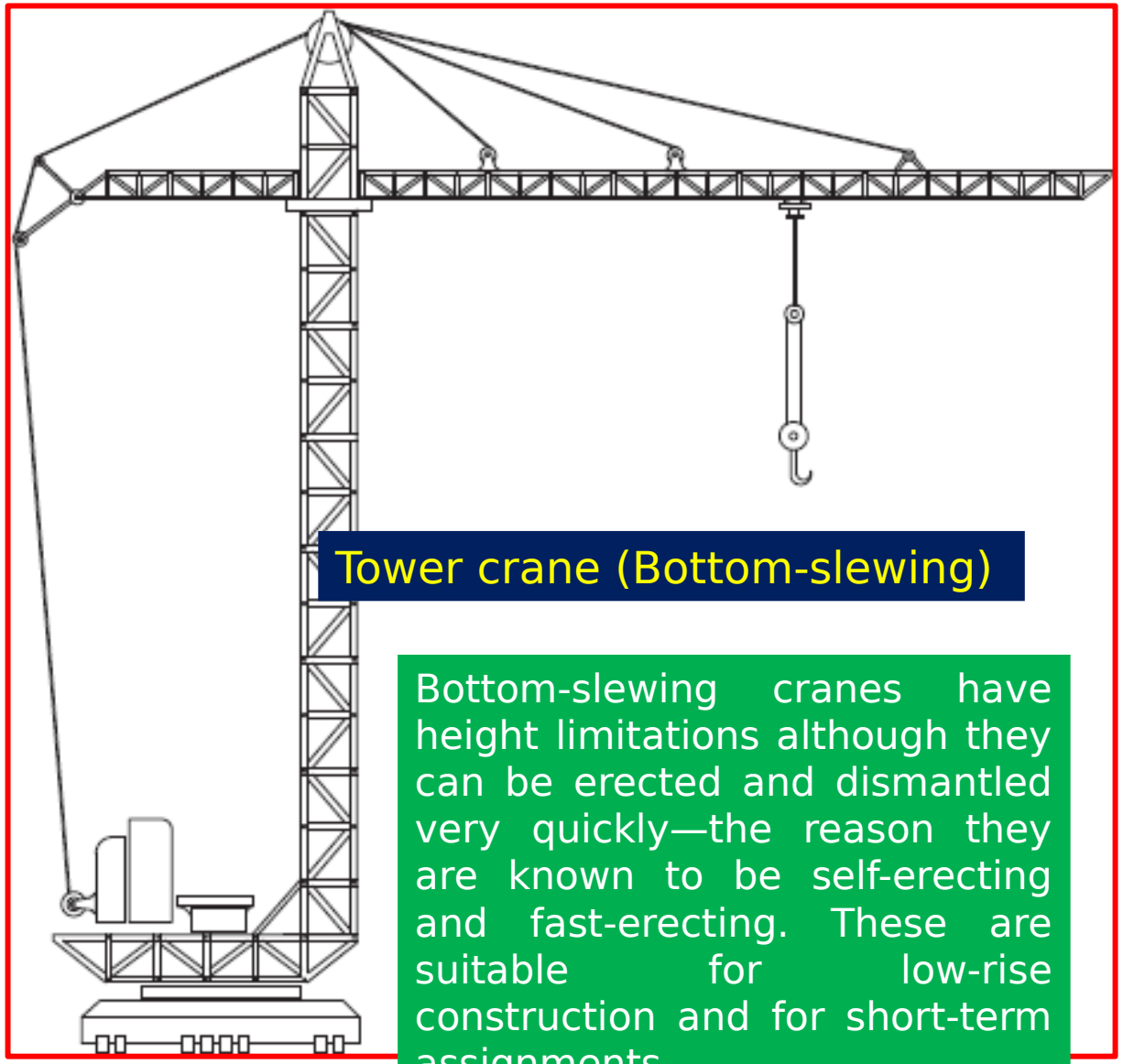
- Tower cranes have distinct advantages over conventional lattice boom crawlers or truck cranes because the boom or jib looms high above the work site.
- The tower crane’s jib can place its load anywhere within the radius of operation without interfering with the structure over which it swings.
- In addition, the operator can either be on crane or control the crane remotely using instrumentation located on the building structure, while enjoying an excellent view of the load and its surroundings at all times.
- The use of tower crane has become synonymous with medium- to high-rise construction, be it for buildings or for bridges, dams, cooling towers, etc.
- Tower cranes can be fixed or can be mounted on *rails*. In the latter case, it is referred to as *travelling tower crane*.





Tower crane (Top-slewing)

Top-slewing cranes require a longer duration to erect and dismantle, but they can be erected virtually up to any height.
These cranes are suitable for medium-to high-rise construction projects where they are needed for longer durations.



Tower crane (Bottom-slewing)

Bottom-slewing cranes have height limitations although they can be erected and dismantled very quickly—the reason they are known to be self-erecting and fast-erecting. These are suitable for low-rise construction and for short-term assignments.

Mobile Crane

- The mobile cranes have their own prime movers and, thus, are capable of moving freely on the project sites.
- Mobile cranes come in a wide variety of designs and capacities.
- The cranes typically consist of an undercarriage, an engine to propel the movement, a boom at an inclination, and an operator's cabin.
- The boom could be either a *lattice-type steel boom* or a *telescopic-type boom*.
- The lattice boom has the advantage of simplicity in design and, consequently, lower cost. In order to extend or shorten the length of the lattice boom, the lifting operation is stopped and the extension pieces (also called *fly jibs*) are added or removed.

