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Project Summary Report 0-4061-S
Project 0-4061: Comparison of Hot Poured Crack Sealant to Emulsified Asphalt Crack Sealant
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PROJECT SUMMARY REPORT

Comparison of Hot Poured Crack Sealant to Emulsified Asphalt Crack Sealant: A Summary

An important element of pavement maintenance is crack sealing and filling. Hot pour materials are the most commonly used, providing good performance in most cases. The performance history and costs of cold pour asphalt emulsion crack sealants are not well known or well documented in comparison to those of hot rubber crack sealants. This report concludes a four-year research project intended to compare the cost-effectiveness, performance, and life-cycle costs of hot pour rubber asphalt crack sealant and cold pour asphalt emulsion crack sealant. A survey of Texas Department of Transportation (TxDOT) districts and state DOTs was conducted on crack sealants, and the long-term performance of seven different sealants were monitored. Installation and lifetime costs were analyzed for the different types of sealants, and recommendations were made to modify TxDOT specifications.

What We Did...

In the first step of this research project, responses to a survey on crack sealants was obtained from 21 districts in Texas and 9 state departments of transportation. Information was collected on existing crack sealing techniques, experience with hot and cold pour sealant techniques, safety, ease of installation, performance, and associated costs.

The second step included a field comparison involving seven different crack and joint sealants: three cold pour (C1, C2, C3) and four hot pour rubber (H1, H2, H3, H4). Sealants were applied to 8 different roads in 5 TxDOT districts between January and April 2001 for a total of 33 different test sections. The test sections were composed of two groups: "non-covered sections," 25 sections that were not overlaid or seal-coated within the time period of the project, and "covered sections," 8 sections that were crack-sealed and then covered with a seal coat.

The sections were visited and monitored for performance at regular intervals throughout the project duration. The first evaluations were conducted within three to four months after crack sealing operations. The covered test sections received a seal coat during the summers of 2001 and 2002. Visual inspections of both the covered and non-covered test sections were performed once every winter (i.e., Jan.-Feb.) and once every summer (i.e., July-Aug.) for three years. The covered test sections were evaluated to determine their tendency to exhibit asphalt bleeding through the subsequent seal coat. Reports 0-4061-1 and 0-4061-2 presented information about the test sections, sealants used, and previously collected performance data. Report 0-4061-3 presented the performance of the sealants throughout the project's duration and explained the performance trends of the sealing materials.

What We Found...

Survey

The survey of districts showed that all participating districts used hot pour sealants, whereas only one-third of the districts also used cold pour sealants. Overall, it was reported that the hot pour sealants performed better than the cold pour sealants. On most of the overall performance evaluation questions, neither hot pour nor cold pour sealants were ranked as poor by the participating districts. Hot pour sealants were ranked as poor or fair by the majority of districts specifically in regard to their resistance to bleeding. As with the Texas districts, the national survey showed that all participating states used hot pour sealants. Only five of the participating states reported using cold pour sealants. For two-thirds of the questions,

Table 1. Treatment Effectiveness Evaluation Results for the Performance after the 2nd Investigation (Winter 2002)

	Treatment Effectiveness (%)					
	2nd Visit (Winter 2002)					
Sealant Material	***Atlanta***	***El Paso***	***Amarillo***	***San Antonio***	***Lufkin***	**AVG.**
C1	53.8	66.9	0	0.3	N/A	30.3
C2	50.7	40.4	N/A	88.9	65.4	61.4
C3	69	N/A	18.6	74.1	77.3	59.8
H1	89.9	N/A	91.9	91	91	91.0
H2	92.7	77.8	N/A	57.6	N/A	76
H3	N/A	76.1	65.8	96.8	N/A	79.6
H4	N/A	N/A	98	92.1	99.3	96.5
Date of investigation	2/13/2002	4/10/2002	5/31/2002	3/8/2002	2/22/2002	
AVG. for Cold Pour	57.8	53.7	9.3	54.4	71.4	49.3
AVG. for Hot Pour	91.3	77.0	85.2	84.4	95.2	86.6
Overall AVG.	71.2	65.3	54.9	71.5	83.3	69.2

