

VERMONT AGENCY OF TRANSPORTATION

**Research & Development Section
Research Report**



**ASSESSMENT OF ASTM D 6690-12
TYPE II AND TYPE IV JOINT SEALERS**

Report 2014 – 08

November 2014

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TYPE II AND TYPE IV JOINT SEALERS**

**Final Report
Report 2014 – 08**

November, 2014

Reporting on Work Plan 2010-R-01

STATE OF VERMONT
AGENCY OF TRANSPORTATION

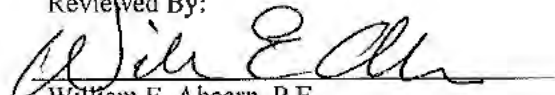
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ABSTRACT

To address the issue of water infiltration and debris retention, bituminous crack sealers and fillers have been developed to help prevent premature pavement distress. If applied appropriately, crack sealers and fillers can significantly extend the life of a pavement. To utilize crack sealers and fillers properly, one must understand that sealers and fillers differ in application and material types. Crack sealers are typically used on cracks that move more than one-eighth inch, with the intention to prevent water and debris from entering the pavement structure. The rigorous installation process involves thorough crack preparation followed by placement of high elongation material in a specific configuration. Crack fillers generally use a stiffer material than crack sealers and are typically used on non-working cracks

The purpose of this study was to examine and evaluate the constructability, overall performance and cost effectiveness of AASHTO M324-12 Type II versus IV Joint Sealers. Research personnel assessed each product's durability at each location. Cracks were filled according to the project plans. Efforts were made to provide a comparative analysis with regard to performance and cost of both material types by minimizing application variations in weather conditions, equipment used, and application crewmembers by applying material on the same day and/or conditions.

Over a three-year span and six data collection timeframes, the type IV material resulted in an average of a 10% less allowance of water passage through the length of a filled crack. A ten percent better performance of a material over a comparable alternative is considerable and should not be ignored, and results in approximately 2 feet less of compromised length of a full width transverse crack.

INTRODUCTION

Increasing construction costs combined with a rapidly deteriorating highway infrastructure has prompted State Transportation Agencies to seek cost effective methods for increasing the service life of pavements. Pavement preservation, according to the American Association of State Highway and Transportation Officials (AASHTO), is a planned strategy of cost-effective treatments to an existing roadway system that preserves the system, retards future deterioration and maintains or improves the functional condition of the system without significantly increasing structural capacity. The application of a preventative maintenance treatment at the proper time provides a cost effective alternative that typically extends the serviceability of the pavement until the time when a corrective (or rehabilitative) treatment is needed. Studies have shown that any delay in preventative maintenance directly increases the quantity and severity of pavement defects, consequently resulting in higher costs over time (1). Preventative maintenance treatments include, but are not limited to, bituminous crack fill sealant, chip seal, micro-surfacing, slurry seal, cape seal, fog seal, paver placed surface seal, ultra-thin bituminous overlay, profile milling, cold milling and bituminous overlay, and hot-in-place bituminous overlay.

Bituminous concrete pavements deteriorate over time due to several distress factors including water infiltration, temperature extremes, inadequate structural layers, construction quality, temperature susceptibility including freeze thaw cycles, aging characteristics of the asphalt cement, and vehicular loading (2). Research has shown that water infiltration is one of the most common factors that lead to accelerated deterioration. This can cause cracking, raveling, oxidation, stripping, and softening or weakening of the base and/or subbase leading to a loss of structural support and subsequently a shorter life span in asphalt pavements. Studies have shown that an increase in moisture from 16 to 18 percent in silty clay can cause a 75 to 100 percent reduction in strength, as measured by the California bearing ratio. Free water in granular base courses can easily reduce their strength by 25 percent or more under dynamic load (3).

To address the issue of water infiltration and debris retention, bituminous crack fillers have been developed to help prevent premature pavement distress. If applied appropriately, crack fillers can significantly extend the life of a pavement. Crack filling is a preventative maintenance method intended to reduce the amount of water and debris infiltrating into the underlying pavement structure (4).

According to the Federal Highway Administration (FHWA) cracks must be evaluated prior to specifying the appropriate sealer or filler to discern whether they are a working or non-working crack and whether the crack undergoes horizontal or vertical movement. Working cracks are defined as having 1/8 inch or more in vertical or horizontal movement (see Figure 1.) Typically, working cracks are transverse to the direction of the highway; however, longitudinal and diagonal cracks can be classified as working if they meet the movement criteria. Horizontal

movement is driven by shrinkage and expansion of the pavement due to thermal changes within the pavement material. Vertical movement is driven mostly by moisture related changes within the substrate and typically applies to concrete pavements. Non-working cracks typically have minimal or no movement because of the relatively close spacing of free edges between the cracks (5). Cracks can be classified as working or non-working after one year of monitoring the horizontal movement of the crack (6).

