REDUCING the ADVERSE EFFECTS of TRANSVERSE CRACKING

Construction Report
Project HR-217

DEPARTMENT OF TRANSPORTATION
IOWA

Highway Division
February 1981

Disclaimer

The contents of this report reflect the views of the author and do not necessarily reflect the official views of the Iowa Department of Transportation. This report does not constitute a standard, specification or regulation.

TABLE OF CONTENTS

CONSTRUCTION REPORT
FOR
PROJECT HR-217

REDUCING THE ADVERSE EFFECTS OF TRANSVERSE CRACKING

BY
VERNON J. MARKS
RESEARCH ENGINEER
515/296-1447

IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION
OFFICE OF MATERIALS
AMES, IOWA 50010

REDUCING THE ADVERSE EFFECT OF TRANSVERSE CRACKING

INTRODUCTION

Over the years, there have been a number of changes in asphalt paving. Lake asphalts were used prior to 1900 when asphalt from refined crude oil became available. There have also been changes in the design thickness. Most of the early asphalt concrete paving in the U.S. was two to four inches thick. It has, therefore, commonly been referred to as flexible pavement and rightly so. When these pavements were subjected to heavy loads during periods of unstable subgrade conditions, the structure was inadequate and the result was failure. The design has been changed to greater thickness or full depth asphalt concrete pavements to provide more structural capacity. These full depth designs are less flexible and present problems commonly encountered in rigid pavements.

PROBLEM

One of the most serious problems of asphalt pavements today is related to transverse cracking and subsequent crack deterioration. With the heavier vehicles, thicker sections and higher stabilities were needed to carry the loads without resulting in permanent distortion. These changes have produced a pavement that generally exhibits transverse cracks at a relatively uniform spacing on any individual project. The spacing is apparently dependent on many factors, but is quite related to pavement thickness.

The uniformly spaced transverse cracks do not initially present any objectionable conditions. Water movement through the cracks results in stripping of the asphalt cement. Further pumping or hydraulic pressure dislodges and expels aggregate and fine material from the crack. This action can result in a large void which given time will slough off and produce a dip. Even though the crack itself is not detrimental, subsequent deterioration results in an unacceptable riding quality and intense maintenance. This reduces the effective life of an otherwise structurally sound roadway.

OBJECTIVE

The objective of this research project is to identify a method of reducing the adverse effect of transverse cracking and improving the performance of asphalt pavement.

PROJECT LOCATION AND DESIGN

The research was incorporated into Jones County asphalt concrete paving project F-64-1(12)--20-53 on Iowa 64 from U.S. 151 (Anamosa) to the west junction of Iowa 38. This project was selected because it is typical of many Iowa primary roadways with three inches of asphalt surface over eight inches of asphalt treated base (ATB) (Appendix A).

CONTRACTOR AND CONTRACTUAL ARRANGEMENTS

The successful bidder for the project was Cessford Construction Company of LeGrand, Iowa. The research was added by extra work order. The sawing and sealing portion of the research was subcontracted to Concrete Specialists of Cedar Rapids.

RESEARCH OVERVIEW

The research involved three variations from the contractors planned operation. Briefly, they were:

1. Use of another asphalt cement.
2. Saw and seal transverse joints.
3. Increased asphalt cement content.

The research was placed between the stations noted:

1. Sugar Creek Asphalt Cement
   a. Stations 150+00 to 170+00
   b. Stations 210+00 to 230+00
2. Transverse Joints
   a. Stations 170+00 to 193+60
   b. Stations 230+00 to 253+20

   Each research section includes:

   1. 15 joints at a 40' spacing
   2. 10 joints at a 60' spacing
   3. 7 joints at an 80' spacing
   4. 6 joints at a 100' spacing
3. Increased Asphalt Cement Content
   a. Stations 190+00 to 210+00
   b. Stations 250+00 to 270+00

Use of Another Asphalt Cement

Substantial study of stiffness and temperature susceptibility of asphalt cements has been conducted by Norman W. McLeod.[1] The results of these studies provide a quantitative number for describing the temperature susceptibility of an asphalt cement. This aspect of the research was developed to determine if a correlation could be established between the temperature susceptibility as determined by the Pen-Vis Number (PVN) and the severity of transverse cracking.

Due to economic benefits, the contractor normally uses asphalt cements that are relatively temperature susceptible. Initial plans for the research were based on this assumption. An asphalt cement produced by Amoco Oil Company at the Wood River, Illinois refinery is partially blown and exhibits one of the lowest temperature susceptibilities of any asphalt cement commonly used in Iowa. Plans were to require a Wood River asphalt cement in both the base and surface courses for two 2000' sections.

