Evaluation of Cost-Effectiveness for Different Sealant Materials Used in Highway Maintenance Operations

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Abstract

An important element in pavement maintenance practices is the sealing and filling of cracks. Hot pour materials are the most commonly used material, providing good performance for most of the cases. However, some maintenance processes utilize cold pour asphalt emulsion crack sealants. Cold pour crack sealants require longer setting and curing times, especially in areas of high humidity. In addition, the performance history of these cold pour sealants is not known nor well documented in comparison to the performance of hot rubber crack sealants. The costs associated with the use of this material versus hot rubber asphalt are also not well documented or determined. An extensive, three year research has been completed in cooperation with the Texas Department of Transportation (TxDOT) in pursuit of evaluating and comparing the cost-effectiveness for hot pour and cold pour sealants. Eight different roads in five districts were selected for the comparison of the sealants. A total of thirty-three different test sections were obtained through this operation. The surveys and field study indicate that hot pour rubber sealants performed better than cold pour sealants. In the test sections, hot pour sealants performed better over time than cold pour sealants. The cost analysis for this research is based on the comparison of all aspects related to the placement of hot and cold pour sealants. Construction cost is not the sole factor in cost-effectiveness. Performance of a sealant is also another significant factor, because a poorly performing sealant will require sealing to occur more often. Based on the service-life information collected from field evaluations, life-cycle costs can be calculated. The average annual cost (AAC) values were calculated for each sealant in twenty-five test sections in five districts. The cost analyses showed that the overall AAC for cold pour materials is $0.351/m, and for hot pour materials, the average AAC is $0.147/m.

1. Introduction

An important element of pavement maintenance practices is the sealing and filling of cracks. Hot pour materials are the most commonly used material, providing good performance in most cases. Some Texas Department of Transportation (TxDOT) districts have looked into the use of cold pour asphalt emulsion crack sealants. Cold pour crack sealants require longer setting and curing times, especially in areas of high humidity. In addition, the performance history of these cold pour sealants is not known nor well documented in comparison to the performance of hot rubber crack sealants. The costs associated with the use of this material versus hot rubber asphalt are also not well documented or determined.

This research work is intended to compare the cost-effectiveness, performance, and life-cycle costs for hot pour rubber asphalt crack sealant and cold pour asphalt emulsion crack sealant. The comparison includes seven different crack and joint sealants: three cold pour and four hot pour rubber sealants. Eight different roads in five districts were selected for the comparison of the sealants. A total of thirty-three different test sections were obtained through this operation. The crack-sealed sections in all five districts were visited and monitored at regular intervals. The surveys and field study indicate that hot pour rubber sealants performed better than cold pour sealants. In the test sections, hot pour sealants performed better over time than cold pour sealants. The cost analyses showed that the overall average annual cost (AAC) for cold pour materials is \$0.351/m and for hot pour materials, the average AAC is \$0.147/m.

2. Materials Used in the Test Sections

Through coordination with the Texas Department of Transportation (TxDOT), eight asphalt pavement roads in five different districts were selected for the application of different sealants. Both cold pour and hot pour sealants were applied to the roads. Applying both types of sealants to the cracks of the same pavement was intended to make the results of the analysis more reliable because influencing factors such as traffic, climate, and pavement type and condition remain the same for both types of sealants. Table 1 shows the districts and sealants used for comparison. Table 1 presents those test sections that were not covered (overlaid or seal coated) for at least 3 years after they were crack sealed, referred to as *non-covered sections*. The purpose of regular visits was to evaluate the treatment effectiveness of the sealants.

Table 1. Crack-Sealed Highway Non-Covered Test Sections

Sealant	Cold Pour C1	Cold Pour C2	Cold Pour C3	Hot PourH1	Hot Pour H2	Hot Pour H3	Hot Pour H4
	Crack Seal	Crack Seal	Joint Seal	Crack Seal	Crack Seal	Crack Seal	Joint Seal
TxDOT Districts	TxDOT Specification						
	Item 3127	Item 3127	DMS-6310, Class 9 (Joint Seal)	GSD 745-80-25, Type I, Class A	GSD 745-80-25, Type III, Class B	GSD 745-80-25, Type I, Class A	DMS-6310, Class 3 (Joint Seal)
Atlanta	√	√	√	√	√		
El Paso	√	√			√	√	
Lufkin		√	√	√			√
Amarillo	√		√	√		√	√
San Antonio	√	√	√	√	√	√	√
Total	4	4	4	4	3	3	3

In labeling the sealants in Table 1, numbers (1, 2, etc.) are used simply to distinguish between different brands of sealants. Letters C and H in the label refer to the type of sealant. Cold pour sealants (those labeled C in the tables) are in liquid form and are applied at ambient temperature. Hot pour rubber sealants (those labeled H in the tables) are available in the form of solid blocks and are applied at temperatures exceeding 190 °C. Crack sealants and joint sealants of each type, hot pour and cold pour, were used in this study. Crack sealants are used to fill pavement cracks, whereas joint sealants are generally used to seal concrete pavement joints. Two different cold pour crack sealants (C1 and C2) and one cold pour joint sealant (C3) were applied. Crack sealants C1 and C2 met TxDOT requirements for Item 3127 specifications. The joint seal C3 satisfied TxDOT requirements of DMS-6310, Class 9 specifications. Three hot pour crack sealants (H1, H2, and H3), and one hot pour joint sealant (H4) were used. Crack sealants H1 and H3 satisfied TxDOT's GSD Spec. 745-80-25, Class A requirements, and crack sealant H2 satisfied GSD Spec. 745-80-25, Class B requirements. Joint sealant H4 met DMS-6310, Class 3 specification requirements.

