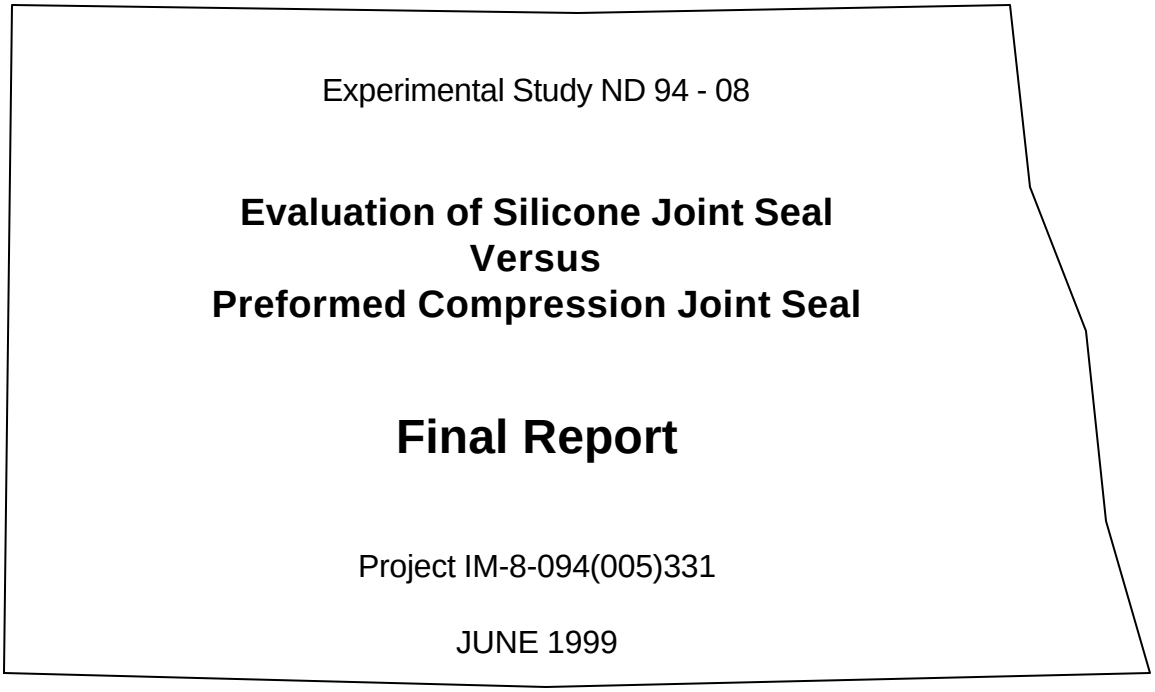
NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION



Experimental Study ND 94 - 08

Evaluation of Silicone Joint Seal Versus Preformed Compression Joint Seal

Final Report

Project IM-8-094(005)331

JUNE 1999

Prepared by

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
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MATERIALS AND RESEARCH DIVISION
Ron Horner

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT

EXPERIMENTAL PROJECT NO.

	STATE	YEAR		NUMBER	SURF
1	ND	94	-	08	

CONSTRUCTION PROJ NO: IM-8-094(005)331

LOCATION: Cass County

28

EVALUATION FUNDING

1 X HP&R 3 DEMONSTRATION
48 2 CONSTRUCTION 4 IMPLEMENTATION

NEEP NO. 49

PROPRIETARY FEATURE? 51 Yes X No

SHORT TITLE

TITLE 52: Silicone Versus Preformed Compression Joint Seals for Concrete Pavement

THIS FORM

DATE 140: MO. 0 1 - YR. 9 9

REPORTING: 1 INITIAL 2 ANNUAL 3 X FINAL

KEY WORDS

KEY WORD 1: 145 PAVEMENT CONCRETE

KEY WORD 2: 167 JOINTS

KEY WORD 3: 189 Contraction

KEY WORD 4: 211

UNIQUE WORD: 233

PROPRIETARY FEATURE NAME: 255

CHRONOLOGY

Date Work Plan Approved	Date Feature Constructed:	Evaluation Scheduled Until:	Evaluation Extended Until:	Date Evaluation Terminated:
05-94	09-94	10-99		01-99
277	281	285	289	293

QUANTITY AND COST

QUANTITY OF UNITS: 159118 — 297

UNITS — 305

1 X LIN. FT
2 SY
3 SY-IN
4 CY
5 TON
6 LBS
7 EACH
8 LUMP SUM

UNIT COST (*Dollars, Cents*): 1.65 — 306

AVAILABLE EVALUATION REPORTS

X CONSTRUCTION — 315

X PERFORMANCE

X FINAL

EVALUATION

CONSTRUCTION PROBLEMS — 318

1 NONE
2 X SLIGHT
3 MODERATE
4 SIGNIFICANT
5 SEVERE

PERFORMANCE — 319

1 EXCELLENT
2 GOOD
3 SATISFACTORY
4 MARGINAL
5 UNSATISFACTORY

APPLICATION

320

1 ADOPTED AS PRIMARY STD.
2 PERMITTED ALTERNATIVE
3 ADOPTED CONDITIONALLY
4 PENDING
5 REJECTED
6 NOT CONSTRUCTED

(Explain in remarks if 3, 4, 5, or 6 is checked)

REMARKS

321 Silicone sealant has essentially failed while the neoprene seal is performing marginally. No appreciable change from previous evaluations. Decision was to finalize project.

700

Form FHWA 1461

Experimental Study ND 94 - 08

Evaluation of Silicone Joint Seal Versus Preformed Compression Joint Seal

FINAL REPORT

IM-8-094(005)331

JUNE 1999

By

Jeff M. Richter

Disclaimer

The contents of this report reflect the views of the author or authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not reflect the official views of the North Dakota Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

TABLE OF CONTENTS

Objective 1

Scope 1

Location 1-2

Construction 3-14

Summary 14-17

Recommendation 18

Appendix A

Project location, specific joint locations, joint details, and specifications.

Objective

The objective of this report was to determine which joint sealant, silicone or preformed compression, has the best performance judged by durability and cost. This evaluation was also designed to determine which sealer will perform more effectively with the climatic changes North Dakota experiences.

Scope

This scope of this evaluation was to visually and mechanically inspect the condition of the silicone and preformed compression joint sealants for leaks caused by; adhesion failure (loss of bond), cohesion (loss of the joint materials ability to bond to itself), or spall related failures (edges of concrete saw joint deteriorating). In an effort to rate the severity levels of joint and joint sealant damage, the "Strategic Highway Research Program (SHRP) manual on Distress Identification for Long-Term Pavement Performance" was used as a reference. This manual rates joint sealant damage levels in the following way:

Joint seal damage: Any condition which enables in compressible materials or a significant amount of water to infiltrate the joint from the surface.

Low: Joint seal damage that exists over less than 10% of the joint.

Moderate: Joint seal damage that exists between 10%-50% of the joint.

High: Joint seal damage that exists over more than 50% of the joint.

Location

The joint material was installed on project IM-8-094(005)331. This project consists of the eastbound lanes of Interstate 94 between the Casselton Interchange and the Mapleton Interchange in Cass County, North Dakota. The project started at milepoint 331.04 and ends at milepoint 338.63. The total length of the project is 7.6 miles. The contractor was Progressive Contractors (PCI). Preformed compression elastomeric and silicone joint seals were placed at the following locations.

CONTRACTION JOINT SILICONE SEAL

Station 855+48.4 to Station 882+78.4 Rt
Station 983+11.1 to Station 1014+76.1 Rt
Station 1179+35 to Station 1183+05.7 Rt

PREFORMED COMPRESSION ELASTOMERIC JOINT SEAL

Station 1060+85 to Station 1179+35 Rt
Station 1186+20.7 to Station 1250+11.8 Rt

A detailed drawing of the project overview and the individual sections is in the project plans section, located in appendix A.

Concrete pavements tend to go through many cycles of contraction and expansion due to changes in climatic conditions. This is especially true in North Dakota where temperatures can range from 40 degrees below zero Fahrenheit to 120 degrees Fahrenheit. To allow for contraction and expansion in the concrete pavement slabs and to reduce the uncontrolled cracking of the pavement surface, a system of joints are incorporated into the pavement structure.

Transverse joints are planned breaks in the pavement structure that are typically designed to have a certain spacing along the length of the roadway and are skewed perpendicular to the roadway. Joints are an important element of a pavement structure, but the principle disadvantage is that a high percentage of failures in concrete pavements occur at or near the transverse contraction joints. This is due to water infiltrating through failed joint openings and because foreign materials can become lodged between the joint seal and the concrete.

Many joint seals fail within a few years after construction. Some joints fail to relieve (crack) the pavement initially and when the joints expand they may expand farther than designed. Also, compression joint seals are not designed for tension. When the joints open farther than intended the joint seal can fail. The failure will then cause the compression seal to either fall into the joint or to become detached from the face of the joint. In either case the joint fails and will no longer properly seal the joint.

Construction

The contraction joint silicone sealant used on this project was a low modulus silicone rubber called "888 Silicone Joint Sealant" made by DOW Corning. It is a one-part cold applied material that comes ready to apply, usually in 55 gallon drums.

The preformed compression elastomeric joint seals used on this project are a "V Series Delastic preformed neoprene seal" made by The D. S. Brown Company. These preformed compression seals are neoprene (polychloroprene) based. A lubricant adhesive called "Delastiseal" was used during installation to lubricate and bond the neoprene seals to the joints. The joint materials conform to the material specifications of Section 826 of the North Dakota Department of Transportation Standard Specifications as shown in Appendix A.

The installation steps included the initial sawing of the pavement to the desired depth within 24 hours of placement of the portland cement concrete (PCC), widening the joints to approximately 3/8" wide, sandblasting, removing any debris, and installing the joint seal. This was the normal procedure followed by the contractor regardless of which type of sealant was installed and conforms to the construction requirements specified in Section 550.04.M of the North Dakota Department of Transportation Standard Specifications. This part of the project was completed during September and October of 1994.

The first annual evaluation was conducted in October of 1995 and January of 1996. This evaluation was both visual and mechanical. The mechanical inspection involved the use of the Iowa Vacuum Joint Seal Tester (IA-VAC) a nondestructive broad coverage tester . The Iowa Vacuum Joint Seal Tester (IA-VAC), a chamber 48" long by 6" wide, uses a vacuum pump to apply a low vacuum (0 to 10 psi) to a joint seal that has been sprayed with a soap-water solution. Any unsealed area or leak that exists along the joint will become visible by the development of soap bubbles at the point where air is escaping past the joint sealant.

The IA-VAC System:

The Iowa Vacuum Joint Seal Tester (IA-VAC) shown in **photo 1** , was utilized in the first evaluation of the transverse joint sealants.

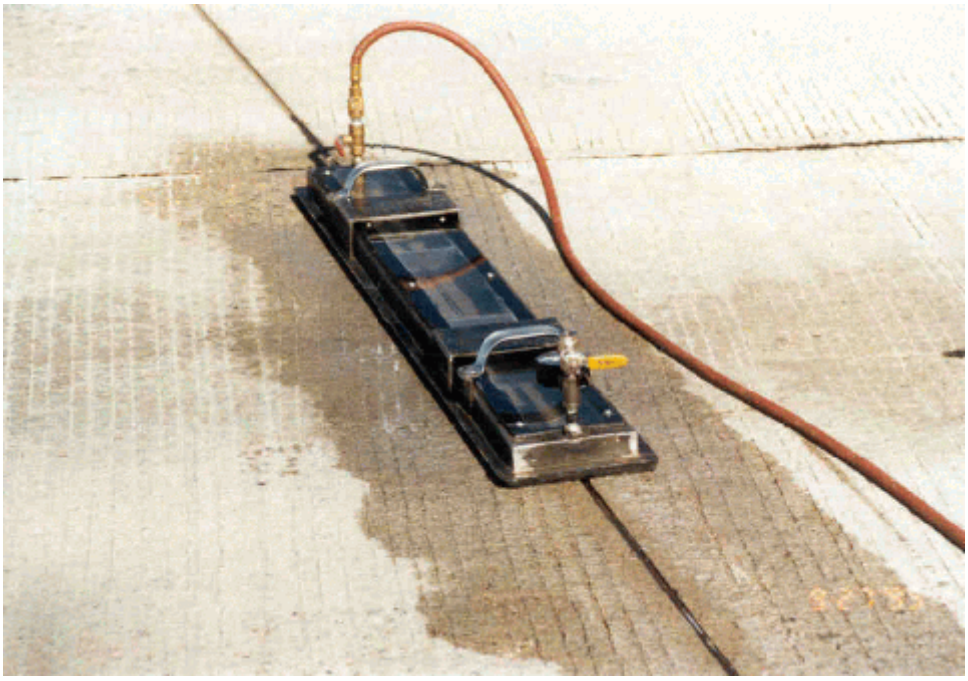


Photo 1. (IA-VAC) joint sealant tester

The IA-VAC system applies a low vacuum (0 to 10 psi) to the joint seal. The seal has been sprayed with a foaming soapy-water solution as shown in **photo 2** . This unit is operated through the use of a vacuum pump and a portable generator.

