CHAPTER THREE

EQUIPMENT MANAGEMENT

1. EQUIPMENT MANAGEMENT IN CONSTRUCTION PROJECTS

1.1 GENERAL

The cost of equipment in a project varies from 10 to 30% of the total cost of the project, depending upon the extent of mechanization. In modern fully mechanized projects the cost of equipment goes up to 30%. Proper planning, selection, procurement, installation, operation, maintenance and equipment replacement policy plays an important role in equipment management for the successful completion of the project. With the growing use of machinery it has become necessary for construction engineers to be thoroughly familiar with the construction application and upkeep of the wide range of the modern equipment.

Equipment manager's main task is to reduce downtime, achieve optimum equipment utilization and increase production at minimum cost. The cost analysis and the will of adopting proper techniques suited to the situation are the basic factors for the success and therefore, there is a need for a rational planning, proper selection, and judicious deployment of equipment in relation to the conditions so as to achieve optimum utilization. Equipment engineer should coordinate with various wings of the organization in discharging his job of equipment planning, balancing, selection of equipment and its utilization, personnel selection and training, financial planning, preventive maintenance and general supervision. Thus equipment management integrates and continuously interacts with human, technical, financial and production system in order to achieve top efficiency and cost effectiveness.

1.2 EQUIPMENT PLANNING

Modern construction projects are complex in nature and success of a project depends greatly on proper and scientific planning. Before starting every project its planning is done with great care, as the efficiency of the whole project largely depends upon its planning. While planning each and every detail should be worked out in anticipation and should be considered carefully.

Planning of a construction project involves deciding about the extent of mechanization, equipment planning, execution planning etc. While planning a project we must very carefully decide about the extent of use of construction equipments. On major construction projects mechanization is indispensable; while for middle and minor construction projects a compromise between manual and mechanical means have to be made. In a country, like Ethiopia where man-power is cheaply and easily available we can take advantage of this facility especially for the activities which can be easily carried out by the manpower. However, a combination of manual labor and machines is preferred. Now the question arises before the planner that: To what extent mechanization is desirable?

1.3 EXTENT OF MECHANIZATION

Extent to which mechanization in a project should be planned depends upon the following main factors:

(1) Manpower: Type of manpower required by the project for its execution, is first decided and whether this type of manual labour is cheaply and sufficiently available round the year. In case the manual labour is costly or available only for limited duration or required type of labour is not available in the area, then the solution is only mechanization. To decide whether the labour is costly or cheap, planner must consider the output given by the labour and overhead expenditure for the labour like accommodation, transportation to be provided to them etc. on one hand and output of the equipment and expenditure on the equipment on the other hand.

(2) Completion period: Every project is required to be completed in a particular duration. Since delay in completion of project means increase in construction cost due to rise in prices, payment of overhead for more period, imposition of penalty for delay etc. The overhead expenses include depreciation of equipments, supervisory expenses, accommodation expenses, light, water, power and insurance expenses etc. This completion period plays a deciding role about the extent of mechanization, since less the completion period more the mechanization. By employing more number of construction equipment project can be completed in lesser duration.

(3) Nature of work: Where the nature of work is such, which is beyond the scope of human labour to perform, use of construction equipments is unavoidable. Nature of work includes adverse weather, climatic conditions, topography, toughness, handling of large quantities of construction material for long distance.

(4) Availability of money: Since cost of equipment is too high and to be spent initially, it needs heavy investment in the beginning. Therefore availability of money is a main factor in deciding the extent of mechanization.

(5) Availability of Indigenous Equipment: The import of costly equipment and of spare parts proves a drain on foreign exchange resources of the country. After sales service, repair facilities are also considered where equipments manufactured in our own country are not available. Because time required for importation, shipment, installation and commissioning of the equipment and thereafter lead time for the purchase of repair spares will hamper the progress of the project adversely.

(6) Social objects of the project: Sometimes projects are sanctioned with the object of providing employment opportunities, to improve the economic condition of the masses in addition to the development in the area. In such cases manual labour is preferred over the use of machines unless otherwise any particular activity is beyond the capacity of manual labour.

(7) Labour Relations: In certain areas, past experience indicates labour unrests, strikes, absenteeism, uncertainty, unavailability of labour or seasonal fluctuations. In such circumstances machines are preferred being more reliable to complete the project in time.

(8) Overseas Projects: Large numbers of projects are in hand in other countries. It is difficult and expensive to send large number of man-power required in adopting the manual means in these projects, therefore only alternative left is to execute the project using construction equipments only.

(9) Quality and Performance: The work carried out by means of construction equipments is of high standard of quality and performance. The quality is consistent, execution is fast,

work is more durable, maintenance and repair will be very limited if projects are executed by using the construction equipments.

(10) Development of Industries: In countries like Ethiopia where industries are in developing stage, it is the need of time to use construction equipments for the development of manufacturing industry and faster industrialization of the country.

1.4 USE OF MACHINES V/S USE OF MANUAL LABOUR

The advantages and disadvantages of using machines and manual labour in construction projects are briefly described hereunder:

Points in favor of Machines	Points in favor of Manual labour
1. It can handle tough works which cannot be performed by manual labour.	1. Initial heavy investments are not required to be made.
2. It is cheaper when quantum of work is more and material is required to be transported for long distances.	2. Valuable foreign exchange is saved by employing exchange is saved by employing manual labour instead of using machines which are to be imported.
3. Machines when used in the project, it delivers better quality of work.	3. Small and short duration projects are sometimes found to be economical with manual labour.
4. It is possible to adhere to schedules.	4. Direct advantage to considerably large number of people by way of employment which help in social and economic betterment.
5. It is easy to predict the behavior of a machine as compared to that of man, hence planning is easy.	5. No problem due to delay in procurement of spares for the repair of machines. The delay (lead time) is substantially high in case of imported equipments.
6. Being lesser number of persons, (operators only), it is easy to supervise and control.	6. Project can be started immediately, which is not possible in case machines are used. Since importation, shipment, transportation installation and commissioning of equipments require a substantial time.
7. It helps in development of technical knowhow, skill and industrial development of the country.	7. Disposal of equipment and its balance spare parts poses a problem after the project is completed.
8. Availability of Manpower and seasonal	

fluctuations will not affect the project's progress. 9. Effect of climate and topographic conditions is less when machines are used as compared to that when manual labour is used. 10. No problem for housing and transportation of persons and also for the arrangement for supply of food, water, light and medicines etc.	

1.5 FORECASTING EQUIPMENT REQUIREMENT

As discussed earlier extent of mechanization depends upon the nature and quantity of work to be handled, the specifications to be adopted, time period of completion, availability of skilled and unskilled labour. There are certain type of works where man cannot work and only alternative is to use construction equipments e.g. earth work compaction, construction of bridges, working under water, concreting, dewatering, construction of bituminous/rigid pavements, working steep slopes etc.

Considering the above mentioned factors, planners are required to decide the extent of mechanization, which means out of large number of activities involved in the completion of the projects, which are the activities which should be completed by using the equipments. With the identification of the activities which will be carried out with the help of equipments, work of equipment planning starts. Following are the main points planner has to decide in equipment planning.

a) Working Shifts: By increasing the number of shifts we can reduce the number of equipment required, as the same equipment can be used in second and third shift. This helps in reduction in initial investment of capital. But the number of shift in which work can be executed depends upon the nature of work, the area in which the work is spread over etc. While planning the number of shifts it must be kept in mind that in double shifts, only 60 to 70% (nearly) extra work can be achieved and not really double. Similarly in triple shift only 110 to 125% of extra work, as compared to single shift can be achieved. This is because the efficiency in the evening and night shifts is less as compared to that in day shift, besides maintenance also becomes difficult.

Since repair facility for the break downs occurred in the night shift is not fully available, provisions for standby equipment are desired. Experience has shown that this provision should be as below;

(i) For equipments used in single shift 10% standby
(ii) For equipments used in double shifts 20% standby
(iii) For equipments used in triple shifts 30% standby

(b) Number and Size of Equipments: For deciding the number and size of the equipments following factors should be considered.

(i) Quantum of work,
(ii) Working days available for completion of project.
(iii) Number of shifts planned.

When quantum of work is too much then bigger size equipments are selected. The average rated output of these equipments will help in deciding number of the equipments required keeping in view the number of working days available and number of shifts planned per day.

(c) Matching Units: There are certain equipments, which are used together in a team with other equipments, like scraper with pusher Dozer, concrete batching plant with truck mounted concrete mixers, paver finisher with road rollers, asphalt mixing plant with tipper trucks, wheel loaders with dumpers/dump trucks etc. These number and size of the matching equipments should be planned for each activity, keeping in view that complete matching set must be utilized at the maximum and combination must be optimum.

(d) Procurement Scheduling: Procurement scheduling is done considering procurement time required and time when equipment is required. The time when equipment is required is decided by the starting time of the activity for which this equipment is required to be used. While purchasing an equipment, maintenance spares should also be purchased.

(e) Workshop and Stores Planning: While planning for the purchase of equipments, it is necessary to plan for the workshop and stores for carrying out the repair and maintenance.

(f) Man power planning: Planning for manpower in order to operate the equipment and to carry out the repair and maintenance is also necessarily be done sufficiently in advance. In case skilled

and trained manpower for the operation, maintenance and repair is not available then efforts should be made to train them before the arrival of equipments in the project.

(g) Site Conditions: Site conditions play an important role in deciding the type of equipment. The type of equipment selected mainly depends upon soil available, and valley conditions, surface and strata where work is to be carried out. This helps in deciding whether to use wheeled equipments or crawler type equipments, to use dragline excavator or power shovel, to use crane or cable ways, to use rear dump trucks or side dump trucks or bottom dump trucks etc.

Rear-dump trucks are suitable for dumping to hoppers or fills, side dump trucks are suitable for dumping in long length or on sides of roads i.e. on shoulders, while bottom dump trucks are suitable for discharging free flowing materials like sand, gravel, dry earth etc. while moving i.e. in windrows. Dragline is used for digging water saturated material from below footing level, while power shovels are used for loading hard soil or rock into the vehicle and digging above footing level. Thus the type of equipment should be selected after knowing the type of work required to be done by the equipments.

1.6 SCIENTIFIC PLANNING

As discussed earlier the success of a project depends greatly on equipment planning, it is therefore most essential to follow scientific and rational planning techniques. This means that the data or basis taken should be based on past experiences gained in various projects and on work studies carried out in various conditions at various places. Planner should use the mathematical models of the operation of equipments. The examples of such models are mathematical programming queuing, simulation and other techniques. He should not use the assumptions, which may mislead the results.

