Chapter 02

Owning and Operating costs for Construction Equipment

Types of Equipment:

Standard Types of Equipment:

- There is no clear definition of standard equipment.
- Equipment that is standard for one contractor may be special for another.
- But it may be defined as the equipment that can be used economically on more than one project, its repair parts may be obtained more quickly, and it can be easily disposed of at more favorable price.

Special Equipment:

- It is the equipment that is manufactured for use on single project or for a special type of operation.
- Such equipment may not be suitable or economical for use on other project.
  Factors that affect the cost of owning and operating construction equipment:
- Kept records for equipment previously used should give information which may be used as a guide for the particular equipment it was used under the same conditions. Factors that affect the cost of owning and operating construction equipment include:

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1) The cost of the equipment delivered to the owner.
2) The severity of the conditions under which the equipment is used.
3) The number of hours the equipment is used per year.
4) The number of years the equipment is used.
5) The care with which the owner maintains and repairs the equipment.
6) The demand for used equipment when it is sold, which will affect the salvage value.

The Cost of Owning and Operating Construction Equipment:

- For construction firms, 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 adversely affect the profit margin of the firms especially engaged in projects with more involvement of different types of construction equipment‟s.
- The total cost of a piece of construction equipment consists of two components namely ownership cost and operating cost.

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- This is also referred as O&O cost of the construction equipment.
- The selection of a piece of equipment in a construction project depends on the total cost associated with that equipment.
- The details about equipment ownership cost and operating cost are presented below.

- Ownership cost is the total cost associated with the construction equipment for owning it irrespective of the equipment is employed or not in the project. The ownership cost consists of the following;

1.1. Depreciation Cost:

Depreciation: Is the loss in value of a piece of equipment over time, generally caused by wear and tear from use, the profitable owner of equipment must recover this loss during its useful life.

Depreciation Accounting Value:

- The depreciation accounting value (usually termed book value), is the systematic allocation of the costs of a capital investment over some specific number of years.
- This value can be calculated by subtracting the depreciation at m year times the no. of the year (m) from the actual cost of equipment.
- There are number of methods to calculate the depreciation, but before calculating it using any method, close estimation of the following items must be known:

1. **The purchase price (termed P).**
2. **The economic life of the equipment (termed N).**
3. **The estimated resale value at the close of the economic life, known as salvage value (termed S).**

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- With these three items of information known or estimated, the depreciation can be calculated; the most commonly used methods are the following:

I. Straight-line (SL) method.

II. Sum-of-the-years (SOY) method.

III. Declining-balance method.

1-Straight-line method (SL):

- This method is the easiest one to calculate and probably the most widely used method in construction.
- The annual amount of depreciation (Dm), for any year (m), is a constant value, and thus the book value decreases at a uniform rate over the useful life of the equipment.
- The equations used are:

$$\text{Depreciation rate, } R_m = \frac{1}{N}$$

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- Annual depreciation amount, $D_m = R_m(P-S) = \frac{(P-S)}{N}$
- Book value at year m, $BV_m = P - mD_m$

Or:

- Book value at year m, $BV_m = BV_{m-1} - D_m$

Example:

A piece of equipment is available for purchase for ($12000), has an estimated useful life of (5 years), and an estimated salvage value of ($2000).Determine the depreciation and the book value for each of the 5 years using the SL method.

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Solution:

$$R_m = \frac{1}{5} = 0.2$$

$$D_m = 0.2(12000 - 2000) = \$\ 2000 \text{ per year}$$

m	BV_{m-1} ($)	D_m ($)	BV_m ($)
0	0	0	12000
1	12000	2000	10000
2	10000	2000	8000
3	8000	2000	6000
4	6000	2000	4000
5	4000	2000	2000

2-Sum-of-the-years method (SOY):

This is an accelerated method, which is a term applied to accounting methods which permit rates of depreciation faster than straight line. The rate of depreciation is a factor times the depreciable [illegible] (D.S). This factor is calculated as follows:

$$R_m = \frac{N - m + 1}{SOY}$$

$$SOY = \frac{N(N+1)}{2}$$

SOY can be calculated by a accumulating the years of the equipment life such as if the useful life was 5 years then SOY=1+2+3+4+5=15.