Photo 2. Joint sprayed with soapy solution

Any unsealed areas that exist along the joint will become visible by the development of bubbles at the leak point as shown in **photo 3**. This testing apparatus is nondestructive and is a broad coverage tester as opposed to destructive testing methods such as coring.

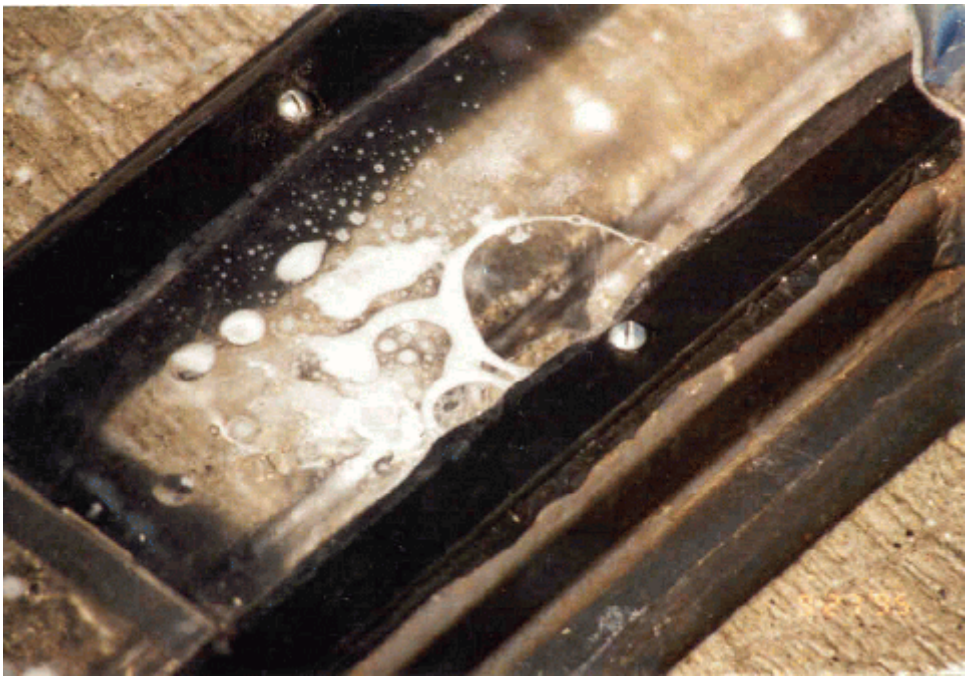


Photo 3. Bubbles indicate a leak

Several photographs of various distress areas that were located in the preformed compression joint sealant sections were taken for explanatory purposes. These photos will be discussed in the following paragraphs.

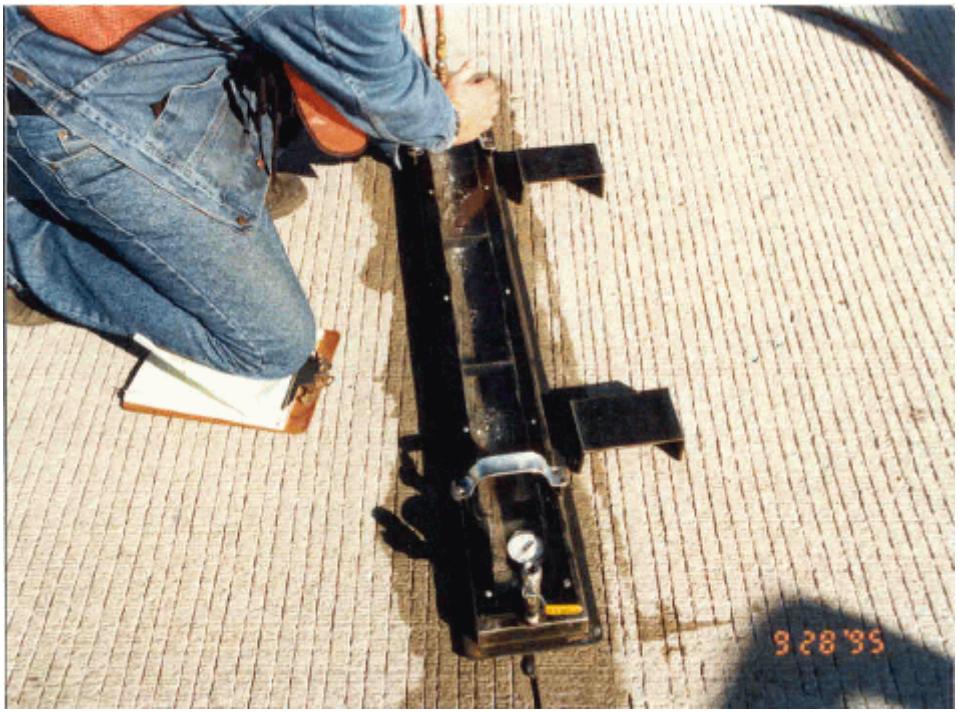


Photo 4. (IA-VAC) in use on a neoprene seal

Photo 4 shows the IA-VAC system as it is used on a preformed compression joint sealant (station 1074+96).

Photo 5. Leaks depicted through window of IA-VAC

Photo 5, depicts several leaks by the presence of soap bubbles at the top of the IA-VAC. After removing the IA-VAC apparatus **(photo 6)** evidence of leaks is still present.

Photo 6. Leaks depicted after IA-VAC is removed

These leaks were categorized as adhesion leaks since there was little spalling around the joint and the joint material did not appear to have any deterioration.

A few stations later, at station 1135+00, similar leaks were found as shown in **photos 7 & 8.** Notice from **photos 7** & **8** that some of the leaks appear very close together while others seem to be isolated.

Some of the leaks produced tiny bubbles while others produced larger ones. This may be attributable to the size of the leak or it may be an indication of a group of leaks

Photo 7. Series of small leaks in station 1135+00

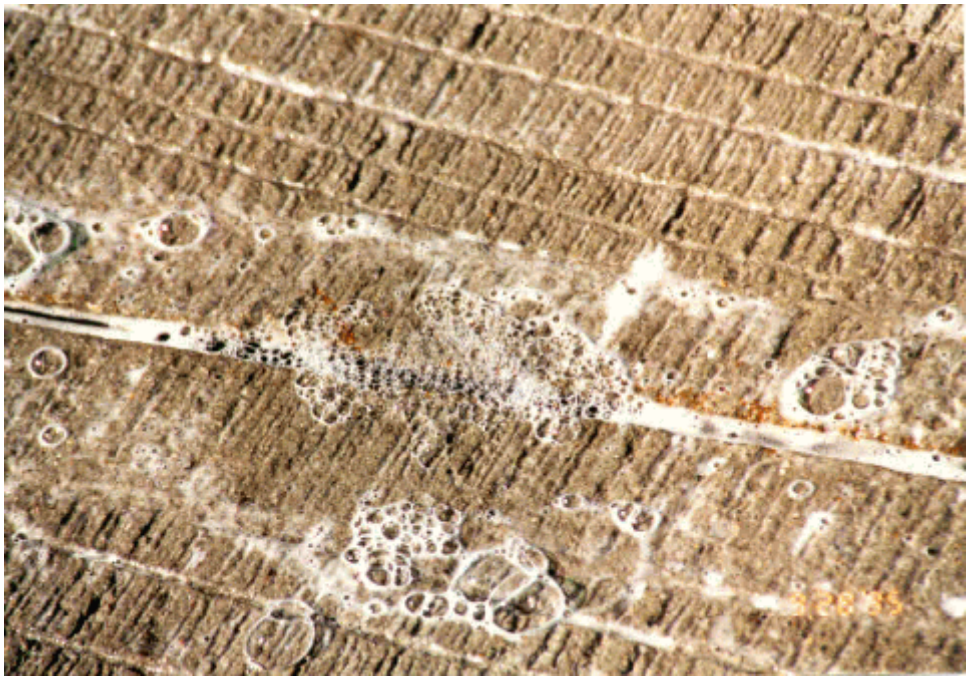


Photo 8. Close-up of station 1135+00

Photos 9 &**10** show a passing lane joint with a preformed compression sealant that has an unusual amount of leaks relative to the previous joints.

The leaks in this joint were attributed to adhesive failure. This joint, located at station 1094+95, is suffering a succession of leaks across nearly its entire length.

Photo 9. Severe leakage of joint at Station 1094+95

Photo 10. Close-up of Station 1094+95

Photo 11 shows a leak that was detected which was classed as being an adhesion leak, however, upon further inspection it was determined that the joint itself was irregular in shape. The irregularity may have been caused by improper saw cutting practices. This may have caused the sealant to not be flush with the wall of the joint, thereby creating an opportunity for leakage.

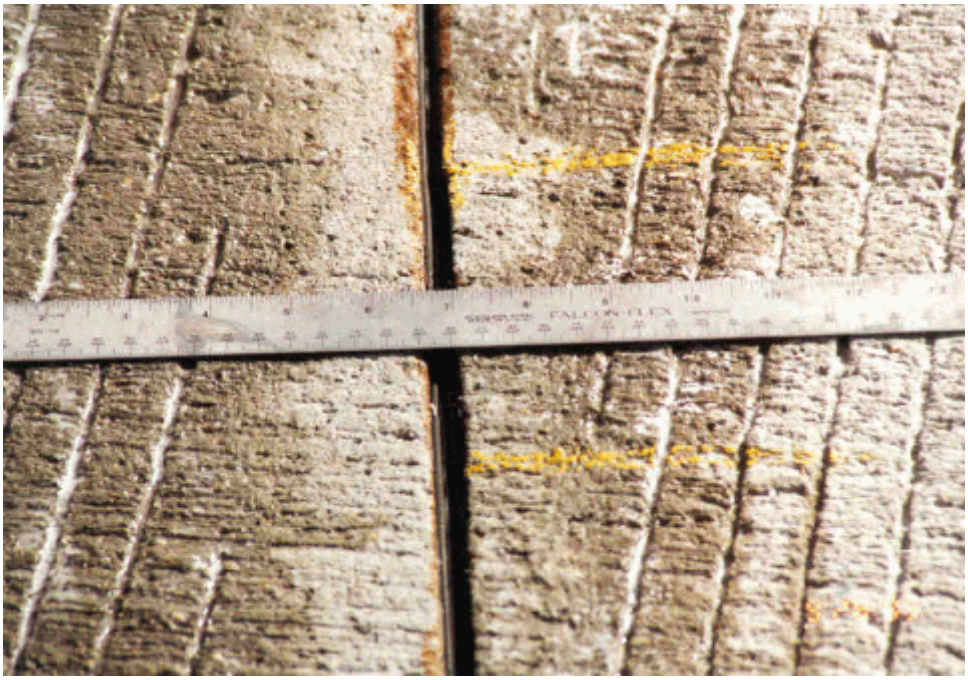


Photo 11. View of sealant in an irregular sawed joint

Evaluation of Preformed Compression Joint Sealants During Winter Months

For the cold weather inspection Materials and Research selected certain joints that were included in the warm weather inspection of the preformed compression sealants. Many of these joints ranged in width from 3/8" to ½". The sealants in these joints looked to be in good condition. Approximately one in twenty (1 in 20) joints would be encountered that would be extra wide (5/8" to 3/4"). In several of these extra wide joints the preformed compression seal was breaking away from the wall of the joint and was starting to sink down into the joint. This is depicted in **photo 12**.

