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ND 98-05	January 2007	N/A	NH-7-085(028)126

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14. Supplementary Notes

15. Abstract

Objective

The objectives of this study are; to determine the effectiveness of sawing and sealing joints in bituminous paving to control random cracking, to determine the optimum spacing of the sawed joints, to evaluate the sealant, and to evaluate the construction practices used in the sawing and sealing.

Scope

Five different joint sections were installed into the pavement. The joint spacing of the first three saw and seal sections were 30’, 40’, and 80’ with Type A joint dimensions. The reservoir dimensions for Type A are 3/8” deep and 3/4” wide. The next saw and seal section has 40’ joint spacing and Type B joints with reservoir dimensions that are 5/8” deep and 3/4” wide. The last saw and seal section had 80’ joint spacing and Type C joints with reservoir dimensions that are 3/4” deep and 3/4” wide. The control section will have no joints installed into the pavement. The pavement joint spacing and joint reservoirs are evaluated annually. The study is projected to last for ten years from when it was constructed or until failure.

Summary

The result from this research project provides recommendations in two areas:

The distance between joints to control random cracking. All three different lengths of joint spacings appeared to work well for controlling random cracking. The 80’ joint spacing more stress in the joint sealant than the other joint spacing lengths. This may result in a failure in the reservoir type.

The reservoir type that provides improved sealant adhesion. The deeper reservoirs type B and C performed better than reservoir type A. The recommended reservoir is a type B reservoir. Also, the joints may need to be resealed after 7 to 10 years

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NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION

Experimental Study ND 98-05

Sawing and Sealing Joints in Bituminous Pavement to Control Cracking

Final Evaluation

Project NH-7-085(028)126

January 2007

Prepared by

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RCS HHO-30-19

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT	EXPERIMENTAL PROJECT NO. 1 — STATE: ND, YEAR: 98 - NUMBER: 05, SURF:	CONSTRUCTION PROJ NO 8 NH-7-085(028)126	LOCATION McKenzie County 28
	EVALUATION FUNDING 48 — 1 X HP&R; 2 CONSTRUCTION; 3 DEMONSTRATION; 4 IMPLEMENTATION	NEEP NO. 49	PROPRIETARY FEATURE? Yes 51 X No
SHORT TITLE	TITLE 52 Sawing and Sealing Joints in Bituminous Pavement		
THIS FORM	DATE 140 — MO. 01 -- YR. 07	REPORTING 1 INITIAL; 2 ANNUAL; 3 X FINAL	

KEY WORDS		
	KEY WORD 1 145 ASPHALT	KEY WORD 2 167 PAVEMENT
	KEY WORD 3 189 JOINTS	KEY WORD 4 211 OVERLAY
	UNIQUE WORD 233 SAWING & SEALING	PROPRIETARY FEATURE NAME 255

CHRONOLOGY	Date Work Plan Approved	Date Feature Constructed:	Evaluation Scheduled Until:	Evaluation Extended Until:	Date Evaluation Terminated:
	02-98	10-98	01-07		02-07
	277	281	285	289	293

QUANTITY AND COST	QUANTITY OF UNITS (ROUNDED TO WHOLE NUMBERS)	UNITS	UNIT COST (*Dollars, Cents*)
	14,510 linear feet 297	1 X LIN. FT 2 SY 3 SY-IN 4 CY 5 TON 6 LBS 7 EACH 8 LUMP SUM 305	$1.25 per linear foot total=$18,137.50 306

AVAILABLE EVALUATION REPORTS	X -CONSTRUCTION 315	X -PERFORMANCE	X FINAL

EVALUATION	CONSTRUCTION PROBLEMS	PERFORMANCE
	1 NONE 2 X SLIGHT 3 MODERATE 4 SIGNIFICANT 5 SEVERE 318	1 EXCELLENT 2 X GOOD 3 SATISFACTORY 4 MARGINAL 5 UNSATISFACTORY 319

APPLICATION			
	1 ADOPTED AS PRIMARY STD. 2 PERMITTED ALTERNATIVE 3 ADOPTED CONDITIONALLY 320	4 X PENDING 5 REJECTED 6 NOT CONSTRUCTED	*(Explain in remarks if 3, 4, 5, or 6 is checked)*

REMARKS

321

The pavement is in good shape. Sawing in the joints will control the transverse crack pattern. The joint success will be determined by the type of reservoir and length between the joints. It has been used in two different projects. It is not a current practice of the NDDOT.

Experimental Study ND 98-05

Sawing and Sealing in Bituminous Pavement To Control Cracking

Final Evaluation

Project NH-7-085(028)126

January 2007

Written by
Kyle Evert
Jeff M. Richter

Disclaimer

TABLE OF CONTENTS

Sawing and Sealing Joints in Bituminous Pavement to Control Cracking

Purpose and Need

The purpose of this project is to evaluate the ability of placing joints to control random asphalt pavement cracking. Asphalt pavements are subjected to thermal stresses due to extreme low temperatures in the northern climate. These thermal stresses cause the formation of random unsealed cracks. These unsealed cracks allow moisture to infiltrate the subgrade and base. This moisture can cause stripping of the asphalt binder on the walls of the cracks, causing the pavement structure to weaken. The weakened pavement may form depressions at the cracks, which lead to bad ride characteristics and may also cause secondary cracking.

Sawing joints into new asphalt pavements at regular intervals may help control the location of thermal cracking in flexible pavement. Sawed joints are easier to fill initially and maintain in the future. Early sawing and sealing joints into the pavement controls the infiltration and reduces the stripping of asphalts.

Objective

The objectives of this study are; to determine the effectiveness of sawing and sealing joints in bituminous paving to control random cracking, to determine the optimum spacing of the sawed joints, to evaluate the sealant, and to evaluate the construction practices used in the sawing and sealing.