1.6.1 Quantum of work

The first stage of planning is to calculate the total quantity of work involved in each operation. For correct planning it is very much essential to ascertain quantity of work as accurate as possible. This should be found out by using the detailed drawings, designs and surveying the site. This estimate should be made using all scientific methods and not on merely assumptions. Care should be taken in categorizing each operation according to its characteristics for example, earth

cutting can be cutting of ordinary soil, hard soil or soil mixed boulders, or rock cutting operation. This categorization is necessary to know the machine hours required to do a particular operation, since each category requires different machine hour efforts i.e. output rate for each category is different for the equipment.

While calculating the quantity of work involved it is necessary to take a note of various constraints, for example, (i) limitation of working space, which may affect the efficiency of the machine, so as to assess the output rate of equipment to be used, (ii) location of quarries and amount of material available in each of them, so as to know the correct lead and to assess the efforts involved in shifting the crusher location.

1.6.2 Output and Capacity of Equipment

Next phase of planning is to decide the equipment on the basis of its output and capability. The equipment must be capable to handle the work efficiently on which it is to be engaged. The output of the equipment so decided should be determined on the basis of past experiences on similar works. As we have discussed earlier that the same equipment gives different output in different conditions of work, therefore it is very essential to use the past output data of similar works handled by the equipment in similar conditions.

Output of the equipment varies with various conditions. Following are some of them:

(i) Different type of soil needs different amount of effort and hence equipment engaged on them gives different output.
(ii) Reduction of horse power of engine due to altitude.
(iii) Time spent on servicing and inspection varies with the working conditions.
(iv) Output of the equipment also depends upon the operator's efficiency.
(v) Output of dumper etc. depends on the condition of haul road.
(vi) Time spent on the unproductive works.
(vii) Changing weather conditions are also responsible for variation in output.
(viii) Capacities of the matching machineries working in the same group.

While selecting an equipment care must be taken that the equipment should neither be of too big size nor of too small size than required for the work. It should be able to complete the work

economically in completion period. Since too big size equipment will complete the work before time and its residual value (initial cost minus depreciation) will be high, which may not be gainfully used after completion of the job. Similarly with too small size of equipment, more number of equipment will be required for completing the quantity of work involved, which means un-economical proposition. Therefore most economical planning is to select and equipment which can be fully depreciated by the time project is completed. It means the equipment must complete its economical life as soon as the project is completed.

1.6.3 Utilization and Time-period

It is always a good practice to utilize equipment to the limit of its useful life on one particular project. For a project of nearly 4 years or more duration, it is possible to use the equipment to its full economic life. The number of shifts per day should be decided, keeping this factor in view.

Experience has shown that a yearly utilization for as equipment under average working condition in most case is as follows:

Single shift operation – 1500 hrs.
Double shift operation – 2500 hrs.
Triple shift operation – 3200 hrs.

Thus, an equipment with an estimated economical life of 10,000 hours, when used on a 4 years project should work for 2500 hours per year. This means the equipment must be engaged on double shift, so that it can be depreciated fully to keep the production cost as lowest. In case the same equipment when used on 6 years project must be used on single shift operation.

When the project duration is less than 3 years, the equipment should be used in triple shift, so as to depreciate fully. This will not only avoid wastage in terms of residual value of the equipment but shall need lesser number of equipment with lesser investment on the capital items.

Two shift operation of equipment is economical and should be employed whenever possible. Three shift working results in frequent breakdowns and low availability, which means more standbys and increase in cost. The three shifts should be used only when project duration is less, immediate repair facilities even in the night are available, proper lighting facilities in the area exists. Single shift should be used only when project duration is more than 5 or 6 years or where

works are located in difficult terrain, or when equipments are scattered over a long distance where it is difficult to provide supporting facilities for a multi-shift operation.

1.6.4 Equipment Operation Planning

Since the success of a mechanized construction shall be judged by its low cost, timely and safe completion, therefore it is essential that operation should also be well planned. Following are the main points which should be considered while planning for equipment operation:

(a) Equipments must work in coordination, especially when they are required to work in a team, for example, the working of big size crusher where stones are fed by the dumpers, which are loaded at the quarry by the wheel loaders. In this case wheel loader, dumpers and crushers are required to work in a team and therefore their operation would be planned in such a way that there is no waiting at any place. The capacities of all the connected equipments should be properly balanced.

(b) Proper working and the maintenance of auxiliary equipments should also be ensured. Since the auxiliary equipments, may be small in size, may affect the whole activity and there by idling all the equipments used in the team.

(c) Poor maintenance of service roads may result in more cycle time of trucks, dumpers etc. besides causing more downtime. Properly graded, sprinkled with water and then rolled service roads add to the efficiency of the equipment and of the operator.

(d) In order to ensure proper operating of equipment and to eliminate delays it is necessary to ensure scheduled maintenance in addition to watch the working by the operator.

(e) Safety on the work is a must. In order to ensure proper safety, equipment must be kept in good condition, operate them properly, working area should be well-lighted and observe proper traffic control.

(f) Good workmen should be given proper incentives. Incentives may be provided by way of bonus, additional increment in salary, cash awards, promotion, appreciation certificates. This will help in increasing the production.

(g) Proper records should be maintained for production equipment operations, maintenance, breakdown, consumption of stores and spare parts, repair etc. It will help future estimation, reviewing the plan in addition to the cost accounting of the equipment and evaluating the progress of work

1.6.5 Manpower Planning

To achieve maximum production at lower cost and at desired quality, right man at right place at right job and at right time must be put. This is what is called scientific assessment of manpower planning. This reduces idle hours, cost of production and helps to set up the moral of employees. It also develops cooperation and team spirit among each others. Manpower planning may be defined as, the scientific process of allocating the right quantity of right men to be required in future at right time on the right job.

Manpower planning involves two stages. The first stage is concerned with detailed planning of manpower requirement for all types and levels of employees throughout the period of the plan and the second stage is concerned with the right type of people from all sources to meet the planned requirements.

Following are the essential requirements for a sound manpower planning:

1. It should be done sufficiently in advance.
2. It should be reviewed periodically, so that modifications or alternations if any can be incorporated.
3. The planning should have top management support.
4. It should be need based.
5. It should be economic in nature.
6. It should incorporate the elements of flexibility and elasticity.
7. It should provide a suitable policy

Manpower planning is a very complex, dynamic and complicated work. For an effective and efficient manpower planning following main factors should be considered:

(a) Working Hours. Manpower requirement is directly related to the total hours worked per day by the employee in a project. If number of hours for which a worker has to work is more, less manpower will be needed and vice versa. For example, in overseas projects, where it is too expensive to send the manpower, working hours are generally kept as 10 hrs. a day instead of 8 hrs.

(b) Number of shifts. It has been experienced that production falls in the night shifts as compared with day shifts. This factor should be considered while running the construction project in shifts and deciding manpower requirements.

(c) Nature of work. Nature of work decides the output and capabilities hence plays and important role in deciding manpower requirement. Nature of work includes adverse weather, climatic conditions, topography, toughness etc.

(d) Operators Efficiency. Normally following standard is considered as guidelines for measuring workers efficiency:

(i) Operators having one year of job experience = 85%

(ii) Newly appointed operators after training = 60%

Total available days for work are 365-52 Sundays -10 holidays-10 casual leaves-10 sick leaves-20 Earned leaves, equals to 263 days.

Considering 85% operators efficiency and 90% equipment utilization, effective working hours/worker/year

= 263 x 8 x 0.90 x 0.85 = 1600 hours. (approx).

1.7 SELECTION OF EQUIPMENT

Proper selection of equipment for a construction project is of vital importance for its speedy and economical completion. Problem of equipment selection has become more complicated, because large varieties of equipments are being manufactured now-a-days. For proper selection of equipment, a considerable experience in the operation and maintenance in the field is essential. Records kept for operation, maintenance and actual output obtained under comparable conditions of previous projects will greatly help in taking decision for equipment selection.

Following are the main points which should be considered in the process of equipment selection.

1. Suitability for Job Conditions. The equipment must meet the requirement of the work, climate and working conditions.

2. Size of the Equipment. Size of equipment should be such that it must be able to be used with other matching units. If the equipment selected is of larger size, that will remain idle for most of the time or shall work on part loads, which means production cost will be more. On other side, if the equipment is of smaller size than desired, the equipment will not be able to work with the matching equipments and hence other equipments will have to remain idle or to be allowed to work on part loads, which shall again be uneconomical.

3. Standardization. It is better to have same type and size of equipments in the project. It means lesser spare parts' reserve, more interchangeability of parts if required, easy for the operators to understand it, mechanics will be able to maintain and repair better as they become expert by handling one type of equipment.

4. Availability of Equipment in the market. The equipment which is easily available in the market should be purchased. It should also be ensured that the equipment is of repute and is likely to be continued to be manufactured in future also. This is necessary for future standardization and ensuring spare parts supply. It is easy to dispose off such equipment after completion of project.

5. Availability of Spare Parts. While selecting a particular type or make of equipment, it should be ensured that the spare parts will be available at reasonable price throughout the working life of the equipment. It should also be ensured that the downtime of the equipment for want of spare parts may not be more. This is all the more necessary in case of imported equipments.

6. Multipurpose Equipments (Versatility). There are certain types of equipments which are not utilized fully. Therefore if possible, they must be capable of performing more than one function for example; Excavator with wheel loader bucket arrangement or with rock breaker attachment.

7. Availability of Know-how. The equipment selected should be satisfactorily handled by available operators and mechanics. A sophisticated equipment may give excellent performance but it may be difficult to handle and maintain it through available know-how.

8. Use in Future projects. When equipment completes only a part of their useful life in a project, it should be kept in view that the equipment can be used in future projects and may not become obsolete.

9. The Economical Aspects. While selecting the equipment, it should be considered that the cost of unit production should be minimum.

10. Reliability of the Equipment. Equipment selected for the project must be reliable one.

11. Service Support. Service support should be available in the area of project where the equipment shall be used. Service after sales is a major criteria for selection of equipment.

12. Operating Requirements. The equipment selected should be easy to operate and maintain, acceptable to the operator and should have lesser fuel consumption.

13. Past performance. If the equipment being purchased is of new make and model, it is desirable to enquire about its performance from other users, who are using this make and model.

14. The size and numbers. Should be such that full life is utilized in the project with very little residuals.

15. Reputation of the manufacturer.

16. Warranty or guarantee offered by the manufacturer.

17. Use of standard components in the equipment.

18. Adequacy of drive mechanism or power of the prime-mover.

19. Versatility of the equipment should be given due priority. This means a machine which can be used for many jobs. The versatility promises extra profit from two directions; (i) allows one machine to do the job of several machines and thus cutting into ownership and operating costs associated with additional plant and labor, (ii) it increases utilization, which means a machine earns money when it might otherwise be idle. Now-a-days attachments can be fitted or changed quickly with the help of couplers.