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$$D_m = R_m(P-S) = \frac{N-m+1}{SOY}(P-S)$$

$$BV_m = P - mD_m = P - m\left(\frac{N-m+1}{SOY}(P-S)\right) \text{ or } BV_m = BV_{m-1} - D_m$$

Example:

A piece of equipment is available for purchase for ($12000), has an estimated useful life of (5 years), and an estimated salvage value of ($2000). Determine the depreciation and the book value for each of the 5 years using the SOY method.

Cont...

Solution:

Using Eq. (2-6): $SOY = \frac{N(N+1)}{2} = \frac{5(5+1)}{2} = 15$, or $SOY = 1+2+3+4+5 = 15$

Using Eq. (2-5):

$$R_m = \frac{N-m+1}{SOY} = \frac{5-m+1}{15}$$

Using Eq. (2-7):

$$D_m = R_m(P-S) = \frac{5-m+1}{15}(12000-2000)$$

$$D_m = \frac{5-m+1}{15}(10000)$$

$$D_m = R_m(10000)$$

Cont...

Then tabulate the results as follows:

year	R_m	D_m ($)	BV_m ($)
0		*0*	*12000*
1	$\frac{5-1+1}{15}=\frac{5}{15}$	$R_m(10000)=3333$	$12000-3333=8667$
2	$\frac{5-2+1}{15}=\frac{4}{15}$	$R_m(10000)=2667$	$8667-2667=6000$
3	$\frac{5-3+1}{15}=\frac{3}{15}$	$R_m(10000)=2000$	$6000-2000=4000$
4	$\frac{5-4+1}{15}=\frac{2}{15}$	$R_m(10000)=1333$	$4000-1333=2667$
5	$\frac{5-5+1}{15}=\frac{1}{15}$	$R_m(10000)=667$	$2667-667=2000$

Notice that the allowable depreciation in this method is different for each year of the equipment

3-Declining-balance method:

- This method is also an accelerated depreciation method that provides for larger portions of cost to be written off in the early years; this method nearly approximates the actual loss in market value with time.
- Declining methods range from 1.25 times the current book value divided by the life to 2.00 times the current book value divided by the life (the latter is termed double declining balance).
- The estimated salvage value (S) is not included in the calculation, but the book value cannot go below the salvage value.
- Following are the equations necessary for the use of the declining balance methods:

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1. Depreciation rate, R:

- For 1.25 declining balance (1.25DB)method, $R = 1.25/N$.
- For 1.50 declining balance (1.50DB)method, $R = 1.50/N$ ...
- For 1.75 declining balance (1.75DB)method, $R = 1.75/N$ .....
- For double declining balance (DDB)method, $R = 2/N$ ....

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2. The allowable depreciation D_m for any year m and any rate R would be:

$$D_m = (BV_{m-1})R \quad \ldots\ldots (2$$

3. The book value for any year m would be $BV_m = BV_{m-1} - D_m, \Rightarrow BV_m \geq S$

Since (BV) can never go below (S), the declining balance method must be forced to intersect the value (S) at time (N).

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- **Example:**
  A piece of equipment is available for purchase for ($12000), has an estimated useful life of (5 years), and an estimated salvage value of ($2000). Determine the depreciation and the book value for each of the 5 years

Solution:

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Using Eq. (2-12); calculate R: $R = \frac{2}{N} = \frac{2}{5} = 0.4$

Using Eq. (2-13); calculate D_m: $D_m = 0.4(BV_{m-1})$

Using Eq. (2-14); calculate BV_m: $BV_m = BV_{m-1} - D_m$

Then tabulate the results as follows:

Cont...

year	D_m ($)	BV_m ($)
0	0	12000
1	$0.4(12000) = 4800$	$12000 - 4800 = 7200$
2	$0.4(7200) = 2880$	$7200 - 2880 = 4320$
3	$0.4(4320) = 1728$	$4320 - 1728 = 2592$
4	$0.4(2592) = 1037$	$2592 - 1037 = 1555$
4	592	$2592 - 592 = 2000$
5	0	2000

Example:

- A piece of equipment costing ($10000) new, with a (5 years) useful life, and an expected salvage value of ($1000) is being considered for purchase. Calculate the yearly o he three m

Solution:

1. **SL method:**

$$R_m = \frac{1}{5} = 0.2$$

$$D_m = 0.2(10000 - 1000) = \$\ 1800 \text{ per year}$$

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m	BV_{m-1}($)	D_m($)	BV_m($)
0	0	0	10000
1	10000	1800	8200
2	8200	1800	6400
3	6400	1800	4600
4	4600	1800	2800
5	2800	1800	1000

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2. SOY method:

Using Eq. (2-6): $SOY = \frac{N(N+1)}{2} = \frac{5(5+1)}{2} = 15$, or $SOY = 1+2+3+4+5 = 15$

Using Eq. (2-5): $R_m = \frac{N-m+1}{SOY} = \frac{5-m+1}{15}$

Using Eq. (2-7): $D_m = R_m(P-S) = \frac{5-m+1}{15}(10000-1000)$, $D_m = \frac{5-m+1}{15}(9000)$

Then tabulate the results as follows:

year	R_m	D_m($)	BV_m($)
0		*0*	*10000*
1	*5/15=0.333333333*	$Rm(9000) = 3000$	$10000-3000=7000$
2	*4/15=0.266666667*	$Rm(9000) = 2400$	$7000-2400=4600$
3	*3/15=0.2*	$Rm(9000) = 1800$	$4600-1800=2800$
4	*2/15=0.133333333*	$Rm(9000) = 1200$	$2800-1200=1600$
5	*1/15=0.066666667*	$Rm(9000) = 600$	$1600-600=1000$

Cont...

3. DDB method:

Using Eq. (2-12); calculate R: $R = \frac{2}{N} = \frac{2}{5} = 0.4$

Using Eq. (2-13); calculate D_m: $D_m = 0.4(BV_{m-1})$

Using Eq. (2-14); calculate BV_m: $BV_m = BV_{m-1} - D_m$

Then tabulate the results as follows:

year	D_m ($)	BV_m ($)	
0	*0*	*10000*	
1	$0.4(10000) = 4000$	$10000 - 4000 = 6000$	
2	$0.4(6000) = 2400$	$6000 - 2400 = 3600$	
3	$0.4(3600) = 1440$	$3600 - 1440 = 2160$	
4	$0.4(2160) = 864$	$2160 - 864 = 1296$	
5	$0.4(1296) = 518.4$	$1296 - 518.4 = 777.6$	<1000
5	*296*	$1296 - 296 = 1000$	

1. 2. Investment Costs:

- Owning equipment costs money, one part of ownership costs is Investment costs which include the following:
  - The interest on the money invested.
  - Taxes of all types which are assessed against the equipment.
  - Insurance.
  - Storage.
- The rates for these costs vary among different owners, with location and whether or not the equipment is actually used.
- The average annual cost of interest (I), is based on the average value of the equipment (P) during its useful life, which can be calculated based on straight-line depreciation as follows:

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$$\overline{P} = \frac{P(N+1)+S(N-1)}{2N}$$

Where:

P = total initial cost

$\overline{P}$ = average value

N = life in years

S = Salvage value

If there was no salvage value, then Eq. (1-15) would be:

$$\overline{P} = \frac{P(N+1)}{2N}$$

1.3. Taxes

- It represents the property taxes to be paid to the state or central government.
- It depends on the value of the equipment owned and the applicable tax rate for a given location.
- The property tax can be calculated as a percentage of the average annual investment or a percentage of the book value in a given year.
- Generally it ranges from 2 to 5% of the average annual investment or book value of equipment.

1.4. Insurance cost

- It represents the annual premium to be paid to insurance companies to cover the cost incurred due to accident, fire, theft etc. for the construction equipment.
- In other words, it represents the cost that protects the owner of the equipment against these damages. Similar to taxes, the insurance cost can be calculated as a percentage of the average annual investment or the book value in a given year.
- It is generally about 1 to 3% of the average annual investment or book value of equipment.

1.5 Storage cost

- It is the cost of keeping the equipment in storage yards when it is not operating at the work site.
- Storage cost includes the rental and maintenance charge for storage yards, wages of security guards and wages of workers employed for bringing in and out of the storage yards. It is around 0.5 to 1.5% of the average annual investment or book value of equipment.
- The annual storage cost can be calculated for the entire fleet of equipment and is then prorated to individual equipment requiring the storage facility.

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- It may be noted here that the annual rates (%) mentioned above for taxes, insurance and storage costs are typical values.
- However the actual rates will vary depending on the type and size of equipment, place of purchase, location of project site etc.

2 Operating costs:

- Operating costs are those costs associated with the operation of a piece of equipment.
- Operating costs usually occur only when the equipment is being used; it includes:

2.1 Maintenance and Repair Parts cost:

- Maintenance and Repair cost is incurred as the construction equipment is subjected to wear and tear due to the operations it performs.
- The repair and maintenance cost includes the cost of replacement parts, labor charges and the cost of setting up and operating facilities to carry out major repair and maintenance operations.
- The repair and maintenance cost varies from one year to another over the service life of the equipment, however it increases with age of the equipment.
- This cost contributes a substantial portion of the operating cost.