Scope

Five different joint sections were installed into the pavement. The joint spacing of the first three saw and seal sections were 30’, 40’, and 80’ with Type A joint dimensions. The reservoir dimensions for Type A are 3/8” deep and 3/4” wide. The next saw and seal section has 40’ joint spacings and Type B joints with reservoir dimensions that are 5/8” deep and 3/4” wide. The last saw and seal section had 80’ joint spacings and Type C joints with reservoir dimensions that are 3/4” deep and 3/4” wide. The control section will have no joints installed into the pavement. The pavement joint spacing and joint reservoirs are evaluated annually. The study is projected to last for ten years from when it was constructed or until failure.

The crack spacing success is determined by the ratio of sawed and sealed joints to the sawed and sealed joints added to the transverse cracks in between the joints, example:

$$\frac{\text{\# of Sawn Joints}}{\text{\# of Sawn Joints + \# of Cracks Between Joints}} \times 100 = \text{\% of Crack Control}$$

The North Dakota Department of Transportation is trying to achieve a success rate of 85% or greater. A failure in the joint sealants occurs when the sealant loses adhesion or tears.

Location

The location of the test sections is on US Highway 85 in McKenzie County and included in Project NH-7-085(028)126, which begins at the Little Missouri River and continues north to Watford City. The beginning reference point is 127.0004 (station 6700 + 34) and the ending reference point is 141.0002 (station 7392 + 48) for a length of 14.728 miles. Figure 1 is a map displaying the project location and limits.

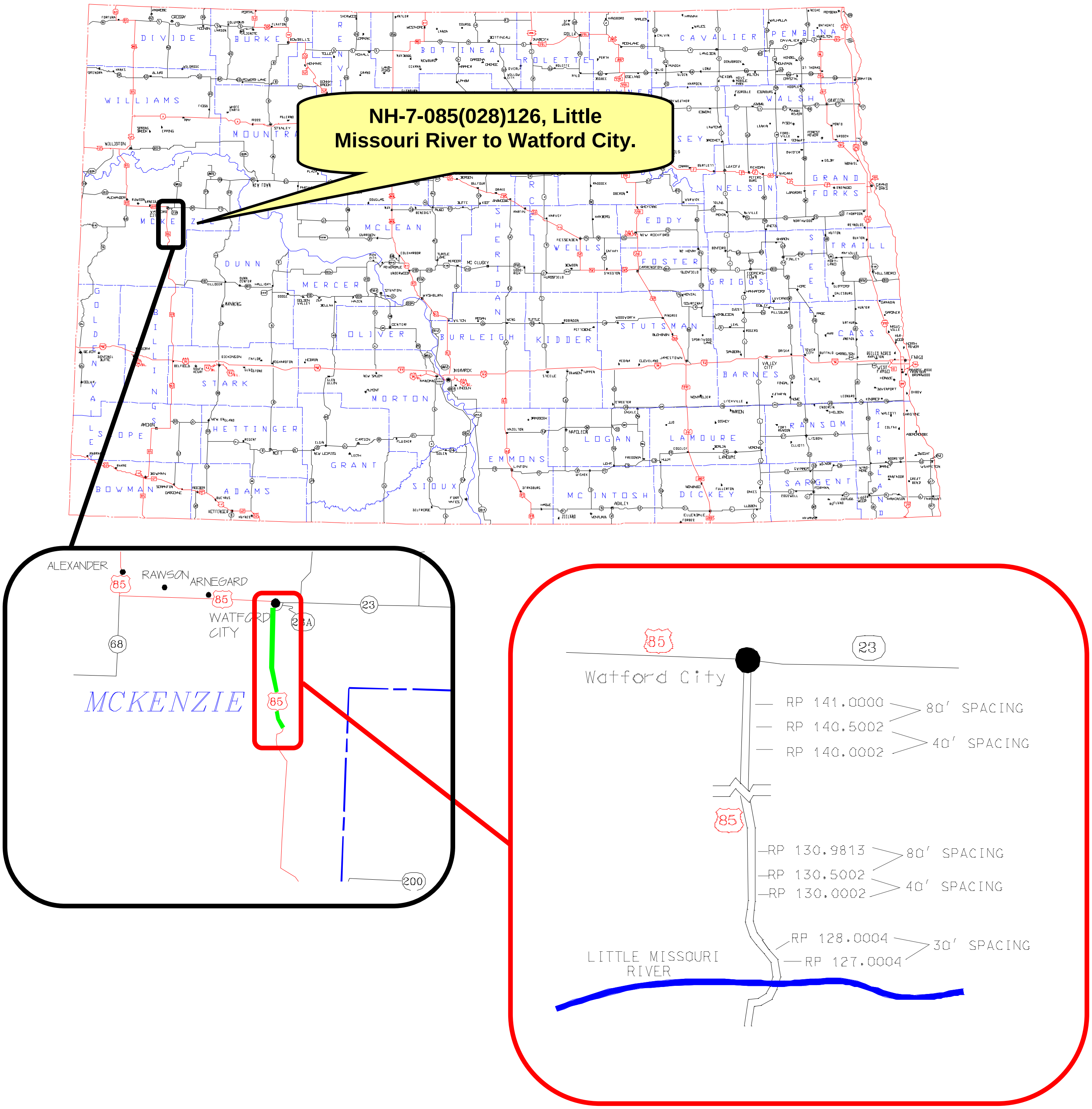


Figure 1 – Project Location.

