Life Cycle analysis of Flexible Pavements and Rigid Pavements in Urban Areas

Nikhil Ramesh Fendar[1],
Civil Engineering Department,
Dr. Rajendra Gode Institute of Technology& Research, Amravati, India

Dr. B. S. Shete[2],
Civil Engineering Department,
Dr. Rajendra Gode Institute of Technology& Research,Amravati, India

Abstract*:*

Majority of pavements in India are bituminous pavements which might be displaying early signal of distresses and additionally require periodic upkeep for strengthening. Now a day's cognizance is on pavements which might be upkeep unfastened or having low upkeep and not pricey than bendy pavements. Concrete pavements are an awesome opportunity to bituminous pavements, those pavements carry out for a long time and actually have a totally low upkeep price,even though the preliminary price of those pavements is excessive whilst existence cycle price is taken into consideration the general price of those pavement is much less than that of typical price of bituminous pavements. In the prevailing study, a strive is made to assess the existence cycle price of latest bituminous and urban pavements or even the existence cycle price (LCC) of bituminous overlays and urban white toppings is being evaluated with the assist of internet gift cost technique of existence cycle price analysis.

Keywords: LCC, White Topping, Pavement Rehabilitation, Alternative to bituminous pavements, Overlays**.**

I.   INTRODUCTION

Infrastructure Development performs a vital position in improvement of a country. In case of growing international locations like India, scarcity of budget for infrastructure venture is a first-rate problem. Therefore, earlier than production of latest street and earlier than rehabilitation of bituminous pavements, pavements which carry out for long time have to be considered.In India majority of the pavements are bituminous pavements, which might be displaying early signal of distresses because of growing traffic, growing load, excessive tyre stress etc. Distresses like rutting, cracking, getting old are the maximum not unusual place in bituminous pavements. Concrete pavements carry out for an extended length and may be followed as excellent opportunity for bituminous pavements. Even in case of rehabilitation of present bituminous pavements, concrete overlays or white topping may be excellent and useful opportunity whilst in comparison to bituminous overlays. This paper highlights the lifestyles cycle fee (LCC) evaluation of cement concrete avenue and bituminous avenue. It presents outcomes approximately the exceptional suitable, cost effective and fee powerful pavements andadditionally offers the distinction among concrete and inflexible pavement and overlays.Net gift price approach of LCC is used for comparing the pavements, this approach takes into attention preliminary production price and renovation price for layout existence duration of each the pavements. With the assist of this evaluation an assessment of general existence cycle price of concrete pavements and bituminous pavements may be located out and satisfactory pavement opportunity may be considered. Life cycle price evaluation: It is an essential monetary evaluation used with inside the choice of options that effect each preliminary and destiny price. It evaluates the price performance of options primarily based totally at the internet gift price (NPV) approach which presents the full price required at some stage in existence cycle of the project.

A. Types of Pavements

1.   **Flexible pavement:** Flexible pavement may be described because the pavements which might be surfaced with sporting path of bituminous or asphalt layers. These pavements commonly encompass 4 layers which might be sub-grade, sub-base, base path and sporting or floor path. Due to growing traffic, growing load, excessive tyre stress etc. distresses like rutting, cracking, potholes etc. are visible in those pavements. Though the preliminary value of those pavements is low their carrier existence isn't always as correct as inflexible pavements and their upkeep value is likewise excessive.

2.   **Rigid Pavements:** Rigid pavements are composed of a cement concrete floor route and hid base and sub base courses. The floor route is the inflexible layer and gives the bulk of electricity. Rigid pavements have excessive flexural electricity than bendy pavements because of which they could transmit the wheel load stresses over a much wider area. Initial value of those pavements is excessive compared to bendy pavements however their renovation value is low. These pavements have a provider existence of twenty years and more.

II.   OBJECTIVES OF STUDY

1. The main objective of this paper is to calculate the total cost of bituminous and concrete pavements by using life cycle lost analysis (LCCA) methodology, which could assist in the pavement selection process and help to improve the pavement system.
2. Compare the overall cost for 1 kilometer of both flexible and rigid pavements.
3. To suggest a better alternative for the maintenance and rehabilitation required in bituminous pavements.

III. METHODOLOGY

In this study the cost required for initial construction and for maintenance of the pavements is calculated by using net present value method of life cycle cost analysis. IRC SP-30 (2009) gives the formula for net present value. Agency costs are calculated from the district schedule of rates of Public Works Department (PWD) Pune region. The procedures of construction and estimates were studied from case studies done on three different roads.
1) Construction of pavements UTWT and TWT, Madhuban area at old Sanghvi ward no 59, PCMC.
2) Construction of PQC pavement road from Chaphekar chowk to bridge on Pavana River towards Thergaon. PCMC
3) Development of 45.00W wide road from Pune Alandi road to Dabhadewasti in PCMC area.

