REDUCING the ADVERSE EFFECTS of TRANSVERSE CRACKING

Final Report
Project HR-217

Highway Division
May 1984

Iowa Department of Transportation

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FINAL REPORT

FOR

PROJECT HR-217

REDUCING THE ADVERSE EFFECTS OF TRANSVERSE CRACKING

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ABSTRACT

One of the most serious problems of asphalt pavement today is transverse cracking and subsequent crack deterioration which reduces the effective life of an otherwise structurally sound roadway. Iowa Department of Transportation personnel have been reviewing the frequency of transverse cracking on various asphalt concrete paving projects in recent years. These reviews indicated that the frequency of transverse cracking may be related to the temperature susceptibility of asphalt cement (AC). Dr. Norman W. McLeod has conducted substantial study of stiffness and temperature susceptibility of asphalt cements. Based on this research, Dr. McLeod has established a Pen-Vis Number which is a numeric rating of the temperature susceptibility of asphalt cements.

This research was initiated to identify methods either to reduce the occurrence of transverse cracking or methods to prevent the deterioration of joints sawed to replace the random transverse cracking.

This research was incorporated into a Jones County asphalt concrete paving project on Iowa 64 from U.S. 151 to the west junction of Iowa 38. Eight (four repetitive) research sections were established to study three variations in the asphalt concrete pavement. The first variation was the comparison of a low and high temperature susceptible AC from two different sources. The second variable was to saw and seal transverse joints at spacings varying from 40 to 100 feet. The third variable was to increase the AC content in the asphalt treated base by one percent. The research sections were constructed with relatively few problems. The general appearance of the asphalt paving in the research area immediately after construction in August, 1980 was good.

Crack and joint surveys have been conducted on all research sections at less than one year intervals since construction. No cracking was identified in any of the research sections after the first winter season. The sawed joints also remained sealed through the first winter. During the second winter season at an age of approximately 1 1/2 years, there was substantial cracking of the high temperature susceptible AC sections and substantial failure of the sealant material in the sawed joints. Evaluation was continued for almost four years after construction. The asphalt pavement constructed with the high temperature susceptible AC produced a crack interval of 35 feet, while the standard construction with the low temperature susceptible AC yielded a crack interval of 170 feet. The low temperature susceptible AC with an increased AC content in the asphalt treated base (ATB) yielded a crack interval of 528 feet.

The Pen-Vis Number is an effective measure of temperature susceptibility of asphalt cements. The frequency of tranverse cracking is affected by the temperature susceptibility of the AC. An increased AC content in the ATB also reduces the frequency 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 AC from refined crude oil became available. The introduction and acceptance of AC from crude oil increased the supply, but also presented many more variables in the characteristics of AC. There were substantial variations in the raw product from "heavy" to "light" crude oils. This variation in crude oils necessitated differences in the refinery process, which coupled with preferential differences, yielded a wide variation in AC.

Much 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 greater stability were needed to carry the loads without 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 AC. 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 was to identify a method of reducing the adverse effect of transverse cracking and to improve the performance of asphalt pavement. This objective can be achieved either by reducing the occurrence of the transverse cracking or preventing deterioration of joints sawed to take the place of random cracking.

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 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 contractor's 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 (Figure 1):

1. Sugar Creek Asphalt Cement

    a. Stations 150+00 to 169+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:

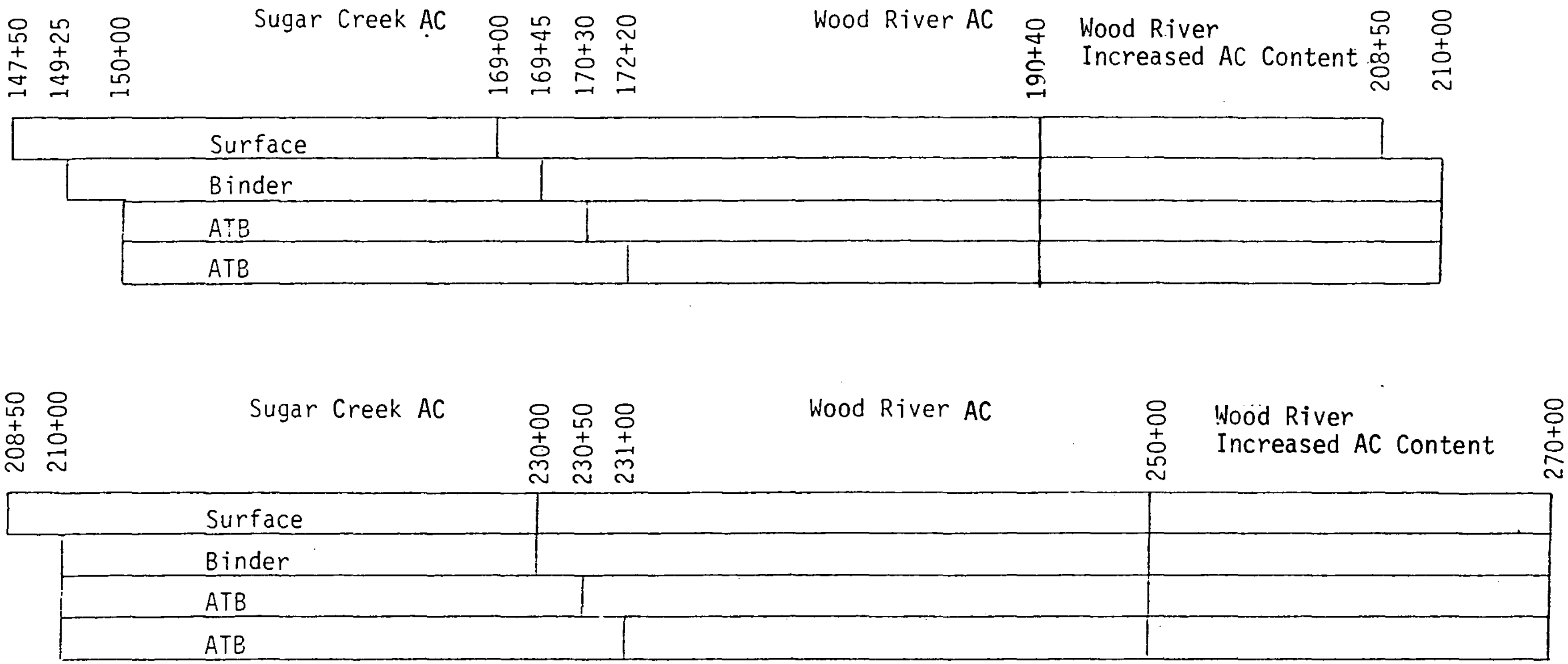
    1. 15 joints at a 40' spacing
    2. 10 joints at a 60' spacing
    3. 7 joints at an 80' spacing
    4. 6 joints at a 100' spacing

