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CENTERLINE (LONGITUDINAL) JOINT ADHESIVE PERFORMANCE: TWO TO THREE-YEAR REVIEW

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Centerline (Longitudinal) Joint Adhesive Performance: Two to Three-Year Review

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ABSTRACT

This report discusses preliminary evaluations of adhesive use along longitudinal paving joints on hot mix asphalt pavements to help prevent longitudinal cracking. Seven pavements where adhesive was applied to the vertical or sloped face of the first lane paved prior to overlaying the second lane are being evaluated for development of centerline cracking and ravelling. Three pavements were overlaid in 2004 and four pavements were overlaid in 2005. Three adhesive products made by different companies were used at bead widths of 2 inches and 4 inches. The 2 inch bead was used on all pavements while the 4 inch bead was used on two pavements. All but one pavement had non-adhesive (control) section. This report only evaluated the use of longitudinal joint adhesives on overlays, although the adhesive could be used on the top layer of newly reconstructed pavements. This is a review of the distress found after at least one follow-up visit to all sites. A summary of the literature search is also presented.

Conclusions from the limited data available were that longitudinal joint adhesives sections appear to be performing as least as well or better than non-adhesive sections. Further, using adhesives along centerline paving joints appears to be practical partial solution to longitudinal joint cracking. Additional site evaluation is required to determine long-term performance and cost effectiveness of the longitudinal joint adhesives.

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I. INTRODUCTION

It has been noted that cracking frequently develops along the longitudinal joint formed when adjacent lanes are paved separately, usually along pavement centerline. This cracking develops mainly due to difficulty to achieve proper density of Hot Mix Asphalt (HMA) along the centerline when lanes are paved separately causing a natural seam to be created. Once cracking develops along the seam, water and foreign matter is able to infiltrate the joint and with freeze/thaw cycles and the effects of traffic, the crack widens and lengthens causing eventual loss of asphalt.

Several methods have been used to alleviate this problem including but not limited to:

1. Paving both lanes simultaneously: This method is the best solution as it eliminates the longitudinal joint but usually is not practical for various reasons.
2. Use of butt joint: In this method, when the first lane is paved, a perpendicular face is formed by some means thus allowing for the second lane to be compacted to proper density. The perpendicular face and proper density of the first lane is difficult to achieve and the seam between lanes is still present.
3. Use of wedge joint: When the first lane is paved, a sloped face is formed and when the second lane is paved it overlaps the first lane (standard NYS practice). Due to temperature differential of the material in the two lanes, achieving proper density at centerline is difficult.
4. Use of various rolling patterns: Different roller patterns have been used in an attempt to achieve proper density along the longitudinal joint. Examples are: either starting from cold lane or from hot lane at various distances from centerline, or starting with the roller overlapping the centerline with the majority of the roller either on the hot or cold lane. All of these rolling patterns have had different degrees of success.

The purpose of this study is to examine the use of joint adhesive along the joint face placed prior to paving the second lane. Use of an adhesive could potentially delay formation of centerline cracks and if cracking did develop, potentially limit the depth which water infiltrates into the joint thus delaying damage caused by freeze/thaw cycles and traffic.

II. SUMMARY OF LITERATURE SEARCH

A literature search was performed to discover what other transportation agencies, if any, were using or testing longitudinal joint adhesives. Reports describing work by five other agencies were found. At the time of the literature search, the transportation agencies of Colorado, Pennsylvania, Maine, Kentucky, and New Jersey have used or tested longitudinal joint adhesives.

Colorado Department of Transportation tested adhesive use along with six various paving/rolling techniques to investigate the problem of differential densities along longitudinal joint. Evaluations of the performance of the different techniques after one and two years were described in two reports. After one year, the adhesive test section showed no cracking and only slight ravelling. The adhesive section performed no worse than any of the other paving techniques tested and better than two of them. It was stated that advantages of joint adhesive if any would likely be evident after several years[1]. After the second year‘s evaluation, the joint adhesive was ranked third in performance with 4 percent of the centerline cracked and areas of slight ravelling. Rank was determined by average rating given by five evaluators[2].