A balance between reliability, investment cost, and operating cost should be found, since a policy of selecting the lowest priced equipment can often lead to overall higher costs.

1.8 Forward planning

The planning of a project should be made at least 6 to 9 months in advance of commencement of work. This time lead is essential for the following main tasks to be performed before the commencement of project:

(a) Purchase of Equipment. This includes the formalities for calling enquiries from manufacturers, selecting an equipment; time taken by the supplier for supply of the equipment and transporting it to the project site, installation and commissioning it. In case of imported equipments, export-import formalities and shipment of the equipments are also required to be performed.

(b) Workshop Installation. A well equipped workshop should be installed in the project, so as to fulfill the requirement of repair of equipment.

(c) Spare Parts Stock. A place to keep the spare parts should be planned. Initial lot of spares should be purchased along with the equipment. Thereafter the spares should be purchased based on the experience about the requirement of spares, lead time for their work.

(d) Posting of Personnel. Well trained operation and maintenance personnel are selected well in advance and posted in proper time to carry out their work efficiently without loss of time.

1.9 PURCHASE OF EQUIPMENT

Once the selection of the equipment is done the purchase order for the selected model and type is issued considering lead time for the supply of equipment, time required for its installation and commissioning, and the time when equipment should be available for use. The process of selection of equipment is generally a part of procurement, followed by equipment planning and helps in purchase of equipment. The complete procurement action is divided in various activities like calling enquiries, its technical and financial evaluation, ordering, contract-making, transporting, assembling and installation and commissioning, and should be followed vigorously, as any delay in any of these activities will result in delay in completion of the project. Therefore these activities are monitored at top most priority.

Generally fast moving or maintenance spares are purchased along with the equipment especially for a period of one or two years.

Equipments should be purchased in phases, so that the money is not blocked and equipments required later do not remain idle.

1.9.1 Purchasing v/s Hiring

Contractors and other users of construction equipment are required to take a decision as to whether to purchase an equipment or to acquire it on hire. This decision should be in favor of the source which is more economical. The decision is required to be taken after careful consideration. Following are the points which are in favor of purchasing an equipment:

(i) When the equipment used for the most of the construction period and likely to complete almost its full life, while working in the project.
(ii) It remains available for use whenever it is needed.
(iii) Purchased equipment means an own equipment, is generally kept in better mechanical condition and is more reliable. This means matching equipments will not be affected adversely due to frequent breakdowns.

Following are the points which are against owning the equipment:

(i) When the equipment cannot be used for its full life, then the owning may be more expensive than hiring.
(ii) The purchaser is required to do huge investment initially, which otherwise he may need for other purposes.
(iii) Contractor may have to face the danger of obsolescence of the equipment.

1.9.2 Hiring with an Option to Purchase

In this system user hire the equipment at the prevailing rate with a provision that he may purchase it at a later date if he wishes to do so. In case he decides to purchase the equipment, a specified portion (generally about 80%) of the hire charges paid shall be adjusted against the original purchase price of the equipment. An agreement, specifying the percentage of hire

charges to be adjusted along with other terms and conditions, is made between both the parties. The specified portion allows the previous owner of the equipment to cater for the interest, insurance, taxes etc.

1.10 WORKSHOP INSTALLATION

A workshop should be installed in the project so as to enable to carry out necessary repair and maintenance of the equipment. Workshop should cater for the following facilities:

a) Servicing, which includes cleaning, cooling, lubrication, and check-ups.
b) Field repairs.
c) To carry out inspection at regular specified intervals to detect faults which can be rectified in time to avoid breakdowns. It detects the defects in operation, change in adjustments, wear and tear, cracks or any other indication for likely breakdown in near future.
d) Tire repair.

A central workshop can also be provided if it is thought proper to carry out major repairs in the project itself. The location, layout and various facilities of the central workshop are arranged in such a way that the repair can be carried out efficiently and with minimum delay. The equipments maintained, serviced and operated in a proper manner are sent to the central workshop for overhauling in a phased manner. The workshop should be fully equipped with necessary machines, store, tools and other accessories.

1.11 SPARE PARTS MANAGEMENT

Machines worth millions of Birr are idle for want of spares, on other hand huge stock of spares are lying which perhaps may not be used. This emphasizes the need of paying more attention on the management of spares. Improvement in the capacity utilization and cost reduction can be achieved by better spare parts management. The objective of spare parts management is to provide right parts in right quantity, in right place, at right time and at right cost. The parts must be properly codified and classified. Various cost reduction techniques for spares help the manger to control large number of spare parts selectively and effectively, which help to utilize his energy to problem areas resulting in optimal use of his efforts. These methods demand more

concentration in areas of more importance, while areas of least importance can be left to supervisory level. Some of these techniques are mentioned below which can be used either independently or jointly:

S.No.	Tittle of technique	Basic	Application
1	ABC (Always Better Control)	Annual Consumption value in Birr	Inventory control.
2	HML (High, Medium, Low)	Unit price of Material	Delegation of purchase powers.
3	VED (Vital Essential, Desirable)	Operational Characteristics	Storage point.
4	FSN (Fast, Slow, Non-moving)	Issues form Stores	Obsolescence control.
5	SDE (Scarce, Difficult, Easy)	Availability of items	Purchase strategy
6	FAN (Failure Analysis)	Design of issue of spares	Reliability Engineering
7	GOLF (Govt. Ordinary, Local, Foreign	Source of origin of material	Purchase strategy.

1.12 MAINTENANCE MANAGEMENT

Every machine is thoroughly tested and inspected by the manufacturers before selling. When used it is subjected to wear and tear, hence proper attention should be given to protect the machine and its components from undue wear and thus protect them from failures. A proper attention means lubrication, cleaning, timely inspection and systematic maintenance. Maintenance means efforts directed towards the up keep and the repair of that machine. Repair must be done at a time when it may have least disruptions i.e. machine may be repaired when it is not being used or its use may be postponed without affecting the production much. Thus, maintenance is responsible for the smooth and efficient working of an industry and helps in improving the productivity. It also helps in keeping the machine in a state of maximum efficiency and economy.

Following are the types of maintenances:

a) **Repair Maintenance** can be followed for non-critical equipments, and where failures are unpredicted.
b) **Corrective Maintenance** should be adopted for frequently falling components.
c) **Preventive Maintenance (planned or scheduled or systematic maintenance)**. Periodic inspection or checking at the pre-decided frequency helps to find out the reasons leading to breakdown and to rectify them when they are in minor (or initial) stages. Thus enable to carry out the repair when one wants to do it i.e. when it has least effect on the production schedule. Further this repair requires lesser time as compared to that of breakdown repairs and thus down time is reduced by doing preventive maintenance.

1.12.1 Functions of Preventive Maintenance

Following are some of the important functions of the preventive maintenance programme:

(i) Inspection or checkups at carefully decided frequencies.
(ii) Lubrication. Mechanical components like gears, bearings, bushes and other friction surfaces give good performance for long periods, when they are systematically lubricated i.e. application of right type of lubricant at the right time, at the right place and in right quantity.
(iv) Every preventive maintenance work should be preplanned.
(v) Good record keeping is essential for good preventive maintenance.
(vi) Training of maintenance personnel.
(vii) Storage of maintenance spares.

Advantages of Preventive Maintenance

(i) Less overtime work required as it is pre-planned.
(ii) Less repair costs
(iii)Less Production downtime.
(iv) Less stand-by equipments needed.
(v) Increased life expectancy.
(vi) Better spare parts control leading to reduced inventory.
(vii) More reliability.

1.12.2 Tyre Maintenance

It will be needless to assert that tyers are an expensive item in the cost budget and consumes a very high proportion of operation costs, and rate only next in expenditure to fuel. But these are mostly ignored from the time of initial fitment until the time of ultimate failure and as a result millions of potential tyre kilometers are wasted every year. Correct tyre selection and proper tyre maintenance are therefore very essential for ensuring economic operation. For proper maintenance of tyres and tubes following factors should be considered:

(a) Proper inflation.
(b) Proper Loading.
(c) Proper Speed.
(d) Keeping the tyre up to desired temperature.
(e) Proper driving habit.
(f) Avoiding vehicles' mechanical irregularities.
(g) Storing of tyres properly.
(h) Tyre rotation.
(i) Retreading at right time.

1.13 DOWN-TIME AND AVAILABILITY

Let us say, an equipment failed 5 times in a year and total time required to put it in operation is about 30 days, considering 300 working days, the equipment was thus not available for 10% is downtime. The downtime is the duration from the time when equipment goes under breakdown to the time when it is restored to service and includes time for reporting of failure, time required for reaching to the site and initial inspection of the equipment, actual repair time, time required for final inspection and trial.

Down time can be reduced by following ways:

(i) Speedy Fault Detection. Fault should be detected before it becomes serious enough to affect performance.

(ii) Speedy Fault Diagnosis. The time spent in fault diagnosis can be reduced by following a logical method of fault diagnosis.

(iii) Speedy repairs. Time for repairs include time required for fault detection and diagnosis, removal of assembly, stripping, adjustments, assembly and then final trial test. For speedy repairs it is essential to use latest tools, immediate decisions should be taken whether to recondition or replace a particular part.

(iv) Reduction in Waiting Time. Waiting time for repair is considerably higher than actual time taken for repairs due to the irregular (random) arrival of repair jobs. Queues are formed mainly because of the mismatching of arrivals and servicing rate. Waiting time can be reduced by increasing the efficiency of repair crew (through training, incentive etc.), and by adopting policy of replacing first and repairing afterwards for jobs involving heavy repairs. For this purpose some assemblies or sub-assemblies are kept in reserve. Waiting time may also be reduced by increasing the manpower.

Due to the trend towards more sophisticated equipment, the cost of construction equipment is continuously increasing. Hence the importance of maintaining availability also increases, as there is a greater loss whenever an equipment is under breakdown.

1.14 OPERATION AND UTILISATION

Since this is the task directly responsible for production, maximum managerial care should be given to the 'operation'. Following are the main factors which effect the operation:

(i) Availability of Trained Personnel. Since there is general shortage of trained personnel in our country for construction equipment operators, there is need to impart proper training by organizing training programs in order to achieve optimum utilization of construction equipment.

(ii) Adequate repair and maintenance facilities in the projects.

(iii) Availability of spares required for repair and maintenance.

