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EFFECTS OF LOW-COST MAINTENANCE PROGRAM ON VEHICLE OPERATING COST FOR INDIAN ROAD NETWORKS

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Abstract:

In the present study, ananalysis has been made for thevehicle operating cost with theexisting road maintenance system, which is based ona road roughness progression during the age of the unmaintained pavement, andthe same has been compared with the timely maintained road. A sixty-two km road length of existing National highway from Madhya Pradesh was selected for study purposes.Based on road roughness progression, the age of the pavement, and future traffic projections, the complete rehabilitation module was designed,and low-cost maintenance treatments were proposed throughout the design life of the pavement to maintain theroad surface roughness, and the structural stability as per the requirement of the road users.Accordingly, vehicle operating cost was estimated for the design period of Ten years for both options. The classification of the vehicles considered are new technology cars (NTC), two-wheelers (TW), buses, light commercial vehicles (LCV), and multi-axle heavy commercial vehicles (HCV).The VOC has been computed by using models developed by Dr. L.R. Kadiyali& Associates and Dr. Reddy 2003 with some modifications in the price rise factor, which has been kept at 1.75 due to an increase in the cost of fuel and spare parts of the vehicle.Structural strength, future traffic growth, width, age, and roughness of pavement were considered as main parameters.The study shows that thin renewalsstartfrom rating good with an initial roughness of 1.798 meters/Km and end with a roughness of more than 5.5 meters/Km, and causeheavy vehicle operating costs. Whereas as well-maintained road throughout the design life starts with an initial roughness of 1.8 meters/Km and ends in rating good with a roughness of 2.5 meters/km. Itprovides a benefit to road users andis highly cost-effective

1. Introduction

Under the presentguidelines, the roughness has been considered as a prime indicator for selecting the road stretches for maintenance works and priority is given to worst road sections. This system of maintenance results in heavy vehicle operating costs and loss of natural resources. In India, the concept of reactive maintenance is dominant in road maintenance practices and still followsthe worst first concept and it becomes highly expensive in later stages to restore the pavement to the original position and ultimately results in heavy vehicle operating Costs. Keeping vehicle operating cost low, proper rehabilitation of existing roads as per the actual road requirement, and active maintenance methodology with the provision of cost-effective treatments throughout the design life of the pavement, that preserves the riding quality and retards future deterioration, and maintains the functional condition of the road without significantly increasing the structural capacity is the need of the time.

2. Objectives of the Study

- To find out the vehicleoperating costsunder no maintenance of rods
- To find out the vehicle operating costs for well-maintained roads
- To provide comparative vehicle operating costs under both modules.
- To provide the overall effect of the continued maintenance program over no maintenance on vehicle operating costs.

3. Data Collection

Data aboutlocation, background, history, details of the road sections, functional and structural characteristics, soil sub-grade values field, and laboratory testswere collected. Table 1 shows details of traffic count stations and average daily traffic.

Table.1: Average daily traffic

Sr.No	Details of the traffic count station	
1	Name of Road	Indore-Betul road
2	National Highway No	59A
3	Location of the Count Post	Kannod Town
4	Km of Count Station	Km 90/2
5	Month and Year of Census	July 2014
6	Duration of Census in Days	7 Days
7	Average Daily Traffic in Numbers Of Vehicles	(Sum of Both Direction)
8	BUS	300
9	Truck Two/Multi Axle	2330
10	Agriculture Tractor with Trolley	59
11	Total Commercial Vehicle (CVPD)	2689
12	Passenger Car Unit	8545.00 PCU
13	Traffic Growth Rate per annum	7.5%
14	Vehicle Damage Factor(F)	4.5(for roling/plan Terrain)
15	Lane Distribution factor	1.00
16	Period of Construction	2 Year

4. Methodology and Analysis of Data

The Vehicle operation cost has been estimated for the design period of Ten years for both options under routine and active maintenance programs. Parameters considered mainly roughness, width of pavement, and rise and fall. The classification of the vehicles considered are new technology cars (NTC), two-wheelers (TW), buses, light commercial vehicles (LCV), and multi-axle heavy commercial vehicles (HCV). The width of the road has been taken 10 meters including hard shoulders in case of active maintenance program as the entire stretch was upgraded and redesigned with rehabilitation. The width of the road under routine maintenance has been considered 7meters. withgranular shoulders. The VOC has been computed by using

models developed by Dr. L.R. Kadiyali& Associates and Dr. Reddy 2003. Price rise factor 1.75 has been considered due to an increase in fuel, cost of vehicle, and spare parts in the voc calculations for RM and PM. Table2 shows the equations for vehicle operation cost in (Rupees/Km).

