EVALUATION OF ADJACENT AC AND CRC PAVEMENT LANES

Final Report

FHWA Experimental Feature
Project No. OR 89-04

by

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Federal Highway Administration
Washington, D.C. 20590

February 1995

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
EF-OR-89-04		
4. Title and Subtitle Evaluation of Adjacent AC and CRC Pavement Lanes on an Interstate Highway Final Report		5. Report Date February 1995 6. Performing Organization Code
7. Author(s) Haiping Zhou, Scott E. Nodes, and Jefferey L. Gower		8. Performing Organization Report No.
9. Performing Organization Name and Address Oregon Department of Transportation Engineering Services Section Research Unit 2950 State Street Salem, Oregon 97310		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Federal Highway Administration Washington D.C. 20590		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

On some of Oregon's highways, particularly on the interstate freeways in Eastern Oregon, most of the heavy trucks travel in the outside lane (right lane). With this kind of truck traffic pattern, the right lane experiences significantly higher axle loadings than the left lane, and consequently, the right lane deteriorates much faster than the left lane. After years of service, the left lane pavement is still in good condition while the right lane pavement shows severe surface distress and has to undergo some major rehabilitation in order for the pavement to provide satisfactory service. Maintenance activities, which add additional costs, are often necessary before the major rehabilitation.

In 1989, to resolve this type of pavement problem, the Federal Highway Administration (FHWA) and Oregon Department of Transportation (ODOT) jointly developed an experimental features project constructing a pavement with Asphalt Concrete (AC) material in the left travel lane and Continuously Reinforced Concrete (CRC) material in the right travel lane (AC/CRC adjacent lane), on a section of Interstate 84 (I-84) in eastern Oregon. The construction of the pavement was completed in 1989.

This final report of the experimental features project presents a description of the feasibility of the AC/CRC adjacent lane construction and an evaluation of the cost-effectiveness and performance of the AC/CRC adjacent pavement.

17. Key Words	18. Distribution Statement
Pavements, Asphalt Concrete, Continuously Reinforced Concrete	Available through the Oregon Department of Transportation Research Unit.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8-72)Reproduction of completed page authorized

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

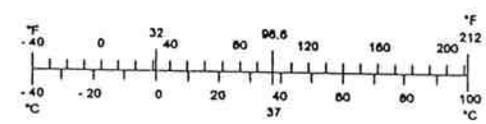
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

(4-7-94 jbp)

ACKNOWLEDGEMENTS

The authors thank Eric Brooks of the Oregon Department of Transportation (ODOT) Research Unit for performing pavement condition surveys on this project. In addition, the authors thank the following people for reviewing this report: Tony George, Kevin Groom, Liz Hunt, Keith Martin, Bo Miller, and Roger Olson of ODOT and Jim Huddleston of the Asphalt Pavement Association of Oregon.

Evaluation of Adjacent AC/CRC Pavement Lanes

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1.0 INTRODUCTION

1.1 BACKGROUND

The wearing surfaces of highway pavements are generally either asphalt concrete (AC) or continuously reinforced concrete (CRC) for the entire cross-section of the travel lanes of the same direction. Once these pavements are built, they will experience traffic loadings and environmental conditioning and eventually begin to deteriorate and show distress. The rate of pavement deterioration is a function of traffic loadings, material properties, and environment, or environment alone. In the same environment, the rate of deterioration for pavements constructed with the same material will primarily depend on the traffic applications. The greater and heavier the traffic loadings, the faster the pavement deteriorates. If different materials are used in the same environment, the pavement constructed with a more durable material would be able to carry greater and heavier traffic loadings than a less durable material, if other things are equal such as base and subgrade condition. In general, CRC materials are considered relatively more durable than AC materials under the same environmental and traffic conditions. However, pavements constructed with AC materials typically have lower initial construction costs than those constructed with CRC materials. Therefore, it may be more cost-effective to use the more durable CRC material for pavements that are expected to carry greater and heavier truck traffic loadings, and use the relatively less durable AC material for pavements that are designed to sustain less and lighter traffic applications.

On some of Oregon's highways, particularly on the Interstate freeways in eastern Oregon, most of the heavy trucks travel in the outside lane or right lane. With this kind of truck traffic pattern, the right lane experiences significantly higher axle loadings than the left lane and consequently, the right lane deteriorates much faster than the left lane. After years of service, the left lane pavement is still in good condition while the right lane pavement shows severe surface distress and has to receive some major rehabilitation in order for the pavement to provide a satisfactory function. Maintenance activities, which add additional costs, are often necessary before the major rehabilitation.

In 1989, to investigate a more cost-effective pavement, the Federal Highway Administration (FHWA) and Oregon Department of Transportation (ODOT) jointly developed an experimental features project constructing a pavement with AC material for the left travel lane and with CRC material for the right travel lane (AC/CRC adjacent lane), on a section of Interstate Highway #84 (I-84) in eastern Oregon. The construction of the project was completed in 1989. Since then, the Research Unit of the ODOT has been monitoring the performance of the AC/CRC adjacent lane pavement.

1.2 OBJECTIVES

The objectives of this experimental features project are to examine the feasibility of constructing an AC lane next to a CRC lane or visa versus, to evaluate the cost-effectiveness and initial pavement performance of the AC/CRC adjacent lane, and to address any operation or safety concerns regarding this type of pavement.

The construction, first year, and second year pavement performance have been documented in a single report (*1*) published in June 1991. This final report presents a summary description of the pre-construction activities, construction, and pavement performance evaluation; in addition, the report includes a cost analysis of the project.

2.0 PROJECT DESCRIPTION

The following describes the location, pavement condition before construction, traffic information, and pavement design of the project.

2.1 PROJECT LOCATION

This project is located in northeastern Oregon on the Old Oregon Trail Highway #6 (U.S. I-84), westbound, between the cities of Pendleton and LaGrande. The highway has two 12-foot lanes in each travel direction and is divided by a median with varying width. Figure 2.1 shows the vicinity and specific location of the project.

The project is in a high mountain forest area with an elevation of 3,500 to 4,000 feet. The average daily high and low temperatures of the coldest month, January, are 39°F and 11°F, respectively. The average daily high and low temperatures of the hottest month, July, are 85°F and 37°F, respectively. This area receives an average annual precipitation of 39 inches.

This project is 12.3 miles long and has sections of all CRC and CRC/AC. From mile point (MP) 225.7 to 232.9 the pavement is CRC for both lanes. From MP 232.9 to 238.0 the pavement includes an AC left lane and a CRC right lane, parallel to each other. Within the all CRC section, one segment, (MP 230.5 to 232.5) is used as a control section. Within the AC/CRC section, one segment (MP 235.5 to 237.5) is used as a test section. The test and the control sections were used for the performance evaluation.

2.2 PAVEMENT PRIOR TO CONSTRUCTION

The original pavement was constructed in the late 1950s and early 1960s with four inches of AC over a varying depth of aggregate base. In 1974, the pavement received a five-inch AC overlay. By 1982, the right lanes had severe ruts up to one inch or more in the wheel tracks. Approximately four inches of AC were removed from the right lanes and replaced with the same thickness of Class "B" AC containing recycled material. The ODOT Class "B" AC is a dense-graded mix with ¾-inch to 0-inch aggregate (*2*).

In 1983, an open-graded Class "E" AC overlay was applied full width along with an emulsion seal coat in the outside lanes to seal some relatively open-graded areas in the recycled mix put down in the previous year. The right lanes in this section immediately began to exhibit various forms of distress including excessive bleeding, pot-holing, loss of the "E" mix, and loss of the recycled mix. The deterioration continued at an accelerating rate, aided by increased truck volumes and axle loads. In 1986, maintenance costs for this section of highway increased dramatically to an estimated $130,000 per year. Typical pavement conditions prior to construction are shown in Figure 2.2.

2.3 TRAFFIC INFORMATION

This highway experiences a considerable amount of heavy truck traffic throughout the year. In 1990, the average daily traffic (ADT) on the highway was about 6,200, of which 30% was heavy trucks. The majority of these trucks (95%) travel in the right lane. In the winter, many of these trucks use tire chains.

