

The Feasibility of Asphalt Pavement Rejuvenator Applications

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With shrinking budgets and higher oil prices, agencies such as local governments and private Homeowners Associations struggle to maintain their asphalt roadways. This study's intended audience are such agencies and the intention is to contribute to their respective pavement management programs by analyzing a method that will extend the life of their asphalt roads and maximize their maintenance investment.
The objectives of this study are to identify the barriers of using asphalt rejuvenators as a method of road maintenance and determine its optimal use and feasibility.
Data was gathered and analyzed from numerous applications and laboratory tests performed on rejuvenators since its introduction to the industry in the 1960's. In addition, the experience of a local government agency with the use of rejuvenators was studied, in order to design a feasible method of application with the goal of maximizing road maintenance budgets.
Conclusive history shows that the use of rejuvenators can extend the life of asphalt pavement.

Key Words: asphalt rejuvenators; asphalt paving; road maintenance; local government agencies

Introduction

As agencies in charge of pavement maintenance look for ways to maximize their limited funds, many are taking a much closer look at the practice of pavement preservation.

There are several methods of pavement preventive maintenance such as rejuvenators, slurry seals, surface treatments, and crack sealing. This study concentrates on asphalt pavement rejuvenators and the feasibility of their use. Rejuvenators are emulsions sprayed onto existing asphalt pavement to extend the life cycle of a road by improving resistance to oxidation.

Background

Extensive studies performed on rejuvenators have proven that the method penetrates oxidized pavement and softens the asphalt binder to reduce cracking. However, care must be taken to ensure the proper rate of application is employed for this method to be successful. In a study of asphalt rejuvenators (Boyer, 2000) states that oxidation and weathering reduces the maltenes to asphaltenes ratio in asphalt pavement, resulting in dry and brittle pavement. The study further states that rejuvenators can improve or restore this ratio, but in order to achieve this it must be able to penetrate to an optimal depth. In addition, research shows that the method of pavement rejuvenation is applicable only to low traffic roads due to the temporary loss of skid resistance.
Proper investigation is necessary to determine the candidates for this method. In a study of asphalt preventive maintenance (Brown, 1988) it is suggested that preventive maintenance can extend an asphalt road life significantly. The study also shows that, in order to select the appropriate procedure and optimize performance, the pavement must be properly investigated. The goal of applying rejuvenators to asphalt pavement is to retard its deterioration process by adjusting the viscosity and elasticity of the binder. In other words, the purpose of rejuvenators is to keep a good road good longer. This delay allows agencies in charge of asphalt pavement maintenance additional time to reduce their inventory of more distressed roads and in need of major work.

Asphalt Rejuvenators

In the asphalt rejuvenator study (Boyer, 2000) states that pavement deterioration can be the result of poor design or poor construction practices, but the most common cause is oxidation. The reversing of oxidation in an otherwise structurally sound asphalt road is the reason for using a rejuvenator.

As written (Boyer, 2000) also states that the greatest change in the composition of asphalt binder takes place during the manufacture of hot mix asphalt (HMA) and that applying a rejuvenator agent to a new surface a few weeks after installation restores the original asphalt properties, assist in sealing the pavement and improves the durability of the surface course.

Furthermore, in the past several years the asphalt industry is widely using reclaimed asphalt pavement (RAP) in asphalt pavement mixtures. The use of recycled materials can make the mix too stiff and difficult to compact which can result in premature failure (Mogawer, 2012); rejuvenators can reduce the stiffness of the aged binder from recycled materials (Shoohyok, 2013).

Study Objectives

The objectives of this study are to determine the best method of applying asphalt pavement rejuvenators in terms of pavement life so that in turn the feasibility of this method can be determined. This information can then assist agencies in charge of pavement maintenance in developing a feasible pavement management method.