Table.2: Equations for vehicle operating cost (Rs/km/vehicle) Dr. Reddy 2003

Vehicle type	VOC equations
New technology cars/jeeps	Log_e VOCOBC=1.381-0.115*W+0.00008300*RG+0.01302*RF
Old technology cars	Log_e VOCOBC=1.666-0.134*W+0.00008789*RG+0.01145*RF
LCV	Log_e VOCLCV=2.143—0.039*W+0.00002668*RG+0.01323*RF
Buses	Log_e VOCBUS=2.135-0.070*W+0.00004553*RG+0.01208*RF
Two-Wheelers	Log_e VOCTW=0.452-0.13*W+0.0000111*RG+0.01473*RF
HCV 2-axle	Log_e VOCHCV=2.472-0.065*W+0.00004121*RG+0.00992*RF
HCV Multi-axle	Log_e VOCMAV=2.926-0.050*W+0.00002969*RG+0.01443*RF

W= Width of road RG= Roughness of Road RF= Rise and fall

4.1 Roughness progression model for (NH)

The road section performance is predicted by using the roughness progression model developed by (Reddy 1996) using extensive field data. The IRC:SP:16:2004 considered critical values of roughness adoptedfor the different types of surfacing. The roughness progression model is a function of initial roughness after construction, deflection, and CSA. Due to fatigue, the tope asphalt surface starts cracking with time which results in more roughness so the model also considers age as one of the parameters. Table 3 shows the model for roughness progression.

Table 3:Model for roughness progression. (Reddy 1996)

$$Uit-=UI_0[1+0.3012(N_t \text{ X } DEF_0)^{0.08\ Age}$$

Uit= Roughness at any time, UI0=Initial roughness, N_t= Cumulative traffic at any time t

[N=64, R2=0.7, S.E=0.2067]

4.2 Traffic projections for design life

Traffic volume has been projected for Indore-Betul Road NH-59A for the design life of Fifteen years from 2014 considering a growth rate of 7.5% per year as per the IRC guideline. Fig-1 shows the individual projection of different classes of vehicles graphically for the design life of the next fifteen years. Table 5 shows the pavement condition rating under preventive maintenance (PM)