(iv) Working Conditions. Efficient operation does not depend only on the capacity of the machine, operating skill, spares availability and working conditions etc. also effects the

economic operation of the equipment. Therefore before executing the project, data pertaining to the geology, quarries, geographical locations are studied in detail. The production during the operation of the equipment is effected by these factors.

(v) Haul roads should be well maintained for better operation, utilization and better output of the equipment.

(vi) Information Monitoring System. Since information is an evaluated data, therefore the various data related to operation should be recorded, and evaluated for information/monitoring the operation task. The information transmitted from the site should be given immediate attention. The information which should be maintained for the purpose of monitoring are: daily production report, maintenance history reports, frequency analysis, man power utilization report (actual manpower utilized V/s available, category wise), list of equipments under repair and likely date of completion of their repair etc.

(vii) Feedback should be extended to the manufacturers in respect of performance levels, repetitive breakdowns and operational difficulties.

(viii) Since the tyre is a costliest item and due to increasing cost proper care is necessary as described earlier.

(ix) Norms of output for each type of equipment in each project is determined considering the operational factors. The output of each equipment should be compared with that of pre-determined norms to enable to improve utilization (output) over existing levels. A care should be taken that to achieve production target, it may not lead to mal-utilization of equipment.

(x) Encourage operators and maintenance personnel for giving long life of the equipment.

Equipment Replacement

Equipment replacement decision plays an important role in the economic running of any concern for years. The reasons for replacement of equipment are: deterioration, obsolescence and inadequacy. The equipment is replaced in order to reduce production cost, to reduce fatigue, to raise quality, to increase output, to secure greater convenience, safety and reliability. The capital needed for the replacement of the equipment is recovered during its life cycle through depreciation realized every year.

1.15 MANAGEMENT TECHNIQUES

(a) Network Techniques. Network techniques can be used to prepare equipment schedules, organizing and executing the work of assembling, installation and commissioning of plants, to organize and execute major repair job of equipment involving concurrent action in different shops by different crews to decide deployment policy by way of doing resource leveling and resource smoothening and giving priorities to critical activities. It also helps in coordinated scheduling with civil engineering works and project monitoring.

(b) Work Study. Work study is performed to determine:

(i) A best way of doing a work so as to get maximum output without affecting the equipment adversely.

(ii) How much time a unit of work should take to perform or how much work per hour should be performed by the equipment? This will enable to decide output norms, such as quarry material or aggregate or asphalt mix or base course mix transported by a dump truck per hour, surface of base course or asphalt course compacted per hour by a particular type of roller, volume of quarry material removed by the dozer during an hour, area graded per hour by a motor grader etc. The actual output achieved is then compared with these norms and various managerial efforts can be made to improve the productivity.

(c) Operation Research Techniques. Operation research is a method of analysis by which management receives aid for their decision. It offers alternative plans for a problem for decision by adopting analytical methods. Best alternative is then selected and implemented. The methods of operation research which can be applied to equipment management are: Waiting line models, equipment replacement models, simulation and transportation model.

(i) **Waiting Line Model**. It is useful for deciding size and quantity of matching equipments like wheel loader loading the material in dump trucks, dump trucks feeding the material into the crusher, pusher dozers loading a fleet of scrapers etc. This model can also be applied to servicing facilities. The object of this waiting line model, also known as queuing theory, is to examine the problem of waiting and minimizing the waiting period i.e. reducing the queues.

(iii)**Transportation Model**. These models are used to solve the problems arising when a single type of equipment is to be allocated among a number of demands. This helps in deciding the location for installation of stone crushing and screening plant, aggregate base missing plant, hot mix asphalt plant, concrete batching plant etc. S

(iv) **Simulation Technique**. It is a quantitative technique used for evaluating alternative courses of action based on facts and assumptions, with a mathematical model representing actual decision making under conditions of uncertainty.

(d) Communication. Communication means transmission of ideas, information, directions etc. The communication is a continuous process and must move freely in both directions and can be either oral or written, and flows either in upward or downward or horizontal directions. Communication may be in the form of reports, letters, statements or returns etc. and can be sent by post, messenger, telephone, telex or through wireless set. For immediate action wireless sets are very useful, e.g. for sending the message from asphalt laying site to the site of asphalt plant regarding break down in the paver so as to immediately stop asphalt plant, otherwise the plant will continuously go on mixing the asphalt, till the message through any other means reaches, and this will result in a huge loss, because this asphalt will not be laid and shall set. Frequency of reports and returns should be decided considering the urgency, delicacy and requirement of work for monitoring and issuing directions. The proforma for these is prescribed as per requirement and should be easily understandable so as to avoid need for any clarification or observation.

Use of wireless set (two-way radio) is desirable for a project that is spread over a large area, where one operation is dependent on another. This permits quick contacts between different sites, and between key personnel, thus increases the efficiency. It also permits quick calls for first-air or for break down etc. The wireless sets may be mobile or stationary or of both types i.e. Stationary at project head quarter and at workshop, while mobile at asphalt plant, concrete plant, crusher site or at paver finisher or at the place of other important activity.

(e) Computerization in Equipment management. Computers are sued effectively for various aspects related to the equipment management like, availability of equipment with

that of other equipments used together for one or related activities, resource leveling, maintenance of history cards and then using them for planning the over hauling of assemblies/equipment as a whole. The computer can also be used for determining the economic ordering size of spares considering the past consumption data, and to carry to various analysis such as ABC; FSN (Fast, slow and non-moving) etc. as these help in inventory control, reduction in down-time and better financial control.

Various problems related to operation research techniques like, queuing models, transportation models etc. as explained earlier can be solved very easily by using computers. CPM/PERT network techniques can be applied for equipment planning, monitoring controlling, scheduling, and resource allocation purposes through computers.

(f) Value Engineering. Value engineering is a tool of management to determine the approaches for saving the cost from the point of 'value.' Thus the job of value engineers is to make a study of the design, specifications, materials and methods of construction of the project at a lesser cost without reducing the equality and usefulness of project. Value engineering is generally applied immediately after completion of the plan but before the call of tenders from the contractors. The object of the study in this stage is to determine if modifications can be made in design or specifications or materials to reduce the cost of the project without adversely affecting the quality and purpose. While in the second stage, the study is conducted by the value engineers of the contractor after award of the work to him. If the study at this stage indicates that cost can be reduced, the detailed report is required to be submitted by the contract to the project owner, who in turn will consult this value engineers, professional engineers and architect.

1.16 REDUCTION OF CONSTRUCTION COST

A cost reduction in construction can be achieved by adopting following ways:

(i) Proper planning

(ii) Timely supply of funds, equipment, materials, and personnel (i.e. men, material money and machines).

(iii) Proper equipment planning and selection. For this engineers should keep informed on the developments of new construction equipment.

(iv) Proper equipment operation, maintenance and utilization.

(v) Adopting proper inventory control.

(vi) Engaging experienced operators

(vii) Monitoring progress and adopting scientific methods.

(viii) Ensuring continuous supervision.

(ix) Adopting innovations and latest techniques suitable for the job. If necessary, modify the design or construction methods to permit the use of economical equipment.

(x) Eliminate unnecessary construction requirements.

(xi) Use local materials when they are satisfactory.

(xii) By applying value Engineering. Value Engineering may be applied after initial planning is done, to determine if modification can be made in the design or specifications of the material to be used to reduce the cost of the project without affecting its object. After this study, plans are finalized. For conducting the study, questions asked regarding each item of the project are; what is its purpose? What does it cost? What modifications are possible? What is the saving due to these modifications? What shall be the effect of these modifications on quality and time etc.?

Cost Control

Cost control enables a contractor to analyze the performance of labour and equipment, during the period of construction itself. It gives the costs and volume of production by labour and equipment. If the costs are higher than those estimated, either the estimate was too low or the costs are too high. Later condition can be rectified and the loss can be reduced or converted to profit. Cost control is thus not merely book-keeping, since the book keeping enables the contractor to determine whether he made a profit and that too after the project is completed.

Cost Accounting

Cost accounting should provide the costs of material, labour and equipment separately for each operation, grouping of cost of all equipment or material or labour into one item do not serve any purpose, as it doesn't permit determination of correct cost of an operation.

Training Equipment Operators

Even the best equipment of the world is valueless without the competent operator. A little thought is given as to who will run this equipment and how they will be trained to make maximum use of their capabilities. Most operators have acquired their skills by self-instruction or from other operators mostly by trial and error. Contractors have now begun to realize that such a haphazard approach is wasteful and can be dangerous. With equipment becoming more sophisticated each day, it is not desirable to have just any one learn how to operate machine on a trial and error basis. Such operators have little knowledge of the special features built in to the equipment they drive.

Realizing this problem, manufacturers have started helping the users to make best use of the equipment. Following are the few methods out of which one or more methods are being adopted by most manufacturers:

(a) Use of still films with commentary.
(b) Lecture.
(c) Study Booklets.
(d) Work sessions.
(e) Operator-trainer discussions.
(f) Practical-training on grounds resembling the work site.
(g) Training in the training centers.
(h) Motion picture films in which an experienced demonstrator-operator helps to train new operators.
(i) Own Training programme. Contractors/users find it necessary to train their operators through their trained and experienced supervisory personnel. As he knows better weak and strong points of the operator. He can teach how to operate and maintain their

equipment properly through routine servicing and making running adjustments in the fields and how to follow safe practices.

1.17 DECISION-MAKING

Decision-making is the most important task in equipment management and we can say that good decision making ability is the key to success. Management without decisions is like a man without backbone. Efficiency, loss or profit, and working atmosphere of a construction firm are affected by these decisions. The days of hit and mis methods in management are over and have been replaced by new concepts and scientific techniques.

In general, decisions are the output of the following inputs:

(i) Knowledge and information,

(ii) Ability and skill: Communications, analytical, or conceptual.

(iii) Value system: Opinions, attitudes, habits, or belief

The job of equipment management involves a large number of decisions e.g.

(i) Which equipment should be used?

(ii) What work is to be done by equipment?

(iii) Whether to use equipment or to do it manually?

(iv) What make and model of the equipment is to be purchased?

(v) Which of the matching equipment and of what size and in what number to be deployed?

(vi) Which of the accessories to be purchased with the equipment?

(vii) Whether to purchase the equipment or take on hire.

(viii) When to purchase from own capital or take loan?

(ix) Whether to purchase a particular spare for store or purchase when needed, if required for stores then in how many numbers. What shall be minimum and maximum levels, and reordering level, and economic ordering quantity?