- **Fuel Consumption:** When operating under standard conditions, a gasoline engine will
  consume approximately (0.06 gal, 0.23 liter) per each flywheel horsepower hour, while a diesel engine will consume approximately (0.04 gal, 0.15 liter) per each flywheel horsepower hour.
- Engines used in construction industry seldom operate at a constant output or at a rated output, except for short periods of time, also, construction equipment is seldom operated the entire 60 min in an hour.
- ***Fuel consumed per hour= operating factor×hp×engine consumption***

Lubricating Oil Consumption:

- The quantity of lubricating oil used by an engine will vary with the size, the capacity of the crankcase, the condition of the piston rings and the number of hours between oil changes.

$$q = \frac{hp \times f \times 0.0027(kg/hp-hr)}{0.89(kg/l)} + \frac{C}{t}$$

q = Quantity of oil consumed (l/hr)

hp = Rated horsepower of the engine

f = Operating factor

C = Capacity of crankcase (gallon or liter)

t = Number of hours between oil changes

Examples illustrating the cost of owning and operating construction equipment

Example:

Determine the probable cost per hour for owning and operating a (1.5 m3) diesel engine crawler power shovel, the following information will apply:

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Cost of equipment	$82260
Shipping cost	$2448
Unloading &assembling at destination	$220
Engine	160 hp
Crankcase capacity	22.71 liter
Hours between oil changes	100 hr
Operating factor	0.6
Useful life, with no salvage value	6 years
Hours operated per year	2000
Weight	61700 kg
Cost of fuel per liter	0.33 $/liter
Cost of oil per liter	0.53 $/liter
Maintenance	100% of Depreciation
Investment	12% of Average Value

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Solution:

Fuel consumed per hour = operating factor × hp × engine consumption

Fuel consumed per hour = 0.6 × 160 × 0.15 = 14.4 liter

$$q = \frac{hp \times f \times 0.0027(kg/hp-hr)}{0.89(kg/l)} + \frac{C}{t}$$

$$q = \frac{160 \times 0.6 \times 0.0027}{0.89} + \frac{22.71}{100} = 0.52 \ liter$$

Cost to owner:	
Cost of equipment	82260
Shipping cost	2448
Unloading &assembling at destination	220
Total Cost	84928

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Average value of the equipment $\overline{P} = \frac{P(N+1)}{2N} = \frac{84928(6+1)}{2(6)}$	
Average value of the equipment $(\overline{P})$=	49541
Annual Costs:	
Depreciation: $D = \frac{P}{N} = \frac{84928}{6}$	14155
Maintenance: $M = 100\%D = 1(14155)$	14155
Investment: $I = 12\%\overline{P} = 0.12(49541)$	5945
Total Annual Fixed Cost	34255
Hourly Costs:	
$34255/2000$	17.13
Fuel: $14.4(0.33)$	4.75
Lubrication Oil: $0.52(0.53)$	0.28
Total Cost per hour, excluding labor	$22.16

QUIZ 5%

1. A crawler tractor costs $250, 000 has an estimated salvage value of $50,000, and has a 5-year life. Calculate the average hourly owning cost for the ***first year life*** of the tractor if the tractor is operated 2000 hours during the first year. The rate for interest, taxes, and insurance is 12% and the rate for storage and miscellaneous is 2%. Use the sum-of-the-years'-digits method of depreciation?

Answer

Solution

Owning Cost

Depreciation cost:

$$D_1 = \frac{5}{15}\, x\, (250,000 - 50,000) = \$66,666.65$$

$$\text{Depreciation} = \frac{66,666.65}{2000} = \textbf{\textit{\$33.33/hr}}$$

Investment, tax, insurance, and storage cost:

Cost rate = investment + tax, insurance, and storage = 12 + 2 = 14%

$$\textbf{\textit{Average investment}} = \frac{\mathbf{250,000+50,000}}{\mathbf{2}} = \mathbf{\$150,000}$$

$$\text{Investment, tax, insurance, and storage} = \frac{\mathbf{150,000}\ x\ 0.14}{2000} = \textbf{\textit{\$10.5/h}}$$

Total Owning Cost = 33.33 + 10.5 = ***$43.83/h***