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FIBER PAVE, POLYPROPYLENE FIBER

DONNA S. HARMELINK
Colorado Department of Transportation
4201 East Arkansas Avenue
Denver, Colorado 80222

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U.S. Department of Transportation
Federal Highway Administration

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

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16. Abstract

This report documents the performance of Fiber Pave. Fiber Pave 3010, which is manufactured by Hercules Incorporated, consists of short-length polypropylene fibers designed for use as a reinforcement in bituminous concrete and asphalt pavements. It is marketed for its ability to increase the cohesive strength of the asphalt binder, improve its workability, and extend the service life of the pavement by making it more resistant to shoving, rutting, and thermally induced reflective cracking.

It is very difficult to draw any definitive conclusions in terms of overall pavement performance of the Fiber Pave. The test section which contain the fibers and the control section performed equally well. Both the cracking and rutting at the end of the evaluation for both the test and control sections were minimal. However, with the thickness of the widened section (4-1/2") it is possible that the three year evaluation was not long enough to fully evaluate the pavement's ability to resist rutting.

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I. INTRODUCTION

Asphalt pavement's ability to resist rutting has been a continuing concern for designers of paving mixes. In recent years these concerns have increased as asphalt pavements have been subjected to higher loadings and have shown a tendency to rut earlier in their lives.

Rutting affects many asphalt pavements in Colorado and can appear early in the life of a new pavement. If not controlled a rutted pavement can lead to premature pavement performance failure.

In 1986, at the request from the District 4 Engineer, an evaluation of the product Fiber Pave was initiated. This product had not been used on Colorado highways before this time.

Fiber Pave 3010, which is manufactured by Hercules Incorporated, consists of short-length polypropylene fibers designed for use as a reinforcement in bituminous concrete and asphalt pavements. It is marketed for its ability to increase the cohesive strength of the asphalt binder, improve its workability, and extend the service life of the pavement by making it more resistant to shoving, rutting, and thermally induced reflective cracking.

II. OBJECTIVE

The objective of this study was to evaluate the effect the Fiber Pave additive had on the performance of the pavement when compared to the standard mix without the fibers. The standard HBP 1/2" mix used at this time was a GR EX at a minimum of 5.4% AC. Appendix A contains the specification for the standard mix as well as the mix containing the Fiber Pave product. Also included in this Appendix is information about Fiber Pave furnished by the supplier.

III. CONSTRUCTION

This project, FR 034-2(10), was located on SH34 approximately 20 miles east of Greeley and extended 2.7 miles east between M.P. 133.1 and 135.8. A map of the location is shown in Figure 1. State Highway 34 is classified as a principal arterial (with 2750 ADT and 15% trucks).

The existing 24-foot roadway section consisted of 18 feet of concrete (PCCP) with 3 feet of asphalt pavement on both sides. The existing 3" HBP shoulders were removed and the roadway was widened by 17 feet on both sides of the existing concrete pavement (Appendix B, Photo 1). This project increased the existing roadway width to 52 feet. This provided for 4 eleven-foot traffic lanes with 2, 4-foot shoulders. After the subgrade was graded and compacted, the added lanes on each side of the old roadway were paved with two inches of HBP Grading EX to bring it to the elevation of the PCCP. The entire roadway then received a 1-3/4" Grading EX overlay and 3/4" Type A PMSC. A sketch showing the lay-out of the different mat thicknesses is shown in Figure 2.

To reduce the concern over variability in the subgrade between the test and control sections the subgrade was tested prior to construction. It was found that the subgrade was uniform throughout the project (nonplastic A-2-4(0)).

In a 1000-foot test section the Fiber Pave product was placed in all lifts except the PMSC. Within the 1000-foot Fiber Pave section a 500 foot test section was established in the eastbound direction for evaluation. This test section begins at M.P. 133.3 and extends 500 feet in the eastbound direction.

The control section containing the standard Grading EX Hot Bituminous mix without fibers starts at M.P. 133.7 and extends 500 feet in the eastbound direction. This control section is the basis for comparison with the Fiber Pave test section. Figure 3 shows the location of the test and control sections.

Approximately 1076 tons of fiber reinforced pavement was placed in the 1000 feet of pavement in the west and east bound lanes. The polypropylene fibers were added to the falling aggregate prior to the introduction of the asphalt above the pugmill. The cycle time in the pugmill was not changed but the AC content was increased by 0.3% over the standard mix design to accommodate the fiber surface area. The polypropylene fibers constituted 0.3% by weight of the mix. The mix temperature was carefully monitored to ensure that the mix stayed between 280^{o}F-290^{o}F (to keep the fibers from softening and melting).

Representatives from Fiberized Products and Bowman Construction were on hand for technical assistance at the plant. The hot mix was then transported (covered) about 25 miles to the job.

At the start of paving, air temperatures were in the mid 70's. There appeared to be no handling difference between the Fiber Pave and standard hot mixes. The only indication that the fibers were, in fact, in the mix was the "fuzzy" appearance of mix on the shovels and rakes after they had been in the hot mix (Appendix B, Photo 2). Compaction with the vibratory breakdown roller was basically uneventful however, thin chunks of the Fiber Pave picked up on the tires of the rubber-tire roller and then fell back onto the pavement (Appendix B, Photo 3). After several passes with the finishing steel roller, the loose chunks of Fiber Pave could not be seen in the pavement surface. An observation made by the project engineer was that the addition of the fibers made the pavement "set-up quicker" allowing traffic on the new pavement sooner than the standard HBP.