Once the decision is taken, it should be ensured that it is implemented. It is not true that decisions are required to be taken only in the initial stages and not later-on, actually large numbers of decisions are also required to be taken during the course of running a project. Such

problems may arise due to the changes in the situations and due to other unforeseen circumstances during the course of work. Such problems may be related to the organizational structure, procedure, coordination, division of work and responsibility, deviation of quality standard, reduction in output, break-down of an equipment, repairs of the equipment, employment of operators, mechanics etc.

"Decision-Making" is defined as an intellectual activity, because it calls for both judgment and imagination to select one among many alternatives.

Characteristics of Decisions

Main characteristics of a good decision are:

(i) It is the choice of the best course among various alternatives.
(ii) It is the end process preceded by the deliberations and reasoning
(iii) It is associated with commitment.
(iv) It is rational.
(v) Evaluation process exists in every course of decision making.

Procedure for Decision-Making

Good decisions can only be made if following steps are taken before a final decision is taken:

(1) Recognizing and analyzing the problems.
(2) Finding relevant facts.
(3) Determining possible alternatives.
(4) Evaluating the impact of alternatives.
(5) Selecting the best solution.
(6) Implementation of the decision.

Decisions Under Certainty

These are the decisions, which are taken when the problems are under certainly i.e. where a complete knowledge about the nature of future conditions is known e.g. location of central workshop and field workshop in a construction project is a decision to be taken where future conditions are certain.

Decisions Under Uncertainty

When complete idea about the future conditions which will come across for various alternatives are not known, it is said to be decision-making under uncertainty. In such cases either to use thumb rules and experiences or to deal systematically with the uncertainty itself with the careful use of statistical information or theory of probabilities. In general, it is always better to consider an intermediate position for dealing with uncertainty.

2. ECONOMICS OF CONSTRUCTION EQUIPMENT

Principles and techniques of engineering economics are utilized while making equipment selection and planning of finances for the purchase of construction equipments. Economics of construction equipment deals with the study of working of the equipment and to compute the unit costs of production. This economic evaluation helps in taking a decision to select an equipment to hire it. Unit cost of production is calculated after estimating the best of production by calculating hourly ownership and operating cost of the equipment and knowing hourly production of that equipment.

Equipment selection is a decision making from various alternatives which gives least cost of unit production considering various factors of economics being described in this chapter. It should consider the rate of interest on the equipment, time required to complete the project and effect of time on the project, as we know that time is money.

Hourly Working Rate

Hourly working rate of construction equipment comprises of the following component:

(i) Owning Cost. It is made up of the following costs:

(a) Investment cost,
(b) Depreciation cost,
(c) Major repair cost.

(ii) Operating Costs. It includes the following cost:

(a) Cost of fuel (or power),
(b) Cost of lubricant,
(c) Servicing and maintenance cost,
(d) Labor cost,
(e) Cost of field repairs,
(f) Various other overheads.

2.1 OWNING COSTS

2.1.1 Investment Costs

This is a kind of fixed cost and continues to be incurred whether the equipment is used or not. Investment costs comprises of the following:

(a) Interest on the money invested in the procurement of the equipment.
(b) Various taxes on the equipment.
(c) Insurance expenses.
(d) Storage costs.

If the money spent on the purchase of the equipment, was invested in the bank or similar other agencies, it would have earned an interest. Now this amount, equivalent to the interest, should be recovered from this equipment. The rate of interest should be equal to the prevailing bank rates.

Taxes pertaining to ownership of the equipment are those paid by the owner for the equipment. Similarly owner is also required to pay the insurance premium of the equipment, in order to cover the risk of the equipment and any other loss caused due to any accident by the equipment. Storage cost is the cost of space required by the equipment and other expenses to be incurred by the owner for keeping the equipment.

Generally these investment costs are taken as about 10 to 15% of the total cost of the equipment. This total cost comprises of the following:

(a) F.O.B. Price of the equipment with all attachments and accessories.
(b) Insurance and freight charges.
(c) Expenses on un-loading, clearance and custom duty.
(d) Cost of transportation to the job site including loading and unloading.
(e) Erection and commissioning charges.

2.1.2 Depreciation

Due to use and obsolescence every equipment loses its value. This loss is accounted for by depreciating the equipment every year. The depreciation and obsolescence are described in detail hereunder:

1. Depreciation. Whenever any machine or equipment performs useful work its wear and tear is bound to occur. This can be minimized up to some extent by proper care and maintenance but can't be totally prevented. Its efficiency also reduces with the lapse of time and at one time it becomes uneconomical to be used further and needs replacement by new unit.

Therefore, we can say that efficiency and value of machine of asset constantly reduces with the lapse of time during use, which is known as "depreciation". Some money must be set aside yearly from the profits, so that when an equipment becomes uneconomical, it can be replaced by the new one. Therefore, the initial cost of machine plus installation charges + repair charges – scrap value is charged against overheads and spread over the machine's useful life.

For this purpose depreciation account for an individual equipment is opened in the company's Books and is known as "depreciation fund', or "sinking fund". This amount is deducted yearly from the profits and kept separately to have sufficient money for replacement at the end of useful life.

2. Obsolescence. Suppose a contractor purchase a machine for his production but after some duration a better machine comes in the market, whose production rate is very high and is more economical. Although the old machine is efficient but becomes out of fashion and uneconomical due to the new better machine which has come in the market. This is known as "Obsolescence". Consideration of this factor is of much importance and some money should also be set aside from the profits for this cause.

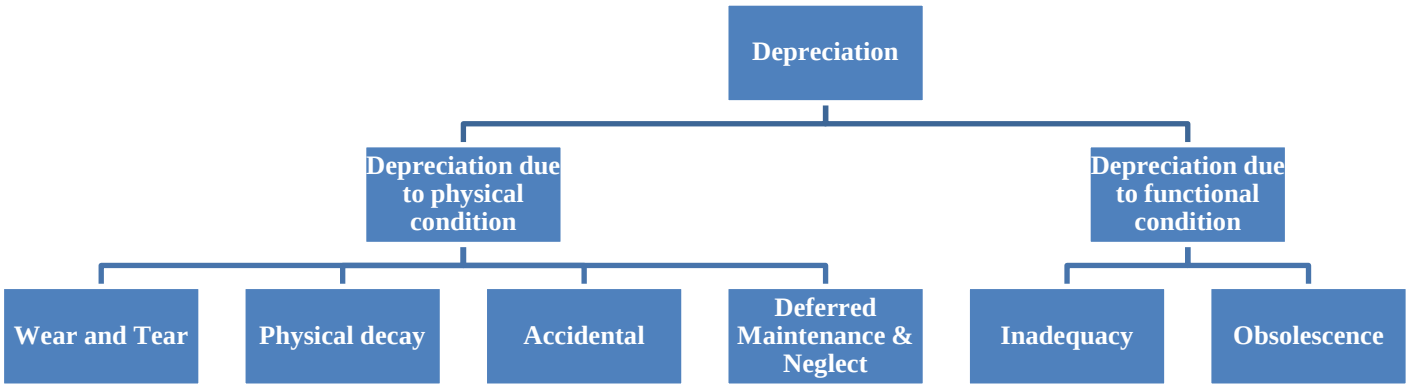
Hence "Obsolescence" is the depreciation of existing machinery or asset due to new and better invention, design of equipment of processes etc.

It is very difficult problem for estimator to provide for the on cost on obsolescence, because nobody can predict when a revolutionary change in the machine is coming in the market. But it is a general practice to reduce the life of a machine so as to account for the effect of obsolescence. The depreciation and obsolescence charges are then calculated for the reduced life.

Suppose an estimator expects the life of machine as 10 years then the depreciation rate will be 100/10 = 10%. By considering obsolescence also, its life may be taken as 8 years. Then the combined depreciation and obsolescence charges will be 100/8 = 12.5% instead of 10%. Therefore, the difference 12.5 – 10.0 = 2.50% will be obsolescence charges.

The other causes of depreciation are physical decay, accidents, deferred maintenance and neglect, inadequacy etc.

For further understanding depreciation can be classified as under:



Now, each type of depreciation is explained in short below:

(a) Depreciation Due to Wear and Tear. Everybody knows that when any machinery performs work, wear and tear of certain components takes place, although sufficient precautions are taken i.e. proper lubricating and cooling is done, which minimize wear and tear but it cannot be totally prevented. The cost of replacement because of this cause; is the value of depreciation due to wear and tear.

(b) Depreciation due to "physical Decay". There are certain items which get decay, because of climatic and atmospheric effect; there will be reduction in their value. This reduction in cost is depreciation due to physical decay.

(c) "Accidental" Depreciation. Although, the machine might have installed even few days back and sufficient care is taken to prevent accident, even then, accident may occur due to some wrong operation, or some loose component or some other cause, which may result in a heavy damage. The depreciation in machine cause due to this reason is called accidental depreciation.

Now-a-days, to cover this risk most of the owners get their equipment insured with the insurance companies. For that owners have to pay certain premium yearly. The amount of premium depends upon the cost and life of equipment.

(d) Depreciation Due to "Deferred maintenance and Neglect". Every manufacturer supplies certain instructions for the smooth and efficient running of an equipment. For example, in the case of a vehicle, a manufacturer gave the following instructions:

(i) Lubricating Oil 20 W 40 should be used in Engine.

(ii) Oil should be drained and new 20 W 40 oil should be refilled after 5000 km running.

(iii) All the bolts and nuts should be re-tightened after 15000 km running.

(v) Decarbonizing after 60000 km running, and so on.

Now, if these instructions are not properly followed because of neglect and proper maintenance is not done as recommended by manufacturer, the life of the vehicle may be reduced, and depreciation in value because of this, is called depreciation due to deferred maintenance and neglect.

(e) Inadequacy. This is the form functional depreciation. Inadequacy means reduction in, efficiency of an asset. This may result firstly, even if any equipment is serviced under proper precautions and sufficient maintenance is provided, there is fall in efficiency with the lapse of time.

Secondly, suppose after 2-3 years of running, the work requirement is increased, but the plant cannot cope-up with the increased demand. This needs additional money either to

replace with the bigger size plant or installation of additional similar plants. This is what is called depreciation due to inadequacy.

(f) Depreciation by Obsolescence. Now-a-days because of scientific advancement, there are large changes every day. If a new machine comes in the market which is more efficient because of new invention and better design than the existing one, and the production by the new one is much cheaper and better than the existing machine has to be replaced to withstand market competition. This is called depreciation by obsolescence and is of functional type.

Methods of Calculation: The following are the methods for calculating depreciation.

