Investigating Life Cycle Cost Analysis to Identify a Sustainable Pavement Maintenance and Rehabilitation Strategy: A Case study on Ontario Highways

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ABSTRACT

Pavement maintenance and rehabilitation (M&R) are the most critical and expensive components of infrastructure asset management. Increasing traffic load, climate change, and resource limitations for road maintenance accelerate pavement deterioration and eventually increase the need for future maintenance. Consequently, pavement management programs are becoming increasingly complex. The complexities are attributed to the realistic prediction of pavement service life. As such, identification of associated sustainable M&R treatments is complicated in pavement management systems (PMS). The objective of this study is aimed at identifying sustainable M&R treatments by predicting service life in a realistic way and investigating life cycle cost analysis (LCCA). At first, the service life of pavement and the distresses are predicted by considering all variables (traffic, climate, materials' properties) affecting pavement with the application of the mechanistic-empirical approach. From the predicted distresses, the overall condition of the pavement and deterioration pattern is assessed by regression analysis. Finally, a LCCA is carried out for a period of forty years for alternate resurfacing options. Comparison of net present worth (NPW) of the alternative treatment options reveals that the resurfacing of pavement with dense friction course (DFC) and hot laid -1 (HL1) are more cost-effective than other alternative options.

Key Words: Pavement Condition Index (PCI), maintenance and rehabilitation (M&R), life cycle cost analysis (LCCA).

1. INTRODUCTION

Transportation agencies spend billions of dollars on infrastructure asset management every year. The American Society of Civil Engineers (ASCE) graded the U.S. pavement infrastructure as the top infrastructure concern and estimated $91 billion budget is scheduled to maintain the pavements but there is still a shortfall annually (ASCE 2013). Identification and implementation of cost-effective practices to preserve the huge investment made in the highway infrastructure is always challenging for highway agencies. In Canada, there is no common convention for classifying pavement maintenance and rehabilitation activities (TAC 2013). In Ontario, the Ministry of Transportation Ontario (MTO) invests about $200 million annually to ensure that the Ontario highway network is maintained above the level of serviceability required for each classified highway (Ningyuan et al. 2001). Thus, a cost-effective pavement maintenance and rehabilitation (M&R) approach is needed to allocate the budget in an efficient way. Subsequently, selection of an appropriate M&R strategy is a key aspect of the pavement management system (PMS).

Rapidly increasing traffic loading, climate change, and resource limitations for road maintenance accelerate pavement deterioration. Thus, sketching the realistic distress prediction and predicting cost-effective M&R schedules are becoming progressively more complex. Such cost-effective road maintenance practices are possible when pavement service life prediction models or deterioration condition models are accurate and realistic.

This study focuses on investigating sustainable pavement maintenance and rehabilitation strategies based on major distresses predicted by the mechanistic-empirical approach.

2. LITERATURE REVIEW

The life cycle of a typical pavement starts with initial construction and is followed by various forms of maintenance such as preventive, routine, and corrective when it is needed. Routine maintenance treatments are generally reactive and relatively inexpensive. Corrective maintenance treatments are applied to immediately address specific problems. Pavement preservation normally occurs earlier in the service life of the pavement before it has reached a limit of serviceability. Pavement rehabilitation consists of structural enhancements that improve the service life of an existing pavement as well as load-carrying capacity (TAC 2013). Commonly used routine maintenance, preservation and rehabilitation treatments for flexible pavement in Canada are listed in Table 1. However, selection of the right M&R strategy is a key step for achieving a sustainable pavement management process. It requires detailed analysis for priority selection among road sections considering cost-benefit analysis within the available budget. Recent studies on life cycle cost analysis (LCCA) were found mainly focusing on cost effectiveness.

Mandapaka et al. (2012) evaluated and selected an optimal M&R strategy for a flexible pavement road section by integrating LCCA and California Mechanistic-Empirical (CalM-E) design procedures. LCCA was carried out based on the mechanistic-empirical predicted distresses in an integrated way, which is state-of-the-art practice. However, it is found that this study is carried out for one road section for selected distresses of Mechanistic-Empirical Pavement Design Guide (MEPDG). Overall, the condition of the pavement is not considered for LCCA, which is generally used for M&R schedules. Therefore, this method for any PMS might not help based on overall performance of the road section and also for setting a priority of road sections.