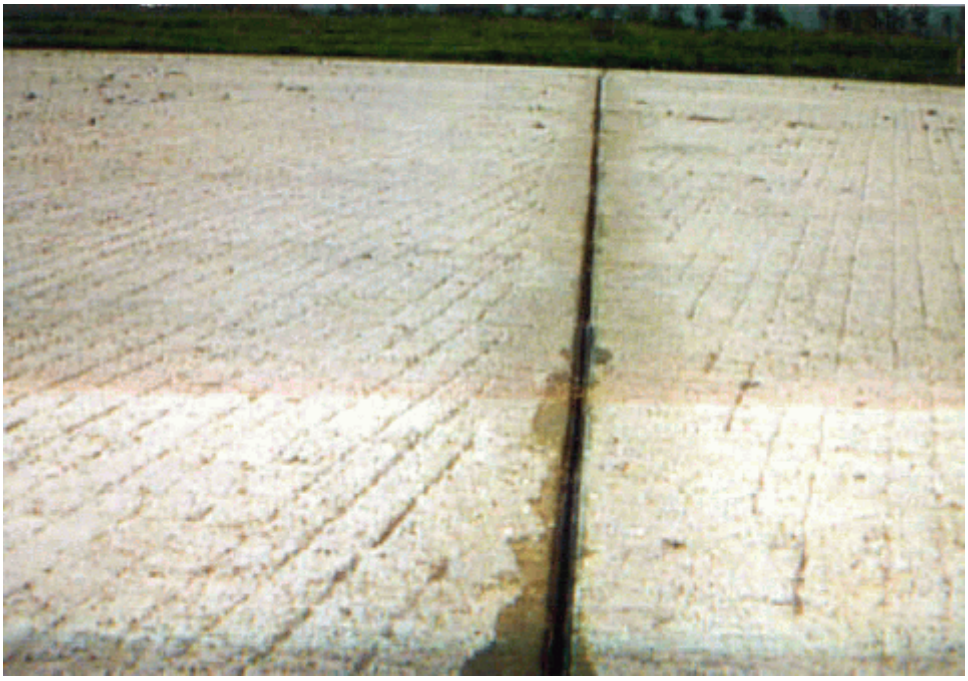


Photo 12. Failing neoprene seal

Photo 13. Close-up view of failing neoprene joint

Photo 13 is a close up view of the same joint. On the bottom center of **photo 13,** pea size pebbles are present and have managed to lodge themselves between the joint wall and the neoprene seal. The pea sized pebbles will in all probability remain lodged between the joint wall and the sealant. When the concrete starts to expand as the weather warms the pebbles will keep the sealants from flushing up to the joint walls and create an opportunity for moisture to leak into the joint.

Contraction Joint Silicone Sealants Evaluation

Photos 14 &**15** show evidence of leakage using the IA-VAC system. Some of the leaks in these photos (Station 877+00) were attributed to spalling along the joint.

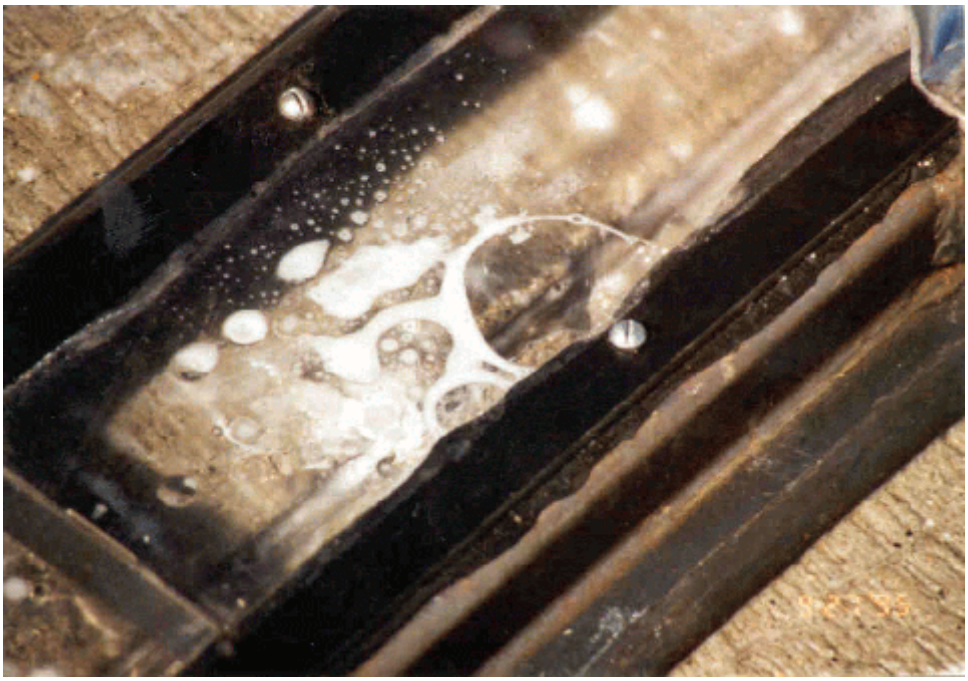


Photo 14. Leakage depicted in silicone sealed joint

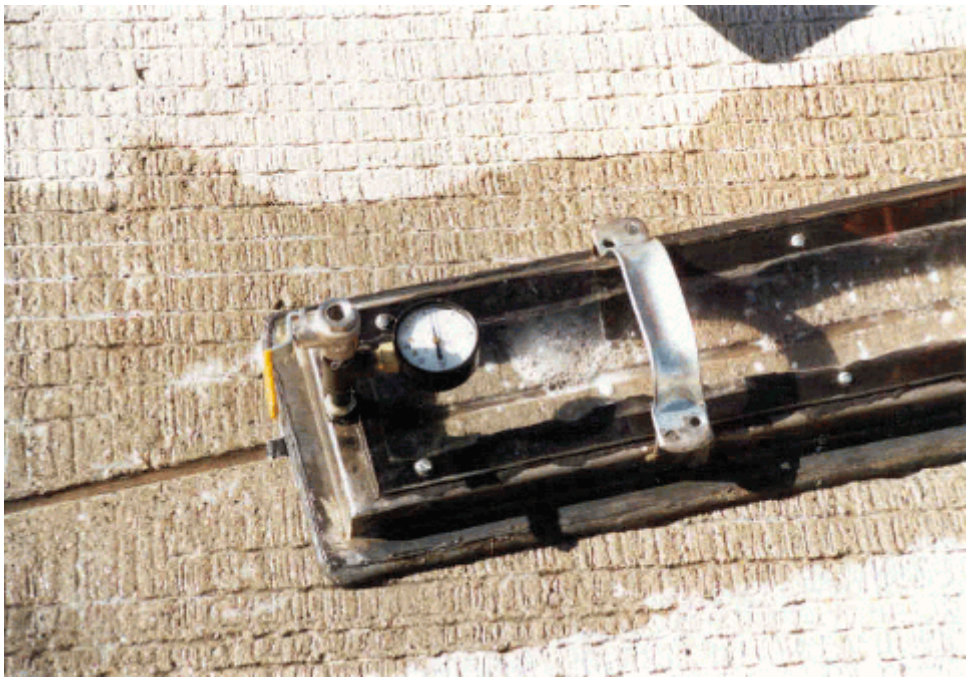


Photo 15. Leakage depicted in silicone sealed joint

Photo 16 shows a close-up of a spall related distress that was leaking near a joint installed with silicone sealant (station 995+00).

Photo 16. Spall related distress in a silicone sealed joint.

Some of the leaks incurred under the "other" category were considered to be bubbles in the silicone sealant. They were probably formed during the construction of the joints. Differences in air pressure in the applicator pump may have contributed to the forming of the bubbles. This category includes leaks caused by an overlapping of the silicone material. Conditions occur during installation when the contractor either loses pressure in the applicator wand or tries to apply the material too fast leaving a gap and trying to restart the application again.

Evaluation of the Contraction Joint Silicone Sealers

Photo 17 shows a typical transverse joint where silicone sealant was installed. The joint located at station 990+00 is an example of a joint in good condition.

Photo 17. Typical joint where silicone sealant is applied

The width of the joint was measured to be 3/8". This was the same width of the joint when it was sawed in the fall of 1994. This appeared to be the case with many of the joints. Upon further inspection it was found that on the average, approximately 1 out of every 20 sawed joints were extra wide (5/8" to 7/8"). In several locations the silicone sealant was beginning to break away from the walls of the joints.

Summary:

The comparison of leaks relative to each of the two different sealants is obvious. In the 336 linear feet of joint sealant tested, the preformed compression sealant had an increase from a total of 485 leaks to 533 leaks during the period between the 1994 post construction evaluation and the 1995 evaluation but decreased to 227 in the 1996 evaluation and remained approximately the same in the 1997 and the 1998 evaluation. The decrease from previous levels was probably attributable to the smaller leaks developing into larger leaks, making the count less but the effective leaking area remained the same or is increasing. During the evaluation there appeared to be as many leaks in the passing lane as in the driving lane. A comparison of the leaks, as shown in tables 1 and 2, include where joints had a greater number of leaks in the 1994 post construction evaluation than what was tabulated for that same joint in the 1997 and 1998 evaluations. In most of these cases the leaks were so numerous that only an estimate could be made.

TABLE 1. RESULTS OF THE PREFORMED COMPRESSION JOINT SEALANT INSPECTION (1994, 1995, 1996, AND 1997)

TEST LOCATION	TYPE OF LEAK												TOTAL LEAKS PER JOINT			
	SPALL				ADHESION				OTHER				94	95	96	97
	94	95	96	97	94	95	96	97	94	95	96	97				
1065+00	0	4	3	3	17	17	15	15	0	0	1	1	17	21	19	19
1074+96	0	0	1	1	28	39	22	30	0	0	1	1	28	39	24	X
1085+02	0	0	1	1	46	45	14	14	0	0	1	1	46	45	15	16
1094+95	0	0	0	0	66	54	25	X	0	0	1	1	66	54	28	XX
1105+00	0	1	0	0	35	48	19	2	0	0	0	0	35	49	19	2
1115+00	2	1	1	1	44	28	25	X	0	0	1	1	46	29	26	XX
1125+00	0	0	0	0	45	35	29	X	0	0	1	1	45	35	29	XX
1135+00	0	0	0	2	43	37	24	20	0	0	1	1	43	37	24	23
1145+00	0	0	0	0	18	28	16	16	0	0	0	0	18	28	16	16
1155+00	0	0	1	1	23	37	21	25	0	0	0	0	23	37	22	26
1165+00	0	0	0	1	35	37	17	10	0	0	0	0	35	37	17	11
1175+00	0	0	0	0	33	39	12	6	0	0	1	1	33	39	12	7
1188+00	0	0	0	3	35	43	11	4	0	0	0	0	35	43	11	7
1195+00	0	0	3	3	15	40	13	30	1	0	1	0	16	40	16	33
TOTAL NUMBER OF LEAKS IN SECTION:													485	533	277	

Other represents: bubbles, overlaps, unknown

A "X" REPRESENTS A LOCATION WHERE THERE WERE SO MANY LEAKS IT WAS IMPOSSIBLE TO DETERMINE A NUMBER. A "XX" REPRESENTS A JOINT THAT IS CONSIDERED FAILED.

THE 1998 EVALUATIONS REVEALED THAT THE JOINTS WERE ESSENTIALLY IN THE SAME CONDITION AS IN THE 1997 EVALUATION. THE JOINTS FAIL TO HOLD VACUUM BUT ARE IN PLACE AND KEEPING INCOMPRESSIBLES OUT OF THE JOINT.

TABLE 2: RESULTS OF THE CONTRACTION JOINT SILICONE SEALANT INSPECTION (1994, 1995, 1996, and 1997)

TEST LOCATION	TYPE OF LEAK												TOTAL LEAKS PER JOINT			
	SPALL				ADHESION				OTHER							
	94	95	96	97	94	95	96	97	94	95	96	97	94	95	96	97
856+00	0	8	14	X	1	3	10	10	0	0	0	0	1	11	24	X
859+00	0	1	1	5	1	0	7	8	0	0	1	1	1	1	8	14
862+00	0	2	2	6	0	2	2	4	0	0	0	2	0	4	4	12
865+00	0	3	5	10	0	0	5	7	0	2	0	1	0	5	10	18
868+03	0	0	2	3	0	1	3	3	0	0	0	4	0	1	5	10
871+00	0	1	3	6	0	0	1	1	0	0	0	3	0	1	4	10
873+95	3	5	10	20	0	2	3	4	0	0	0	2	3	7	13	26
877+00	2	4	5	10	1	5	13	20	0	1	0	4	3	9	18	34
881+00	3	13	19	X	5	11	13	X	0	1	1	X	0	25	32	XX
883+00	0	2	5	X	0	5	8	X	0	0	1	X	0	7	13	XX
885+95	1	3	7	X	0	3	9	X	0	3	1	X	1	9	16	XX
888+97	0	7	4	X	0	3	39	X	0	4	1	X	0	14	43	XX
893+00	1	4	9	X	0	0	6	X	0	0	1	X	1	4	15	XX
895+03	0	6	7	X	0	0	10	X	0	3	1	X	1	3	17	X
TOTAL NUMBER OF LEAKS IN SECTION:													19	107	222	

Other represents: bubbles, overlaps, unknown

A "X" REPRESENTS A LOCATION WHERE THERE WERE SO MANY LEAKS IT WAS IMPOSSIBLE TO DETERMINE A NUMBER. A "XX" REPRESENTS A JOINT THAT IS CONSIDERED FAILED.