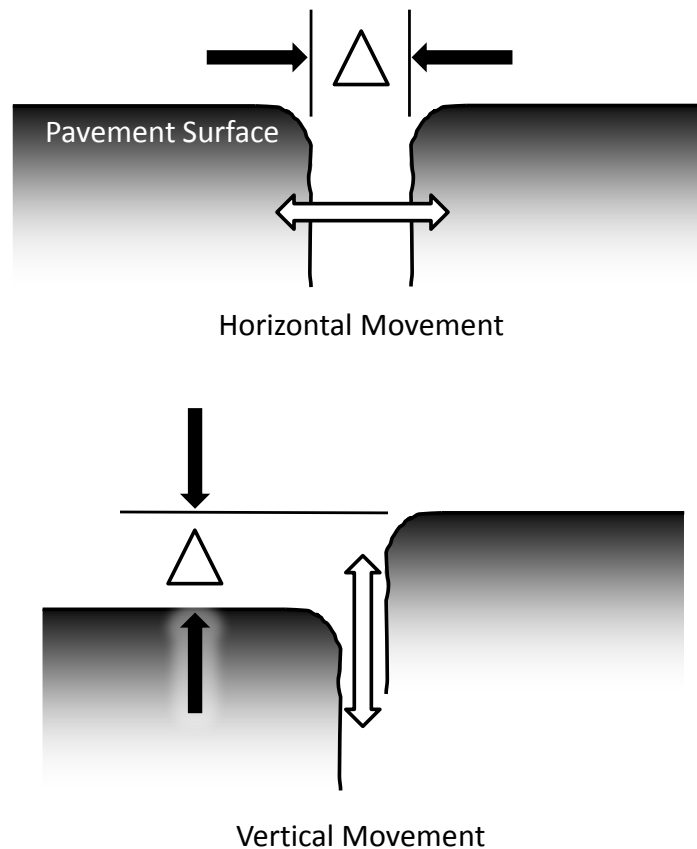


Figure 1 Definition of Movement. Δ is 1/8 inch or greater for working cracks.

In the 2011 Vermont Agency of Transportation Standard Specifications for Construction, the specification for crack (joint) seals states the following:

- 707.04 (a) – Joint Sealer, Hot Poured: This material shall consist of a hot applied, single-component, low-modulus, elastic sealant meeting the requirements of AASHTO M 324 (ASTM D 6690) Type II or Type IV as specified in the Contract Documents.

The description of the two material types are as follows:

- Type II: A joint and crack sealant capable of maintaining an effective seal in most climates. Material is tested for low temperature performance at -29°C using 50 % extension.
- Type IV: A joint and crack sealant capable of maintaining an effective seal in climates experiencing very cold temperatures. Material is tested for low temperature performance at -29°C using 200 % extension.

Therefore a type IV material should be able to bridge and seal cracks that expand a large amount at any point, while a type II will not stretch as much but may provide a stiffer barrier. The results of this research project provide a better understanding how each may perform on Vermont roadways and when each should be used.

PROJECT LOCATION AND SUMMARY

The purpose of this study is to examine and evaluate the constructability, overall performance and cost effectiveness of ASTM D 6690-12 Type II versus IV Joint Sealers. Research personnel assessed each product's durability at each location. Cracks were filled or sealed according to the project plans. For the purpose of this study, the FHWA definitions of working and non-working cracks will be used. Movement will be assumed to be the result of temperature changes and vehicular loading. Following one year of service after filling, all cracks were classified as working or non-working cracks. Efforts were made to provide a comparative analysis with regard to performance and cost of both material types by minimizing application variations in weather conditions, equipment used, and application crewmembers by applying material on the same day and/or conditions if possible.

All locations were specified within the 2010 Statewide Crack Sealing project, STP CRAK (28). According to the project plans, work performed included routing and sealing of cracks in bituminous concrete pavement. Two segments of the project were chosen as the experimental test sites for this research initiative. The first location is along Vermont Route 73 in the towns of Chittenden and Rochester for a project distance of 8.924 miles. The AADT at this location is 1,025. The second location is on US Route 4 in the towns of Killington and Bridgewater extending a project distance of 6.918 miles. The AADT at this location is 6,600.

Both locations were last paved in 2007. The Rochester-Chittenden-Rochester location received a ½" Type IV Marshall Mix leveling course and 1 ½" Type III Marshall Mix wearing course. The Killington-Bridgewater location received a ½" leveling course and was paved with Type IV binder course and 1 ¾" Type III Superpave mix-wearing course. At both locations, the

entire eastbound lane utilized Type IV joint sealer and the westbound lane received Type II in order to provide a direct, side-by-side analysis of each material type while eliminating as many variables as possible.

Both types of crack fill were produced by the same manufacturer and used as recommended. All other locations throughout the state within the overall statewide crackfill project used Type IV joint sealer for the entire project length in both lanes. Each of the two experimental locations contains four test sites, including one manufactured section.