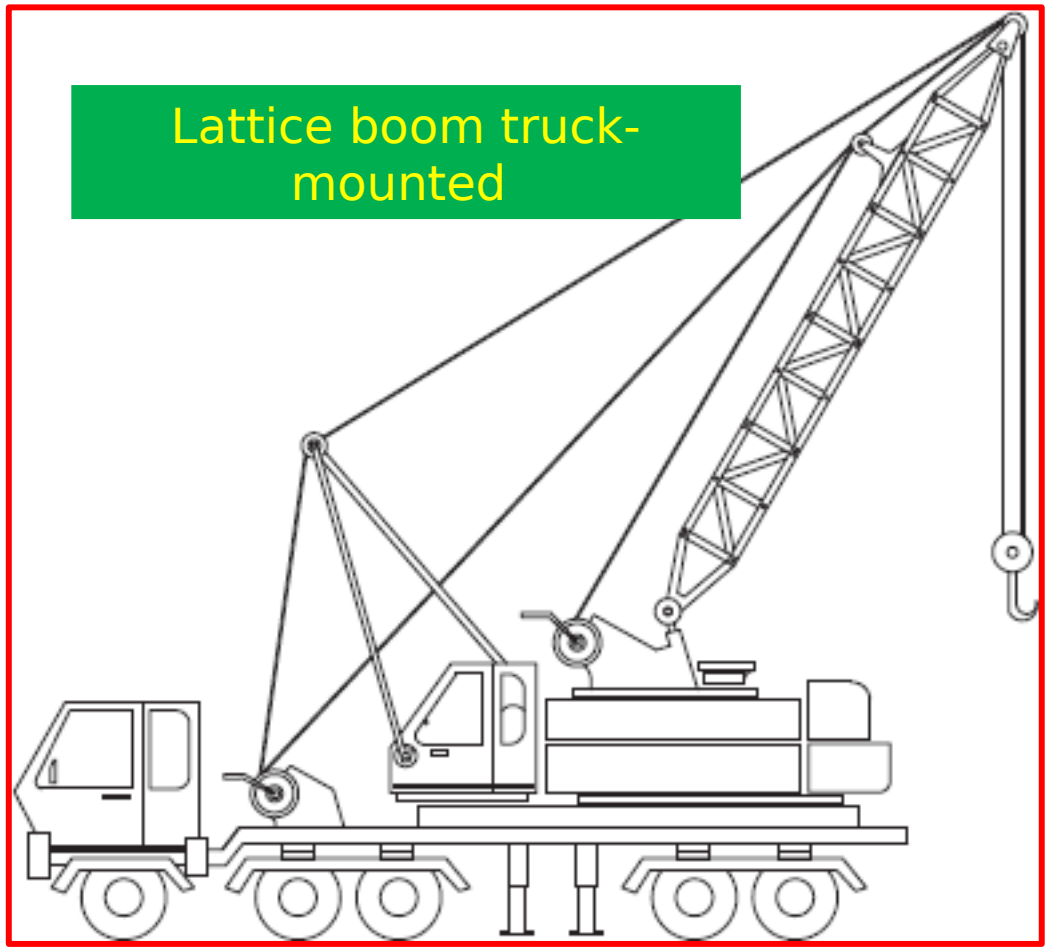
Mobile …

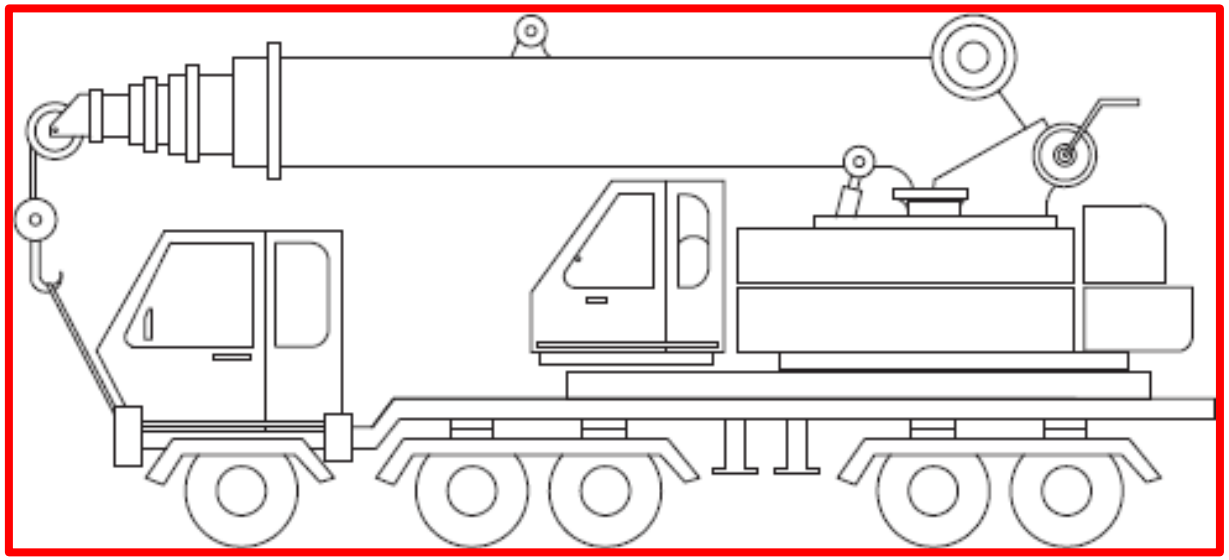
- The telescopic boom has the advantage of having a boom that can be adjusted in length even during the lifting operation, which makes it faster when compared to lattice boom structure.
- Also, in contrast to tower cranes, mobile cranes can be used for purposes other than lifting such as excavation, pile driving and demolition, if fitted with suitable attachments.

Mobile …

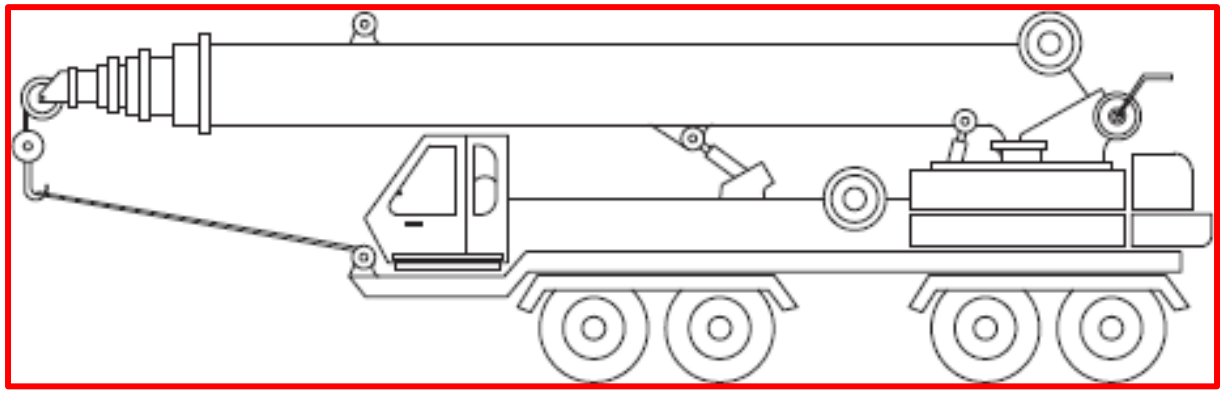
- Mobile cranes are characterized by the maximum lifting capacities.
- The lifting capacities vary at different radii and inclinations.
- In all type of cranes, the shorter the lifting radius, the greater will be the lifting capacity.
- Mobile cranes can be classified into four major categories—(1) truck crane; (2) crawler crane; (3) rough-terrain crane; and (4) all-terrain crane

Lattice boom truck-mounted



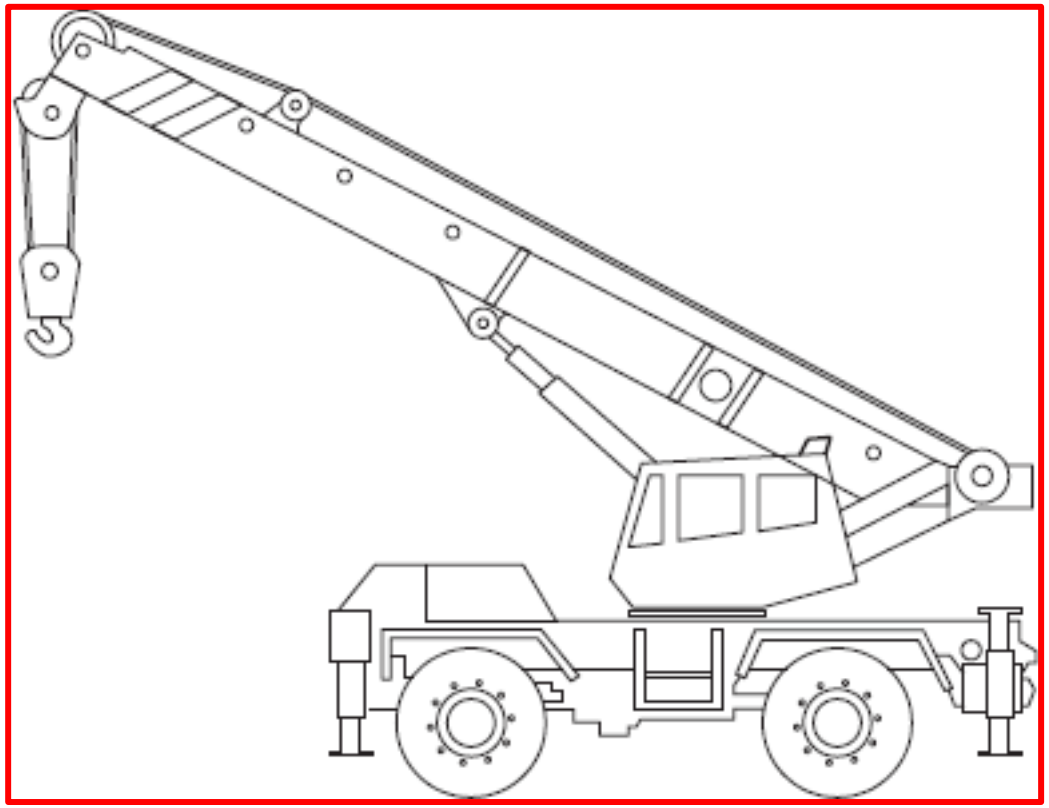


Telescopic boom truck-mounted



All-terrain mobile crane

- As the name suggests, all-terrain cranes can maneuver through rough terrain as well as public roads with ease.
- These cranes are *technologically the most advanced* of all the mobile cranes. They come in both lattice-type and telescopic-type boom options.



Rough-terrain mobile crane

Plant and equipment acquisition

- A construction company can acquire a construction plant and equipment through:
  1) *Cash or outright purchase*
  2) *Hire purchase and*
  3) *Leasing*
- The decision to choose between purchasing and renting is an important one, and it is governed by a number of factors.
- The title (ownership) of the plant and equipment is with the company in the purchasing option.

Calculating equipment costs

- The subject of calculating and accounting for owned equipment cost is one that is ignored by some organizations or lost sight of by others who believe their accountants are taking care of it.
- To estimate work and bid a job, a contractor needs to know exactly how much equipment is going to cost per unit time, and has to include all maintenance and replacement costs to do that.