Immediately following the preconstruction conference, information became available showing that due to current economic conditions, the asphalt cement in the contractors storage was predominately the low temperature susceptible Wood River asphalt cement. Research plans were changed to require an Amoco Oil Company Sugar Creek, Missouri highly temperature susceptible asphalt cement for two 2000' sections in the ATB, binder and surface.

Increased Asphalt Cement Content

The intent was to increase the asphalt cement content in the base, binder and surface by one percent. An additional mix design for the surface was made and the results were not favorable for increased asphalt content. Consequently, the asphalt cement content was increased 1% for the ATB with no increase for the binder and surface.

Saw and Seal Transverse Joints

Transverse joints were cut in the surface at spacings of 40, 60, 80, and 100 feet. The saw cut was a nominal 1/4" wide and a minimum of 3" deep. This research is similar to earlier Minnesota research[2] except for sealing. In this research, the joints were sealed with an upgraded rubber asphalt sealant meeting Iowa DOT Standard Specification 4136.02A.

MATERIALS

All asphalt cement for the asphalt treated base (ATB), binder and surface was an AC-10 grade. The asphalt cement was predominately Wood River for the majority of the project. The PVN for Wood River will average about -0.6 (Pen=100 Vis=1100). The high temperature susceptible asphalt cement was from Sugar Creek with a PVN of about -1.2 (Pen=75 Vis=900). The contractor used two storage tanks (figure 1) at the plant site. One tank was used only for Sugar Creek asphalt and the other only for the predominately Wood River asphalt. Delivery tankers were scheduled carefully to maintain an adequate asphalt supply.

Figure 1 - Cedar Rapids Batch Plant With Dual Storage for Two Sources of Asphalt Cement

The ATB was a 3/4" Class I produced from 65% crushed limestone and 35% sand, both from the B. L. Anderson Quarry at Anamosa. The intended asphalt content was 4.75% for all ATB except the two increased asphalt content sections placed at 5.75%. The typical aggregate gradations for the ATB are shown in Table I.

TABLE I
TYPICAL GRADATIONS
for
ATB and BINDER MIXES

Material	Crushed Limestone	Sand	ATB	Type B Binder	Type B Binder
Proportions			65% L.S. 35% Sand	60% L.S. 40% Sand	50% L.S. 50% Sand
Sieve Size					
3/4"	100		100	100	100
1/2"	84		90	90	92
3/8"	65	100	77	79	82
#4	36	97	57	60	66
#8	25	87	47	50	56
#16	19	73	38	41	46
#30	17	48	28	29	32
#50	16	15	16	16	16
#100	15	1.6	10	9.6	8.3
#200	10	0.5	6.7	6.2	5.2

Two different mix combinations were used for the 3/4" Type B Binder. Both mixes used crushed limestone and sand from the B. L. Anderson Anamosa Quarry. The strengthening and leveling binder mix used 60% crushed limestone and 40% sand with an intended asphalt content of 5.75%. The typical aggregate gradations for that mix are given in Table I.

A 50% crushed limestone and 50% sand mix with an asphalt content of 6.25% was used for the 1-1/2" thick Type B binder course. The typical Gradations for that mix are given in Table I.

The 1/2" Type A surface mix was produced using 65% crushed limestone from the B.L. Anderson Anamosa Quarry and 35% sand from the B.L. Anderson Ivanhoe Pit in Linn County. An asphalt content of 6.00% was used for the 1-1/2" thick lift. The typical gradations were:

	Percent Passing		
Sieve Size	Crushed Limestone	Sand	Type A
1/2"	100		100
3/8"	88	100	92
#4	52	98	68
#8	32	90	52
#16	24	75	42
#30	21	46	30
#50	18	13	16
#100	16	1.6	11
#200	9.0	0.5	6.0

The filler-bitumen ratio (material passing the #200 screen divided by the amount of asphalt) ranged from 1.08 to 1.44 for the Type A surface.

All prime and tack coat bitumen was diluted SS1 emulsified asphalt.

CONSTRUCTION

Most of the construction operation was standard practice. All asphaltic concrete mix was produced in a Cedar Rapids batch plant (figure 1) located at the B. L. Anderson Anamosa Quarry.

All asphalt layers were laid full width with a Barber Green laydown machine (figure 2). Initial compaction was made with a Buffalo Bomag vibratory steel roller. A Hyster rubber tired roller was used for final compaction.