Currently, the number of equivalent single axles loads (ESALs) on this highway increases at an annual rate of 4.5%. At this rate, the projected 30-year traffic applications, converted to an 18-Kip load will be over 65 million ESALs in the right lane and 45 million ESALs in the left lane.

2.4 PAVEMENT DESIGN CONSIDERATION

During pavement design, two alternatives were considered (*3*). The first alternative was to construct CRC pavement for both travel lanes. The second alternative was to construct an AC pavement for the left lane and a CRC pavement for the right lane (AC/CRC). Most of the heavy truck traffic was in the right lane as well as most of the pavement distress. It may be more cost-effective if a pavement suitable to this type of traffic movement distribution and surface distress pattern could be provided. The second alternative appears to be more cost effective, however, both the first and second alternatives were designed so that they could be compared.

The pavement thickness required to carry the projected traffic applications was determined using the 1986 AASHTO Guide for the Design of Pavement Structures (*4*). The final recommended pavement structural design is shown in Figure 2.3. To compare the performance of the AC/CRC design versus the all CRC design, both design alternatives were adopted in construction. It may be noted in Figure 2.3a that the left lane has a thinner CRC layer thickness (8 inches) which reflects the lower traffic loadings expected in that lane.

Figure 2.3b shows the typical cross-section for the AC/CRC design. The left lane has a 2-inch AC inlay and a 3-inch AC overlay. The right lane has an 11-inch CRC inlaid partially into the existing AC pavement.

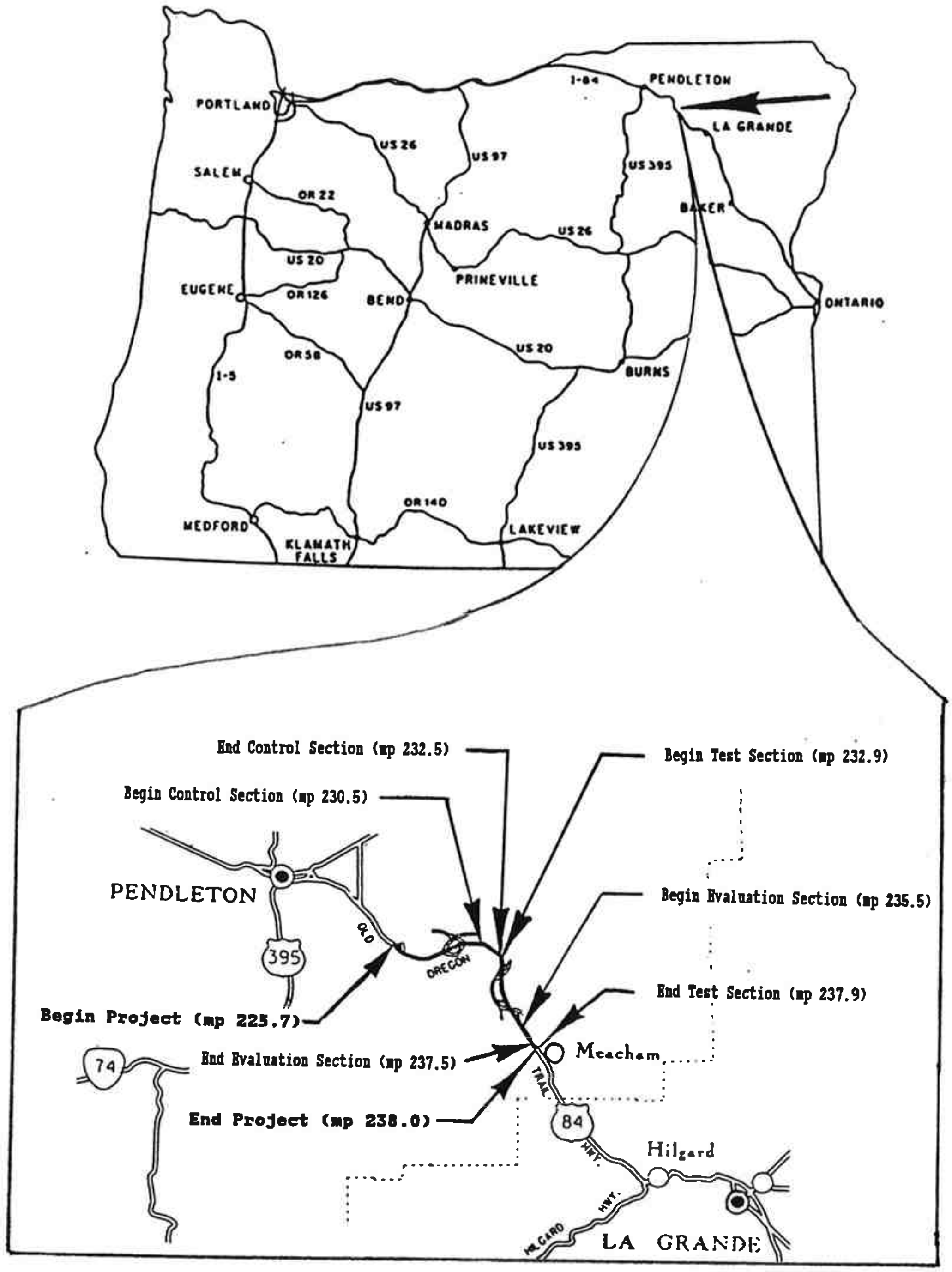
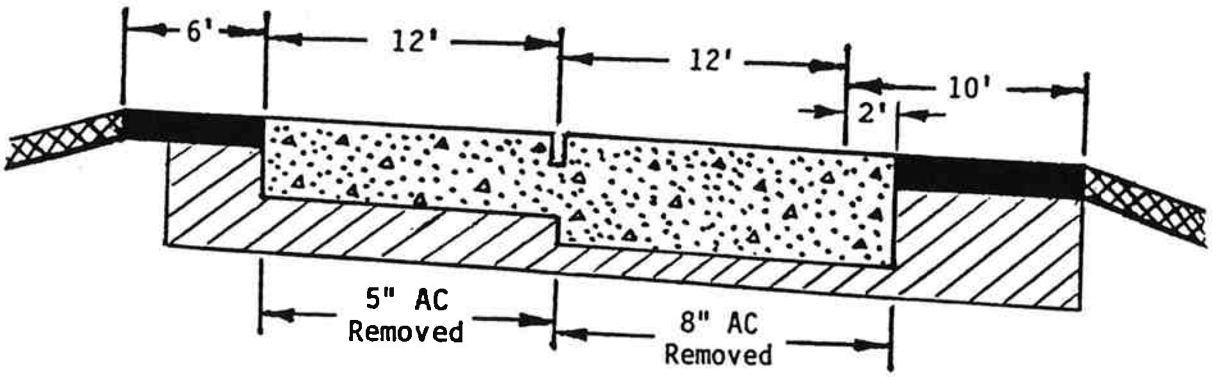


Figure 2.1 Project Location

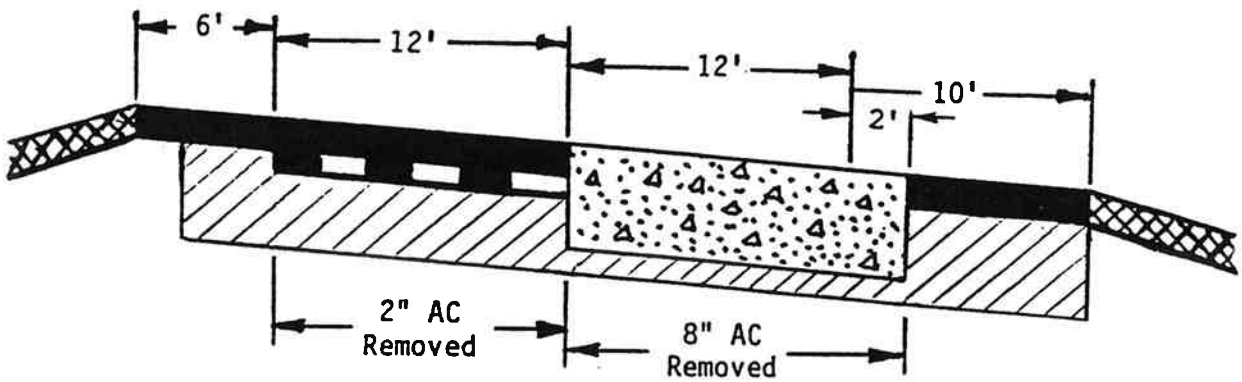
a) 1986 Pavement Condition at MP 236.5 (WB) (within test section)

b) 1986 Pavement Condition at MP 231.0 (WB) (within control section)

