Chapter-four: Acquisition of Equipments and Plants

Definitions terms:

- **Initial cost:** is the total cost of acquiring the asset.
- **Depreciation:** It represents the reduction in market value of an asset due to age, wear and tear and obsolescence.
- **Salvage value**: represents estimated market value of the asset at the end of its useful life.
    - It is the expected cash inflow that the owner of the asset will receive by disposing it at the end of useful life.
- **Book value**: is the value of asset recorded on the accounting books of the firm at a given time period.
    - It is generally calculated at the end of each year. Book value at the end of a given year equals the initial cost less the total depreciation amount till that year.
- **Useful life:** represents the expected number of years the asset is useful in terms of generating revenue.

The commonly used depreciation methods are:

- **straight-line depreciation method**
    - It is the simplest method of depreciation.
    - In this method it is assumed that the book value of an asset will decrease by same amount every year over the useful life till its salvage value is reached.
    - In other words the book value of the asset decreases at a linear rate with the time period.
- **declining balance method**
    - It is an accelerated depreciation method.
    - In this method the annual depreciation is expressed as a fixed percentage of the book value at the beginning of the year and is calculated by multiplying the book value at the beginning of each year with a fixed percentage.
- **Sum-of-years-digits method**.
    - It is also an accelerated depreciation method.

In this method the annual depreciation rate for any year is calculated by dividing the number of years left (from the beginning of that year for which the depreciation is calculated) in the useful life of the asset by the sum of years over the useful life

Equipment cost

Modern construction is characterized by the increasing utilization of equipment to accomplish numerous construction activities. It is important to

accurately estimate the equipment cost as part of the total cost of the construction project.
Inaccurate estimation of construction equipment cost may negatively affect the profit margin of the firms especially engaged in projects with more involvement of different types of construction equipments.

Ownership costs

Ownership costs are costs incurred regardless of whether the equipment is operated or idle.
The total cost associated with the construction equipment for owning it **irrespective** of the equipment **is employed or not** in the project.
The total cost of a piece of construction equipment consists of two components namely:

- ownership cost
- operating cost

The ownership cost consists of the following;

a) Initial cost,
b) Salvage value,
c) Interest cost or cost of capital investment,
d) Taxes,
e) Insurance cost, and
f) Storage cost.

Initial cost:

Is the capital investment required to own the equipment.
It includes purchase cost, sales tax, transportation cost (or freight charges) to bring the equipment to company's storage yard or construction site and cost of assembly and installation of the equipment.

Depreciation:

It represents the decline of the market value of a piece of equipment due to:

- ✓ Physical deterioration occurring from wear and tear of machine.
- ✓ Obsolescence occurring over the passage of time.

There are two type of depreciation calculations:

- o Depreciation for tax accounting purpose
- o Depreciation for accounting the purchase expenses and salvage value to account the consumption of the asset.

Depreciation for tax accounting purpose:

- – Depreciating a machine's loss in value with age will lessen the net cost of machine ownership. The cost saving, the prevention of a cash outflow, afforded by tax depreciation is a result of shielding the company from taxes.
- – There are various methods of taxes depreciation, for instance:
  - Straight line method

    - Double decline method
- Depreciation for accounting the purchase expenses and salvages value.
- Various methods can be used to calculate the depreciation portion of ownership: For example
    - Time value method
    - Average annual investment method

In the appraisal of depreciation, some factors are explicit while others are estimated.
Generally, the asset costs are known which include:
Initial cost: the amount needed to acquire the equipment.
Useful life: the number of years it is expected to be utility value.
Salvage value: the expected amount the asset will be sold at the end of its useful time.
However, there is some uncertainty about the exact length of useful time of the asset and about the precise amount of salvage value which will be realized when the asset is disposed.
Among many depreciation methods the commonly used are:

- Straight-line (SL) method;
- Sum-of-the-years` digits (SOY) method;
- Declining-balance method.