IV. LIFE CYCLE COSTANALYSIS

Analysis period considered is 20 years starting from 2016. Discount rate of 12% is considered as per government policy and inflation rate of 5.5 % has been considered for rise of prices of material in future.
A] Life cycle cost of bituminous pavements:
1) Cost of construction of is shown in Table I

Table I. Construction Cost of Bituminous Pavements

Pavement Layer	Cost/km	Length (m)	Thick (mm)	Width (m)	Rate (Rs)
Bituminous Concrete	3,272,800	1000	40	10	8182.0 /Cum
Dense Bituminous Macadam	7,115,000	1000	100	10	7115.0 /Cum
Wet Mix Macadam	2,875,000	1000	250	10	1150.0 /Cum
Granular Sub-Base	3,175,000	1000	250	10	1270.0 /Cum
Prime Coat	210,000	1000	1 Coats	10	21.00 /Sqm.
Tack Coat	350,000	1000	2 Coats	10	17.50 /Sqm.
Initial Cost	16,997,800				

2) Maintenance cost of bituminous pavement.
Overlay shall be provided at every 10th year after construction for strengthening of existing pavement having a 75mm DBM layer and 40mm BC layer. Overlay cost is shown in Table II.

According to MoRTH guidelines a layer of 25mm BC is to be provided once in 5 years. Cost of overlays is shown in Table III.

Table II. Cost of Overlay to be provided at every 10th year

Overlay Layer	Cost/km	Length (m)	Thick(mm)	Width (m)	Rate (Rs)
Bituminous Concrete	3,272,800	1000	40	10	8182.0 /Cum
Dense Bituminous Macadam	5,336,250	1000	75	10	7115.0 /Cum
Tack Coat	350,000	1000	2 Coats	10	17.50 /Sqm.
Initial Cost	8,959,050				

Overlay Year	Initial Cost (Rs)	Inflated Cost @5.50% p.a.
10 th Year	8,959,050	16,145,035.95
Total	8,959,050	16,145,036

Table III. Periodic Resurfacing in every Five Years (BC 25mm)

Pavement Layer	Cost/km	Length (m)	Thick(mm)	Width (m)	Rate (Rs)
Bituminous Concrete	2,045,500	1000	25	10	8182.0 /Cum

Year	Cost per Km.	Inflated Cost @5.50% p.a.
5th Year	2,045,500	2,820,422.96
	2,045,500	4,566,530.66
18th Year	2,045,500	5,657,130.76
Total	6,136,500	13,044,084

B) Life Cycle Cost of Concrete Pavement

1) Construction Cost is shown in Table IV

Table IV. Construction Cost of Concrete Pavements

Pavement Layer	Cost/km	Length (m)	Thick (mm)	Width (m)	Rate (Rs)
PQC	1,72,23,000	1000	300	10	5741.0 /Cum
DLC Layer	25,96,000	1000	100	10	2596.0/Cum
GSB Layer	31,75,000	1000	250	10	1270.0/Sqm.
Initial Cost	2,29,94,000				

2) Maintenance cost of Concrete Pavements

Joint Sealing: 50 % of the joint sealants are to be replaced in every 5 year.

Joint Length: Contraction Joint length per km. for 10m wide carriageway 10000m.

Longitudinal Joint length for 1 km and two joints in 10m width 10000m Length to be replaced every 5 years is 30% of total length
Contraction joint = 3333.333 m
Longitudinal joint = 3333.333 m
Cost of joint seals in shown in Table V

Table V Cost of Joint Seals (Preformed Seals) per Km

Item	Unit	Quantity	Rate (Rs.)	Cost /Km.
Contraction Joint	m	3333.333 m	150	500000
Longitudinal Joint	m	3333.333 m	100	333333.333
			Total	833333.333

Concrete spalling: -

0.5% of Joint length for a width of 500mm in every 10 years

10th year spalling concrete = 50 SqmRepairs of concrete spalling = 50*6889.2 = 344460 Rs

Table VI Total Cost and Inflated Cost of Concrete Spalling

CONCRETE SPALLING		
Maintenance Year	Maintenance Cost (Rs.)	Inflated Cost @5.50% p.a.
10 th Year	344,460	620,748.75
Total	344,460	620,749

