International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

A STUDY ON LIFE CYCLE COST ANALYSIS FOR ROADS

Kashmira Rasane[1], Harshita Ambre[2]

[1]Student M.Tech Construction Management, Department of Civil Engineering, Sandip University, Nashik
[2]Assistant Professor, Department of Civil Engineering, Sandip University, Nashik

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Abstract - *Life-cycle cost analysis (LCCA) is an essential component of modern roadway infrastructure design and system selection. LCCA embraces maintenance and rehabilitation costs, not just initial construction costs when evaluating pavement alternatives. This paper presents a study on LCCA of roads and also throws light on the previous literature work. The scope of life cycle costing varies considerably and therefore the results are sensitive to the defined system boundaries. Road user costs related to road works becomes a relevant parameter in life cycle cost analysis of pavements for choosing optimal alternative. Future rehabilitation costs were reduced. The optimal alternative would result in higher future costs if it was not optimized. Life cycle costing is a methodology that gives project managers a decision support tool to select. To determine the managerial consequences of this increase in operation and maintenance costs, these costs need to be assessed in an asset management perspective. Environmental excellence can be achieved through reduction in environment pollution as mentioned earlier. The quality remains the same. The development of a life-cycle cost tool allows for the examination of various design options to determine which pavement type is the most cost +effective over the total life-cycle of the pavement.*

Key Words: Life Cycle Cost Analysis, Road Construction, Highway Construction.

1. INTRODUCTION

The Organization for Economic Co-Operation and Development (OECD) defines a road as "a line of communication (travelled way) using a stabilized base other than rails or air strips open to public traffic, primarily for the use of road motor vehicles running on their own wheels", which includes "bridges, tunnels, supporting structures, junctions, crossings, interchanges, and toll roads, but not cycle paths". Roads provide one of the most significant functions of infrastructures, and they play a key role in the development of the society all around the world. Despite being a crucial part of national economies, modern road network systems require a high level of national investments. In order to keep the quality of the roads at an acceptable level, a large amount of investments for rehabilitation and maintenance activities are necessary in addition to investments in new and reconstructed roads. India has the one of largest road network across the world, spanning over a total of 5.5 million km. This road network transports 64.5 per cent of all goods in the country and 90 per cent of India's total passenger traffic uses road network to commute. Road transportation has gradually increased over the years with the improvement in connectivity between cities, towns and villages in the country.

1.1 CASE STUDY

The case study which I studied is of the highway, Ghoti Sinnar Highway, Behind SMBT College, Ghoti khurd, Igatpuri, Maharashtra 422403. The Sinnar-Ghoti bypass road is 53 km, while the Ghoti-Nashik-Sinnar route is 63 km in length. The patch that is being considered for this case study is of 26 km. The Sinnar Ghoti road passing through the country side through the hills is a good stretch providing a good alternative for cars and heavy traffic moving towards Sinnar, Pune, Shirdi and Aurangabad till Nagpur. The countryside area has a very heavy rainfall every year. As the road is a short route, it bares heavy traffic as it connects Shirdi and Mumbai. It is one of the important roads as it connects religious place to the metro city. As the road stretch through is Nashik is a long route people prefer Ghoti Sinner highway as it is a short route. Due to heavy rainfall and heavy traffic the first patch of 10km needs to be repaired.

1.2 ROAD CONSTRUCTION

India has a road network of over 5,903,293 kilometers (3,668,136 mi) as of 31 January 2019, the second largest road network in the world. At 1.70 km of roads per square kilometer of land, the quantitative density of India's road network is higher than that of Japan (0.91) and the United States (0.989888) to, and far higher than that of China (0.46), Brazil (0.18) or Russia (0.08). Adjusted for its large population, India has approximately 4.63 km of roads per 1000 people. However, qualitatively India's roads are a mix of modern highways and narrow, unpaved roads, and are being improved. As on 31 March 2016, 62.5% of Indian roads were paved. India in its past did not allocate enough resources to build or maintain its road network. This has changed since 1995, with major efforts currently underway to modernize the country's road infrastructure. The first evidence of road development in the Indian subcontinent can be traced back to approximately 2800 BC from the ancient cities of Harappa and Mohenjo-Daro of the Indus Valley Civilization. Ruling emperors and monarchs of ancient India had constructed roads to connect the cities. Archaeological excavations give us fresh information about road connectivity in ancient India.