Pennsylvania Department of Transportation tested the use of a joint adhesive along with seven various paving/rolling techniques. Performance was rated by four or five evaluators in four different years with the last evaluation being six years after construction of the test sections and rankings were the average of the evaluators' ratings. In the four years that joint adhesive was evaluated, it was not ranked lower than third of eight techniques and was first in two years including the sixth year. In the sixth year it was given a rating of 9.88 of a possible 10.0. There was no cracking (only technique without any) and only slight ravelling[3].

Maine Department of Transportation tested three products: asphalt rubber joint adhesive, asphalt rubber joint sealer, and emulsified asphalt sealer. The use of emulsified asphalt sealers along the longitudinal joint is their standard practice and this section was used as the control. After five years, all sections displayed some cracks. The emulsified asphalt sealer section performed best, with only 5 m of identified joint separation. The majority of joint separation in other the two sections was located within the first 25 m of the sections and in both cases, cracking was attributed to poor joint construction. In the first 25 m, the asphalt rubber joint adhesive section had 18 m and the asphalt rubber joint sealer section had 13 m of identified joint separation. The remaining portions of asphalt rubber joint adhesive and asphalt rubber joint sealer sections had 1 m and 4 m of identified joint separation respectively. Permeability tests were performed at several locations throughout each section. No water loss, a key gauge in permeability testing, was recorded at any test location. All sections were said to be performing very well[4]. Due to this study, the use of rubberized crack sealer is now recommended, which is specified in Special Provision – Section 424 – Joint Sealer of the Maine DOT Standard Specifications which was provided in the report.

Kentucky Department of Transportation tested the use of joint adhesive on three pavements and a joint tape on two pavements as part of research project studying four other longitudinal joint construction techniques. Both the adhesive and the tape were found to decrease permeability at the joint. Joint tape was more labor intensive to install (it was noted that a newer, easier to install tape was available at time of the report but had not been tested). After one to two years, both the adhesive and the tape appear to be performing as least as well or better than sites where they were not used[5].

New Jersey Department of Transportation recommends the use of joint adhesives and has published revisions to their Standard Specifications pertaining to longitudinal joints on HMA pavements. Revisions include the use of polymerized joint adhesive[6].

III. ADHESIVE PLACEMENT AND LOCATIONS

Adhesives made by three different companies were used (Crafco, Deery, and Asphalt Materials, Inc.). All adhesives were placed using standard crack sealing equipment and were placed along top face of first lane centerline joint prior to paving the second lane. Either a 2 inch or 4 inch bead was placed along the joint face, (Photos 1 thru 8).

Photo 1: Loading Adhesive into Melting Pot

Photo 2: Overview of Application Equipment

Photo 3: Applicator Wand with 4 inch Shoe

Photo 4: Applicator Wand with 2 inch Shoe

Photo 5: Applicator Wand with 2 inch Shoe

Photo 6: Wedge Joint

Photo 7: Adhesive on Top Edge of Wedge Jt.

Photo 8: Paving Second Lane

Adhesives were placed experimentally on three pavements in 2004 and used on four pavements in 2005. The three pavements in 2004 are I87, Saratoga County, NYSDOT-Region 1 (Deery); I81, Cortland County, NYSDOT-Region 3 (Asphalt Materials, Inc.); and Route 417, Stueben County, NYSDOT-Region 6 (Crafco)(See Table 1). On all pavements, the adhesive was placed with 2 inch bead for approximately 0.1 mile. On I87, a 4 inch adhesive bead was also placed for 0.1 mile. On all pavements, an adjacent or nearby 0.1 mile where adhesive was not used was selected as control section. I87 and Route 417 were paved using wedge joints and I81 used a butt joint. On I87, adhesive was placed between center and third lanes (see Table 1).