Figure 2.2 Typical Pavement Condition Prior to Construction



(a) CRC Cross-Section (MP 225.7 - 232.9)



(b) AC/CRC Cross-Section (MP 232.9 - 237.9)

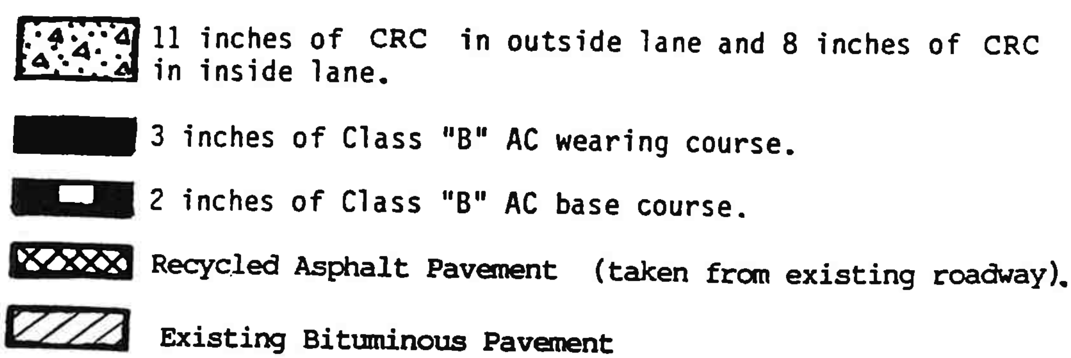


Figure 2.3 Pavement Cross-Sections

3.0 CONSTRUCTION

The construction began in 1989 with the removal of the existing AC pavement to the designed depth and grade. For the CRC section, five inches of AC in the left lane and eight inches of AC in the right lane were removed. For the AC/CRC section, the top two inches of AC in the left lane and top eight inches of AC in the right lane were cold planed. Areas with base or subgrade failure were also removed and replaced with new AC material to provide a uniform base for surface paving.

Conventional construction procedures were followed for the CRC section, which was placed in a single 26-foot wide panel. A longitudinal sawcut, $^{1}/_{4}$-inch wide and $^{2}/_{3}$-inches deep, was made between the left lane and the right lane of the pavement.

For the AC/CRC section, the CRC pavement was constructed first. There was no additional equipment necessary for paving the CRC. Because the left and right lanes were to be paved with different materials, the key to the CRC paving was to assure a neat and vertical face at the concrete edge. During construction, the CRC finishing equipment was modified with a special cut-off plate. This modification, however, did not provide satisfactory results due to a high concrete slump which made concrete difficult to work with. The inside edge of the CRC lane was then trimmed 1-inch to 2-inches, using a concrete saw, to produce a vertical edge face.

A dense-graded Oregon Class "B" AC was used for the left lane. There were no problems encountered during the paving. Before the AC material was put down, a tack coat was applied to the edge of the CRC slab and to the cold planed pavement surface. The AC material was then compacted to match the grade of the adjacent concrete lane. Special attention was given to the compaction near the AC/CRC joint to prevent any damage to the concrete slab edge and to provide adequate AC density to minimize the potential differential settlement between the AC lane and the CRC lane.

Although two completely different materials were used in the pavement, there were no significant problems encountered during the pavement construction. The paving was completed in the fall of 1989.

4.0 PAVEMENT PERFORMANCE AND EVALUATION

The construction of the all CRC and AC/CRC lanes was completed in the fall of 1989. After its completion, ODOT Research Unit Staff conducted pavement inspections on an annual basis. This section describes the initial pavement performance evaluation based on the collected data.

4.1 PAVEMENT CONDITION

The first pavement condition survey was conducted in May of 1991. The survey included detailed visual inspections of the pavement condition, surface distress, and joint condition. The survey followed the procedures recommended in the Strategic Highway Research Program's "Distress Identification Manual for the Long-Term Pavement Performance Studies" (*5*). The second pavement condition survey was performed one year later in May of 1992. The last pavement condition survey was conducted in April of 1994. The survey results are summarized and presented in Table 4.1.

4.1.1 Test Section

The typical pavement condition is shown in Figure 4.1. The measured ruts (less than ¼-inch) on the AC lane were about the same for 1991 and 1992. In most areas, these ruts were unnoticeable. The ruts on the CRC lane were in a range of 0 to 1/16-inch, and there were no increases in rutting depths from 1991 to 1994.

There are a few sections in the AC lane showing low level transverse cracking. These transverse cracks appear to be thermal cracks. The typical thermal cracking pattern is shown in Figure 4.2a. In most cases, these cracks extend through the entire pavement cross-section, including both the AC and CRC lane as well as the AC shoulders. The transverse cracks in the CRC lane are generally evenly distributed, averaging 24 cracks per 100-foot section. The typical cracking pattern in the CRC pavement is also shown in Figure 4.2b. The majority of these cracks are hairline type of low severity and are typical of those found in relatively new CRC pavements.

Differential settlement due to the use of different materials has been one of the major concerns in the project. Based on the survey results, the dropoff and separation between the AC lane/CRC lane and CRC lane/AC shoulder have been in a range of 0 to ¼-inch and 3/16 to 5/8-inch, respectively. The dropoff between the CRC lane and the AC shoulder has been in a range of 0 to ¼-inch. The separation between the CRC lane and the AC shoulder has increased slightly from a range of 0 to ¼-inch to 3/8-inch to 3/4-inch. Figure 4.3 shows the typical dropoff and separation between the AC and the CRC lanes. Figure 4.4 illustrates the typical dropoff and separation between the CRC lane and the AC shoulder.

There is one section, starting from M.P. 236.75 and extending to the end of the AC/CRC section, in which the AC/CRC joint was sealed with asphalt (Figure 4.5). At the time of the 1994 survey, the sealer was failing in some sections. It was replaced with a standard hot joint compound. The sealer was used to prevent water and incompressibles (sand and other debris) from entering the AC/CRC joint and causing subsequent pavement damage. No noticeable differences were found when the sections with and without joint sealer were compared.

However, the joint is always a major concern for the AC/CRC pavement. A potential problem is that water can enter into the joint, and cause pumping and loss of base support. The severe weather conditions in this area may further accelerate the problem at the joint due to water freezing and expanding. One solution to this problem, as performed in this project, is to seal the joint. This may be a short term solution; as the sealing material ages or is stripped off the joint due to traffic loads or lane separation, water may get into the base. The second solution is to provide subsurface drainage at the joint by using permeable materials with an appropriate lateral drain system. This design will increase the cost, but should provide a long term solution to eliminate potential water problems at the joint. This design has been successfully used on another AC/CRC project.

4.1.2 Control Section

The rutting in both CRC lanes is approximately 0 to 1/16-inch, as shown in Figure 4.6. The cracking pattern (Figure 4.7) and number of cracks per 100-foot section for both lanes in the control section are the same as in the CRC lane of the test section. The cracking in the CRC section is expected and not necessarily an indication of distress.

