The Economics of Flexible Pavement Preservation

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ABSTRACT

The California Department of Transportation (Caltrans) pavement preservation treatment costs presented in their Maintenance Technical Advisory Guide (MTAG) for flexible pavement was used as a basis for estimating the impact of project size, restricted construction work times, and delays in placing treatments. The impact of these factors were calculated as a percent change in costs, which assumes the relative percent differences between options will remain more consistent that oil prices.

The results show that increasing the size of projects from one to two days of work to more than one week of work can result in a reduction in the dollars per square yard cost of from 15 to 43%, depending on the type of preservation treatment. Thin overlay (non-structural) pavement preservation treatments placed in urban areas will likely be placed at night and under construction time restrictions. The standard cost of these treatments should be routinely increased by 22 to 25% to account for the restricted work premium. Delaying pavement preservation by applying a treatment on an existing pavement with a PCI of 60 instead of 80 will result in an increase in equivalent annual treatment costs between about 70 to 100%. Delaying the application of the treatment to an existing pavement condition of 40 will result in an increase in the equivalent annual treatment cost of about 300%.

KEYWORDS: Pavement preservation, life cycle cost, pavement management systems

INTRODUCTION

Pavement management started with the recognition that agencies needed to measure the condition of the pavement so that maintenance and rehabilitation decisions could be prioritized more effectively (Finn 1997). By 1980, only five states (Arizona, California, Idaho, Utah, and Washington) were in the process of developing systematic procedures for managing maintenance of pavement networks on a project by project basis (Finn, 1997). While all United States (US) agencies now have a pavement management system (PMS), these decision making tools have not historically been used for managing pavement preservation activities. The main impediments to using the pavement condition data contained in a PMS for pavement preservation are the lack of guidance available for users on: typical costs of the wide range of materials and treatments available for pavement preservation, estimated treatment life, and the impact of the condition of the existing pavement surface on the life of each treatment.

In 2001, Caltrans initiated the development of the Maintenance Technical Advisory Guide (MTAG) for flexible pavement as a means of providing technical and uniform guidance to Caltrans personnel. Since the goal of the guide was to provide an evolving document which represents the most current technical expertise and innovative ideas in pavement preservation, Caltrans established the Pavement Preservation Task Group (PPTG). The PPTG is a dynamic partnership between Caltrans, regional and local agencies, industry, and academia to assist with the development and continual review of the guide. The flexible pavement PPTG is divided into 15 subtask groups covering a wide range of topics including: project selection strategy, binders, chip seals, crack seals and joint re-sealing, education, spray seals (fog and rejuvenating), innovative materials and processes, pavement management systems for pavement preservation, pavement management for local agencies, interlayers, patching and repairs, recycling, slurry seals and microsurfacing, thin overlays (non-structural), and warranties. The membership of each subtask group is comprised of topic-specific experts and stakeholders from state, regional and local agencies as well as from industry including materials suppliers, industry organizations, and contractors.

The first edition of the flexible pavement MTAG was produced in 2003 and after review, the Federal Highway Administration (FHWA) decided to develop a web site for sharing the knowledge contained in this guide. The second edition of the MTAG, issued February 2008, consists of thirteen chapters devoted to the identification of flexible pavement distresses, materials commonly used in both the original construction of hot mix asphalt (HMA) pavements and preservation treatments for HMA, treatment selection, and specific information on a wide range of preservation treatments. Also contained in this guide are consensus-developed estimates of ranges of costs for pavement preservation treatments by typical project size, construction project constraints as well as anticipated treatment life depending upon the condition of the existing pavement prior to treatment.