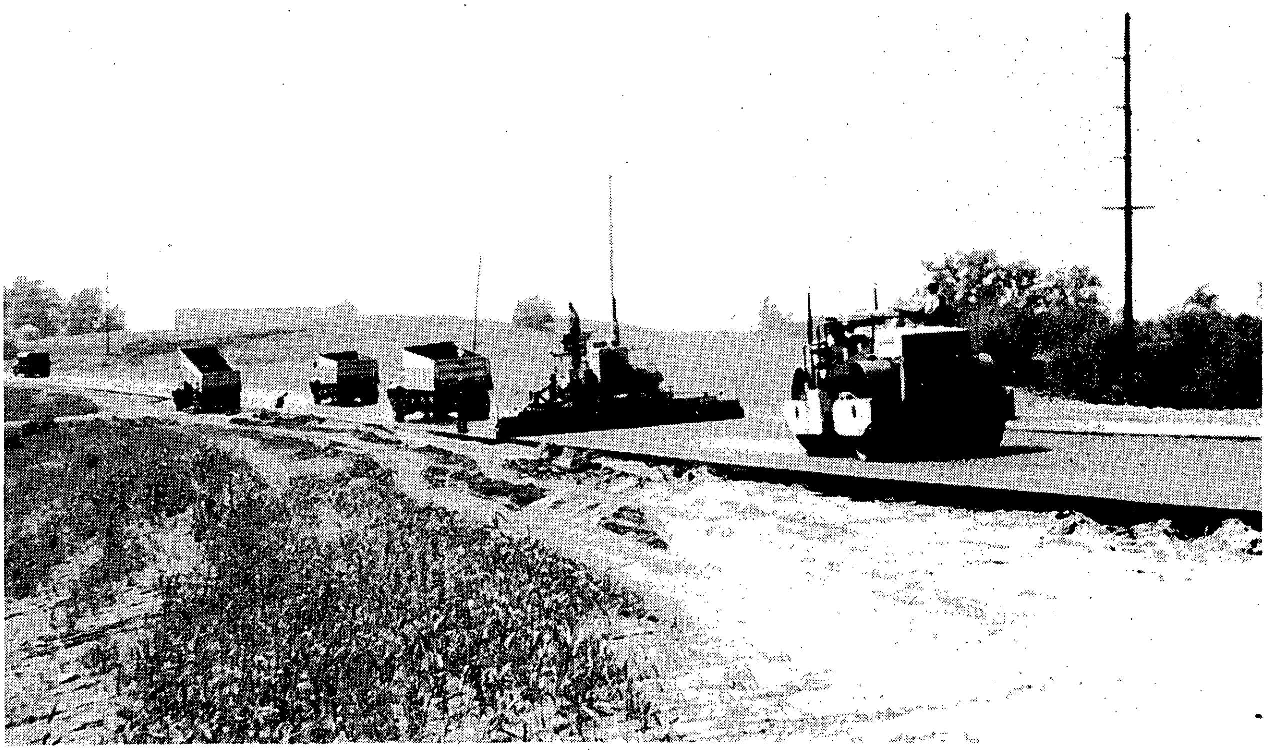


Figure 2 - Typical Laydown Operation

The subcontractor cut the transverse joints with a 1/4" carborundum blade without water (figure 3). Initially, there were substantial problems as the cutting residue would adhere tightly to the surfaces within and adjacent to the cut (figure 4). It appeared that this operation would not provide a satisfactorily clean saw cut for sealing. The subcontractor used compressed air cleaning immediately following the cutting operation and this removed the cutting material.

