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LIFE CYCLE COST ANALYSIS OF RIGID AND FLEXIBLE PAVEMENTS

[1]Pooja B. Kale, [2]Prof. M.C. Aher , [3]Prof.P.D.Aher

1Pg Student,2 Assistant Professor Ndmvp' s Kbtcoe,Nashik,(India)
3. Assistant Professor Ndmvp's Kbtcoe, Nashik, (India)

ABSTRACT

Life cycle costing is the process of identifying and documenting all the costs involved over the life of an asset.The cost of road construction consists of design expenses, material extraction, construction equipment, maintenance and rehabilitation strategies, and operations over the entire service life. An economic analysis process known as Life-Cycle Cost Analysis (LCCA) issued to evaluate the cost-efficiency of alternatives based on the Net Present Value (NPV) concept. It is essential to evaluate the above mentioned cost aspects in order to obtain optimum pavement life-cycle costs. However, pavement managers are often unable to consider each important element that may be required for performing future maintenance tasks. Over the last few decades, several approaches have been developed by agencies and institutions for pavement Life-Cycle Cost Analysis (LCCA). While the transportation community has increasingly been utilising LCCA as an essential practice, several organisations have even designed computer programs for their LCCA approaches in order to assist with the analysis. Current LCCA methods are analysed and LCCA software is introduced in this article. Subsequently, a list of economic indicators is provided along with their substantial components. Collecting previous literature will help highlight and study the weakest aspects so as to mitigate the shortcomings of existing LCCA methods and processes. LCCA research will become more robust if improvements are made, facilitating private industries and government agencies to accomplish their economic aims. I have done a literature study on various papers related to life cycle co is costing. The data is collected related to the case study of life cycle costing of roads and one work on have done an analytical work on life cycle costing of rigid and flexible pavement of JNPT –Package IV.

Keywords : LCC, LCCA, NPV

I. INTRODUCTION

Construction of infrastructure does not only mean large capital investments but also future costs to operate and maintain these assets. Decision making in planning and design of roads will impact the need of future operation and maintenance activities Road authorities of all around the world are finding and innovating ways to cope with the high cost of road network maintenance, the increasing demands of road users and the changing traffic type and volume. The road network plays a vital role in contributing to the economic, social, cultural and environmental development of the country. A well-maintained road is needed to make the network sustainable for future generations. Improving road maintenance management has become a key factor in developing nations like India. Life cycle costing is a methodology that takes into account costs throughout an asset's life cycle including investment, operation, maintenance and disposal**.** Life cycle costing of existing road is becoming more significant to determine the proper time of maintenance and the proper action, which should be taken for maintenance. An efficient maintenance policy is essential for a cost-effective, comfortable and safe transportation system. But, the decision to maintain the road facilities, consider a number of possible ways from routine maintenance action to reconstruction of the road network. Moreover, an economic analysis of a road network is dependent upon a number of factors, which are responsible for deciding road serviceability level.

For effective implementation of life cycle costing in road planning, design and management, different considerations need to be understood. In this thesis the application of life cycle costing has been studied through case study research.

II. LITERATURE SURVEY

Adamany, H. G. and F. A. J. Gonsalves (1) describes to Life cycle management (LCM) has been developed to make life cycle costing a reality. It combines advanced cost management techniques, new performance measures, and the portfolio concept of investments. The goal is to provide more useful information about an investment throughout its life. Ali Azhar Bhutt (2) has describes Life cycle assessment of asphalt roads .Transport infrastructures such as roads are assets for the society as they not only ensure mobility but also strengthen society's economy. Considerable amount of energy and materials, that include bitumen, aggregates and asphalt, are required to build and maintain roads Dan M. Frangopol, Fellow, Kai-Yung Lin, and Allen C. Estes(3) has studied Life-cycle cost design of deteriorating structure .A lifetime optimization methodology for planning the inspection and repair of structures that deteriorate over time is introduced and illustrated through numerical examples. The optimization is based on minimizing the expected total life-cycle cost while maintaining an allowable lifetime reliability for the structure Dayong Wu,Changwei Yuan &HongchaoLiu (4) has studied A risk-based optimisation for pavement preventative maintenance with probabilistic LCCA: a Chinese case .Compared to major structural repair or even replacement, preventative preservation of in-service pavements has been more popular in engineering practices, but recently, pavement preventative maintenance (PPM) has become more complex in China as the competition for pavement preservation funds has grown and the need to justify decisions has increased. Donald P. Coffeltand Chris T. Hendrickson (5) have done Life-Cycle Costs of Commercial Roof Systems .The roofing industry in the United States generates annual revenues in excess of $23 billion. This represents a significant annual investment in infrastructure maintenance cost and the opportunity cost of these resources can significantly detract from an owner's ability to invest in other areas. Erika Levander, JuttaSchade and Lars Stehn (6) have done a work on Life cycle costing for buildings: theory and suitability for addressing uncertainties about timber housing .Most commonly, production cost is the main cost factor in construction and is often set to the minimum, which does not necessarily improve the lifetime performance of buildings. However, a higher production cost might decrease the total life cycle cost (LCC).