FIGURE 1
PROJECT LOCATION MAP

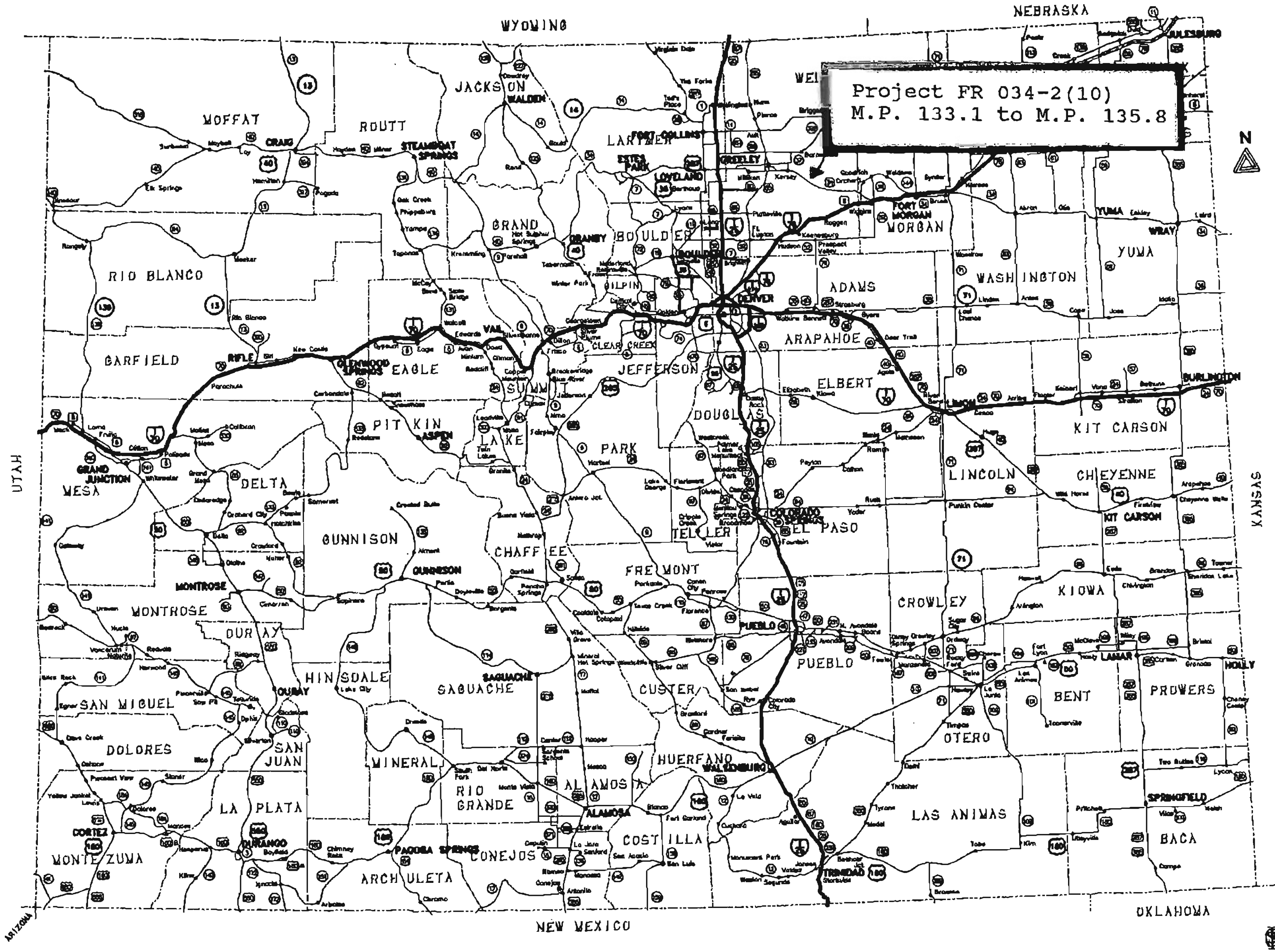


FIGURE 2

TYPICAL SECTION

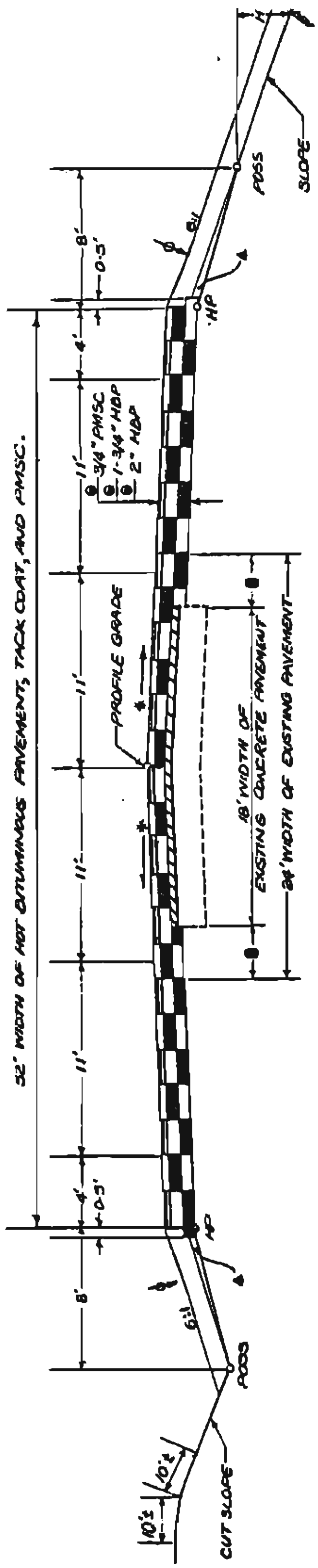
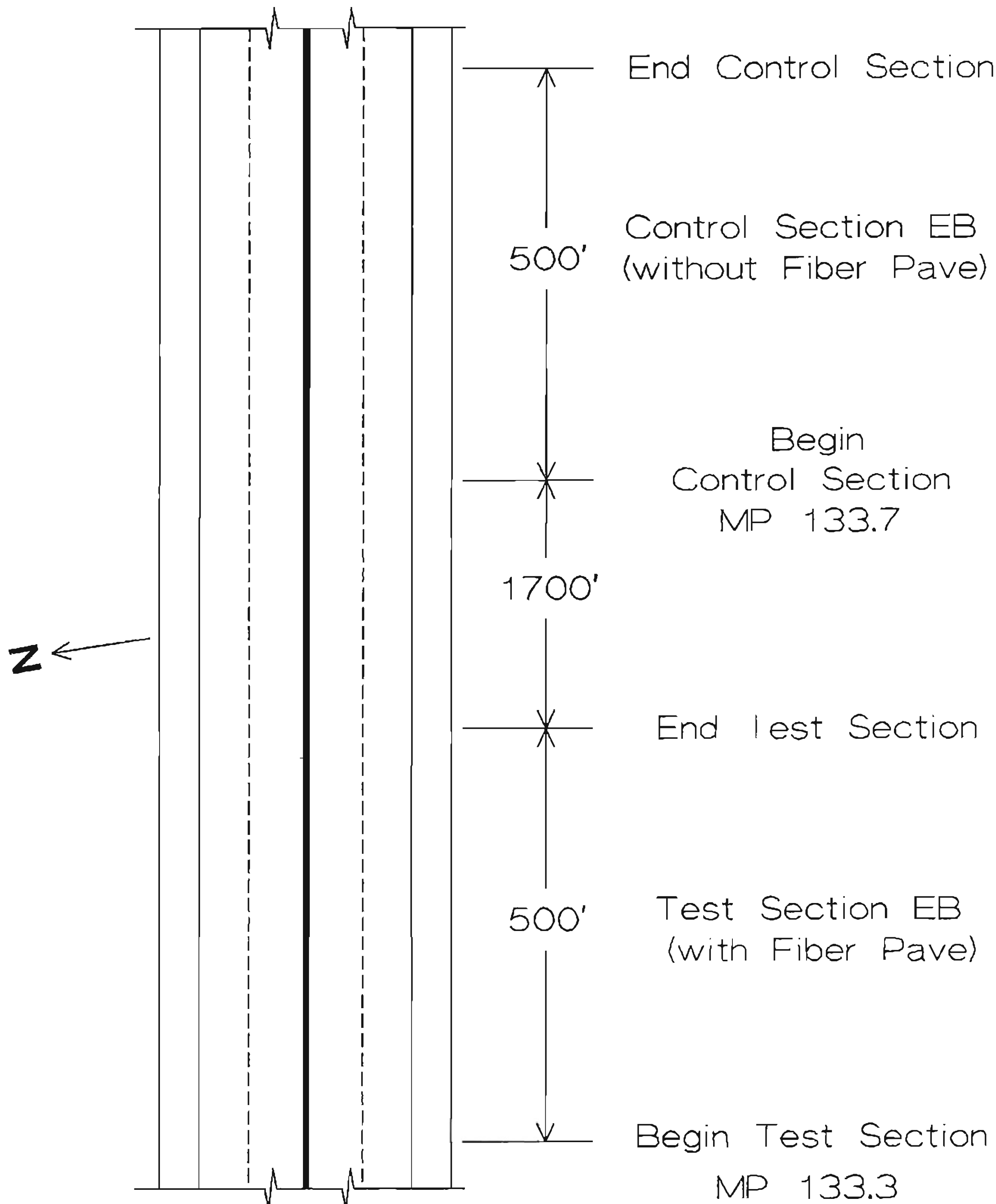


FIGURE 3

EVALUATION SITE LOCATION MAP

Fiber Pave

U.S. 34 East of Greeley



IV. PRE-CONSTRUCTION AND POST-CONSTRUCTION EVALUATIONS

A pre-construction evaluation was performed. This evaluation included rutting measurements (using a 6-foot straight edge), crack mapping, and a visual observation of the roadway surface condition. Since this project included widening, the information obtained during this evaluation was used to evaluate the performance of the passing lane only in the test and control sections. This section contained the existing concrete pavement.

Post-construction evaluations included rutting measurements (using a 6-foot straight edge), crack mapping, core sampling, and visual observation of the roadway surface condition. In addition, deflection measurements (using the Dynaflect) were taken in the control and test sections of the widened section. These evaluations were performed immediately following construction and once a year for three years.

For evaluation the project was divided into two separate evaluation sites. The first site consisted of HBP over the existing concrete pavement (passing lane); and the widened section (driving lane) as the second site. A separate control and test section was established at each site.

Evaluation of Passing Lane

This section consisted of the original pavement. The 11-foot passing lane consisted of 9 feet of concrete pavement with 2 feet of widened asphalt. During construction this area was covered with 1-3/4" of Gr EX HBP and 3/4" of Type A PMSC (Figure 2). Photo 4 in Appendix B shows the condition of the pavement prior to construction. This condition was typical throughout the project.