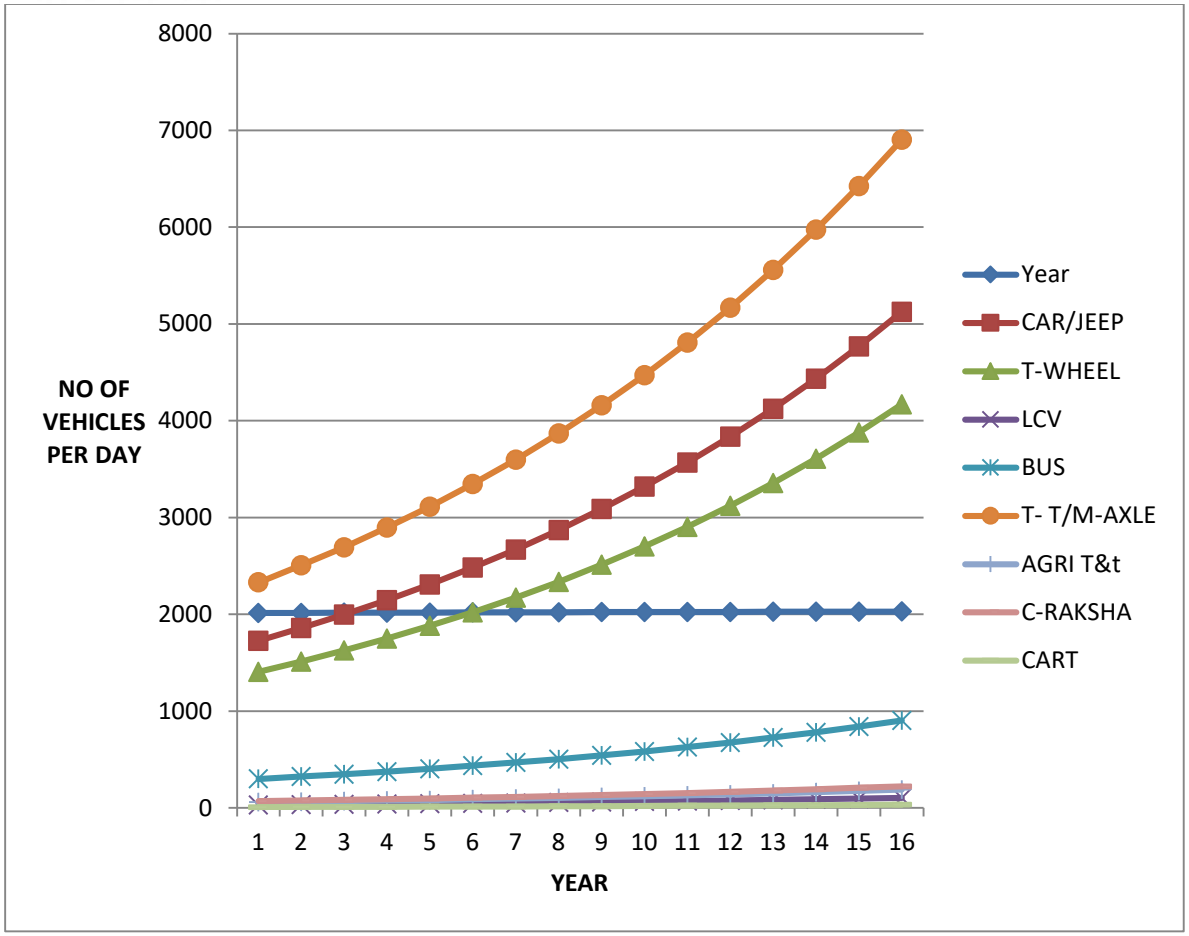

Fig.1 shows the Individual projection of different classes of vehicles graphically for the design life

4.3 Analysis for roughness progressionswith no maintenance

The selected road sections have been analyzed with two proposed periodical renewals, provided each after 5 years, whenever roughness exceeds 4000 mm/Km, with provision of 75mm DBM and 40 mm AC. BBD test was done on the entire length to know the structural strength of the road before the treatment. The roughness progression has been worked out for the design life of the proposed periodical renewal using extensive field data and traffic projections. The structural condition deterioration models were used for roughness progression. It was observed that the entire pavement is reaching to reconstruction stage in the year 2023 and structurally failed. Table4showsroughness progression under routine maintenance for periodical renewal. Fig.2shows roughness progression under routine maintenance respectively.

Table 4: Roughness progression under no maintenance

YEAR	Roughness at any time t (mm/km)
2014	1800
2015	2596.1
2016	2872.9
2017	3294.9
2018	3938.6
2019	1800
2020	2530.2
2021	2811.2
2022	3234.2
2023	3878.1
2024	4870.3

4.4 Analysis ofthe performance of proposed rehabilitated/ reconstructed pavement with continued maintenance program

Under the active maintenance program firstly entire length of 69 KM was redesigned as mentioned in the design section.An active maintenance program has been given to the entire road length throughout the design period while maintaining the roughness between 2000 mm/Km to 2500mm/Km when the road is generally in good condition, Roughness progression was controlled with the application of various active maintenance programs throughout the design life of the pavement. The roughness values related to active maintenance techniques have been referred from the Highway Research Board in October 2007.Table 5 shows roughnessfor NH 59-A under the active maintenance program. Table 6 shows a comparison between roughness progression under routine and active maintenance programs. Fig.2 shows Comparative roughness progression for routine and maintenance programs.

Table 5: Roughness and Deflection progression for NH59 A under continued maintenance program

YEAR	Roughness mm/km (PM)
2014	1800
2015	2322.5

2016	2370.5
2017	1500
2018	2013.4
2019	2000
2020	2731.14
2021	1800
2022	2355.7
2023	2364.6
2024	2000

Table 6: Comparison between roughness progression under no maintenance and active maintenance programs.

YEAR	Roughness mm/km (RM)	Roughness mm/km (PM)
2014	1800	1800
2015	2596.1	2322.5
2016	2872.9	2370.5
2017	3294.9	1500
2018	3938.6	2013.4
2019	1800	2000
2020	2530.2	2731.14
2021	2811.2	1800
2022	3234.2	2355.7
2023	3878.1	2364.6
2024	48730.3	2000