III. METHODOLOGY

3.1 Problem Statement

Procurers to end user generally wish to lower the cost and increase the profit. Hence the main problem arising in minimizing the expected total life cycle cost considering with all cost associated with life of road. Main drawback at time of choosing alternative is that considering only initial price with little or no consideration of operation, maintenance cost and energy cost. To overcome this we have to calculate LCC at base date considering time value of money and investing most cost efficient solution to the road at initial stage. This analysis will help us to reduce LCC of structure and gives better saving through the life of road

3.1.1 LCC applied on roads -Estimating Total Life-Cycle Cost

Total life-cycle cost combines estimated initial costs and the future maintenance and rehabilitation costs for each alternative. The inputs used for evaluating the total life-cycle cost.

The required inputs include:

General inputs.

1. Analysis period.
2. Discount rate.
3. Site description/dimensions.

All pavement types.

1. Unit costs.
2. Initial pavement layer thickness.
3. Maintenance and rehabilitation plan and quantities

-Net present value

Life cycle costing depends upon prediction of expenditure and income and determining expenditure in terms of net present value at the start of the project.

$$\mathbf{NPV = A + \sum Fn \frac{1}{(1+i)^n}}$$

where, A= cost of construction spent on the project at year 0;

Fn= maintenance cost in the n year;

i= discount rate;

n= number of years in the future

-After collecting all this cost data, By using Net Present Value method all cost are discounted to base date.

-Summing up all discounted cost to get total life cycle cost

3.2 Methods of Calculating Life Cycle Costing

3.2.1 Simple Payback

Calculates the time required to return the initial investment. The investment with the shortest payback time is the most profitable one.

1. Advantage: Quick and easy calculation. Result easy to interpret
2. Disadvantage: Does not take inflation, interest or cash flow into account
3. Usable for: Rough estimation to see if the investment is profitable.

3.2.2 Discount Payback Method

Basically the same as the simple payback method, it just takes the time value into account

1. Advantages: Takes the time value of money into account
2. Disadvantages: Ignores all cash flow outside the payback period
3. Usable for: Should only be used as a screening device, not as a decision advice

3.2.3 Net Present Value Method

NPV is the result of the application of discount factors, based on a required rate of return to each years projected cash flow, both in and out, so that the cash flows are discounted to present value. In general, if the NPV is positive it is worthwhile investing (Smullen and Hand, 2005). But as the focus in LCC is on cost rather than on income, the usual practice is to treat cost as positive and income as negative. Consequently, the best choice between two competing alternatives is the one with minimum NPV

1. Advantages: Takes the time value of money into account. Generates the return equal to the market rate of interest. It uses all available data.
2. Disadvantage: Not usable when the comparing alternatives have different life lengths. Not easy to interpret
3. Usable for: Most LCC models utilize the NPV method

3.2.4 Internal Rate of Return

The IRR is a discounted cash flow criterion which determines an average rate of return by reference to the condition that the values be reduced to zero at the initial point of time. It is possible to calculate the test discount rate that will generate an NPV of zero. The alternative with the highest IRR is the best alternative (ISO, 2004).

1. Advantages: Result get presented in percent which gives an obvious interpretation
2. Disadvantages: Calculations need a trial and error procedure. IRR can only be calculated if the investments will generate an income
3. Used for: Can only be used if the investments will generate an income, which is not always the case in the construction industry.