3. Cost Analysis

3.1. Crack Seal Installation Cost Analysis

The cost analysis for this research is based on the comparison of all aspects related to the placement of hot and cold pour sealants on five highways in Texas. The test sections included in the cost comparison were ones that were not covered with a seal coat. The average annual cost (AAC) values were calculated for each sealant in twenty-five test sections in five districts.

In the present study, the initial cost analysis also was carried out for non-covered test sections. Initial cost values were calculated based on sealing materials, equipment for traffic control, sealing equipment, hot pour equipment, and crew labor costs. Initial construction cost values used in this research work were taken from Report 4061-1. More detailed information about the initial cost analysis can be found in Report 4061-1 (8).

3.2. Life-Cycle Cost Analysis

Construction cost is not the sole factor in cost-effectiveness. Performance of a sealant is also another significant factor, because a poorly performing sealant will require sealing to occur more often. Based on the service-life information collected from field evaluations, life-cycle costs can be calculated. However, a life-cycle cost analysis can only be done when all the treatments reach the failure point. For the analysis process, the failure point was considered to be when the treatment effectiveness of the sealant went below 60%. Based on this criterion, the service life for each sealant in each district was calculated. By the last field visit some of the hot pour materials had not failed. For those materials, based on the treatment effectiveness information collected previously, service life was estimated by an extrapolation of the treatment effectiveness versus time curve.

In the analysis process, the results obtained between different districts were similar except for the Amarillo District. The cost/m of the given sealant was inversely proportional to the crack length of the section being sealed. Thus, a longer crack length resulted in a lower cost/m and alternately, a shorter crack length resulted in a higher cost. This case was more evident in the Amarillo District where the total crack length being sealed was 850m, while the other test sections' lengths were around 3km. Since, the test sections built in Amarillo had a much higher initial cost value than the rest of the test sections, the values from the other four sections are given. The AAC values for Amarillo were calculated separately. Cost-effectiveness was calculated based on the explanations provided in SHRP-H-348 "Materials and Procedures for Sealing and Filling Cracks in Asphalt-Surfaced Pavements" (9). AAC values were calculated based on a 3.0% interest rate. Average values for AAC and their construction cost (CC) and AAC for 15km imaginary length values from the report 4061-1 are included in Table 2 (8). Tables 3-7, show the results of the carried calculations.

Table 2. Cost-Effectiveness

Sealant	CC for 15km Imaginary Length ($)	AAC for 15km Imaginary Length ($)	Average AAC ($/m)
C1	5256	6526	0.43
C2	6060	5779	0.38
C3	5789	3780	0.25
H1	4288	1360	0.09
H2	5573	4037	0.27
H3	4611	1825	0.12
H4	5393	1831	0.12

Table 3. Cost-Effectiveness Table for Atlanta

Sealant	Initial Cost for 15km Imaginary Length ($)	Life (in yrs.)	AAC ($)	AAC ($/m)
C1	4,419.65	0.927	4992	0.33
C2	4,400.99	0.905	5115	0.33
C3	5,895.86	1.598	3901	0.26
H1	3713.97	4.137	912	0.06
H2	3649.32	3.633	1031	0.07

Table 4. Cost-Effectiveness Table for El Paso

Sealant	Initial Cost for 15km Imaginary Length ($)	Life (in yrs.)	AAC ($)	AAC ($/m)
C1	6,317.58	1.631	4144	0.27
C2	9,179.92	0.811	11401	0.75
H2	6,423.95	2.153	3162	0.21
H3	6,276.01	2.536	2700	0.18

Table 5. Cost-Effectiveness Table for Amarillo

Sealant	Initial Cost for 15km Imaginary Length ($)	Life (in yrs.)	AAC ($)	AAC ($/m)
C1	11,037.83	0.320	35000	2.3
C3	11,061.05	0.691	16300	1.07
H1	9,140.31	2.751	3450	0.23
H3	10,352.95	1.740	6300	0.41
H4	9,438.94	1.927	5150	0.34

Table 6. Cost-Effectiveness Table for San Antonio

Sealant	Initial Cost for 15km Imaginary Length ($)	Life (in yrs.)	AAC ($)	AAC ($/m)
C1	5,031.42	0.489	10443	0.69
C2	4,970.63	1.563	3323	0.22
C3	5,254.48	1.538	3712	0.25
H1	4,484.45	3.281	1461	0.09
H2	6,646.10	0.844	7917	0.52
H3	2,946.79	3.366	950	0.063
H4	5,459.81	3.168	1846	0.12