3. Increased Asphalt Cement Content

    a. Stations 193+60 to 208+50
    b. Stations 253+20 to 270+00

Figure 1

SCHEMATIC LAYOUT OF ASPHALT CEMENT SOURCES



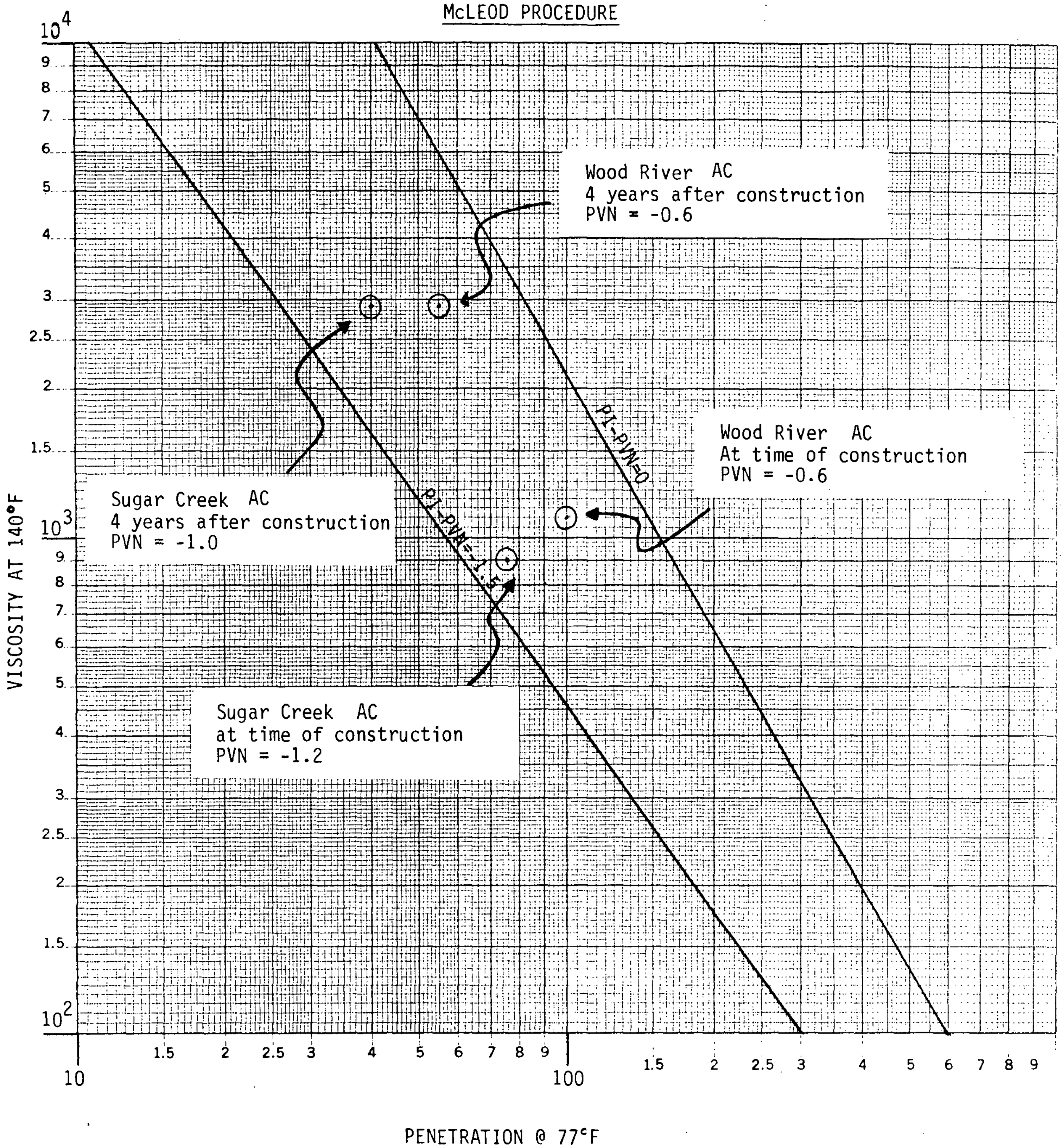
Use of Another Asphalt Cement

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 AC. This aspect of the research was developed to determine if a relationship could be identified between the temperature susceptibility as determined by the Pen-Vis Number (PVN) at penetration (77° F) and viscosity (140° F) and the frequency of transverse cracking. Dr. McLeod established the PVN = 0 to represent an excellent AC with low temperature susceptibility and PVN = -1.5 to represent an AC with very high temperature susceptibility (Figure 2). Iowa DOT personnel have been determining the PVN of all asphalt cements used in Iowa in recent years by the McLeod graph. Even though it is accepted that there are probably many factors that affect the frequency of transverse cracking, a trend seemed to indicate that transverse cracking did relate to the PVN. Research was needed where all other factors were held constant.

The contractor had normally used a relatively high temperature susceptible AC meeting Iowa DOT specifications. Initial plans for the research were based on this assumption. An AC produced by Amoco Oil Company at the Wood River, Illinois, refinery was partially blown and exhibited one of the lowest temperature susceptibilities of any asphalt cement commonly used in Iowa. Plans were to require a Wood River AC in both the base and surface courses for two 2000' sections.

Figure 2

CHART FOR CALCULATING
MODIFIED PENETRATION INDEX
FROM PENETRATION @ 77°F & VISCOSITY @ 140°F
McLEOD PROCEDURE



Immediately following the preconstruction conference, information became available showing that due to current economic conditions, the AC in the contractor's storage was predominately the low temperature susceptible Wood River bitumen. Research plans were changed to require an AC from Amoco Oil Company of Sugar Creek, Missouri, (a high temperature susceptible AC) 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 by one percent with some increase in the binder and surface. An additional mix design for the surface was made and the results were not favorable for increased AC content. Consequently, the AC content was increased 1% for the ATB with no increase for the binder or 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

Prior to 1975, Iowa DOT specifications had required 85-100 penetration grade AC for surface courses on high traffic volume roadways. In 1975 the Iowa DOT changed to a viscosity grading specification requiring AC-10 for high traffic volume surface courses. All AC for the ATB, binder and surface on this project was an AC-10 grade. The AC was predominately Wood River for the majority of the project. The PVN (Figure 2) for Wood River averaged -0.6 (Pen=100 Vis=1100). The high temperature susceptible AC was from Sugar Creek with a PVN of -1.2 (Pen=75 Vis=900). The contractor used two storage tanks (Figure 3) at the plant site. One tank was used for Sugar Creek AC only and the other only for the predominately Wood River AC. Delivery tankers were scheduled carefully to maintain an adequate AC supply.