Manufactured sections contained no natural cracking, but rather a specific pattern was routed out and filled for a controlled comparison where both products would be tested within the exact same pattern (see Figure 2.) The manufactured test sites were also included in the project to study if tire tracking was a concern. Every test site stretches over both lanes of travel, and extends 100 feet lengthwise. Table 1 exhibits the different test site locations within each project location. For this project, the crack seal was evaluated in four different categories: spalling, adhesion, cohesion, and overall crack width spreading. Crack filling operations occurred between June 21 and July 1, 2010 in both locations. Test sites were chosen prior to material installation to determine pre-existing conditions but were not revealed to the contractor, with the exception of the manufactured sites.



Figure 2 An example of a Manufactured Cracked Test Site

Table 1 Test Site locations

Project	Test Site	Type of Test Site	Town	Mile Marker	Length of Test Site
Rochester - Chittenden - Rochester	1	Natural Cracking	Rochester	1.4253	100
	2	Natural Cracking	Rochester	4.9783	100
	3	Manufactured Cracking	Rochester	Approximately 6.0 - Just EB of CCC Camp and pull off on WB lane	25
	4	Natural Cracking	Rochester	Approximately 6.9 - Just WB of Bridge #17	100
Killington - Bridgewater	1	Manufactured Cracking	Bridgewater	0.3830	25
	2	Natural Cracking	Bridgewater	0.9169	100
	3	Natural Cracking	Bridgewater	4.7740	100
	4	Natural Cracking	Bridgewater	2.4430	100

MATERIAL DESCRIPTION

Certified ASTM D 6690-12 Type II and Type IV joint sealers were used as per the project plans. The product and manufacturer were determined by the Contractor. Annseal Inc. performed crack sealing on both projects, and selected Crafcro Inc. as the material provider. Road Saver 231 was provided by Crafcro as the Type IV Joint Sealer, and Road Saver 221 was provided as the Type II Joint Sealer. The material provided was inspected by the Resident Engineer as per the Bituminous Crack Sealing specification (417.03) in the Vermont 2006 Standard Specifications for Construction (7).

The materials are packaged individually by weight and shipped to the project location where it is then melted in a portable kettle at 380-400 degrees Fahrenheit, depending on which type of joint sealer is being melted. According to the Hot-Applied Road Saver Installation Instructions provided by Crafcro Inc. (8), the material has an application life of 12-15 hours while heated to application temperature. This life span can be extended when new product is added. Material may be reheated once to the application temperature after the initial heat up. The Installation Instructions also state that the pavement temperatures should be above 40 degrees Fahrenheit to reduce the risk of lower adhesion due to the presence of moisture.

PERFORMANCE AND OBSERVATIONS

Installation of all materials at all locations was completed without incident. Figure 3 depicts a typical installation. In all instances, cracks were first routed with a routing cart, cleared off with a blower, further cleaned with a heat lance/blower, and the cracks filled via a wand that is attached to the kettle. On warm days, filled cracks can be cooled quicker with the application of a water spray.



A. Routing the crack.



B. Cleaning the crack with a blower.



C. Further cleaning with a heat wand.



D. Filling of routed cracks with fill material.



E. Water spraying to cool cracks quicker.

Figure 3 Steps of the Crack Filling Process.

The first site visits after installations were performed on July 28 (Rochester) and September 20 (Killington). During these visits, cracks were chosen within each test site to be monitored. Nails were placed approximately 6 inches apart perpendicularly on either side of these cracks (see Figure 4.) The distance between the nails was measured. These distances will be measured during each future site visit to determine the amount of movement of each crack. Cracks that move more could be expected to develop more crack fill distresses in the future. The nail distances were measured with the use of a set of calibrated calipers with a 1/1000th of an inch resolution. The majority of cracks to be evaluated are transverse, going full width across both lanes of road when possible so that the two types of material can be evaluated on the same crack. A few sets of longitudinal cracks were also chosen, where there was similar cracking in both lanes. Table A1 in the appendix shows a list of all cracks chosen in each test site, the original nail distances recorded, and the overall length of the cracks. Two other important items of note related to crack fill inspection are tracking and debris retention. Tracking is the tendency for material to stick to vehicle tires and spread across the asphalt before it is fully cooled and solidified. Debris retention comprises of stones or other contaminants embedded into the material, usually prior to being fully cooled. Both of these are negative aspects attributed to crack fill; neither was found to have occurred on any test site on either project.

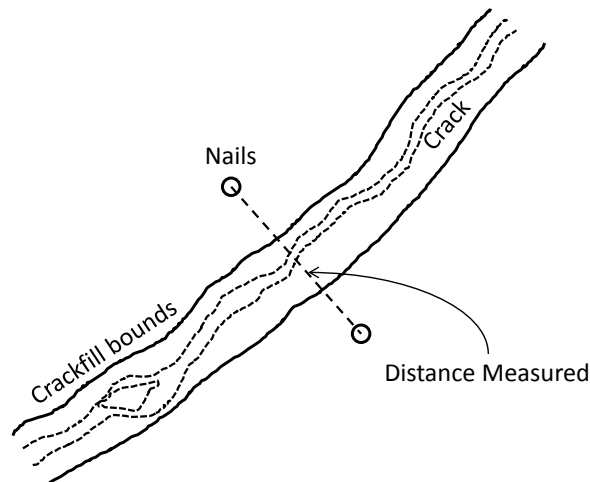


Figure 4 Typical Test Location

During the installation, various samples of the heated crack fill materials were collected and later subjected to laboratory analysis. This was to determine definitively that the material going down was in fact Type II or IV in the correct locations. The laboratory test was ASTM D