Calculating …

- A contractor must have this information to accurately price the work at a profit and to know whether ongoing jobs are profitable.
- The basic concept for costing of equipment is quite simple, but calculating it can be another story.
- If the equipment will need major overhauls such as engine replacements 2-3 years, these costs have to be factored into the estimated maintenance and accounted for from the *first month the equipment is put into service.*
- If this is not done, the company will be overstating their real profit by not charging the wear of the equipment to the jobs that caused it.
  - *It creates a **false economy**.*

Elements of equipment cost

- Hourly cost of operation of the equipment can be determined using commonly employed methods in the construction industry.
- It is necessary to estimate many factors, such as fuel consumption, tire life, and so on.
- The best basis for estimating such factors is the use of *historical data*, preferably those recorded by your construction company operating similar equipment under similar conditions.
- If such data are not available, consult the equipment manufacturer/data book for recommendations.

Owning and operating costs

- Contractors face many equipment concerns such as whether to ***buy or lease,*** which equipment to invest in, and when to invest.
- ***Equipment-intensive*** contractors, like road builders, landscapers, and others have to make these decisions often, and they have a long-term and profound effect on success.
- Equipment owning and operating costs (frequently referred to as *O & O costs*), as the name implies, are composed of owning costs and operating costs.
- Owning costs are fixed costs that are incurred each year whether the equipment is operated or not.
- Operating costs, however, are incurred only when the equipment is used.

Owning costs

- Owning costs are made up of the following principal elements:
  - *Depreciation*
  - *Investment (or interest) cost*
  - *Insurance cost*
  - *Taxes*
  - *Storage cost*

How much to own

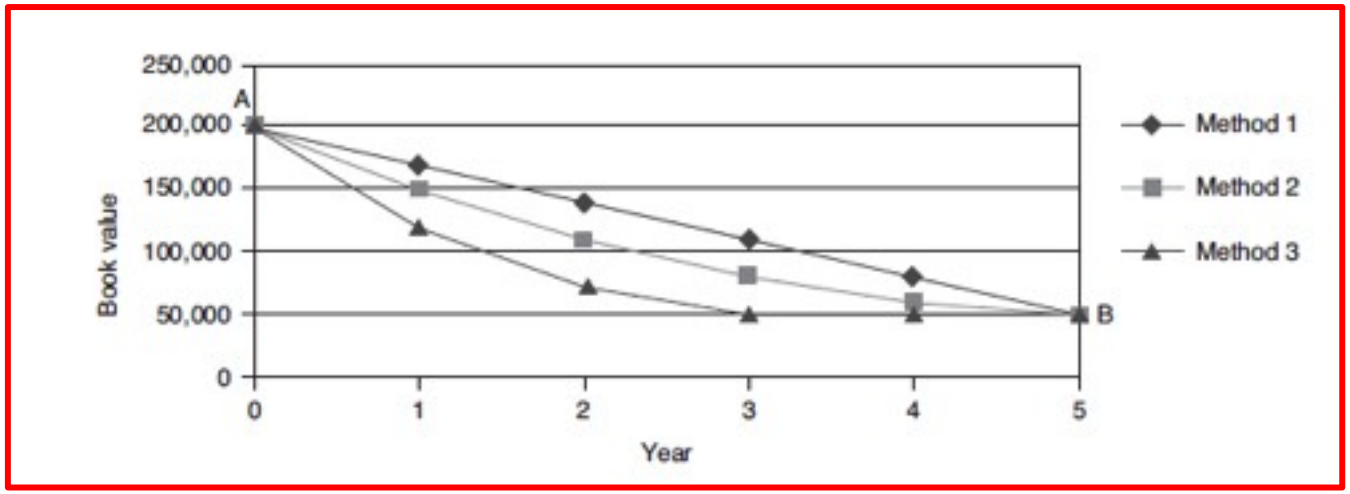
- The *first step in controlling equipment costs* is to control the amount of equipment owned.
- The decision to purchase new equipment is made for basically two reasons: to *replace aging equipment /obsolesce* or for *expansion*.
  - Both reasons are certainly valid business reasons.
  - Nevertheless, both reasons must be considered judiciously because the company is usually committing a great deal of its money with limited assurance of future work.

How …

- Even if a company has contracted for more work than their current equipment will bear, the conditions of an expanding marketplace still make purchasing risky.
- Once the existing work starts to finish up and the equipment used on those jobs becomes available, the company may have idle machinery.
- Increasing inventory of equipment should be very carefully thought out, not only as it relates to the work, but also as it relates to the marketplace, the company's competitive position, and resources to do the additional work at a profit.
- Many successful contractors have loaded up on equipment in good times only to be forced into severe difficulties by the very same equipment when the marketplace went back to normal. The equipment begins to run these contractors instead of the other way around.

Depreciation

- From the point of view of bookkeeping, *depreciation* is considered as an expense and is listed as such (as an expense) in the firm's financial statement.
- It may be noted that this '*expense*' is only technical in nature and the funds are not really transferred out of the system.
- As far as the idea of the final value is concerned, it is referred to as the *salvage value*.
- Now, depending upon various factors, an asset may take different periods of time to depreciate to its salvage value, and therefore, the concept of *'service life'* also needs to be borne in mind.



- Depending on the nature of the variation taken between A and B (as schematically shown by methods 1, 2 and 3), the annual depreciation cost and the book value (calculated by subtracting the total depreciation from the initial cost) of the asset can be quantitatively determined.
- It should be borne in mind that it is entirely possible for a firm to continue to have (own) *assets that have zero book value.*
- In other words, the actual service life (the period during which an asset continues to be functionally useful) and the book life (the period during which the asset depreciates to its final value) could

Depreciation

- Depreciation represents the decline in market value of an item of equipment due to *age, wear, deterioration, and obsolescence*.
- In accounting for equipment costs, however, depreciation is used for two separate purposes:
  1. Evaluating tax liability, and
  2. Determining the depreciation component of the hourly equipment cost
- Note that it is possible (and legal) to use different depreciation schedules for these two purposes.
- For tax purposes many equipment owners depreciate equipment as rapidly as possible to obtain the maximum reduction in tax liability during the first few years of equipment life.

Depreciation

- In calculating depreciation, the initial cost of an item of equipment should be the *full delivered price*, including transportation, taxes, and initial assembly and servicing.
- For *rubber-tired equipment*, the **value of tires should be subtracted** from the amount to be depreciated because tire cost will be computed separately as an ***element of operating cost***.
- Equipment salvage value should be estimated as realistically as possible based on *historical data*.

Depreciation

- The equipment life used in calculating depreciation should correspond to the *equipment's expected economic or useful life*.
- The life for general construction equipment is mostly 5 years.
- The most commonly used depreciation methods are the *straight-line method*, *the sum-of-the-years'-digits method*, *the double-declining balance method*.

Straight-Line Method

- The *straight-line* method of depreciation produces a uniform depreciation for each year of equipment life.
- *Annual depreciation* is thus calculated as the amount to be depreciated divided by the equipment life in years.
- The amount to be depreciated consists of the equipment's initial cost less salvage value (and less tire cost for rubber tired equipment)

$$D_n = \frac{Cost - Salvage(-tires)}{N}$$

where N = equipment life (years)
n = year of life (1, 2, 3, etc.)

Example 1

- Given that the gross income is *ETB*200,000, and assuming that (i) depreciation expenses are fully deductible from gross income and (ii) the income tax is 25% of the taxable income, determine the tax liability in cases when (a) there are no depreciation expenses, and (b) there is

	Case I			Case II		
Gross income (a)	Depreciation expense (b)	Net income (c) = (a) − (b)	Tax payable @25% of (c)	Depreciation expense (b)	Net income (c) = (a) − (b)	Tax payable @25% of (c)
200,000	Nil	200,000	50,000	40,000	160,000	40,000

- Summarizes the total and taxable incomes, and the tax liability in the two cases.
- It can be clearly seen that there is a net saving of *ETB*10,000 in taxes for the conditions given.
- Now, having explained the implication of depreciation expenses on the tax liability, another related issue is how should the total amount of depreciation be distributed over the service life of the asset.