1. **Straight line Methods**
2. **Diminishing Balance Method**
3. Sinking fund Method
4. Annuity Charging method
5. The Insurance policy method
6. The Revaluation or Regular Valuation method
7. Machine Hour Basis method
8. The sum of the year's Digits method

Straight Line Method

This method assumes that the loss of value of machine is directly proportional to its age. It means one should deduct the scrap value from the original value and divide the remaining value by the number of years of useful life.

Let C be the Initial cost of a machine.
S be the scrap value.
N be the Number of years of life of machine.
and D be the depreciation amount per year.

Then, $D = \frac{C - S}{N}$ Birr

This method of calculating depreciation fund is also known as "Fixed installment" method, because every year some (fixed) amount is deducted and no consideration is made about the maintenance and repair charges, which gradually increases as the machine is getting old.

Example-1

(a) A machine was purchased for Birr 450,000 on 1st January, 1991, the erection and installation work costs Birr 70,000. This was replaced by a new one on 31st Dec, 2010. If the Scrap Value was estimated as Birr 150,000 what should be the rate of depreciation and depreciation fund on 15th June, 2000?

(b) If after 12 years of running, some assemblies are replaced and the replacement cost is Birr 150,000 what will be the new rate of depreciation?

Solution

(a) Total cost = Machine Cost + Erection and installation charges

C = 450,000 + 70,000 = 520,000 Birr

Scrap value S = 150,000 Birr

Life of machine = From 1st January, 1991 to 31st Dec, 2010

= 20 years.

$\therefore$ Rate of depreciation; $D = \frac{C - S}{N}$

$= \frac{520,000 - 150,000}{20}$

$= \frac{370,000}{20}$ = Birr 18,500.00

$\therefore$ Depreciation per year = **+ Birr 18,500 only**. **Ans.**

Now, depreciation fund on 15th June, 2000 i.e., 9 Installments (form 1st January, 1991 to 15th June, 2000) could be accumulated.

∴ Depreciation fund collected up to 15 June, 2000.

= 9 X 18,500 = **166,500.00 Birr only** **Ans.**

b) As after 12 year assemblies have been replaced and cost of replacement is Birr 150,000.

Now, book value in 12 years will be Birr 520,000-12 x 18,500

= Birr 298,000

And replacement cost = Birr 150,000

Hence, new book value = 298,000 + 150,000.

= 448,000 Birr

As scrap value is same i.e. Birr 150,000 hence the depreciation for the rest 8 years will be (Birr 448,000 – 150,000)

= Birr 298,000

∴ New rate of depreciation = Birr $\frac{298,000}{8}$

= 37,250

∴ New rate of depreciation per year = **Birr 37,250** **Ans.**

Example 2

Consider an excavator purchased for 3.1 million birr having a useful life of 5 yrs. Determine the depreciation and book value for each of the 5 years using Straight Line method. Assume a salvage value of S = 860,000 birr.

$$Depreciation\ Rate = \frac{1}{N} = \frac{1}{5} = 0.2$$

$$Dn = \frac{3,100,000 - 860,000}{5}$$

$$= 448,000 \quad birr$$

or

$$(3,100,000 - 860,000) * 0.2$$

Year	BV_{n-1}	Dn	BV_n
0	0	0	3100
1	3100	448	2652
2	2652	448	2204
3	2204	448	1756
4	1756	448	1308
5	1308	448	860

Diminishing Balance Method

This is also called "Reducing Balance" Method. The diminishing value of machine is greater in the early years. It depreciates rapidly in the early and later-on slowly. Therefore, it is better to depreciate more during the early years, when the repair and renewals are not costly.

So under this method, the book value of the machine goes on decreasing as its existence continues. A certain percentage of the current book value is taken as depreciation. Therefore, this is also called "percentage on Book Value" method.

In this, let x be the fixed percentage taken to calculate the yearly depreciation on the book value.

Then $x=1-\left(\frac{S}{C}\right)^{\frac{1}{N}}$

Where, C = initial cost, S = Scrap Value, N=No. of the years of life.

It will be more clear by the following solved example.

Example - 3

A lathe is purchased for Birr 800,000 and the assumed life is 10 years and scrap value Birr 200,000. If the depreciation is charged by diminishing Balance method, calculate the percentage by which value of the lathe is reduced every year and depreciation fund after 2 years.

Solution

Here C = 800,000

S = 200,000

N = 10

We know that $x = 1 - \left(\frac{S}{C}\right)^{\frac{1}{N}}$

Substituting the given values in the above formula

$$X = 1 - \left(\frac{200,000}{800,000}\right)^{\frac{1}{10}}$$

$$= 1 - (0.25)^{1/10}$$

Solving $(0.25)^{1/10}$ we get

$$(0.25)^{1/10} = 0.8706$$

$\therefore$ x = (1 – 0.8706) = 0.1294 = 12.94%

$\therefore$ Required % = 12.94 **Ans.**

$\therefore$ Value of lathe after 1year

= 800,000 x (1 – 0.1294) = 800,000 x 0.8706

= Birr 696,480

$\therefore$ Depreciation fund after 1 year

= 800,000 – 696,480 = 103,520

Now value of lathe after 2 years

= 696,480 x (0.8706) = Birr 606,355

$\therefore$ Depreciation of 2nd year

= 696,480 – 606,355 = Birr 90,125

∴ Depreciation fund after 2 years

= 103,520 + 90,125 = **Birr 193,645** **Ans.**

2.1.3 Major Repair Cost

While minor or field repairs are carried out during the day to day working of the equipment the major repairs are carried out after the substantial use of the equipment. Major repairs and over hauls are the replacement of major parts of the equipment because of the excessive wear through a long period of use. Since these repairs require a heavy amount of expenditure, they are met from the major repair fund. The major repair cost is spread out during the entire life span of the equipment and a flat rate is levied per working hour in order to have a uniform rate. The amount thus collected in the pool is known as major repair fund, and major repairs and overhauls are carried out from this pool.

Usual practice is to consider this major repair cost as a percentage of straight line depreciation cost and is generally taken as 80 to 200% of the cost of depreciation depending on the type of equipments.

2.2 OPERATING COSTS

2.2.1 Cost of Fuel

Prime movers for construction equipments are generally diesel engines or electric motors. The actual consumption of fuel or electricity in these construction equipments depends upon:

i) Engine B.H.P
ii) The load factor, which means the extent to which the engine will operate at full power. Load factor generally vary from 30% to 70%.
iii) The conditions of the engine

Optimum fuel consumption in liters per hour may be calculated using following formula:

Fuel consumption = 0.27 x load factor.

Equipment used in the construction industry seldom operate at a rated output, except for a short period of time.

During the balance part of its cycle the demand on the engine will be reduced substantially, resulting in decreased consumption of fuel. To allow for this the value of load factor (C) may be taken as follows as recommended by the "construction plant and machinery committee – 1972 (central water and power commission)", taking into consideration the job conditions also.

S.No.	Type of Equipment	Excellent	Average	Severe
1	Wheel type equipment (highway)	0.25	0.30	0.40
2	Wheel type equipment (off highway)	0.50	0.55	0.60
3	Truck type tractors	0.50	0.63	0.75
4	Excavators	0.50	0.55	0.60

Construction equipment is seldom operated for 60 min in an hour and therefore, the actual fuel consumption is calculated by multiplying utilization factor to the fuel consumption arrived from above formula.

2.2.2 Cost of Lubricants

Lubricants include the following:

i) Engine oil
ii) Air filter oil
iii) Transmission oil
iv) Hydraulic oil
v) Greases etc.

The quantity of lubricating oil depends upon various factors. Some of these factors are:

i) Capacity of the crank case

ii) Condition of piston rings

iii) Number of hours between oil changes. This depends on the operating conditions and the manufactures recommendations. In extreme dusty conditions oil is required to be changed after every 50 hours of working, while in normal conditions it may vary from 100 hours to 200 hours.

Lubricating Oil Consumed

Requirement of lubricants including engine oil, air cleaner oil, transmission oil, greases, and hydraulic oil, can be assessed on the basis of information supplied by the equipment manufacturer. Although actual consumption of lubricants depend on the condition of equipment, but, as a thumb rule expenditure on the lubricants can be taken as 30% of the fuel cost in diesel engine and about 20% of the fuel cost in petrol engines.

Following formula is used for estimating the quantity of oil required per hour:

$$Q = \frac{HP \times f \times 0.006 \times 4.5}{7.4} + \frac{C}{t} \, lit/hr$$

Where, Q = Quantity of oil consumed in lit/hr

HP= Rated horse power of the engine

F = operating factor

C = Capacity of crankcase, in lit.

T = Number of hours between oil changes.

2.2.3 Servicing and Maintenance Cost

Regular servicing and maintenance of each equipment is very essential in order to have the equipment in reliable and perfect condition of working. This cost includes:

i) Change of lubricants

ii) Checking and servicing of fuel and lubricating systems, including change of filter elements.

iii) Care of tyres and tubes

iv) Care of Battery and electrical system

v) Cleaning of the equipment and other similar works.

2.2.4 Labour Cost

Labour cost is an important element of operating cost and contributing a major part of it. Labour cost element includes the salaries of operators, and helpers engage on the equipment. Provision for leave reserve (may vary from 10 to 12%) is also made under the bead of labour cost. A percentage of the wages of supervisory staff, depending upon the attention required on that particular equipment, is also to be added.

2.2.5 Cost of Field Repairs

This is the cost incurred on minor repairs which are carried out on the site or in field workshops. These repairs include replacement of minor parts, such as fan belts, filters, bearings, wire ropes etc. and other adjustments required to be carried out during normal working of the equipment.

2.2.6 Overheads

These are the charges which are incurred on complete fleet of the equipment. Therefore proportional expenditure is booked under this head on each equipment. These charges includes the pay on watchman, light and water charges in the storage yards, uniform to the operating and maintenance staff etc.

Repair Reserve Fund

A provision for the repair of an equipment for its entire life is made by charging a percentage of the book value (excluding the value of tyre). The equipment earns this fund during the working of the equipment in order to carry out the repairs subsequently during its course of operation. Percentage for some of the major construction equipments are mentioned hereunder:

Crawler tractor/Dozer 240

Wheeled tractor/Dozer 200

Shovels/Draglines, hyd. Excavators, vibratory compactors, wheeled loaders…….150

Dumpers, Tractor trailers 140

Crawler and mobile cranes, transit mixers 120

Air compressors and water pumps with diesel engine 100

Air compressors with electric motors, Wagon drills, concrete mixers …….80

Batching and mixing plants, towed scrapers .....……75

Determination of Owning and Operation Costs

To determine the cost of owning and operating following procedure is adopted.