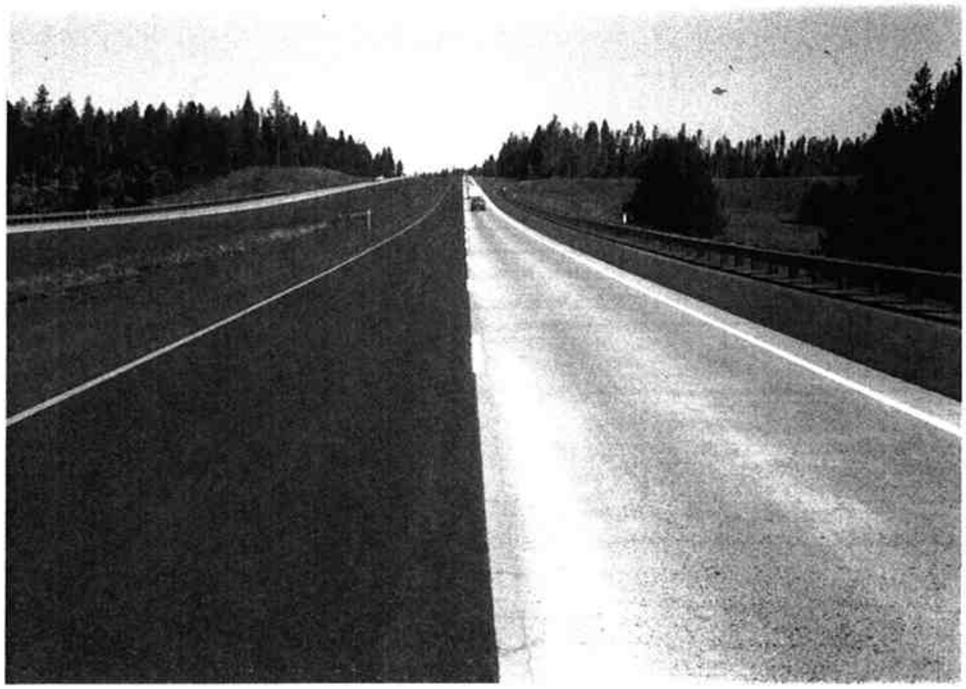
During the pavement condition survey in 1992, it was also noticed that the surface color of the right lane is much darker than that of the left lane and the right lane shows more aggregate popouts and polishing; these factors indicate that the right lane has experienced considerably more traffic than the left lane.

There was no lane-to-lane dropoff, and the construction joint between the CRC lanes was in relatively good condition (Figure 4.8). The dropoff between the CRC lane and the shoulder is not significant, ranging from 0 to ¼-inch (1994 survey results). The separation between the CRC lane and the shoulder, however, has increased since 1991.

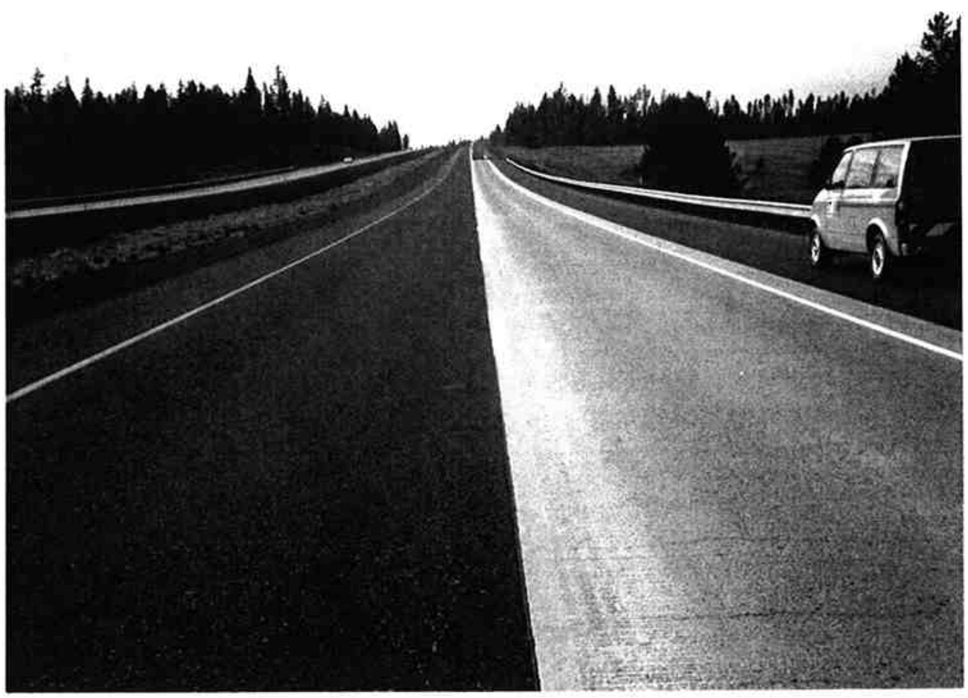
Table 4.1 Summary of Pavement Condition Survey Results

DISTRESS TYPE	TEST SECTION		CONTROL SECTION	
	AC Left Lane	CRC Right Lane	CRC Left Lane	CRC Right Lane
1991 SURVEY RESULTS				
Rutting	**0 - 3/16"**	**0 - 1/16"**	**0**	**0 - 1/16"**
Tranverse Cracking	A few sections showing low level cracking	24[1](7)[2]	23 (4)	24 (3)
Ravelling	Light	-	-	-
L.S.D.[3] L.S.S.[4] L.L.D.[5] L.L.S.[6]	0 0 0 - ¼" 0 - ½"	0 - ¼" 0 - ¼" 0 - ¼" 0 - ½"	0 - ⅛" 0 - ¼" 0 ¼"	0 - ½" 0 - ½" 0 ¼"
1992 SURVEY RESULTS				
Rutting	**0 - 1/4"**	**0 - 1/16"**	**0**	**0 - 1/16"**
Tranverse Cracking	A few sections showing low level cracking	23 (5)	24 (2)	24 (4)
Ravelling	Light	-	-	-
L.S.D. L.S.S. L.L.D. L.L.S	0 0 0 - ¼" 0 - ½"	0 - ¼" ¼" - ½" 0 - ¼" 0 - ½"	0 - ¼" 0 - ¼" 0 ¼"	0 - ¼" ¼" - ½" 0 ¼"
1994 SURVEY RESULTS				
Rutting	**0 - 1/4"**	**0 - 1/16"**	**0 - 1/16"**	**0 - 1/16"**
Tranverse Cracking	15 (6)	33 (9)	24 (2)	24 (4)
Ravelling	Light	-	-	-
L.S.D. L.S.S. L.L.D. L.L.S	- - - -	0 - 1/4" 3/8" - 3/4" 0 - 1/4" 3/16 - 5/8"	- - - 3/8 - 5/8"	- - 0 - 1/4" 3/16 - 5/8"

1 Average number of cracks per station
2 Standard deviation of number of cracks per station
3 L.S.D. = Lane to shoulder dropoff
4 L.S.S. = Lane to shoulder separation
5 L.L.D. = Lane to lane dropoff
6 L.L.S. = Lane to lane separation



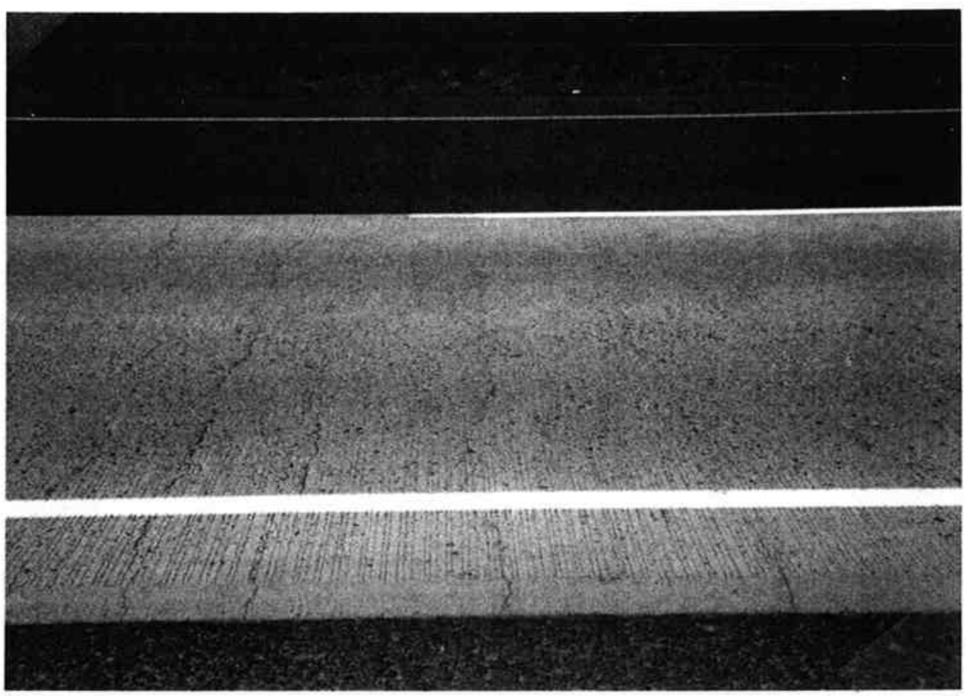
a) AC/CRC Pavement Condition in May 1991 at MP 236.37