De la Graza et al. (2010) developed a decision-making tool for network-level optimization for pavement maintenance programming problems through linear programming. This decision-making tool presents alternative highway maintenance strategies through an automated process in Microsoft Excel. A total of nine treatment types with unit prices are analyzed for fifteen years. However, this study focused on the budget allocation process depending on the condition of lane-mile.

Labi and Sinha (2005) investigated the cost-effectiveness of various levels of life-cycle preventive maintenance for three asphaltic concrete pavement functional class families. This study estimated cost-effectiveness using existing performance models, performance jump models, and cost models for each maintenance treatment type. However, performance jump models were based on experience.

Ningyuan et al. (2001) presented an integrated dynamic performance prediction for pavement M&R optimization methodology. This optimization model considered cost-effectiveness based on multi-year priority programming. This study selected M&R strategy based on predicted improved value of pavement condition index (PCI). Improvement of the PCI value is predicted based on the historical record of that treatment type. However, the traffic, materials, weather, and other local existing factors might have a significant influence on predicted pavement serviceability.

Whiteley et al. (2005) considered the variability associated with the discount rate and incorporated all associated variability into the LCCA of the asphalt overlay sections which are taken from the Canadian Long Term Pavement Performance (C-LTPP) project. With the LCCA values for typical design life, a sensitivity analysis was performed to evaluate the impact of 10%, 20%, and 30% differences in the in-service performance as compared to the design life. These LCCA differences were then used as a basis for establishing pay factors. However, in this study, the variability factors such as overlay thickness variation, total prior cracking variation, and accumulated Equivalent Single Axle Loads (ESALs) after eight years variation are considered in the LCCA.

From the above recent studies, it can be seen that they focussed mainly on the comparison of treatment options. However, the overall condition of pavement is neither investigated nor estimated in the LCCA. Some studies (Mandapaka et al. 2012) compared single-cracking predicted by the mechanistic-empirical approach. However, road condition assessment by using a failure trigger value of single cracking might not capture the actual overall condition of the road. This study will compare the overall condition and deterioration of pavement considering predicted distresses depending on specific materials and traffic pattern.

3. SCOPE AND OBJECTIVE OF STUDY

This study will analyse the life cycle costs of pavement considering the overall condition of the pavement and deterioration model of overall performance index depending on specific materials and traffic level. These investigations are conducted in three steps. First, distresses are predicted by the mechanistic-empirical approach. Second, the overall condition and deterioration pattern of performance indices are identified. Finally, based on the specific deterioration pattern of the performance model, LCCA is carried out depending on the properties of materials and traffic levels.

4. ROAD PERFORMANCE DATA AND SELECTED ROAD SECTIONS

This study uses historical pavement performance data which are recorded in the MTO PMS-2 database. Experimental design consists of a total of 117 highway sections (146 performance cycles) from the northern and southern Ontario. Highway sections which are considered for experimental design are listed in Table 2.

5. RESEARCH METHODOLOGY

The objective of this study is aimed at investigating the LCCA of pavement by considering (i) predicted major distresses by the mechanistic-empirical approach; (ii) traffic volume in terms of Annual Average Daily Traffic (AADT); and (iii) properties of material layers. MEPDG based distresses are predicted by using AASHTOWare Pavement-ME.

As discussed, the experimental design consists of 117 highway sections. These highway sections are investigated for a period of service life which started from new construction or overlay design and ended before applying any other treatment which improves service life. This time period is considered as one performance cycle for that specific treatment type.

After predicting the distresses, the PCI as an overall condition is anticipated from the predicted MEPDG distresses. The deterioration rate of the overall condition is found to change depending on the type of materials and AADT level. This variation of deterioration is taken into account for predicting future performance and corresponding remaining service life. LCCA is carried out by considering this variation of deterioration for materials and traffic volume. In this study, LCCA is carried out for period of 40 years.

This study is carried out into three steps. Prediction of distresses is used in the first step to illustrate the future performance and pavement service life. Since LCCA is carried out by predicting future performance for the type of treatment applied, it is imperative to predict the deterioration of pavement in a precise way by considering properties of materials and traffic level as well. In the second step, the overall condition of pavement is assessed from the predicted distresses. In third step, based on the predicted future performance, the LCCA is calculated for a period of 40 years. The steps utilized in this methodology are presented in Figure 1.