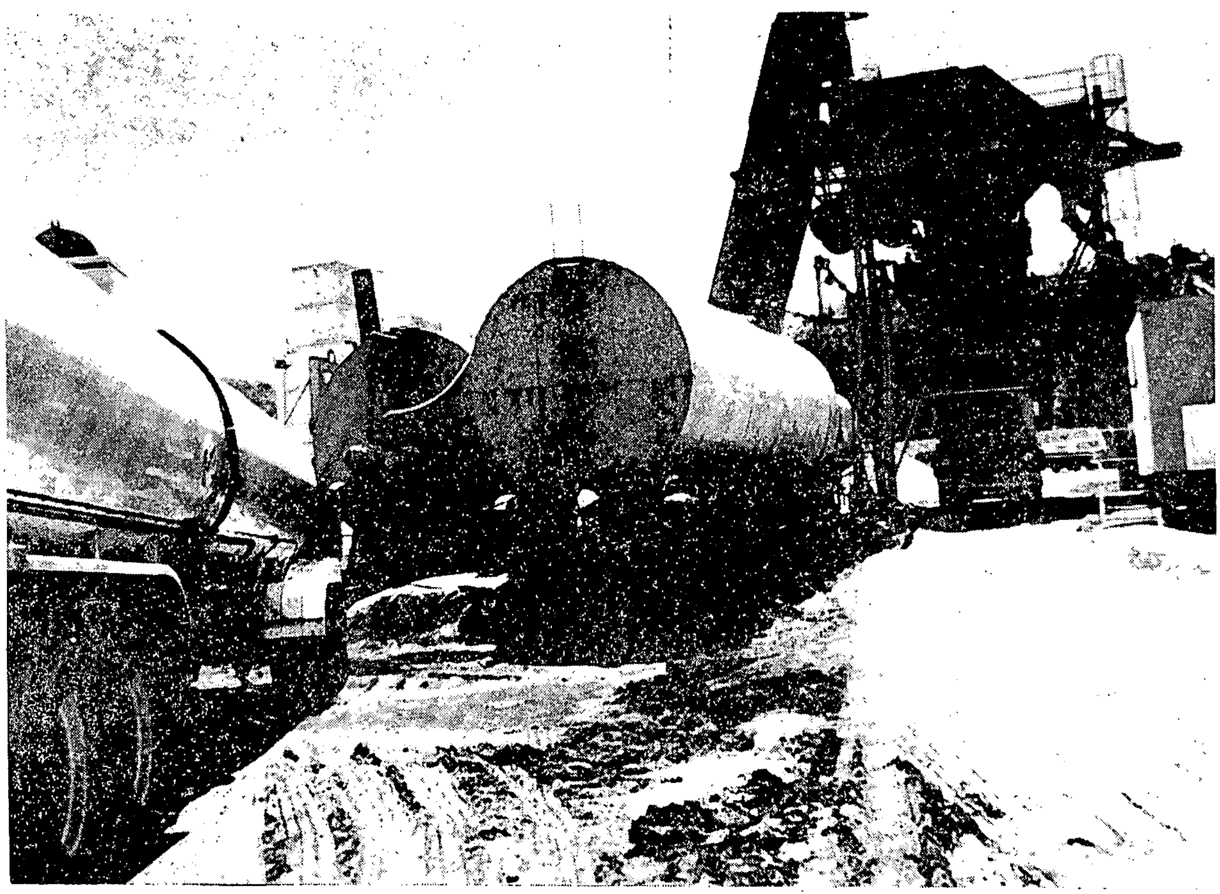


Figure 3 - Cedar Rapids Batch Plant With Dual Storage For Two Sources of Asphalt Cement

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 AC was 4.75% for all ATB except the two increased AC 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	98	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 were produced from crushed limestone and sand from the B. L. Anderson Anamosa Quarry. The strengthening and leveling binder mix was 60% crushed limestone and 40% sand with an intended AC 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 AC 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 AC content of 6.00% was used for the 1-1/2" thick lift. The typical gradations are given in Table II.

TABLE II, TYPICAL GRADATIONS FOR TYPE A SURFACE MIX

	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 AC) ranged from 1.08 to 1.44 for the Type A surface.

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

CONSTRUCTION

Construction of the ATB began on June 16, 1980. The final lift of the asphalt concrete surface was laid on August 22, 1980. Most of the construction operation was standard practice. All asphaltic concrete mix was produced in a Cedar Rapids batch plant (Figure 3) located at the B. L. Anderson Anamosa Quarry.

All asphalt layers were laid full width with a Cedar Rapids laydown machine (Figure 4). A Dynapac CC 50A was used for breakdown compaction followed by final compaction with an 8-10 ton static steel Bomag roller.