Deflection Measurements

It was determined that deflection measurements would not provide any information because of the thin lift over the concrete pavement. Therefore deflection measurements were not taken.

Rutting Measurements

Rutting measurements were taken on the existing concrete pavement during the pre-construction evaluation and once a year during the evaluation period.

The initial rutting measurements on the existing pavement averaged 3 tenths of an inch. This value, based on the Colorado Department of Transportation Design Manual, is considered of low severity (under 1/2 inch).

Rutting in the passing lane over the evaluation period was minimal. However this is expected as rutting of a thin lift pavement over concrete pavement is not typical. There was not a significant difference in the amount of rutting noted in the test as compared to the control section.

A bar chart showing the rutting measurements for the test and control sections prior to construction and for each evaluation following construction can be found at the end of this section (Figure 4).

Cracking

Cracking in this section over the evaluation period is limited to reflective cracking from the joints in the existing concrete below. The total amount of cracking at the end of the evaluation period in the control section was the same as recorded in the test section. The severity of the cracking in both the control and test sections were both at a low level based on the Colorado Department of Transportation Design Manual. Photo 5 in Appendix B shows the cracking in the pavement as of August 1992. This cracking pattern is similar to the cracking found on the initial pavement. The majority of the cracking found during the August 1992 evaluation are reflective cracking.

Both the test and control section had a longitudinal crack which extended throughout the entire section length. However this is a result of the construction joint.

A bar chart comparing cracking of the control and test sections in the passing lane over the evaluation period can be found at the end of this section (Figure 5).

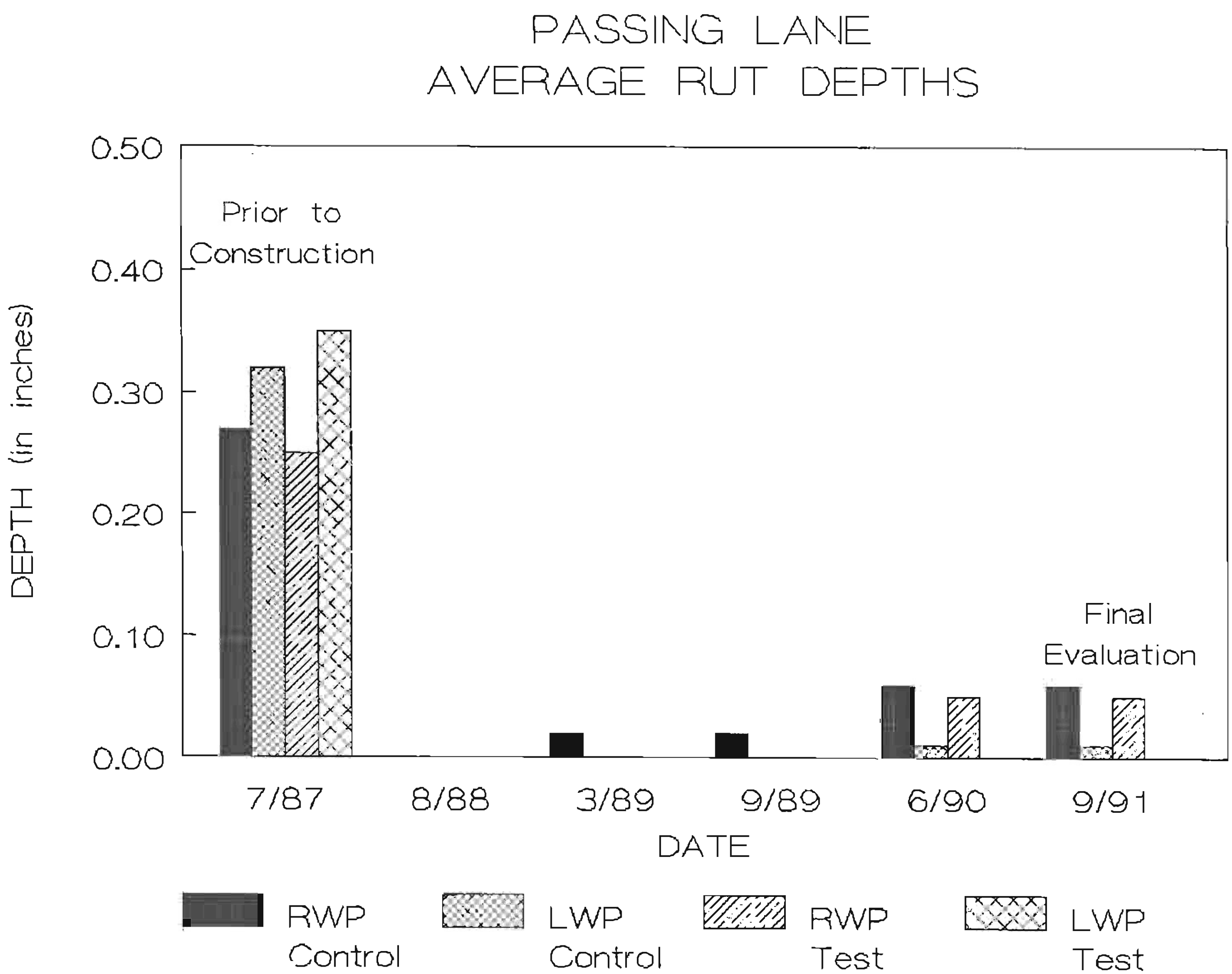

PASSING LANE
AVERAGE RUT DEPTHS
DEPTH (in inches)
0.50
0.40
0.30
0.20
0.10
0.00
Prior to
Construction
Final
Evaluation
7/87
8/88
3/89
9/89
6/90
9/91
DATE
RWP
Control
LWP
Control
RWP
Test
LWP
Test