Example 2

- Let the total depreciation involved in an asset be ETB50,000 over a two-year period. Assuming a gross income of ETB100,000 in each year, and taxes payable at a rate of 20% of the net income, compare the tax liabilities in the following cases:
  - Case I: Depreciation amounts in the first and second years are equal (ETB25,000)
  - Case II: Depreciation amounts in the first and second years are ETB40,000 and

		Case I			Case II		
Year	Gross income (a)	Depreciation expense (b)	Net income (c) = (a)−(b)	Tax payable [20% of (c)]	Depreciation expense (b')	Net income (c') = (a)−(b')	Tax payable [20% of (c')]
1	100,000	25,000	75,000	15,000	40,000	60,000	12,000
2	100,000	25,000	75,000	15,000	10,000	90,000	18,000

Observations from the example

- Considering the *time value for money*, payment of taxes in a manner suggested in Case II is beneficial on two counts—(a) more funds remain available at the end of year 1, considering that depreciation expenses are *only a bookkeeping exercise,* and (b) less tax is paid in year 1, and additional funds are available, at least for some time.
- It is for these reasons that accountants prefer to use methods that allow for faster initial depreciation in order to maximize the returns on tax savings.
- It is in this backdrop that regulatory measures are required to define a framework for *calculations of depreciation rates and*

Ethiopian Ministry of Revenue Depreciation accounting

- Tax rules of the Ethiopian *Ministry of Revenue* treat any gain (amount received in excess of the equipment's depreciated or *book value*) on the sale of equipment as *ordinary income.*
- *Article 36(4) of regulation states: No depreciation deduction shall be allowed for the cost of a depreciable asset or business intangible acquired by a taxpayer from a related person ("transferor") when the cost of the asset or intangible had been fully depreciated by the transferor.*
- When the methods of *engineering economics* are used, the *depreciation and investment* components of equipment owning costs are calculated together as a single cost factor.

Ethiopian Ministry of Revenue …

- 1/ Subject to sub-article (2), a taxpayer may determine the depreciation deduction allowed under Article 25(1) of the Proclamation according to the *straight-line method* under Article 37 of these Regulations or the *diminishing value method* under Article 38 of these Regulations provided:
  a) The taxpayer has used the same method of depreciation in its financial accounts prepared in accordance with financial reporting standards; and

  b) The same method of depreciation is used by the taxpayer for all depreciable assets owned by the taxpayer.

Ethiopian Ministry of Revenue …

- *Article 37* (regulation) *Straight-line Depreciation*

1. *Subject to Article 25(3) and (4) of the Proclamation, the depreciation deduction allowed to a taxpayer for a tax year in respect of a depreciable asset or business intangible under the straight-line method shall be calculated by applying the rate specified in Article 39 of these Regulations against the cost of the asset.*
2. *The total deductions allowed, or that would be allowed but for Article 25(4) of the Proclamation, to a taxpayer in respect of a depreciable asset or business intangible to which this Article applies for the current tax year and all previous tax years shall not exceed the cost of the asset.*

Ethiopian Ministry of Revenue …

- *Article 38* (regulation) *Diminishing value depreciation method*

1. *Subject to Article 25(3) and (4) of the Proclamation, the depreciation deduction allowed to a taxpayer for a tax year in respect of a depreciable asset under the diminishing value method shall be calculated by applying the rate specified in Article 39 of these Regulations against the net book value of the asset at the beginning of the year.*
2. *If Article 25(4) of the Proclamation applies to a depreciable asset for a tax year, the net book value of the asset shall be calculated on the basis that the asset has been used in that year solely to derive business income.*

Article 39 (regulation) *Rates of Depreciation*

1. *Rates of depreciation applicable to a depreciable asset are specified in the following table based on the following categories:*
2. *The rate of depreciation applicable to a business intangible shall be:*
   a) *for preliminary expenditure, 25%;*
   b) *for a business intangible with a useful life of more than 10 years, other than a business intangible referred to in paragraph (a), 10%; or*
   c) *for any other business intangible, 100% divided by the useful life of the intangible.*
3. *In this Article, "preliminary expenditure" means expenditure referred to in paragraph (4) of the definition of "business intangible" in Article 25(7)(a) of the Proclamation incurred by a taxpayer before the*

Depreciable Asset	Straight-line Rate	Diminishing Value Rate
Computers, software, and data storage equipment	20%	25%
Greenhouses	10%	-
Structural Improvement other than a greenhouse	5%	-
Any other depreciable asset	15%	20%
Depreciable asset used in mining and petroleum development operations	25%	30%

Example 3

- Using the straight-line method of depreciation, find the annual depreciation and book value at the end of each year for a track loader having an initial cost of $50,000, a salvage value of $5,000, and an expected life of 5 years.

Solutions

$$D_{1,2,3,4,5} = \frac{50{,}000 - 5000}{5} = \$9000$$

Year	Depreciation	Book Value (End of Period)
0	0	$50,000
1	$9,000	41,000
2	9,000	32,000
3	9,000	23,000
4	9,000	14,000
5	9,000	5,000

Sum-of-the-Years'-Digits Method

- The sum-of-the-years'-digits method of depreciation produces a *nonuniform depreciation* which is the highest in the first year of life and gradually decreases thereafter.
- The amount to be depreciated is the same as that used in the straight-line method.
- The depreciation for a particular year is calculated by multiplying the amount to be depreciated by a depreciation factor.

Sum-of-the-Years'-Digits …

- The denominator of the depreciation factor is the sum of the years' digits for the depreciation period (or 1 + 2 + 3 + 4 + 5 = 15 for a 5-year life).
- The numerator of the depreciation factor is simply the particular year digit taken in inverse order (i.e., 5 - 4 - 3 - 2 - 1).
- Thus for the first year of a 5-year life, 5 would be used as the numerator.

$$D_n = \frac{Year\ Digit}{Sum\ of\ year's\ Digit}\ X\ Amount\ to\ be\ depreciated$$

Example 4

For the loader of *Example 3*, find the annual depreciation and book value at the end of each year using the *sum-of-the-years'-digits* method.

$$D_1 = \frac{5}{15} \times (50{,}000 - 5000) = 15{,}000$$

$$D_2 = \frac{4}{15} \times (50{,}000 - 5000) = 12{,}000$$

$$D_3 = \frac{3}{15} \times (50{,}000 - 5000) = 9{,}000$$

$$D_4 = \frac{2}{15} \times (50{,}000 - 5000) = 6{,}000$$

$$D_5 = \frac{1}{15} \times (50{,}000 - 5000) = 3{,}000$$

Year	Depreciation	Book Value (End of Period)
0	0	$50,000
1	$15,000	35,000
2	12,000	23,000
3	9,000	14,000
4	6,000	8,000
5	3,000	5,000

Double-declining-balance method

- The *double-declining-balance* method of depreciation, like the *sum-of-the-years'-digits* method, produces its maximum depreciation in the first year of life.
- However, in using the *double-declining-balance* method, the depreciation for a particular year is found by multiplying a depreciation factor by the equipment's *book value* at the beginning of the year.
- The *annual depreciation factor* is found by dividing 2 (or 200%) by the equipment life in years.
- Thus for a *5-year life*, the annual depreciation factor is 0.40 (or 40%).

Double-declining-balance …

- Unlike the other two depreciation methods, the *double-declining-balance* method does not automatically reduce the equipment's *book value* to its *salvage value* at the end of the depreciation period.
- Since the *book value* of equipment is not permitted to go below the equipment's *salvage value*, care must be taken when performing the depreciation calculations to stop depreciation when the *salvage value* is reached. The correct procedure is as follows:

$$D_n = \frac{2}{N} X \, Book \, Value \, at \, beginning \, of \, year$$

Example 5

- For the loader of *Example 3*, find the annual depreciation and *book value* at the end of each year using the *double-declining-balance* method.

$$\text{Annual depreciation factor} = \frac{2.00}{5} = 0.40$$

$$D_1 = 0.40 \times 50{,}000 = 20{,}000$$
$$D_2 = 0.40 \times 30{,}000 = 12{,}000$$
$$D_3 = 0.40 \times 18{,}000 = 7{,}200$$
$$D_4 = 0.40 \times 10{,}800 = 4{,}320$$
$$D_5 = 0.40 \times \ \ 6{,}480 = 2{,}592 \text{ use } \$1{,}480^*$$

Year	Depreciation	Book Value (End of Period)
0	0	$50,000
1	$20,000	30,000
2	12,000	18,000
3	7,200	10,800
4	4,320	6,480
5	1,480*	5,000

*Because a depreciation of $2592 in the fifth year would reduce the book value to less than $5000, only $1480 ($6480 − $5000) may be taken as depreciation.