Straight-line depreciation:

Straight-line depreciation method is the simplest to understand as it makes the basic assumption that the equipment will lose the same amount value in every year of its useful life until it reaches its salvage value.
The depreciation can be expressed by the equation:

$$D_n = \frac{\mathrm{IC} - S - \mathrm{TC}}{N}$$

Where $\mathbf{D}_n$ is the depreciation in year n;
IC is the initial cost ($);
S is salvage value ($);
TC is tier and track cost ($);
N is the useful life (years) .

Sum-of-the-years` digits depreciation:

The Sum-of-the-years` digits tries to model depreciation assuming that is not a straight line.
The actual market value of a piece of equipment after 1 year is less than the amount predicted by the straight line. Thus this is an accelerated depreciation method and models more annual depreciation in the early years a machine`s life and less in its later years.
The calculation is straight forward and done by the following equation.

$$D_n = \frac{(\text{year } "n" \text{ digit})}{1+2+\cdots+N}(\text{IC} - S - \text{TC})$$

Where $\mathbf{D}_n$ is the depreciation in year n; n digit is the reverse order: if solving for $\mathbf{D}_1$ or 1 if solving for $\mathbf{D}_n$; **IC** is the initial cost($); **S** is salvage value($); **TC** is tier and track cost($); and **N** is the useful life (years)

Double Declining Balance Depreciation Method:

It is another method for an accelerated depreciation rate. It produces more depreciation in the early years of a machine`s useful life than the-sum- of-years`-digits depreciation method. This is done by depreciating the "book value " of the equipment rather than just its initial cost. The book value in the second year is merely the initial cost minus the depreciation in the first year.
Then the book value in the next year is merely the book value of the second year minus the depreciation and so on until the book value reaches the salvage value.
The book value should never drop below the savage value.

$$D_n = \frac{2}{N}(\text{BV}_{n-1} - \text{TC})$$

Where $\mathbf{D}_n$ is the depreciation in year n; **TC** is tier or track cost($); and **N** is the useful life (years)
$\mathbf{BV}_{n-1}$ the book value at the end of the previous year, and $\mathbf{BV}_{n-1} \geq \mathbf{S}$.
Example-1: Compare the depreciation in each year of the equipment `s useful life for each of the above depreciation methods for the following wheeled front-end bucket loader.
- initial cost: $148,000 includes delivery and other costs
- Tier cost: $16,000
- Useful life: 7 years
- Salvage value: $18,000

Strait-line method:

The depreciation in the first year D_1 is equal to the depreciation in all years of the loader`s useful life:

$$D_1 = \frac{\$148{,}000 - \$18{,}000 - \$16{,}000}{7 \text{ years}} = \$16{,}286/\text{year}$$

Sum-of-the-years` digits depreciation:

The depreciation in the first year D_1 and second year D_2 are:

$$D_1 = \frac{7}{1+2+3+4+5+6+7}(\$148{,}000 - \$18{,}000 - \$16{,}000) = \$28{,}500$$

$$D_2 = \frac{6}{1+2+3+4+5+6+7}(\$148{,}000 - \$18{,}000 - \$16{,}000) = \$24{,}429$$

Double-declining balance method:

Use this when cost of tire is not involved
Depreciation = Book value x Depreciation rate
Book value = Cost - Accumulated depreciation
Double-declining balance method:
The depreciation in the first year D_1 **is**

$$D_1 = \frac{2}{7}(\$148{,}000 - \$16{,}000) = \$37{,}714$$

And the book value at the end of year$_1$ = $ 148,000 - $ 37,714 = $ 94,286

However, in year 6, this calculation would give an annual depreciation of $ 7,012 which when subtracted from the book value at the end of year 5 gives a book value of $17,531 for year 6. This is less than the salvage value i.e. $18,000. Therefore, the depreciation in year 6 is reduced to the amount that would bring the book value to be equal to the salvage value or $ 6,543 and the depreciation in year 7 is taken as zero, which means that the machine was fully depreciated by the end of year 6.