Project Historical Information

RIMS data

ND 85		Reference Point 126.7430 to Reference Point 130.0000				
Year	Components	Depth (in)	LSHLD WDTH (ft)	RDWY WDTH (ft)	RSHL WDTH (ft)	Oil
1983	Grade	-	-	54.0	-	-
1983	Aggregate Base	6.0	-	50.0	-	-
1984	Recycled Bituminous Base	2.5	-	46.0	-	SH-1H
1984	Recycled HBP	4.0	-	45.0	-	200-300
1985	Drive Slope Flattening	-	-	-	-	-
1988	Contract Chip Seal	-	-	45.0	-	HFMS-2
1998	Blended Base	11.5	-	48.0	-	-
1998	HBP	5.0	-	36.0	-	PG 58 - 28
2002	Contract Chip Seal	-	6.0	24.0	6.0	HFMS - 2

Table 1

ND 85		Reference Point 130.0000 to Reference Point 142.2660				
Year	Components	Depth (in)	LSHLD WDTH (ft)	RDWY WDTH (ft)	RSHL WDTH (ft)	Oil
1960	Grade	-	-	44.0	-	-
1960	Emulsified Base	7.0	-	40.0	-	SS-1
1962	HBP	2.5	-	25.0	-	150-200
1977	HBP	2.0	-	38.0	-	120-150
1985	Drive Slope Flattening	-	-	-	-	-
1988	Contract Chip Seal	-	-	38.0	-	HFMS - 2
1998	Blended Base	11.5	-	48.0	-	-
1998	HBP	5.0	-	36.0	-	PG 58-28
2002	Contract Chip Seal	-	6.0	24.0	6.0	HFMS - 2

Table 2

Traffic

The one-way traffic for ND Highway 85 is shown below in table 3.

Year	Passenger Car	Trucks	Total	Flexible ESALs
1997	1,192	211	1,403	148
1998	1,192	211	1,403	148
1999	1,039	210	1,249	148
2000	1,039	210	1,249	148
2001	1,069	422	1,491	307
2002	1,069	422	1,491	307
2003	947	273	1,220	187
2004	947	273	1,220	187
2005	947	273	1,220	187
2006	1,204	352	1,556	266

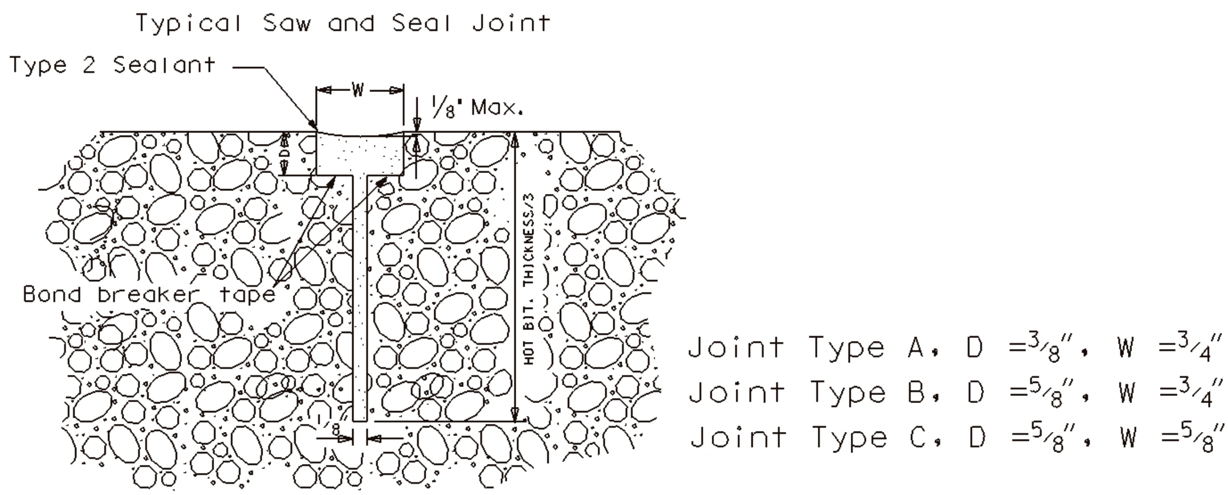
Table 3

Design

The roadway was reconstructed with a mine and blend option. The base was constructed by blending existing aggregate base, existing asphalt, and additional virgin Class 5 aggregate to create an 11.5" base. The asphalt section is 5" of Class 31 Hot Bituminous Pavement (HBP). The asphalt binder used was PG 58-28.

Joints were sawed and sealed into the roadway to prevent cracking due to thermal contraction. Thermal contraction is the contracting of a material due to the lower temperatures. There are three joint spacing sections of sawed and sealed joints; they are 30', 40', and 80'. These joint spacings were chosen to try to reproduce the lengths between the natural cracks formed by thermal contraction. This procedure helps to control where thermal cracking occurs in the pavement.

The beginning of the project has three sections of 30', 40', and 80' joint spacing with Type A joints. The 30' section has a length of one mile. The 40' and 80' sections each have a length of one half of a mile. The control section follows the three sections at the beginning of the project. The control section is approximately 9 miles long. Following the control section is a 40' section with Type B joints and a 80' section with Type C joints. Each section has a length of one half of a mile that proceeds to the end of the project. Figure 2 depicts the typical section of a sawed and sealed joint.



Sawed/Sealed Joint Locations (Test Section)
RP 127.0004 to 128.0004, 30' Spacing, Type A
RP 130.0002 to 130.5002, 40' Spacing, Type A
RP 130.5002 to 130.9813, 80' Spacing, Type A
RP 140.0002 to 140.5002, 40' Spacing, Type B
RP 140.5002 to 141.0002, 80' Spacing, Type C

Figure 2 – Typical Saw and Seal Joint

The construction and material requirements for the sawed and sealed joints followed Special Provision-“Joint Sawing and Sealing” 41(97), which can be found in Appendix A. Backer tape was used on this project. A test section without the backer tape was also used in this project to see if any difference in performance of the joint was noticed. The joints without backer tape are located at Reference Points 127.0288, 127.0345, 127.0402, 127.0458, and 127.0515.