3.2.5 Net Saving

The NS is calculated as the difference between the present worth of the income generated by an investment and the amounted invested. The alternative with the highest net saving is the best

1. Advantages: Easily understood investment appraisal technique
2. Disadvantages: NS can only be used if the investment generates an income
3. Used for: Can be used to compare investment options (ISO, 2004). But only if the investment generates an income

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IV. LIFE CYCLE COSTING

4.1 Life Cycle Costing

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. Unlike the project costing that ceases when the system or product becomes operational, the LCC continues till the product or the system is useful.

The LCC caters to the strategic aspect of project management as well as the enterprise decision making 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 is a very important aspect for cost accounting purposes. 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

4.2 Purpose

Life Cycle Costing (LCC) is an important economic analysis used in the selection of alternatives that impact both pending and future costs. It compares initial investment options and identifies the least cost alternatives for a twenty year period. As applied to building design energy conservation measures, the process is mandated by law and is defined in the Code of Federal Regulations (CFR), Title 10, Part 436, Sub part A: Program Rules of the Federal Energy Management Program.

The A/E shall contact local utility companies to determine available demand-side management programs and no cost assistance provided by these companies to designers and owners.

4.3applications

Basic applications of LCC are addressed within the individual chapters herein and may be further defined within an A-E's design programming scope requirements. In general, LCC is expected to support selection of all building systems that impact energy use: thermal envelope, passive solar features, fenestration, HVAC, domestic hot water, building automation and lighting. However, LCC can also be applied to building features or involve costs related to occupant productivity, system maintenance, environmental impact and any other issue that impacts costs over time. It is very important to recognize the significance of integrated building systems design in the overall efficiency of the design.

4.4 Procedures and Approach

-The most effective approach to LCC is to appropriately integrate it into the design process.

-The building design evolves from general concepts to detailed analysis. LCC needs to follow the same approach paralleling the focus to the current level of detail study.

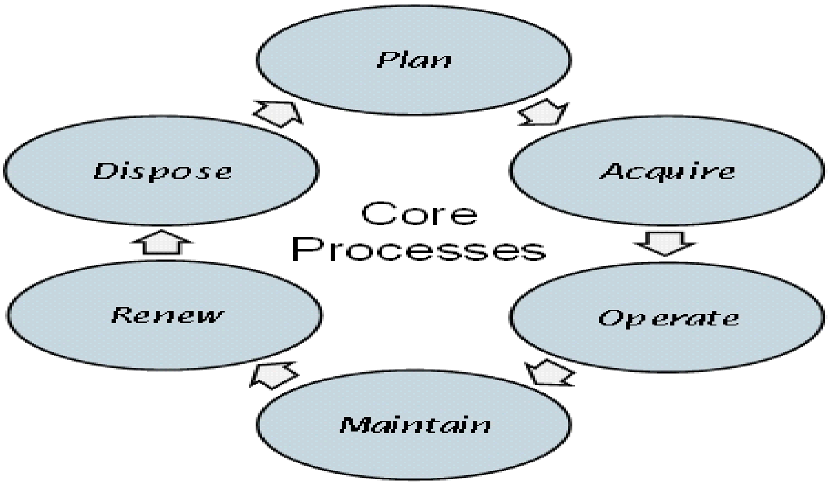
-It is extremely important for the effective development of the project that commitments are made and retained on the building systems, in a general sense, during the Conceptual Phase.

-The building systems should be analyzed for appropriateness during the first stages of the Design Development Phase. A commitment on direction for the systems needs to be made at this time, and any further LCC studies focused on detail within each system.

4.5 Life Cycle Costing Methodology Used For This Tool

1. The life cycle of an asset is defined as the time interval between the initial planning for the creation of an asset and its final disposal. This life cycle is characterized by a number of key stages:
2. Initial concept definition;
3. Development of the detailed design requirements, specifications and documentation;
4. Construction, manufacture or purchase;
5. Warranty period and early stages of usage or occupation;
6. Prime period of usage and functional support, including operational and maintenance costs, with the associated series of upgrades and renewal;
7. The disposal and cleanup at the end of the asset's useful life.