The MTAG data were used to develop economic comparisons of various pavement preservation treatments based on the size of the projects, the time of day for construction, the anticipated length of the work window, and the condition of the roadway when the treatment is applied. Additionally, a table included in the MTAG training materials was used to provide consensus estimates of the life of selected treatments when placed on existing pavements with three levels of pavement condition index (PCI) values (40, 60, and 80 PCI). This information was used to estimate the relative cost of delaying pavement preservation treatments

The objectives of this analysis were to use the MTAG data to:

- Assess the impact of project size, construction restrictions (e.g., nighttime paving, limited time roadway access), and delays in applying treatments.
- Provide pavement management administrators with a simple method of adjusting pavement preservation strategy budget forecasts

The MTAG treatment selection tables contain estimates of historical costs and estimates of treatment life for a range of flexible pavement preservation treatments. While the costs of paving materials are currently increasing at previously unheard of rates, the assumption of this analysis is that comparisons of percent changes rather than actual costs will provide a reasonable means of estimating the relative impact of various factors on treatment costs.

MTAG DATA BACKGROUND

Table 1 shows the relevant excerpt from the MTAG flexible treatment matrix (Caltrans 2008) that was used for this analysis. The pavement preservation treatments in this table represent those treatments currently used by Caltrans. The consensus-derived cost range estimates are based on the size of the project. There are no cost estimates for several types of treatments on higher traffic volume facility treatments. This is because these construction processes are not commonly used in these cases. While there is no formal definition of small, medium and large projects in the MTAG manual, reasonable definitions of these designations are:

- A small project is one that lasts for about one to two days of work.
- A medium project takes about three to five days of work to complete
- A large project requires the contractor to be on site for more than one week

Table 1 also contains estimates of premium charges associated with night time and limited facility access (short duration) conditions. Almost all of the cost estimates include a range of costs (low and high) for each type of treatment.

Table 1. Excerpts from the MTAG Table 3-4 (Caltrans 2008).

Preventative Treatment		Treatment Costs,$/sq yd (Treatment Only)									
		Large Projects		Medium Projects		Small Projects		Additional Premium for night work		Additional premium for short work periods or work zones	
		Low	High	Low	High	Low	High	Low	High	Low	High
Crack Sealing	Emulsion	$0.50	$0.65	$0.60	$0.75	$0.70	$0.85	$0.15	$0.20	$0.60	$1.00
	Modified (Rubber)	$0.66	$0.70	$0.65	$0.80	$0.75	$0.90	$0.15	$0.20	$0.60	$1.00
Seal Coats	Fog Seal	$0.15	$0.30	$0.15	$0.30	$0.15	$0.30	$0.05	NA	$0.10	NA
	Rejuvenator	$0.20	$0.50	$0.20	$0.50	$0.20	$0.50	$0.10	NA	$0.20	NA
	Scrub Seals	$2.15	NA	$2.15	NA	$2.15	NA	NA	NA	NA	NA
Slurry Seals	Type II	$1.60	$2.20	$1.75	$2.40	$1.90	$2.60	NA	NA	$0.30	NA
	Type III	$1.60	$2.00	$1.75	$2.40	$1.90	$2.60	NA	NA	$0.30	NA
	REAS	$1.20	$1.80	$1.20	$1.80	$1.20	$1.80	NA	NA	$0.30	NA
Microsurfacing	Type II	$2.00	$2.80	$2.10	$2.90	$2.25	$3.00	$0.10	$0.20		
	Type III	$2.00	$2.80	$2.10	$2.90	$2.25	$3.00	$0.10	$0.20	NA	NA
Chip Seal	PME - Med. Fine	$1.80	$2.00	$2.25	$2.75	$3.00	$3.50	NA	NA	$0.50	$1.00
	PME - Medium	$1.80	$2.00	$2.25	$2.75	$3.00	$3.50	NA	NA	$0.50	$1.00
	PMA - Medium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	PMA - Coarse	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	AR - Medium	$3.75	$4.55	$4.00	$4.75	$4.25	$5.00	NA	NA	$0.50	$1.00
	AR - Course	$3.75	$4.55	$4.00	$4.75	$4.25	$5.00	NA	NA	$0.50	$1.00
Cape Seals	Slurry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Micro	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PM Alternative (> 30,000 ADT)	PBA-OGAC	$8.0	$12.0	$8.0	$14.0	$10.0	$16.0	NA	NA	$1.20	$4.00
	RAC-O	$10.0	$14.0	$10.0	$14.0	NA	NA	NA	NA	$1.50	$3.50
	RAC-O-HB	$10.0	$14.0	$10.0	$14.0	NA	NA	NA	NA	$1.50	$3.50
	RAC-G	$10.0	$14.0	$10.0	$14.0	NA	NA	NA	NA	$1.50	$3.50
	PBA-G	$8.0	$12.0	$8.0	$14.0	$10.0	$16.0	NA	NA	$1.20	$4.00
	BWCR	$10.0	$14.0	$10.0	$14.0	NA	NA	NA	NA	$1.50	$3.50
	BWC-RAC-O/G	$10.0	$14.0	$10.0	$14.0	NA	NA	NA	NA	$1.50	$3.50