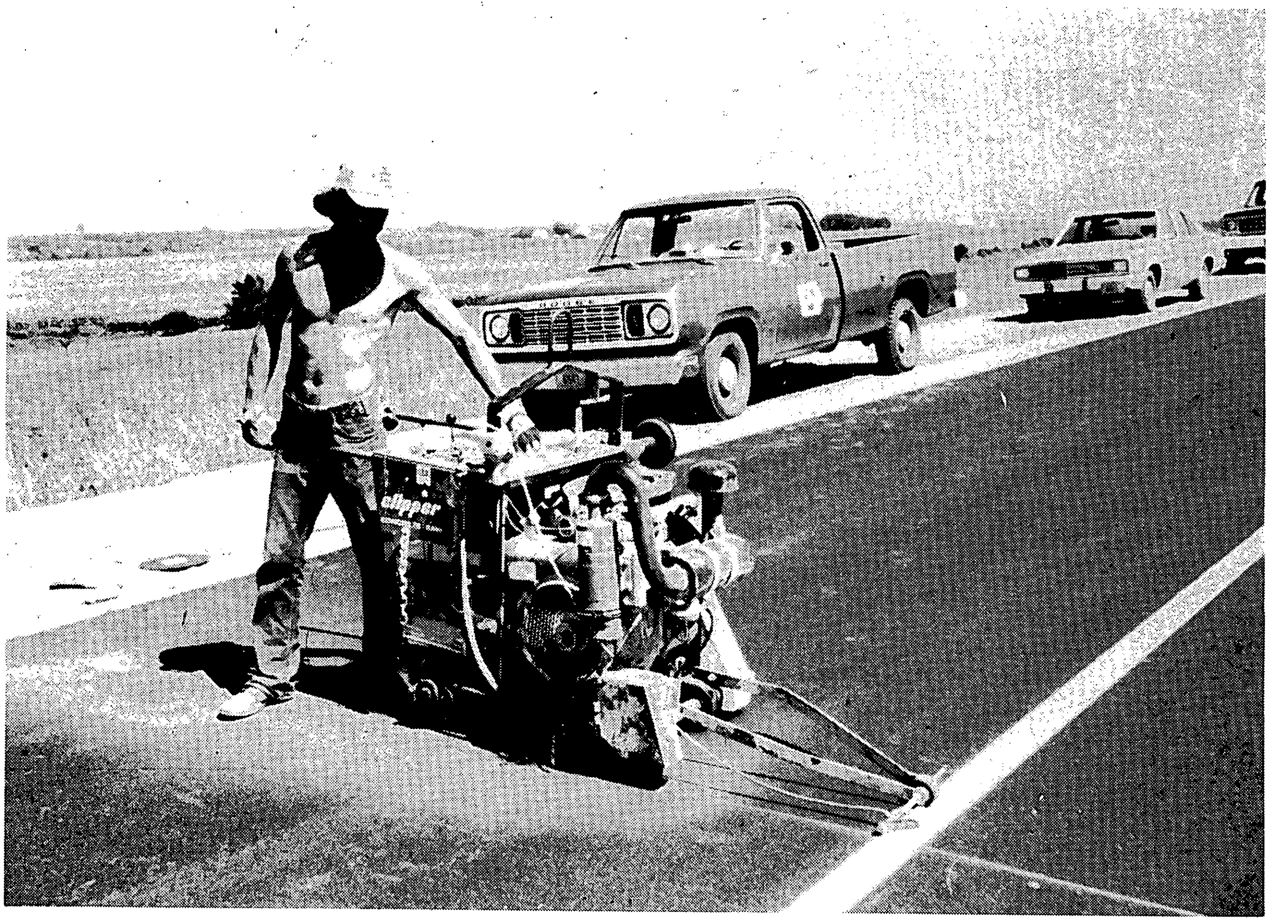


Figure 3 - Sawing of Transverse Joints

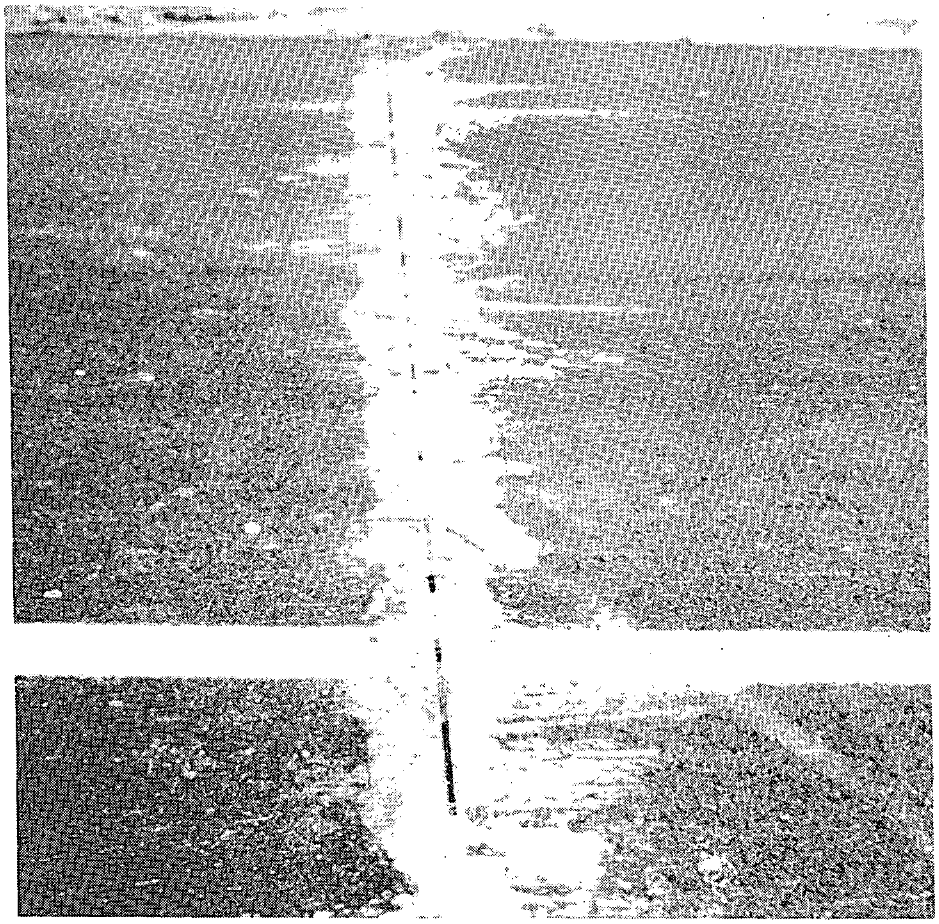


Figure 4 - Sawing Residue Adhering to Surface

An excess of sealant material was used leaving some along the joint (figure 5) and allowing traffic to carry some down the roadway (figure 6).