Table 1: 2004 Sites

Route	I87	I81	417
County	Saratoga	Cortland	Stueben
Region	1	3	6
Begin RM	87I-1509-1256	81I-3402-3102*[1]	17-6404-1173
Site length	0.3 miles	0.2 miles	0.2 miles
Direction	NB	NB	WB
Product	Deery	Asphalt Materials, Inc	Crafco
Joint type	Wedge	Butt	Wedge
2 inch Bead	≈RM 1257	RM 3102	RM 1173
4 inch Bead	≈RM 1258	NA	NA
Control	≈RM 1256	RM 3083	RM 1172

RM – Reference Marker, NA – Not Applicable

1. Beginning of adhesive section, adhesive & control sections not adjoining

Chris Euler and Zoeb Zavery of NYSDOT Materials Bureau observed the I87 installation. Zoeb Zavery observed the I81 installation. Information on the Route 417 installation was provided by NYSDOT-Region 6 personnel.

The 2005 highways where adhesives were used are Route 3 and Route 481, both in Oswego County, NYSDOT-Region 3 (both Deery); Route 50, Schenectady County, NYSDOT-Region 1 (Crafco); and Route 7, Otsego County, NYSDOT-Region 9 (Crafco) (See Table 2). On Route 3, a 2 inch bead of adhesive was placed for entire length of the job (6.3 miles). On Route 481, adhesive was placed in a 4 inch bead on two sites (0.7 miles and approximately 0.1 mile), a 2 inch adhesive bead was placed on one site (approximately 0.1 mile), while adhesive was not used on three sites (0.5 miles, 0.3 miles, and 0.4 miles). On Route 50, the adhesive was placed on one site in a 2 inch adhesive bead (0.6 miles) and adhesive was not used on one site (0.3 miles). On Route 7, a 2 inch adhesive bead was placed on two sites (6.5 miles and 1.6 miles) while adhesive was not used on one site (0.6 miles) (see Table 2). All of the 2005 installations used a wedge joint.

Table 2: 2005 Sites

Route	3	481	50	7
County	Oswego	Oswego	Schenectady	Otsego
Region	3	3	1	9
Begin RM	3-3401-1000	481-3402-4000	50-1602 1028	7-9403-3046
Site length	6.3 miles	2.2 miles	0.9 miles	8.7 miles
Direction	NB	NB	SB	EB
Product	Deery	Deery	Crafco	Crafco
Joint type	Wedge	Wedge	Wedge	Wedge
2 inch Bead (length)	RM 1000 (6.3 miles)	RM 4016 (0.1 mile)	RM 1028 (0.6 miles)	RM 3046, 3117 (6.5 & 1.6 miles)
Test Section	RM 1055 to 1056		RM 1025 to 1024	RM 3123 to 3124
4 inch Bead (length)	NA	RM 4000, 4012 (0.7 & 0.1 miles)	NA	NA
Test Section		RM 4004 to 4005		
Control (length)	NA	RM 4007, 4013, 4017 (0.5, 0.3, & 0.4 miles)	RM 1022 (0.3 miles)	RM 3111 (0.6 miles)
Control Section		RM 4008 to 4009	RM 1021 to 1020	RM 3114 to 3115

RM – Reference Marker, NA – Not Applicable

Chris Euler observed the installations on Route 3, Route 81, and Route 50. Ed Denehy of NYSDOT Office of Operations Management observed the installation on Route 7.

Adhesive was placed just prior to paving the second lane on all jobs except the Oswego County highways. On Routes 3 and 481, adhesive was placed the day before the second lane was paved meaning the longitudinal joint with adhesive in place was left open to traffic overnight. There appeared to be no concerns from construction or inspection personnel about leaving the joint and adhesive in this condition. When paving was done next morning, small spots (generally less than 1 inch diameter) of melted adhesive appeared at the surface along centerline in random areas, ensuring that the adhesive was being melted by the hot-mix asphalt being placed thus creating a seal along the longitudinal seam (Photo 9).

Photo 9: Adhesive Beads @ Surface After Rolling

IV. SITE EVALUATIONS

I87 was visited in January 2007 by Chris Euler and Rick Morgan (see Table 1 for locations). The entire length of the control section had a single crack (Photo 10). In the 2 inch bead section, approximately 40 percent of the centerline (Photo 11) was cracked while 80 percent of the 4 inch section was cracked (Photo 12). There are minor areas of ravelling appearing along the centerline of all three sections.

