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Review on Life Cycle Cost Analysis for a Bridge Rehabilitation Project

Aishwarya D. Khedekar[1], B. A. Konnur[2]

[1]P.G. Student, Department of Engineering, Government College of Engineering, Karad, Maharashtra, India
[2]Professor, Department of Engineering, Government College of Engineering, Karad, Maharashtra, India

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Abstract - *Performance of function, cost, safety and reliability are four important requirements, a structure has to satisfy. Construction industry is only aim at aesthetic design of structure and its functional goal to fulfil the client's expectation. Clients also look at the initial construction cost. Instead of considering construction cost of structure, owners have to include entire cost of a structure over its expected life. There is need to consider all components of cost which include initial cost of construction, operation, maintenance, repair, replacement and disposal cost. Because sometime operation, repair, replacement and disposal cost can be more than the initial cost of a project. Life cycle cost analysis (LCC analysis) is the method of analysis which considers all these types of cost for economic analysis of a construction project. Typical LCC analysis are based on: Construction cost, Operational costs including utility costs such as energy and water use, Maintenance costs including all costs of replacement, maintenance and repair, removal, recycling or refurbishment and decommissioning.*

Key Words: Life Cycle Cost(LCC), Life Cycle Cost Analysis(LCCA), Bridge Rehabilitation, Net Present Value Method…..

1. INTRODUCTION

LCC analysis is calculate the all costs of project alternatives and to select the option that will provide the lowest complete cost of ownership along with its quality and function. The Life cycle cost analysis should be done initially in the design process so there will be still a chance to make changes to the design to ensure a reduction in life-cycle cost of construction project.

The LCC analysis a method of calculating whole cost of a structure over its whole expected life along with operational and maintenance cost. Life cycle cost can be improved by adopting alternative techniques without much changes in the structure. Life cycle cost effectiveness can be calculated at different stages of entire span of the life of structure. This is also helpful in taking financial decisions for decision makers with the financial information necessary for maintaining, improving, and constructing facilities. Financial benefits relating with the usage of energy are also calculated by life cycle cost analysis.

1.1 Definition Life Cycle Cost Analysis

Life-Cycle Costing (LCC) is a methodology that is used in determining or estimating the total cost of ownership of any product, structure or system, which is developed or procured off the self, over its useful life. The LCC caters to the strategic aspect of project management also because the enterprise deciding process where the operational costs of a product or systems, if considered, based on the long-term consequences at the outset before kick starting a project or acquisition of a product or system, make a considerable impact upon the validity of the important decisions. The life cycle cost analysis for cost accounting purposes so much important. It can help in deciding to produce or purchase a product or service. A timetable of life cycle costs helps show what costs need to be allocated to a product or service so that an organization can plan to invest and find ways to recover its costs. If all the costs cannot be recovered then it may not be a wise decision to produce the product or service.

2. LITERATURE REVIEW

S. R. Mahajan, S. V. Pataskar and N. S. Jain(1) have study that residential buildings have based on estimates of the initial construction cost, with little or no consideration for costs relating to operation and maintenance are calculated. Comparative Life Cycle Cost analysis (LCCA) was carried on a building with normal building and building with energy use.

C. Hema(2) has discussed the advantages for construction company and construction workers when green techniques are included in a project. Life cycle cost analysis (LCC) was carried out on buildings with green technology used and green technology not used.

Nilima N. Kale, Deepa Joshi and Radhika Menon(3) have considered the three buildings for a life cycle cost analysis. LCCA has been calculated with recent position and with energy efficient approach (EEA) using NPV method for building. A panel of solar which has minimum capacity and solar panel with desired capacity as per the requirements of the building has been advised. The comparison of LCC of existing structure with proposed solar panel system shows that 5% of cost can be reduced in case of minimum capacity solar panel and 55% cost can be lowered for capacity solar panel system, along with other added advantages of solar energy.

Saurabh V. Birajdari, Sunil S. Pimplikar(4) have mainly focused on, with the economic development, energy consumption is increasingly serious, land resources becoming scarcer and scarcer. Resource shortage problem is can be solved by sustainable building; however, because of higher cost development rate of green buildings is low, compared with conventional buildings. Based on LCCA construction cost of sustainable building and traditional building is analyzed. The key factors that affect the cost are determined by considering the cashflow. The finding from this research is construction technology, building materials prices and local conditions are factors which affect cost of green building.

Arash Noshadravan, Travis R. Miller and Jeremy G. Gregory(5) have discussed that at the time of financial decision in construction projects decision maker always think in the short term. In a high construction projects more importance is given to the initial costs, with less attention to future cost. In order to consider long term decision making life cycle cost analysis is important. Purpose of life cycle cost analysis is to calculate cost of project for any number of years. In this study various economic evaluation methods to calculate life cycle cost (LCC) of building has been discussed and comparison of these methods has been carried out.

Daniel Maceka, Vaclav Snizekb(6) have mainly focused on economical construction of civil engineering works - bridges. Due to the estimated service life (100 years), significant operating costs are incurred related to the unkeep and renovation of individual structural elements, bridges have high investment costs. Latest innovations in modelling the life cycle costs of bridges built last year are summarized in this paper. Individual structural elements replacement cycle revaluation, which is predicted relies on the newest technical knowledge resulting from real conditions of serviced bridges.