5329-07, “Standard Test Methods for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphaltic and Portland Cement Concrete Pavements,” cone penetration test (9). Table 2 shows the results of this test for all samples received. The specification states that penetration values, at 25°C, should be a maximum of 90 for a Type II crack filler and between 90 and 150 for a Type IV. This was the criteria applied to the values to determine whether a material passed or failed in Table 2.

Table 2 Laboratory testing results of applied crack fill.

Sample Number	Type	Project	Penetration 1	Penetration 2	Penetration 3	Average Penetration	Pass/Fail
R1A	II	Rochester	90	85	93	89	P
R2A			119	94	95	102	F
R3A			78	80	79	79	P
4A			83	84	83	83	P
K5A			75	78	77	77	P
6A			80	79	78	79	P
97A	IV	Killington	131	131	135	132	P
98			131	134	134	133	P
15			164	163	170	166	F
39			164	163	160	163	F
K3A			135	137	142	138	P
K2A			134	135	137	135	P
K1A			138	137	137	137	P
K4A			137	138	137	137	P
37		Rochester	129	132	131	131	P
R6A			129	127	126	127	P
R5A			125	126	125	125	P
35			122	123	122	122	P
36			122	122	123	122	P
38			138	139	132	136	P

The penetration results show a distinct difference between the Type IV and II materials, with all Type IV resulting in values of 122 or higher, and Type II having values of 102 and lower. The testing verified the materials that were placed indeed had characteristics of the correct types that were required as part of the construction project. On the Killington-Bridgewater portion of the project, construction did not collect any Type II samples for testing; therefore, laboratory verification of the Type II product used in that location was not performed.

Semi-annual site visits continued through three total years to assess crack movement and distresses. Site visits were performed on: September 20, 2010 (Nail Installation); March 9, 2011

(Winter 1); August 19, 2011 (Summer 1); March 8, 2012 (Winter 2); November 16, 2012 (Summer 2), March 4, 2013 (Winter 3), and August 14, 2013 (Summer 3). Table 3 shows all crack movement values (in inches) during the six overall site visits. Cracks moved (spread) much more early on in the project and less as time went on. Using the conditions stated earlier of a moving crack exhibiting movement of 1/8th of an inch or more, the Rochester-Chittenden project during the first winter are the only set of cracks that were working within the entire study. As of the last year of readings, cracks were not changing much during seasonal changes, at least at the time of measurements.

Table 3 Average crack width increase from initial readings, in inches.

Project Crack Seal Type	Rochester-Chittenden		Killington-Bridgewater	
	II	IV	II	IV
Winter 1 (2011)	0.178	0.167	0.027	0.029
Summer 1 (2011)	-0.011	-0.016	-0.061	-0.002
Winter 2 (2012)	0.055	0.100	0.044	0.017
Summer 2 (2012)	0.003	0.001	0.006	0.001
Winter 3 (2013)	0.010	0.054	0.063	0.024
Summer 3 (2013)	-0.023	-0.014	0.011	-0.002

Table 4 and 5 show the average distresses within each test site for the first three and last three site visits respectively. While spalling and cohesion values remained low, adhesion (the crack fill not remaining adhered to the pavement along some portion of its length) values increased dramatically. Measurement discrepancies were noted for the type IV crack fill materials on the Rochester project during the Winter 3 site visit. Average adhesion values during the three site visits for those measurements went from 8% up to 16% then down to 7%. While small variances can be expected within the measurement process, the 16% during the winter 3 visit was an outlier. Issues occurred over all three natural cracking test sites, therefore it was a natural phenomenon, not simple measurement or recording errors; the same personnel also performed the measurements as for other site visits. Distress lengths are measured and binned by the visual condition at the time of the site visits, therefore are subject to the measurement person's discretion. It is hypothesized that the weather/temperature conditions leading up to the visit produced a certain geometry that exposed the adhesion failures more than was ever noticeable during other visits. This skews the overall comparison between type II and IV material, as type II looks superior based on winter 3 readings, while type IV does during the subsequent summer readings.

Table 4 Average distresses, as a percent of original length, over the first three site visits.