5.1. Investigation of the overall Condition of Road based on MEPDG Distresses

Performance improvements or treatment effects on overall condition index for typical pavement rehabilitation activities are mainly based on experience or engineering judgment (Ningyuan et. al 2001). The mechanistic-empirical approach will predict the future distresses by considering properties of materials to be used, existing condition of pavement and all other local factors. The major distresses for flexible pavements are : (i) Terminal International Roughness Index (IRI); (ii) total permanent deformation or rut depth, (iii) total cracking (reflective + alligator); (iv) Asphalt Concrete (AC) bottom-up fatigue cracking; (v) AC top-down fatigue cracking ; and (vi) Permanent deformation – AC only.

Prediction of distresses is considered in the first instance on the understanding of the overall condition of the pavement. It is realized that failure of any certain distress is not a main maintenance driver on the Ontario highway networks, but the overall condition would therefore be more meaningful for the assessment of the condition. First, highway sections are investigated for future performance and service life. Failure road sections are also further investigated.

On Ontario highways, PCI is used generally as an overall index in the pavement M&R decision tree. PCI is calculated from the deterioration condition measured by the three components: IRI, rut depth, and Distress Distress Manifestation Index (DMI). In this study, IRI, rut depth, and DMI are considered as independent variables to estimate PCI based on the predicted MEPDG based distresses. DMI and PCI models are estimated by regression analysis and results are found as:

$$DMI = 7.741 + 2.344\, Scaled\ Bottom\ up\ Fatigue\ Cracking + 0.671\, Scaled\ Top\ Down\ Fatigue\ Cracking + 0.46 Scaled\ Thermal\ Cracking \quad [1]$$

Where,
DMI =Distress Manifestation Index
Scaled Bottom up Fatigue Cracking = Predicted Bottom up Fatigue Carking / 25, in %
Scaled Top Down Fatigue Cracking = Predicted Top Down Fatigue Cracking /378.80, in m/km
Scaled Thermal Cracking = Predicted Thermal Cracking / 189.40, in m/km

$$PCI = 62.621 - 32.19\ Scaled\ IRI - 16.13\, Sacled\ Rut\ Depth + 4.644\, DMI \quad [2]$$

Where,
PCI =Pavement Condition Index
Scaled IRI= Predicted Terminal IRI/2.30, in m/km
Scaled Rut Depth = Predicted Rut Depth/ 19.0, in mm

5.2. Investigation of Deterioration Pattern of Overall Condition depending on Traffic Level

The deterioration pattern of the overall pavement condition is assessed by a general sigmoidal form, with different model coefficients (Ningyuan et. al 2001):

$$P = P_0 - 2e^{(a-bc^t)} \quad [3]$$

Where,
P = performance index
P_o = P at age 0
t = log e(1/Age)
a,b,c = model coefficients

In this study, it is found that the deterioration pattern of condition index is varied in different rates depending on types of materials and AADT levels. For this reason, pavement sections are analysed based on pavement surface layer and traffic levels.

In this study, most of the road sections were observed to service a high traffic volume. The AADT of the highways were found to vary between 9,965 to166,353. Also, a yearly growth rate of AADT is observed as a compound factor and varies between 0.02 to 19.54. Since the highway sections consist of high traffic volume, the AADT is categorized into three levels which are shown in Table 3.

5.3. Investigation of Deterioration of Pavement depending on Materials' Properties

From the PMS-2 database, historical pavement structure layers are investigated. Since AASHTOWare Pavement-ME software analyses only overlay of the M&R design, this study considers overlay design. The pavement structure of the selected road sections is mainly found as overlay design with Dense Friction Course (DFC) and Hot Laid (HL) surface. Average thickness, average service life, and initial PCI values are investigated for all types of pavement layers. These are summarized in Table 4. Pavement performance is investigated in terms of deterioration of overall condition by considering the materials' properties of the surface layer, and their different ranges of AADT levels. The deterioration of PCI is estimated by regression analysis by considering the year of service as an independent variable. Finally, based on the material properties of the top surface layer and there different ranges of AADT level, the deterioration pattern of condition index is listed in Table 5.