b) AC/CRC Pavement Condition in May 1992 at MP 236.37

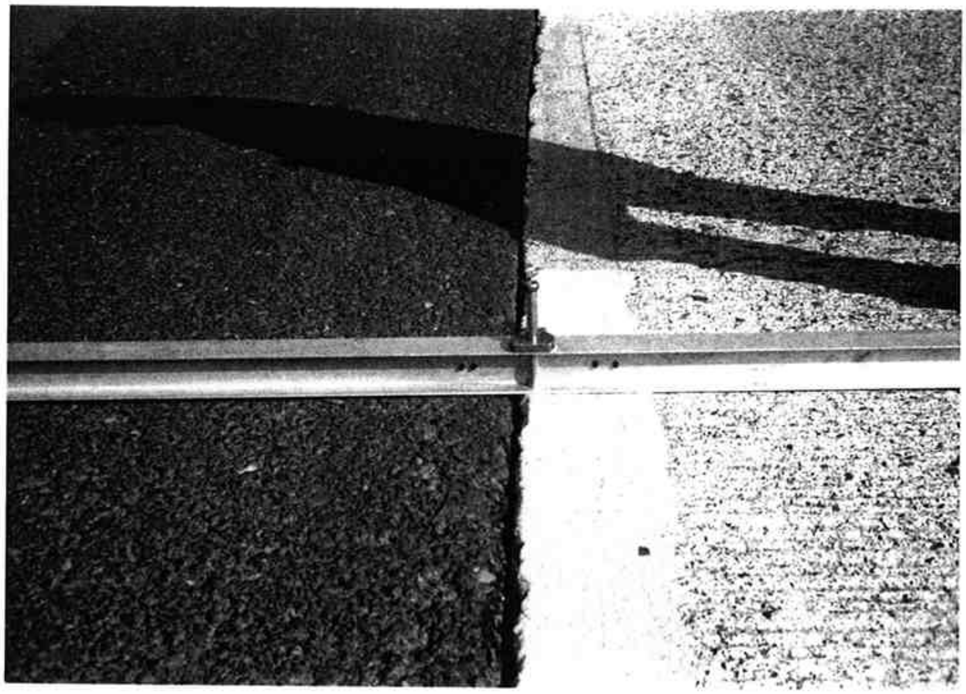
Figure 4.1 Typical Pavement Condition

a) Thermal Cracking in the AC Pavement and Shoulder (1992)

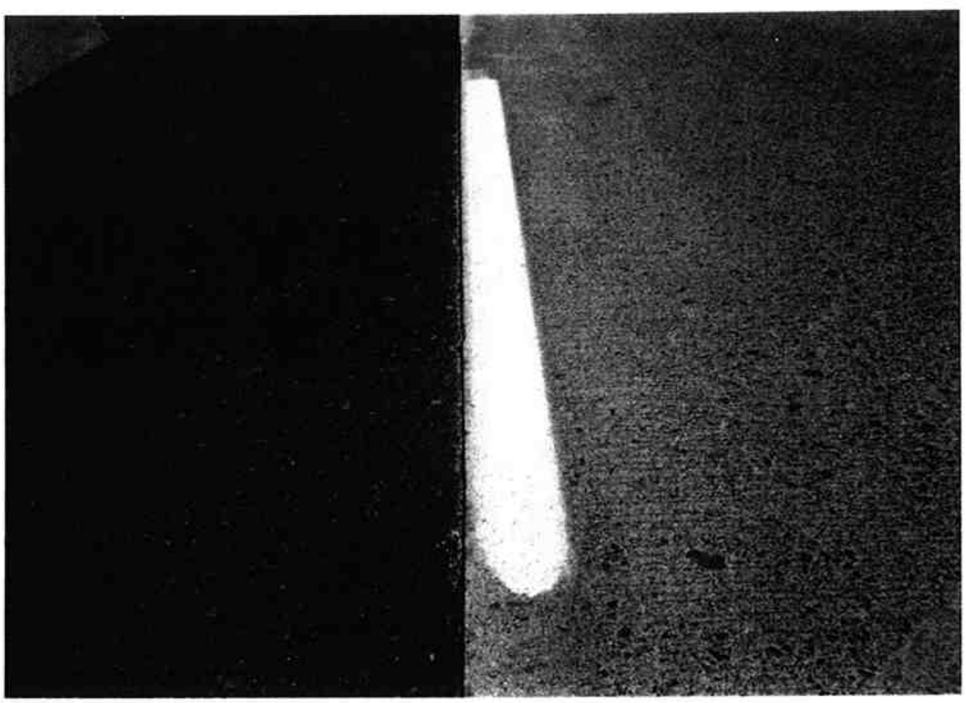


b) Typical Cracking Pattern in the CRC Pavement (1992)

Figure 4.2 Cracking in Test Section



a) Typical Dropoff Between the AC Lane and the CRC Lane



b) Typical Separation Between the AC Lane and the CRC Lane

Figure 4.3 Dropoff and Separation Between the AC and the CRC Lanes

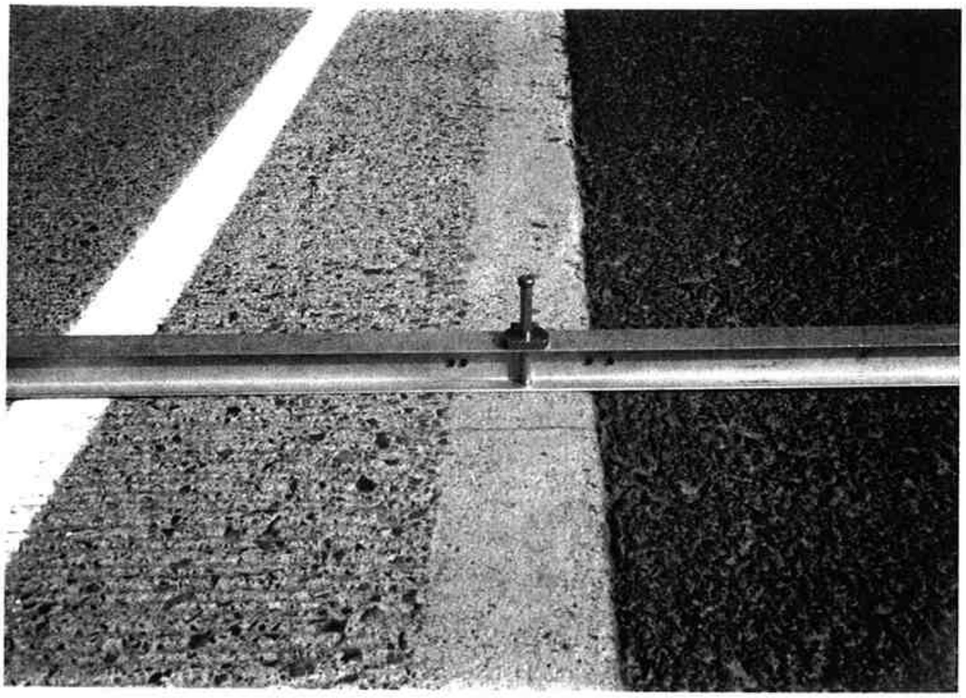


Figure 4.4 Typical Dropoff and Separation Between the CRC Lane and the AC Shoulder