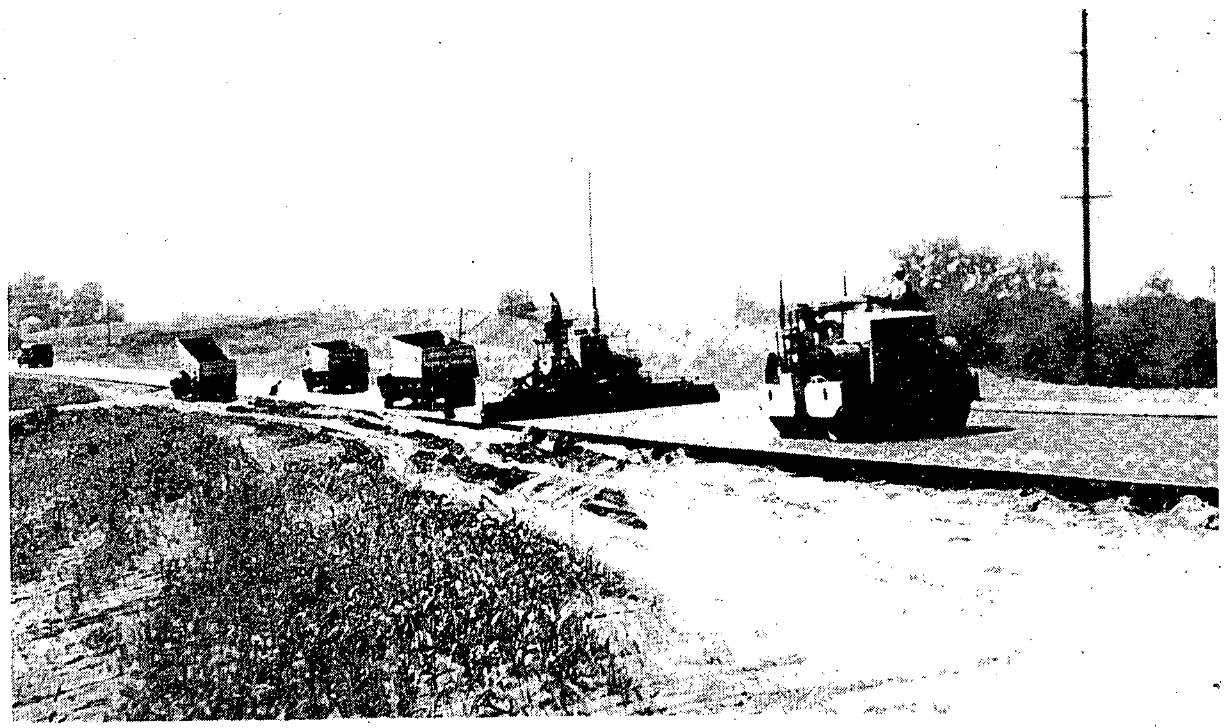


Figure 4 - Typical Laydown Operation

The subcontractor cut the transverse joints with a 1/4" carborundum blade without water (Figure 5). Initially, there were substantial problems as the cutting residue would adhere tightly to the surfaces within and adjacent to the cut (Figure 6). It appeared that this operation would not provide a satisfactorily clean saw cut for sealing. The subcontractor added compressed air cleaning immediately following the cutting operation and this removed the cutting material.

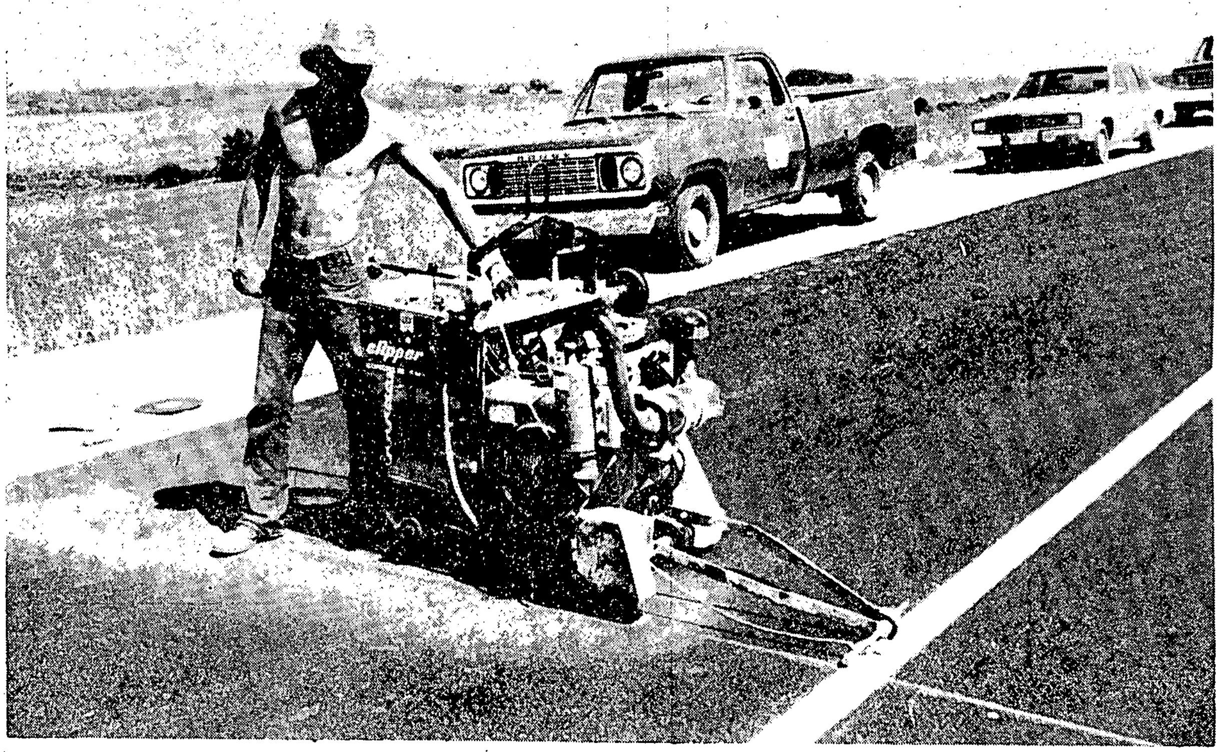


Figure 5 - Sawing of Transverse Joints.