C) Life Cycle Cost of Overlays

1) Bituminous overlays

Bituminous Overlays		
Overlay	Initial Cost	Inflated cost
Strengthening overlay	8,959,050	16,145,036
Periodic overlays	6,136,500	13,044,084
Total	15,095,550	29,189,120

2) Concrete overlays

Table VIII Thin White Topping overlay

Pavement Layer	Cost/km	Length (m)	Thick (mm)	Width (m)	Rate (Rs)
Thin White Topping (TWT)	8,6,11,500	1000	150	10	5741.0 /Cum
Milling	26,775	1000	50	10	53.6 /Cum
Initial Cost	8,638,275				

Table IX Ultra-Thin White Topping Overlay

Pavement Layer	Cost/km	Length (m)	Thick (mm)	Width (m)	Rate (Rs)
Ultra-Thin White Topping (UTWT)	5,741,000	1000	100	10	5741.0 /Cum
Milling	26,775	1000	50	10	53.6 /Cum
Initial Cost	5,767,775				

Maintenance cost for concrete overlays will be same as that of new concrete roads.

Table X Maintenance cost of Concrete Pavements

Stages	Initial cost	Inflated cost
Joint sealing	2,500,000	46,13,498
Concrete spalling	344,460	620,749
Re-Texturing	20,00,000	4,011,548
Total	**46,53,400**	**9,245,795**

V. RESULTS AND DISCUSSION

1) Life cycle cost comparison of new bituminous and concrete pavements is shown in Table no XI

2) Life cycle cost comparison of bituminous and concrete Overlays is shown in Table no XII.

Table No XI Life Cycle Cost Comparison of New Bituminous and Concrete Pavements.

NPV Bituminous Pavements					NPV Concrete Pavements				
Sr No	Year	Construction & Maintenance cost	$(1/1.12)^n$	NPV	Sr No	Year	Construction & Maintenance cost	$(1/1.12)^n$	NPV
1	2016	16997800	1.00	16997800	1	2016	22994000	1.00	22994000
2	2017		0.89	0	2	2017		0.89	0
3	2018		0.80	0	3	2018		0.80	0
4	2019		0.71	0	4	2019		0.71	0
5	2020		0.64	0	5	2020		0.64	0
6	2021	2,820,422.96	0.57	1,600,383.73	6	2021	1,149,035.67	0.57	651,993.70
7	2022		0.51	0	7	2022		0.51	0
8	2023		0.45	0	8	2023		0.45	0
9	2024		0.40	0	9	2024		0.40	0
10	2025		0.36	0	10	2025		0.36	0
11	2026	16,145,035.95	0.32	5,198,269.48	11	2026	1,846,203.67	0.32	594,428.17
12	2027		0.29	0	12	2027		0.29	0
13	2028		0.26	0	13	2028		0.26	0
14	2029		0.23	0	14	2029		0.23	0
15	2030	4,566,530.66	0.20	934,402.65	15	2030		0.20	0
16	2031		0.18	0	16	2031	1,962,718.92	0.18	358,581.41
17	2032		0.16	0	17	2032		0.16	0
18	2033		0.15		18	2033		0.15	0
19	2034	5,657,130.76	0.13	735,650.96	19	2034		0.13	0
20	2035		0.12	0	20	2035		0.12	
21	2036		0.10	0	21	2036	2,565,195.13	0.10	265,925.48
			Total	**25466506.83**				**Total**	**24864928.76**

Table No XII Life Cycle Cost Comparison of Bituminous and Concrete Overlays.