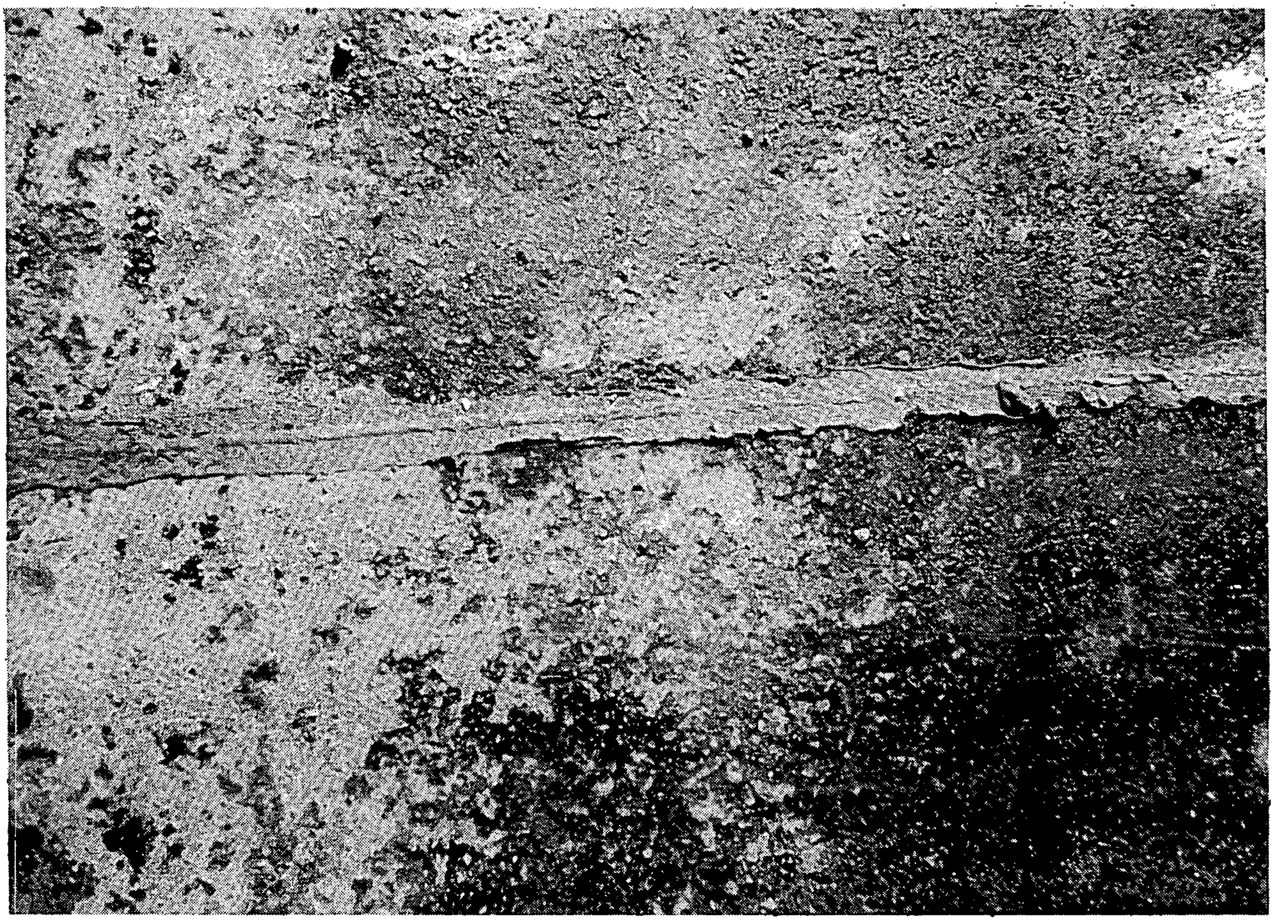


Figure 5 - Excess Sealant Material Along a Transverse Joint

Except for the changes required for the research sections, the construction problems were minimal. The general appearance of the asphalt paving in the research area is good.

Figure 6 - Sealant Material Tracked by Traffic

EVALUATION

Cores were drilled from each layer of the asphalt pavement. Density, percent of lab density and voids have been determined. For research evaluation purposes, eight sections have been established. A 2000 foot section of standard design and construction (control section) at both ends of the research will be included for comparison. A summary of that data is given in Table II.