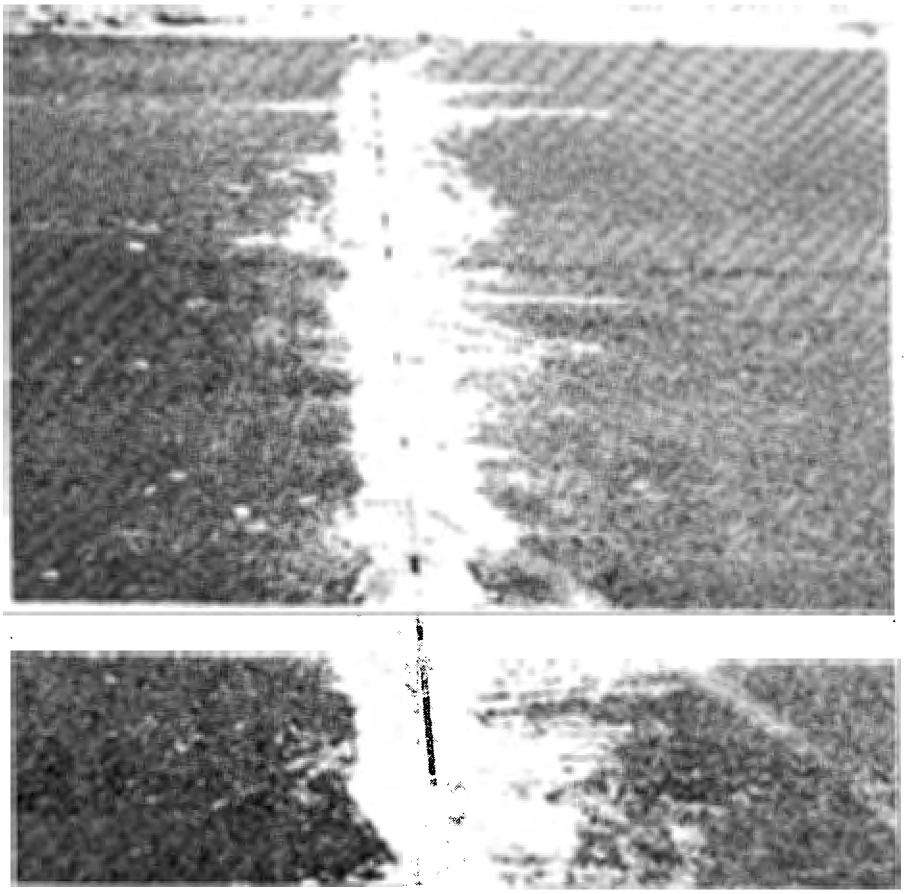


Figure 6 - Sawing Residue Adhering to Surface

An excess of sealant material was used leaving some along the joint (Figure 7) and allowing traffic to carry some down the roadway (Figure 8).

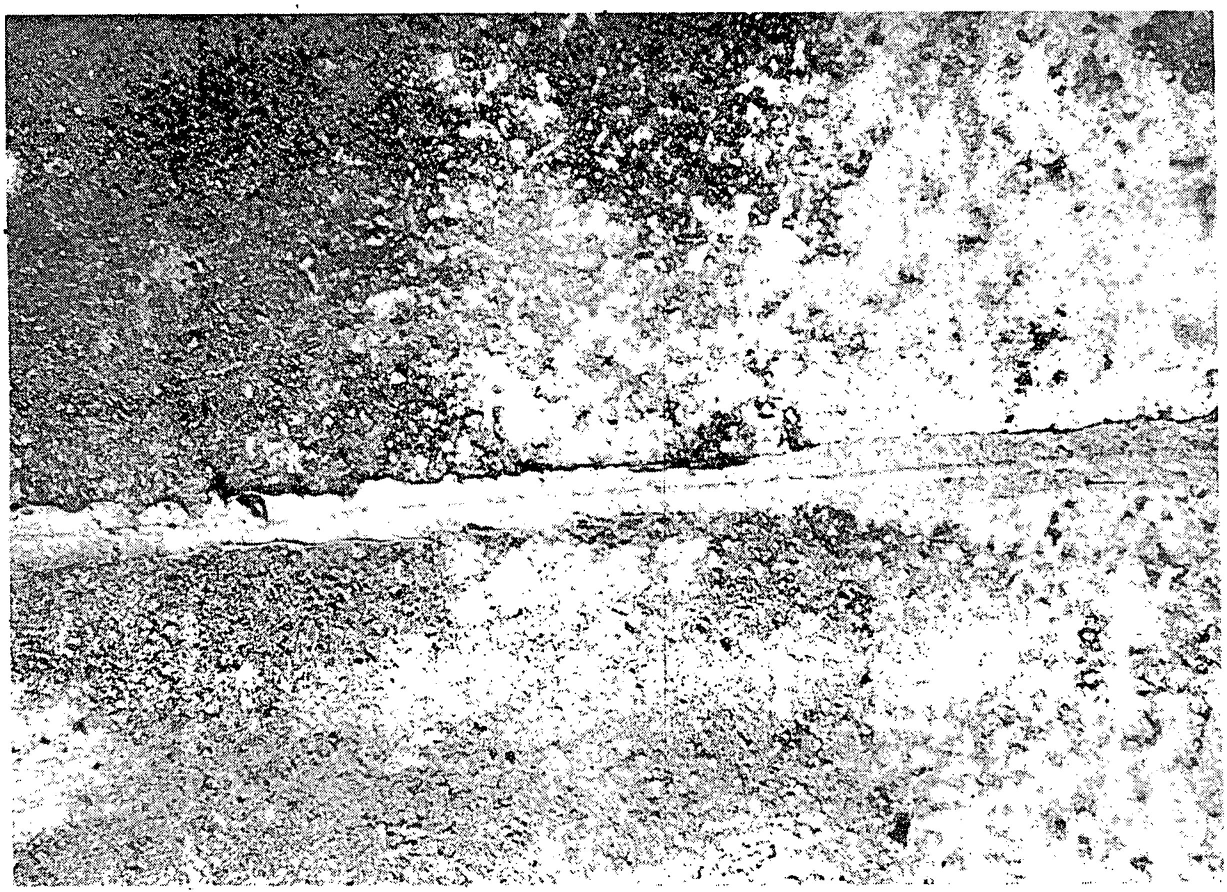


Figure 7 - Excess Sealant Material Along a Transverse Joint

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 was good.

Figure 8 - Sealant Material Tracked by Traffic

EVALUATION

Post Construction Testing

Cores were drilled from each layer of the asphalt pavement soon after construction. Density, percent of lab density and voids were determined. For research evaluation purposes, eight (four repetitive) sections were established. 2000-foot sections of standard design and construction (control section) at both ends of the research were included for comparison. A summary of the core data is given in Table III.

Two cores were drilled through the asphalt pavement to inspect the quality of the cutting and sealing of the transverse joints (Figure 9). 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.

TABLE III

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	169+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.	193+60	208+50	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.	253+20	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	147+40	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

Figure 9 - Core Exhibiting Complete Filling of Saw Cut

Periodic Field Reviews

Construction of the asphalt concrete surface was completed in August 1980. No distress was identified in any of the research sections during the late fall and early winter of 1980. Temperatures in Iowa during the 1980-81 winter season were relatively mild.

Transverse Joints

All transverse joints appeared to be well sealed during a field review on January 22, 1981. They continued to provide a tight seal through October of 1981.

Iowa experienced an extended period of severely cold temperatures during the winter of 1981-82. A visual review of the joints on March 1, 1982, revealed substantial failure of the sealant material. There are a total of 77 joints and only 14 (18.2%) remained sealed. There were 22 (28.6%) with partial failure and 41 (53.2%) that were essentially unsealed. The bond between the sealant and the face of the saw cut failed due to the thermal contraction stress from the severe temperatures.