REAS: Rubberized emulsion asphalt slurry
AR: Asphalt Rubber
PME: Polymer modified emulsion
OGFC: Open graded friction course
PMA: Polymer modified asphalt
RAC: Rubberized asphalt concrete
BWCR: Bonded wearing course rubber
RAC-O: Rubberized asphalt concrete, open graded
RAC-O-HB: Rubberized asphalt concrete, open graded, high binder
RAC-G: Rubberized asphalt concrete, gap graded
NA: Not available

ANALYSIS OF PAVEMENT PRESERVATION ECONOMICS

The following analyses are based on the high estimation of costs for a given type of treatment.

Impact of Project Size, Construction Restrictions, and Delays on Treatment Costs

Project Size Cost

Figure 1 shows the cost estimate for 15 treatments applicable for Caltrans small projects. Crack sealing (average \$0.87/yd^2) and spray applied seals (fog and rejuvenator, average \$0.40/yd^2) have the lowest costs. The next, and largest, group of treatments is seal coats (average \$3.33/yd^2). This group includes various types of slurry seals, microsurfacing, and chip seals. Cape seals can be used on Caltrans jobs; however the limited use of this treatment resulted in no consensus of typical costs. The last group of treatments includes the thin overlays (non-structural) alternatives to seal coats for higher traffic volume roadways (\$16.00/yd^2). It should be noted that that the PPTG considered most of the thin overlay options infrequently used for small projects, which is why they are not included in Figure 1.