5.4. Investigation of LCCA

Since the deterioration of the overall condition has a variation on the road segment depending on the types of AC layer and AADT levels, it will impact the maintenance decision and scheduling. For this reason, LCCA is carried out by considering this variation due to types of pavement layer and AADT levels. In this study, LCCA is carried out for a period of 40 years. In this study variation of layer thickness is not taken into consideration as layer thickness was not found varying to a large scale. Unit costs of materials that are used in this study are shown in Table 6.

For empirical investigations, a typical pavement structure is considered which consists of a one kilometre length section with 3 lanes in each direction (average 3.65m width for each lane). The thickness of a specific layer is taken from the average thickness shown in Table 4. A sample cost estimation for a typical pavement structure is shown in Table 7.

Net present worth (NPW) is compared for each alternative overlay layer for a period of 40 years life span. NPW is calculated following equation (TAC 2013):

$$NPW = IC + \sum_{i=1}^{k} M\&R_j \; \left(\frac{1}{1+i_{discount}}\right)^{nj} - sv \; \left(\frac{1}{1+i_{discount}}\right)^{AP} \quad [4]$$

Where,

NPW= Net Present Worth ($)

IC= Initial Cost ($)

k= Number of future maintenance, preservation and rehabilitation activities

$M\&R_j$= Cost of j^{th} future maintenance, preservation and rehabilitation activities ($)

$i_{discount}$= Discount Rate

n_j= Number of years from the present of the j^{th} future maintenance , preservation or rehabilitation treatments

SV= Salvage Value

AP= Number of years in analysis period

In this study, a discount rate of 5% is used and the salvage value is not taken into consideration. The PCI value is considered as a trigger level for maintenance when it becomes 65 or less. LCCA results are summarised in Table 8.

6. DISCUSSION ON RESULTS

DMI and PCI are estimated from the MEPDG based predicted distresses by using regression analysis. For DMI, it is found that a bottom-up fatigue cracking has more weighing than the top-down fatigue cracking and thermal cracking. In the PCI model, IRI, and rut depth have more weighing than the DMI.

From Table 5, it is found that the deterioration pattern of PCI varies depending on types of pavement layers and AADT levels.

As one would expect from the variation of deterioration, certain materials are more appropriate than others, however, the unit price and thickness might have a significant impact on LCCA also. With the LCCA, the existing pavement surface is considered to be resurfaced when it is required and an alternate resurface layer is selected from DFC, HL1, HL3, HL4, and HL8.

From Table 8, a comparison of NPW among alternative treatment options reveals that the resurfacing of pavement with DFC and HL1 are more cost-effective than other resurfacing options. For AADT ≤25,000, resurfacing with DFC and HL1 are both found as cost-effective treatment options. However, for AADT >25,000 to ≤ 500,00, and >50,000 resurfacing with DFC is found as a cost-effective treatment option.

7. CONCLUSIONS

This study investigates LCCA by considering the overall condition of pavement (in terms of PCI) which is estimated from the MEPDG based predicted distresses. Experimental investigations include assessment of overall condition in terms of DMI and PCI. The deterioration pattern of PCI was found to vary depending on the type of materials and AADT levels.

A comparison of NPW among the alternative treatment options reveals that the resurfacing of pavement with DFC and HL1 are more cost-effective than other alternative options.

Resurfacing with DFC and HL1 are both cost-effective treatment options for highway sections with AADT ≤25,000.

Resurfacing with DFC is a cost-effective treatment option for highways with higher AADT (>25,000 to ≤ 50000, and >50,000).