FIGURE 4

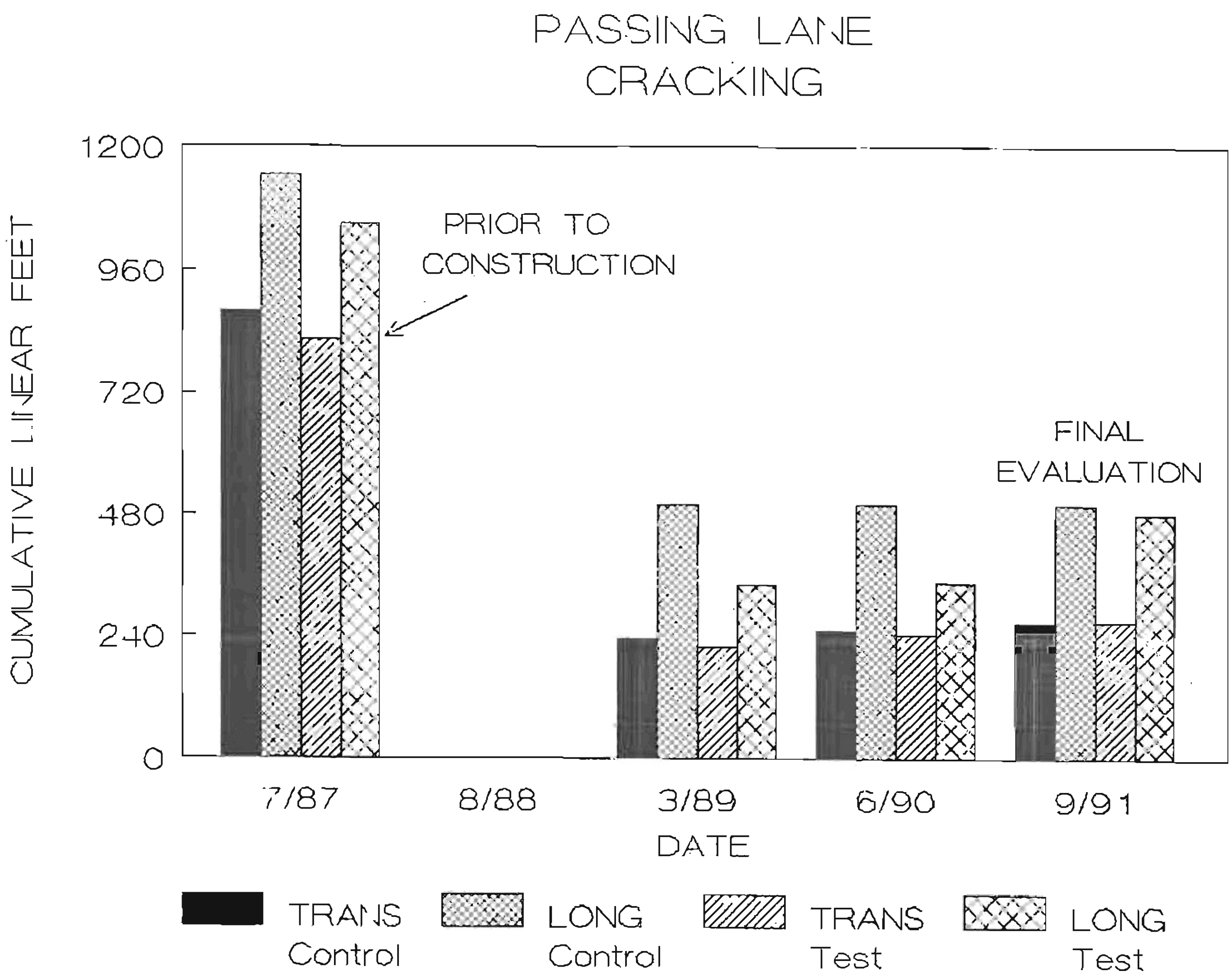

PASSING LANE
CRACKING
CUMULATIVE LINEAR FEET
1200
960
720
480
240
0
PRIOR TO
CONSTRUCTION
FINAL
EVALUATION
7/87
8/88
3/89
6/90
9/91
DATE
TRANS
Control
LONG
Control
TRANS
Test
LONG
Test

FIGURE 5

Evaluation of Driving Lane

This area consisted of 11-foot of the widened section from the skip stripe to the inside edge of the 4 foot shoulder. This section was reconstructed with 2 inches of Gr EX HBP, 1-3/4 inches of Gr EX HBP and 3/4 inches of Type A PMSC (Figure 2).

Deflection Measurements

Deflection measurements were taken during each evaluation following construction.

Although the magnitude of the maximum deflections do not differ significantly between the test and control section, there is a definite trend indicating that the test section is somewhat stronger throughout the analysis period.

After a slight strength increase for both the control and test section over the first three years, there is a reversal evident. This could be explained by the additional compactive effort by traffic. The graph of the maximum deflections over the evaluation period is shown in Figure 6.

The Surface Curvature Index (SCI) data reflects the relative stiffness of the asphalt mat. The graph shown in Figure 7 indicates that the test section has a stiffer mat than the control section, as anticipated by the inclusion of Fiber Pave, which is supposed to reduce the rutting problem. While the difference between the test and control section deflections are not great, the deflections in the test sections are consistantly less. The mat stiffness is also affected by traffic during the first several years after construction during which the stiffness increases to some extent.