Project	Filler Type	Test Site	Winter 1			Summer 2			Winter 2		
			Adhes.	Spall.	Cohes.	Adhes.	Spall.	Cohes.	Adhes.	Spall.	Cohes.
Rochester Chittenden Rochester	II	1	2	10	0	7	2	0	9	9	0
		2	4	9	0	1	2	1	7	4	0
		3	0	0	0	0	0	0	0	0	0
		4	1	4	0	0	3	0	4	0	3
	IV	1	13	10	0	8	7	0	14	8	0
		2	1	2	0	0	2	0	6	1	2
		3	0	0	0	0	0	0	0	0	0
		4	2	6	0	1	6	0	2	3	0
Killington Bridgewater	II	1	0	0	0	0	0	0	0	0	0
		2	1	4	0	3	2	0	0	3	0
		3	4	9	0	0	4	0	3	1	0
		4	7	7	0	2	4	0	3	0	0
	IV	1	0	0	0	0	0	0	0	0	0
		2	6	4	0	2	0	0	0	0	0
		3	1	1	0	0	1	0	2	0	0
		4	1	11	1	1	0	0	0	0	0
Average	II		2	5	0	1	2	0	3	2	0
	IV		3	4	0	1	2	0	3	1	0

Table 5 Average distresses, as a percent of original length, over the final three site visits.

Project	Filler Type	Test Site	Summer 2			Winter 3			Summer 3		
			Adhes.	Spall.	Cohes.	Adhes.	Spall.	Cohes.	Adhes.	Spall.	Cohes.
Rochester Chittenden Rochester	II	1	17	4	2	28	4	0	30	3	6
		2	10	0	3	15	4	0	19	3	2
		3	0	0	0	0	0	0	0	0	0
		4	3	0	3	10	1	0	11	2	5
	IV	1	25	0	5	23	5	0	11	5	0
		2	2	0	1	26	4	0	10	2	0
		3	0	0	0	0	0	0	0	0	0
		4	4	0	4	16	5	0	5	3	0
Killington Bridgewater	II	1	0	0	0	0	0	0	0	0	0
		2	2	0	4	6	3	0	18	4	0
		3	3	0	4	1	3	0	8	1	0
		4	1	0	7	1	8	0	5	6	0
	IV	1	0	0	0	0	0	0	0	0	0
		2	1	0	1	1	1	0	10	2	0
		3	0	0	0	0	0	0	4	2	0
		4	2	0	1	8	4	0	4	0	0
Average	II		5	1	3	8	3	0	12	3	2
	IV		4	0	2	10	2	0	6	2	0

Another item of note that is evident in Tables 4 and 5 is that the manufactured sections, test site 3 in Rochester and 1 in Killington, showed no distress over the length of the study. This proves that, given ideal conditions, both types of fill material have the ability to succeed in our climate.

Table 6 summarizes the water-infiltration failure rates for the fill types over each of the measurement cycles. Overall, both materials performed very similarly over many of the cycles. By the three-year mark it was evident that, during the final site visit, the type IV was outperforming the type II crack fill by exhibiting an average of 10% less water infiltration length per crack. This would equate to approximately two feet better protection over the length of a full two-lane transverse crack, which could be considered a considerable benefit. When failure rates are calculated on a per-project location basis, it is revealed that the harsher of the two locations, Rochester showed a 24% failure rate for type II material as compared to 9% for type IV. At the more moderate Killington location, the rates were 10 and 6% respectively. This shows that the more harsh the climate, i.e. more freeze thaw cycles and lesser-engineered roadway, the more dramatic the need for the more elastic type IV material is.

Table 6 Overall water infiltration lengths, as a percent of crack length without manufactured test sections included.

Failure Percents		
	Type II	Type IV
Winter 1	3	4
Summer 1	2	2
Winter 2	5	4
Summer 2	10	7
Winter 3	11	14
Summer 3	18	8

SUMMARY AND RECOMMENDATIONS

It was determined, within the context of this evaluation, that the more elastic type IV crack fill material may provide a greatly increased benefit on Vermont's roads over type II material. The two types of material were evaluated side by side on two differing project locations for failure lengths that would allow the ingress of water down through filled pavement cracking. Over a three-year span and six data collection timeframes, the type IV material resulted in an average of a 10% less allowance of water passage through the length of a filled crack. A ten percent better performance of a material over a comparable alternative is considerable and should not be ignored, and results in approximately 2 feet less of compromised length of a full width transverse crack. The difference between the two materials was even more dramatic in the more remote and harsh climate location of Rochester, where the type IV material

reduced water infiltration lengths by 15% of the crack length. The difference between materials at the less harsh location in Killington was only 4%.

Cost of the two materials is almost identical. Currently, for the Crafc materials used in this study, the Type IV product costs approximately five cents more per pound than the type II. Bid documents for the two project locations within this study estimated 7,600 lbs of each material would be used. At the 5 cent per pound difference, the cost increase from type II to IV throughout would have been \$760. All labor, equipment and miscellaneous costs for each product are identical, as they require the same installation methods.

With respect to these findings, it is recommended to use only the more elastic type IV crack fill material on any roads with working cracks and roads where excessive freeze/thaw or crack movement may be expected.

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APPENDIX

Table A1. Crack labels, types, lengths, and nail distances.