Construction

Project NH-7-085(028)126 was constructed in 1998. The project was located in the Williston District on US Highway 85 from the Little Missouri River to Watford City. Northern Improvement was awarded the contract for a contract cost of $3,947,310.78 and was increased to $4,485,860.27 due to change orders and increased project quantities. Sawing and Sealing Joints was a separate bid item at $1.25 per linear foot for a total bid price of $18,137.50.

Evaluation

The final evaluation for project ND 98-05 took place on January 11, 2007. The project was evaluated in the beginning of the year to allow for the cold temperature to provide for maximum expansion of the joints. The maximum expansion of the joints will help determine the effectiveness of the sealant in the different types of reservoirs. A failed sealant is a joint where the sealant material has torn or the adhesion between the sealant and side wall of the reservoir has failed.

The number of transverse cracks between the sawed and sealed joints will determine the success of the different lengths between the saw and sealed joints. All of the joints are cracked completely through the asphalt. This can be seen on the slough of the roadway. The crack travels or migrates completely through the pavement. A working joint is defined as a joint that is expanding and contracting throughout the year. A nonworking joint is defined as a joint that does not expand or contract throughout the year.

The pavement distress scores collected by the Pathways Van are included in the evaluation because the scores will reflect the pavement distresses and quality.

Reference Point 127.0004 to Reference Point 128.0004

This section has 30' joint spacing and Type A reservoirs. This section still does not have any transverse cracks between the joints since it was constructed. Table 5 displays the success of the joint spacing. The sealant is still in the joint, but small areas of the sealant are no longer adhesion with the sidewall. These joints would be considered a failure since the sealant is lost adhesion across the entire roadway. The majority of the joints have the sealant adhesion across the entire roadway and the severity of the sealant without adhesion is less than other sections of this roadway. Table 5 displays the success of the reservoir.

Year	Section (RP feet)		Length of Section (ft)	# of Sawn Joints	# of Cracks between Joints	Success of Crack Control
	Begin	End				
2003	127.0004	128.0004	30	176	0	100%
2004	127.0004	128.0004	30	176	0	100%
2005	127.0004	128.0004	30	176	0	100%
2007	127.0004	128.0004	30	176	0	100%

Table 4 – Success of joint spacing

Year	Reservoir	Length of Section (ft)	Working Joints	Nonworking Joints	Failed Sealants	Not Available
2005	A	30	136	30	3	7
2007	A	30	157	18	36	7

Table 5 – Success of reservoir

There are two patches on this section between the stations 6700+34 to 6753+14. These patches are approximately 50' to 80' in length and are in both lanes of the roadway. These patches are the reasons 7 of the joints are not available. Each patch has a transverse crack in it. These cracks were omitted from the success calculation because they appear to be caused from settlement of the subgrade.

The Pathways Van evaluated distresses for the whole project. The distress scores for the whole project can be seen in Appendix B. There was a large increase IRI from 2002 to 2003. A new Pathways van was used between 2002 and 2003. This is most likely the large jump in IRI, as this jump has been seen in other roads. The IRI differences for this section between 1998 and 2006 can be seen in Table 6.

Highway 85	Reference Point 127							
Year	1998	1999	2000	2001	2002	2003	2004	2005
IRI	62	58	70	65	64	97	109	111
Scale: Excellent < 60; Good 61 - 95; Fair 96 -132; Poor > 132								

Table 6

Visible rutting has begun to occur in this section. This section is located on a large hill. The crack control and reservoirs do not appear to have been affected by this rutting. The joints do appear to have shoved in the wheel paths. Photo 1 displays the joints shoving in the wheel paths.

Photo 1 – Roadway shoving in wheel paths.

Reference Point 130.0002 to Reference Point 130.5002

This section has 40' joint spacing and Type A reservoirs in the joints. This section has not developed any transverse cracks in between the joints since the roadway was constructed. The success of the joint spacing can be seen in Table 7. The sealants in this section appear to be separating from one of the sidewalls of the joint. There has been a large increase in sealant failures since the previous evaluation. The increase in failures can be seen below in Table 8. A photo of a joint with the sealant separating can be seen in Photo 2.

There is also a longitudinal crack along the cold joint in between the two lanes. There are longitudinal cracks randomly throughout the whole project at the centerline.

Year	Section (RP feet)		Length of Section (ft)	# of Sawn Joints	# of Cracks between Joints	Success of Crack Control
	Begin	End				
2003	130.0002	130.5002	40	66	0	100%
2004	130.0002	130.5002	40	66	0	100%
2005	130.0002	130.5002	40	66	0	100%
2007	130.0002	130.5002	40	66	0	100%

Table 7 – Success of joint spacing

Year	Reservoir	Length of Section (ft)	Working Joints	Nonworking Joints	Failed Sealants	Not Available
2005	A	40	64	2	8	0
2007	A	40	65	1	47	0

