
9 Life Cycle Costing

9.1 INTRODUCTION

When a project is examined for implementation, many issues such as user benefits, environmental aspects, defense considerations, political necessities, financial considerations and economic considerations come up for consideration. However, since resources are scarce and are required to be expended judiciously, cost consideration becomes a significant element among these various issues. The approach towards arriving at the optimum cost has changed over the years. The traditional practice for financial evaluation of any project is to base the decision solely on the initial capital costs of different options with little regard to future operating and maintenance costs or replacement intervals. It is, however, increasingly being felt that the evaluation should be done on a suitable basis, which considers the long-term effects of different options. Life cycle costing (LCC – sometimes referred to as whole life costing: WLC), can fulfill this objective. The philosophy behind LCC is that not only the initial costs, but also all future operating and maintenance costs to be incurred during the subsequent life spans of the competing projects, are to be considered for evaluating the total costs. Thus, in an aggressive environment, a special corrosion-resistant painting system, which would initially cost more, but would last longer than normal painting system may prove to be more economic over a period of time if analyzed with LCC. Additionally, the life of the structure may be extended, thereby delaying heavy capital expenditure for replacement of the structure.

In this system, the future costs are brought together into a single value, often by applying the traditional present value concept on a base date corresponding to the initial costs. It is thus useful to evaluate trade-off situations, such as choosing between one asset and another or choosing a higher initial cost item to save future running costs.

9.2 KEY STAGES OF A PROJECT

Life cycle of a project is the time period between conception of an idea about an asset and its final disposal.

The key stages comprise:

- Conception of the idea;
- Strategic planning;
- Creation of the asset;
- Operation;
- Maintenance;
- Rehabilitation;
- Decommissioning;
- Disposal.

9.3 BASIC CONCEPT OF LIFE CYCLE COSTING

The philosophy behind LCC is that not only the initial costs of the asset but also the future costs incurred during the subsequent life span of the asset are put into a comparable form and brought together into a single value for the purpose of comparison with alternative solutions. Therefore, by applying LCC concept, a solution with a higher initial cost may be justified because of reduced future running costs compared to a solution with a lower initial cost, but with high running costs over the study period. Thus, the lowest initial cost of a project is not necessarily the lowest total cost, if we consider LCC. While calculating the future costs, the benefits or profits from the project need also to be taken into account. The method can be used for comparison of different solutions using different systems, different materials or different specifications. While analyzing, the future costs are brought together into a single value, often by applying the traditional 'present-value' concept on a base date corresponding to the initial costs. The present value can be calculated by the following formula:

$$PV = \frac{C}{(1+r)^t}$$

where

PV = present value

C = cost at current prices

r = selected discount rate per annum expressed in decimal

t = time in years when the future cost is incurred

As an example, if the discount rate is 12% and a sum of \$10,000 is required for maintenance after 5 years, the present value of the sum will be:

$$PV = \frac{10,000}{(1.12)^5} \text{ or about } \$5,675$$

The present values of all maintenance costs to be incurred at intervals of say 5 years up to a specific period (design life of the structure) can be calculated in a similar manner and added to the initial costs to give the net present value (NPV) of a particular system under consideration. Similar values of other options may also be calculated and the results compared for financial evaluation.

Apart from cost considerations, quality of the product or the service provided needs also to be considered while analyzing LCC. Meeting minimum quality standards is an obligatory requirement in all cases.

9.4 FUNDAMENTAL ISSUES

LCC thus involves the following issues:

- Initial costs;
- Future costs;

- Life of the structure;
- Discount rate.

9.4.1 INITIAL COSTS

Initial costs of a structure include costs for acquisition of land, planning, design, construction and testing. The cost of construction includes not only the costs incurred at site, but also the costs incurred in the workshops, transport costs, etc., which are incurred prior to site activities. It is the total of all costs, direct and indirect, in converting a design into a commissioned project ready for operation, i.e., the sum of all costs including labor, supervision, administration tools, raw materials, engineering, installation, commissioning, etc. Investment in a project is met by borrowed capital (thus incurring an interest charge) or by the promoter's own resources (thus foregoing potential interest income). Because of these issues, construction cost should take into account the time value of money in the form of interest on the capital invested for the duration of the project. Thus, a solution with long construction period would attract more interest resulting in higher costs.

9.4.2 FUTURE COSTS

Future costs may be either regularly recurring costs or costs which occur occasionally. These costs include the following:

- Annual maintenance costs*: these costs comprise regular preventive maintenance costs. The objective of annual maintenance is to carry out the activities so that an acceptable standard of service can be maintained. These include labor, material, equipment, testing costs, structural assessment and design costs incurred in carrying out inspection, preventive maintenance, including minor repair work.
- Special inspection and maintenance costs*: most structures need thorough inspection every 5–7 years. The costs include those for inspection and major repair or renewal work and upgrading as necessary.
- Renewal of deterioration protection system*: interval of renewal of deterioration protection system depends on the type of the system adopted as well as the environmental conditions. In case of steel structures, prevention of corrosion becomes a very important determinant. Costs involved in carrying out inspection maintenance are to be included under this head also.
- Operating costs*: these costs relate to most of the civil engineering structures such as public buildings, airports, marine structures, roads and railways. These include costs for lighting, security arrangement, safety provisions and similar expenses for operating the facilities.
- Disruption costs*: the costs due to disruption of the user's normal working during repair or maintenance work are considered as indirect costs by some authorities. This is quite logical as disruptions are bound to affect the user. Thus if a particular area in a factory premises is under repair, production gets disturbed and consequently the net profit of the unit is affected.