Project	Test Site	Crack #	Lane	Material Type	Crack Type	Crack Length (inches)	Nail Widths (inches)
Rochester	1	1a	WB	II	Lane Transverse	204	5.627
Rochester	1	1b	EB	IV	Lane Transverse	120	5.586
Rochester	1	2a	WB	II	Lane Transverse	156	5.626
Rochester	1	2b	EB	IV	Lane Transverse	72	5.608
Rochester	2	1a	WB	II	Lane Transverse	144	5.699
Rochester	2	1b	EB	IV	Lane Transverse	132	5.737
Rochester	2	2a	WB	II	Lane Transverse	48	5.596
Rochester	2	2b	EB	IV	Lane Transverse	132	5.455
Rochester	2	3a	WB	II	Lane Transverse	132	5.505
Rochester	2	3b	EB	IV	Lane Transverse	72	5.682
Rochester	3	1a	WB	II	Lane Transverse	132	5.575
Rochester	3	1b	EB	IV	Lane Transverse	132	5.505
Rochester	3	2a	WB	II	Longitudinal	192	5.644
Rochester	3	2b	EB	IV	Longitudinal	192	5.478
Rochester	3	3a	WB	II	Lane Transverse	132	5.644
Rochester	3	3b	EB	IV	Lane Transverse	132	5.471
Rochester	4	1a	WB	II	Lane Transverse	144	5.715
Rochester	4	1b	EB	IV	Lane Transverse	96	5.648
Rochester	4	2a	WB	II	Lane Transverse	144	5.698
Rochester	4	2b	EB	IV	Lane Transverse	96	5.724
Rochester	4	3a	WB	II	Lane Transverse	96	5.825

Project	Test Site	Crack #	Lane	Material Type	Crack Type	Crack Length (inches)	Nail Widths (inches)
Rochester	4	3b	EB	IV	Lane Transverse	108	5.694
Killington	1	1a	WB	II	Lane Transverse	132	6.003
Killington	1	1b	EB	IV	Lane Transverse	132	5.944
Killington	1	2a	WB	II	Longitudinal	204	5.526
Killington	1	2b	EB	IV	Longitudinal	204	5.363
Killington	1	3a	WB	II	Lane Transverse	132	5.466
Killington	1	3b	EB	IV	Lane Transverse	132	5.847
Killington	2	1a	WB	II	Shoulder Transverse	72	5.585
Killington	2	1b	EB	IV	Shoulder Transverse	84	5.859
Killington	2	2a	WB	II	Longitudinal	96	5.826
Killington	2	2b	EB	IV	Longitudinal	120	5.705
Killington	2	3a	WB	II	Lane Transverse	168	5.873
Killington	2	3b	EB	IV	Lane Transverse	48	5.853
Killington	3	1a	WB	II	Longitudinal	132	5.868
Killington	3	1b	EB	IV	Longitudinal	120	5.674
Killington	3	2a	WB	II	Lane Transverse	132	5.781
Killington	3	2b	EB	IV	Lane Transverse	156	5.661
Killington	3	3a	WB	II	Lane Transverse	60	5.859
Killington	3	3b	EB	IV	Lane Transverse	264	5.943
Killington	4	1a	WB	II	Lane Transverse	36	5.728
Killington	4	1b	EB	IV	Lane Transverse	60	5.712
Killington	4	2a	WB	II	Lane Transverse	48	5.617
Killington	4	2b	EB	IV	Lane Transverse	60	5.762

Prepared By: Wendy Kipp

Date: March 9, 2010

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH SECTION

WORK PLAN FOR
RESEARCH INVESTIGATION

Assessment of AASHTO M 364 Type II and IV Joint Sealers

Work Plan No. WP-2010-R-01

INTRODUCTION:

Ever increasing construction costs combined with a rapidly deteriorating highway infrastructure has prompted State Agencies to seek cost effective methods for increasing the service life of pavements. Pavement preservation, according to the American Association of State Highway and Transportation Officials (AASHTO), is a planned strategy of cost-effective treatments to an existing roadway system that preserves the system, retards future deterioration and maintains or improves the functional condition of the system without significantly increasing structural capacity. The application of a preventative maintenance treatment at the proper time provides a cost effective alternative that typically extends the serviceability of the pavement until the time when a corrective (or rehabilitative) treatment is needed. Studies have shown that any delay in preventative maintenance directly increases the quantity and severity of pavement defects, consequently resulting in higher costs over time (1). Preventative maintenance treatments include, but are not limited to, bituminous crack fill sealant, chip seal, micro-surfacing, slurry seal, cape seal, fog seal, paver placed surface seal, ultra-thin bituminous

overlay, profile milling, cold milling and bituminous overlay, and hot-in-place bituminous overlay.

Bituminous concrete pavements deteriorate over time due to several distress factors including water infiltration, temperature extremes, inadequate structural layers, construction quality, temperature susceptibility including freeze thaw cycles, aging characteristics of the asphalt cement, and vehicular loading (2). Research has shown that water infiltration is one of the most common that lead to accelerated deterioration. This can cause cracking, raveling, oxidation, stripping, and softening or weakening of the base and/or subbase leading to a loss of structural support and subsequently a shorter life span in asphalt pavements. Studies have shown that an increase in moisture from 16 to 18 percent in silty clay can cause a 75 to 100 percent reduction in strength, as measured by the California bearing ratio. Free water in granular base courses can easily reduce their strength by 25 percent or more under dynamic load (3).