Investment Cost

- *Investment cost* (or *interest*) represents the annual cost (converted to an hourly cost) of the capital invested in a machine.
- If borrowed funds are utilized, it is simply the interest charge on these funds.
- However, if the item of equipment is purchased from company assets, an interest rate should be charged equal to *the rate of return on company investments.*
- Thus investment cost is computed as the product of an *interest rate multiplied by the value of the equipment, then converted to cost per hour*.

Investment …

- The *true investment* cost for a specific year of ownership is properly calculated using the *average value of the equipment* during that year.
- However, the average hourly investment cost may be more easily calculated using the value of the average investment over the life of the equipment given by Equation.

$$Average\,investment = \frac{Initial\,cost + Salvage}{2}$$

Investment …

- The results obtained using the above equation should be sufficiently accurate for calculating *average hourly owning costs over the life of the equipment.*
  - However, students are cautioned that the investment cost calculated in this manner is not the actual cost for a specific year.
  - *It will be too low in the early years of equipment life and too high in later years.*
- Thus this method should not be used for making ***replacement decisions*** or for other purposes *requiring precise investment cost for a particular year.*

Insurance, Tax, and Storage

- ***Insurance cost*** represents the cost of fire, theft, accident, and liability insurance for the equipment.
- ***Tax cost*** represents the cost of ***property tax*** and licenses for the equipment.
- ***Storage cost*** represents the cost of rent and maintenance for equipment storage yards and facilities, the wages of guards and employees involved in handling equipment in and out of storage, and associated ***direct overhead***.

Insurance, Tax …

- The cost of *insurance and taxes* for each item of equipment may be known on an *annual basis*.
- In this case, *these costs are simply divided by the hours of operation* during the year to yield the cost per hour for these items.
- *Storage costs* are usually obtained on an *annual basis* for the entire equipment fleet.
- *Insurance and tax* cost may also be known on a *fleet basis*.
  - *It is then necessary to prorate these costs to each item.*
  - This is usually done by converting total annual cost to a percentage rate by dividing these costs by the total value of the equipment fleet.
  - When this is done, the rate for insurance, tax, and storage may simply be added to the investment cost rate to calculate the annual cost of investment, tax, insurance, and storage.

Total Owning Cost

- Total equipment owning cost is found as the sum of *depreciation*, *investment*, *insurance*, *tax*, and *storage*.
- As mentioned earlier, the elements of owning cost are often *known on an annual cost basis*.
- However, whether the individual elements of owning cost are calculated on an annual-cost basis or on an hourly basis, total owning cost should be expressed as *an hourly cost*.

Depreciation Bonus

- At times in order to stimulate the economy and encourage businesses to purchase new equipment, governments sometimes created a depreciation bonus for equipment purchases.
- When in effect, such laws provide an immediate depreciation equal to a designated percentage of the cost of new equipment for the year in which the equipment is placed in service.
- The remaining portion of equipment cost is then depreciated according to normal depreciation procedures.

Investment Credit

- *Investment credit* is another mechanism sometimes used by government to encourage industry to modernize production facilities by providing a tax credit for the purchase of new equipment.
- When in effect, *investment credit* provides a direct credit against *tax due*, not merely a reduction in taxable income.
- The *investment credit* last authorized allowed a tax credit equal to say 10% of the investment for the purchase of equipment classified as 5-year property and 6% for equipment classified as 3-year property.

Operating Costs

- ***Operating costs*** are incurred only when equipment is operated. Therefore, costs vary with the amount of equipment use and job operating conditions. Operating costs include operators' wages, which are usually added as a separate item after other operating costs have been calculated.
- The major elements of ***operating cost*** include:
  1. *Fuel cost*
  2. *Service cost*
  3. *Repair cost*
  4. *Tire cost*
  5. *Cost of special items*
  6. *Operators' wages*

Fuel Cost

- The hourly cost of fuel is simply fuel consumption per hour multiplied by the cost per unit of fuel (gallon or liter).
- Actual measurement of fuel consumption under similar job conditions provides the *best estimate of fuel consumption*.
- However, when historical data are not available, fuel consumption may be estimated from *manufacturer's data* or by the use of Table 1.
- Table 1 provides *approximate fuel consumption factors in gallons per hour per horsepower* for major types of equipment under *light*, *average*, and *severe load* conditions.

Table 1 Fuel consumption factors (gal/h/hp)

Type of Equipment	Load Conditions*		
	Low	*Average*	*Severe*
Clamshell and dragline	0.024	0.030	0.036
Compactor, self-propelled	0.038	0.052	0.060
Crane	0.018	0.024	0.030
Excavator, hoe, or shovel	0.035	0.040	0.048
Loader			
Track	0.030	0.042	0.051
Wheel	0.024	0.036	0.047
Motor grader	0.025	0.035	0.047
Scraper	0.026	0.035	0.044
Tractor			
Crawler	0.028	0.037	0.046
Wheel	0.028	0.038	0.052
Truck, off-highway	0.014	0.020	0.029
Wagon	0.029	0.037	0.046

*Low, light work or considerable idling; average, normal load and operating conditions; severe, heavy work, little idling.

Service Cost

- *Service cost* represents the cost of *oil*, *hydraulic fluids*, *grease*, and *filters* as well as the *labor required to perform routine maintenance service*.
- Equipment manufacturers publish consumption data or *average cost factors* for oil, lubricants, and filters for their equipment under average conditions.
- Using such consumption data, multiply hourly consumption (adjusted for operating conditions) by cost per unit to obtain the hourly cost of consumable items.
- Service labor cost may be estimated based on prevailing wage rates and the planned maintenance program.

Service …

- Since *service cost* is related to equipment size and severity of operating conditions, a *rough estimate of service cost may be made based on the equipment's fuel cost (Table 2).*
- For example, using Table 2 the hourly *service cost* of a ***scraper*** operated under ***severe conditions*** would be estimated at 50% of the hourly fuel cost.

Table 2 Service cost factors (% of hourly fuel cost)

Operating Conditions	Service Cost Factor
Favorable	20
Average	33
Severe	50

Repair Cost

- *Repair cost* represents the cost of all equipment repair and maintenance except for *tire repair* and *replacement*, *routine service*, and *the replacement of high-wear items*, such as *ripper teeth*.
- It should be noted that repair cost usually constitutes the largest item of *operating expense for construction equipment*.
- Lifetime repair cost is usually estimated as a percentage of the equipment's initial cost less tires (Table 3).
- It is then necessary to convert lifetime repair cost to *an hourly repair cost.*

Repair …

- This may be done simply by *dividing lifetime repair cost by the expected equipment life in hours to yield an average hourly repair cost.*
- Although this method is adequate for lifetime cost estimates, it is not valid for a particular year of equipment life.
- Repair costs are typically low for new machines and rise as the equipment ages.

Table 3 Typical lifetime repair cost (% of initial cost less tires)

Type of Equipment	Operating Conditions		
	Favorable	*Average*	*Severe*
Clamshell and dragline	40	60	80
Compactor, self-propelled	60	70	90
Crane	40	50	60
Excavator, hoe, or shovel	50	70	90
Loader			
Track	85	90	105
Wheel	50	60	75
Motor grader	45	50	55
Scraper	85	90	105
Tractor			
Crawler	85	90	95
Wheel	50	60	75
Truck, off-highway	70	80	90
Wagon	45	50	55

It is suggested that the following equation be used to obtain a more accurate estimate of *repair cost during a particular year of equipment life.*

$$\textbf{Hourly repair cost} = \frac{\textbf{Year Digit}}{\textbf{Sum of year's Digits}} X \frac{\textbf{Life time repair cost}}{\textbf{Hours Operated}}$$

This *method of prorating repair costs is essentially the reverse of the sum-of-the-years'-digits method of depreciation* explained earlier, because the year digit used in the numerator of the equation is now used in a normal sequence (i.e., 1 for the first year, 2 for the second year, *etc.*).

Example 6

- Estimate the hourly repair cost for the first year of operation of a crawler tractor costing $136,000 and having a 5-year life.
- Assume average operating conditions and 2,000 hours of operation during the years.