Photo 10: Crack in Control Section – I87

Photo 11: Crack in 2 inch Bead Section – I87

Photo 12: Crack in 4 inch Section – I87

I81 was evaluated in January of 2005, 2006, and 2007 by Chris Euler (see Table 1 for locations). In 2005, both the control and adhesive section had between 20 to 30 percent centerline cracked. After the 2005 evaluation, the entire length of the test and control sections were crack sealed as part of a maintenance contract, thereby negating data from the 2006 and 2007 evaluations. Regional Material personnel believed there were not sufficient cracks in either section to warrant crack sealing.

Route 417 was evaluated in January of 2005, 2006, and 2007 by Chris Euler (see Table 1 for locations). Neither the test or control sections showed any cracking but the control section had areas of ravelling developing along centerline in 2005. The joint was in the same general condition in 2006. In 2007, approximately 25 percent of the test section had a single crack along the edges of the centerline paint stripes while none of the control section was cracked.

Route 3 was evaluated in January 2006 and 2007 by Chris Euler and in July 2006 by Rick Morgan (see Table 2 for locations). There is no control section on this route. In January 2006, the test section was examined and there was no cracking in the section. In July, the entire job was examined and there was no visible distress noted along entire length of the site (Photo 13). In 2007, the test section was again evaluated with no cracking visible.

Photo 13: Good Centerline Seam – Route 3

Route 481 was evaluated in the same months as Route 3 by the same personnel (see Table 2 for locations). In January 2006, neither the test section nor the control section showed any visible distress. In July 2006, the entire job was examined. Approximately thirty centerline cracks were noted with the majority of crack widths between hairline and 1/8 inch wide. Fifty percent were less than 3 feet long with only two cracks greater than 10 feet long. Approximately 40 percent of the cracks were in the control site. Overall, centerline was in very good condition in all three treatments, 2 inch bead, 4 inch bead and control. In 2007, the test section had a single crack along approximately 10 percent of its length with no cracking in the control section.

Route 50 was evaluated in September, 2006 by Rick Morgan and in January 2007 by Chris Euler and Rick Morgan (see Table 2 for locations). In 2006, the entire job was examined with no cracking noted in either the control or test sites. There were areas of minor ravelling developing in both sites. In 2007, the test and control sections were evaluated. There were no cracks in either section. Raveled areas were noted in both sections, especially at intersections and turning lanes, locations where traffic was crossing the longitudinal joints.

Route 7 was evaluated in September, 2006 by Rick Morgan and in January 2007 by Chris Euler (see Table 2 for locations). In 2006, the entire job was examined with approximately 20 to 25 percent of the centerline in the test sites was cracked (hairline to 1/4 inch wide, less than 3 feet to 250 feet in length, and varied depths). There were areas of ravelling along centerline in the test sites of varying lengths (similar to cracking lengths). In the control site more than 60 percent of the centerline was cracked with entire first 0.2 mile cracked. Crack widths, depths, and lengths in the remaining 0.4 mile, were similar to test sites. Areas of ravelling were also present along centerline in the control site (Photos 14 thru 16). In 2007, the test and control sections were evaluated. The test section had a single crack along 20 percent of its length while the control section had a single crack along approximately 80 percent of its length.

Photo 14: Ravelling Along Centerline – Route 7

Photo 15: Cracking in Adhesive Section – Route 7

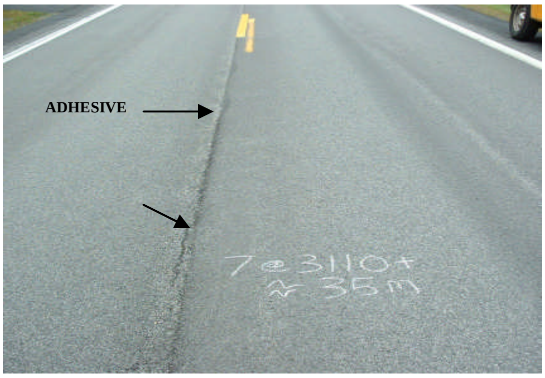

Photo 16: Cracking & Adhesive @ Surface – Route 7

All adhesive sites on all routes had areas at which adhesive was forced to surface during rolling. This demonstrates that during the rolling process, adhesive is forced into areas other than where it was placed thereby sealing more surface area within the seam. These areas at the surface varied in size from spots less than 1 inch diameter to beads up to 6 inches in length.