Table 2. Treatment Effectiveness Evaluation Results for the Performance after the 4th Investigation (Winter 2003)

	Treatment Effectiveness (%) 4th Visit (Winter 2003)					
Sealant Material	***Atlanta***	***El Paso***	***Amarillo***	***San Antonio***	***Lufkin***	**AVG.**
C1	6.4	9.7	0	1	N/A	4.3
C2	3.4	2.4	N/A	8.7	23.2	9.4
C3	16.3	N/A	0	11.2	N/A	9.2
H1	88.4	N/A	75.6	85	86	83.8
H2	84.8	65.1	N/A	51	N/A	67.0
H3	N/A	76.2	17.9	95.1	N/A	63.1
H4	N/A	N/A	42	89.4	91.1	74.2
Date of investigation	1/23/2003	3/27/2003	3/28/2003	1/30/2003	1/24/2003	
AVG. for Cold Pour	8.7	6.1	0	7.0	23.2	9.0
AVG. for Hot Pour	86.6	70.7	45.2	80.1	88.6	74.2
Overall AVG.	39.9	38.4	27.1	48.8	66.8	44.2

cold pour sealants were ranked as poor by some of the participating states. Hot pour sealants were ranked as poor by some states only in regards to their resistance to bleeding. In an overall evaluation of the survey, it was reported that hot pour sealants performed better than cold pour sealants. The questionnaire used for the survey is included in Report 0-4061-1.

Field Performance

In the test sections, hot pour sealants performed better over time than cold pour sealants. For the purposes of this study, when a sealant treatment effectiveness decreases below 60%, it has failed. The first evaluations of hot pour and cold pour materials in non-covered test sections during summer 2001 indicated that they both performed well. The results indicated an average treatment effectiveness level of approximately 100% for hot pour sealants. The cold pour sealants exhibited an overall average treatment effectiveness of greater than 90% with one exception. In the first visits to the covered sections, no bleeding was observed.

During subsequent visits, hot pour continued to outperform cold pour sealants. While the second visit in winter 2002 showed a general decrease in treatment effectiveness for all sealants, the decrease was much more rapid for cold pour sealants. Similar trends were observed in the remaining visits to the test sections throughout the project. By the fourth investigation, all cold pour sealants fell below a treatment effectiveness level of 60%, and hot pour sealants performed better comparatively. Table 1 shows the first winter performance evaluation results data collected in winter 2002 and Table 2 shows the second winter performance evaluation results data collected in winter 2003.

The results from the final investigation in winter 2004 (3 years after application), presented in Table 3, show that hot pour sealants performed better than cold pour sealants in every district. Test sections in Lufkin were not evaluated after the summer 2002 investigation because the sections had been given a new overlay.

In the first winter visit it was observed that in Atlanta, C1 and C2, and in San Antonio, C1 and H2 went below the 60% effectiveness level. In the second winter visit, all of the cold pour materials in all test sections failed, whereas only H2 in San Antonio and H3 and H4 in Amarillo fell below the 60% effectiveness level. In the last winter visit in 2004, it was observed that 7 out of the 12 test sections with hot pour sealant were still above the 60% effectiveness level.

In winter 2004, hot pour materials had an average treatment effectiveness of 42.95%. In the Atlanta district in the final investigation, H1 and H2 had a treatment effectiveness level of 73.7% and 68.2%, respectively. In the El Paso district, H2 and H3 had a treatment effectiveness of 23.9% and 28.4%, respectively. In the Amarillo district, sealant H4 exhibited the best performance in the final visit, with a final treatment effectiveness of 47%. Finally, in the San Antonio district, hot pour sealants attained a high treatment effectiveness level in the final investigation. With the exception of H2, the hot pour sealants in San Antonio had an average treatment effectiveness level of 68%.