TABLE II

CORE DENSITY SUMMARY

Section	Experimental Feature	Station from	Station to	Course	Density gr/cm^3	% of lab density	Voids %
1A	Sugar Creek A.C.	150+00	170+00	ATB 1st	2.24	95.2	11.3
				ATB 2nd	2.24	96.1	11.8
				Type B	2.19	94.2	11.2
				Type A	2.29	95.4	6.6
1B	Sugar Creek A.C.	210+00	230+00	ATB 1st	2.28	96.1	9.8
				ATB 2nd	2.22	95.0	--
				Type B	2.22	95.3	9.9
				Type A	2.32	96.7	5.4
2A	Transverse Joints	170+00	193+60	ATB 1st	2.27	96.1	10.7
				ATB 2nd	2.23	95.2	12.3
				Type B	2.25	97.0	8.9
				Type A	2.30	95.8	6.2
2B	Transverse Joints	230+00	253+20	ATB 1st	2.26	95.2	10.6
				ATB 2nd	2.30	96.8	8.3
				Type B	2.17	93.5	12.1
				Type A	2.31	95.8	6.2
3A	Increased A.C.	190+00	210+00	ATB 1st	2.30	95.8	6.6
				ATB 2nd	2.29	96.4	5.2
				Type B	2.22	95.7	10.1
				Type A	2.28	95.0	7.0
3B	Increased A.C.	250+00	270+00	ATB 1st	2.29	96.7	--
				ATB 2nd	2.25	96.7	8.2
				Type B	2.20	96.6	11.1
				Type A	2.31	95.8	6.2
4A	Control	130+00	150+00	ATB 1st	2.27	96.7	9.9
				ATB 2nd	2.24	96.0	11.9
				Type B	2.21	92.1	10.2
				Type A	2.28	95.0	7.0
4B	Control	270+00	290+00	ATB 1st	2.23	96.3	11.5
				ATB 2nd	2.17	93.9	--
				Type B	2.21	95.2	10.5
				Type A	2.30	95.4	6.6

Two cores were drilled through the asphalt pavement to inspect the quality of the cutting and sealing of the transverse joints (figure 7). The saw cut was the size specified and the sealant filled the entire saw cut. Further testing demonstrated that the sealant was bonded to both faces extremely well.