On sites constructed in 2004, after three years, the I81 site had no relevant data due to receiving an application of crack sealant. Both the test and control sections did have approximately 25 percent of the centerline cracked in the first evaluation (January 2005). At the I87 site, the entire length of control section, 40 percent of the 2 inch bead section, and 80 percent of the 4 inch bead section was cracked with slight ravelling in all sections. At the Route 417 site, there was no cracking in control section with slight ravelling while 25 percent of the test section had a single crack (see Table 3).

Table 3: Distress – 2004 Sites

	I87		I81		Route 417	
Date			**01/05**		**01/05**	
Distress	Crack	Ravel	Crack	Ravel	Crack	Ravel
Control			25%	No	0	Yes
2 inch			25%	No	0	No
4 inch			--	--	--	--
Date			**01/06[1]**		**01/06**	
Distress	Crack	Ravel	Crack	Ravel	Crack	Ravel
Control			0	No	0	Yes
2 inch			0	No	0	No
4 inch			--	--	--	--
Date	**01/07**		**01/07**		**01/07**	
Distress	Crack	Ravel	Crack	Ravel	Crack	Ravel
Control	100%	Yes	0	No	0	Yes
2 inch	40%	Yes	0	No	25%	No
4 inch	80%	Yes	--	--	--	--

1. Entire length was crack sealed during 2005 construction season

On 2005 sites, after 2 years, two sites (Route 481 and Route 3) had no ravelling and two sites (Route 50 and Route 7) had slight to minor ravelling in both the test and control sections. No cracking was apparent on two sites (Route 50 and Route 3). The Route 481 site had no cracking in the control section while the 4 inch adhesive section had single crack on approximately 10 percent of its length. The Route 7 site had cracking in both the test and control sections, 20 percent in the test section and 80 percent in the control section (see Table 4).

Table 4: Distress - 2005 Sites

	Route 3		Route 481[2]		Route 50		Route 7	
Date	**01/06[1]**		**01/06[1]**					
Distress	Crack	Ravel	Crack	Ravel	Crack	Ravel	Crack	Ravel
Control	--	--	0	No				
2 inch	0	No						
4 inch	--	--	0	No				
Date	**07/06**		**07/06**		**09/06**		**09/06**	
Distress	Crack	Ravel	Crack	Ravel	Crack	Ravel	Crack	Ravel
Control	--	--	10%	No	0	Yes	60%	Yes
2 inch	0	No	>10%	No	0	Yes	20%	Yes
4 inch	--	--	>10%	No	--	--	--	--
Date	**01/07[1]**		**01/07[1]**		**01/07[1]**		**01/07[1]**	
Distress	Crack	Ravel	Crack	Ravel	Crack	Ravel	Crack	Ravel
Control	--	--	0	No	0	Yes	80%	Yes
2 inch	0	No			0	Yes	20%	Yes
4 inch	--	--	10%	No	--	--	--	--

1. During these evaluations, 0.1 mile test & control sections were evaluated while in 07/06 & 09/06 evaluations, entire length of each treatment was evaluated.
2. On Route 481, no 0.1 mile section was chosen where the 2 inch bead was applied as it was less than 0.1 mile in length

V. CONCLUSIONS

After two to three years, with exception of the 4 inch bead section on I87, adhesive sites are performing well. Generally, the adhesive sections are performing as least as well or better than non-adhesive sections.

Two sites had more cracking in the test section than in the control section. The first site (Route 417) had 25 percent of the test section cracked and none of the control section. The second site (Route 481) had 10 percent of the test section cracked to none of the control section. At the second site, when entire site was evaluated, the control site had slightly higher percentage of cracking than test site but neither were cracked badly (total of approximately thirty cracks in 2.2 miles with only two cracks greater than 10 feet long).