This table demonstrated depreciation method comparison for wheeled front-end loader:

YEAR							
METHOD	**1**	**2**	**3**	**4**	**5**	**6**	**7**
SL (Dm)	$16,286	$16,286	$16,286	$16,286	$16,286	$16,286	$16,286
SOYD (Dm)	$28,500	$24,249	$20,357	$16,286	$12,214	$8,143	$4,071
DDB (Dm)	$37,714	$26,939	$19,242	$13,744	$9,817	$6,543	$0
DDB (BV)	$110,286	$83,347	$64,105	$50,361	$40,544	$18,000	$18000

Selecting a depreciation method to compute ownership cost is a business policy decision. The purpose of calculating depreciation amount is to arrive at hourly rental rate so that the estimator can use this figure out to the cost of equipment-intensive features of work. While this obviously impacts a company`s ultimate productivity.

Interest cost or cost of capital investment:

Investment (or interest cost) represents the annual cost invested in a machine.

If borrowed funds are utilized for purchasing a piece of equipment, the equipment cost is simply the interest charged on these funds.

If the equipment is purchased with the company's assets, an interest rate that is equal to the rate of return on company investment should be charged.

Therefore, investment cost is computed as the product of interest rate multiplied by the value of the equipment which is then converted into cost per hour of operation. The average annual cost of interest should be based on the average value of the equipment during its useful life.

The average value of equipment can be determined from the equation:

$$P = \frac{IC(n+1) + S(n-1)}{2n}$$

Where **IC** is the total initial cost, **P** is the average value, **S** is salvage value and **n** is the useful life (year).

Example-2: Consider a piece of equipment costing $50,000 with an estimated salvage value of $15,000 after 5 years.
Using the above equation, the average value is:

$$P = \frac{50{,}000(5+1) + 15{,}000(5-1)}{2(5)}$$
$$= \frac{300{,}000 + 60{,}000}{10}$$
$$= \$36{,}000$$

Insurance, Tax and Storage costs:
Insurance cost represents the cost inured due to fire, theft, accident and liability insurance for the equipment.
Tax costs represent the cost of property tax and license for the equipment.
Storage costs include the cost of rent and maintenance for equipment storage yards, the wages of guards and employs involved in the in moving the equipment in and out of storage and associated direct overheads.
The cost of insurance and tax for each item of equipment may be known on an annual basis.
In this case the cost is simply divided by the hour 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 costs may also be known on a fleet basis. It is then necessary to prorate these costs for each item. This is usually doe by

converting the total annual cost in to a percentage rate, then dividing these cost by the total value of the equipment fleet.
By doing so, the rate for insurance, tax and storage may be simply added to the investment cost for calculating the total annual cost of investment, insurance, tax and storage.
The average rate for insurance, tax, and storage found from found in the literature are listed in the table below. These rates will vary according to related factors such as the type of equipment and location of the job site.

Average rate for investment costs

Item	**Average value (%)**
Interest	3-9
Tax	2-5
Insurance	1-3
storage	0.5-1.5

Year	**Straight Line method**		**Sum-of-years-digits method**		**Decline balance method**	
	Depreciation (Br.) Dm	**Book value (Br.)BVm**	**Depreciation (Br.) Dm**	**Depreciation (Br.) Dm**	**Depreciation (Br.) Dm**	**Book value (Br.) BVm**
0	**-**	**3500000**	**-**	**3500000**		**3500000**
1	**300000**	**3200000**	**545454.55**	**2954545.45**	**700000**	**2800000**
2	**300000**	**2900000**	**490909.09**	**2463636.36**	**560000**	**2240000**
3	**300000**	**2600000**	**436363.64**	**2027272.73**	**448000**	**1792000**
4	**300000**	**2300000**	**381818.18**	**1645454.55**	**358400**	**1433600**
5	**300000**	**2000000**	**327272.73**	**1318181.82**	**286720**	**1146880**
6	**300000**	**1700000**	**272727.27**	**1045454.55**	**229376**	**917504**
7	**300000**	**1400000**	**218181.82**	**827272.73**	**183500.80**	**734003.20**
8	**300000**	**1100000**	**163636.36**	**663636.36**	**146800.64**	**587202.56**

9	**300000**	**800000**	**109090.91**	**554545.45**	**117440.51**	**469762.05**
10	**300000**	**500000**	**54545.45**	**500000**	**93952.41**	***375809.64***
Correction to get the predicted salvage value					**87202.56**	**500000**
					0	**500000**

Example

The initial cost of a piece of construction equipment is 3500000 **Br**. It has useful life of 10 years. The estimated salvage value of the equipment at the end of useful life is 500000 **Br**. Calculate the annual depreciation and book value of the construction equipment using straight-line method and double-declining balance method.