I. Ownership Charges

i) Depreciation

A. Total cost of equipment less cost of tyres Birr _____

B. Deduct salvage value (generally 10% of A) Birr _____

C. Total investment to be depreciated (A-B) Birr _____

D. Economic life in hours Birr _____

E. Depreciation per hour (C/D) Birr _____

ii) Interest, Insurance, Taxes and Storage

F. Annual expenditure on these items Birr _____

G. Interest, Ins, Taxes and Storage charges/hr

$$\frac{F}{Annual\ldots use\ldots in\ldots hrs.}$$ Birr _____

Total Owing Costs = E + G Birr_____

II. Operating charges

iii) Fuel Charges

H. Consumption in lit per hour Birr _____

I. Cost of fuel per lit Birr _____

J. Fuel charges/hr (H x I) Birr _____

iv) Lubricants and Filters Charges

K. Engine oil (consumption/hr x rate) Birr_____

L. Transmission oil ('do") Birr _____

M. Final drive oil ('do") Birr _____

N. Hydraulic oil ('do") Birr _____

O. Grease ('do") Birr _____

P. Filters ('do") Birr _____

Q. Total lub. And filter charges (total of k to p) Birr _____

v) Cost of Tyres

R. price of 1 set of tyre Birr _____

S. Estimated tyre life Hrs _____

T. Cost of Tyres $\left(\frac{R}{S}\right)$ is per hr Birr _____

vi) Repair Charges

U. Repair Factor x Depreciation per hr Birr _____

vii) Operator's and Helper's Hourly Wages

V. Operator's and Helper's Hourly Wages Birr _____

viii) Special Items

W. Special Items (like cutting edge Rippers, drill rods, bits etc.) Birr _____

Total Operating Costs = J + Q + T + U + V+W = Birr _____

Total Hourly Owning and Operating Costs = Birr _____

2.3 EQUIPMENT RENTAL RATES ACCORDING TO ETHIOPIAN ROADS AUTHORITY (ERA)

The major components of the rental rate of the equipment are **Owning & Operating costs**. Some study has been attempted to analyze some of the existing rental rate, which will be applicable and useful for construction and maintenance.. The study is based on existing data of ERA and data collected from various construction equipment suppliers and construction companies as well as literature such as hand books of Construction Methods & Management. These rates may be useful to apply on others construction sector dealings. The results have supported by reasonable assumptions & justifications as much as possible & all assumptions are attached here with. However, comments from users especially from Equipment Management Division for improvement are appreciable.

The other components of the rental rates are **Overhead cost** & **Profit**. It was very important to include overhead cost in the rental rate, but for things to simplify, the overhead and profit percentage figures have been included in the analysis of the unit price.

Interest is also one of the components of the owning cost. We found that there is no interest or negligible amount of interest on loans of Road Funds. However assuming that ERA or any purchaser of the equipment can earn money by depositing this money in Bank (money has its own time value). So that we assumed interest to be as equal as interest rate of depositors, as per the rate of Commercial Bank of Ethiopia, i.e. **6%** of initial cost of the equipment per year. To calculate the total interest rate, we converted the hourly-indicated lifetime of the equipment to years, by dividing the hours by 2000.

Operators cost is not included in operating cost of the equipment rather it is included in the calculation of the unit price.

Initial cost of the equipment depends on make, model, country of origin etc. To sate the proper current initial purchase cost, the ERA current purchase data & price quoted by suppliers were the bases & average method is used. For equipment, which have no current purchase price data, the existing data of ERA are taken as a base & the expected price change is considered using

average price change of the other equipment as a source. The rental rates have calculated on the bases of new machine prices.

Equipment Rental Rate is the sum of the Owning cost, Operating Cost, & Profit for organizations having commercialization concept.

Therefore Rental rate shall be calculated as follows:-

Rental rate = Owning Cost + Operating cost

2.3.1 OWNING COST

The **Owning cost** of equipment has two main components, i.e. **depreciation** and **investment** costs. **(Oc =Dc + Ic)**

Where: - Oc = Owning cost

Dc = Depreciation cost

Ic = Investment cost

1. DEPRECIATION COST

Due to use and obsolescence every equipment loses its value. This loss is accounted for by depreciating the equipment every year. To determine the depreciation rate of equipment, one must know the value to be depreciated, the economic life of the equipment during which it depreciates, and the like. These are the acquisition price of the equipment, the salvage value, economical working life of the equipment, inflation rate which affects replacement cost, and the depreciation method to be applied.

Thus hourly Depreciation cost; (Dc)

For Equipment without tire $= \frac{\text{Initial cost - Salvage value}}{\text{Life time (hrs)}}$

$= \frac{\text{90\% Initial cost}}{\text{Life time (hrs)}}$

For Equipment with tire = $\frac{\text{Initial cost - Salvage value - Tire Cost}}{\text{Life time (hrs)}}$

= $\frac{\text{90\% Initial cost - Tire cost}}{\text{Life time (hrs)}}$

i) **Initial Cost of the equipment (Ic):-** To sate the proper current initial purchase cost, the ERA current purchase data & price quoted by suppliers are taken, & average method is used. For equipment, which have no current purchase price data, the existing data of ERA is taken as a base & the expected price change is considered using the average price change of the other equipment as a source.

ii) **Salvage Value (Sv):- This** value varies with the degree of up-keep, condition of operation, maintenance, market value etc, however in this case 10% of the initial purchase price is considered for all equipment.

iii) **Tyre cost (Tc)**:- To calculate the deprecation cost the equipment a set of tyre cost purchased with the equipment should be deducted from initial cost of the equipment. Tyre is a consumable item and shall be included in operating cost.

iv) **Economic Life Time of the Equipment (Lte):-** The **Cat** & **Komatsu** application handbooks as well as other suppliers data are used as a base to estimate the economic service life of the equipment (see annex-XII)

2. INVESTMENT COST

The main components of the investment costs are Interest, Insurance & Tax

i) **Interest:-** We found that there is no interest or negligible amount of interest on loans of Road Funds. However ERA or any purchaser of the equipment can earn money by depositing money in Bank & money has its own time value, therefore we assumed interest to be as equal as interest rate of depositors, as per the rate of Commercial Bank of Ethiopia, i.e 6% of initial cost of the equipment per year. To calculate the interest rate, we converted the hourly-indicated lifetime of the equipment to years, by dividing the total lifetime hours by 2000.

Years of interest (n) = $\frac{\text{Total service life in hours}}{2000}$

Interest (Int) = (Initial cost) x [(1+Interest rate) ^{n} - 1]

$Int/_{hr}$ = Ic [(1+0.06) ^{n} -1] / Lte(hr)

Where:- **Int/hr = Interest per hour**

Ic =Initial cost of the equipment

Interest rate = 6%

Lte = Life time of the equipment

n = number of years for which interest to be assumed

ii) **Insurance:-** ERA has insurance cost only for vehicles and hourly cost of insurance found to be negligible as compared to other costs & decided to be left out. Therefore, only interest will be considered in investment cost.

Investment cost = Interest cost (Int .c)

Int .$c/_{hr}$ = Initial cost [(1+0.06)^{n} -1] /Lte (hr)

Where:- **Lte = Economic life time of the Equipment**

2.3.2 OPERATING COST

Operating costs are costs, which incurred during operation of the equipment. The main components of the operating costs to be considered there are; fuel cost, service cost, maintenance & repair cost, as well as tyre cost. Operator cost is one of the operating costs and it varies depending on the type of equipment, salary scale of the organization etc, however we have incorporated these costs only in the computation of the unit prices.

1. FUEL COST

The hourly cost of fuel is simply fuel consumption per hour **(lt)** multiplied by unit price of fuel. But fuel consumption vary depending 0n make, model, HP, working condition, maintenance condition etc. Actual measurement of fuel consumption under similar job conditions provides the best estimate of fuel consumption. However, as we could not find

equipment historical data from the project and districts, fuel consumption have been taken and estimated from manufacture data and summarized in the following table.

Type of the Equipment	* **Average** Fuel consumption (lit/hour)
Compactor, self propelled	**0.20**
Excavator, hoe, or shovel	**0.15**
Loader:- Crawler	**0.16**
-Wheel	**0.14**
Motor Grader	**0.13**
Scraper	**0.13**
Tractor:- Crawler	**0.14**
- Wheel	**0.14**
Unit price of fuel is taken at Addis Ababa price	

F cost = F cons x F price

Where;

F cons = Hourly fuel consumption, in liters,

F cost = Hourly fuel cost

F price = Price of fuel per liter (Birr).

2. SERVICE COST

Service cost represents the cost of oil, hydraulic fluids, grease, filters, replacement of high wear items as well as the labor required to perform routine maintenance service. Equipment manufacturers publish consumption data and average cost factors for oil, lubricants and filters for their equipment under average conditions. The service cost can be estimated in relative to the fuel cost.

Service cost = x % fuel cost (depending on the type of the equipment)

Service Cost Assumptions

I/N	Equipment Type	Cost Consideration
1	Plants	**33%** of the fuel cost of the Diesel Engine
2	Crawler Dozer & Scrapers	**30%** of the fuel cost
3	Loaders, Excavators & Graders	**25%** of the fuel cost
4	Asphalt distributor, pavors & kettles	**25%** of the fuel cost
5	Rollers & Trucks	**20%** of the fuel cost
6	Compressor, Gen. Sets, Mixer, etc.	**14%** of the fuel cost
7	Non fuel consuming equipment	**10%** of the depreciation cost

3. REPAIR COST

Repair cost represents the cost of all equipment repairs & maintenance except for 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 the operating expense for construction equipment.

Repair cost is usually estimated as a percentage of depreciation cost (the equipment's initial cost less tires). Average hourly maintenance & repair cost is then found by dividing the lifetime repair cost to the corresponding expected equipment lifetime (hrs)

Repair cost (Rc) = x % Depreciation cost (Dc) (**depending on the type of equipment at an average condition (see the table below).**

Repair Cost Assumption

Typical Life Time Repair Cost (% of Depreciation cost)

Type of Equipment	Operating condition		
	Favorable	*Average	Severe
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
NB: * In this case the Average operating condition is taken for all & for un indicated equipment, repair cost considered accordingly.			

Repair cost (Rc) = X % of Total Depreciation value (Dc)

Repair cost /hr = X % (Dc/hr.)

4. TYRE COST

This is a cost of a set of tyres during its lifetime. The ERA current tyre price data is taken & some are adjusted accordingly to come up with current price. The manufacturer data, CAT handbook, literatures, Experience of ERA & other Ethiopian enterprises are the bases to estimate the lifetime of the tyre. (see table X)

The hourly cost of tyres (Tc/hr) = Tp / Ltt

Where:

Tc = Hourly cost of a set of tyres

Tp = Purchase price of a set of tyres

Ltt = Operating lifetime of the tyres in hours

2.4 STANDARD COSTING

Standard Cost

Standard cost is an estimated cost of a job or project prepared in advance of execution. This is prepared considering normal cost of normal production with in normal capacity and under normal conditions and efficiency. The standard cost is determined following a systematic and scientific study of each element of cost and is for a given period and indicating ways to maintain and improve efficiency.