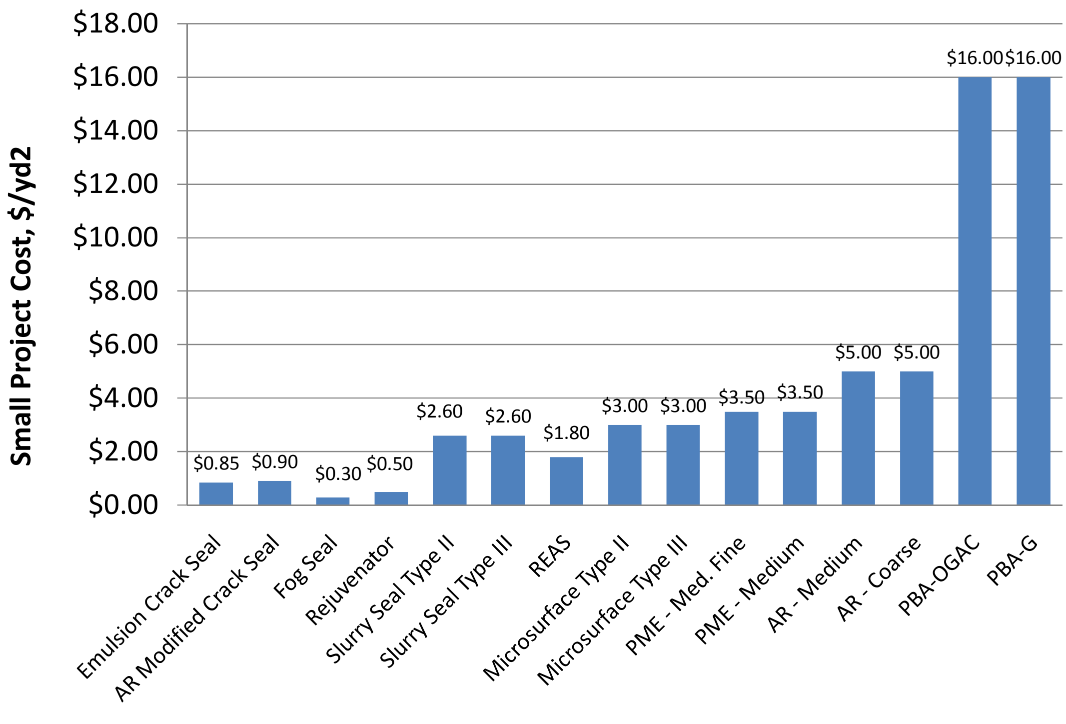

Figure 1. Estimated upper cost for each type of preservation treatment for small size construction projects.

The percent reduction in the project cost by increasing the size of the project from small to medium and from small to large is shown in Figure 2. Only the spray applied seals and the REAS costs are not impacted by increasing the size of the project. The PME chip seals save less than 10% by increasing the project size. Crack sealing costs decrease by 14% and 23% by increasing the project size to medium and large, respectively. A smaller savings (11 to 15%) is achieved by increasing project size for the slurry seal type II. More of a cost savings is realized when using a slurry seal type III on large projects (23%). The best cost reduction due to an increase in project size is obtained when placing either a type II or type III microsurfacing. There is a 25% reduction in cost for increasing to medium size projects and 43% reduction for increasing to large projects.