To address the issue of water infiltration and debris retention, bituminous crack sealers and fillers have been developed to help prevent premature pavement distress. If applied appropriately, crack sealers and fillers can significantly extend the life of a pavement. To properly utilize crack sealers and fillers, one must understand that sealers and fillers differ in application and material types. Crack sealers are typically used on working cracks with the intention to prevent water and debris from entering the pavement structure. The rigorous application process involves thorough crack preparation followed by placement of high-quality material in a specific configuration. Crack fillers generally use a lesser quality material than crack sealers and are typically used on non-working cracks. Crack filling is a process designed to reduce but not eliminate the amount of water and debris infiltrating the underlying pavement structure (4).

According to the Federal Highway Administration (FHWA) cracks must be evaluated prior to specifying the appropriate sealer or filler to discern whether they are a working or non-working crack and whether the crack undergoes horizontal or vertical movement. Working cracks are defined as having .12 inches or more in vertical or horizontal movement. Typically working cracks are transverse in orientation but longitudinal and diagonal cracks can be classified as working if they meet the movement criteria. Non-working cracks typically have minimal or no movement because of the relatively close spacing or free edges between the cracks (5). Cracks can be classified as working or non-working after one year of monitoring the horizontal movement of the crack (6).

BACKGROUND

In the 2006 Vermont Agency of Transportation Standard Specifications for Construction, “Joint Sealers – Hot Poured (707.04)” are to be used for “Bituminous Crack Fill Sealants (417.02)” (7). All joint sealers require a Type B or Type C certification. A brief excerpt of the 707.04 specification is included below:

- 707.04 (a) – Joint Sealer, Hot Poured: The material shall consist of a hot applied, single-component, low-modulus, elastic sealant meeting the requirements of AASHTO M 324 “Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements” (8). The sealant shall allow up to 200 percent elongation at temperatures down to -29°C (-20°F) when placed in a typical joint configuration .

In the past there have been some misconceptions regarding the interpretation of this specification. As a result, although the intent of the Vermont specification is to use an AASHTO Type IV joint sealer, AASHTO Type II joint sealers have been utilized. The AASHTO M324 standard specification classifies the two types as follows:

- Type II: A joint and crack sealant capable of maintaining an effective seal in most climates. Material is tested for low temperature performance at -29°C using 50 % extension.
- Type IV: A joint and crack sealant capable of maintaining an effective seal in climates experiencing very cold temperatures. Material is tested for low temperature performance at -29°C using 200 % extension.

OBJECTIVE:

The purpose of this study is to examine and evaluate the constructability, overall performance and cost effectiveness of AASHTO M324 Type II versus IV Joint Sealers. Research personnel will assess each product’s durability at each location. All cracks will be filled or sealed according to the project plans. For the purpose of this study working cracks will be defined as those experiencing equal to or more than 1/8 inches in vertical or horizontal movement as a result of temperature changes and vehicular loading. All non-working cracks will be defined as having no or minimal vertical or horizontal movement less than 1/8”.

Following one year of service, all cracks will be classified as working or non-working cracks. Efforts will be made to provide a comparative analysis with regard to performance and cost of both material types by minimizing application variations in weather conditions, equipment used, and application crew members by applying material on the same day and/or conditions if possible.

PROPOSED LOCATIONS:

All proposed locations are specified within the Statewide Crack Sealing project, STP CRAK (28). According to the project plans, work to be performed includes routing and sealing of cracks in bituminous concrete pavement. The first location is along Vermont Route 73 in the towns of Chittenden and Rochester for a project distance of 8.924 miles. The AADT at this location is 1,025. The second location is on US Route 4 in the towns of Killington and Bridgewater extending a project distance of 6.918 miles. The AADT at this location is 6,600. Both locations were paved in 2007. The Rochester-Chittenden-Rochester location received a ½” Type IV Marshall mix leveling course and 1 ½” Type III Marshall mix wearing course. The Killington-Bridgewater location received a ½” leveling course and was paved with Type IV binder and 1 ¾” Type III Superpave mix wearing course. At both locations, the entire eastbound lane will utilize AASHTO Type IV joint sealer and the westbound lane will receive AASHTO Type II. All other locations within the project plans will use AASHTO Type IV joint sealer for the entire project length in both lanes.

MATERIAL:

Certified AASHTO M324 Type II and Type IV joint sealers will be used as per the project plans. The product and manufacturer will be determined by the Contractor.