THE 1998 EVALUATION HAS REVEALED THAT THE SILICONE JOINTS HAVE FAILED OVER MOST OF THE PROJECT. DUE MOSTLY TO EXCESSIVE SPALLING OF THE CONCRETE ALONG THE JOINT. MOST OF THE SILICONE MATERIAL HAS REMAINED IN THE JOINT, BUT MUCH OF THE MATERIAL HAS FALLEN INTO THE JOINT OR IS SO BADLY SPALLED THAT INCOMPRESSIBLES ARE GETTING INTO THE JOINTS.

The results of the evaluation of the contraction joint silicone sealant show an increase in total leaks. Of the 336 linear feet evaluated, the total leaks have increased from 19 to 107 to 222 to very severe failure in 1997 and even more so in 1998. In 1996 this seemed attributable to many spall and puncture failures but inspection of the joints in 1997 and 1998 show a dramatic increase in the amount of spalling failures, so much so that the joints are considered to have failed. The joint details in the construction plans show the silicone sealant to be installed in these joints at a thickness of 1/4" and a width of 3/8", which results in an acceptable shape factor of 0.67. The typical newer low modulus silicone material used on this project can stretch up to 100% of its applied width or be compressed to about 50% of the applied width. In theory it can stretch to approximately 3/4 of an inch, making the widest joints be at the limit of the sealants capabilities. It is possible that the silicone is pulling apart the concrete.

The degree of damage to the sections utilizing the preformed compression joint sealant was assessed to be moderate to high severity. The degree of damage to the sections utilizing the silicone joint sealant was assessed to be of high severity to total failure.

At this time the preformed compression joint seals are out-performing the contraction joint silicone seals by a wide margin. During the 1997 evaluation it appeared that both types of joints were failing at an accelerated rate, however, since the evaluation of 1997 the silicone joint seal has continued to fail at even more accelerated rate and has essentially failed. On the other hand, the preformed compression joint seals have remained relatively the same as in 1997.

An observation made while testing the joints is that the silicone joints have a preponderance of the spall failures. This could be due to improper construction techniques, improper sawing (sawing too green) or the properties of the silicone may be such that when the joints expand the adhesive strength of the silicone is enough to pull the concrete apart at the edges of the joints. The number of punctures developing in the silicone appears to remain constant with the 1997 findings but the spalling failures have essentially caused total failure of the joints. The preformed compression joint seals appear to be failing due to loss of adhesion of the material to the side walls of the joint either from poor application of adhesive or failure of the adhesive. It is rather obvious from the 1998 evaluation that the silicone joint seals have failed, there are a preponderance of spalls and the joints leaked over approximately 75% of their lengths.

Recommendations

In this study neither the silicone nor the preformed joint sealer achieved the results desired, neither worked as a joint sealant. Both keep the incompressible material out of the joint but neither keep moisture out of the joint. The preformed because of loss of adhesion and the silicone because of spalling. NDDOT is continuing to evaluate different types of joints and also is evaluating sections with unsealed joints.

Appendix A

DESIGN DATA					
Traffic	Average Daily				Est Hourly
Current 1994	Pass. 3,455	Trucks 700	Total 4,155		450
Forecast 2014	Pass. 5,080	Trucks 1,050	Total 6,130		775
Minimum Sight Dist. for Stopping 625 FT		Design Speed			70 MPH
Full Control of Access					
No Point of Access Other Than at Interchange Ramps					

JOB# 9

FISCAL YEAR OF LETTING	STATE	PROJECT NO.	SHEET NO.
8	ND	IM-8-094(005)331	1

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

IN CASS COUNTY

FEDERAL AID PROJECT IM-8-094(005)331

PCC RECYCLING & SPS-2 EXPERIMENTAL SECTIONS

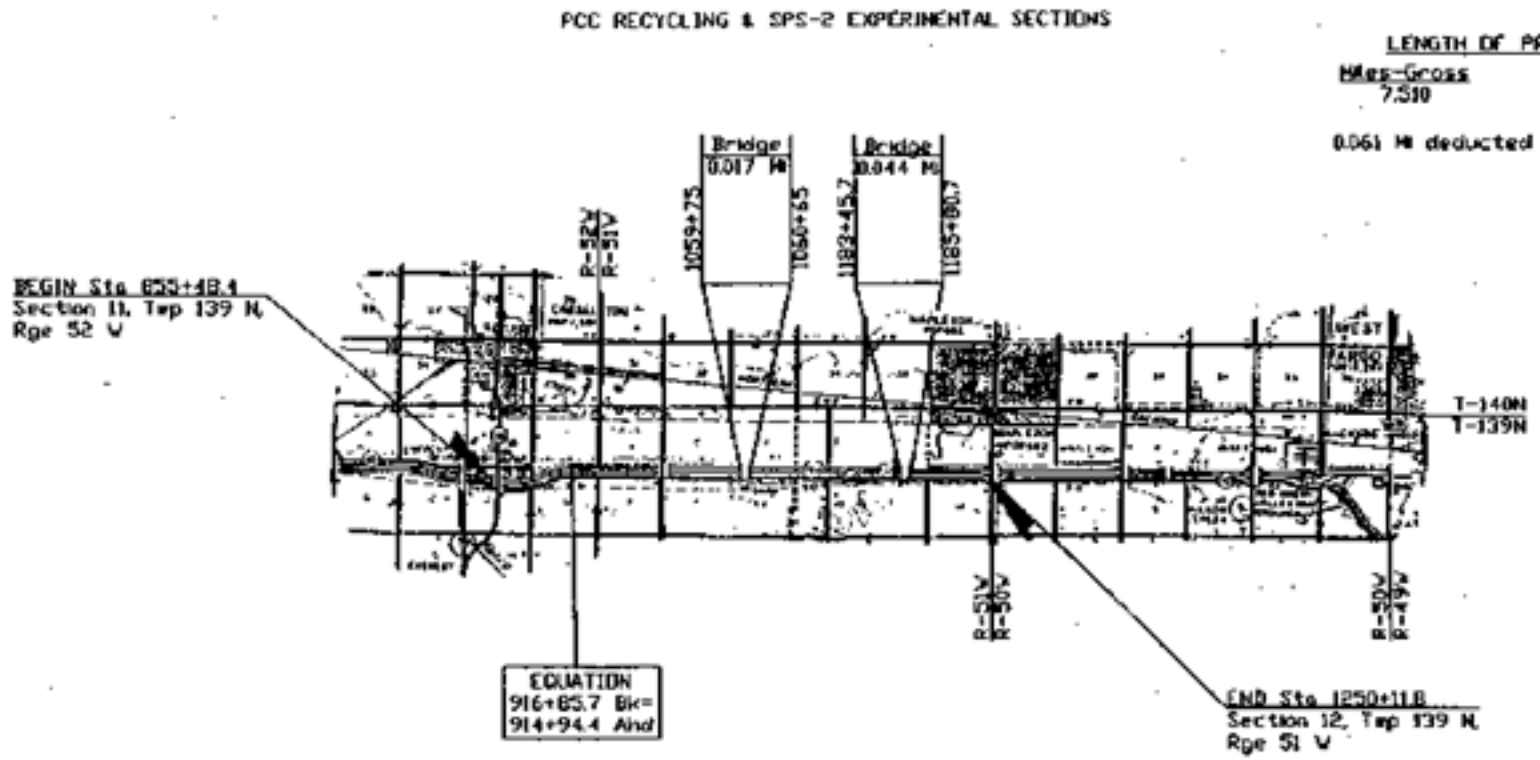
GOVERNING SPECIFICATIONS:

Standard Specifications adopted by the North Dakota Department of Transportation September 1990, Standard Drawings currently in effect, and other Contract Provisions submitted herein.