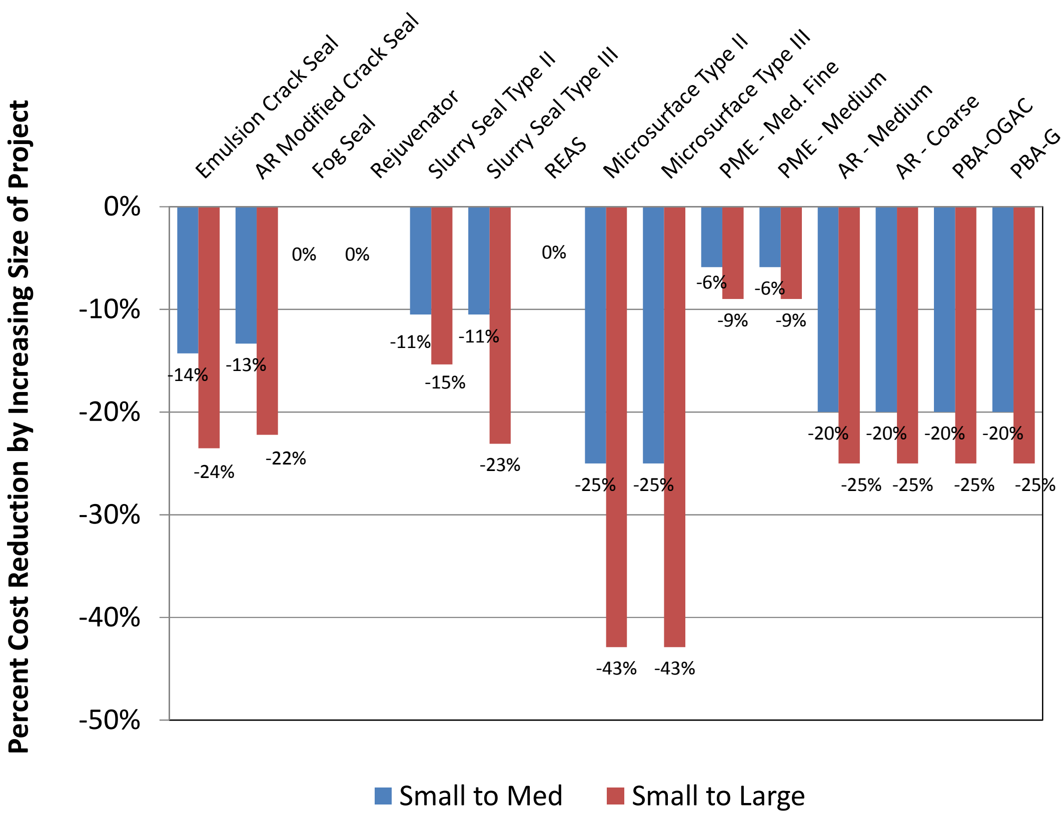

Figure 2. Reduction in treatment cost achieved by increasing the size of the treatment project.

The AR chip seals and the PMA open- and gap-graded thin overlays show similar anticipated cost reductions of 20% for medium and 25% for large projects. Given that the thin overlay treatments cost significantly more than the chip seals, the dollar savings for increasing the size of the thin overlay projects is significantly more than for the chip seals. That is, a 25% reduction is $4/yd^2 for the $16/yd^2 thin overlay will have a more significant budget impact than saving $0.83/yd^2 for the $3.30/yd^2 AR chip seal.

This type of economic information can be used for encouraging local agencies to partner when bidding work for the same pavement preservation treatment in a common geographic location. It can also be used to help local agencies decide when there is either no or limited economic advantage to partnering. For example, there will likely be only a limited cost saving for increasing the project size through partnering for the spray seals, REAS or PME chip seal treatments. Partnering to increase the project size to several weeks of work for the contractor will likely result in a cost saving of between 15 and 25% for slurry seals, crack sealing, AR chip seals, and thin overlay treatments. The best cost saving is realized by partnering to increase the weeks of work for the microsurfacing treatments. Delaying the application of a treatment until a larger quantity of roads in need of treatment within a given agency should ***NOT*** be considered a good option (see Treatment Delay Costs) for increasing project size.

Table 2. Treatment cost reduction achieved by increasing the size of the project.

Treatment Type	Cost Reduction by Increasing to Medium Size	Cost Reduction by Increasing to Large Size
Spray Seals*	0%	0%
REAS	0%	0%
PME Chip Seal	6%	9%
Slurry Seals – Type II	11%	15%
Slurry Seals – Type III	11%	23%
Crack Sealing	14%	23%
AR Chip Seal	20%	25%
Thin Overlay – PBA Open and Gap Graded	20%	25%
Microsurfacing	25%	43%

*Fog and rejuvenator

Construction Restrictions

Crack sealing and PME chip sealing treatments have a $1.00/yd^2 premium for restricted (short) work intervals while the thin overlay treatments have an average of $3.73/yd^2 for restricted construction times (Table 2, Figure 3). Given the low initial cost of crack sealing and PME chip seals, the cost of short work durations increases the cost of these treatments by 153% and 50%, respectively (Figure 4). Given the large percent cost increase, an agency needs to carefully consider whether the improvement in the pavement life warrants the increased costs when using these treatments as stand-alone preservation activities. Short work intervals increase the cost thin overlay treatments between 22 and 33%. Given that most of the thin overlay treatments can be used on higher traffic volume roadways, this percent increase in treatment cost should be routinely included when forecasting urban roadway budgets.