Table 8 – Success of reservoir

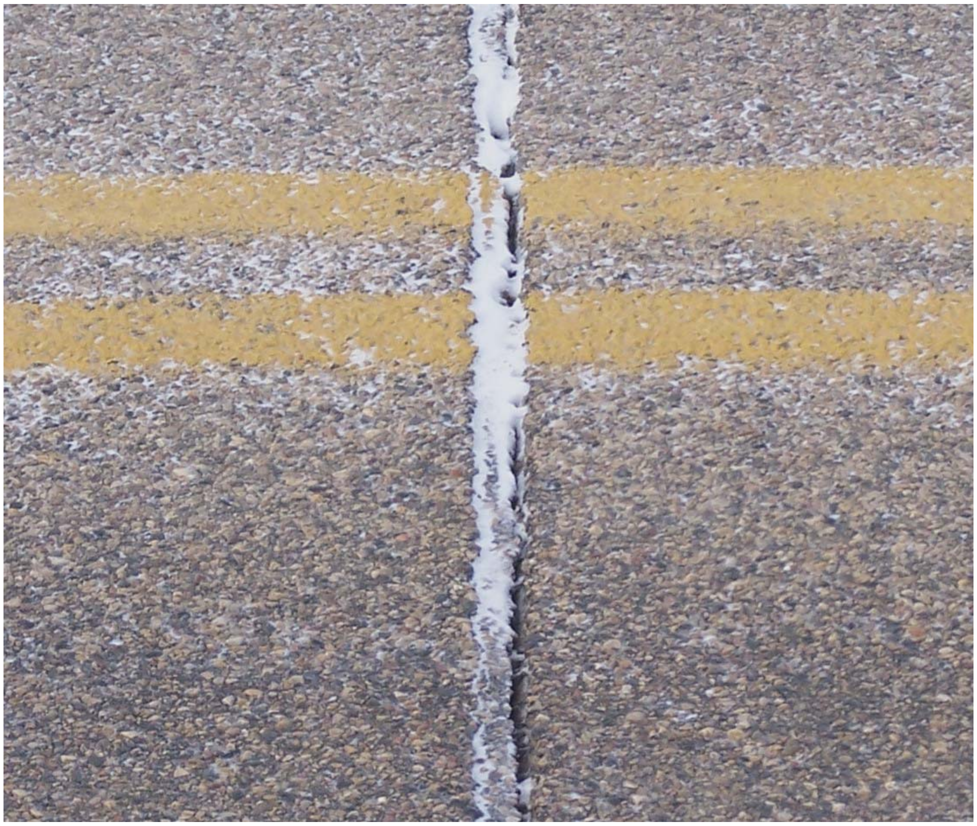


Photo 2 – Joint with sealant separating from sidewall due to adhesion failure.

The Pathways Van evaluated distresses for the whole project. The distress scores for the whole project can be seen in Appendix B. There was a large increase in IRI from 2002 to 2003. A new Pathways van was used between 2002 and 2003. This is most likely the large jump in IRI, as this jump has been seen in other roads. The IRI differences for this section between 1998 and 2005 can be seen in Table 9.

Highway 85	**Reference Point 130**							
Year	1998	1999	2000	2001	2002	2003	2004	2005
IRI	55	50	98	53	60	94	91	86
Scale: Excellent < 60; Good 61 - 95; Fair 96 -132; Poor > 132								

Table 9

Reference Point 130.5002 to Reference Point 130.9813

This section has 80' joint spacing and Type A reservoirs in the joints. This section has one transverse crack in between the joints. This transverse crack is over a pipe. The sealants for this section appear to be having a problem with adhesion to the sidewall of the reservoir of the joint. There were 34 joints in this section and 28 of the joints had the sealant detached from a sidewall for most of the pavement width. Table 10 and Table 11 display the results for the success of the transverse crack control and the effectiveness of the joint reservoir.

Year	Section (RP feet)		Length of Section (ft)	# of Sawn Joints	# of Cracks between Joints	Success of Crack Control
	Begin	End				
2003	130.5002	130.9813	80	34	1	97%
2004	130.5002	130.9813	80	34	1	97%
2005	130.5002	130.9813	80	34	1	97%
2007	130.5002	130.9813	80	34	1	97%

Table 10 – Success of joint spacing

Year	Reservoir	Length of Section (ft)	Working Joints	Nonworking Joints	Failed Sealants	Not Available
2005	A	80	34	0	21	0
2007	A	80	34	0	28	0

Table 11 – Success of reservoir

The pavement distress scores are the same as the previous section. The distress scores from the Pathways van are reported per mile leaving these two sections with the same distress scores. The Pathways Van evaluated distresses for the whole project. The distress scores for the whole project can be seen in Appendix B. There was a large increase IRI from 2002 to 2003. A new Pathways van was used between 2002 and 2003. This is most likely the large jump in IRI, as this jump has been seen in other roads. The IRI differences for this section between 1998 and 2005 can be seen in Table 12.

Highway 85	Reference Point 130							
Year	1998	1999	2000	2001	2002	2003	2004	2005
IRI	55	50	98	53	60	94	91	86
Scale: Excellent < 60; Good 61 - 95; Fair 96 -132; Poor > 132								

Table 12

Reference Point 140.0002 to Reference Point 140.5002

This section has 40' joint spacing and Type B reservoirs in the joints. This section has one crack in between the joints. The sealant in this section is beginning to fail. There were 17 joints that had joint sealant loosing adhesion from the sidewall. In the previous evaluation, the sealant did not have any adhesion loss from the sidewall. Only a portion of the joint sealant lost adhesion for most of the joints. Table 13 and Table 14 display the results for the success of the transverse crack control and the effectiveness of the joint reservoir.

Year	Section (RP feet)		Length of Section (ft)	# of Sawn Joints	# of Cracks between Joints	Success of Crack Control
	Begin	End				
2003	140.0002	140.5002	40	66	1	99%
2004	140.0002	140.5002	40	66	1	99%
2005	140.0002	140.5002	40	66	1	99%
2007	140.0002	140.5002	40	66	1	99%

Table 13 – Success of joint spacing

Year	Reservoir	Length of Section (ft)	Working Joints	Nonworking Joints	Failed Sealants	Not Available
2005	B	40	66	0	0	0
2007	B	40	66	0	17	0

Table 14 – Success of reservoir

The IRI in this mile also increased significantly after the change in Pathways van in 2002. The IRI is still in the low 60's which indicates that the ride for this mile is still very good. The IRI scores for this section between 1998 and 2005 can be seen in Table 15.