Solutions

- Lifetime repair cost factor = 0.90 (Table – 3)
- Lifetime repair cost = 0.90 X 136,000 = $122,400

$$\textbf{\textit{Hourly repair cost}} = \frac{1}{15} X \frac{122,400}{2,000} = \$4.08$$

Tire Cost

- Tire cost represents the cost of *tire repair and replacement*.
- Among operating costs for rubber-tired equipment, tire cost is usually exceeded only by repair cost.
- Tire cost is difficult to estimate because of the difficulty in estimating tire life.
- As always, historical data obtained under similar operating conditions provide the best basis for estimating tire life.
- However, Table 4 may be used as a guide to approximate tire life.
- *Tire repair will add about 15% to tire replacement cost.*

Table 4 Typical tire life (hours)

Type of Equipment	Operating Conditions		
	Favorable	*Average*	*Severe*
Dozers and loaders	3,200	2,100	1,300
Motor graders	5,000	3,200	1,900
Scrapers			
Conventional	4,600	3,300	2,500
Twin engine	4,000	3,000	2,300
Push-pull and elevating	3,600	2,700	2,100
Trucks and wagons	3,500	2,100	1,100

Equation below may be used to estimate tire repair and replacement cost.

$$Tire\ cost = 1.15\ X\ \frac{Cost\ of\ a\ set\ of\ tires}{Expected\ tire\ life\ (h)}$$

Special Items

- The cost of replacing high-wear items such as dozer, grader, and *scraper blade cutting edges* and *end bits*, as well as *ripper tips*, *shanks*, and *shank protectors*, should be calculated as a separate item of operating expense.
- As usual, unit cost is divided by expected life to yield cost per hour.

Operator

- The final item making up equipment operating cost is the *operator's wage*.
- Care must be taken to include all costs, such as worker's compensation insurance, Social Security taxes, overtime or premium pay, and fringe benefits, in the hourly wage figure.

Total Owning and Operating Costs

- After owning cost and operating cost have been calculated, these are totaled to yield total owning and operating cost per hour of operation.
- Although this cost may be used for estimating and for charging equipment costs to projects, notice *that it does not include overhead or profit.*
- Hence overhead and profit must be added to obtain an hourly rental rate if the equipment is to be rented to others.

Example 7

- Calculate the expected hourly owning and operating cost for the second year of operation of the twin-engine scraper described below.
  - *Cost delivered = $152,000*
  - *Tire cost = $12,000*
  - *Estimated life = 5 years*
  - *operation during the year = 2000 hrs*
  - *Salvage value = $16,000*
  - *Depreciation method = sum-of-the-years'-digits*
  - *Investment (interest) rate = 10%*
  - *Tax, insurance, and storage rate = 8%*
  - *Operating conditions = average*
  - *Rated power = 465 hp*
  - *Fuel price = $1.30/gal*
  - *Operator's wages = $32.00/h*

Owning Cost

Depreciation cost:

$$D_2 = \frac{4}{15} \times (152{,}000 - 16{,}000 - 12{,}000) = \$33{,}067$$

$$\text{Depreciation} = \frac{33{,}067}{2000} = \$16.53/\text{h}$$

Investment, tax, insurance, and storage cost:

$$\text{Cost rate} = \text{Investment} + \text{tax, insurance, and storage} = 10 + 8 = 18\%$$

$$\text{Average investment} = \frac{152{,}000 + 16{,}000}{2} = \$84{,}000$$

$$\text{Investment, tax, insurance, and storage} = \frac{84{,}000 \times 0.18}{2000} = \$7.56/\text{h}$$

$$\text{Total owning cost} = 16.53 + 7.56 = \$24.09/\text{h}$$

Operating Cost

Fuel cost:

$$\text{Estimated consumption} = 0.035 \times 465 = 16.3 \text{ gal/h} \quad \text{(Table 1)}$$

$$\text{Fuel cost} = 16.3 \times 1.30 = \$21.19/\text{h}$$

Service cost:

Service cost = 0.33 × 21.19 = \$7.06/h (Table 2)

Repair cost:

Lifetime repair cost = 0.90 × (152,000 − 12,000) = \$126,000 (Table 3)

$$\text{Repair cost} = \frac{2}{15} \times \frac{126{,}000}{2{,}000} = \$8.40/\text{h}$$

Tire cost:

Estimated tire life = 3000 h (Table 4)

$$\text{Tire cost} = 1.15 \times \frac{12{,}000}{3000} = \$4.60/\text{h}$$

Special item cost: None

Operator wages = \$32.00/h

Total operating cost = 21.19 + 7.06 + 8.40 + 4.60 + 32.00 = \$73.25/h

Total O & O Cost

Owning and operating cost = 24.09 + 73.25 = \$97.34/h

Leasing

- A leasing arrangement is fundamentally different from either *outright* purchase in that the title theoretically never passes to the *lessee* (user)*or hire.*
- A lease may be *defined as a contract* whereby, in return for payment of specified rentals, the *lessee* obtains the use of a capital asset owned by another party (the *lessor*).
- Within this definition, however, there are several varieties of lease to suit the parties concerned, of which the ***finance lease*** and ***operating lease are two forms appropriate to plant acquisition.***

Finance lease

- The rental charges will cover the *asset's capital cost*, *except for its expected residual value at the end of the lease, together with a service charge designed to meet the lessor's overheads, interest charges, servicing costs and an element for profit* in which this type of lease is generally arranged by a *financial institution*
- The *lease usually will be divided into two parts*: in the *primary period*, which normally lasts 3 to 5 years, rentals are set at a level sufficient to recover all the above-mentioned costs.
- The *secondary* (or *continuation*) period, which could be a fixed time interval, is extended to suit the lessee's needs and may require only a nominal rental.

Finance …

- At the end of the lease the asset is sold by the lessor, but not directly to the lessee, this being specifically written into the contract to comply with the terms of the current taxation legislation.
- Because the lessor often has no direct interest in the leased asset, it is usual that the contract cannot be cancelled until the lessor has realized the investment at the end of the primary period.
- Meantime the lessee has full use of the asset as though it were owned.
- Unlike outright purchase, however, leasing does not allow the lessee company to take advantage of the *capital allowances on the asset*.

Operating lease

- Whereas a finance lease is generally offered by a financial institution, the lessors in the case of an ***operating lease*** are likely to be the manufacturers or suppliers of the asset, whose purpose is to assist in the marketing of the item.
- The primary period lease would be uncancellable and charges are frequently lower than those required by a *finance lease*, because the type of asset involved would either have a good second-hand value, or be tied to a lucrative service agreement or supply of spare parts.
- Indeed the profit expected by the lessor might well come from these latter services, which would continue into the secondary period of the lease.
- Clearly this type of arrangement is most appropriate for large and/or technically sophisticated plant items where the manufacturers have skilled personnel and are capable of carrying out the required servicing and maintenance.
- Some haulage truck manufacturers have offered this method of trading when a healthy second-hand market existed.

Operating …

- A further advantage to the lessee is that the title remains with the lessor but unlike finance leases *no entry is required on the lessee's balance sheet.*
- Consequently the capital gearing would remain unchanged and this could therefore be particularly convenient to a highly geared company, which might otherwise find difficulty in raising loan capital for direct purchase or even hire purchase of the plant item.
- The lease charges are considered as a business expense and so are included as costs in the profit and loss account.

Equipment rental

- Historically there has been a growing use of rental equipment by contractors and subcontractors.
- With the growing demand for rental equipment, several national equipment rental chains have been formed along with increased rental of equipment by major equipment manufacturers.
- Since a *rental agreement is a short-term arrangement* (usually having a duration of less than 1 year) and no advance payment is normally required, rental equipment provides the contractor with great flexibility in meeting project requirements.
- In addition, the rental dealer commonly provides all equipment maintenance except for high-wear items.
- A ***Rental-Purchase Option*** (***RPO***), which credits a portion of the rental payments to the purchase price if the option is exercised, may also be available.

The rent-lease-buy decision

- The question of whether it is better to purchase a piece of construction equipment rather than renting or leasing the item is difficult to answer.
- Leasing involves a commitment for a fixed period and may include a purchase option in which a portion of the lease payments is credited toward the purchase price if the option is exercised.
- In recent years, there has been a trend toward increased leasing and renting of construction equipment.
- Some of the reasons for this trend include the *rising cost of equipment*, *rapid changes in equipment technology*, and the *wide fluctuation in the rate of demand for construction services*.

The rent-lease-buy …

- Advantages of equipment ownership include governmental tax incentives *(investment credit and depreciation)*, *full control of equipment resources*, and *availability of equipment when needed*.
- However, leasing and renting require *little initial capital (usually none for renting)* and equipment costs are fully tax deductible as *project expenses*.
- A *rational analysis* of these alternatives for obtaining equipment is complex and must include cost under the expected conditions, as well as *equipment availability and productivity*.