LENGTH OF PROJECT

Miles-Gross	Miles-Net
7.510	7.449

0.061 MI deducted for bridges.



A-1

PAVING SECTION Larson Bolme

URBAN SECTION

TRAFFIC SECTION Stacy Schofield

RURAL SECTION

RECOMMEND APPROVAL 2-1 1994

DESIGN ENGINEER Dwight Lee

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPROVED

DIVISION ADMINISTRATOR DATE

APPROVED DATE 2-1-94

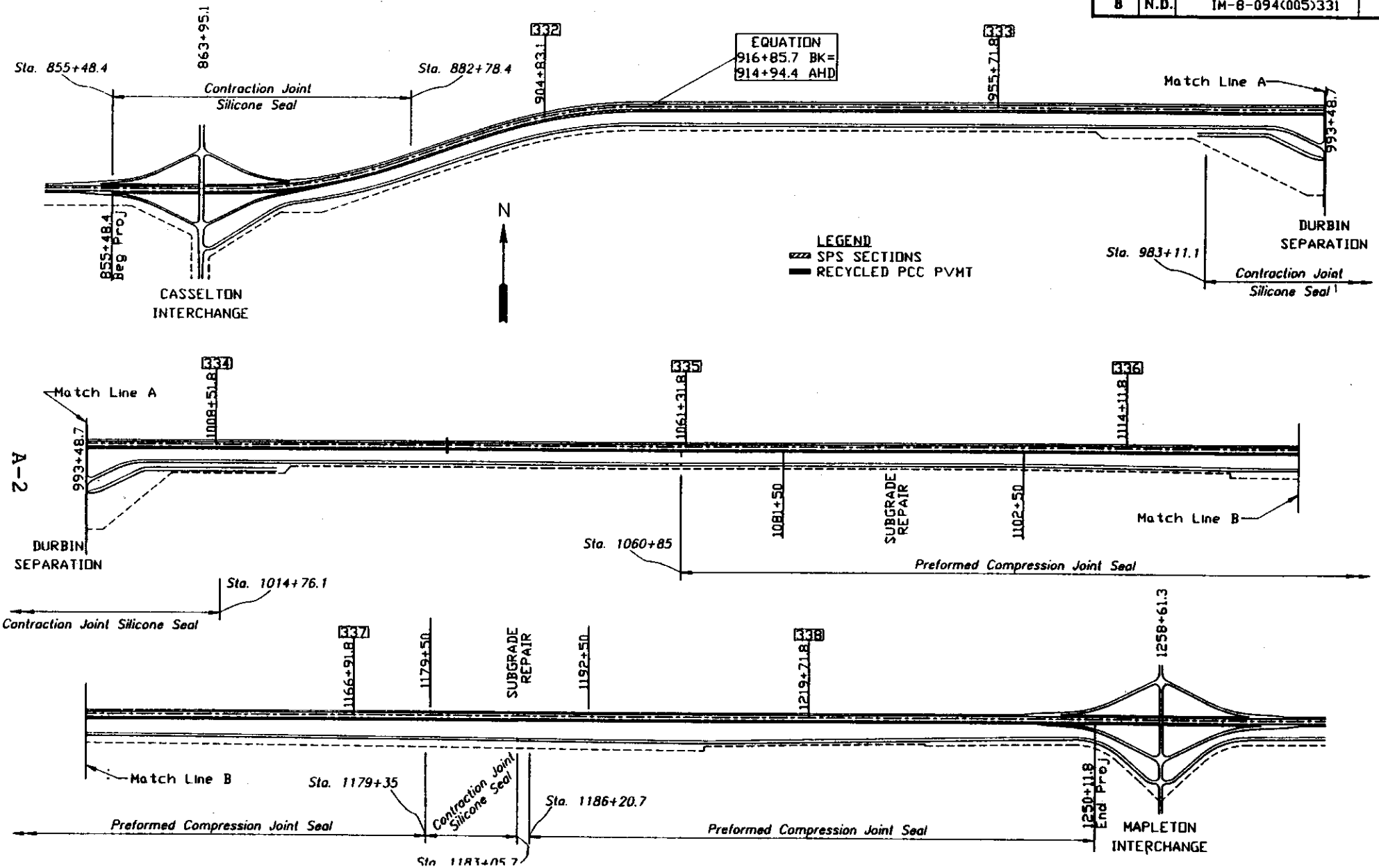
Ray Zink

DIRECTOR OF HIGHWAYS AND ENGINEERING

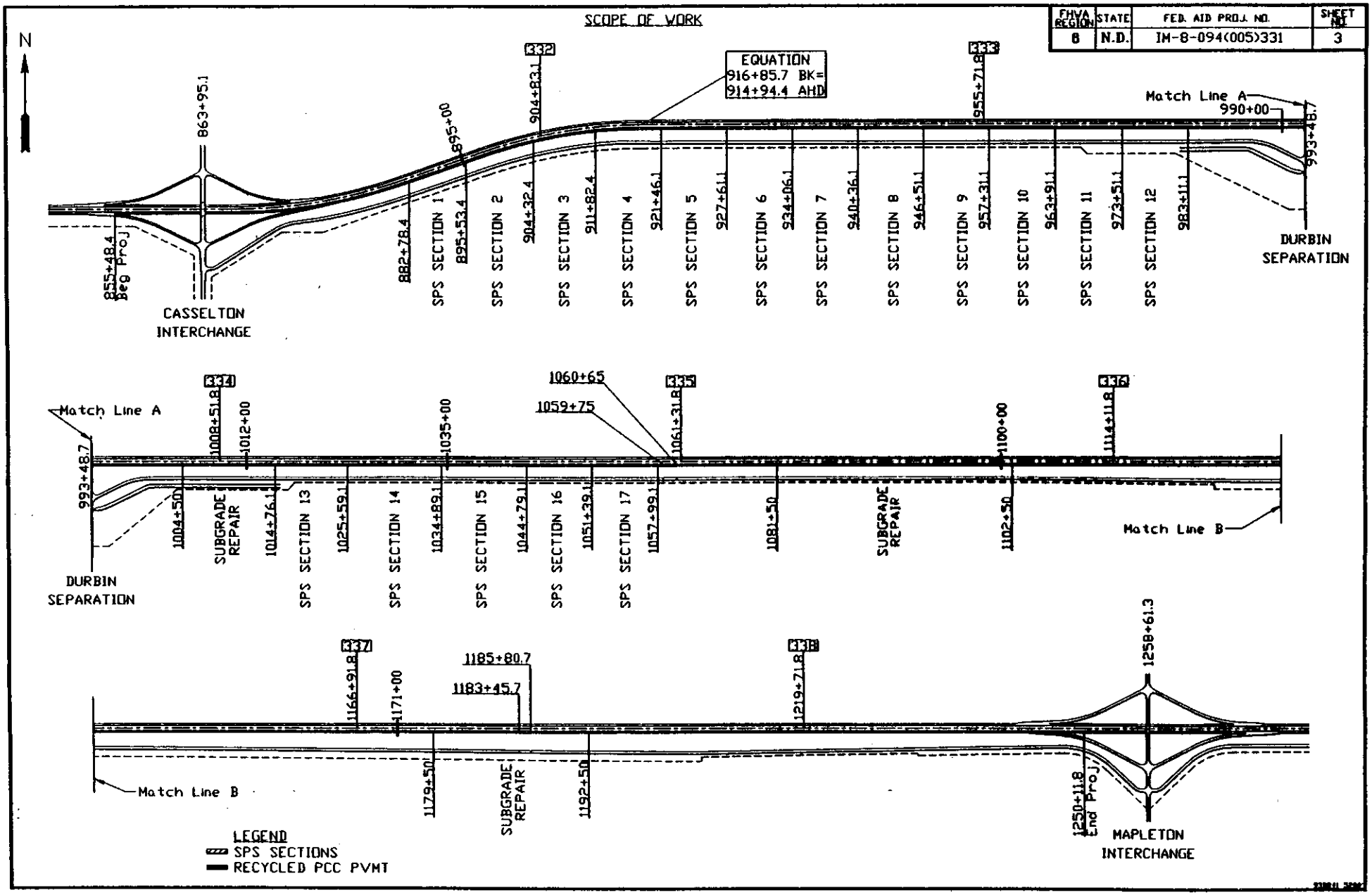
NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

RAY ZINK
REGISTERED
ENGINEER

FHWA REGION	STATE	FED. AID PROJ. NO.	SHEET NO.
8	N.D.	IM-8-094(005)331	



A-2


SCOPE OF WORK
FHWA REGION 8 | STATE N.D. | FED. AID PROJ. NO. IM-8-094(005)331 | SHEET NO. 3
N
863+95.1
855+48.4 Beg Proj
CASSELTON INTERCHANGE
332
904+83.1
EQUATION
916+85.7 BK=
914+94.4 AHD
333
955+71.8
Match Line A
990+00
993+48.7
DURBIN SEPARATION
882+78.4
895+00
895+53.4
904+32.4
911+82.4
921+46.1
927+61.1
934+06.1
940+36.1
946+51.1
957+31.1
963+91.1
973+51.1
983+11.1
SPS SECTION 1
SPS SECTION 2
SPS SECTION 3
SPS SECTION 4
SPS SECTION 5
SPS SECTION 6
SPS SECTION 7
SPS SECTION 8
SPS SECTION 9
SPS SECTION 10
SPS SECTION 11
SPS SECTION 12
334
Match Line A
993+48.7
1008+51.8
1012+00
1035+00
1059+75
1060+65
335
1061+31.8
1100+00
336
1114+11.8
DURBIN SEPARATION
1004+50
SUBGRADE REPAIR
1014+76.1
1025+59.1
1034+89.1
1044+79.1
1051+39.1
1057+99.1
1081+50
SUBGRADE REPAIR
1102+50
Match Line B
SPS SECTION 13
SPS SECTION 14
SPS SECTION 15
SPS SECTION 16
SPS SECTION 17
337
1166+91.8
1171+00
1185+80.7
1183+45.7
338
1219+71.8
1258+61.3
Match Line B
1179+50
SUBGRADE REPAIR
1192+50
1250+11.8 End Proj
MAPLETON INTERCHANGE
LEGEND
SPS SECTIONS
RECYCLED PCC PVMT

ESTIMATED QUANTITIES

FHWA REGION	STATE	FED. AID PROJ. NO.	SHEET NO
8	N.D.	IM-8-094(005)331	11

SPEC	CODE	ITEM DESCRIPTION	UNIT	MAINLINE	CROSSROADS AND RAMPS	SHRP SECTIONS	TOTAL
550	0192	11IN NON REINF CONC PVMT (550 PSI FLEXURAL)	SY			14,405	14,405
550	0193	11IN NON REINF CONC PVMT (900 PSI FLEXURAL)	SY			10,033	10,033
550	0240	DOWELED CONTRACTION JOINT ASSEMBLY	LF	39,216	1,680	19,024	59,920
550	0809	PREFORMED ELASTOMERIC COMPRESSION JT SEAL 9/16IN	LF	46,816	1,512		48,328
550	0958	LONGITUDINAL JOINT SILICONE SEAL	LF		2,282		2,282
550	0959	CONTRACTION JOINT SILICONE SEAL	LF	16,094	4,224	27,828	48,146
550	2040	PORTLAND CEMENT	TON	6,798	562		7,360
550	2044	FLYASH	TON	1,600	133		1,733
560	1580	PREPARE STOCKPILE SITE	L SUM	1			1
560	1590	REMOVAL OF CONCRETE PAVEMENT	SY	104,895	1,406		106,301
560	2005	10IN NON-REINFORCED RECYCLED CONCRETE PAVEMENT	SY	103,473	8,454		111,927
702	0100	MOBILIZATION	L SUM	1			1
704	0100	FLAGGING	M HR	200			200
704	0104	OBLITERATION OF PAVEMENT MARKING	SF	100			100
704	1000	TRAFFIC CONTROL SIGNS	UNIT	5,152			5,152
704	1052	TYPE III BARRICADE	EA	10			10
704	1060	DELINEATOR DRUMS	EA	72			72
704	1065	TRAFFIC CONES	EA	163			163
704	1067	TUBULAR MARKERS	EA	50			50
704	1081	VERTICAL PANELS (BACK TO BACK)	EA	101			101
704	1087	SEQUENCING ARROW PANEL - TYPE C	EA	5			5
708	0300	FIELD LABORATORY - TYPE C	EA	1			1
708	1300	DITCH CHECKS	LF	300			300
708	2240	SEEDING TYPE B - CL II	ACRE	98	5		103

FHWA REGION	STATE	FED. AID PROJ. NO.	SHEET NO.
8	N.D.	IM-8-094(005)331	2

TABLE OF CONTENTS

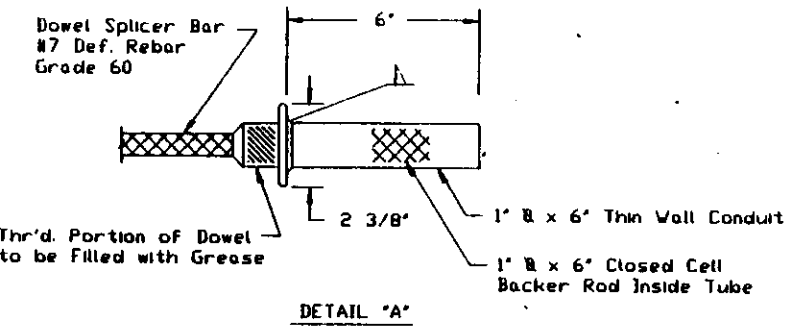
SHEET NO	DESCRIPTION
1	Title Sheet
2	Table of Contents
3	Scope of Work
4-9	Note Sheets
10-14	Estimated Quantities
15	Basis of Estimates & Aggregate Data
16-38	Typical Sections
39-44	SHRP Pavement Details
45-48	Joint Details
49-52	Ramp Details
53	Edge Drain, Outlet Pipe, & Headwall Details
54-62	Traffic Control
63-64	Durbin Separation Plan & Profile
65-67	Soil Profile
68-78	Pipe Extension, Subgrade Repairs, & Subcut at Pipe
79-80	Weigh In Motion System
81	Moisture Sensor System
82-102*	Signing Details
103	Typical Surfacing at Bridge End Guardrail
104-123	Guardrail Layouts
124-128	Fencing Layout
129-142	Cross-Sections
143-147	Pit Plats

STANDARD NO	DESCRIPTION
D-704-8	Breakaway Systems for Construction Zone Signs
D-704-9,10,11,12,13,14,22,& 24	Construction Sign & Barricade Location Details
D-704-35	Sign Layout for One Lane Closure(Interstate)
D-704-42	Road Construction Guide Sign
D-706-1	Type C Field Laboratory
D-708-2	Temporary Erosion and Siltation Control
D-714-1	RCP Culverts and End Sections
D-714-22	Concrete Pipe Ties
D-754-20	Mile Post(Expressway-Freeway Use)
D-754-21A	Reflectorized Delineators
D-754-22A	Typical Interchange Delineation
D-762-2	Interstate Pavement Marking
D-762-4	Pavement Marking
D-764-1	Beam Guardrail-General Details
D-764-2	Modified Eccentric Loader Terminal
D-764-2A	Diaphragm Buffered & Strut & Yoke Detail
D-764-3,4,& 5	W-Beam Guardrail at Bridge Ends
D-764-9	Guardrail at Bridge Ends
D-764-13	Typical Grading at Bridge Ends With Flared W-Beam Guardrail
D-764-17	Guardrail at Obstructions
D-764-21	Typical Grading at Obstructions
D-764-32	Three Cable Guardrail
D-764-36	Three Cable Guardrail at Hazards
D-770-1	Concrete Foundations-Traffic Signal & Highway Lighting
D-772-2	Traffic Signal Standards

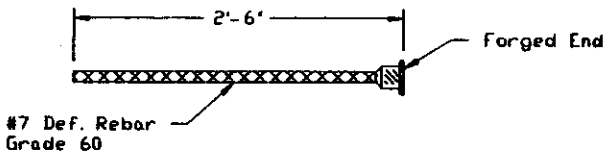
*Sheet 98 has been deleted.