Similarly, if a toll road is closed to traffic, not only the earnings from tolls suffer, but also the diversion and consequent delay causes heavy loss to the user. Costs due to such delays need to be considered while assessing the operation costs of an asset.

- f. *Occasional costs*: there may be some costs which cannot be predicted at the initial stage of a project, e.g., repair of damage due to accidental impact on buildings, road side structures. There may also be costs for modified demands such as upgrading the runway of an airport or strengthening a structure for heavier loads. Another example of modified demand is widening of a road way or bridge structure to suit specific traffic requirement.
- g. *Costs for demolition*: structures that can no longer be used have to be removed. This operation may incur considerable costs. These will include costs for demolition at site, transportation and disposal of surplus materials. The proceeds obtained from sale of scrap material can offset a part of the costs of demolition.
- h. *Benefits*: these include all negative costs that accrue to the owner from the structure by way of rents, toll or similar earnings. These are to be credited as and where applicable.

9.4.3 LIFE OF THE STRUCTURE

For carrying out the costing over the life span of a structure, by implication, the end point of life needs to be defined. There are more ways than one in which this can be done.

Typically, a designer may assume certain specified life span for a structure depending on the material being used. Thus, life of a new structure may be assumed nominally to be 120 years. But long before that the structure may become functionally obsolete due to change in the technology used for the product for which the structure was initially constructed. Therefore, it may not be appropriate to consider the future costs over the full 120 years. On the other hand, from the investor's point of view, the life of a structure may be assumed to be the time to repay the investment. But actual serviceability of a structure is one matter and repayment of loan is another. In this case, it will also be inappropriate to take the time of repayment of the investment as the life span for computation of future costs. It is thus not easy to arrive at a fool-proof yardstick for assessing the service life of a structure. This would largely depend on the following parameters:

- Quality of material;
- Workmanship;
- Internal environment;
- External environment (including local environments);
- In-use conditions;
- Maintenance conditions.

These parameters may increase or decrease the expected (predicted) service life of a structure, depending on the effect of these parameters on the structure. However, there is need for adequate predictive models and historical data for initiating procedures for using the above parameters.

9.4.4 DISCOUNT RATE AND INFLATION

Discount rate is the rate at which future costs are discounted to the present. It reflects the investor's time value of money. In other words, it takes into account of the fact that money, if not consumed today and invested, grows to be worth more at a future date. Consequently, money received or paid at a future date is not as valuable as the equal amount received or paid today. Thus, discount rate is used to convert costs occurring at different time to equivalent costs at a common point of time. At the same time, it has also to consider that cost increases with the passage of time due to inflation. Inflation is the general reduction in the purchasing power of money from year to year. LCC analysis can be calculated in two ways, viz., including or excluding the effects of inflation. In either case, a consistent system should be adopted throughout the LCC analysis.

Calculation of discount rate, though apparently simple, depends on several uncertain parameters such as inflation, policy of the government and interest rate on borrowings. It is thus not very easy to predict the rate with certainty. However, for comparing different competing solutions, the same discount rate can be adopted for each solution to give sufficiently accurate result for ranking purpose.

9.5 LIMITATIONS

In LCC computation, the parameters that control the results (costs, life of the structure and discount rate) are only assumed values and are, therefore, uncertain. Thus, if these parameters vary, the result will also vary. In order to assess the effects of the variations of the parameters, it is necessary to carry out a number of computations by varying the parameter(s) and arriving at a set of present-value costs. Final selection of the choice is made by sound engineering judgment and other decision criteria.

In the area of maintenance of an asset, LCC approach can be applied both for future assets and for those which are already in existence. However, some perceived difficulties come in the way of practical application of this system in general. Some of these are as follows:

- Useful life of an asset cannot be forecast accurately, particularly when functional, technological or social obsolescence may reach first;
- It is also difficult to forecast the future economic scenario which primarily affects the discount rate;
- It is not easy to predict costs over a long period. Consequently, the future maintenance costs appear to be 'idealistic' as against capital costs which are regarded as 'real';
- As it is, resources are scarce. This position imposes natural restrictions on the initial capital expenditure of any project. Therefore, it becomes more difficult to allow extra expenditure towards superior specifications for uncertain future gains by way of lower operating/maintenance costs.

The above difficulties may be real, but are so only varying degrees. No doubt, there are some uncertainties in the parameters used in the method and a certain amount

of inaccuracy may creep into the estimates of future costs. However, this should not deter us from using the technique. The results will at least give an idea about the impact of future expenses even if these may not be absolutely correct.