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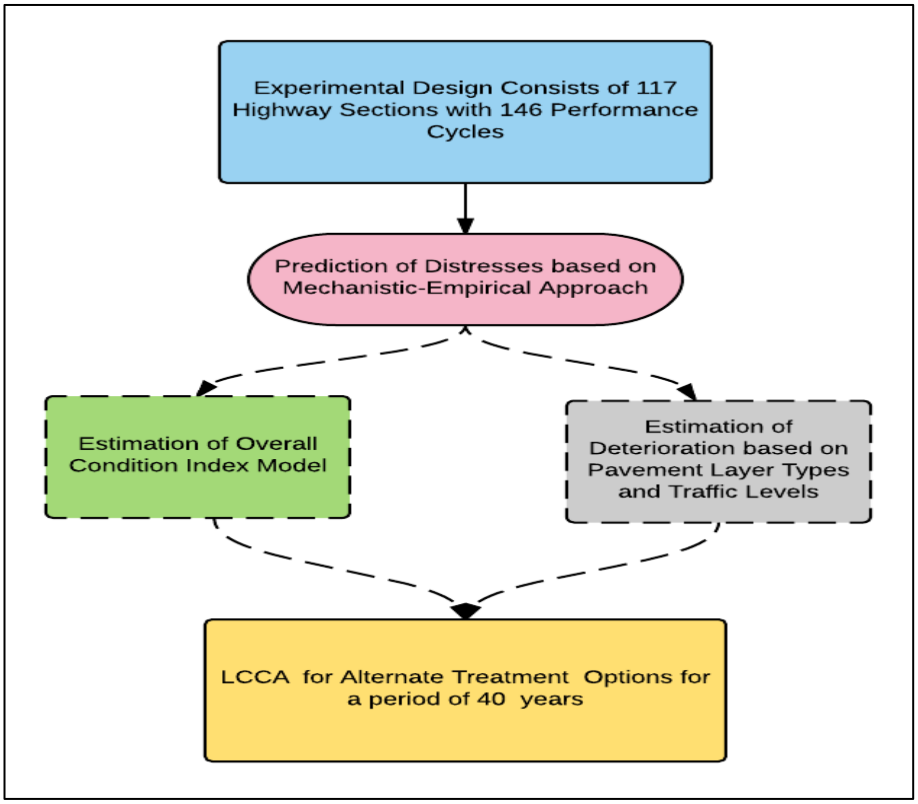

Figure 1: Steps in Methodology

Table 1: Commonly used Routine Maintenance, Preservation and Rehabilitation Treatments for Flexible Pavements (TAC 2013)

Action Type	Treatments for Flexible Pavement
Routine maintenance	Pothole repair
	Shallow Patching
	Drainage Improvement
Preservation	Crack Sealing
	Spray Patching
	Full Depth Patching
	Hot-in Place Recycling Thin Asphalt Overlay
	Resurfacing Functional
	Milling and Resurfacing-Functional
	Bonded Concrete Overlay
	Slurry Sealing
	Seal Coat
	Micro-surfacing
Rehabilitation	Resurfacing –Structural
	Milling and Resurfacing-Structural
	Cold In-Place Recycling
	Bonded Concrete Overlay
	Un-Bonded Concrete Overlay
	Full Depth Reclamation

Table 2: Selected Highway Sections for Experimental Investigation

Location	Type of Highways	Layer	Number of Highway Sections	Number Performance Cycle
Northern Ontario	Freeway	HL1	5	7
		HL3	5	7
		HL3M	5	11
		HL4	3	3
		RHL	3	3
	Arterial	HL1	1	1
		HL4	1	1
	Sub Total Northern Ontario		***23***	***33***
Southern Ontario	Freeway	HL1	18	22
		HL3	3	4
		HL3M	2	2
		HL4	3	3
		DFC	49	60
		HDB	2	2
		HL8	1	1
		MDB	1	1
		Superpave	1	2
	Arterial	HL1	10	12
		HL3	1	1
		HL4	1	1
		HL4	1	1
		HL8	1	1
	Subtotal Southern Ontario		***94***	***113***
Total			***117***	***146***

Table 3: Traffic Category used in Study

Category	AADT
Low High	≤25,000
Medium High	>25,000 to ≤ 50,000
Highly High	>50,000

Table 4: Materials' Thickness, Service Life and Initial PCI Value

Material Type	Thickness		Service Life Span before any treatment, in year		Initial PCI value	
	Average in mm	Standard Dev. in mm	Average	Standard Dev.	Average	Standard Dev.
DFC[1]	40.19	1.995	7.78	2.71	91	5.83
HL1[2]	40.24	1.543	9.05	3.65	89	6.99
HL3	41.67	3.892	8.83	3.88	89	5.88
HL3M	41.15	6.504	8.23	3.75	91	5.52
HL8	58.00	25.456	4.50	0.71	93	5.30
HL4	41.25	3.536	8.25	3.65	89	8.19