Standard Costing V/S Budgetary Control

A) Common principles

i) Establishing predetermined standards, target or yardstick of performance.

ii) Measuring actual performance as compared to yardstick.

iii) Locating variances between actual and standard performances

iv) Disclosing reasons for such variances.

B) Differences

No.	Standard costing	Budgetary Control
i	Applicable only to production, operation and project costs	Applicable to all functional areas of an enterprise.
ii	More intensive in nature	More extensive in nature
iii	It projects cost accounts.	It projects financial accounts
iv	More improved system	Elementary system.

Essential Requirements for Standard Costing

Standard cost of a work requires following:

i) Technical specifications of quality, type and quantity of direct material for each item.

ii) Estimated prices of all materials required, based on current prices and anticipated changes during the period.

iii) Estimates of direct labour time for each category of labour

iv) Standard hourly rates of each category of direct labour.

v) Estimate overhead recovery rate

Uses of Standard Costs

i) Assisting the management in better planning, coordination and control.

ii) Facilitates in comparing with actual costs.

iii) Provides basis for measuring the productivity improvement.

iv) Provides basis for measuring the productivity improvement.

2.5 COST CONTROL AND COST REDUCTION

Cost control is a method of comparing actual costs with predetermined standards or targets. Whereas the cost-reduction is meant to take drastic actions, sometimes by changing rigid boundaries laid down by the standards or targets. Cost control is therefore a continuous process, while cost-reduction measures are adopted only with a well – knit programme.

Steps for Cost Control and Cost Reduction

Following essential steps are required to be taken for effective cost control and cost-reduction.

i. Inculcating an all-round cost consciousness in the organization.

ii. While setting standards and norms, scope of cost reduction is to be explored.

iii. Decide priorities for attack to achieve quick results.

iv. Control on consumption as well as on block-up of capital is to be exercised.

v. Provide right climate to encourage creativity.

vi. Reporting and monitoring system should be strengthened.

Cost saving Areas

As we know that cost of the production consists of (i) material cost, (ii) labour cost, (iii), overheads. Therefore to reduce the cost, it is necessary to bring down the expenditure on these

elements. Some of the areas, in which saving can be achieved are: material, labour and overheads, by way of judicious and rational distribution of manpower mainly operators, deployment of machines, increasing the utilization and reliability of equipment, selection of right size and type of equipment and their accessories. Decision whether to use equipment or to do work with manpower also helps in reducing cost. These are illustrated hereunder:

a) Reduction in Material Cost

i) Ensure purchase of right quantities of right quality at right time from right source and at right price.

ii) Avoid overstocking or inventory build-up

iii) Planning material procurement in advance, scientifically and from practical consideration.

iv) Decision regarding whether to purchase aggregate etc. or to manufacture.

v) Minimum handling of material be ensured.

vi) Utilize scrap and waste material.

vii) Avoid wastage of material.

b) Reduction in Labour Cost

i) Judicious and rational distribution of workmen

ii) Labour rate should be decided considering actual norms of output.

iii) Suitable inspection and supervision methods be introduced.

iv) Decision for single shift, double shift, triple shift, or extended shift (one shift of 10 to 12 hrs) be taken, considering overall economy.

v) Operators should be trained from time to time to make them well conversant with the latest technology to enable to achieve maximum productivity.

C) Reduction in Overheads

i) Overhead expenditure should be maintained in a proper record and compared with estimates or standards from time to time.

ii) To keep control on indirect labour.

iii) To have versatile machines with different accessories to have optimum utilization.

iv) Reduction in avoidable unproductive expenditure to the maximum.

v) Construction of colonies, office etc. be made by utilizing the local material for economy and location be decided after careful considerations.

2.6 Cost- Accounting

In the current days of competition, it is necessary that the concern should have utmost efficiency and minimum possible wastage and losses. In the past when construction companies were limited, they could get attractive rates of production, but now a days competition is really very tough to get a contract. Therefore the construction companies are required to make continuous efforts to produce the work of acceptable quality at low prices; therefore, cost Accounting helps the management of the concern to constantly measure their performance objectives. Cost Accounting provides detailed analysis of the expenses incurred by a concern, and to help the management to pin-point weak spots and to know the places of losses. Having known the point of problem it becomes easy to take preventive steps. This provides the information for the purpose of managerial decision making.

Where standards have not been developed cost accountant has past figures with him and he compares present performance with that of past performance, and locates wastages and losses.

Financial or Accounting Ratio Analysis

Financial or accounting ratio may be defined as relating one accounting figure to another to provide better comparison. Different financial ratio are:

A) Activity Ratio

i) Inventory Turnover = $\frac{\cos t\ of\ material\ consumed}{Average\ inventory}$

ii) Average inventory period (months) = $\frac{Average\ inventory}{consumption\ per\ month.}$

B) Cost Ratio (per cent)

i) Employee expenses as percentage of production

ii) Fixed costs as percentage of production

iii) Variable costs as percentage of production.

C) Profitability Ratios (percentage)

i) Gross Operating Margin =

$$\frac{Gross\ \ operating\ \ profit\ \ before\ \ depreciation\ \ \text{int}erest\ and\ \ tax}{Turnover} \times 100$$

ii) Return on Equity

$$= \frac{Net\ \ profit\ after\ tax\ and\ \ preference\ \ dividend}{equity\ \ paid\ up\ and\ \ free\ \ reserves} \times 100$$

D) Return on investment (R.O. I)

$$\text{R.O.L} = \frac{Net\ \ profit}{Capital\ \ employed}$$

$$= \frac{Net\ \ profit}{turnover} \times \frac{Turnover}{Capital\ employed}$$

= Net profit ratio X capital turnover ratio

Uses of Financial Ratio Analysis

Financial rations provide useful indications to appraise financial health of a concern and overall efficiency of the project. Computation of rations often leads to a further enquiry into various aspects of project, and which enables to bring out some important facts, which ultimately helps in:

a) Planning: short, medium, and long range.
b) Diagnosis of financial ills or industrial sickness.
c) Decision marking of all types
d) Keeping a continuous watch on the financial trends and taking corrective actions well in advance.

Estimation of Cost of Project

In our country most of the large construction projects are financed and got executed by the government. For the purpose of sanction of the project a feasibility report is required to be

prepared to estimate the cost of the project and its gain (social as well as economical). To calculate the estimated cost of the project, all the factors like material cost, labour cost, costs related to the equipments as mentioned in earlier paragraphs, and other overheads should be considered very carefully. Since construction projects are generally executed by other construction agencies, their expected margin of profit should also be considered to have correct assessment of the likely cost of the project.

Bidding by the Construction Agencies

As stated earlier, after the approval of the project by the government and concerned organization the bid (tenders) will be floated for executing the project. The construction agencies (contractors) now calculate the cost of the project form their own assessment and add suitable profit and submit the bid for consideration and award of the contract. The chances for award of the contract mainly depend upon the correct assessment of the cost of the project and the value of the profit. The profit must cover for the risk involved, time value of money (effect of time on money), and income tax to be paid by the contractor. The value of the profit is decided after considering several factors, some of them are:

1. Competition in the market
2. Size of the project.
3. Facilities available like, mobilization advances, interval at which payments will be made to the contractor.
4. price escalation
5. Risk involved
6. Chances for utilizing the equipment after completion of the project.
7. Availability of raw material from open market or on control and its lead time.
8. Maintenance period after completion of the project.

2.7 REPLACEMENT OF EQUIPMENTS

The main reasons for the replacement of the equipment are:

a) Deterioration. It becomes necessary to replace the machine when it wears out and does not function properly. Such machines start lowering the quality of product, decreasing the production and increase in labour and maintenance costs.

b) Obsolescence. Whenever new equipment comes in the market, which is capable of producing more products of good quality with less labour and has more efficiency, the existing machine is to be replaced with this machine although it was functioning well. Generally this necessitated because the products manufactured by new machine will be cheaper.

c) Inadequacy. With the change of product design to meet the customers demand or quantity to be manufactured, old machinery becomes inadequate and, therefore, calls for different manufacturing equipment.

Equipment Replacement Policy

Equipment replacement decision plays an important role in the economic running of any concern. A firm has to face three types of replacement decisions.

a) The replacement of capital equipment, as it wears out.

b) The capital equipment required for expansion.

c) The replacement of old technology by the new (replacement of obsolete equipment)

Equipments are used to produce at profitable rate, so that the production can stand competition. Replacement decision is not an easy job, it requires several considerations. As it involves large capital investment, hence a wrong decision may adversely affect the profitability of whole concern. Therefore, a scientific approach to solve this problem is essential.

Sometimes a decision-maker has to face a very serious problem of replacing the equipment. This is a continuous process and, therefore, a set system for this must be evolved. The main consideration is “when” to replace, but this when requires many considerations to reach at suitable conclusion.

Large numbers of factors are responsible to replace the equipment before the expiry of the estimated life, namely:

i) To reduce production cost.
ii) To reduce fatigue.
iii) To raise quality
iv) To increase output
v) To secure greater convenience, safety and reliability.

Guidelines in Replacement Analysis

There are certain rules which may be used as guidelines for replacement analysis.

1. For equipment in use

Do consider:

i) Operating cost
ii) Repairs and maintenance cost.
iii) Down time cost.
iv) Salvage value
v) Rebuilding cost

Do not consider:

i. Original cost.
ii. Money already spent on repairs and maintenance
iii. Unrealistic book value

2. For new equipment

Do consider:

i. Initial cost
ii. Interest on capital investment.
iii. Salvage value at the end of useful life
iv. Cost advantage of improved product
v. Labour savings.

Do not consider:

i. Any savings not clearly assessable.

ii. Overhead charges

Almost all the equipments are subjected to deterioration and obsolescence in varying degree with the passage of time. Thus with the passage of time operating inferiority increases. Hence the old machine has this operating inferiority high and book value as low. While a new machine to be purchased will have operating as low. While a new machine to be purchased will have operating inferiority minimum and costs at a maximum. Hence the problem before manager is to choose between more capital cost and less imperfection on one hand, and less capital cost and imperfection on the other.

For estimating as to whether the proposed replacement is profitable, the 'adverse minimum' of the existing equipment and those of the proposed equipment are found and compared.

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