Criteria

In the study of rejuvenators (Boyer, 2000) recommends developing a periodic maintenance program using the product in three to five year cycles. Strange (2014: 19-21) describes the experience of the town of Avon, Indiana in developing a condition rating method and a maintenance method using a combination of crack sealing and a rejuvenator. They planned this maintenance program in 5 year intervals and after 14 years the town's consultants found that they were able to gain 10 years of pavement life over a 13 year period.

One of the respondents of the survey administered by this study, the City of Orlando, Florida, reports that their City Engineer successfully established a method of road preservation which consists in applying a rejuvenator within the first year of the pavement's life and again at approximately five years.

These findings suggest that rejuvenators should be applied shortly after installation of new asphalt followed by an additional application at approximately five years.

Pavement Management

In order to determine which roads meet the requirements for any maintenance application, it is necessary to have updated information on the pavement inventory. For this, a well-planned pavement management program should be employed.

While a Pavement Management Program may denote the use of a computer software application, it is definitely not the only component of such a program. The software provides an expedient way to perform the necessary calculations to determine the pavement condition index (PCI) of the pavement inspected as well as assist with reporting tools, but the method of field data collection is critical to the process. Agencies with vast amounts of asphalt to maintain must employ mechanical methods of data gathering while smaller agencies typically will employ inspectors to visually identify pavement distresses. This is an advantage for the smaller agencies since by visually inspecting their road inventory they are better able to detect candidate roads for preventive measures such as

rejuvenators. It is important to note that surveying roads, and the resulting PCIs, are subjective and dependent on the experience level of the person performing the inspection.

The NCHRP (National Cooperative Highway Research Program) Report 523 (2004: 4) notes the problem with preventive methods applied at wrong times and how these applications could yield erroneous results, which would lead some agencies to conclude that preventive measures do not work.

Rationale

The hypothesis developed by this study is that asphalt rejuvenators will sufficiently extend the life of pavement to render the method feasible.

Data related to pavement rejuvenation history, main functions, and chemical composition have been studied from some of the tests performed and journals written on the subject. Rejuvenators were developed in the 1960's and have been tested by many agencies including the US Corps of Army Engineers and the US Department of the Navy.

Historical data of roads treated with rejuvenators was obtained from a local government agency, the City of Roswell, Georgia which maintains 350 center line miles of asphalt roads. Additional information was obtained from a survey administered to government agencies in charge of road maintenance, although at the time of the writing of this study a limited number of responses to the survey have been recorded.

The City of Roswell's rating system consists of the Pavement Condition Index (PCI) method which rates roads from an index of 0 (worst condition) to and index of 100 (best condition) using MicroPaver, a Pavement Management Software. This program calculates and projects PCIs using field distress inspection data, historical data, and the application of maintenance methods including rejuvenation. Table 1 below is a chart of the rating classifications employed by the City of Roswell:

Table 1

City of Roswell, GA PCI Classifications

PCI	Classification
86-100	Good
71-85	Satisfactory
56-70	Fair
41-55	Poor
26-40	Very Poor
0-25	Serious

Using this system, candidate roads for rejuvenators should have a PCI index between 86 and 100 (good rating). In addition to this data, inspection records and comments need to be reviewed to ensure that no other issues are affecting the pavement. Rejuvenators are only designed to improve oxidation resistance and do nothing to improve other pavement distresses such as poor base, poor drainage and overloading.

Data Analysis & Results

The rating system employed by the City of Roswell provided the road condition data used by this study. Following are charts comparing the PCI at the time of treatment with a rejuvenator for a sample of roads within the City of Roswell in 2013. The data is then compared to the PCI two years later in 2015 and with the PCI of similar but untreated roads during the same time period.

Table 2

Roads treated with a rejuvenator

Road	2013 PCI (Pre-Treatment)	2015 PCI (Post-Treatment)	PCI Difference
Pine Grove Road	98	96	-2
Magnolia Street	99	98	-1
Coleman Road	88	83	-5
Jones Road	93	91	-2
Bowen Road	90	89	-1
Warsaw Road	97	95	-2
			Average -2

Table 2 above shows an average PCI reduction of -2 for roads that have been treated with a rejuvenator. The road that was treated at a borderline PCI of 88 shows the most drop in PCI. This indicates that the best candidates for rejuvenator treatment will have an index between 90 and 100. It also indicates that at PCIs lower than 90 the reduction in the index is significantly higher.

