A Comprehensive Study on Life Cycle Cost Examination for highways in India

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ABSTRACT

Life cycle cost Examination 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 Examination of a road network is dependent upon a number of factors, which are responsible for deciding road serviceability level. Optimization model is an analytical model, which helps to make a cost benefit Examination and compare that with various possible alternatives to give out the best possible activity within the allocated budget, before being carried out in field work. In the present study, the aim was to develop a general optimization model to give the most cost effective activity. The choice of maintenance action is divided in four groups from no action to rehabilitation. Various factors like traffic growth, environmental conditions are taken into account, along with the International Roughness Index (IRI). „C” language program is used to formulate the model.

1. INTRODUCTION

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. As per a student paper submitted on 2006 at Atlantic International University, Life cycle cost Examination (LCCA) is a financial Examination instrument which is valuable in deciding the execution of a roadway. The instrument thinks about and examines the relative monetary alternatives of diverse constructional and recovery plans for a roadway. It decides the execution data by Examination of pavement administration information and verifiable experience to assess the pavement condition. As per Bangasan (2006), Life-Cycle Cost Examination is a process for evaluating the total economic worth of a usable project segment by analyzing initial costs and discounted future costs, such as maintenance, user, reconstruction, rehabilitation, restoring, and resurfacing costs, over the life of the project segment.

Objectives

The main objective of this study is to review few literatures on life cycle cost Examination of roads and apply some of them to develop a model as a general form to analyze life cycle cost Examination of roads in general. Development of an optimization model can be more useful if along with reduction of maintenance cost, the road condition also improves and being serviceable for a longer duration during the design period. The thesis is divided into five chapters of which this is the first. The second chapter presents a review of the past work done on LCCA in accordance with roads as well as the literature model development and expresses the motivation for this thesis. In Chapter 3, the data calibrated for this thesis work are described. The governing factors such as the distress values and cost of maintenance works and their limitations are prescribed. Chapter 4 describes in detail the proposed model for Cost Examination of roads. The chapter defines the model and presents the results obtained from the proposed model. These results are used to validate the model.

LITERATURE REVIEW

Jain et al. (2004) presented that the flexible maintenance strategies after an Examination period of twenty years can save more than thirty three percent highway agency cost than that of scheduled maintenance strategies. They
compared their adopted model with predefined models on selected pavement sections. As the fund granted for maintenance management is only 60 percent of the fund required, they prepared an optimized and prioritized work process for 60 percent budget availability. They showed us that the average roughness value of the highway network increases with reduction in budget levels, which in turn can lead to a very high road user cost values. Zhang (2009) developed a new life cycle optimization model for pavement asset management system. He evaluated three potential overlay systems. One of these is a concrete overlay system.

He observed the application of dynamic programming as an optimization tool in life cycle optimization of pavement overlay systems, which obtain outputs considerably faster and more accurately compared to conventional methods. His results demonstrate the importance of including user costs and roughness effects in pavement management accounting. Whiteley-Lagace et al. (2011) attempted to show us the challenges and successes of implementing a pavement management system for roads. Their project team developed a 5 and a 10 year budget plans for road network and developed a number of recommendations to improve the level of detailed data to be added to the system to refine the models. They collected data for four years. They collected performance based data, which included the distress data for asphalt and concrete, gravel and native roads. They calibrated decision trees and cost models for all pavement types. They translated distress rating scores into individual distress index scores and then combined both to create a single surface condition rating.

Zhang et al. (2013) described about the development of a new pavement network management system that helps Examination and optimization. This LCCA optimization was implemented to regulate the optimum conservation scheme for a pavement network and to reduce supportability metrics within a given Examination period. They discussed about pavement deterioration, which is a main aspect to focus future pavement conservation procedures and is extremely difficult to focus faultlessly.

Pradhan Mantri Gram Sadak Yojona (2006) presented the choice of the appropriate economical and advantageous pavement type, was made by carrying out life cycle cost Examination, which takes into account the initial cost and the maintenance cost. They also presented the cost of construction for both rigid and flexible pavements. They also estimated an economical cost Examination, which showed us that the life cycle cost of concrete pavement is about twenty to twenty five percent lower than bituminous pavement.

A picture demonstration is given below to show how maintenance strategy and rehabilitation action taken into action for a pavement.