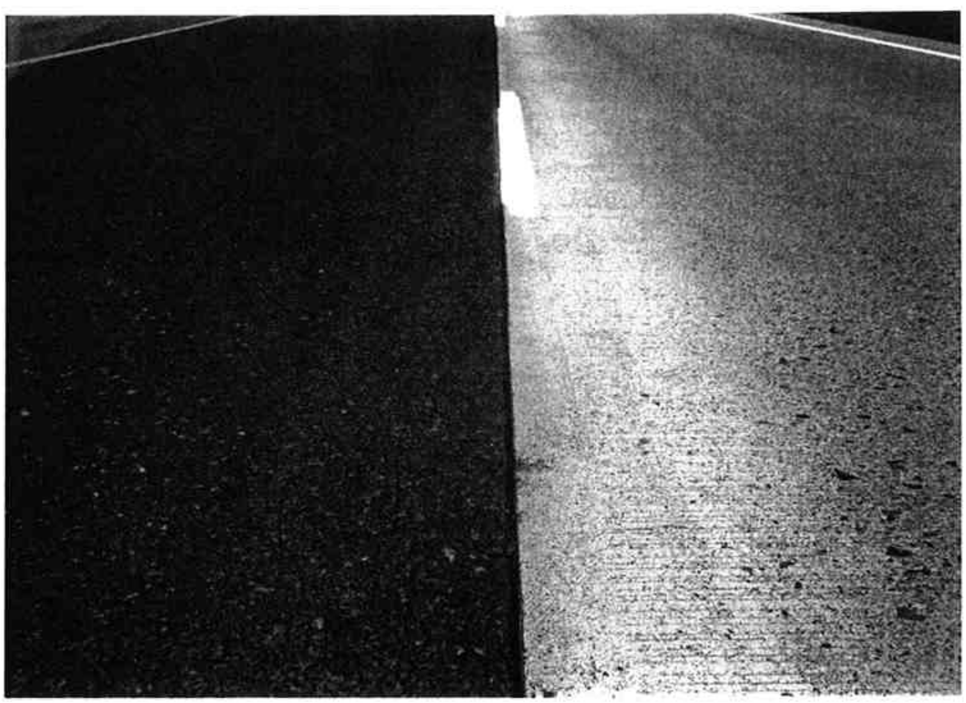
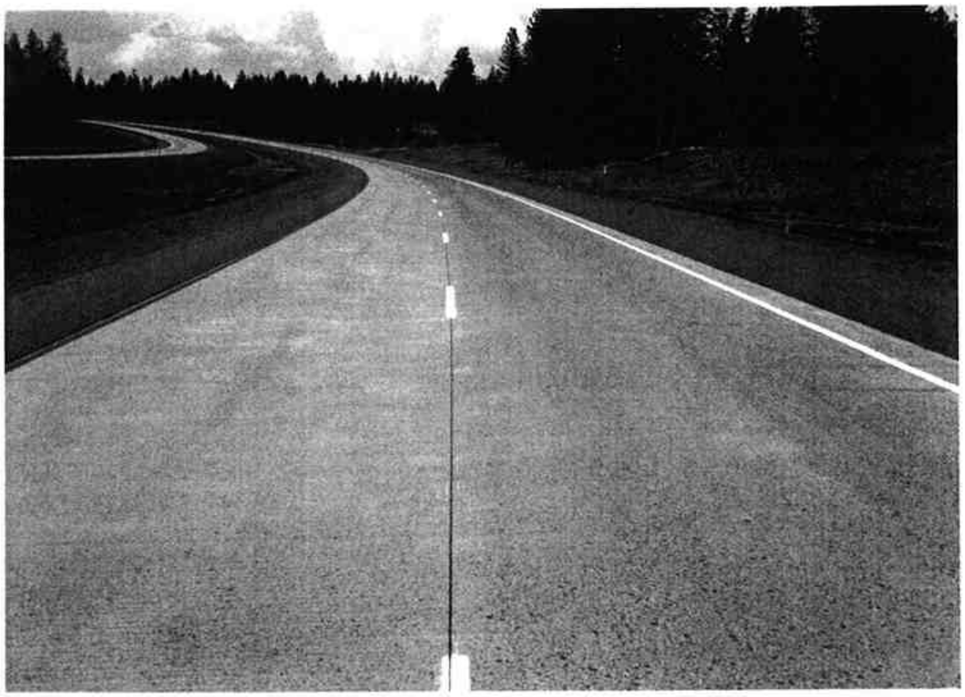
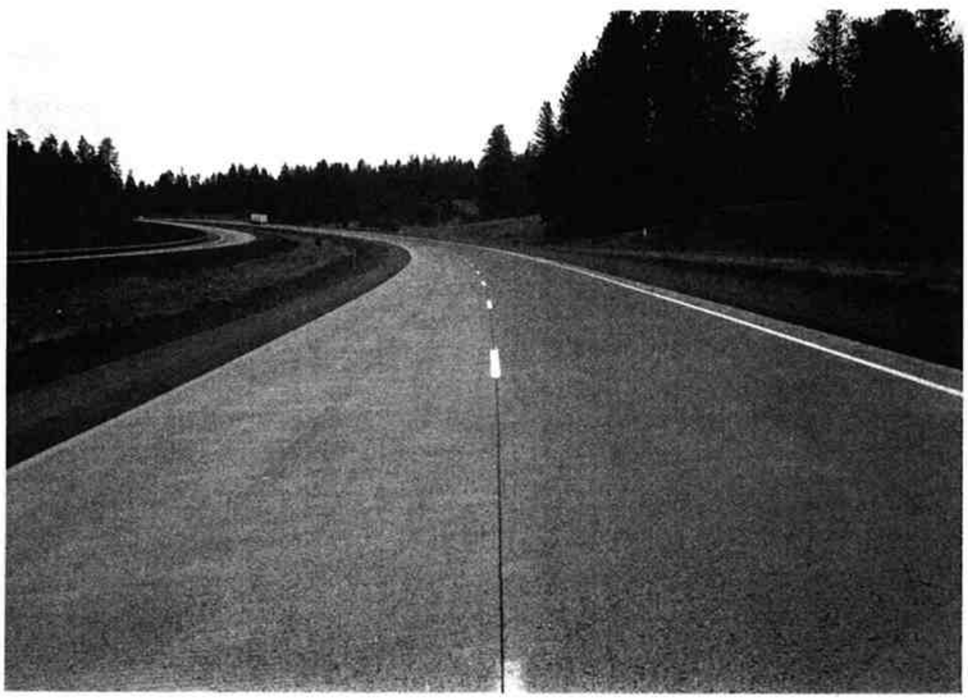