Overall pavement structural strength as shown in Figure 8, Pavement Structural Index (PSI), is the aggregate strength of all pavement layers. Hence the mat containing the fibers should yield lower deflection differentials. Again, while the magnitudes in deflections are not very large, the test section is consistently stronger than the control section.

Rutting Measurements

Rutting measurements were taken every 50 feet throughout the test and control section. Evaluations were made immediately following construction and during each evaluation over the analysis period.

Based on the Colorado Department of Transportation Design Manual the final average rutting measurement (taken September 1991) of 1/5 of an inch found in both the test and control section is considered low severity (under 1/2 inch). Although the amount of rutting found in the evaluation sections was not significant the addition of Fiber Pave in the test section does not appear to increase the pavement resistance to rutting under the conditions found on this section of roadway (Appendix B, Photo 6)

A bar chart showing the rutting measurements over the evaluation period can be found at the end of this section in Figure 9.

Cracking

The cracking in the control and test sections was minimal. Following the final evaluation (September 1991) the control section only had 95 linear feet of transverse cracking and the test section had 80 linear feet of transverse cracking. The cracking which has appeared in these sections are a result of sympathy cracking produced from the (existing concrete) passing lane (Appendix B, Photo 7). There was no longitudinal cracking found in either sections.

For comparison a bar chart containing the cracking data over the evaluation period can be found at the end of this section in Figure 10.

Mix Design Properties

The lab design properties for the hot bituminous pavement (HBP) was as follows:

HBP without Fiber Pave		HBP with Fiber Pave	
Optimum Percent Bitumin	6.0%	Optimum Percent Bitumin	6.5%
Stability	38	Stability	38
% Voids @ optimum	4.9%	% Void @ optimum	5.3%
Lottman	107	Lottman	108

Cores were taken from the test and control sections each year during the evaluation period, results indicated that %AC, Lottman and stability values of the Fiber Pave and control sections were comparable to the proposed mix designs.

FIGURE 6

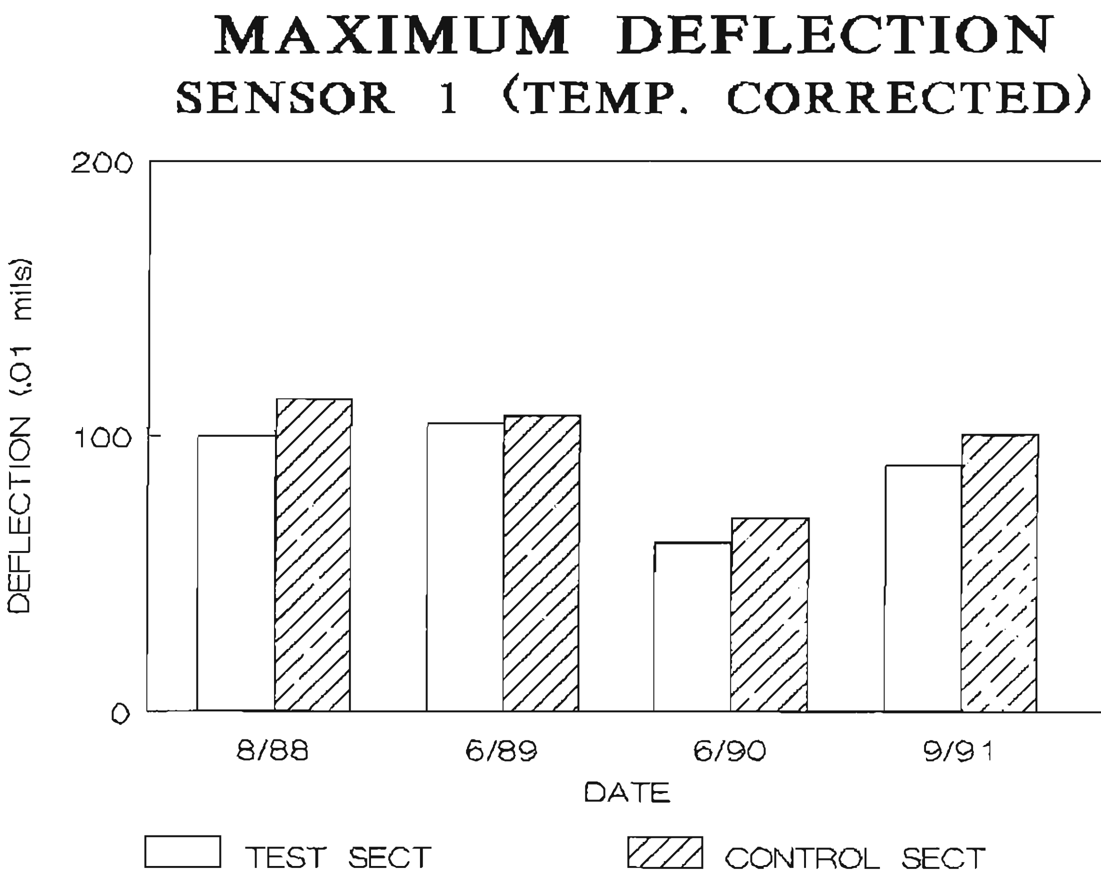

MAXIMUM DEFLECTION
SENSOR 1 (TEMP. CORRECTED)
200
100
0
DEFLECTION (.01 mils)
8/88
6/89
6/90
9/91
DATE
TEST SECT
CONTROL SECT