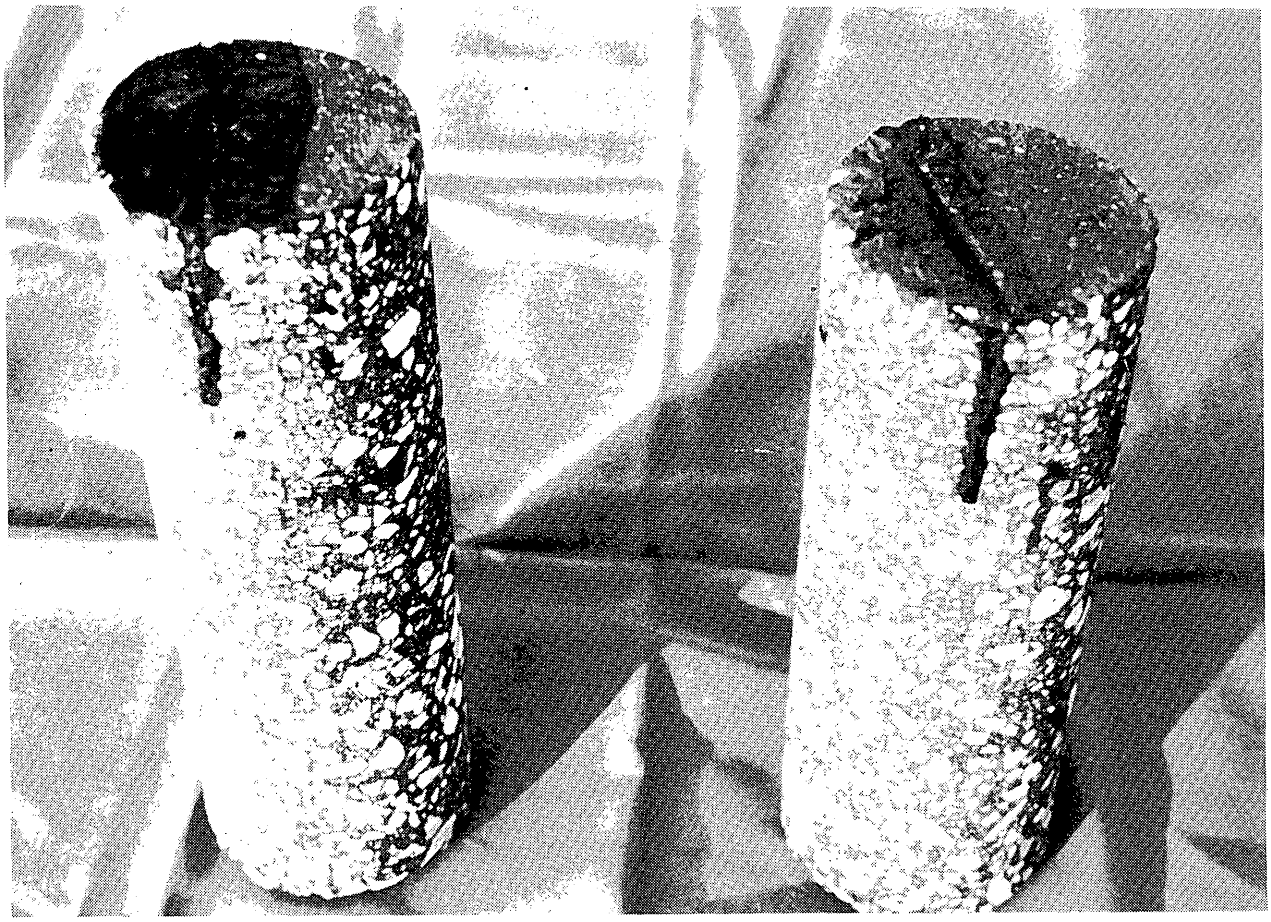


Figure 7 - Core Exhibiting Complete Filling of Saw Cut

A field review of the research portion of the project was conducted on January 22, 1981. The surface was dry and under those conditions, no cracks were noted from a visual observation.

ACKNOWLEDGEMENTS

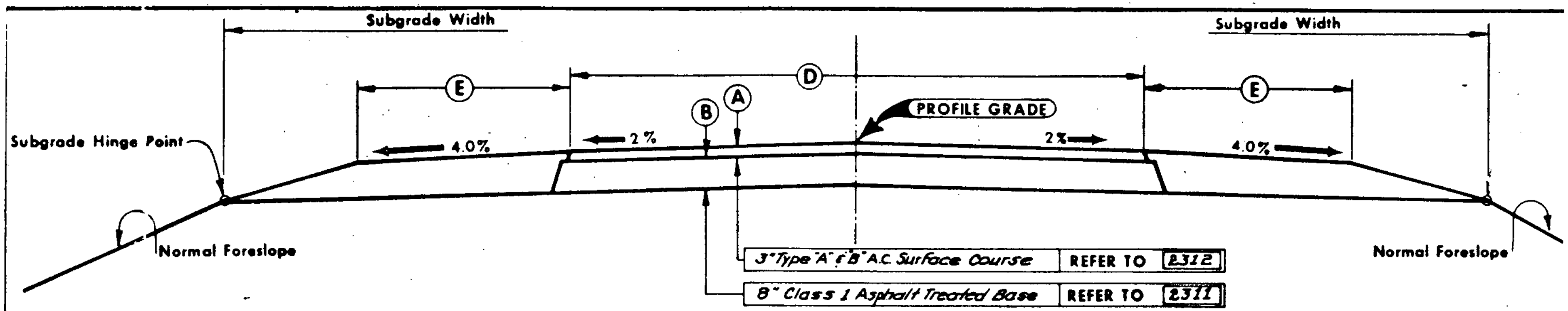
We appreciate the cooperation of Larry Parrot and the Cessford Construction Company personnel in constructing the special sections. Iowa DOT personnel William Crawford, Erv Shaffer, Raymond Ellis, and others of the Manchester Construction Residency along with Dick Merritt, Dennis Lohrer and the District VI Materials provided good inspection, monitoring, and documentation of the research.

Charles Huisman, Robert Shelquist, Don Jordison, and Lowell Zearley supported the research with their expertise.

REFERENCES

1. McLeod, N.W. "Asphalt Cement: Pen-Vis Number and It's Application to Moduli of Stiffness", ASTM Journal of Testing and Evaluation, Vol. 4, No. 4, July, 1976.

2. Morchinek, R.M., "Sawing Joints to Control Cracking in Flexible Pavement", Minnesota DOT Special Study No. 315, Progress Report - 1974.