The rent-lease-buy …

- In general, purchasing equipment will result in the lowest hourly equipment cost if the equipment is properly maintained and fully utilized.
- However, as we noted earlier, equipment owning costs continue whether equipment is being *utilized* or *sitting idle*.
- Therefore, renting is usually least expensive for equipment with low utilization.
- Leasing is intermediate between the two and may be the best solution when capital is limited and equipment utilization is high.
- The lease-with-purchase option may provide an attractive opportunity to purchase the equipment at low cost after lease costs have been paid under a cost-type contract.

Example 8

- Analyze the cost of renting, leasing, and purchasing an item of construction equipment under the conditions described. Evaluate total net after-tax cash flow and its present value.
- Basic assumptions:
  - Company's marginal tax rate = 46%
  - Company's after-tax rate of return = 8%
  - Planned equipment use = 2000 h/year for 5 years
- Purchase assumptions:
  - Equipment cost = $150,000
  - Estimated resale value after 5 years = $60,000
  - Cost recovery method = 5-year *Accelerated Cost Recovery System* (ACRS)(yearly depreciation of 15%, 22%, 21%, 21%, and 21%)

Example …

- Investment credit (10%) = $15,000
- Cost basis = $142,500 (cost less $^1/_2$ investment credit)
- Down payment (20%) = $30,000
- Loan period = 36 months
- Loan interest rate = 12%
- Monthly payment = $3,985.72

Loan amortization:

Year	Payments	To Principal	Interest
1	$47,828.64	$35,329.91	$12,498.73
2	$47,828.64	$39,810.61	$ 8,018.03
3	$47,828.64	$44,859.48	$ 2,969.16

Lease assumptions:

- Term of lease = 5 years
- Lease payment = $2,800 per month
- Initial payment = 3 months in advance

Rental assumptions:

- Rental period = 5 years, month to month
- Rental rate = $5,150 per month

- Mid-year present worth factors (average of start-of-year and end-of-year values) for i = 8%:
  - Initial (year 0) = 1.00000
  - Year 1 = 0.96297
  - Year 2 = 0.89164
  - Year 3 = 0.82559
  - Year 4 = 0.76443
  - Year 5 = 0.70781
  - Final (end of Year 5) = 0.68058

Solution

Values are rounded to nearest whole dollar.

	Purchase Cost ($)							
	Initial	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Final**	**Total**
Payments	30,000	47,829	47,829	47,829	0	0	0	173,487
Resale	0	0	0	0	0	0	(60,000)	(60,000)
Tax at resale	0	0	0	0	0	0	27,600	27,600
Tax savings—depreciation	0	(9,832)	(14,421)	(13,766)	(13,766)	(13,766)	0	(65,551)
Tax savings—interest	0	(5,749)	(3,688)	(1,366)	0	0	0	(10,803)
Investment credit	0	(15,000)	0	0	0	0	0	(15,000)
Net cost	30,000	17,248	29,720	32,697	(13,766)	(13,766)	(32,400)	49,733
Present value of net cost	30,000	16,609	26,500	26,994	(10,523)	(9,744)	(22,051)	57,785

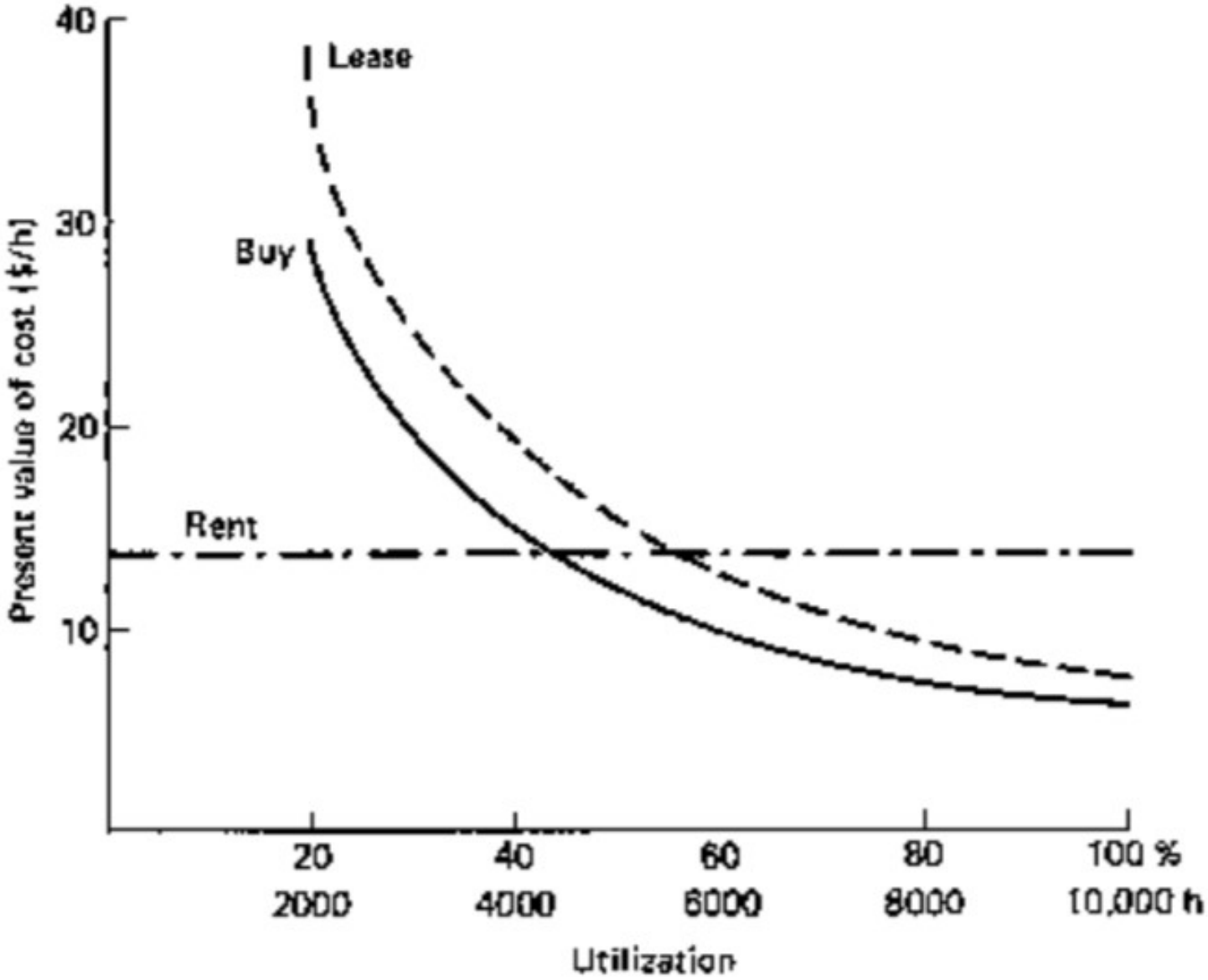
Lease Cost ($)

	Initial	Year 1	Year 2	Year 3	Year 4	Year 5	Final	Total
Payments	8,400	33,600	33,600	33,600	33,600	25,200	0	168,000
Tax savings—payments	(3,864)	(15,456)	(15,456)	(15,456)	(15,456)	(11,592)	0	(77,280)
Net cost	4,536	18,144	18,144	18,144	18,144	13,608	0	90,720
Present value of net cost	4,536	17,472	16,178	14,980	13,870	9,632	0	76,668

Rental Cost ($)

	Initial	Year 1	Year 2	Year 3	Year 4	Year 5	Final	Total
Payments	0	61,800	61,800	61,800	61,800	61,800	0	309,000
Tax savings—payments	0	(28,428)	(28,428)	(28,428)	(28,428)	(28,428)	0	(142,140)
Net cost	0	33,372	33,372	33,372	33,372	33,372	0	166,860
Present value of net cost	0	32,136	29,756	27,552	25,511	23,621	0	138,576

Hourly cost of buying, leasing, and renting for Example



Example of depreciation calculations for equipment at a site

- A large company continues to buy different pieces of individual equipment at different points in time at different costs, and they are used at different sites for *varying periods of time*.
- Thus, for the purpose of bookkeeping and the expenses incurred at a particular site on account of depreciation of equipment used at that site, the actual depreciation expenses incurred at any site need to be determined.
- In this context, a month or a quarter could be taken as single units for calculating depreciation expenses.
- The following example has been included to illustrate the concept of this integration of depreciation expenses at a single site.