For structures with long lives, the difficulties may perhaps be significant. However, the method is considered more useful for formulating short-term strategies for maintenance, repair and replacement of different elements in buildings and other structures. In such a case, values to be assigned to the different parameters like life expectancy, discount rate and costs can be realistic and the results are likely to be more accurate. Also, because the same parameters are used for different competing solutions, the results can be effectively utilized for comparison purpose.

From the point of view of future costs, one aspect regarding life cycle needs particular consideration. Life expectancy of a structure as a whole may be different from the life expectancy of its individual components. In a factory shed, the life of the structure and that of the cladding will be different. Similarly, in a steel structure, life of paint is much less than that of the steelwork. There may be many more examples like these such as a lift in a building or wearing course in a roadway bridge. Therefore, in order that the life of components can be forecast with fair accuracy, there is need to build up a database indicating life cycles and other relevant information for the critical elements of a structure. Maintenance strategies can be formulated on the basis of the available data by using LCC method.

One impediment for correctly assessing future costs, even for a short time frame, is that while the designer in the project office has all inputs for estimating the initial capital costs, very often, the maintenance costs are not readily available with him, since these are normally maintained by the operation department. There is thus a need to bridge the gap of communication and information exchange between these two units so that a database of historical costs may be set up. This would certainly enhance the reliability of LCC.

9.6 APPLICATIONS OF LCC

Despite certain perceived difficulties, LCC analysis has immense potential in formulating strategies for evaluating different engineering projects. The method brings to focus the fact that future operating and maintenance costs need to be studied and given due importance during the initial design stage itself. Some of the applications of LCC are outlined in the following paragraphs.

9.6.1 COMPARING COSTS OF ALTERNATIVE SCHEMES

The costs between alternative schemes can be evaluated by LCC concept taking into consideration future costs and benefits. Thus in an aggressive environment, a special corrosion-resistant painting system which would initially cost more, but would last longer than normal painting system on a steel structure may prove to be more economical over a period of time if analyzed with LCC. Additionally, the life of the structure may be extended, thereby delaying heavy capital expenditure for replacement of the structure.

9.6.2 CHOICE BETWEEN REHABILITATION AND REPLACEMENT

The decision whether to repair just some parts and thereby rehabilitate a structure or to replace the entire structure can be analyzed by LCC. For this purpose, it is necessary first to inspect the structure and evaluate its present condition. If necessary, a rehabilitation scheme has to be designed. The estimated cost of rehabilitation plus future costs with appropriate discounting will have to be compared with the initial cost of the new structure plus discounted future costs before making a suitable decision.

9.6.3 PRIORITIZING OF RESOURCES

Resources are scarce, and it is imperative that these should be used with utmost care. There is thus a compulsive need for prioritizing the allocation of resources for maintenance, rehabilitation and replacement of existing assets. In planning these actions, LCC system can be effectively applied.

9.6.4 BALANCING INITIAL AND FUTURE COSTS

The comparatively recent trend of privatization of infrastructure, particularly in the road development work, has created a new opportunity for the application of LCC concept. Depending on the period of operation after which the project has to be handed over to the authorities, the entrepreneur would like the designer to adopt a solution with comparatively less expensive construction techniques and materials to keep the initial costs low, which may tend to increase the future maintenance costs. The reason is obvious. The initial construction cost has to be financed by the entrepreneur from borrowings carrying high interest rate. It would therefore be expedient for him to keep the cost as low as possible. The higher future costs would be substantially offset by earnings from tolls, advertisements and other such benefits. In such cases, LCC concept can provide useful data for balancing the different options available to the entrepreneur.

9.6.5 IMPROVING PRODUCTIVITY IN THE WORKPLACE

It may be useful to extend the LCC concept to include indirect costs (or benefits) of solutions such as improving internal environment (air conditioning, ventilating, heating, etc.), which will increase the productivity (benefit) of the user over a period.

9.7 STAGES FOR LCC ASSESSMENT

Generally, LCC assessment comprises the following stages:

1. Identification of the target, alternative solutions and constraints for the alternatives;
2. Establishment of the basic assumptions for LCC analysis;
3. Selection of appropriate discount rate and computation of present value of all initial and future costs;

4. Defining the expected life of the asset;
5. Computation of LCC for each alternative solution;
6. Comparison of results and determination of the one with minimum LCC.

9.8 CONCLUDING REMARKS

In spite of its limitations, LCC method has its utilities also. It addresses the future costs in proper perspective and allows for an informed and rational way of comparing alternative solutions over the predicted life of an asset. It gives the designers an awareness of the future consequences of their present actions. It also highlights the importance of good workmanship in workplace in order to reduce the future maintenance costs. For achieving high-quality workmanship, it may be expedient to introduce quality assurance plan (QAP) in the process. LCC method can thus be used as a worthwhile qualitative tool for decision making. However, to make it more effective, the engineer needs reliable inputs such as databases of maintenance costs and service lives as well as appropriate discount rates.

LCC should not be considered as an exact science. It is only an indicative method for studying future costs and giving these costs appropriate weightage in the initial stage of a project.

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