N. Kale and A. Joshi(7) discussed that decision maker tempting to think in the short term while taking the financial decision for construction projects. Future costs have given less attention than the upfront cost in high construction project. In this study various economic evaluation methods to calculate life cycle cost (LCC) of building has been discussed and comparison of these methods has been carried out. The study shows that NPV method is more appropriate.

Satish Chandra(8) has described methodology of life cycle cost analysis (LCCA) ,gives the best economic design for both structural integrity and durability, comparison of alternative design alternatives, comparison of alternative strategies, identification of cost effective improvement, Project's budget cum economic viability assessment and future long run financial planning. With the age of the bridge structure structural deterioration increases attributable to concrete spalling, rebar rusting, corrosion, fatigue, wear and tear and other methods of other things deterioration. In future traffic volume, vehicles number and legal load limits increases with time. The structural capability of bridges reduced when old bridges are subjective to excessive loads. That's why LCCA is used.

3. LIFE CYCLE COST ANALYSIS

For predicting and assessing the cost performance of the assets, LCC proved as a valuable technique. To quantify the life cycle cost for input into a decision making or evaluation process is a purpose of LCC. For different purposes like procurement of equipments, health, education and welfare department; assessments of the buildings, military purposes, LCC is getting while very long time. Different costs involved in the total life span of an asset such as construction cost, operation and maintenance costs, electricity cost, equipment replacement costs and disposal cost are include in LCCA. Initial capital costs, life of the asset, the discount rate, analysis period, operation and maintenance costs, disposal cost, information and feedback these are the elements of a LCCA. To calculate costs of whole building its systems and components and materials LCCA applied. Operation and maintenance costs associated with an item are future costs, before adding them to the item's acquisition or procurement cost for LCCA they have to be discounted to their present value. Over the years, various formulas have been developed in the area of economics for converting money from one point of time to another. Below are the steps include in life cycle costing methodology:

Step-1: Determine the objectives of life cycle cost analysis.

Step-2: Literature review and problem statements.

Step-3: The method used for Life cycle cost analysis is Net Present Value method.

Step-4: Collection of all necessary data required of a bridge rehabilitation project.

Step-5: Apply the data collected to the selected methods.

Step-6: Calculating total life cycle cost.

Step-7: Formulating the life cycle cost analysis results. Formula for Life Cycle Costing is as following

Life Cycle Costing (LCC) = C+R+A+M+E-S

Where,

C= Initial cost.

R=Present value of replacement cost.

A=Present value of annual operation, maintenance and repair cost.

M=Present value of non-annual operation, maintenance and repair cost.

E =Present value of energy costs.

S =Present residual value or salvage value.

3.1 Terminologies used for LCCA

Following are the terminologies used while calculating LCC of a Structure.

Initial cost: This cost includes land acquisition cost, design cost and construction cost.

Operation Cost: This cost includes cost required for annual building utilities and services excluding maintenance and repair cost involved in the operations of facility.

Maintenance cost: This cost includes cost required for the maintenance of water pump, maintenance of passenger lift, annual roof inspection etc.

Repair costs: This cost includes cost required to extend the building life without replacing the system entirely

Replacement costs: This cost required to Replacement of entire component.

Residual Value: This value is the value of the building at the end of the study period or at the life cycle period.

Energy costs: This cost includes expenses for energy and other utilities.

3.2 The Economic Evaluation Methods for LCC

Life cycle cost analysis can be done by six economic evaluation methods. These are as follows:

Simple payback (SPP) method

Discounted payback (DPP) method

Net present value (NPV) method

Equivalent annual cost (EAC) method

Internal rate of return (IRR) method

3.3 Comparative Study of Various Economic Evaluation Methods for LCC

Life cycle cost analysis can be done by many economic evaluation methods such as Simple payback (SPP) method Discounted payback (DPP) method, Net present value (NPV) method, Equivalent annual cost method Internal rate of return method, Net saving (NS) method. The payback period method is not suitable for economic evaluation because there are some weakness that are payback method doesn't take into account inflation and the cost of capital, it ignore time value money, it does not consider the cash flow after payback period. In discounted payback it does not consider cash flow after payback period. NPV considers all the cash flows till the end of the life and considers time value of money. Internal rate of return ignores dollar value of the project and does not understand economies of scales. Two projects with same IRR it cannot differentiate but huge difference between dollar returns. On the other hand, NPV gives absolute terms and therefore this point are not ignored. IRR consider cash flows of discounting and reinvestment at same rate. If the IRR of a very good project is say 45%, it is practically not possible to invest money at this rate in the market. Whereas, NPV assumes a rate of borrowing and lending near to the market rates. IRR enters the problem of multiple IRR when we have negative net cash flow more than one and the equation is then satisfied with two values therefore have multiple IRRs. With NPV such problems does not exist. IRR is measured in terms of expected percentage return and NPV measured in terms of currency. After comparison of NPV and IRR, it can be seen that in long term projects, NPV better than IRR. Not only because NPV considers different discount rates and takes into account the cost of capital. Equivalent annual cost gives an average number. It does not show the actual cost during each year of the LCC. If the investment generates an income, net saving can be used. Therefore most of time NPV method is used for LCCA. But if the alternatives have different life length then NPV cannot be used.

4. CONCLUSION

It is found that many researchers have done research on life cycle cost analysis for various construction projects. Literature is available on LCC analysis of buildings, bridges and other civil engineering structures. However little study is carried out on LCC analysis of rehabilitation projects. It is observed that there is scope to provide best rehabilitation alternative which will be cost effective by carrying out LCC of rehabilitation of bridge project.

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