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Life Cycle Cost Analysis of a Major Public Project

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Abstract*: India is a fast growing country and being a developing nation, one of its major focuses is infrastructure development. The term infrastructure mainly refers to railways, highways, airports, bridges, ports and harbors,etc. Of these, the most important is the roadways. A country can develop only if it has a planned and efficient road network. Cost of road works involves initial costs for land acquisition, design expenses, construction of road pavement, etc. and future costs for maintenance, repairs, reworks, rehabilitation, and operation over the entire life span of the road project. It is very important to thoroughly study and analyze these costs beforehand so as to make the right investment and to avoid losses in the future.*

Life cycle cost analysis is an economic tool which is used to evaluate the feasibility of the project considering various costs associated with the project over its total life span. This research paper deals with the LCCA of an existing flexible pavement to check if the money spent on maintenance and repairs is justified. This is done by the Net Present Value method of analysis. Further, a conclusion is drawn whether to continue spending on maintenance or to entirely demolish the pavement and reconstruct a new one. This paper also compares the life cycle costs of flexible and rigid pavements and suggests an economical alternative to avoid losses and improve the serviceability of the road.

Keywords*: Analysis period, Construction Cost, Internal Rate of Return(IRR), Life Cycle Cost Analysis(LCCA), Maintenance and repair cost, Net Present Value(NPV)*

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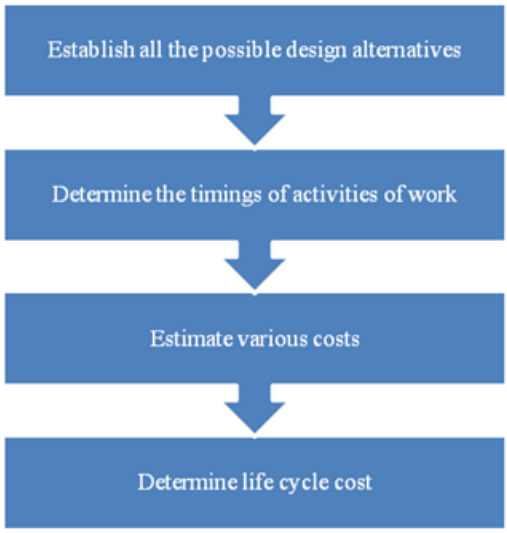
I. Introduction

LCCA is a cost evaluation tool which is often used at the initial phase planning in construction, and which examines all the costs associated with the project. While designing a project, a number of options are first proposed. These options may have different initial costs, maintenance costs, etc. Considering a particular alternative, LCCA helps in determining the total cost of the project for a particular life span. It includes economical examination of various alternatives that considers all of the significant costs of ownership over the useful life. Finally, the project alternative with the best economic feasibility is selected. The various costs considered in LCCA include:

- Initial costs
- Financing costs
- Maintenance and repair costs

For getting the best outcome for a LCCA, an in-depth understanding of the theoretical engineering and economics is required because input parameters in LCCA are intrinsically tentative (E.g. Analysis period, type and timings of activities, etc.). And as the accuracy of prediction of costs is very important in LCCA, any error in estimation of these costs can drastically change the final outcome. Hence, the LCCA cannot be necessarily considered to be a full proof prediction of the future. In spite of these limitations, LCCA can provide the decision-makers useful information based on which they can use limited funds in the most cost-effective way.
The basic steps involved in LCCA are:



Objective

1. To evaluate the economic effectiveness of different investment alternatives over a certain period.
2. To determine the current worth of the project.
3. To identify the most cost-effective alternative.
4. To analyze various costs associated with the project.
5. To check if it is feasible to spend on repair works or should an existing project be demolished and reconstructed.

Scope Of Work

To find out the life cycle costs associated with the project and to check if the money spent on maintenance and repair works is justified. Further, to come to a conclusion whether to continue spending on maintenance or to demolish the project entirely and replace it with a new project.

II. Literature Review

As per Mr. AkhaiMudassar Mohammed Shafi, LCCA can be used to select an alternative pavement design which will result in reduction of costs of construction and maintenance and will also offer sufficiently serviceability over the entire design life of the road. Waldo Galle presents Life cycle costing as an early stage feasibility analysis. Mr. Shirole Pratik Anil in his paper differentiates between flexible and rigid pavements suggesting the better option of the two. A report by the American Society of Civil Engineers and Eno Centre for Transportation suggests LCCA as method for maximizing the value of investment in transportation industry under constrained budget. Another report by the US Department of Transportation recommends technical guidance on carrying out LCCA and discusses its input parameters along with their variability and uncertainty. Mr. MehulRathore emphasizes on the application of LCCA in value engineering while studying a RMC plant office.SofiaLingegard gives maintenance strategies with large technical systems.