Figure 4.5 AC/CRC Joint Sealed with Asphalt



a) CRC Pavement Condition in May 1991 at MP 231.82



b) CRC Pavement Condition in May 1992 at MP 231.82

Figure 4.6 Typical Pavement Condition

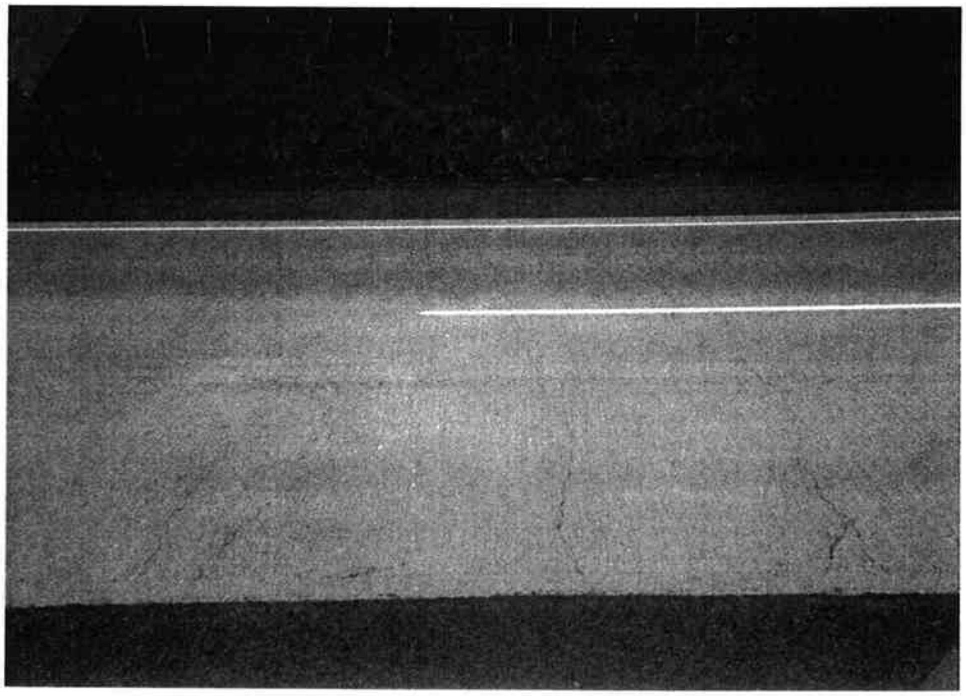


Figure 4.7 Typical Cracking Pattern in the CRC Pavement (1992)

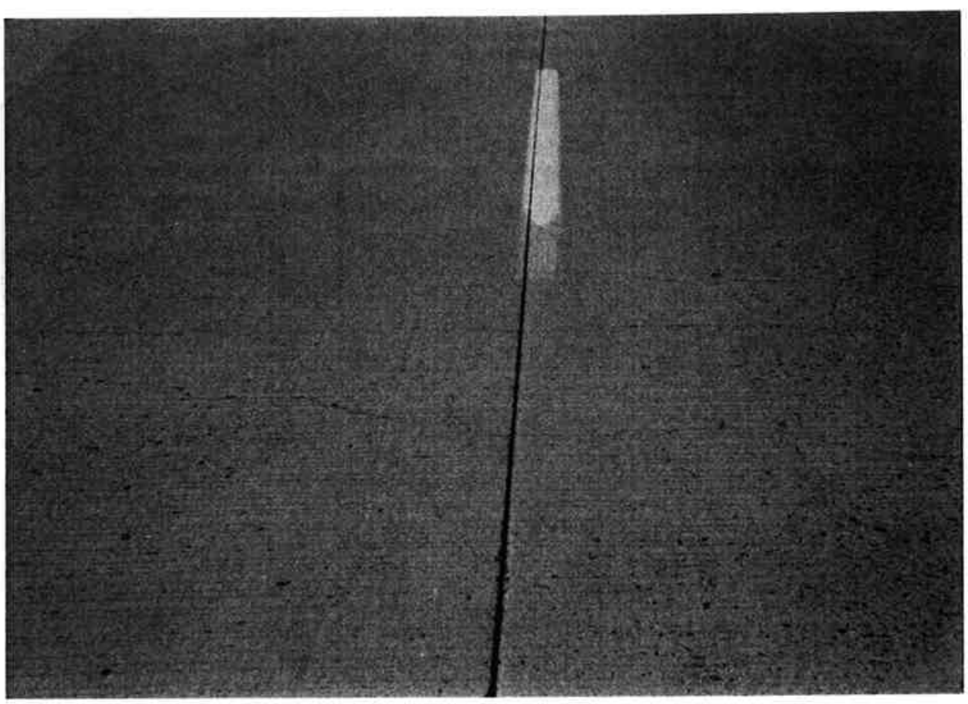


Figure 4.8 Typical CRC Joint

4.2 SAFETY CONCERNS

4.2.1 Friction Tests

Pavement friction tests were performed in the summers of 1990, 1991 and 1994. The tests were conducted using the K.J. Law friction tester, and the friction was measured at a speed of 40 mph in the left wheel path of the testing lane. All tests were performed in accordance with AASHTO T-242 standard procedures (*6*).

The 1990 test results show that in the test section, the average friction number (FN) on the AC left lane is very close to that on the CRC right lane. This may indicate that the frictional properties on the AC surface are similar to those on the CRC surface and that the drivers may not experience any difference in steering the vehicle during lane change.

In 1991, friction tests were performed on the CRC right lane in both the test and the control sections. The average FNs in both sections have increased; it is not clear what caused this increase. It may have been caused by the CRC surface becoming rougher due to an increase in the amount of popouts, or by the seasonal variability of the FNs.

In 1994, friction tests were performed on both the test and control sections. The average FNs for the right lanes in both sections are very similar. The FNs for left lane of both sections are also similar. The average FNs in both sections have increased since the 1991 friction tests were performed.

4.2.2 Drivers' Responses

Shortly after the project was completed, some highway users indicated that they had an awkward or uncomfortable feeling when driving on this new lane configuration. However, much of this concern was regarding a construction detour in which the motorists would drive with two wheels on AC and two wheels on CRC. After the construction detour was removed and the motorists were used to the new AC/CRC lanes, they became accustomed to it and were no longer bothered by the difference in pavement type. Many did not even notice the change in surface as they drove over it, but some drivers indicated that the AC lane had a much smoother and quieter ride.

4.2.3 Traffic Accident

Selkirk and Miller (*1*) compiled and studied detailed accident reports for this area from 1986 through 1990. They reported that the number of accidents in the test and control sections were very similar, and there was no indication that the accidents could be related to the difference in pavement surface type.

4.3 COST EVALUATION

4.3.1 Paving Materials Costs

Table 4.2 provides paving materials costs for the construction of the pavements. The costs are from the actual bid price. The AC lane costs included those for 2-inch cold pavement removal, 5-inch thick AC mixture (3-inch AC overlay, 2-inch AC inlay), asphalt, hydrated lime, and tack coat. For comparison, the AC costs were converted to dollars per square yard, as shown in Table 4.2. The comparison shows that an initial savings of $9.19 per square yard resulted when the AC material was used in the left lane instead of 8 inches of CRC. It should be noted that these are only the material costs and do not include any other construction costs.

Table 4.2 Paving Materials Costs

Pavement Type	Cost/sq.yd. ($)	% Increase
AC Left Lane (3" overlay & 2" inlay, 12' wide)	8.27[1]	-
AC Left Lane (3" AC inlay, 12' wide, future rehab)	5.44[1]	
8" CRC (12' wide)	17.46[2]	+111[3]
11" CRC (14' wide)	22.45[2]	+171[3]

1 Calculated using the actual bid price listed below:
Cold pavement removal: $1.16 sq.yd.
AC mixture: $15.00/ton
Asphalt in mixture: $160/ton
Hydrated lime in mix: $140/ton
Asphalt in tack coat: $150/ton
AC mixture density: 145 pcf

2 Costs included $1.16/sq.yd. for cold pavement removal. The cost could be higher because of the depth of AC to be removed.

3 Compared with the initial cost of the AC left lane.

If the CRC design alternative had been used for the entire project, the estimated total pavement cost would be $15 million. If the AC/CRC design alternative had been used, the estimated total pavement cost would be $13.5 million, for a savings of $1.5 million.

4.3.2 Life Cycle Cost

A life cycle cost analysis was performed in an attempt to evaluate the potential savings from using the AC/CRC pavement construction. Figure 4.9 illustrates the simplified life cycle cost analysis diagram. The following assumptions were made for the life cycle cost analysis:

1) A 30-year period is used for the analysis.

2) The AC left lane in the test section will receive a rehabilitation after 15 and 25 years of service. The rehabilitation will be a three inch AC inlay. This assumption is based on the historical performance of the old AC left lane which performed well from 1974, the year the pavement received a five-inch AC overlay, to 1989, the time this new rehabilitation was completed. It should be pointed out that in 1989, before the rehabilitation had taken place, the left lane was still in good condition. The three-inch AC inlay, to be placed at year 15 and year 25, is intended primarily to eliminate possible surface distress due to environmental deterioration and increased traffic wear. With over 12" inches of AC in place, the left lane is not expected to have a significant serviceability loss or structural failure immediately at year 15 and year 25. With appropriate maintenance as described above, the AC left lane should be able to provide satisfactory service for the entire design period. However, it is assumed that the AC left lane will have no remaining life at the end of the 30-year period.