S. No.	Description (A)	Nos (B)	Month (C)	Opening book value as on 31.12.2005 (D)	Opening value for total (E) (BXD)	Dep. rate (F)	Dep. per month* (G)	Total dep. (H) (BXCXG)
1	Mixer machine	13	4	73,360	953,680	4.75%	443	23,036
2	Tippers—6 m³	2	12	315,054	630,108	11.31%	5,664	135,936
3	Vibrators	13	4	20,704	269,152	5.15%	137	7,124
4	Builders hoist—2t	4	13	109,230	436,921	4.75%	657	34,164
5	Compressor	1	13	242,375	242,375	5.15%	1,609	20,917
6	Compression testing machine—100 t	4	13	118,805	475,220	4.75%	716	37,232
7	Concrete pump	2	15	6,114,175	12,228,350	4.75%	36,951	1,108,530
8	Earth rammer	1	21	30,654	30,654	11.31%	556	11,676
9	Woodcutting and planner	1	8	21,865	21,865	4.75%	131	1,048
10	Level	1	21	289,915	289,915	4.75%	1,754	36,834
11	DG set—65KVA	1	13	203,555	203,555	5.15%	1,352	17,576
12	Welding generator	1	13	48,275	48,275	5.15%	322	4,186
	Total depreciation							1,438,259

* As mentioned in the text, the *rate of depreciation* is included only for the sake of completion, and cannot be directly used to determine the actual depreciation involved (*shown in column G*). The latter is based on the initial cost (and the salvage value, depending upon the method used), and these values have not been provided here. In other words, for the sake of illustration, the values in column G have been provided independently in this example.

Systematic plant selection

- A number of researchers have worked to develop a method to assist in equipment selection and, consequently, different models have evolved over the years.
- For example, there are optimization model, graphics model and database-centred models to select tower cranes.
- Different expert systems have also been developed to assist in equipment selection.
- Finally, there are artificial intelligence-based models. Harris and McCaffer (2001) have developed their equipment selection model based on multi-attribute decision-making.
- Dynamic programming-based models have also been developed for equipment selection. A number of computer programs have been developed to assist in the equipment-selection process.

Systematic …

- The decision to purchase an item of plant should be based on economic considerations because, unless it can be demonstrated that the investment will yield a satisfactory rate of return, there should be no purchase at all.
- However, in practice several more factors need to be considered before a decision is possible.
- Many makes of machine are available; sometimes the broad technical details between the products of the different manufacturers can be closely compared, but often this is not possible.
- Intangible areas exist, such as after-sales service, maintenance, delivery and payment arrangements.

Systematic …

- They are often not quantifiable and frequently take on a disproportionate influence during the decision-making process.
- Hence all the important and complex factors involved when deciding on the purchase of an item of plant or equipment should be taken into account.
- Only after careful consideration of all the facts, involving many separate judgements, can a decision then be reached.
- Obviously the final choice is bound to be a compromise between what the manager wants ideally, and what can actually be obtained.

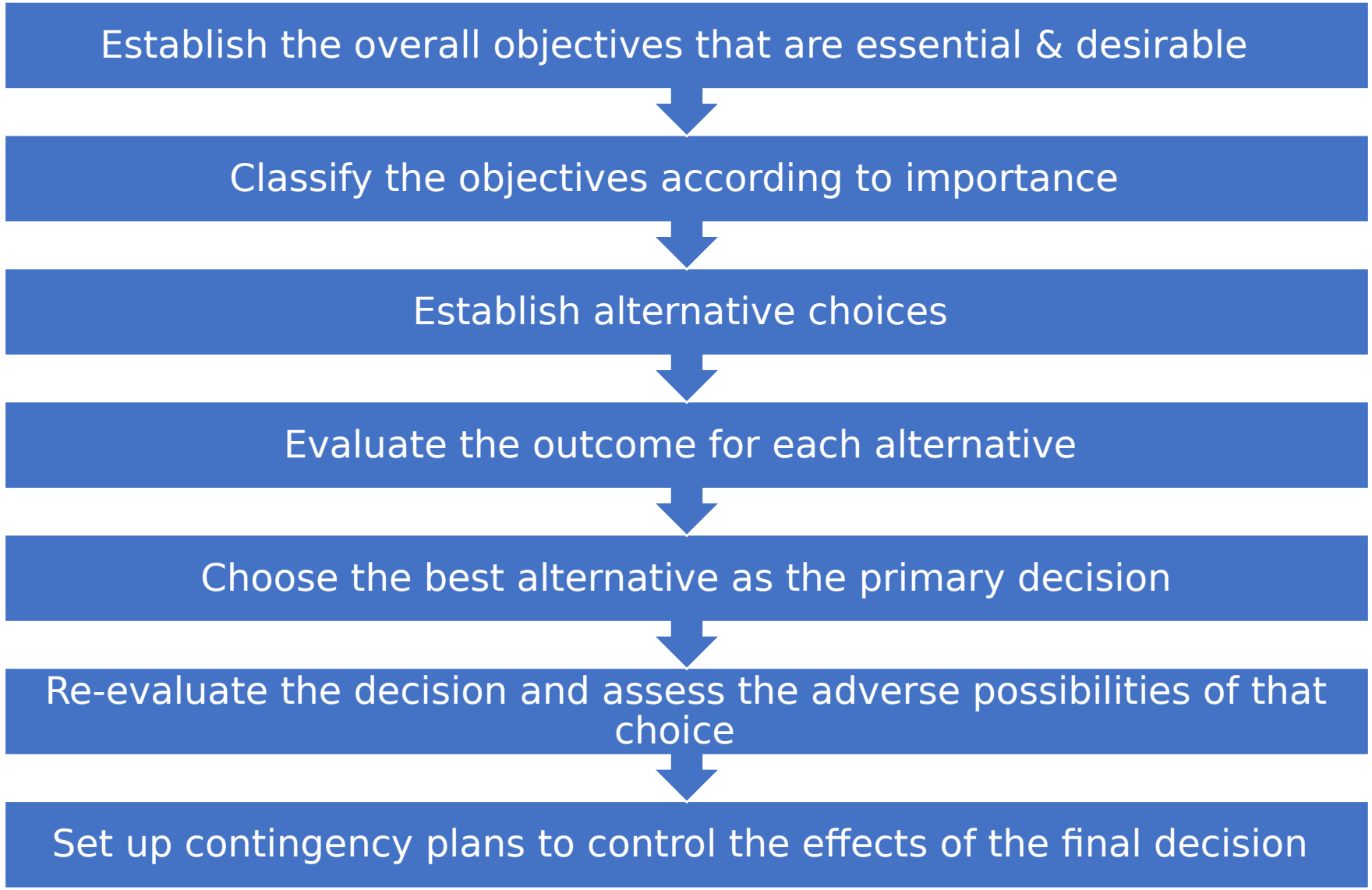
Systematic …

- The problem is best tackled in a systematic and disciplined way, whereby the Kepner and Tregoe decision-making procedure developed for the design process adopted by many manufacturing companies provides a potentially suitable method for application in construction equipment selection (Kepner & Tregoe, 1965).

The essential characteristics of decision situation

- Dixon (1966) described decision as follows:
  - 'Decision making is compromise. The decision maker must weight value judgements that involve economic factors, technical practicalities, scientific necessities, human and social considerations, etc. To make a "*correct*" decision is to choose the one alternative from among those that are available which best balances or optimizes the total value, considering all the various factors.'
- Arising from the above, Kepner and Tregoe, among others, established 7 essential factors to be considered in a decision situation.

Kepner and Tregoe established 7 essential factors



Summary of plant acquisition options

1) When capital allowances are available it may be cheaper to lease than to buy where profits are too low to make full use of capital allowances. The tax allowances are recouped by the lessor and reflected in the lease charges.
2) For rapidly expanding companies and others with capital raising difficulties or high gearing, the lease allows assets to be acquired and potential turnover increased without altering the firm's existing capital structure.
3) Both leasing and hire purchase are long-term commitments, and therefore the revenue (turnover) budget and operating costs budget must be able to accommodate the rental charges over the agreed period of the financial contract.
4) All of the above options imply direct or indirect ownership of the plant, and special facilities will be needed for servicing and maintenance, together with experienced management and skilled staff. Thus, the alternative of hiring in plant should not be overlooked.