Highway 85	Reference Point 140							
Year	1998	1999	2000	2001	2002	2003	2004	2005
IRI	43	43	36	41	39	64	59	61
Scale: Excellent < 60; Good 61 - 95; Fair 96 -132; Poor > 132								

Table 15

Reference Point 140.5002 to Reference Point 141.0002

This section has 80' joint spacing and Type C reservoirs in the joints. This section has 4 transverse cracks in between the joints. All of the transverse cracks are next to an approach or an intersection. The sealant has lost adhesion in 21 of the 34 joints. The sealant lost adhesion to the sidewalls of the joint reservoir. Table 16 and Table 17 display the results for the success of the transverse crack control and the effectiveness of the joint reservoir.

Year	Section (RP feet)		Length of Section (ft)	# of Sawn Joints	# of Cracks between Joints*	Success of Crack Control
	Begin	End				
2003	140.0002	140.5002	80	34	4	89%
2004	140.0002	140.5002	80	34	4	89%
2005	140.0002	140.5002	80	34	4	89%
2007	140.0002	140.5002	80	34	4	89%

*** Cracks located at approaches or intersections**

Table 16 – Success of joint spacing

Year	Reservoir	Length of Section (ft)	Working Joints	Nonworking Joints	Failed Sealants	Not Available
2005	C	80	34	0	8	0
2007	C	80	34	0	21	0

Table 17 – Success of reservoir

The IRI in this mile also increased significantly after the change in Pathways van in 2002. The IRI is still in the low 60's which indicates that the ride for this mile is still very good. The IRI scores for this section between 1998 and 2005 can be seen in Table 18.

Highway 85	Reference Point 140							
Year	1998	1999	2000	2001	2002	2003	2004	2005
IRI	43	43	36	41	39	64	59	61
Scale: Excellent < 60; Good 61 - 95; Fair 96 -132; Poor > 132								

Table 18

Reference Point 130.9813 to Reference Point 140.0002 – Control Section

The control section limits of this research project are from RP 130.9813 to RP 140.0002. This is the entire roadway between the two sawed and sealed sections at the beginning and the end of the project. This section appears to be in good shape and the cracks were not depressed. All of the transverse cracks were counted for reference points 131 through 139. A breakdown of the cracks per mile can be seen in Table 19. Photo 3 displays a transverse crack in the control section. This photo was taken in February when the roadway was frozen, causing the crack to expand. This portion of the roadway was chip sealed in 2002. The random transverse cracks have not been sealed.

Year	Reference Point	Transverse Cracks	Average Distance between Transverse Cracks
2007	131	30	176
	132	46	115
	133	38	139
	134	47	112
	135	42	126
	136	40	132
	137	42	126
	138	49	108
	139	61	87

Table 19

Photo 3 – An expanded random transverse crack.

Summary

The pavement in the saw and seal section is in good shape. There are no new cracks in the saw and seal sections since 2003. A longitudinal crack has developed on the cold joint between lanes. These longitudinal cracks are not related to the saw and seal since they are also in the control section. The random transverse cracks are controlled by the saw and sealed joints. In all three sections there are very few random transverse cracks. The transverse cracks in the research sections are next to intersections, approaches, and pipe.

The joint sealants are beginning to perform worse in all of the sections according to the last evaluation. The joint sealant does not adhere to the side wall in all the joints. When the joints open in the winter, a gap between the joint sealant and sidewall is exposed. With the joint being open, snow and incompressiblies may enter the joint. This may cause damage to the pavement along the joint. When the pavement temperature increases, the joint will close and prevent moisture and incompressibles from entering the joints.

A breakdown of the results can be seen in Table 20. From these results, reservoir B and C performed much better than the sealants with reservoir A. Reservoirs B and C are deeper, this allows for more surface contact area between the sealant and the sidewall. The increased surface contact area appears to provide a stronger bond between the sealant and sidewall. Reservoirs B and C should not be compared to each other because of the difference in distance between the joints. These differences in working distance do not provide equal stresses to the sealants.

1/11/2007	**Section 1**	**Section 2**	**Section 3**	**Section 4**	**Section 5**
	Reservoir A	**Reservoir A**	**Reservoir A**	**Reservoir B**	**Reservoir C**
Length	30'	40'	80'	40'	80'
Working	157	65	34	66	34
Non-working	18	1	0	0	0
Failed Sealant	36	47	28	17	21
NA	7	0	0	0	0
Total	176	66	34	66	34
% Sealant Failure	20.45	71.21	82.35	25.76	61.76

Table 20

In reservoir A, as the distance in between the joints increased, so did the failures in the sealants. This is probably caused by the joints opening up wider because of the increase of pavement mass between the joints.

The distress scores gradually grew worse from when the roadway was constructed. This is typical with any road. The IRI increased noticeably after the roadway was chip sealed. The IRI for section 1 is much worse than the other sections. This portion of the research project is on a large steep hill. The other sections of this project are on flat land and are most likely the reason they have better IRI. The IRI in section 1 has been higher since it was constructed. There is no correlation with the distress scores and the saw and seal joints.

Recommendation

The result from this research project provides recommendations in two areas:

1. The distance between joints to control random cracking. All three different lengths of joint spacing appeared to work well for controlling random cracking. The 80' joint spacing increased the stress in the joint sealant more than the other joint spacing lengths. This may result in a failure in the reservoir type.
2. The reservoir type will determine the effectiveness of the sealant adhesion. The deeper reservoirs type B and C performed better than reservoir type A. The recommended reservoir is a type B reservoir. Also, the joints may need to be resealed after 7 to 10 years.