Solution: Initial cost of the construction equipment = P = 3500000 **Br.**

Estimated salvage value = SV = 500000 **Br.** Useful life = n = 10 years

For straight-line method, the depreciation amount for a given year is calculated using:

D_n = IC – SV /N

D_n = 3500000 **–** 500000 **/**10=3000000

From the table above, it is observed that the book value at the end of useful life i.e. 10 years in double-declining balance method is less than salvage value. Thus the equipment will be depreciated fully before the useful life. In other words the book value reaches the estimated salvage value before the end of useful life. As the book value of the equipment is not depreciated further after it has reached the estimated salvage value, the depreciation amount is adjusted accordingly. The book value of the construction equipment at the end of 8th, 9th, and 10th years are 587202.56 **Br.,** 469762.05 **Br.** and 375809.64 **Br.** respectively (from the Table, Double-declining balance method). Similarly the depreciation amounts for 9th and 10th years are 117440.51 **Br.** and 93952.41 **Br.** respectively. Thus to match the book value with the estimated salvage value, the depreciation in 9th year will be 87202.56 **Br.** (587202.56 **Br.** _ 500000) **Br.** and that in 10th year will be zero. This will lead to a book value of 500000 **Br.** (equal to salvage value) at the end of 9th year and 10th year

Example

A company having a cost of capital rate of 8% purchases a $ 300, 000 tractor. This machine has an expected service life of 4yr and will be utilized 2,500 hr per year. The tires on this machine cost $ 45,000. The estimated salvage value at the end of $ yr is $ 50,000. Calculate the depreciation portion of the ownership cost for machine using AAI. **and Time Value** methods

Time Value method

Initial cost	$300,000
Cost of Tires	-45,000
Purchase Price less tires	$255,000

$$A_P = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] = 255{,}000\left[\frac{0.08(1+0.08)^4}{(1+0.08)^4 - 1}\right] = \$76{,}990 \text{ per year}$$

$$A_s = F\left[\frac{i}{(1+i)^n - 1}\right] = 50{,}000\left[\frac{0.08}{(1+0.08)^4 - 1}\right] = \$11{,}096 \text{ per year}$$

- Therefore, using the time value method the depreciation portion of the ownership cost is

$$\text{Depreciation} = \frac{\$76{,}990/\text{yr} - \$11{,}096/\text{yr}}{2{,}500 \text{ hr/yr}}$$

$$= \boxed{\$26.354 \text{ /hr}}$$

Average Annual Investment Method

- Notes on AAI
  - The AAI is multiplied by the corporate cost of capital rate to determine the ownership cost of money portion.
  - The straight-line depreciation of the cost of the machine less the salvage value and less the cost of tires, if a wheeled machine, is then added to the cost of money part to arrive at the depreciation portion of ownership cost.

A second approach to calculate the depreciation portion of ownership cost is the average annual investment (AAI) method

$$\text{AAI} = \frac{P(n+1)+S(n-1)}{2n} \qquad (1)$$

P = purchase price less the cost of tires.
S = the estimated salvage value.
n = expected service life in years.

$$\text{AAI} = \frac{255{,}000(4+1)+(4-1)}{2(4)} = \$178{,}125 \text{ per year}$$

$$\text{Interest cost part} = \frac{178{,}125 \text{ /yr}\,(0.08)}{2{,}500 \text{ hr/yr}} = \$5.70/\text{hr}$$

- Straight-line depreciation part:

Initial cost	$300,000
Cost of Tires	-45,000
Salvage value	-50,000
	$205,000

$$\frac{\$205{,}000}{4\text{yr}(2{,}500\text{hr/yr})} = \$20.500/\text{hr}$$

$$\text{Depreciation} = 5.700 + 20.500 = \$26.2 \text{ per hr}$$

- Comparison: Examples 2 and 3

Time Value Method $26.35/hr

Average Annual Investment Method $26.20/hr

Difference between the methods $0.15

OPERATING COSTS

Occur only when the equipment is being used.