The Grand Trunk Road was built by the Mauryan Empire and expanded over many different dynasties until being completely revived by Emperor Sher Shah Suriin 1540-45 connecting Sonargaon near Dhaka in Bangladesh with Peshawar in modern-day Pakistan linking several cities from in India. It was also further expanded by the Mughal Empire.

- Nabard Sadak Yojna.
- Vishesh Durusti Karyakaram.
- Khasdar Nidhi Yojna (Khasdar fund).
- Amdar Nidhi Yojna (Amdar Fund).
- Jilha Varshik Yojna Nidhi.
- EPC (Engineering Procurement Construction).
- BOT (Build Operate and Transfer)[Bandha vatap & hastaskhar yojna].

1.3 LIFE CYCLE COST ANALYSIS (LCCA)

Nowadays, highway pavement construction, maintenance and rehabilitation costs are rising dramatically. It is essential for highway agencies to utilize tools and approaches that facilitate proper decision-making by applying economics and operations research such as Life-Cycle Cost Analysis (LCCA) to achieve economically reasonable long-term investments. LCCA is a method based on principles of economic analysis. Life-cycle cost analysis (LCCA) is an essential component of modern roadway infrastructure design and system selection. LCCA embraces maintenance and rehabilitation costs, not just construction costs when evaluating pavement alternatives. With the increasing demand for new road infrastructure, the demand for efficient management of old and new roads is on the rise as well, along with safety demands, accessibility and the implementation of advanced traffic management systems for decreasing socio-economic costs by mitigating maintenance-related environmental effects, traffic issues, and losses. Maintenance backlogs nonetheless increase too. Road authorities thus emphasize more on better efficiency and lower expenses due to limited funds. Since maintenance expenditures normally comprise half the annual road infrastructure funds, it is very important to prioritize efficiency in road maintenance.

OBJECTIVES of the paper

These are some of the specific objectives of this study

- To study the Life Cycle Cost Analysis.
- To study Net Present Value method (NPV).
- To carry out Life Cycle Cost Analysis of Ghoti - Sinner Highway site using NPV method.

2. LITERATURE REVIEW

Zongzhi li and Sunil Madanu (2009)[1], they conducted a case study to examine the impacts of using deterministic, risk based, and uncertainty based project level life cycle cost analysis approaches on computing the benefits of individual highway projects. Hein, David K and Smith, David R (2009) [2]. They have stated that LCCA embraces maintenance and rehabilitation costs, not just initial construction costs when evaluating pavement alternatives. Imam Mirzadeh, Ali Azhar Butt, et al. (2013) [3], they say that a life cycle costing system should include key variables that drive future costs in order to provide a framework for reducing the risk of under or overestimating the future costs for maintenance and rehabilitation aspects. Jan Mikolaj and Lubos Remek (2014) [4], in this article they have explained the economic aspects of Slovakia's pavement management system (PMS) - Road Network Management System (RNMS). They have said that economic efficiency is the criterion, which enables us to create incisive outputs like strategy for allocation of limited funds between particular road sections or the total funding amount is necessary for preserving the road network in serviceable condition. S.Anjan Kumar, Hazera Tahseen, et al. (2006) [5]. In this paper they have explained the phenomenon of rutting of roads and how can it be overcome by using LCC, Rutting in asphalt pavement layers in combination of densification and shear deformation. Arijit Dutta (2014)[6], in this paper he has stated that Life cycle cost analysis of existing road is becoming more significant to determine the proper time of maintenance and the proper action, which should be taken for maintenance. Jonas Wennstrom (2014) [7], this study especially concerns regarding increased road user cost during road works have been expressed. In this study he has examined in two case studies from different perspectives.

PROBLEM STATEMENT

The main problem arising in construction industry is of minimizing the expected total life cycle cost associated with entire life of roads. Only initial price is considered while carrying out costing of roads 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, with a consideration of other mentioned costs. This analysis will help us to reduce LCC of structure and gives better saving through the life of road.

3. METHODOLOGY

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 LCCA is a method based on principles of economic analysis. It improves the estimation of the total long-term economic viability of different investment options. This method finds significant application in pavement design and management. A number of agencies employ the LCCA approach to estimate the economic feasibility of pavement Designs over the long haul. Thus, it is very important for agencies to realistically evaluate pavement Economics in order to provide suitable input to the LCCA.

This study focuses on implementation of the Life Costing methodology in Indian transportation, infrastructure planning and, construction, more specifically on road investments and long term impacts on future operation and maintenance. In this thesis a literature review will first provide different perspectives on methodology, definitions and differences in different types of studies. The main purpose of this project has been to study the implementation through case studies.