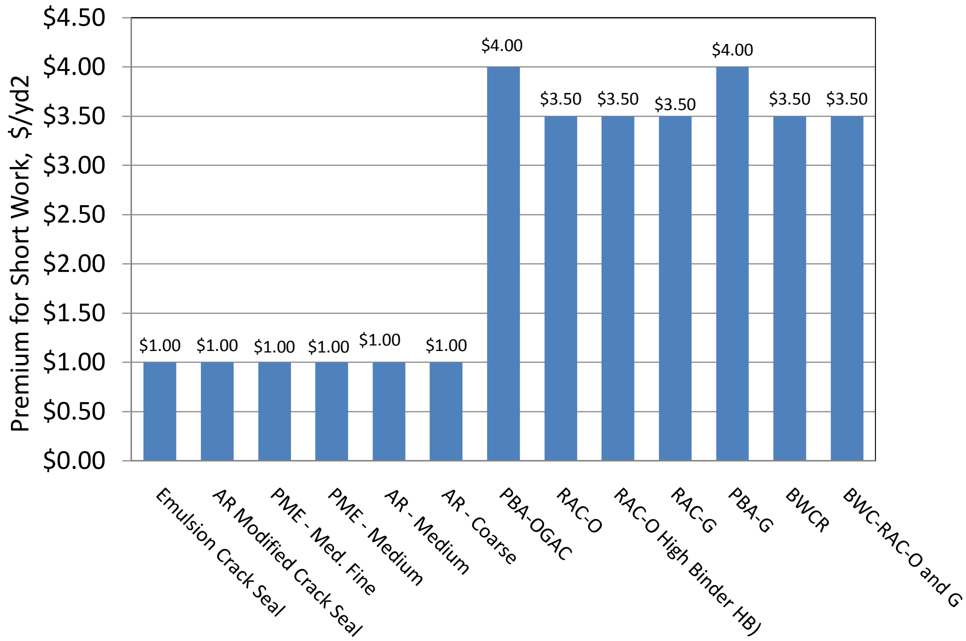

Figure 3. Extra costs for short work intervals for each pavement preservation treatment.

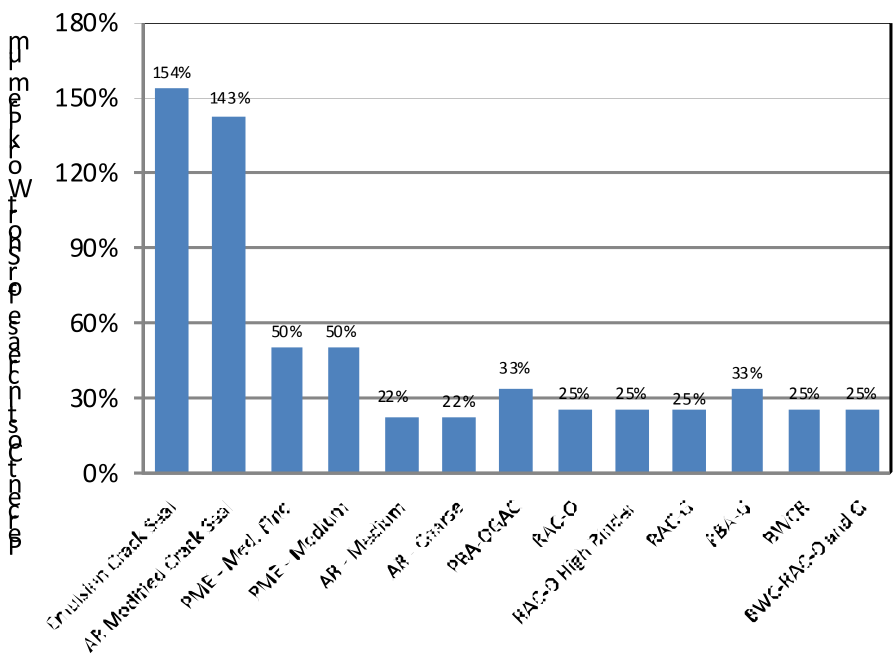

Figure 4. Percent cost increase due to short work intervals.

Table 2 shows only the crack seals and microsurfacing treatments had a consensus on a premium for night time work, which was $0.20/yd^2 for either option. Thin overlay treatments placed on higher traffic volume, more urban roadways, are commonly applied at night with limited roadway access. Therefore the short time premium represents the limited construction time associated with night time construction of these treatments.