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[1] DFC= Dense Friction Course

[2] HL= Hot Laid Asphalt and number refers to mix design

Table 5: Deterioration Pattern of PCI based on Materials and AADT

Surface Material Type	AADT	Deterioration Equation of PCI
DFC	≤25,000	$y = 91.5e^{-0.014x}$[3]
	>25,000 to ≤ 50,000	$y = 91.5e^{-0.017x}$
	>50,000	$y = 91.5e^{-0.019x}$
HL1	≤25,000	$y=90e^{-0.013x}$
	>25,000 to ≤ 50,000	$y = 90e^{-0.018x}$
	>50,000	$y = 90e^{-0.027x}$
HL3	≤25,000	$y = 93e^{-0.016x}$
	>25,000 to ≤ 50,000	$y = 93e^{-0.020x}$
	>50,000	$y = 93e^{-0.030x}$
HL4	≤25,000	$y = 89e^{-0.026x}$
	>25,000 to ≤ 50,000	$y = 89e^{-0.027x}$
	>50,000	$y = 89e^{-0.030x}$
HL8	≤25,000	Not available
	>25,000 to ≤ 50,000	$y = 91e^{-0.055x}$
	>50,000	Not available
HL3M	≤25,000	$y = 91e^{-0.015x}$
	>25,000 to ≤ 50,000	Not available
	>50,000	

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[3] X= year of service life

Table 6: Costs of Materials used in Study

Pavement Material	Quantity(Tonnes)	Average Costs ($)	Standard Deviation
Granular A	0 -1,000	27.89	14.2
	1,000 – 10,000	14.4	3.8
	10,000 -100,000	10.79	2.5
	100,000+	9.22	1.9
Granular B	0 -1,000	10.29	2.9
	1,000 – 10,000	8.98	2.5
	10,000 -100,000	7.16	1.9
	100,000+	5.58	1.3
HL1	0-1,000	97.12	45.2
	1,000-10,000	58.96	10.6
	10,000+	46.49	4.5
HL3	0-1,000	140.15	120.3
	1,000-10,000	74.89	48
	10,000 – 100,000	87.7	73.1
	100,000+	46.83	8.9
HL4	0-1,000	118.31	56.27
	1,000-10,000	109.35	53
	10,000 – 100,000	56.5	18.8
	100,000+	43.62	7.5
HL8	100-1,000	62.9	18
	1,000-5,000	45.17	6.01
	5,000+	38.18	4
HDBC	0-1,000	69.08	15.4
	1,000-5,000	51.14	11.7
	5,000+	43.73	6.6
DFC	0-1,000	85.94	27.3
	1,000-5,000	65.57	9.3
	5,000+	59.32	9.4
Cold In Place Recycled Mix	10,000+	4	1.1
Rout and Seal	100-1,000	7.24	2.8
	1,000-15,000	4.27	4.6
	100,000+	1.1	0.2
Removal Asphalt Partial Depth	0-1,000	10.82	5.1
	1,000-10,000	4.1	2.3
	10,000-100,000	2	1.2
	100,000+	1.19	0.4

Table 7: Cost Estimation for Sample Typical Pavement Structure

Initial Construction	Thickness in mm	Length in m	Width in m	Lanes	Volume	Unit w Wt., t/m3	Total Amount, ton	Cost, $/ton	Activity Cost, $
DFC	40	1,000	3.65	3	438.00	2.4	1,051.20	85.94	90,340.13
Granular A -150 mm	150	1,000	3.65	3	1,642.50	2.2	3,613.50	14.4	52,034.40
Granular B - 450 mm	450	1,000	3.65	3	4,927.50	2.2	10,840.50	8.98	97,347.69
								Total	**239,722.22**