FIGURE 7

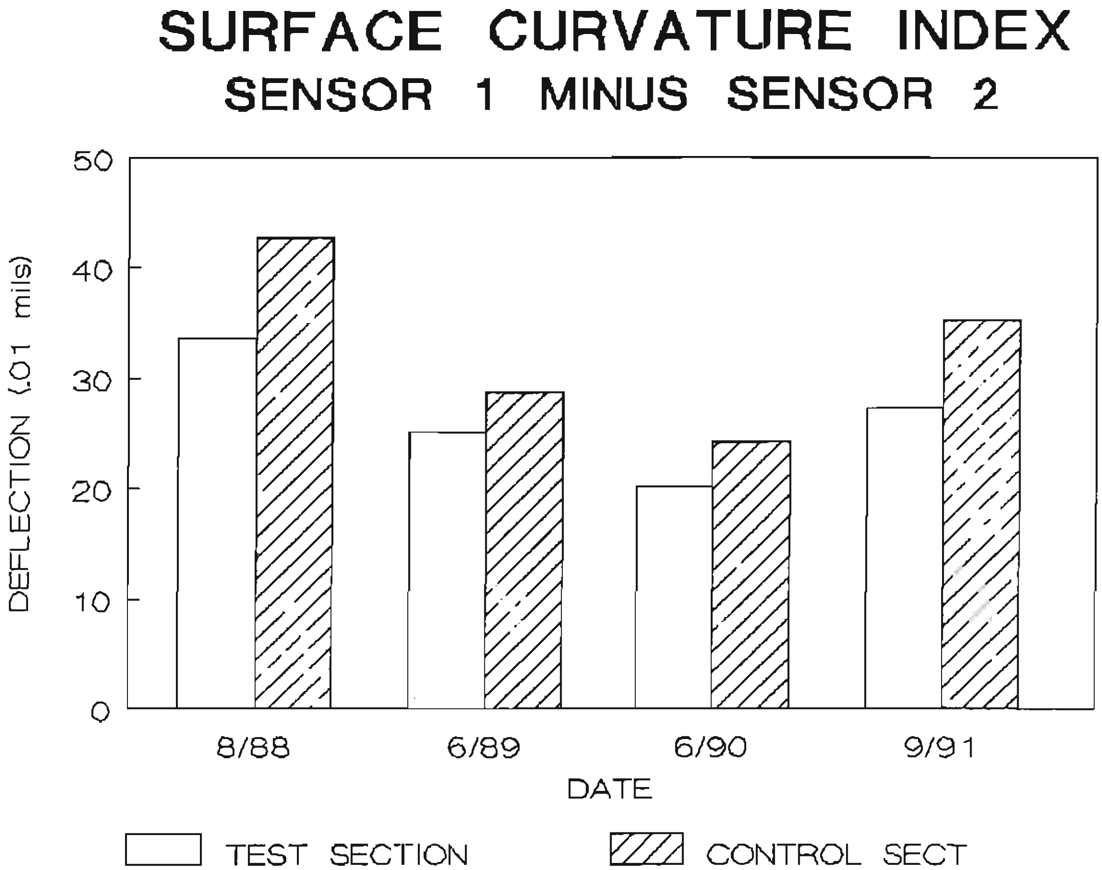
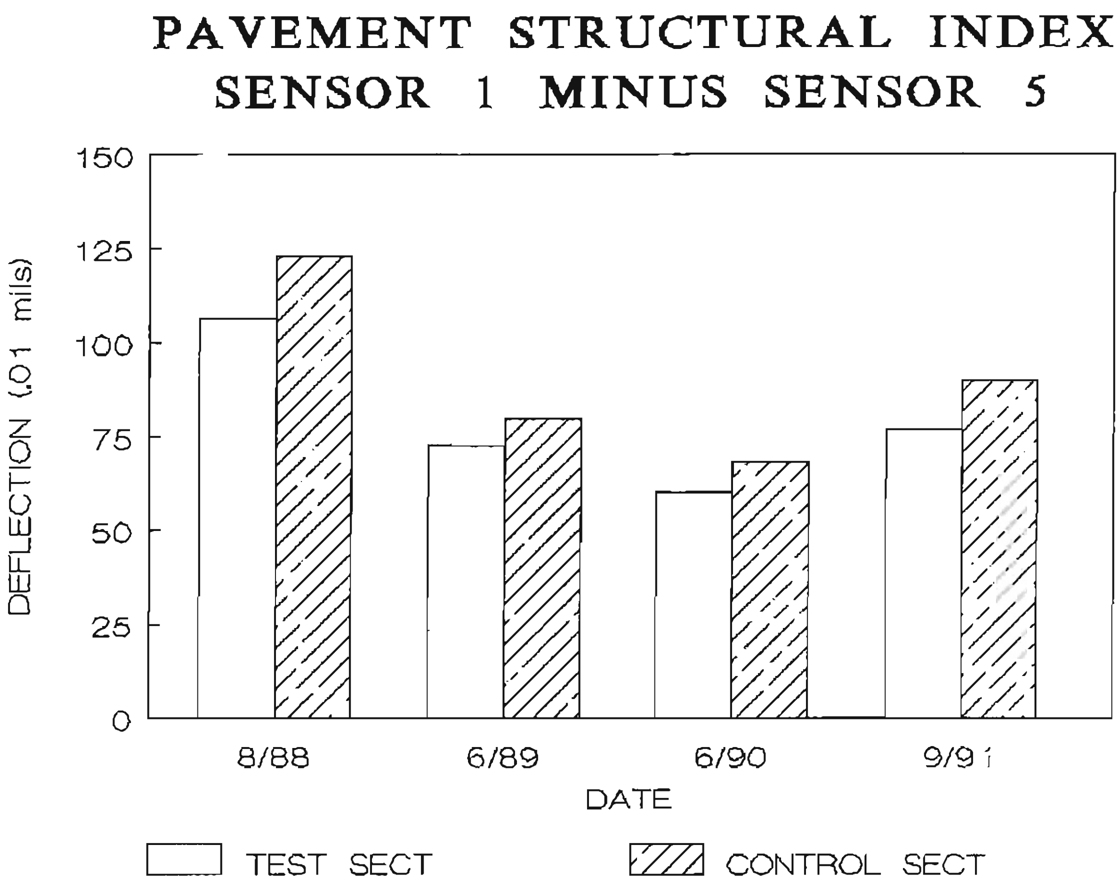