TRANSVERSE CONSTRUCTION JOINT

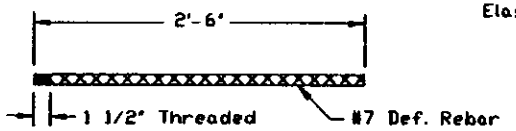
FHWA REGION	STATE	FED. AID PROJ. NO.	SHEET NO.
8	N.D.	IM-8-094(005)331	46



DETAIL "A"



DOWEL SPLICER BAR



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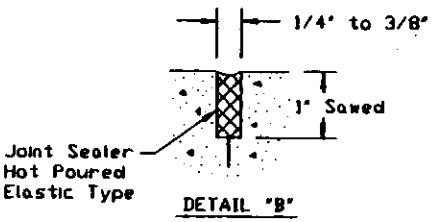
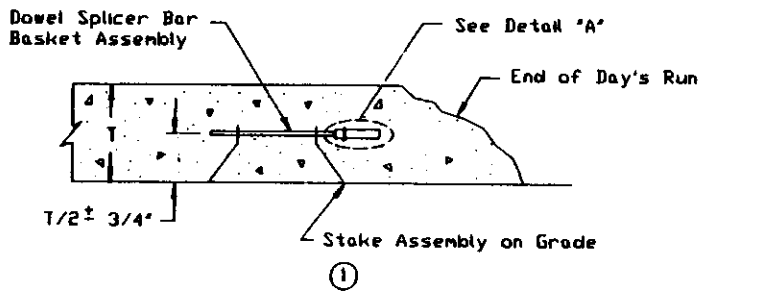


DETAIL "B"

NOTE:
Construction Joints to be
Sawed to a Depth of 1" & a
Width of 1/4" to 3/8" and Sealed



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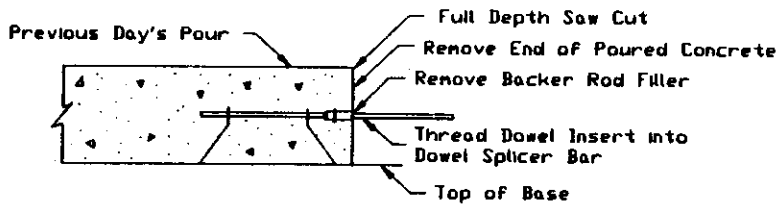

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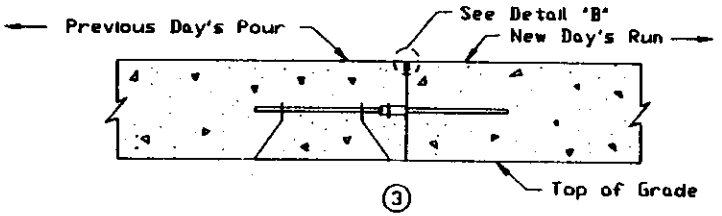

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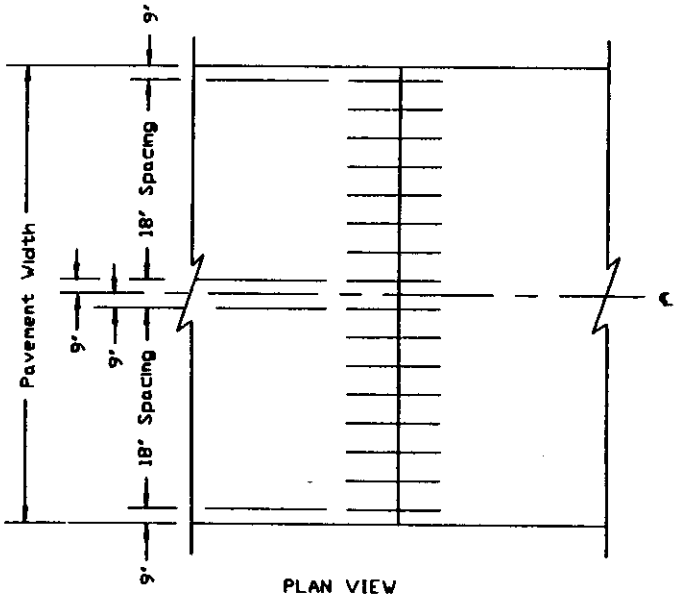
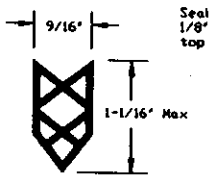


PLAN VIEW

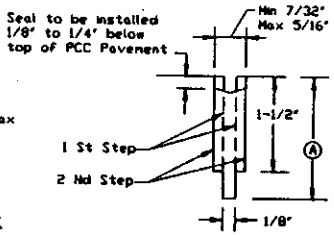
A-6

JOINT DETAILS

FHWA REGION	STATE	FED. AID PROJ. NO.	SHEET NO.
8	N.D.	IM-8-094(005)331	47



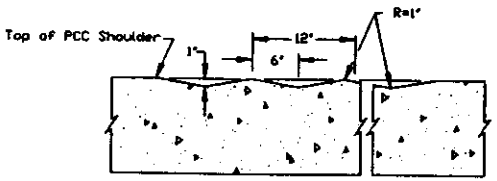
PREFORMED COMPRESSION JOINT SEAL FOR TRANSVERSE CONTRACTION JOINTS



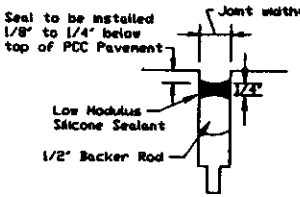
SAWED TRANSVERSE JOINT

PREFORMED COMPRESSION SEAL

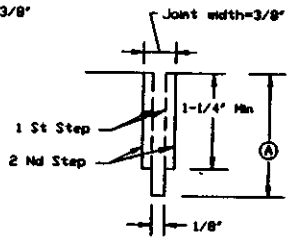
NOTE: Preformed compression joint seals of other shapes may be used. The shape and dimensions must be approved by the Engineer. No preformed compression joint seals with fewer than 5 cells shall be approved.



SECTION OF RUMBLE STRIP

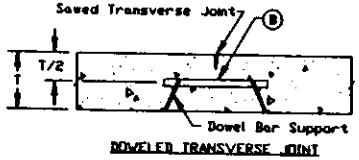


TRANSVERSE JOINT SEAL DETAIL C

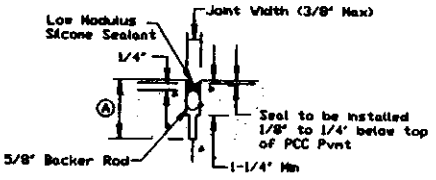


SAWED TRANSVERSE JOINT DETAIL D

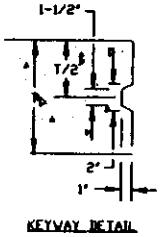
SILICONE SEAL



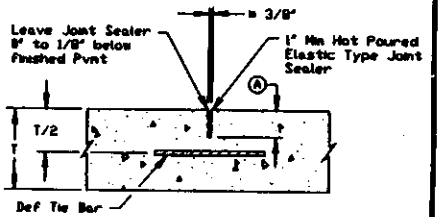
DOWELED TRANSVERSE JOINT



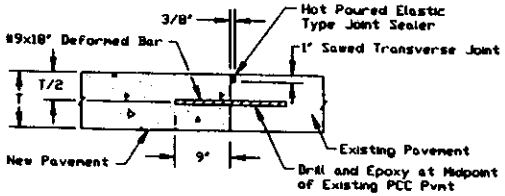
LONGITUDINAL JOINT SILICONE SEAL (Non-Tied Joint) DETAIL E



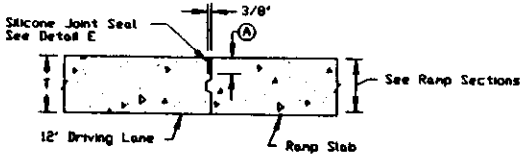
KEYWAY DETAIL



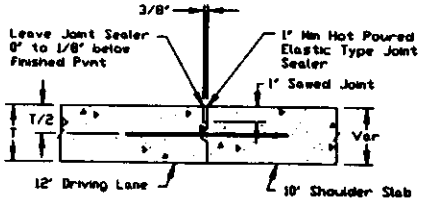
SAWED TIED LONGITUDINAL JOINTS & SEALER (Mainline and ramps)



DEFORMED BAR INSTALLATION (Spaced at 2'-0" C to C)



LONGITUDINAL CONSTRUCTION JOINT AT RAMPS (Keyed)



LONGITUDINAL CONSTRUCTION JOINT AT 10' SHOULDER (Keyed & Tied)

NOTE: (A) = One-Third thickness of PCC Pavement

NOTE: (B) = 1-1/4" x 18" Plain Round Dowel for T=8" or 10"
1-1/2" x 18" Plain Round Dowel for T=11"

*Width requirement for top 1" only; bottom portion of sawcut may be narrower.

All dowel bars used for the Doweled Contraction Joints on this project shall be epoxy coated and conform to AASHTO M-254 Type B.

NOTE: T= Thickness of PCC Pvmt

texture coatings as specified. Treated concrete shall be surface dry within 30 minutes after application.

822.02 TESTING.

The treated concrete shall meet the following requirements:

A. **Absorption.**

Test	Duration	Max. Absorption	Method
Water Immersion	48 hrs.	1% by weight	ASTM C-642
	50 days	2% by weight	ASTM C-642

B. **Chloride Ion Penetration.**

Test	Duration	Max. Absorption Cl-	Method
Salt Water Ponding*	90 days	0.75 lb. per cu. yd. Depth: 1/2 inch to 1 inch	AASHTO T-259 AASHTO T-260

*Based on non-abraded specimens.

C. **Treatment Penetration.**

Test	Minimum Depth	Method
Penetration	0.15 inch	DOT Procedure

D. **Vapor Permeability.**

Treated concrete shall retain its moisture vapor permeability as determined by the Department's test procedure.

SECTION 824
DAMPPROOFING AND WATERPROOFING

824.01 PRIMER.

Primer for use with asphalt in dampproofing and waterproofing shall meet AASHTO M-116.

824.02 ASPHALT FOR DAMPPROOFING AND WATERPROOFING.

Asphalt for dampproofing and waterproofing shall meet AASHTO M-115.

824.03 WOVEN COTTON FABRIC.

Woven cotton fabric saturated with bituminous substances for use in waterproofing shall meet AASHTO M-117.

824.04 BLACK POLYETHYLENE MEMBRANE.

Black Polyethylene Membrane shall be a black polyethylene sheeting 0.010 inch thick plus rubberized asphalt 0.060 inch thick for a total nominal thickness of 0.070 inch. The exposed face of the rubberized asphalt shall have a removeable covering which shall remain on the membrane until it is ready to be placed.

A. **Primer.** The primer to be used with black polyethylene membrane shall be a type recommended by the membrane manufacturer.

B. **Joint Sealing Mastic.** The joint sealing mastic shall be a type recommended by the membrane manufacturer.

SECTION 826
JOINT MATERIALS

826.01 GENERAL

Each shipment shall be marked by the manufacturer with the name of the material, name of manufacturer, brand name, weight, batch number, and if applicable, the pouring temperature recommended by the manufacturer.

826.02 MATERIALS

A. **Hot Applied Joint Sealant.**

1. **Type 1** ..... AASHTO M301 (ASTM D-3405)

2. **Type 2** ..... AASHTO M301 (ASTM D-3405) with the following modifications:

   Penetration at 77°F. ..... 90 – 150
   Bond at –20°F., 3 cycles, 200% extension ..... Pass
   The Sealant shall weigh not less than 9.0 nor more than 9.35 lbs./gallon.

3. **Type 3** ..... The sealant shall meet the following requirements:

   Penetration,
   at 77°F. mm/10 ..... 130 + 20
   at 0°F. ..... 40 min
   Flow, cm ..... 3 max
   Resilience, % ..... 60 min

Elongation, (tensile adhesion)
at 77°F., (1) ..... 600% min
at –20°F., (2) ..... 300% min
Bond Test
at –20°F., 100% Ext. (3) ..... Pass, 3 cycles

Test methods as described in ASTM D-3407 except as noted for modifications.

(1) Test Method ASTM D-3408; sample modified to 3/4 inch by 3/4 inch by 2 inch.

(2) ASTM D-3407 Bond one cycle; sample modified to 1/2 inch by 1/2 inch by 2 inch.

(3) Standard sample; extension increases to 100%.

4. **Type 4.**

The hot applied sealant shall be an extra low modulus material composed of a homogeneous blend of virgin polymers, plasticizers, special fillers, and asphalt compounded specifically for the sealing of cracks in asphalt or concrete pavement. This material shall be melted in an oil jacketed kettle equipped with an agitator, pump, and temperature controls.

The materials shall be flowable and self-leveling at application temperatures and shall meet the following physical requirements:

Cone Penetration, mm/10
at 77°F. 145–170
at 0°F. ..... 50 min
Flow at 140°F., cm ..... 1.0 max
Resilience, % ..... 50 max
Static Tensile Modulus
100% extension at 0°F., psi
2 hours ..... 1.5 max
24 hours ..... 1.0 max

The penetration, flow, and resilience specimens are prepared and tested in accordance with ASTM D-3407.

The static tensile modulus test is conducted as follows:

A 1/2 inch by 2 inch by 2 inch concrete bond specimen is prepared per the ASTM D-3407 procedure. After conditioning 24–72 hours at ambient temperature, the specimen is placed in a freezer maintained at 0°F. (+2°F.) for a minimum of two hours. The specimen is then placed in the jaws of a static tensile testing apparatus, which is also being maintained at 0°F. in the freezer. This extensometer shall be capable of maintaining extensions for long periods of time, and shall be capable of measuring forces in the 2–50 lb. range.

The specimen is then stretched within 30 seconds to 100% extension, 1/2 inch to 1 inch. The test specimen is held in this static extended state at

0°F. for a total of 24 hours. Readings are taken after two hours and 24 hours. If over 10% adhesion loss is experienced during extension, the material should be considered a failure and be subject to retesting. The tensile modulus values during 100% extension at 0°F. shall be calculated at follows:

$$\frac{\text{lbs. force}}{\text{4 sq. in.}} = \text{tensile modulus in psi}$$

Prior approval of any specific sealant material shall be required from the Materials and Research Division.

The crack sealant compound shall be packaged in sealed containers. Each container shall be clearly marked with the name of the manufacturer, the trade name of the sealant, the manufacturer's batch and lot number, the pouring temperatures, and the safe heating temperature.