Table 7. Cost-Effectiveness Table for Lufkin

Sealant	Initial Cost for 15km Imaginary Length ($)	Life (in yrs.)	AAC ($)	AAC ($/m)
C2	5,688.80	1.748	3276	0.22
C3	6,215.87	1.674	3728	0.25
H1	4,666.06	2.787	1707	0.12
H4	5,325.40	3.224	1815	0.12

Figure 1 compares the average AAC values for 15km imaginary length for different materials in the four different districts. The AAC values for 15km imaginary length from the Amarillo District were not included for the calculation in Table 5. As seen in Figure 1, overall AAC values for 15km imaginary length for cold pour materials are higher than those for hot pour materials. The only exception to this is the AAC value for 15km imaginary length of the H2 material in the San Antonio District. The H2 material in this district showed a very low performance and failed in less than a year after construction. Other than this specific situation, in all cases, hot pour materials showed lower AAC values for 15km imaginary length than cold pour materials.

Among the hot pour materials, the lowest AAC values for 15km imaginary length were observed for material H1. Hot pour materials used in the El Paso test section, H2 and H3, showed relatively higher AAC values for 15km imaginary length compared to other sections. Among the cold pour materials, the lowest AAC values for 15km imaginary length were observed for C3. The overall average AAC for 15km imaginary length for cold pour materials is $5362, and for hot pour materials, the average AAC for 15km imaginary length is $2263.

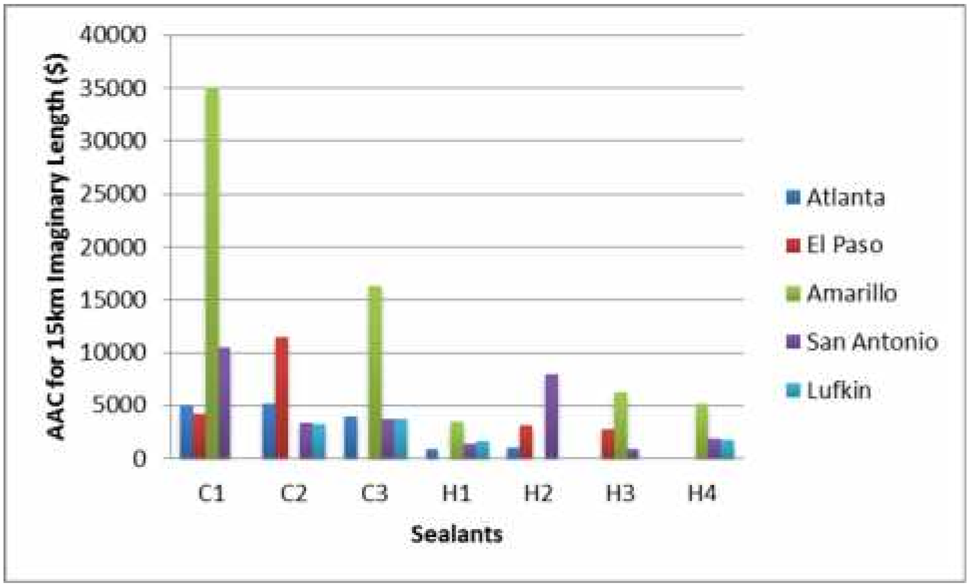

Figure 1. Average annual cost values for 15 km imaginary length for each sealant

4. Conclusions

This study concludes a 4-year research work comparing cold pour and hot pour rubber crack sealants. A survey on crack sealants was conducted for twenty-one districts in Texas and nine state departments of transportation. In the first year, thirty-three test sections in five districts were constructed and the long-term performance of seven different sealants was monitored for 3 years. The performance was evaluated starting from the first 4 months after the construction of the treatment. Installation and lifetime costs were analyzed for the different types of sealants, and recommendations were made to modify Texas Department of Transportation (TxDOT) specifications. The long-term evaluation of the test sections indicated that hot pour sealants perform better over time than cold pour sealants. The results from the final investigation show that hot pour sealants performed better than cold pour sealants in every district. All cold pour sealants in all districts showed very low performance, with only one in the Atlanta District.

The cost analyses showed that the overall average annual cost (AAC) for 15km imaginary length for cold pour materials is $5362, and for hot pour materials, the average AAC for 15km imaginary length is $2263. Among the hot pour materials, the lowest AAC values for 15km imaginary length were observed for material H1. Hot pour materials used in the El Paso test sections, H2 and H3, showed relatively higher AAC for 15km imaginary length values compared to other sections. Among the cold pour materials, the lowest AAC values for 15km imaginary length were observed for C3 (a joint sealant). The initial construction cost analysis for 15km imaginary length presented in the report 4061-1. The cost analysis showed that the overall initial construction cost (CC) for cold pour materials is $5702, and for hot pour materials, the average initial construction cost is $4966 for 15km imaginary length. The initial sealing cost typically should not be the deciding economic factor for the selection of the sealant type. In this study the initial cost values were considered with respect to sealant performance and were used in the life-cycle cost analysis. While performance is important, cost-effectiveness is often the deciding factor in determining which materials and procedures to use.

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