SURVEILLANCE AND TESTING:

The AASHTO Type II and Type IV joint sealers will be monitored during placement in accordance with the contract plans and the Vermont Standard Specifications as well as with the manufacturer’s recommendations. Evaluation shall include the following:

1. **Test Sites:**

A total of four test sites will be established at each project location. The location of each test site will be determined during the preconstruction site visit. Three of the test sites will be fifty feet in length and include all natural existing cracks within each site. The fourth test site will include one twenty-five foot test section of manufactured cracking to be selected by Research personnel. All cracks in this section will be routed during construction per the construction plans in a predetermined pattern and include transverse, longitudinal, and diagonal cracks. These cracks will be routed as will the existing cracks will be routed to be ¾" x ¾" in size. These test sites will be periodically monitored to: 1) observe the adhesion and cohesion properties of the joint sealer material, 2) determine the approximate percentage of water infiltration, and 3) to document stone and debris retention. These monitoring activities are discussed in further detail below under Field Evaluation Methods.

2. **Construction:**

At the time of the application, temperature, relative humidity, precipitation/cloud cover, wind condition, ambient air, pavement temperatures, time of day, and equipment condition will be recorded. All equipment shall be approved by the Resident Engineer as per the Bituminous Crack Sealing specification (417.03) in the Vermont 2006 Standard Specifications for Construction (7). All surface preparation and application procedures and workmanship will be monitored closely. This will include but not be limited to checking the cleanliness of the melting kettle and sharpness of the router. Any problems encountered during application of the joint sealers will be documented.

3. **Site Visits:**

A preconstruction site visit will be conducted to establish the four test sites and document the occurrence and condition of cracks. Photographs and general observations will be recorded. After each application is complete, site visits will be conducted weekly during the first month, biweekly during month two, and once during month three. For the first year, each site will be visited quarterly after the first three months. This will be followed by biannual visits in the winter and summer months for a period of two years

4. **Field Evaluation Methods:**

- **Horizontal Movement:**

- A method developed by the North Dakota Department of Transportation will be used to measure the elongation characteristics of each sealant (9). Two spots will be within each project location. At these locations, square headed concrete nails will be driven flush into the asphalt approximately 3” on each side of the crack. Calibrated micrometer calipers will be used to measure the distance from the outer edge of one nail to the outer edge of the other nail. These measurements will be recorded during each site visit to document crack movement.

- **Adhesion and Cohesion Loss:**

- Any adhesion and cohesion loss will be monitored and used to establish how effective the material is. At each site visit, the amount of material that does not adhere to the sides of the crack will be considered “failed”. The following equations, established by FHWA will be used to determine the overall effectiveness in relation to adhesion and cohesion loss at each test site (10).

Effectiveness = 100 - % Failure, where the % Failure = 100 X [Length of Failed Treatment / Total Length of Treatment]

- **Water Infiltration:**

- In accordance with the National Transportation Product Evaluation Program (NTPEP) work plan for evaluating joint sealers, water infiltration will be measured as the percentage of the overall crack length where water can bypass the sealant and enter the crack either through complete adhesion or cohesion failure (11).

- **Stone and Debris Retention:**

- Stone or debris retention will be monitored and rated using the NTPEP work plan for evaluating joint sealers (11). The descriptions of each rating are below:
 - No Debris Retention: No stones or debris are stuck to the top of the sealant or embedded on the surface of the sealer.

- Low Severity: Occasional stones and/or debris are stuck to the top of the sealant, or debris is embedded on the surface of the sealer.
- Medium Severity: Stones and/or debris are stuck to the sealant and some debris is deeply embedded in the sealant or material embedded between the sealant and the crack face but not entering the crack below the sealant.
- High Severity: A large amount of stones and debris are stuck to and deeply embedded in the sealant or filling the crack, or a considerable amount of debris is embedded between the sealant and the crack face and entering the crack below the sealant.

5. **Laboratory Testing**

The cone penetration test, non-immersed utilizing the American Society for Testing and Materials, ASTM D 5329-07, “Standard Test Methods for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphaltic and Portland Cement Concrete Pavements” test method will be performed by the Materials and Research PG Binder Laboratory if equipment can be procured through project funding(12). This test will verify which type of joint sealer (Type II or Type IV) is being used at each project location. A minimum of two samples of each material type will be collected at the Killington-Bridgewater location and a minimum of three samples of each material type will be collected at the Rochester-Chittenden-Rochester location.

COST:

Material, labor, planning, and equipment costs incurred will be paid for under the project until the construction project is closed. All additional costs including the evaluation during year two and three and report preparation will be paid for by the Research program under the task entitled, “Evaluation of Experimental Features.” The total amount charged to Experimental Features will be approximately \$7,000.00. Costs will total \$2,304.00 for FFY2011 and \$4,644.00 for FFY2012.

STUDY DURATION:

The project will be under evaluation for the length of time required to obtain valid conclusions on the performance and effectiveness of the joint sealers but not less than two years.

REPORTS:

An initial report will be prepared following completion of initial installation. Interim reports will be prepared and submitted as needed but not less than once a year. A final report will be published once the evaluation is complete, but not sooner than 2 years after installation.

Reviewed by: _____

William Ahearn, P.E.

Materials and Research Engineer

Date:

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Approved by Material and Research (WEA)
Approved by Federal Highway Administration (CPJ)