A copy of the manufacturer's recommendations pertaining to the heating and application of the joint sealant material shall be submitted to the Engineer before the commencement of work. These recommendations shall be adhered to and followed by the Contractor. The temperature of the sealer in the field application equipment shall not exceed the safe heating temperature recommended by the manufacturer. Any given quantity of material shall not be heated at the pouring temperature for more than six hours and shall never be reheated. Material shall not be place if the temperature is below the manufacturer's recommended minimum application temperature.

Mixing of different manufacturer's brands or different types of sealant shall be prohibited.

Sealant materials may be placed during a period of rising temperature after the air temperature in the shade and away from artificial heat has reached 40°F. and indications are for a continued rise in temperature. During a period of falling temperature, the placement of sealant material shall be suspended when the air temperature, in the shade and away from artificial heat, reaches 40°F. Sealants shall not be placed when the weather or roadbed conditions are unfavorable.

B. **Cold Applied Joint Sealant.**

1. **Type 5** ..... Low Modulus Silicone Sealant. The Low Modulus Silicone Sealant shall be furnished in a one part silicone formulation. The silicone sealant material shall have a movement capability of +100% and –50% of joint width. This material shall meet the following requirements:

Test	Limit	Method
Flow	0.3 inch maximum	ASTM C-639
Extrusion Rate	75–250 grams/min.	ASTM C-603
Tack-Free Time	20–75 minutes	ASTM C-679
Specific Gravity	1.010–1.515	ASTM D-792, Method A

Durometer Hardness Type A: (Cured 7 days at 77°F. ± 3° and 45% to 50% R.H.)	10–25 (0°F.)	ASTM D-2240
Tensile Stress (at 150% elongation, 7-day cure at 77°F. ± 3° and 45% to 50% R.H.)	45 psi maximum	ASTM D-412 (Die C)
Elongation: (7-day cure at 77°F. ± 3° and 45% to 55% R.H.)	1200% minimum	ASTM D-412 (Die C)
Movement capability and adhesion (7-day cure in air, 77°F. ± 3° then 7 days in water, 77°F. ± 3°)	No adhesive or cohesive failure after 10 cycles (0°F.)	ASTM C-719*
Bonded to concrete mortar concrete briquets (air cured 7 days at 77°F. ± 3°)	50 psi minimum	AASHTO T-132**

*A 1 inch by 2 inch by 3 inch concrete block shall be prepared according to ASTM C-719. A sawed face shall be used for the bond surface. Two inches of block shall be sealed leaving a 1/2 inch on each end of the specimen unsealed. The depth of the sealant shall be 3/8 inch and the width 1/2 inch. The sealant shall be subject to a movement according to ASTM C-719 at the rate of 1/8 inch per hour. One cycle is defined as an extension to one inch and returning to the initial 1/2 inch width.

**Briquets, molded according to AASHTO T-132, shall be sawed in half and bonded with approximately 10 mils of sealant and tested using clips meeting AASHTO T-132. The briquets shall be dried to a constant weight in an oven at 100°C. ± 5°. They shall be tested in tension at a loading rate of .5 inch/minute.

Backer rod shall be of a non-moisture absorbing, resilient material compatible with the sealant. No bond or reaction shall occur between the rod and the sealant.

C. **Preformed Expansion Joint Fillers for Structural Construction.** ..... AASHTO M-213

D. **Preformed Expansion Joint Filler for Concrete (Bituminous Type).** ..... AASHTO M-33

E. **Rubber Gaskets.** ..... AASHTO M-198 (Type A)

F. **Flexible Plastic Gaskets.** ..... AASHTO M-198 (Type B)

G. **Preformed Elastomeric Compression Joint Seal for Concrete.** ..... AASHTO M-220

SECTION 830
PIPE

830.01 CONCRETE PIPE.

A. **Concrete Sewer, Storm Drain, and Culvert Pipe.** ..... AASHTO M-86

B. **Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.** This pipe shall meet AASHTO M-170, M-206, or M-207 for the specified diameters and strength class except that aggregate shall meet AASHTO M-80, Class B.

C. **Precast Reinforced Concrete Manhole Sections.** ..... AASHTO M-199

D. **Fasteners and Tie Bolts.** Tie bolts and nuts shall be of steel meeting ASTM A-307 Grade A. Washers shall be of steel meeting ASTM A-366 or ASTM A-569. Fastener castings shall be gray iron castings meeting ASTM A-48 Class 20.

830.02 METAL PIPE.

A. **Ductile Iron Sewer Pipe.** ..... ASTM A-746

B. **Metallic (Zinc or Aluminum) Coated Corrugated Steel Culverts and Underdrains.** ..... AASHTO M-36

C. **Corrugated Aluminum Alloy Culverts and Underdrains.** AASHTO M-196

D. **Smooth Wall Steel Pipe Culvert.** Smooth wall steel pipe culvert shall be welded steel pipe of new material, meeting ASTM Specifications A-139, Grade B with a minimum yield strength of 35,000 psi. The following minimum wall thickness shall be used:

Diameter of Pipe	Minimum Wall Thickness Through Roadway Embankment	Minimum Wall Thickness Through Railroad Embankment
24 inches	0.250 inch	.344 inch
30 inches	0.312 inch	.406 inch
36 inches	0.375 inch	.469 inch

E. **Structural Plate For Pipe, Pipe Arches, and Arches.** ... AASHTO M-167

F. **Aluminum Alloy Structural Plate for Pipe, Pipe Arches, and Arches.** ..... AASHTO M-219

830.03 PLASTIC PIPE.

A. **Plastic Pipe for Non-Pressure Drainage of Sewage and Surface Water (outside buildings).** Plastic pipe for non-pressure drainage of sewage and surface water shall meet the following:

lished alignment. Forms shall be set sufficiently in advance of placing concrete to provide time for the Engineer to check line and grade. The length of forms in place shall be equal to the anticipated linear feet of pavement to be placed in 2 hours. Forms which are disturbed or show evidence of an unstable foundation shall be reset.

3. **Slip Form Paving.**

   a. **Line and Grade.** The Department will set appropriate stakes for establishing the finished line and grade of the pavement. The Contractor shall erect and maintain the necessary taut lines for operating the automatic equipment and preserve the line and grade stakes set until the pavement is placed.

   b. **Placing Concrete.** When placing concrete pavement on a divided highway, the four-foot inside mainline shoulder and the two 12-foot driving lanes shall be placed in one continuous operation. Concrete shall be uniformly placed at a rate and consistency that produces a dense and homogeneous pavement with a minimum amount of manual finishing.

   Vibration shall be accomplished with vibrating tubes or arms working in the concrete, or with a vibrating screed operating on the surface of the concrete.

   The slip form paver shall be operated in a continuous forward movement. All concrete mixing, delivering, placing, and spreading operations shall be coordinated to provide a continuous and uniform forward movement without stopping and restarting the paver.

   If forward movement of the paver is stopped, all vibrating and tamping elements shall be stopped immediately.

H. **Placing Reinforcement.** Reinforcement, when specified, shall be installed according to details shown on the Plans. The reinforcing steel shall be free from dirt, oil, paint, grease, mill scale, and loose or thick rust which could impair the bond between the steel and concrete.

The reinforcement may be positioned on approved supports in advance of concrete placement, or the reinforcement may be inserted in the plastic concrete by approved mechanical devices after the concrete has been spread, struck-off, and consolidated to full depth.

The vertical location of the reinforcement in the hardened concrete shall be as shown in the Plans.

I. **Joints.**

1. **General.** Joints in concrete pavement shall be of the design specified and shall be constructed at the spacings and locations shown. The ramp joints beyond the ramp taper shall have the same spacing sequence as the mainline. The Contractor shall establish joint locations.

2. **Transverse Contraction Joints.** The contraction joints shall consist of weakened planes created by sawing on main line paving and by either saw-

ing, inserting preformed inserts, or forming grooves in the pavement surface on shoulders, small areas or tapers. The location of grooves to be formed or sawed shall be clearly and accurately marked on the plastic concrete surface by the Contractor. When specified, the contraction joints shall include a load transfer device.

Sawed contraction joints shall be cut to the required dimensions with equipment meeting Section 153.12. The time and sequence of sawing shall be adjusted so all joints are cut before uncontrolled cracking occurs, and to permit sawing without excessive raveling. Joints shall be sawed within 24 hours to prevent uncontrolled cracking. Uncontrolled cracking that occurs shall be routed, cleaned and sealed according to Section 550.04 M.3 at the Contractor's expense. Immediately after sawing, the joint shall be flushed with water under sufficient pressure to remove residue left by the sawing operation. If an uncontrolled crack occurs within 5 feet of any proposed joint location before or during sawing, the joint shall be omitted and sawing of the joint discontinued. Any joint sawed within 5 feet of an uncontrolled crack shall be repaired at the Contractor's expense. When sawing is performed before removing side forms, the initial saw cut will extend to within 1/2 inch or less of the side forms. If the forms have been removed, the saw cut will be extended to the edges of the slab. Any curing media removed during sawing shall be immediately replaced.

Before installing silicone sealant or preformed elastomeric compression joint seal, all joint grooves shall be inspected and spalls which are greater than 1/4 inch in depth shall be repaired by patching with an approved epoxy mortar meeting Section 806. Loose concrete shall be removed from the spalled area and the area shall be thoroughly cleaned. Heavy sheets of polyethylene, polyvinyl chloride, or other suitable material which do not bond to the epoxy shall be inserted in the joint groove to form the faces of the spalled patch. After cleaning, the spalled surface shall be primed with a brush application of epoxy binder, and an epoxy mortar of troweling consistency shall be placed in the spalled area and finished as the original pavement surface. The epoxy binder components shall be mixed in proportions and by methods recommended by the manufacturer. After the epoxy binder is thoroughly mixed, dry concrete sand shall be blended into the mixture to give an epoxy mortar of trowelable consistency. Patching of spalls shall be done only when the air and pavement temperature is above 40°F. Dry concrete sand shall be sprinkled onto the fresh epoxy mortar surface to eliminate any gloss. After the epoxy mortar has cured, the inserts shall be removed.

Formed contraction joints shall be constructed by installing an approved preformed insert into the plastic concrete before final surface finishing. The inserts shall be vibrated into place or installed in a groove formed by a vibrating cutter bar. The inserts top edges shall be flush with the concrete surface. Any voids, depressions, or ridges of concrete caused by installing inserts shall be filled or removed by hand-finishing methods, and the surface across the joint shall be straight-edged according to Section 550.04 J.5. The groove formed by the inserts shall be perpendicular to the pavement surface, true to the required alignment, and continuous along the full length of the joint. Inserts, except those designed to remain, shall be removed without damage to adjacent concrete.

When specified for use with the transverse contraction joint the dowel bars shall be held in the specified position parallel to the slab surface and to the centerline within a tolerance of 1/8 inch per foot vertically and horizontally. The dowel bar assembly shall be an approved metal supporting device securely staked to the roadbed and shall hold the dowel bars at the correct spacing, alignment and elevation. The position of the load transfer units shall be accurately marked with steel pins, or other precise methods, to locate the transverse joint over the center of the dowels.

A thin uniform coat of concrete form release agent shall be applied to the dowel bars within one hour of being covered with concrete. The release agent shall be a non-staining, liquid chemical agent free of kerosene, oil, and wax. The release agent shall provide positive separation between the dowel bars and the concrete, shall not penetrate the concrete, and shall not attract dirt or other deleterious matter. The flash point of the chemical release agent shall not be less than 150°F.

3. **Transverse Expansion Joints.** The expansion joints shall be formed by installing preformed expansion joint filler at designated locations.

Dowel bars shall be installed in the expansion joint to act as a load transfer device. The dowels shall be held in the specified position parallel to the slab surface and centerline by a metal supporting device securely staked to the roadbed and shall hold the dowel bars at the correct spacing, alignment, and elevation. The dowel bars shall be placed within a tolerance of 1/8 inch per foot vertically and horizontally. The "free" half of each dowel shall be coated with a thin uniform coat of concrete form release agent and covered with a metal or plastic dowel cap or sleeve. The caps or sleeves shall fit the dowel bars tightly, and the closed end shall be watertight. The release agent shall be a non-staining, liquid chemical agent free of kerosene, oil, and wax. The release agent shall provide positive separation between the dowel bars and the concrete, shall not penetrate the concrete, and shall not attract dirt or other deleterious matter. The flash point of the chemical release agent shall not be less than 150°F.

Preformed expansion joint filler shall be of the dimensions shown on the Plans and shall extend across the full width and depth of the slab at each transverse expansion joint. Filler shall be furnished in individual sections having a length equal to the pavement slab width being poured. Filler shall be accurately prepunched to fit snugly around the dowels.