Table 8: Summary of LCCA

		Option 1: Resurface with DFC		Option 2: Resurface with HL1		Option 3: Resurface with HL3		Option 4: Resurface with HL4		Option 5: Resurface with HL8		Cost Effective Option
Existing Material Type	AADT Range	Activity	Total NPW ($)	Activity	Total NPW ($)	Activity	Total NPW ($)	Activity	Total NPW ($)	Activity	Total NPW ($)	
DFC	≤25,000	DFC on 24th year along with Rout Seal every 3rd year	267,987	HL1 on 24th year along with Rout Seal every 3rd year	271,590	HL3 on 24th year along with Rout Seal every 3rd year	285,615	HL4 on 24th year and 36th along with Rout Seal every 3rd year	326,978			Option1
	>25,000 to ≤ 50,000	DFC on 21st year along with Rout Seal every 3rd year	272,400	HL1 on 21st year, HL8 on 40th year, along with Rout Seal every 3rd year	283,405	HL3 on 21st and 33rd year along with Rout Seal every 3rd year	322,251	HL4 on 21st year and HL8 on 36th year; along with Rout Seal every 3rd year	296,453	HL8 on 21st year, 28th and 35th along with Rout Seal every 3rd year	294,682	Option1
	>50,000	DFC on 18th and 36th year along with Rout Seal every 3rd year	293,023	HL1 on 18th year, 31st year, along with Rout Seal every 3rd year	304,847	HL3 on 18th and 30th year along with Rout Seal every 3rd year	335,225	HL4 on 18th year and 29th year on 36th year; along with Rout Seal every 3rd year	343,466			Option1
HL1	≤25,000	DFC on 26th year along with Rout Seal every 3rd year	280,369	HL1 on 26th year, along with Rout Seal every 3rd year	280,402	HL3 on 26th year along with Rout Seal every 3rd year	293,124	HL4 on 26th year and 39th year ; along with Rout Seal every 3rd year	329,295			
	>25,000 to ≤ 50,000	DFC on 19th year and HL8 on 40th year; along with Rout Seal every 3rd year	297,220	HL1 on 19th year, HL8 on 38th year along with Rout Seal every 3rd year	302,951	HL3 on 19th year and HL8 on 37th year; along with Rout Seal every 3rd year	321,307	HL4 on 19th year and 31st year ; along with Rout Seal every 3rd year	302,702	HL8 on 19th, 26th, 33th and 40th along with Rout Seal every 3rd year	321,838	Option1

		Option 1: Resurface with DFC		Option 2: Resurface with HL1		Option 3: Resurface with HL3		Option 4: Resurface with HL4		Option 5: Resurface with HL8		Cost Effective Option
Existing Material Type	**AADT Range**	**Activity**	**Total NPW ($)**	**Activity**	**Total NPW ($)**	**Activity**	**Total NPW ($)**	**Activity**	**Total NPW ($)**	**Activity**	**Total NPW ($)**	
HL3	>50,000	DFC on 13th year and 31st year; along with Rout Seal every 3rd year	319,489	HL1 on 13th year, 26and 39th year along with Rout Seal every 3rd year	338,464	HL3 on 13th year, 25th and 37th year; along with Rout Seal every 3rd year	397,536	HL4 on 13th year, 24th and 35th year ; along with Rout Seal every 3rd year	378,741			Option1
	≤25,000	DFC on 23rd year; along with Rout Seal every 3rd year	330,160	HL1 on 23rd year along with Rout Seal every 3rd year	330,160	HL3 on 23rd year; along with Rout Seal every 3rd year	344,887	HL4 on 23rd year, and 36th year ; along with Rout Seal every 3rd year	386,768			
	>25,000 to ≤ 50,000	DFC on 18th year;HL8 on 39th year along with Rout Seal every 3rd year	344,723	HL1 on 18th year, HL8 on 37th year along with Rout Seal every 3rd year	350,658	HL3 on 18th year; HL8 on 36th year along with Rout Seal every 3rd year	370,012	HL4 on 18th year, and 30th year ; along with Rout Seal every 3rd year	377,358	HL8 on 18th, 25th, 32nd and 39th along with Rout Seal every 3rd year	370,549	Option 1
	>50,000	DFC on 12th year and 30th year along with Rout Seal every 3rd year	368,094	HL1 on 12th year,25th, and 38th year along with Rout Seal every 3rd year	399,887	HL3 on 12th year; 24th and 36th year along with Rout Seal every 3rd year	450,043	HL4 on 12th year, 23rd and 34th year ; along with Rout Seal every 3rd year	430,339			Option1