Figure 2 → Life Cycle of an Asset



As shown in Figure 2, there are day-to-day, periodic and strategic activities that may occur for any asset. The asset life cycle begins with strategic planning, creation of the asset, operations, maintenance, rehabilitation, and on through decommissioning and disposal at the end of the assets life.

The life of an asset will be influenced by its ability to continue to provide a required level of service. Many assets reach the end of their effective life before they become non-functional (regulations change, the asset becomes non-economic, the expected level of service increases, capacity requirements exceed design capability). Technological developments and changes in user requirements are key factors impacting the effective life of an asset.

4.6 Estimating Life Cycle Costs

The life cycle cost of an asset can be expressed by the simple formula:

Life Cycle Cost = initial (projected) capital costs + projected life-time operating costs + projected life-time maintenance costs + projected capital rehabilitation costs + projected disposal costs - projected residual value.

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4.7 Impact of Analysis Timing on Minimizing Life Cycle Costs

A major portion of projected life cycle costs stems from the consequences of decisions made during the early phases of asset planning and conceptual design. It is the early decisions made during the design of an asset, definition of operations and maintenance requirements, and setting of the operating context of the asset that commit a large percentage of the life cycle costs for that asset.

4.8 Advantages of Life Cycle Costing

(i) It results in earlier actions to generate revenue.

(ii) It encourages companies to find a balance between costs and expenses.

(iii) When you depreciate your small-business assets, you can spread the cost of those assets over their full life cycle.

4.9 Disadvantages of life cycle costing:

(i) Expenses of an asset are spread over years, it takes longer to turn a profit

(ii) LCC is time consuming.

(iii) LCC is an expensive concept, not appropriate for all applications.

(iv) The accuracy of data is often doubtful.

4.10 Life Cycle Cost Analysis

LCCA is a process of evaluating the economic performance of a building over its entire life. Sometimes known as "whole cost accounting" or "total cost of ownership," LCCA balances initial monetary investment with the long-term expense of owning and operating the building. LCCA is based upon the assumptions that multiple building design options can meet programmatic needs and achieve acceptable performance, and that these options have differing initial costs, operating costs, maintenance costs, and possibly different life cycles. For a given design, LCCA estimates the total cost of the resulting building, from initial construction through operation and maintenance, for some portion of the life of the building (generally referred to as the LCCA "study life"). By comparing the life cycle costs of various design configurations, LCCA can explore trade-offs between low initial costs and long-term cost savings, identify the most cost-effective system for a given use, and determine how long it will take for a specific system to "pay back" its incremental cost. Because creating an exhaustive life cycle cost estimate for every potential design element of a building would not be practical, the Guidelines for LCCA focus on features and systems most likely to impact long-term costs.

4.11 Advantages of LCCA

(i) LCC analysis is a management tool used to select the best project among several alternatives.

(ii) LCC analysis is used to evaluate a specific project by doing trade off studies between initial investment cost and future operating costs to minimize total costs during a project's life cycle.

(iii) The additional analysis required to estimate life cycle operating costs yields insight into reducing initial investments costs and insight into designing equipment to minimize operating costs.

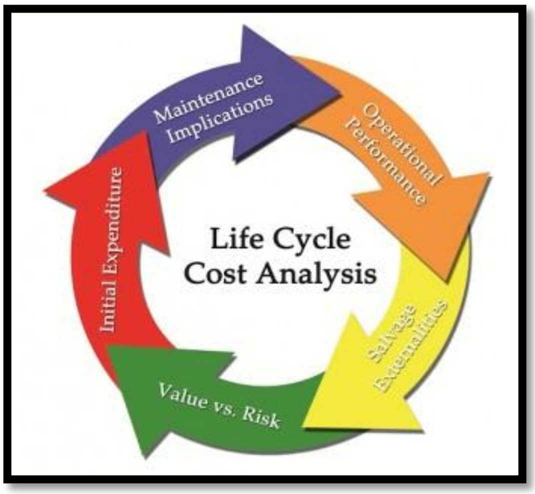

Fig 1. Life Cycle Cost Analysis

4.11 Disadvantages of LCCA

(i) If the estimated project life is too long, which often happens due to new technology, replacing obsolete technology, then more is probably invested in the original project than it is justified.

(ii) LCC is developing a model to decribe the operating costs over a project life time.

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