The analysis above confirms the research findings that rejuvenators work best if applied while the pavement is in good condition. Pavements rated between 90 and 100 perform best when treated with this method, while pavements below the 90 PCI range deteriorate more rapidly even after treatment. The road in question, Coleman Road with a PCI of 88 at the time of the rejuvenator application, was found to have a number of low level cracks which contributed to the lower rating.

The sample of roads that had not been treated with the rejuvenator during the same period of time show greater decline in PCI with an average of -9 as shown on table 3 below. These roads are of similar pavement area and conditions as the treated roads, but they were purposely chosen to have lower daily traffic volumes to prevent this from being a factor in the data results.

Table 3

Roads not treated with a rejuvenator

Road	2013 PCI	2015 PCI	PCI Difference
Upper Hembree Road	96	91	-5
Steeplechase Drive	100	94	-6
Ridgefield Drive	100	90	-10
Old Dogwood Road	100	89	-11
King Road	93	81	-12
Holcomb Woods Parkway	91	84	-7
			Average -9

Table 4 below shows projected PCIs for treated and untreated roads until reaching the lower range of the poor rating (PCI of 41). According to the road maintenance methodology used by the City of Roswell, roads reaching this rating are considered candidates for mill and overlay.

To project the PCI values, the values from the data shown on tables 2 and 3 above were used. For non-treated roads the average value of -4.5 per year (-9 for the two year period 2013 -2015) was used. For treated roads the value of -1 was used for the first 5 years (-2 for the two year period 2013 – 2015) and from the sixth year until the low range of

the satisfactory rating (71-85) is reached the value of -2.5 (-5 for the two year period 2013-2015) was used. After the range of satisfactory is crossed, the non-treated value of -4.5 is used since at that point other distresses are present that accelerate deterioration and the rejuvenator would no longer affect significantly the asphalt condition.

Table 4

Average PCI projections for treated and untreated roads

Year	No Treatment	Rejuvenator
0	100	100
1	96	99
2	91	98
3	86	97
4	82	96
5	77	94
6	73	91
7	68	89
8	64	86
9	59	84
10	55	81
11	50	79
12	46	76
13	41	74
14	37	71
15	32	67
16	28	62
17	23	58
18	19	53
19	14	49
20	10	44
21	5	40