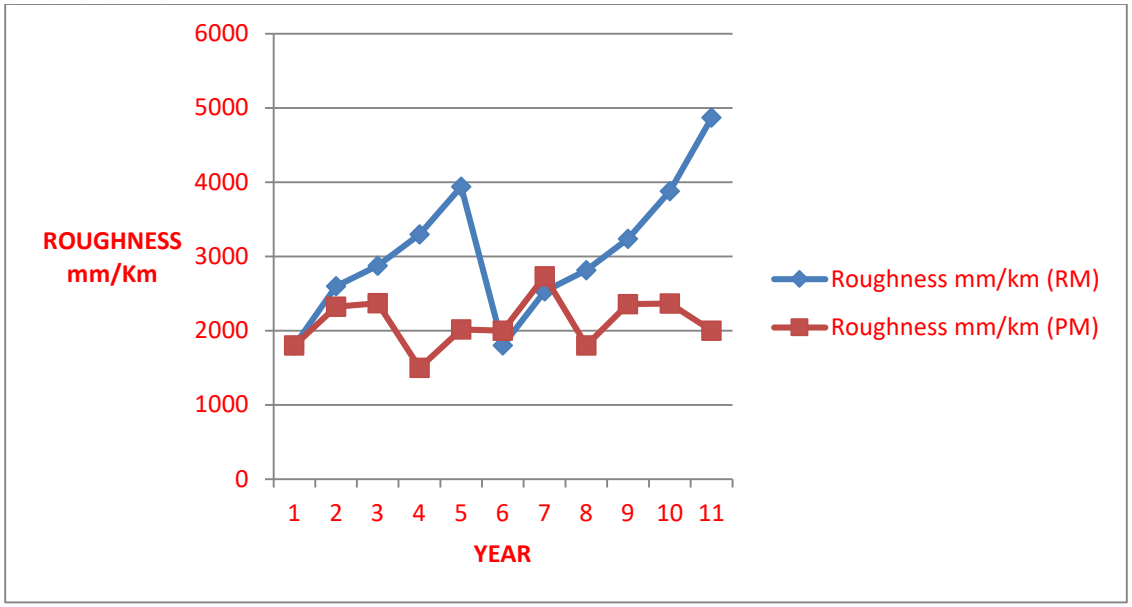

Fig.2: Comparative roughness progression for routine and active maintenance program

4. 5 Vehicle operation cost under RM and PM

The VOC has been computed by using models developed by Dr.L.R. Kadiyali& Associates and Dr. Reddy 2003. Price rise factor 1.75 has been considered due to an increase in fuel, cost of vehicle, and spare parts in the VOC calculations for RM and PM. Table 7 shows the vehicle operation cost inIndian (Rupees/Km) for two different options for different classes of vehicles for a Ten years maintenance program. Fig.3shows the graphical comparison of vehicle operation costs.

Table 7:VOC for RM and PM for various individual classes of vehicles

VOC FOR ROUTINE AND PREVENTIVE MAINTENANCE in Ten years period (unit In rupees/Km)								
ACTIVITY	CAR/JEEP	TWO WHHELER	LCV	BUS	TSAMA	AGRITT	TOTAL	TOTAL %EFFECT
RM	41855558	13314857.99	2272697.137	18690294.33	207585881	4325368.511	288044657.1	
PM	29868145	8879522.038	2032225.287	15330837.64	172950565	3867706.175	232929001.5	
RM-PM							55115655.58	19.13441344

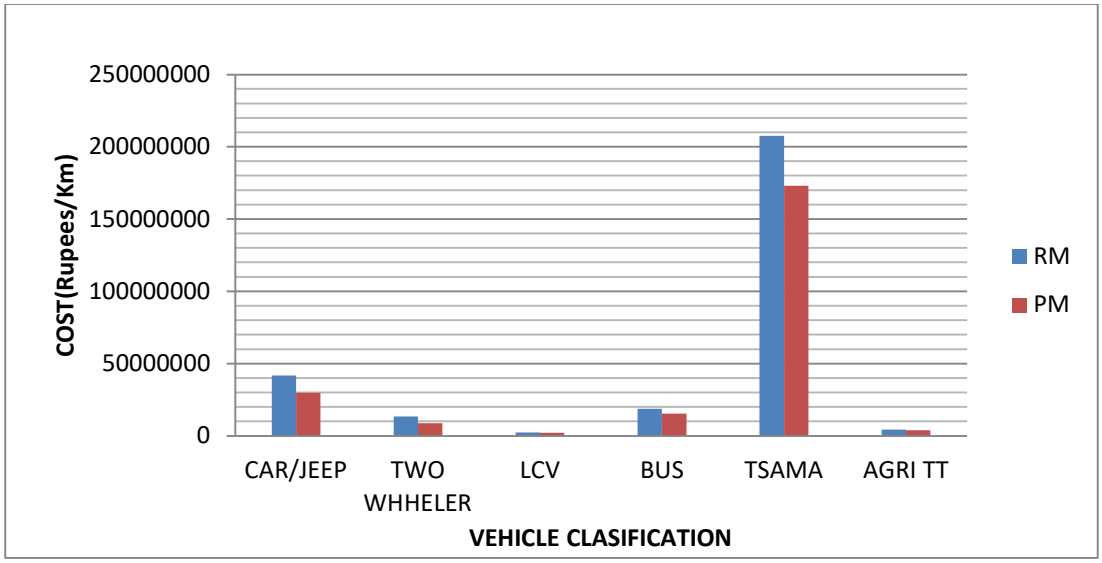

Fig. 3: Comparative vehicle operating cost under routine and active maintenance program

5. Conclusions

- The VOC under no maintenance for the design period of ten years is coming out INR 2880.44 lacs per Km,whereas,
- The study shows that roads with continued maintenance is coming out INR 2329.29 lac per Km.
- Comparative result shows that VOC for 10 year design period, under regular maintenance in comparison to periodical renewals with no maintenanceprovides a benefit of 551.156 lakh per Km to road users.
- The VOC withthe proposed active maintenance model is cost-effective by 19.133%

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