A survey on November 17, 1982, revealed failure of all 39 of the joints between Stations 170+00 and 193+60. The joints between Station 230+00 and 253+20 were in slightly better condition. At the time of the survey, essentially all of the joints at 80' and 100' spacings (14 joints) had failed. Five of the ten joints at 60' had failed. Six of the fourteen joints at 40' had failed. Considering all 77 joints, 64 (83%) had failed and those at a shorter spacing were performing slightly better than the longer interval.

This difference between sections may relate to the cutting and cleaning procedure used by the subcontractor during construction. The cutting residue was more effectively expelled from the joints between 230+00 and 253+20 than those between 170+00 and 193+60.

The last survey of January 25, 1984, during another severely cold winter period, showed that essentially all joints had failed. Some of the joints that had been sawed 1/4" wide had thermal movement, leaving openings up to one inch.

There are no transverse cracks between any of the sawed transverse joints. The joints will be resealed during 1984 in an effort to prevent deterioration of the joint.

Asphalt Source and Content

Crack surveys have been conducted on all research sections at less than one-year intervals since construction (Table IV). No cracking was identified in any of the sections on January 22, 1981, after most of one relatively mild winter. An October 16, 1981, crack survey still did not identify any cracking.

The severely cold 1981-82 winter period did cause substantial cracking in both sections constructed with Sugar Creek AC. In March 1982, there were a total of 110 transverse cracks in 3900 lineal feet or an average crack interval of 35 feet. One crack occurred in the standard Wood River AC section. There were no cracks in the Wood River AC section with increased AC content in the ATB.

TABLE IV

SUMMARY OF TRANSVERSE CRACKING

Research Section	Beginning Milepost	Stations from	Stations to	Number of Cracks 1-22-81	10-16-81	3-1-82	11-17-82	6-2-83	1-25-84
Standard Wood River AC	2.1	130+00	147+40	0	0	1	1	1	4
	4.7	270+00	290+00	0	0	1	1	1	18
Wood River Increased AC in the ATB	3.3	193+60	208+50	0	0	0	0	0	1
	4.4	253+20	270+00	0	0	0	0	0	5
Sugar Creek AC	2.5	150+00	169+00	0	0	41	41	41	41
	3.6	210+00	230+00	0	0	69	69	69	69

Visual crack surveys were made on November 17, 1982, and June 2, 1983, with no additional cracking from that noted in March 1982. The winter of 1983-84 had an extended period of severely cold weather (-20^{o}F) and produced additional transverse cracking. The standard Wood River AC section had a total of 22 cracks in 3740 feet. There were six cracks in the 3170-foot section of Wood River at an increased AC content for the ATB. No additional cracking was identified in the Sugar Creek AC section. The crack intervals for the three research variables 3-1/2 years after construction are:

Variable	Crack Interval, Feet
Sugar Creek AC	35
Standard Wood River AC	170
Wood River Increased AC Content	528

Analysis of Extracted Asphalt Cement

Cores were drilled from all research sections with asphalt mix variables on April 5, 1984, almost four years after construction. The penetration (77°F) and viscosity (140°F) were determined for asphalt cement extracted from various layers (Table V). The average values were:

Sugar Creek - Binder and Surface

Penetration	40
Viscosity	2924
PVN	-1.04

Wood River - Binder and Surface

Penetration	55
Viscosity	2918
PVN	-0.61

Wood River Increased AC Content - ATB

Penetration	73
Viscosity	1983
PVN	-0.55

TABLE V
SUMMARY OF TESTS FROM ASPHALT CEMENT EXTRACTED
FROM CORES DRILLED APRIL 5, 1984

Core Number	Station	Research Section	Course	Penetration	Viscosity	PVN
3	155	Sugar Creek AC	Surface	31	3720	-1.10
			Binder	36	3320	-1.00
4	160		Surface	52	1830	-1.06
			Binder	41	2480	-1.08
7	215		Surface	35	3560	-1.00
			Binder	45	2190	-1.08
8	225		Surface	32	4210	-0.96
			Binder	49	2080	-1.02
		Sugar Creek Averages		40	2924	-1.04
5	200	Increased AC (Wood River)	ATB	74	1990	-0.52
6	205		ATB	66	2440	-0.48
9	260		ATB	72	1880	-0.58
10	265		ATB	79	1620	-0.60
		Increased AC Averages (Wood River)		73	1983	-0.55
1	135	Control (Wood River)	Surface	45	3450	-0.68
			Binder	51	3910	-0.45
2	140		Surface	63	2090	-0.68
			Binder	65	2290	-0.56
11	275		Surface	52	3290	-0.56
			Binder	47	3460	-0.65
12	280		Surface	65	2100	-0.63
			Binder	53	2750	-0.66
		Control Averages (Wood River)		55	2918	-0.61

DISCUSSION OF RESULTS

There is no cracking between any of the transverse joints, with the longest spacing being 100 feet. This is not unexpected as the average crack interval of the comparitive Wood River section is 170 feet at an age of 3-1/2 years. At the present, there are no detrimental aspects of the joints. There is a potential problem in that they are essentially unsealed. Neither the joints nor cracks on this project have incurred any noticeable depressions to date. The sealant failure may have been affected by the subcontractor's difficulty in removal of the cutting residue from the dry sawing operation. Cores soon after construction indicated a tight bond but the sealant was beginning to fail rapidly in less than 1-1/2 years. The section between 170+00 and 193+60 where dry cutting was initiated without immediate compressed air cleaning failed more rapidly than the 230+00 to 253+20 section with improved cleaning. This would indicate that the cutting residue affected the bond between the sealant and the asphalt concrete. If this research were repeated, wet cutting should be required. An improved high modulus sealant should be used. The joints will be resealed in an effort to prevent surface water infiltration.

This research documented the effect of some asphalt cements on the frequency of transverse cracking. The only difference between the Sugar Creek and Wood River sections was the AC source. The Sugar Creek sections exhibited severe transverse cracking at an average interval of 35 feet in less than two years while the Wood River section exhibited only one crack in 3740 feet. In 3-1/2 years the average crack interval for the Wood River section was 170 feet compared to the 35 feet for the Sugar Creek which had remained constant.

The average viscosities of the Sugar Creek and Wood River asphalt cements after almost four years are nearly the same with 2924 and 2918 respectively. Viscosity alone is, therefore, not a good measure of the potential of an AC to yield transverse cracking.