In a comparison of individual sealants in winter 2004, H4 (a joint sealant) achieved the best overall treatment effectiveness of 56.75%. However, no cold pour sealant achieved more than a 2% treatment effectiveness level. Hot pour materials did not go below a 34% treatment effectiveness level. Sealants also performed differently in different districts with varying environmental and traffic conditions. For example, the El Paso test sections were located in an area with heavy truck traffic. The hot pour sealants placed on the test sections in the El Paso district had higher failure rates than hot pour sealants placed in other districts, perhaps due to the effect of the heavy truck traffic crossing the border. In addition, in the Amarillo district, there was a greater fluctuation in treatment effectiveness levels between the winter and summer investigative visits than was experienced in other districts due to the greater difference in local summer and winter temperatures.

Life-Cycle Cost Analysis

Construction cost is not the sole factor in cost-effectiveness. Performance of a sealant is also a significant factor, because a poorly performing sealant will require more frequent re-sealing. Life-cycle costs can be calculated based on the service-life information collected from field evaluations. However, a life-cycle cost analysis can be accomplished only when all treat-

Table 3. Treatment Effectiveness Evaluation Results for the Performance after the Final Investigation (Winter 2004)

	Treatment Effectiveness (%) Final (6th) Visit (Winter 2004)					
Sealant Material	***Atlanta***	***El Paso***	***Amarillo***	***San Antonio***	***Lufkin***	**AVG.**
C1	0.2	0	0	0.1	N/A	0.07
C2	0	0	N/A	0	N/A	0.00
C3	6	N/A	0	0	N/A	2.00
H1	73.7	N/A	6	67	N/A	48.91
H2	68.2	23.9	N/A	9.5	N/A	33.87
H3	N/A	28.4	13.5	71.2	N/A	37.70
H4	N/A	N/A	47	66.5	N/A	56.75
Date of investigation	2/12/2004	2/27/2004	2/26/2004	2/20/2004	2/13/2004	
AVG. for Cold Pour	2.06	0.00	0.00	0.03	N/A	0.52
AVG. for Hot Pour	70.95	26.15	21.17	53.55	N/A	42.95
Overall AVG.	29.62	13.07	13.30	30.61	N/A	21.65

ments have reached the failure point. For this analysis, the failure point was considered to be a treatment effectiveness level of below 60%. Based on this criterion, the service life for each sealant in each district was calculated. At the end of the last field visit some of the hot pour materials had not failed. For those materials, service life was estimated by an extrapolation of the treatment effectiveness versus time curve, based on the treatment effectiveness information collected previously. 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." Average annual cost (AAC) values were calculated based on a 3.0% interest rate. Average values for AAC and their standard deviations and construction cost (CC) and AAC for 50,000 ft imaginary length values from the 0-4061-1 report are included in Table 4.

Figure 1 compares the average AAC values for 50,000 ft imaginary length for different materials in the four different districts. The AAC values for 50,000 ft imaginary length from the Amarillo district were not included for the calculation in Table 4. As can be seen in this figure, the overall AAC values for 50,000 ft imaginary length for cold pour materials are higher than those for hot pour materials. The only exception is the AAC value for 50,000 ft imaginary length of the H2 material in the San Antonio district. The H2 material in this district exhibited very poor performance and failed less than a year after construction. In all other cases, hot pour materials had lower AAC values for 50,000 ft imaginary length than cold pour materials.

Table 4. Cost-Effectiveness

Sealant	CC for 50,000 ft Imaginary Length ($)	AAC for 50,000 ft Imaginary Length ($)	Average AAC ($/ft)	Std. Deviation
C1	5256	6526	0.131	0.068
C2	6060	5779	0.116	0.077
C3	5789	3780	0.076	0.002
H1	4288	1360	0.027	0.008
H2	5573	4037	0.081	0.071
H3	4611	1825	0.037	0.025
H4	5393	1831	0.037	0.000

Among the hot pour materials, the lowest AAC values for 50,000 ft imaginary length were observed for material H1. The hot pour materials used in the El Paso test section, H2 and H3, had relatively higher AAC values for 50,000 ft imaginary length compared to other sections. Among the cold pour materials, the lowest AAC values for 50,000 ft imaginary length were observed for C3. The overall average AAC for 50,000 ft imaginary length for cold pour materials is $5,362 with a standard deviation of $2,981, and for hot pour materials, the average AAC for 50,000 ft imaginary length is $2,263 with a standard deviation of $2,089.