Include: Fuel & lubrication costs.

- ✓ **Operator costs**
- ✓ **Minor maintenance & repair costs.**

Major maintenance, major repair and tires. Sometimes included in ownership costs and sometimes in operating costs.
These are significant costs.

Maintenance and repairs_

Will vary considerably with:

- type of equipment
- service to which it is assigned
- care it receives

May be expressed as a % of annual cost of depreciation or independently of depreciation. For power shovels: 80 to 120% of annual cost of depreciation.
Higher for rock crushing equipment.
Lower for electric motor.
Experience records should be used in estimating these costs.

Operating conditions:

Consumption of fuel and lubricating oil will vary with type of equipment, conditions under which used and location.
Two important conditions to be considered:
1. Extent to which the engine will operate at full power.
2. Actual time the unit will operate in a hour or a day.

Eg. 1) power shovel - full power when loading dipper
- balance period considerably less power.
2) Tractor- full power while going up slope.

Horsepower ratings:

Rating specified in literature provided of various manufactures not determined under same operating conditions.
- Power may be specified for standard conditions
  - -barometric pressure of 29.9 in.(76 Cm) of Hg
  - -temperature 15.5^{0}C (60^{0}F) or for normal operating conditions
  - -Altitude up to 2,000ft (600m) above sea level
  - -temperature up to 30^{0}C

May be maximum a bare engine can develop or flywheel power with all accessories attached.
Accessories usually include: a fan, generator, fuel pump, water pump, air cleaner and lubricating oil pump. These may equal 20 to 25% of rated

flywheel power of engine. Engine rated at 200 fwhp 250 hp as bare engine

Fuel consumed

Under standard conditions:
Gasoline engine will consume approximately 0.23 lit. of fuel per flywheel horse power hour.
Diesel engine fuel consumption 0.15lit / fwhp-hr.
Consider a power shovel with a diesel engine rated of 160 fwhp.

Cycle time - 20 Sec
- 5 Sec max. power while filling dipper

operation time - 50 min. per hr.

Fuel consumed ?

Engine factor:

filling the dipper = 5/20*1 = 0.250
rest of cycle = 15/20*0.5*1 = 0.375
total factor = 0.625
time factor = 50/60 = 0.833
operating factor = 0.625*0.833 = 0.520
Fuel consumed per hr. = 0.52*160*0.15
= 12.48 liters.

Lubricating oil

- quantity of lubricating oil used will vary with:
  - size of engine,
  - capacity of the crankcase,
  - condition of the piston rings,
  - no.of hours between oil changes.
- common practice to change oil every 100 to 200 hrs.
- Extreme dirty conditions - every 50 hrs.

Oil Consumption

$$q = \frac{hp * f * 0.0027 \text{ Kg per hp-hr}}{0.89 \text{ Kg/lit}} + \frac{C}{t}$$

q = Quantity consume, lph
hp = rated horse power of engine
C = capacity of crankcase, lit
f = operating factor
t = no.of hours between changes

Eg. 100 hp engine with crankcase capacity of 15 lit, requiring change every 100 hrs.

$$q = \frac{100*0.6*0.0027}{0.89} + \frac{15}{100} = 0.332 \text{lit/hr}$$

SOURCES OF CONSTRUCTION EQUIPMENT

Options:

1. Purchase it
2. Rent it (using a lease agreement)
3. Rent it with an option to purchase it at a later date.

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.

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.

RENTAL is beneficial

- If the job is of short duration
- Company doesn't foresee a continuing need for the machine.

Firms often use rental as a way to test a machine prior to purchase decision
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.

LEASE

- Long term agreement for the use of an asset.
- Alternative to direct ownership

Advantage:

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

Chapter Four: Productivity of Equipment and Plant

- ✓ Dump truck
- ✓ Loader