Appendix A

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

JOINT SAWING AND SEALING

ACNH-7-085(028)126

April 17, 1998

DESCRIPTION

This work consists of saw cutting, cleaning, drying and sealing transverse joints into new bituminous pavement according to the plans and the NDDOT specifications.

MATERIALS.

Sealant. Joint material shall be a "Type 2 - Hot Applied Joint Sealant" and shall meet the requirements of Section 826, except modified herein.

EQUIPMENT.

General. The melting kettle shall be double jacketed boiler type, equipped with both agitation and recirculation systems capable of melting and applying the sealant through a pressure-fed hose and wand. The melter shall be capable of starting at ambient temperature and bringing the sealing material to application temperature in one hour or less, while continuously agitating and recirculating the sealant. The melter shall be equipped with automatic thermostatic controls and temperature gages to monitor the sealant temperature in the applicator lines and temperature of heat transfer oil in the kettle jacket.

The air compressor shall be capable of producing a continuous stream of clean, dry air through the nozzle at 87 psi (600 kPa) and 38 ft^3/ft (3.5 m^3/m) minimum. The compressed air unit shall be equipped with water and oil traps and must produce sufficient air volume and pressure to remove all debris from the sawed joint and all adjacent road surfaces in a safe manner such that the debris will not re-enter the joint prior to the sealing operation.

The heat lance shall operate with propane and compressed air in combination and be capable of achieving a heated air temperature of 1800 °F (1000 °C) at the exit orifice and a discharge velocity of 3280 ft/s (1000 m/s).

A self-propelled power saw capable of providing a straight cut of uniform depth and width shall be used. Diamond saw blades with either single or gang blade arrangement shall be used. The power saw shall cut in a downward motion. The saw blade or blades shall be of such size and configuration that the desired joint reservoir shape and deep saw cut are achieved in one pass of the saw. Two pass cutting will not be allowed. No spacers between blades shall be allowed unless the Contractor can show that the desired reservoir and saw cut can be obtained with them.

CONSTRUCTION REQUIREMENTS.

General. The Contractor shall conduct the operation so that saw cutting of transverse joints, cleaning, and sealing are a continuous operation. Traffic shall not be allowed to knead together or damage the sawed joints. Sawed joints not sealed before traffic is allowed on the pavement shall be re-sawed, if necessary, at no additional cost to the NDDOT. The joints shall be sealed when the sealant material is at the pouring temperature recommended by the manufacturer. The contractor shall fill the joint such that after cooling, the sealant is flush with the adjacent pavement along the edges and the center does not sag more than 1/8" (3 mm) below the pavement of shoulder surface.

Care must be taken to ensure that the joints are not overfilled and the final appearance shall present a neat fine line. The applicator wand shall be returned to the machine and the joint sealant material recirculated immediately upon completion of each joint sealing. The Engineer may require a squeegee to force the material into narrow joint openings if, in the opinion of the Engineer, the material is not flowing into the joint properly.

Sand shall not be spread on the sealed joints to allow for early opening to traffic. The sealant shall be tack free before opening to traffic.

A given quantity of sealant material shall never be heated at the pouring temperature for more than six hours and shall never be reheated. The contractor shall record the temperature of the kettle and the temperature of the sealant once every hour during sealing and shall report the temperatures to the engineer. Temperatures recorded more than 40 °F (4 °C) above the manufacturers specifications shall result in rejection of the material in use, and the contractor shall dispose of the overheated material in an acceptable manner.

Breaker Tape will be allowed on this project.

Sawing. Each joint shall be cut in one pass and meet the following criteria:

Each saw cut shall be either wet sawed with the following procedures used:

1. Flush the sawed joint with high pressure water until the water runs clear.
2. Clean and dry the joint with compressed air removing all loose material.
3. Heat the joint with a hot-air lance immediately before sealing.

Or dry sawed with the following procedures used:

1. Clean the joint with compressed air removing all loose debris.
2. Heat the joint with a hot-air lance immediately before sealing.

While heating pavement with the lance, be careful not to burn the pavement surface. No more than two minutes shall elapse between the time the hot air lance is used and the sealant is placed.

The contractor shall wait 48 hours, from the time the pavement was placed, before sawing the joints.

Weather Limitations. The weather limitations shall be specified in Section 826.01.

ACCEPTANCE.

Sealed joints shall be rejected if there is evidence of poor workmanship or obvious defects, such as, but not limited to the following:

1. Sawed joint not filled completely
2. Lack of bond to the sides of the joint
3. Excessive debris or moisture in the joint
4. Contamination of the sealant
5. Sawed joint not filled flush

Rejected sealed joints shall be repaired, the sealant removed and disposed of in an appropriate manner, and the joints resealed to the Engineer's satisfaction at no additional cost to the NDDOT.

METHOD OF MEASUREMENT.

This item will be measured by the lineal feet of sawed and sealed joints. Payment shall be full compensation for all labor, equipment, and materials necessary to complete the work as specified.

BASIS OF PAYMENT.