Treatment Delay Costs

The MTAG uses a simplified equivalent annual cost (EAC) calculation for comparing various types of preservation treatments based on their initial cost, anticipated treatment type, and condition of the existing pavement. Table 3 shows the preliminary consensus of the PPTG for the expected treatment life for each of the general categories of treatments for three levels of existing pavement condition: 80, 60, and 40 PCI. This table also presents the average cost for medium size projects for treatments. The EAC, in dollars per square yard per year, was calculated from this information (Table 4).

Table 3. Influence of existing pavement condition on anticipated treatment life.

Treatment	Good Condition (PCI = 80)	Fair Condition (PCI = 60)	Poor Condition (PCI = 40)
Spray Seals	3 to 5	1 to 3	1 to 2
Chip Seals	7 to 10	3 to 5	1 to 3
Slurry Seals	7 to 10	3 to 5	1 to 3
Microsurfacing	8 to 12	5 to 7	2 to 4
Thin Lifts	10 to 12	5 to 7	2 to 4

Table 4. Equivalent annual cost for pavement preservation treatments as a function of the existing pavement condition.

Treatment	Average Cost for Medium Size Projects	Average Life Expectancy			EAC, $/yd^2/year		
		Good (PCI = 80)	Fair PCI = 60)	Poor (PCI = 40)	Good (PCI = 80)	Fair PCI = 60)	Poor (PCI = 40)
Fog Seal	$0.23	4.0	2.0	1.5	0.06	0.12	0.15
Chip Seal	$2.50	8.5	4.0	2.0	0.29	0.63	1.25
AR Chip Seal	$4.35	8.5	4.0	2.0	0.51	1.09	2.18
Slurry Seal	$2.08	8.5	4.0	2.0	0.24	0.52	1.04
Micro-surfacing	$2.50	10.0	6.0	3.0	0.25	0.42	0.83
Thin Overlays	$11.00	11.0	6.0	3.0	1.00	1.83	3.67

Figure 5 shows how the PCI level of the existing pavement can be expected to impact the project costs. The relative differences in the equivalent annual treatment costs are as expected. The annual cost of the spray seals is the lowest, with little change in the annual cost due to the existing pavement condition. The microsurfacing, PME chip seals, and slurry seals have similar cost dependencies on the existing pavement PCI. That is, there are similar slopes to the lines between the different PCI levels for each of these treatments. The AR chip seal is more expensive initially and has a faster cost increase (i.e., steeper line segments) than the other seal coats. Also as expected, the thin overlay treatments are both the most costly initially and have the fastest rate of cost increases with delay of treatment.

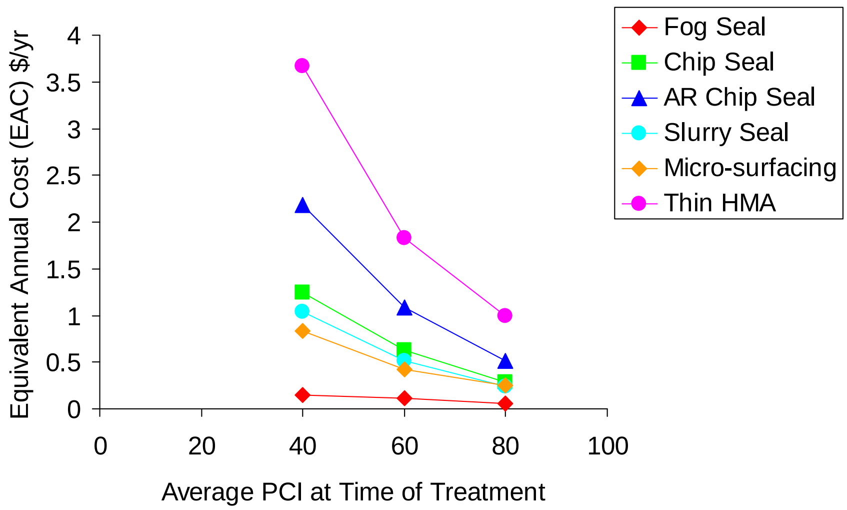

Figure 5. EAC for each treatment category as a function of existing pavement PCI.