The expansion joint assembly shall be securely staked to the subgrade. Unless the preformed filler is adequately supported by a load transfer assembly or other device designed to remain in the pavement, a suitable installing bar or header shall be used to support filler during placement and finishing of adjacent concrete. Filler shall be installed perpendicular to the pavement surface and true to the designated line of the joint. Where more than one section of filler is permitted, abutting ends of individual sections of filler shall be neatly and securely jointed without any gap or offset between sections. The bottom edge of filler shall extend to or slightly below the bottom of the pavement. The top edge of filler shall be approximately 1/2 inch below the pavement surface. During placement and finishing of adjacent concrete, the top

edge of filler shall be protected by a removable channel cap having flanges not less than 1 1/2 inches deep. An aluminum channel cap shall not be used.

Installation of the expansion joint assembly shall be approved before any concrete is placed against the joint. Equal pressure shall be maintained against both sides of the preformed filler as the concrete is placed, and an approved internal vibrator shall be used to consolidate the concrete on each side of the joint. After the concrete has been placed and finished, the protective channel cap shall be removed, the top edge of the filler shall be exposed over its full width and length, and the concrete on each side of the joint shall be edged to the specified radius. After the side forms have been removed, any concrete which flowed around the ends of the joint shall be removed to expose the full thickness and height of the filler.

The expansion joint shall be sealed with a low modulus silicone sealant meeting Section 826.02 B. All materials and installation methods shall meet Section 550.04 M.3.

At structures projecting through, into, or against the pavement, expansion joints of a preformed or poured type shall be constructed as specified.

4. **Transverse Construction Joints.** A transverse construction joint shall be installed at the end of each day's pour and whenever the elapsed time between placement of successive batches or loads of concrete exceeds 45 minutes. Transverse construction joints shall not be installed within 10 feet of any other transverse joint.

The transverse construction joint shall be formed by installing an approved dowel splicer bar basket assembly. The dowel splicer bar assembly shall hold the dowel splicer bars parallel to the centerline and slab surface. The dowel splicer bars shall be placed within a tolerance of 1/8 inch per foot vertically and horizontally.

The dowel splicer basket assembly shall be staked perpendicular to the centerline and marked. The Contractor shall pave over the assembly far enough to maintain the elevation of the top of the slab. A full depth saw cut shall be made to expose the dowel splicer bar, the excess concrete shall be disposed of and the threaded dowel extension bar shall be installed.

After the adjacent slab is placed the construction joint shall be sawed and sealed as specified.

On shoulders or urban projects where the Engineer determines it is not feasible to install a dowel splicer bar basket assembly the transverse construction joint shall be formed by installing an approved header shaped to conform to the cross-section of the slab being placed. The header shall be rigid and secured to prevent bulging or displacement while adjacent concrete is being placed and finished. The face of the header in contact with the concrete shall be perpendicular to the pavement surface and shall be at right angles to the pavement centerline. A two piece or other approved header shall be designed to accommodate proper placement of any dowel bars or reinforcement extending across the joint and to allow removal without damage to the concrete.

Immediately following the grass carpet drag, the surface shall be given a transverse metal tine finish. The tining device shall consist of a single row of tines capable of producing grooves at approximately one-inch centers with groove widths of 1/8 inch and groove depths of 1/8 to 3/16 inch. There shall be no tine finish within 1 1/2 inches of the transverse contraction joints. The texturing equipment shall be self-propelled and mechanically operated.

7. **Imprinting Pavement.** After texturing, the survey station numbers shall be imprinted into the surface by the Contractor about one foot from the edge of the pavement so the numbers can be read in the direction of traffic driving on the outside shoulder. On 2-way roadways, the station numbers shall be imprinted in the direction of stationing. In addition at the beginning and end of each day's pour, the station number to the nearest foot shall be placed at the right edge of slab.

   The month, day, and year shall be imprinted at the beginning and end of each day's pour near the edge of the slab opposite that used for stationing so the numbers can be read in the direction of the pour.

   The Contractor shall furnish devices for imprinting the pavement. The numerals shall be 3 to 4 inches in height and at least 1/4 inch in depth.

K. **Curing Concrete.**

1. **General.** Curing shall be accomplished using a wetted fabric cure or an impervious membrane cure. Any specified method of cure may be used but methods shall not be changed without approval. All concrete pavement shall be cured for a period of at least 72 hours unless high-early strength concrete is utilized. Curing may be suspended for high-early strength concrete when the pavement has attained the minimum strength specified in Section 550.04 O. for opening pavement to public traffic. Curing shall begin as soon as the curing cover can be placed without marring the concrete. If hair-cracking develops before placing the curing cover, curing procedures shall be modified to prevent loss of moisture by utilizing a fog spray of water or a wetted fabric. If hair-cracking continues, concrete placing and mixing shall be suspended until a solution has been found. Failure to provide (a) sufficient cover material of the type specified or (b) the interim cure utilizing a moist fog or moist fabric, will be cause for immediate suspension of concreting operations. No pavement shall be left exposed more than 30 minutes without the applied final cure.

2. **Wetted Fabric Cure.** This method of curing consists of covering pavement with wet mats of cotton, burlap, or other approved highly-absorptive fabric. Mats shall be placed to cover the entire pavement surface and, the exposed sides of the pavement when the forms are removed. Fabric mats shall be kept wet to maintain free water on the pavement surface continuously during the curing period. The fabric mats shall remain in position for at least 72 hours, or after 12 hours if the mats are replaced with impervious membrane.

3. **Liquid Membrane Cure.**

   a. **General.** A uniform film of an impervious, type 2, white pigmented, membrane cure shall be sprayed over the surface immediately after the free water from the final surface finishing has left the surface. The curing compound shall be thoroughly mixed and applied with spraying equipment meeting Section 153.11. Curing cover that is damaged within the curing period shall be immediately recoated. If side forms are removed before expiration of the curing period, the exposed sides of the pavement shall be immediately sprayed with curing compound at the rate specified for the pavement surface.

   b. **Application.** The impervious compound shall be applied to the pavement surface in one or 2 applications. If 2 applications are utilized, the second application shall be made within 30 minutes of the first application. The total rate of application shall be at least one gallon per 150 square feet of pavement. Joints requiring sealing shall be protected against entry of curing compound.

L. **Removing Forms.** Side forms shall remain in place for at least 8 hours, and until the concrete has hardened to the extent that the forms can be removed without damage to the concrete. Pry bars shall not be used against any new pavement to remove forms. Any pavement damage resulting from form removal or use of form pullers shall be repaired at the Contractor's expense.

Before applying curing compound, honeycombed areas in the sides of the pavement or curb shall be repaired using freshly mixed mortar of the same proportions of cement and sand as used in the pavement concrete. If honeycombing occurs frequently, adjustments shall be made in the placement methods, including additional vibration at the form lines if directed by the Engineer.

M. **Sealing Joints and Cracks.**

1. **General.** Within 10 days after concrete placement and before opening the pavement to public or construction traffic, the joints shall be sealed with specified joint material. Before sealing, each joint shall be thoroughly cleaned of all dust, dirt, concrete scale, and other foreign matter and blown out with a jet of compressed air. The joint faces shall be clean and dry when the joints are sealed. Joints shall not be sealed when the air temperature is below 40°F.

   Uncontrolled relief cracks which extend across the full width of a non-reinforced pavement or which occur at the location of a doweled joint in reinforced pavement shall be routed, cleaned, and sealed with an approved joint sealer at the Contractor's expense.

   When the asphalt shoulder joint is to be sealed, the edge of the P.C.C. pavement shall form one vertical side of this joint and shall be cleaned by a device which results in a smooth clean surface. The vertical face of the joint in the asphalt surfacing shall be smooth and vertical, and the line of its edge shall be straight and parallel to the edge of the P.C.C. pavement. The bottom of this joint shall be smooth and level.

2. **Hot Poured Elastic-Type Joint Seal Installation.** The joint shall be filled with an applicator meeting Section 153.13 B. from the bottom up to the required depth.

3. **Silicone Joint Sealant Installation.**

   a. **Cleaning Joints.** Joints shall be sawed and blown out with compressed air.

      Before installing silicone sealant, the vertical joint faces shall be cleaned by sandblasting with a nozzle capable of fitting inside the joint slot. Oil, asphalt, curing compound, paint, rust, and other foreign materials shall be completely removed. The joint shall be blown out with compressed air immediately before installing silicone sealant. All incompressible materials shall be removed from the joint slot.

   b. **Backer Rod Installation.** Backer Rod shall be installed in transverse joints in a manner and at a location that produces the shape factor (width and depth) for the sealant specified.

   c. **Joint Sealer Application.** The joint sealer shall be applied by an approved mechanical device.

      Sealant shall be applied from inside the joint and squeezed against the sides of the joint to provide good adhesion. Sealant surface shall be tooled to produce a slightly concaved surface approximately 1/4 inch below the pavement surface. Sealants that are not self leveling shall be tooled before a skin forms on the surface. Soap or oil shall not be used as a tooling aid.

      Failure of the joint material in either adhesion or cohesion in the first year, will be cause for rejection. Repair shall be at the Contractor's expense.

4. **Preformed Elastomeric Compression Joint Seal.** Immediately before installation of the preformed joint seal, joint grooves shall be thoroughly cleaned of all foreign material using a jet of compressed air at a working pressure of at least 90 psi. The lubricant-adhesion shall be applied to the joint groove walls or to the preformed joint seal or both. The preformed compression joint seal shall be installed by suitable machine tools. On ramps or locations where machine tools would not be practical, hand tools may be used. The seal shall be installed not less than 1/8 inch or more than 1/4 inch below the pavement surface and shall be free from curling or twisting in the joint groove.

   Joints having a length of 24 feet or less shall not contain any splice of the joint seal. Joints having a length over 24 feet shall not have more than 2 splices of the joint seal. The preformed joint seal shall extend one inch beyond each edge of the concrete pavement, and stretching of the preformed joint seal more than 5% is not permitted.

N. **Protection of Pavement.** The newly-placed concrete shall be protected from traffic by employing watch persons, if necessary, and by the erection and maintenance of barricades, fences, warning signs and lights, pavement bridges, and cross-overs.

When the temperature is expected to fall below 35°F., suitable measures shall be taken to maintain the concrete surface temperature above 40°F. for 5 days. Admixtures for curing or temperature control shall be used only as permitted or directed. The admixtures shall not be considered as a substitute for any specified curing requirement. Any concrete pavement damaged before final acceptance or damaged by frost action shall be repaired or removed and replaced at the Contractor's expense.

When bituminous material is applied adjacent to P.C.C. pavement, the adjacent P.C.C. pavement shall be protected from spills and smears. Discolored P.C.C. pavement shall be cleaned at the Contractor's expense. The P.C.C. pavement shall not be used to stockpile, mix, or dry bituminous mixtures.

O. **Opening to Traffic.** Newly constructed concrete pavement shall not be opened to public or construction traffic until all joints have been sealed. Pavement shall not be opened to public traffic or hauling equipment until the concrete has been in place at least 7 days (48 hours if it is high-early strength concrete), and the concrete has attained a flexural strength of at least 500 psi or a compressive strength of 3,000 psi. Specimen beams and cylinders used for testing shall be cured under the same conditions as the concrete pavement or cores may be taken from the pavement. Pavement that has not reached the required flexural and compressive strengths shall not be opened to public traffic or hauling equipment until it has aged at least 14 days.

P. **Tolerance in Surface and Ride Quality.**

   1. **Surface Tolerance.** After the concrete has hardened sufficiently, the pavement surface shall be tested with a 10-foot straightedge. The surface tolerance shall be based on the posted speed limit as follows:

      a. In areas where the posted speed limit is 40 mph or greater, high spots of more than 1/8 inch but not exceeding 1/2 inch in 10 feet shall be ground with diamond grinding equipment to an elevation where the deviation is less than 1/8 inch. When the deviation exceeds 1/2 inch the area shall be ground with diamond grinding equipment or the pavement shall be removed and replaced at the Contractor's expense.

      b. In areas where the posted speed limit is less than 40 mph, high spots of more than 1/4 inch but not exceeding 5/8 inch in 10 feet shall be ground with diamond grinding equipment to an elevation where the deviation is less than 1/4 inch. When the deviation exceeds 5/8 inch the area shall be ground with diamond grinding equipment to the specified 1/4 inch deviation or the pavement shall be removed and replaced at the Contractor's expense.

      If corrective grinding is required and more than 1/2 inch of concrete is removed from any area ground, the area shall be cored. If the core is deficient in length, the unit price for the deficient area will be adjusted according to Section 550.06 A.

      If an area of pavement is removed, it shall be at least 6 feet in length and at least the full width of the lane involved. If the limits of removal extend to within 6 feet of a transverse joint, the pavement shall be removed to that joint. The Contractor shall repair the area as directed by the Engineer, including installing dowel bars at each end of the repair.