NPV Bituminous Overlays					NPV Concrete Overlays (Ultra Thin White Topping Thickness - 100mm)					NPV Concrete Overlays (Thin White Topping Thickness - 150mm)				
Sr No	Year	Constructi on & Maintenan ce cost	(1/1.12) ^n	NPV	Sr No	Year	Construc tion & Maintena nce cost	(1/1.12) ^n	NPV	Sr No	Year	Construc tion & Maintena nce cost	(1/1.12)^n	NPV
1	2016	8959050	1.00	8959050	1	2016	5942775	1.00	5942775	1	2016	8813275	1.00	8813275
2	2017		0.89	0	2	2017		0.89	0	2	2017		0.89	0
3	2018		0.80	0	3	2018		0.80	0	3	2018		0.80	0
4	2019		0.71	0	4	2019		0.71	0	4	2019		0.71	0
5	2020		0.64	0	5	2020		0.64	0	5	2020		0.64	0
6	2021	2,820,422	0.57	1,600,383	6	2021	1,149,035	0.57	651,993	6	2021	1,149,035	0.57	651,993
7	2022		0.51	0	7	2022		0.51	0	7	2022		0.51	0
8	2023		0.45	0	8	2023		0.45	0	8	2023		0.45	0
9	2024		0.40	0	9	2024		0.40	0	9	2024		0.40	0
10	2025		0.36	0	10	2025		0.36	0	10	2025		0.36	0
11	2026	16,145,035	0.32	5,198,269	11	2026	1,846,203	0.32	594,428	11	2026	1,846,203	0.32	594,428
12	2027		0.29	0	12	2027		0.29	0	12	2027		0.29	0
13	2028		0.26	0	13	2028		0.26	0	13	2028		0.26	0
14	2029		0.23	0	14	2029		0.23	0	14	2029		0.23	0
15	2030		0.20	0	15	2030		0.20	0	15	2030		0.20	0
16	2031	4,566,530	0.18	834,288	16	2031	1,962,718	0.18	358,581	16	2031	1,962,718	0.18	358,581
17	2032		0.16	0	17	2032		0.16	0	17	2032		0.16	0
18	2033		0.15	0	18	2033		0.15	0	18	2033		0.15	0
19	2034		0.13	0	19	2034		0.13	0	19	2034		0.13	0
20	2035		0.12	0	20	2035		0.12		20	2035		0.12	
21	2036	5,657,130	0.10	586,456	21	2036	2,565,195	0.10	265,925	21	2036	2,565,195	0.10	265,925
			Total	17178447				Total	7813703				Total	10684203

VI. CONCLUSION

1) Life cycle cost analysis shows that net present value of concrete pavements is less than bituminous pavements.

2) When life cycle cost of bituminous overlays and concrete white toppings is considered the total cost of bituminous overlays is Rs 1,71,78,447 and that of concrete white toppings is Rs 1,06,84,203 for thin white topping and Rs 78,13,703 for ultra-thin white topping, which is 38% and 55% lesser than bituminous overlays.

3) LCCA concludes that concrete pavements are more beneficial than bituminous pavements and concrete overlays can be considered as beneficial option for rehabilitation of existing bituminous pavements.

REFERENCES

[1]. Bageshwar Prasad "Life Cycle Cost Analysis of Cement Concrete Roads VS Bituminous Roads" (Indian Road Congress (IRC) Technical Papers (2007)

[2]. Patel Karan M., Dr. L.B.Zala, Prof. A.A.Amin "Life cycle cost analysis for selecting pavement maintenance alternatives, A case study of Kota- Baran road (NH-27)" International journal of Advance Research in Engineering, Science & Technology Volume 3, Issue 7, July-2016

[3]. Preethi.S, Radhakrishna, Raghavendra Prasad "Life cycle cost analysis of Overlay for an Urban road in Bangalore" International journal of Research in Engineering and Technology eISSN: 2319 -1163 | pISSN : 2321-7308

[4]. Mr. Akhai Mudassar Mohammed Shafi, Mr. Ahmed Afaque Shakeel, Prof. Siddesh Kashinath Pai "Life Cycle Cost Analysis of Road Pavements in Rural Ares" IJSTM International Journal of Science Technology and Management. Vol. No.5, Issue No. 08, August 2016

[5]. Purvesh Raval, Darsh Belani, P. Jayeshkumar Pitroda "A literature review on UTW pavements in Indian Context" (Journal of International Academic Research for Multidisciplinary Impact Factor 1.393, Volume 1, Issue 9, October 2013

[6]. Vinay H N, Sunil S "Rehabilitation of Low Volume Flexible Pavements by White Topping – A Case Study" (IJRET: International Journal of Research in Engineering and Technology

[7]. D.R. Jundhare, K.C. Khare R.K. Jain "Ultra-Thin Whitetopping in India: State-of-Practice" ACEE Int. J. on Transportation and Urban Development, Vol. 2, No. 1, April 2012

[8]. Ankush Kumar Sehgal and S.N. Sachdeva "A review of using thin white topping overlays for rehabilitation of asphalt pavements" (Journal of Basic and Applied Engineering Research) Volume 2, Number 3; January-March, 2015, pp. 182-187.

[9]. D.R. Jundhare, K.C. Khare R.K. Jain "Ultra-Thin Whitetopping in India: State-of-Practice" ACEE Int. J. on Transportation and Urban Development, Vol. 2, No. 1, April 2012

[10]. Mitesh D. Patel, Prof. P.S. Ramanuj, Bhavin Parmar, Akash Parmar "White Topping as a Rehabilitation Method: A Case Study Of Budhel- Ghogha Road" International Journal of Advanced Engineering Research and Studies.