From this research both the penetration and the PVN of the extracted AC relate well to the frequency of transverse cracking. The penetration continues to decrease due to oxidation. In almost four years the penetration of Sugar Creek had decreased from 75 to 40 and Wood River from 100 to 55. The PVN, on the other hand, remains relatively constant as documented by Iowa DOT experience in recent years. The Sugar Creek PVN at construction was -1.2 (based on a very limited number of penetration tests) and -1.0 four years later (Figure 2). The PVN for Wood River was -0.6 both at time of construction and after four years. For this reason, it would appear that the PVN is a more desirable measure of the potential for transverse cracking.

An increased AC content in the ATB has reduced and/or retarded the incidence of transverse cracking. The average crack interval of the standard project construction with Wood River asphalt was 170 feet. An average crack interval of 528 feet was obtained with everything but the AC content remaining constant. The increased AC content resulted in a reduced ATB void content (Table III) from an average of 11.1% for the control to 6.7% for the increased AC section. This may be a very important factor in the improved performance.

CONCLUSIONS

This research on transverse cracking and the temperature susceptibility of asphalt cement supports the following conclusions:

1. An improved sealant or sealing procedure is needed if transverse joints are to be used in asphalt pavements.
2. The PVN is an effective measure of the temperature susceptibility of asphalt cements.
3. The use of a high temperature susceptible asphalt cement produced severe transverse cracking.
4. The use of asphalt cements with low temperature susceptibility will reduce the frequency of transverse cracking.
5. An increased asphalt cement content in the ATB will reduce the frequency of transverse cracking.

RECOMMENDATIONS

Earlier Iowa DOT specifications for asphalt cement did not ensure the best possible pavement. A recommendation for an improved specification was made on the basis of this research. A change from AASHTO M226 Table 1 requirements to Table 2 requirements has been adopted for 1984 projects (Appendix B).

Present Iowa DOT design of ATB is based on a particular AC content. Specifications and design procedures should be changed to allow a greater AC content and a limit on the void content. This would yield improved performance and extended life of full depth asphalt pavements.

ACKNOWLEDGMENTS

Research project HR-217 was sponsored by the Iowa Highway Research Board and the Iowa Department of Transportation. The funding authorized from the Primary Road Research Fund was $43,000. The excellent cooperation of Larry Parrott and the Cessford Construction Company personnel in constructing the special sections was appreciated.

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 6 Materials personnel provided good inspection, monitoring, and documentation of the research. Charles Huisman, Robert Shelquist, Lowell Zearley (Office of Materials) and Don Jordison (Office of Construction) supported the research with their expertise.

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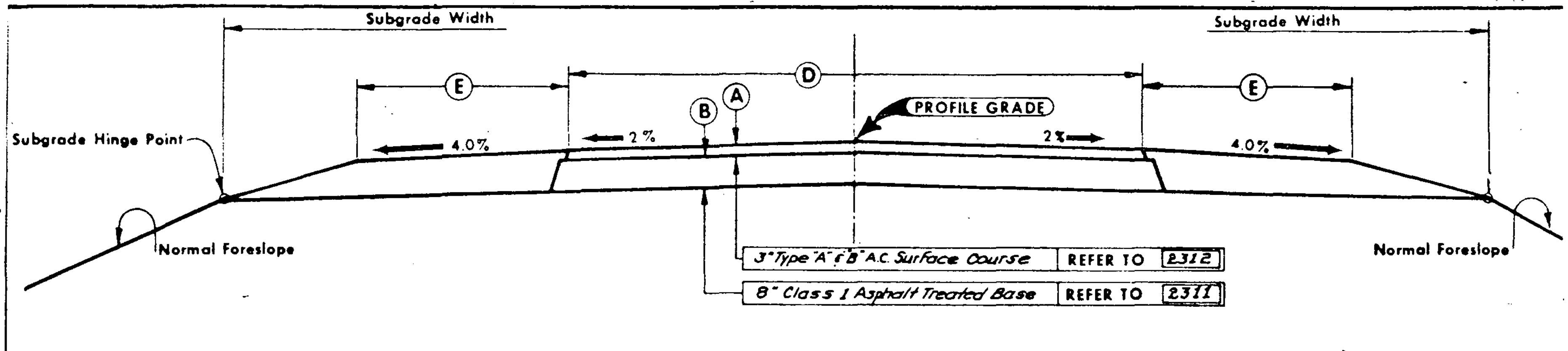

Dimensions indicated hereon are for design purposes. Variation from the normal section will be allowed only at locations specifically designated by the engineer

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
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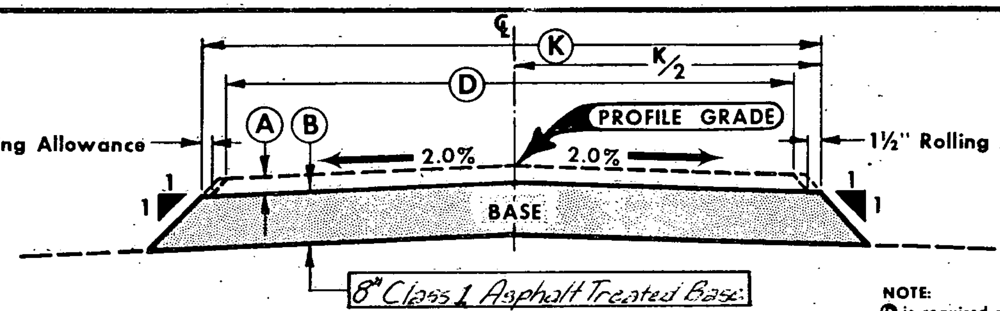

TYPICAL SECTION
BASE

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

Design Weight = 140 lbs. per cu. ft.

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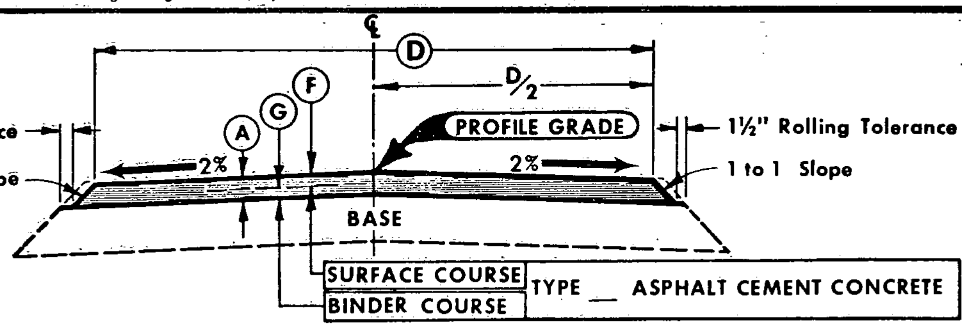

TYPICAL SECTION
SURFACE MAT

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	ASPHALT CEMENT	ASPHALT CEMENT CONCRETE Tons	
A	G	F	D	Gal.	Tons	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.