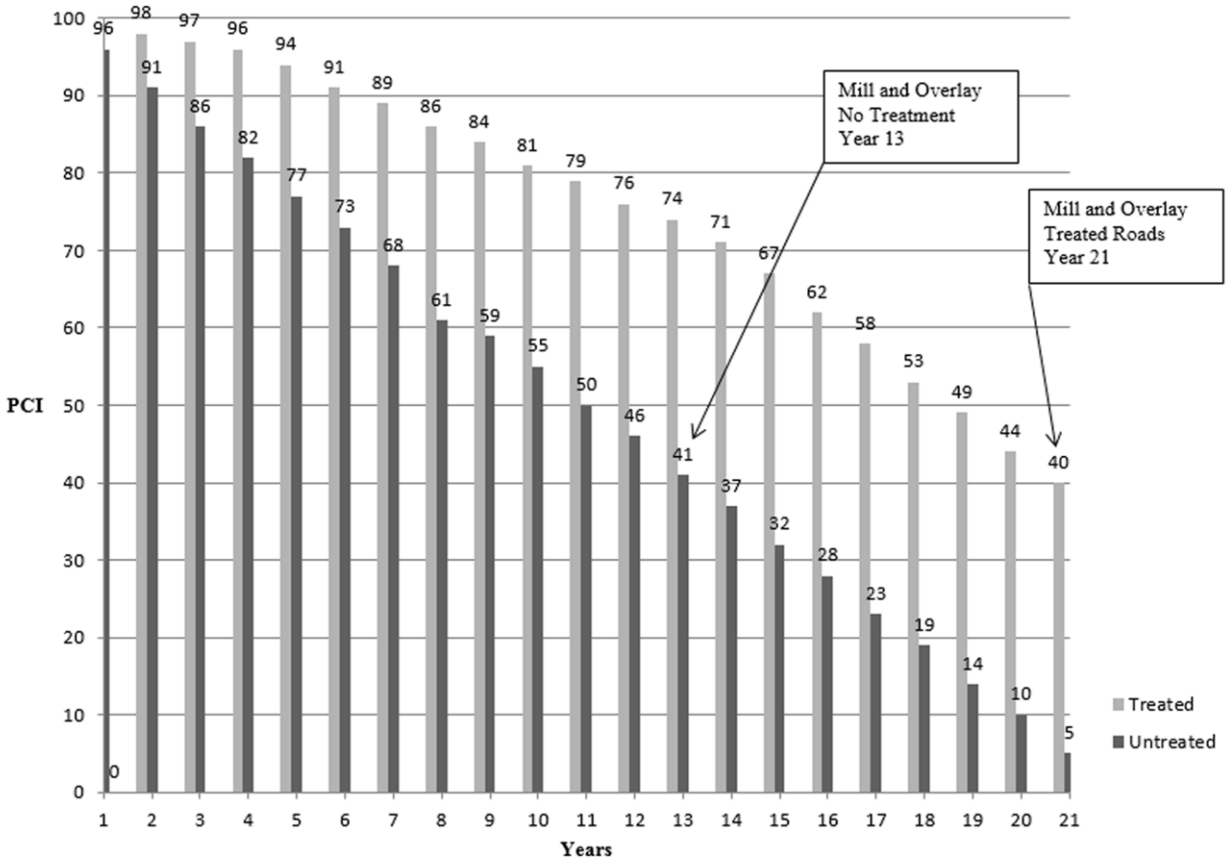

Figure 1: Life cycles of treated with a rejuvenator vs untreated roads

By using the pavement life results from table 4 and figure 1 above, an average cost per square yard per year is determined to study the feasibility of the method. The City of Roswell historical cost values were used to calculate these costs and it should be noted that no inflation or price fluctuations are taken in consideration. The values used are $12.00 per square yard for mill and overlay and $0.79 per square yard per application of the rejuvenator, these costs include materials and labor

Table 5

Pavement life cost analysis

Method	Per sy	Years of Life	Average Yearly Cost Per sy
Resurfacing	$12.00	13	$0.92
Adding rejuvenator applications (2)	$13.58 ($12.00 + $1.58)	21	$0.65

Table 5 above shows a savings of $0.27 per square yard per year of pavement life when using rejuvenators which represents a 29% savings.

Summary and Conclusions

Rejuvenators should be included in the list of tools for Pavement Management Programs. These applications should be made within the first year of pavement life and again at approximately the fifth year.

Roads selection for this process should be made carefully in order for the proper results to be achieved. Low traffic, local roads are excellent candidates and it should be noted that temporary loss of skid resistance is possible.

The first application of rejuvenators is optimal in roads with a PCI value of no less than 90. A subsequent application should be made while still in the good category (PCI above 86) and the PCI should be given priority over the time since the last application. In addition, these roads inspection records should be carefully analyzed to ensure sound structural conditions before applying this method.

Using these guidelines, pavement life can be extended by 8 years resulting in savings of 29% on the life cost of the treated pavement. It should be noted that this is a savings realized over the life of a road candidate for the method of rejuvenation and not an overall maintenance budget savings.

Due to the relatively short history of the City of Roswell with the use of rejuvenators, further data should be collected on the sample roads to better determine the best use of the method. In addition, since the responses from the survey administered to other agencies is relatively low, additional input should be requested to corroborate the findings of this study and ensure optimal use of rejuvenation as a method of asphalt pavement preservation.

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