![Figure 1. Analytical representation of maintenance (Adopted from Markov et al. 1987)](image-url)
EMPERSICAL STUDY AND EXAMINATION

As the study is not case specific, from the past studies, assumptions were made to develop the optimization model. The elements considered are

- Traffic growth
- Climate
- External features
- Environment

Table 1. Primary factors for cost Examination & their values (adopted from report of annual conference of transportation association of Canada, 2001)

<table>
<thead>
<tr>
<th>Year</th>
<th>Traffic growth</th>
<th>Impact Climatic condition</th>
<th>Impact of External features</th>
<th>Impact of Environmental condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>9.693%</td>
<td>20</td>
<td>8.0</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>9.932%</td>
<td>25</td>
<td>8.5</td>
<td>20</td>
</tr>
<tr>
<td>15</td>
<td>5.806%</td>
<td>30</td>
<td>9.0</td>
<td>20</td>
</tr>
<tr>
<td>20</td>
<td>2.118%</td>
<td>35</td>
<td>9.5</td>
<td>20</td>
</tr>
<tr>
<td>25</td>
<td>1.128%</td>
<td>40</td>
<td>10.0</td>
<td>20</td>
</tr>
<tr>
<td>30</td>
<td>0.925%</td>
<td>45</td>
<td>10.5</td>
<td>20</td>
</tr>
</tbody>
</table>

Traffic growth: Traffic growth denotes the increment or growth of traffic volume in the given road section over past years. In this study traffic is represented as the axle load of vehicles. It showed the growth of traffic in percentage with a gap of five years.

Climate: Climate is a measure of the average pattern of variation in temperature, wind, precipitation and other factors. Rainfall or precipitation is the main factor for pavement deterioration. And assumptions were also made to present the climatic condition as a factor.

Other factors: In this study urbanization and development of the area were considered as the other factors in percentage. These factors have huge impact on pavement life.
Environment: Environment is the surroundings of a physical system that may interact with the system by exchanging mass, energy, or other properties. This environmental factor which is presented in percentage is more or less same throughout the life period of a pavement.

PROPOSED MODEL

According to Virginia research council report (2002), „LCCA“ is an economic method to compare among alternatives that satisfy a need in order to determine the lowest cost option. According to Chapter 3 of the AASHTO Guide for Design of Pavement Structures, life cycle costs “refer to all costs which are involved in the provision of a pavement during its complete life cycle.” These costs borne by the agency include the costs associated with initial construction and future maintenance and rehabilitation. In addition, costs are borne by the traveling public and overall economy in terms of user delay. The life cycle starts when the project is initiated and opened to traffic and ends when the initial pavement structure is no longer serviceable and reconstruction is necessary.

In this study no case study was taken into account. Hence, values were assumed from past studies. From that studies International roughness index (IRI) values were taken. And the IRI values vary between 80 inches per mile to 170 inches per mile. In this study from IRI values helped to calculate present serviceability rating (PSR). Where, PSR is a parameter to indicate the road condition. It is used to estimate long term pavement rehabilitation needs. Generally PSR value ranges from 0 to 5 (very poor to very good). From a past study of Al-Omari et al. (2005), following relationship was adopted for PSR values and IRI values. It was also observed that the IRI values for general roads varied from 80 to 200 inches per mile. Hence values within that range have been considered to determine the corresponding PSR values, as given in Table 2.

<table>
<thead>
<tr>
<th>IRI (inches/mile)</th>
<th>PSR=5e^(-0.0041*IRI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>3.601</td>
</tr>
<tr>
<td>85</td>
<td>3.529</td>
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<tr>
<td>90</td>
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<td>95</td>
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<td>100</td>
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<td>105</td>
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<td>110</td>
<td>3.185</td>
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<tr>
<td>115</td>
<td>3.120</td>
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By the motivation from the methodology of Al-Omari and Dartet (2005), the values are analyzed and the PSR values were divided into four groups:

1. A – PSR value greater than 3.200
2. B – PSR value between 3.200 and 2.800
3. C – PSR value between 2.800 and 2.400
4. D – PSR value less than 2.400

### CONCLUSIONS

In this study an attempt was made to determine the most general equation for any general road at moderate weather.

By probabilistic Examination it was concluded that if the roads have roughness of 120 inches per mile to 130 inches per mile, then the road can serve twice its life time with minor maintenance at the end of its initial life period.

In past studies the Examination which were done, were mainly dependent on time factor, in comparison of that this study is analyze with respect to road roughness parameter.
This study tried to show that minor and major maintenance of any general road is more economical and give more benefit in term of serviceability than complete rehabilitation.

REFERENCES

[3]. „Application of mechanistic-empirical and life-cycle cost analyses for optimizing flexible pavement maintenance and rehabilitation.”
[10]. Application Of Low-Volume Road Maintenance Management Systems In New Zealand To The Philippines.