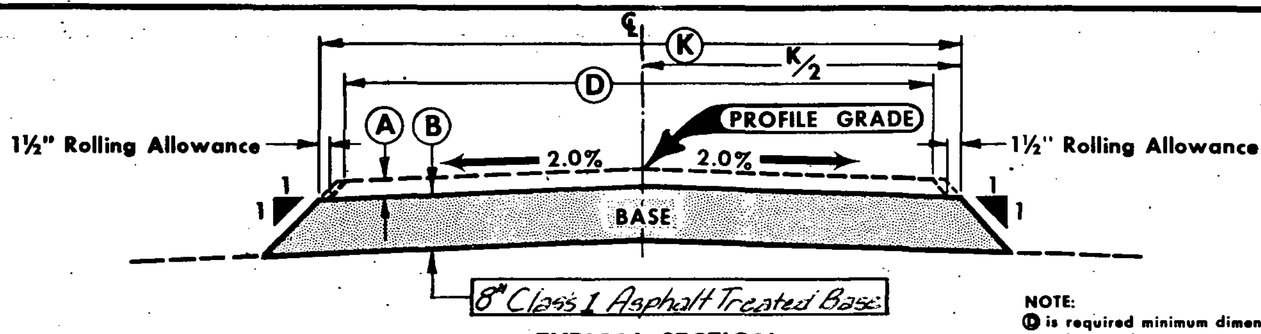


Dimensions indicated hereon are for design purposes. Variation from the normal section will be allowed only at locations specifically designated by the engineer.

TYPICAL CROSS SECTION
FOR PAVING OF
PROPOSED HIGHWAY IMPROVEMENT

LOCATION			DIMENSIONS			SHOULDER	
IDENT.	STATION TO STATION		A	B	D	E	TYPE
Ia. # 64	55+50.00	313+25.00 (OR)	3"	8"	24'	10'	Gran.
Ia. # 64	400+00.00 (OR)	422+00.00 (OR)	3"	8"	24'	10'	Gran.

2311
10-28-77



TYPICAL SECTION BASE

NOTE:
Ⓓ is required minimum dimension upon completion of construction operations and is used for determining quantities.

NOTE:
Where base is constructed on Soil-Lime or Soil-Cement subbase, initial prime is not required. Where base is constructed on Soil Aggregate subbase or on earth subgrade, initial prime is estimated at the rate of 0.20 gal. per sq. yd. but may be eliminated at the direction of the engineer. Article 1109.03 of current Spec's. shall not apply to this work.

NOTE:
For Ⓑ of 8" or less base is assumed to be placed in two lifts.

For Ⓑ of more than 8" base is assumed to be placed in three lifts.

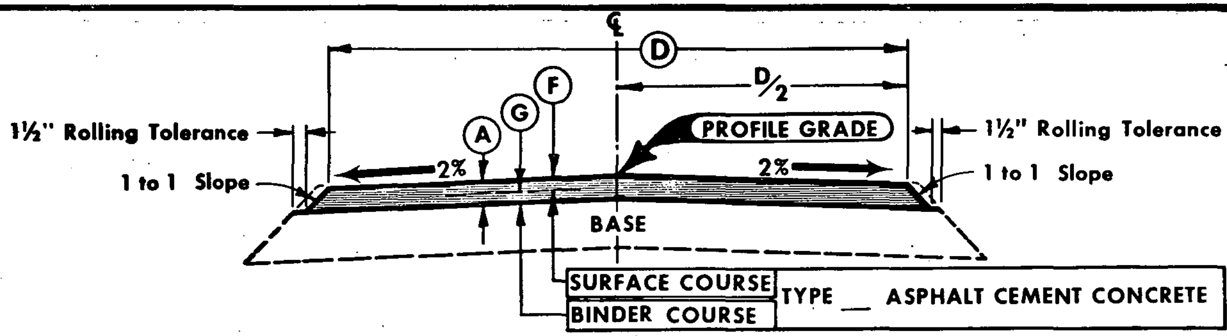
A tack coat of 0.05 per sq. yd. is estimated between lifts of base.

TABLE OF DESIGN QUANTITIES (Per Station)

DIMENSIONS				PRIME COAT Gal.	TACK COAT Gal.	ASPHALT CEMENT Tons	ASPHALT TREATED BASE Tons
K	D	A	B				
24.75'	24.0	3"	8"	62.41	14.12	5.34	118.67

Design Weight = 140 lbs. per cu. ft.

2312
10-28-77



TYPICAL SECTION SURFACE MAT

NOTE:
Ⓓ is required minimum dimension upon completion of construction operations and is used for determining quantities.

A tack coat of 0.05 gal. per sq. yd. preceding each lift of asphalt cement concrete may be required. This coat shall be applied only as directed by the engineer.

Indicated quantity is estimated on the basis of one tack coat preceding each lift.

TABLE OF DESIGN QUANTITIES

DIMENSIONS				PRIME AND TACK COAT Gal.	ASPHALT CEMENT Tons	ASPHALT CEMENT CONCRETE Tons	
A	G	F	D			SURFACE ①	BINDER ②
3"	—	—	24.0'	27.22	—	—	—
—	1.5"	—	24.0'	—	1.17	—	21.33
—	—	1.5"	24.0'	—	1.21	21.11	—

① To be placed in one lift.
② To be placed in two lifts.

Design Weight = 140 lbs. per cu. ft.

Quantities indicated hereon are for design purposes. Variation from the normal section will be allowed only when so specified by the engineer.