At the other five sites, two sites (Route 50 and I81) had no cracking in either the test or control sections. There was no cracking in the site (Route 3) without a control section. One site (I81) had no relevant data after 3 years due the centerline receiving an application of crack sealant. Prior to the crack sealant being applied, the control and test sections were equally cracked at this site, approximately 25 percent. At the remaining two sites (I87 and Route 7), the 2 inch bead sections were performing significantly better than the control sections. The 4 inch bead section at one of these sites (I87) was slightly better than control section (100 percent and 80 percent, respectively).

Overall and for each year constructed, the 2 inch bead sections are performing better than the control sections (see Table 5). The 2005 - 4 inch bead section is performing better than the control sections of that year. While the 2004 – 4 inch bead section is performing worse than the average of the control sections for that year, it is performing better than the control section on the same highway.

From this limited data, the use of adhesive along the centerline paving joint appears to be a practical partial solution to the problem of longitudinal joint cracking. Application entails the use of no specialized equipment, just standard crack sealing equipment. Whether use of joint adhesives is a cost effective solution or that it prevents or delays further deterioration of joint should be determined by further evaluation of these sites and inspection of additional sites as they become available (see Appendix C – Table 6 for results of follow-up evaluations).

Table 5: **Average percent cracked**

	Control	**2 inch Bead**	**4 inch Bead**
Time of Evaluation	**2004 Sites**		
0.5 years	13%	13%	
1.5 years	0%	0%	
2.5 years	50%	38%	80%
	2005 Sites		
0.5 years	0%	0%	0%
1.0 years	23%	8%	10%
1.5 years	27%	7%	10%
	All Sites		
0.5 years	8%	8%	0%
1.0 years	23%	8%	10%
1.5 years	20%	5%	10%
2.5 years	50%	38%	80%

Not every site was evaluated during each inspection period, thereby explaining the occasional drop in percentages from evaluation to evaluation

VI. RECOMMENDATIONS

1. Continue evaluating sites as it is too early determine effectiveness of this procedure, although it does appear to be promising.

2. Include additional sites, if possible, to enhance reliability of adhesives' performance evaluation.

ACKNOWLEDGEMENTS

The author would like to acknowledge Chris Euler, Materials Bureau, for his assistance in observing and photographing the adhesive placement on I87, Route 3, Route 481, and Route 50; and the follow-up site evaluations and photographs. The author would like to acknowledge Zoeb Zavery, Materials Bureau, for his assistance observing the placement on I87 and I81, and Edward Denehy, Office of Operations Management, for his assistance in observing and photographing the installation on Route 7. The author would like to acknowledge the Region 6 personnel who supplied information of the Route 417 installation. The author would also like to acknowledge the Materials Bureau personnel that assisted Chris Euler and the Data Services Bureau personnel that assisted Rick Morgan with evaluations and photography.

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APPENDIX C: TABLE 6: DATA FROM ADDITIONAL EVALUATIONS

TABLE 6

Table 6: Data from additional evaluations
Average percent cracked

	Control	2 inch Bead	4 inch Bead
Time of Evaluation	**2004 Sites**		
0.5 years	13%	13%	
1.5 years	0%	0%	
2.5 years	50%	38%	80%
3.5 years	42%	38%	80%
4.0 years	60%	56%	
4.5 years	77%	73%	100%
	2005 Sites		
0.5 years	0%	0%	0%
1.0 years	23%	8%	10%
1.5 years	27%	7%	10%
2.5 years	50%	25%	25%
3.0 years	63%	42%	70%
3.5 years	90%	33%	70%
	All Sites		
0.5 years	8%	8%	0%
1.0 years	23%	8%	10%
1.5 years	20%	5%	10%
2.5 years	50%	38%	80%
3.0 years	63%	42%	70%
3.5 years			
4.0 years	60%	56%	
4.5 years			

Not every site was evaluated during each inspection period, thereby explaining the occasional drop in percentages from evaluation to evaluation