III. Case Study And Data

1. Project Details

a. Length of road: 31.80km
b. Total cost of construction: Rs. 2884.83 lacs
c. Period of Construction: 18 months
d. Design life: 15 years
e. Analysis period: 9 years

2. Estimated costs:

a) Excavation costs: 3.56crores
b) Base/Sub-base courses: 3.65crores
c) Bitumen works: 9.8 crores
d) Minor bridges and culverts: Rs 1.18 crores
e) Retaining walls: Rs 3.34crores
f) Built-up gutters/drains: Rs 2.34 crores

g) Bus bays/bus shelters/standard junctions: Rs 1.34 crores
h) Road side furniture/Tree cutting/Site office/Toll plaza,etc.: 2.49 crores

3. Maintenance Cost

Year	Maintenance and repair Cost
1	0
2	66.54
3	95
4	98
5	102
6	109
7	113
8	116
9	120

Table 1.Maintencance cost

Life Cycle Cost Analysis:

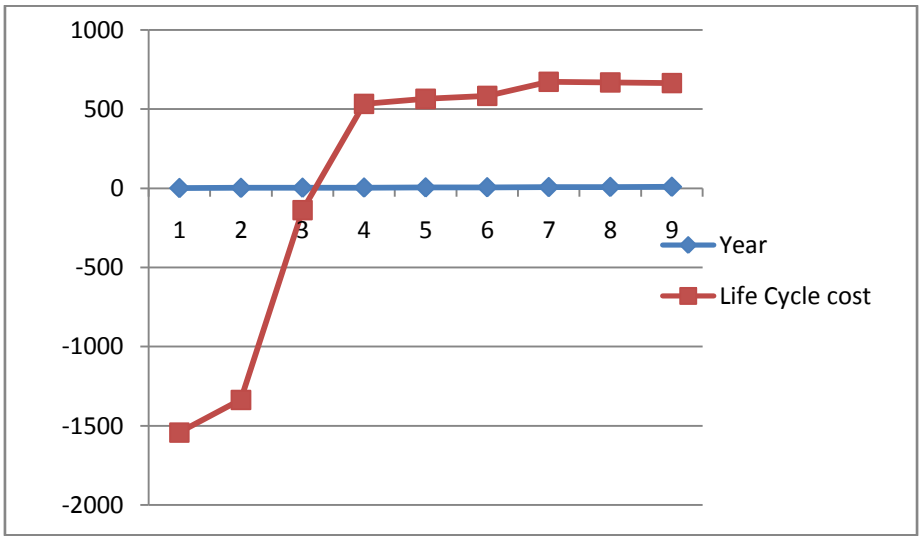
1. Design Life= 15 years(As per IRC 37:2001)
2. Analysis period= 9 years

Net Present value(NPV) = Ct / (1 + r)t – Co

Where, Ct – Cash flow in the year t
Co – Outgoing cost(Initial Investment)
r – discount rate

Flexible Pavement			
Year	**Net income of project(Including debt and interest)**	**Present value**	**I.R.R**
1	-1613.92	-1541.323656	4.71%
2	-1465.01	-1336.177856	4.71%
3	-159.2	-138.6687449	4.71%
4	639.68	532.1206759	4.71%
5	709.12	563.3508273	4.71%
6	768.3	582.9104963	4.71%
7	926	670.9557353	4.71%
8	965	667.7625157	4.71%
9	1004	663.4990059	4.71%
	NPV	**664.429**	

Table no.2 LCCA of flexible pavement



Graph 1.. Life cycle costs of flexible pavement

I.
II.
III.

IV. Alternative Rigid Pavement

1. Expenditure:

- Cost of Construction= 18-20 Lakh per km for single lane.
- No. of lanes= 2
- Total length of the road= 31.8km
- Hence, total construction cost= Rs 1144.8 to 1272 lakh
- **Take construction cost= Rs1272 lakh**
- Discount rate(I.R.R)=4.71%
- Design life=15years
- Analysis period=9years
- Assume maintenance cost to be 0.5%-2% of total project cost per annum.
- Hence, total maintenance cost=Rs 6.36 to 25.44lakh per year
- Consider **the total maintenance cost@2%= Rs 25.44 lakh per annum**