3) The 8-inch CRC left lane in the control section will last the entire 30-year period. During this period, the pavement will not receive any rehabilitation or maintenance. At the end of the analysis period, there will be no remaining life for this pavement.

4) The 11-inch CRC right lane will last the entire 30-year period. During this period, the pavement will receive no rehabilitation or maintenance. At the end of the analysis period, the pavement will have no remaining life.

5) User costs are a difficult item to get a good handle on because of lack of data and therefore, they will not be included in this analysis. However, it is expected that the future rehabilitation will close one lane for short periods of time. With the low volumes of traffic on this section, the lane closure will have only minimal impact on the flow of traffic.

6) Discount rates at three, four, and five percent are assumed for the analysis.

Based on the above information, an annualized cost for each type of pavement is calculated and presented in Table 4.3. The calculations indicate that for the left lane, the AC pavement would have a lower life cycle cost than the 8-inch CRC pavement. The savings are expected in the range of 20% to 40% depending on the discount rate. At any rate, the 11-inch CRC pavement would cost substantially more than either the AC pavement or the 8-inch CRC pavement.

However, it must be pointed out that the left lane is designed to carry substantially less ESALs than the right lane. Therefore, the scheme of the life cycle cost analysis for the left lane will not be suitable for the right lane. If either the AC design or the reduced CRC design is used for the right lane, a different scheme must be developed for the life cycle cost evaluation.

Table 4.3 Summary of Life Cycle Cost Analysis

Pavement Type	Annualized Cost per Square Yard		
	3%[1]	4%[1]	5%[1]
AC left lane	$0.73	$0.77	$0.81
8-inch CRC	$0.89	$1.01	$1.14
11-inch CRC	$1.15	$1.30	$1.46

[1] Discount rate.

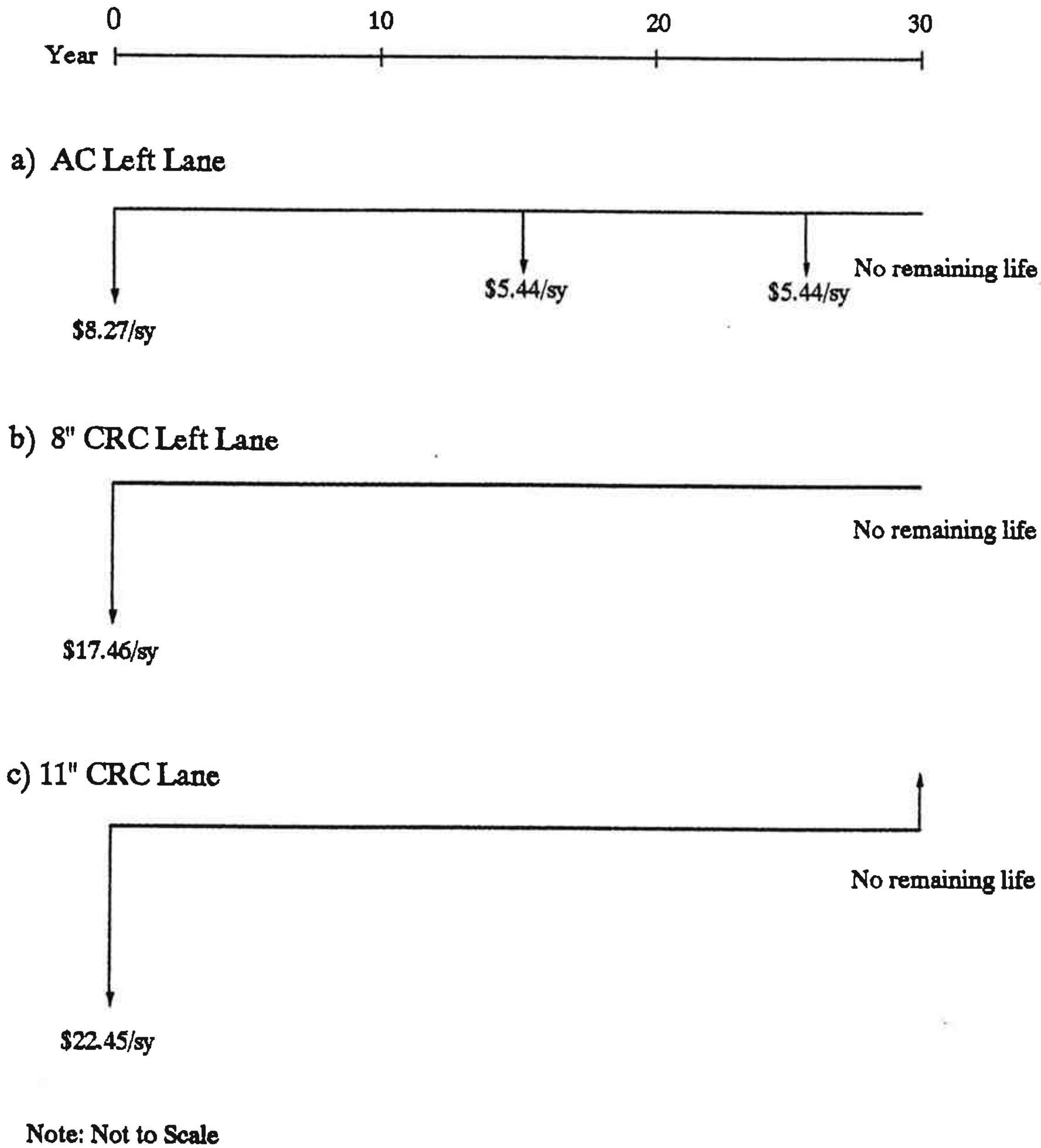


Figure 4.9 Simplified Life Cycle Cost Analysis Diagram

5.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations can be made based upon the construction, cost analysis, and initial pavement performance and evaluation of the project.

5.1 CONCLUSIONS

1. The AC/CRC adjacent lane pavement appears to be a viable alternative to all-AC or all-CRC pavements for highways with at least two travel lanes in the same direction, where one of the travel lanes carries considerably greater and heavier traffic loadings than the other lane(s).

2. No significant problems were encountered during the construction.

3. After about three years in service, both the AC/CRC pavement in the test section and the CRC pavement in the control section are in good to very good condition. The CRC right lane appeared to have experienced considerably more traffic than the left lane.

4. The joint between the AC lane and the CRC lane is in good condition. Lane to lane dropoff and separation are minor.

5. The AC lane had a substantially lower initial material cost than the CRC lane. The life cycle cost analysis also shows that the AC left lane construction is more cost-effective than the CRC lane construction.

6. The AC/CRC adjacent lane pavement has not adversely affected traffic safety. The public is becoming accustomed to this type of pavement.

5.2 RECOMMENDATIONS

1. The AC/CRC adjacent lane pavement is recommended as an alternative for highways with at least two travel lanes in the same direction, where one of the travel lanes is expected to carry greater and heavier truck traffic than the other lane(s).

2. Close attention should be paid during the construction of the joint between the AC and the CRC lanes to avoid any damage to the concrete slab.

3. To prevent potential water problems at the AC/CRC lane joint, an appropriate measure, such as sealing the joint or providing a subsurface drainage system, is recommended. The subsurface drainage may be a better solution than the joint sealing, in the long-run.

4. A long-term pavement evaluation program should be developed to monitor the performance of the AC/CRC pavement. Any maintenance applied to the pavement should be recorded for future life cycle cost evaluations.

6.0 REFERENCES

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5. Strategic Highway Research Program (SHRP), "Distress Identification Manual for the Long-Term Pavement Performance Studies," National Research Council, Washington, D.C., 1990.

6. AASHTO, "Standard Specifications for Transportation Materials and Methods of Sampling and Testing," American Association of State Highway and Transportation Officials, Fourteenth Edition, Washington, D.C., 1986.