Using a PCI of 80 as the most desirable time to place a pavement preservation treatment, the percent change in cost due to delaying the treatment placement was calculated. Figure 6 shows that delaying the placement of any preservation treatment from 80 PCI to 60 PCI results in an average equivalent annual cost increase of about 100%; all of the treatments have a similar rate of increasing costs with the delay of treatment. Delaying the placement of a preservation treatment until the roadway reaches a PCI of 40 will increase treatment costs by approximately 300%, excluding fog seals. The lower slope for the fog seal between the 60 and 40 PCI is a function of the low minimum treatment life; treatment life is similar and close to one year for fog seals on roadways with a PCI of 60 and below.

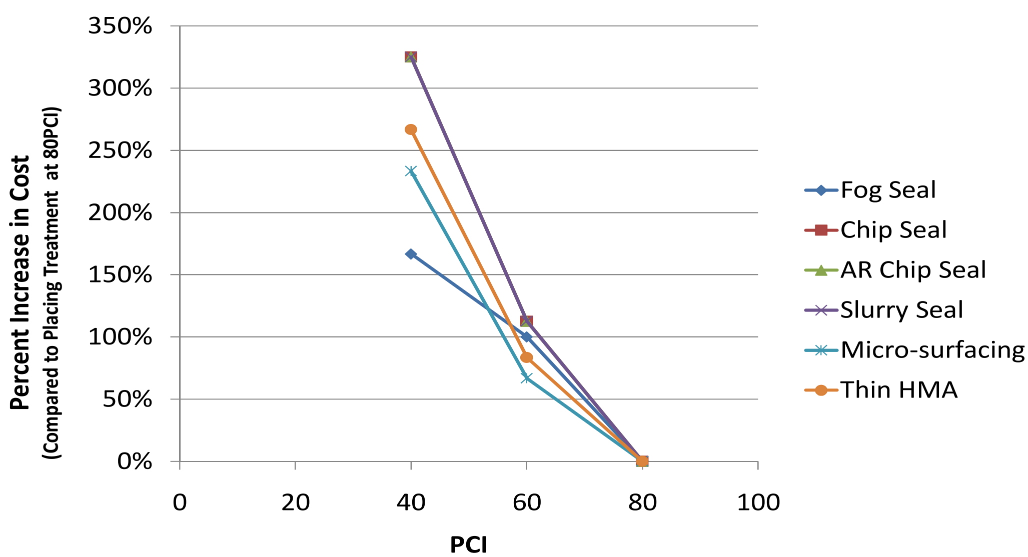

Figure 6. Percent increase in treatment costs with a delay in the placement of the treatment.

CONCLUSIONS

The following conclusions can be drawn from this analysis:

1. Significant cost savings can be achieved by organizing pavement preservation work so that the contractor will have several weeks of work in one geographic area. Providing larger projects for microsurfacing work results in the best potential savings of 43% of the small project cost. A savings of 25% on the cost of AR chip seals and thin overlay treatments can be achieved by providing a contractor with more work in one general location. Packaging slurry seal or crack sealing work so that the contractor will have several weeks of work in one location can result in a cost savings of about 15 to 23 percent.

2. No economy of scale should be expected for spray seal and REAS treatments and only a limited cost savings can be expected for PME chip seals.

3. If crack sealing or PME chip seals are to be done under restricted work timing, then the cost of the preservation treatments need to be increased by 1.5 times the typical crack sealing cost and 0.5 times the standard PME chip seal cost.

4. Thin overlay pavement preservation treatments placed in urban areas will likely be placed at night and under construction time restrictions. The standard cost of these treatments should be routinely increased by 22 to 25% to account for the treatment premium.

5. Delaying pavement preservation by applying a treatment on an existing pavement with a PCI of 60 instead of 80 will result in an increase in equivalent annual treatment costs between about 70 to 100%. Delaying the application of the treatment to an existing pavement condition of 40 will result in an increase in the equivalent annual treatment cost of about 300%.

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