2. Income:

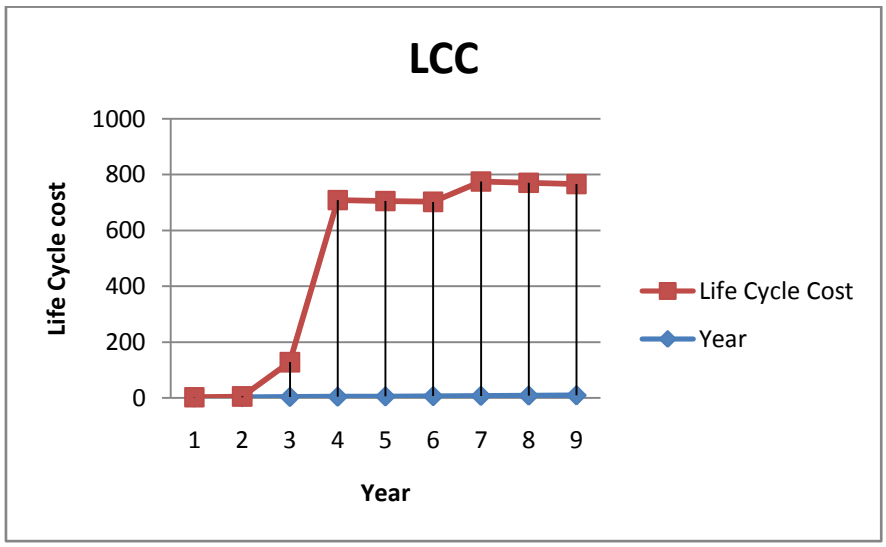
Assume the income to be same as that of flexible pavement.

3. Life Cycle Cost Analysis:

Rigid pavement

Year	Total Income	Construction cost	M&R cost	Life Cycle Cost	I.R.R
1	1	1272	0	0.955019	4.71%
2	3		25.44	2.736182	4.71%
3	142.91		25.44	124.4796	4.71%
4	846		25.44	703.7489	4.71%
5	881		25.44	699.8986	4.71%
6	917		25.44	695.7294	4.71%
7	1059		25.44	767.3241	4.71%
8	1101		25.44	761.8721	4.71%
9	1145		25.44	756.6796	4.71%
Total	6095.91		203.52	4513.423	
	NPV	**3037.903**			

Table no. 3 LCCA of Rigid Pavement



Graph no. 2. LCC of rigid pavement

V. Results, Conclusion And Future Scope

1. Considering I.R.R=4.71%, NPV of the project after 9 years of operation is 664.95.
2. The trend of NPV shows that as the operation of road increases year by year, operation and maintenance cost increases every year affecting present worth of the project.
3. If same road is sustained beyond design life under same/increased traffic conditions, it will mount to deterioration of road resulting in increased maintenance and repair cost.

4. Net income will be reduced at the end of concession period after complete recovery of initial investment collected in the form of tolls and advertisement.
5. A point will be reached where the cumulative operation cost increases than cumulative income cost reducing the present worth of the project thereby incurring losses.
6. Therefore, it can be suggested through this analysis that this road needs to be redesigned and reconstructed after the end of design life or the year in which its worth reduces to a point where it starts incurring losses, whichever is earlier.
7. REMARK/SUGGESTION: The existing road is flexible pavement. Another option for replacement could be change of the pavement type to rigid pavement.

Year	**Flexible pavement (Existing)**			**Rigid Pavement (Suggested)**		
	Income	**Expenditure (Construction+Maintenance)**	**NPV**	**Income**	**Expenditure (Construction+Maintenance)**	**NPV**
1	1	1614.926	-1541.32	1	1272	0.955
2	3	1468.016	-1336.18	3	25.44	2.736
3	142.91	302.071	-138.668	142.91	25.44	124.479
4	846	206.345	532.12	846	25.44	703.748
5	881	171.877	563.35	881	25.44	699.898
6	917	150.695	582.91	917	25.44	695.72
7	1059	133	670.955	1059	25.44	767.324
8	1101	136	667.762	1101	25.44	761.872
9	1145	141	663.499	1145	25.44	756.679
			664.429			**3190.543**

Table no.4 Comparison between flexible and rigid pavement

NOTE:As the NPV of rigid pavement is greater than NPV of flexible pavement, it can be suggested that rigid pavement is feasible than flexible pavement

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