Standard Specification for

Viscosity Graded Asphalt Cement

AASHTO DESIGNATION: M 226-80

1. **SCOPE.**

1.1 This specification covers asphalt cements graded by viscosity at 60 C (140 F) for use in pavement construction. Three sets of limits are offered in this specification. The purchaser shall specify the applicable table of limits. In the event the purchaser does not specify limits, Table 1 shall apply. For asphalt cements graded by penetration at 25 C (77 F), see AASHTO M 20 for Asphalt Cement.

2. **MANUFACTURE**

2.1 The asphalt cement shall be prepared from crude petroleum by suitable methods.

3. **REQUIREMENTS**

3.1 The asphalt cement shall be homogeneous, free from water, and shall not foam when heated to 175 C (347 F).

3.2 The asphalt cements shall conform to the requirements given in Tables 1, 2 or 3, as specified by the purchaser.

4. **METHODS OF SAMPLING AND TESTING**

4.1 Sampling and testing of asphalt cements shall be in accordance with the following standard methods of the American Association of State Highway and Transportation Officials.

Sampling	T 40
Viscosity at 60 C (140F)	T 202
Viscosity at 135C (275F)	T 201
Penetration	T 49
Flash Point (COC)	T 48
Solubility in trichloroethylene	T 44
Thin-film oven test	T 179
Ductility	T 51
Spot test	T 102
Rolling thin film oven test	T 240
Water	T 55

TABLE 1
Requirements for Asphalt Cement Graded by Viscosity at 60 C (140 F)
(Grading based on original asphalt)

TEST	VISCOSITY GRADE				
	AC-2.5	AC-5	AC-10	AC-20	AC-40
Viscosity, 60 C (140 F), poises	250 ± 50	500 ± 100	1000 ± 200	2000 ± 400	4000 ± 800
Viscosity, 135 C (275 F), Cs-minimum	80	110	150	210	300
Penetration, 25 C (77 F), 100 g., 5 sec.-minimum	200	120	70	40	20
Flash Point, COC, C (F)-minimum	163(325)	177(350)	219(425)	232(450)	232(450)
Solubility in trichloroethylene, percent-minimum	99.0	99.0	99.0	99.0	99.0
Tests on residue from Thin-Film Oven Test:					
Viscosity, 60 C (140 F), poisees-maximum	1000	2000	4000	8000	16000
Ductility, 25 C (77 F), 5 cm per minute cm-minimum	100 [1]	100	50	20	10
Spot test (when and as specified)[2] with:					
Standard naphtha solvent	Negative for all grades				
Naphtha-Xylene-solvent, % Xylene	Negative for all grades				
Heptane-Xylene-solvent, % Xylene	Negative for all grades				

[1] If ductility is less than 100, material will be accepted if ductility at 15.6 C (60 F) is 100 minimum.
[2] The use of the spot test is optional. When it is specified, the Engineer shall indicate whether the standard naphtha solvent, the naphtha-xylene solvent, or the heptane-xylene solvent will be used in determining compliance with the requirement, and also, in the case of xylene solvents, the percentage of xylene to be used.

TABLE 2
Requirements for Asphalt Cement Graded by Viscosity at 60 C (140 F)
(Grading based on original asphalt)

TEST	VISCOSITY GRADE					
	AC-2.5	AC-5	AC-10	AC-20	AC-30	AC-40
Viscosity, 60 C (140 F), poises	250 ± 50	500 ± 100	1000 ± 200	2000 ± 400	3000 ± 600	4000 ± 800
Viscosity, 135 C (275 F), Cs-minimum	125	175	250	300	350	400
Penetration, 25 C (77 F), 100 g, 5 sec.-minimum	220	140	80	60	50	40
Flash Point, COC, C (F)-minimum	163(325)	177(350)	219(425)	232(450)	232(450)	232(450)
Solubility in trichloroethylene, percent-minimum	99.0	99.0	99.0	99.0	99.0	99.0
Tests on residue from Thin-Film Oven Test:						
Loss on heating, percent-maximum (optional)[3]		1.0	0.5	0.5	0.5	0.5
Viscosity, 60 C (140 F), poises-maximum	1000	2000	4000	8000	12000	16000
Ductility 25 C (77 F), 5 cm per minute, cm-minimum	100 [1]	100	75	50	40	25
Spot test (when and as specified)[2] with:						
Standard naphtha solvent	Negative for all grades					
Naphtha-Xylene-solvent, % Xylene	Negative for all grades					
Heptane-Xylene-solvent, % Xylene	Negative for all grades					

[1] If ductility is less than 100, material will be accepted if ductility at 15.6C (60 F) is 100 minimum.
[2] The use of the spot test is optional. When it is specified, the Engineer shall indicate whether the standard naphtha solvent, the naphtha-xylene solvent, or the heptane-xylene solvent will be used in determining compliance with the requirement, and also, in the case of xylene solvent, the percentage of xylene to be used.
[3] The use of loss on heating requirement is optional.

TABLE 3. Requirements for Asphalt Cement Graded by Viscosity at 60 C (140 F)
(Grading based on residue from Rolling Thin Film Oven Test)

TESTS ON RESIDUE FROM AASHTO TEST METHOD T 240[1]	VISCOSITY GRADE				
	AR-10	AR-20	AR-40	AR-80	AR-160
Viscosity, 60 C (140 F), poise	1000 ± 250	2000 ± 500	4000 ± 1000	8000 ± 2000	16000 ± 4000
Viscosity, 135 C (275 F), Cs-minimum	140	200	275	400	550
Penetration, 25 C (77 F), 100 g, 5 sec.-minimum	65	40	25	20	20
Percent of original Pen., 25 C (77 F)-minimum	—	40	45	50	52
Ductility, 25 C (77 F), 5 cm per min., cm minimum	100[2]	100[2]	75	75	75
TESTS ON ORIGINAL ASPHALT					
Flash Point, COC, C (F)-minimum	205 (400)	219 (425)	227 (440)	232 (450)	238 (460)
Solubility in Trichloroethylene, percent-minimum	99.0	99.0	99.0	99.0	99.0

[1] AASHTO T 179 (Thin-Film Oven Test) may be used, but AASHTO T 240 shall be the referee method.
[2] If ductility is less than 100, material will be accepted if ductility at 15.6 C (60 F) is 100 minimum.