Pay Item	**Pay Unit**
Sawing and Sealing Joints	Linear Foot

Appendix B

Distress Scores

1998 Distress Scores					
RP	RIDE	DST	RUT	IRI	PRPI
127	3.97	99	0.15	62	GOOD
128	3.99	99	0.15	61	GOOD
129	NA	NA	NA	NA	NA
130	4.11	99	0.15	55	GOOD
131	4.15	99	0.15	54	GOOD
132	4.26	99	0.16	49	GOOD
133	4.11	99	0.17	55	GOOD
134	4.25	99	0.18	50	GOOD
135	4.19	99	0.18	52	GOOD
136	4.03	99	0.16	59	GOOD
137	4.12	99	0.14	55	GOOD
138	4.18	99	0.15	53	GOOD
139	4.37	99	0.14	44	GOOD
140	4.38	99	0.16	43	GOOD

1999 Distress Scores					
RP	RIDE	DST	RUT	IRI	PRPI
127	4.06	99	0.11	58	GOOD
128	4.11	99	0.06	55	GOOD
129	NA	NA	NA	NA	NA
130	4.24	99	0.03	50	GOOD
131	4.18	97	0.04	53	GOOD
132	4.35	99	0.03	45	GOOD
133	4.26	99	0.02	49	GOOD
134	4.37	99	0.02	44	GOOD
135	4.42	99	0.03	42	GOOD
136	4.15	99	0.05	50	GOOD
137	4.21	99	0.04	54	GOOD
138	4.46	99	0.03	51	GOOD
139	4.55	99	0.04	40	GOOD
140	4.41	99	0.03	36	EXCL

2000 Distress Scores					
RP	RIDE	DST	RUT	IRI	PRPI
127	3.79	95	0.17	70	GOOD
128	3.62	98	0.14	77	GOOD
129	NA	NA	NA	NA	NA
130	3.19	95	0.13	98	POOR
131	3.26	97	0.11	95	FAIR
132	3.93	99	0.13	63	GOOD
133	3.35	98	0.13	90	FAIR
134	3.90	99	0.13	65	GOOD
135	3.87	98	0.11	67	GOOD
136	3.55	99	0.12	81	GOOD
137	3.83	99	0.1	68	GOOD
138	3.97	99	0.12	62	GOOD
139	4.39	98	0.1	43	GOOD
140	4.44	95	0.12	41	GOOD

Distress Scores

2001 Distress Scores					
RP	RIDE	DST	RUT	IRI	PRPI
127	3.91	99	0.18	65	GOOD
128	4.07	99	0.19	58	GOOD
129	NA	NA	NA	NA	NA
130	4.16	99	0.11	53	GOOD
131	4.17	99	0.12	53	GOOD
132	4.29	99	0.11	48	GOOD
133	4.24	98	0.1	50	GOOD
134	4.38	99	0.12	43	GOOD
135	4.42	98	0.12	42	GOOD
136	4.20	99	0.15	51	GOOD
137	4.09	99	0.12	57	GOOD
138	4.21	99	0.1	51	GOOD
139	4.46	98	0.14	40	GOOD
140	4.47	99	0.13	39	EXCL

2002 Distress Scores					
RP	RIDE	DST	RUT	IRI	PRPI
127	3.92	99	0.19	64	GOOD
128	3.99	99	0.21	61	GOOD
129	NA	NA	NA	NA	NA
130	4.02	99	0.2	60	GOOD
131	4.11	99	0.2	55	GOOD
132	4.26	99	0.15	49	GOOD
133	4.15	98	0.16	54	GOOD
134	4.29	99	0.17	48	GOOD
135	4.19	98	0.14	52	GOOD
136	4.02	99	0.16	60	GOOD
137	4.09	99	0.13	57	GOOD
138	4.28	99	0.18	48	GOOD
139	4.54	98	0.16	36	GOOD
140	4.50	99	0.17	39	EXCL

2003 Distress Scores					
RP	RIDE	DST	RUT	IRI	PRPI
127	3.21	95	0.12	97	GOOD
128	3.54	95	0.11	82	GOOD
129	NA	NA	NA	NA	NA
130	3.28	92	0.13	94	GOOD
131	3.48	91	0.23	84	GOOD
132	3.50	91	0.19	83	GOOD
133	3.38	91	0.17	89	GOOD
134	3.93	95	0.21	64	GOOD
135	3.80	95	0.15	70	GOOD
136	3.46	91	0.21	85	GOOD
137	3.53	91	0.16	82	GOOD
138	3.66	99	0.13	76	GOOD
139	3.88	92	0.15	66	GOOD
140	3.92	90	0.2	64	GOOD

Distress Scores

2004 Distress Scores					
RP	RIDE	DST	RUT	IRI	PRPI
127	2.96	91	0.27	97	GOOD
128	3.57	89	0.27	82	GOOD
129	NA	NA	NA	NA	NA
130	3.34	88	0.27	94	GOOD
131	3.68	89	0.26	84	GOOD
132	3.79	91	0.26	83	GOOD
133	3.82	91	0.28	89	GOOD
134	3.93	95	0.26	64	GOOD
135	3.79	91	0.26	70	GOOD
136	3.44	91	0.22	85	GOOD
137	3.69	91	0.18	82	GOOD
138	4.02	91	0.23	76	GOOD
139	4.15	91	0.2	66	GOOD
140	4.03	90	0.24	64	GOOD

2005 Distress Scores					
RP	RIDE	DST	RUT	IRI	PRPI
127	2.92	95	0.13	111	GOOD
128	3.58	92	0.14	80	GOOD
129	NA	NA	NA	NA	NA
130	3.44	87	0.2	86	GOOD
131	3.84	89	0.28	68	GOOD
132	3.68	91	0.2	75	GOOD
133	3.65	91	0.2	77	GOOD
134	3.93	95	0.2	64	GOOD
135	4.09	91	0.18	57	GOOD
136	3.67	91	0.26	76	GOOD
137	3.63	91	0.2	77	GOOD
138	3.90	91	0.19	65	GOOD
139	4.02	87	0.17	60	GOOD
140	4.00	90	0.22	61	GOOD