Various types of information are required to perform life cycle costing studies. These include the acquisition cost of the item, the useful operational life of the item in years, the annual maintenance cost of the item, transportation (delivery) and installation costs of the item, discount and escalation rates, the annual operating cost of the item, taxes (e.g., tax benefits from depreciation, investment tax credit), and the salvage value or disposal cost of the item. Although data for life cycle cost analysis can be obtained from many sources, their amount and quality may vary quite considerably. Therefore, prior to starting a life cycle cost study, it availability, data comparability to other existing data, data orientation toward the problem under consideration, and data coordination with other information.

Life Cycle Costing (LCC) = C+O+M+R+S

Where, C= construction cost.
O= Operation cost.
M=Maintenance cost.
R= Repair cost.
S= Salvage value.

NET PRESENT VALUE METHOD:

Life cycle costing is the addition of all costs involved in the construction, operation, maintenance, energy and the disposal costs of the asset throughout its life span. Project costs that occur at different points in the life of an asset cannot be compared or summed directly due to the varying time value of money. They must be discounted back to their present value through the appropriate equations. Costs must first be converted into their time equivalent value at the base date before being combined to compute the LCC of a project. This time equivalent value is referred as the present value of the costs. The discount rate is the interest rate used to convert future expenditures to their present value at the base date, taking into account the time value of money and the rate of inflation.

$$\textbf{NET PRESENT VALUE (NPV)} = \sum \frac{Ct}{(1+r)^t}$$

Where; PV- Present Value.

Ct – Cost in the year t.

r - Discount rate in decimals.

t - Time Period.

- Inflation rate: 4.85%
- Interest rate: 8.25%

The DISCOUNT RATE is calculated as:-

$$(1+r) = \frac{(1+\text{interest rate})}{(1+\text{inflation rate})}$$

$$= \frac{(1+0.0825)}{(1+0.0485)}$$

$$= 0.03242$$

For the calculation of discount rate the inflation rate and interest rate are necessary. The Net Present Value of the Ghoti Sinnar highway is calculated for 10 years. In order to optimize the expenses that may occur in the future life of the highway. The entire idea of Life Cycle Cost analysis is to optimize the extra cost that may occur for the purpose of maintenance or repair or operation in some cases for rehabilitation. The initial cost in the process of LCCA may be more but in future it helps in compensating the extra costs that may be bared in the future. Net Present Value method is one of the methods which is mostly used. The NPV method gives an accurate value that gives an optimized solution and results for the same.

DATA COLLECTION

- The data is collected from a road site of Ghoti-Sinnar-Nagpur Highway located, Behind SMBT College, Ghoti khurd, Igatpuri, Maharashtra 422403.
- Construction of road was completed in year 2016.
- The road patch which is being considered is of 26km.
- Data collected consist of total cost of work and operating and maintenance cost of the Road yearly.

- Life of road is considered to be 10 years.
- This area possess heavy rainfall.

The total construction cost required for the same is rs 26075394/-.The operation and maintenance cost after the completion of the project in 2016.the maintenance cost in the year 2016 is rs 13285338.475/-. The operation and maintenance cost is assumed to be increased by 10% every year.
The salvage value for the same is 10% of the total construction cost.
Salvage value = 10% of 260753940
= 26075394/-

DATA ANALYSIS

Construction cost: 260753940/-

Table no: 1

YEAR	O&M COST
2018	14607932.94/-
2019	14601995.97/-
2020	14137716.65/-
2021	13258363.23/-
2022	12043262.25/-
2023	10596000.37/-
2024	9029909.076/-
2025	7453639.443/-
2026	5959323.683/-
TOTAL COST	**129128450.38/-**

TOTAL O&M COST BY NPV: 129128450.38/-

Life Cycle Costing (LCC) = C+O+M+R+S

=260753940+129128450.38+0+26075394

= 415957784.38/-

RESULT AND DISCUSSIONS

The results for the thesis were obtained by the Net Present Value method. The Operation and maintenance cost obtained was 129128450.38/-. By using this method we can figure out the maintenance and operation whatever amount is required in that particular year in the initial stage by calculating the cost by calculating the Life cycle cost.

CONCLUSIONS

In this thesis we studied the Life cycle cost analysis (LCCA) of Ghoti Sinnar highway by Net Present Value method. By which we obtained the entire cost required for the same, which if calculated in the initial stage will be easy and less time consuming in the coming years. This method initially may be expensive but helps in optimizing the cost in the coming years, which helps to figure out the respective costs that will be required in the coming years.

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