The Researchers Recommend...

Modifications to the specifications for crack sealants currently used at TxDOT were suggested. These modifications include characterizing the sealants by using bending beam rheometer (BBR) and dynamic shear rheometer (DSR) tests, in addition to what is available in the specifications. This research showed that the main failures for sealants occur at cold temperatures during the winter season. Therefore, it is very important to understand sealants' behavior at cold temperatures. Because the BBR examines sealant performance during cold temperatures, this test can be utilized for both hot and cold pour sealants. In project 0-4061, adhesive failures were observed mainly in cold pour materials. Bond tests analyze cohesion and adhesion of sealants to pavement, and therefore, may be good tests for evaluating the potential for the adhesive failure of cold pour sealants.

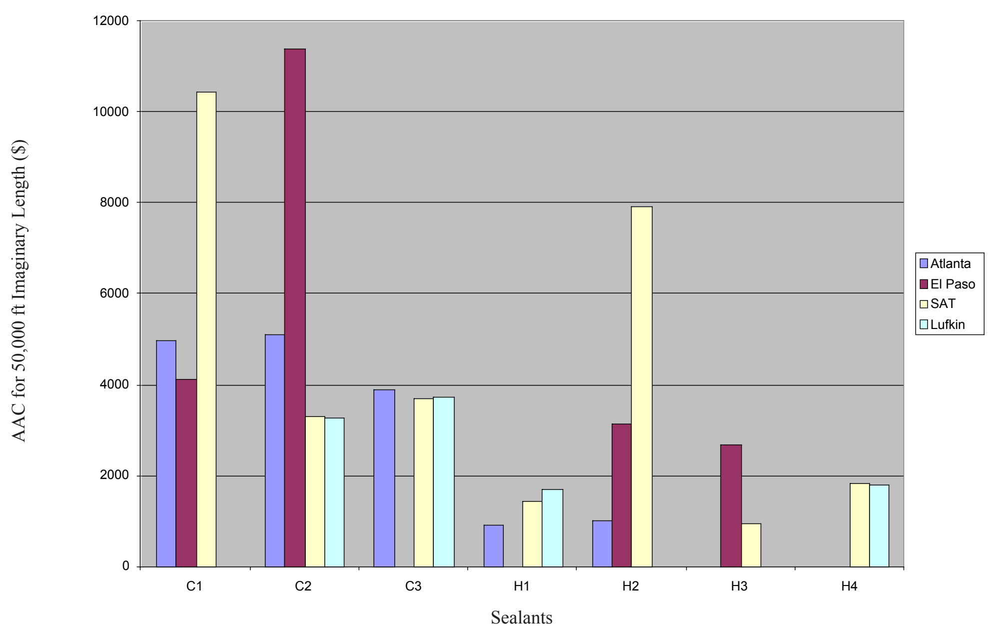

Figure 1. Average Annual Cost Values for 50,000 ft Imaginary Length for Each Sealant

For More Details...

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The research is documented in the following reports:

0-4061-1, *Comparison of Hot Rubber Crack Sealants to Emulsified Asphalt Crack Sealants*
0-4061-2, *Performance Evaluation of Hot and Cold Pour Crack Sealing Treatments on Asphalt Surfaced Pavements*
0-4061-3, *Performance Comparison of Hot Rubber Crack Sealants to Emulsified Asphalt Crack Sealants*

To obtain copies of a report: CTR Library, Center for Transportation Research,
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