SURFACE CURVATURE INDEX
SENSOR 1 MINUS SENSOR 2
DEFLECTION (.01 mils)
0
10
20
30
40
50
8/88
6/89
6/90
9/91
DATE
TEST SECTION
CONTROL SECT

FIGURE 8


PAVEMENT STRUCTURAL INDEX
SENSOR 1 MINUS SENSOR 5
150
125
100
75
50
25
0
DEFLECTION (.01 mils)
8/88
6/89
6/90
9/91
DATE
TEST SECT
CONTROL SECT

DRIVING LANE
AVERAGE RUT DEPTHS

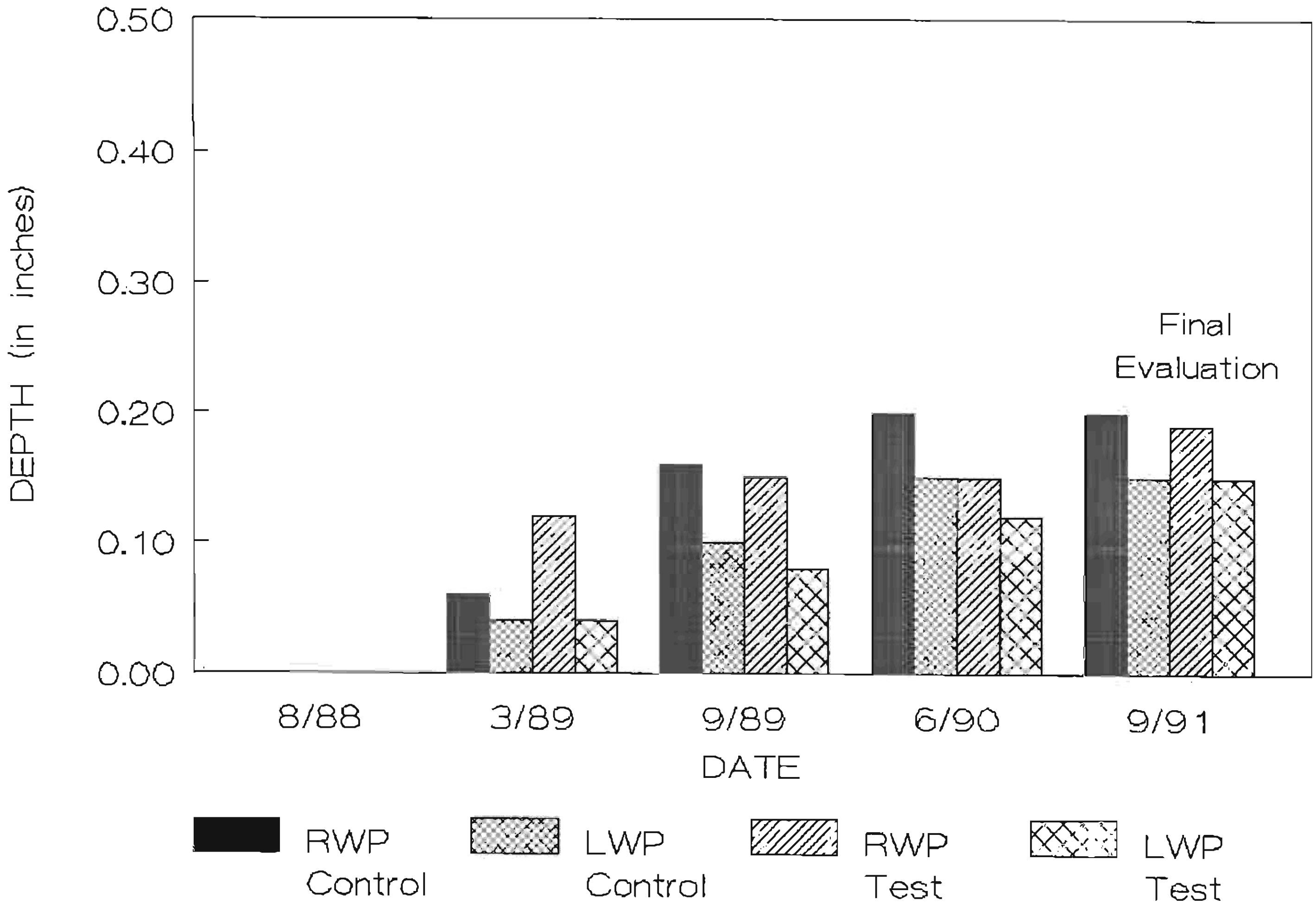


FIGURE 9

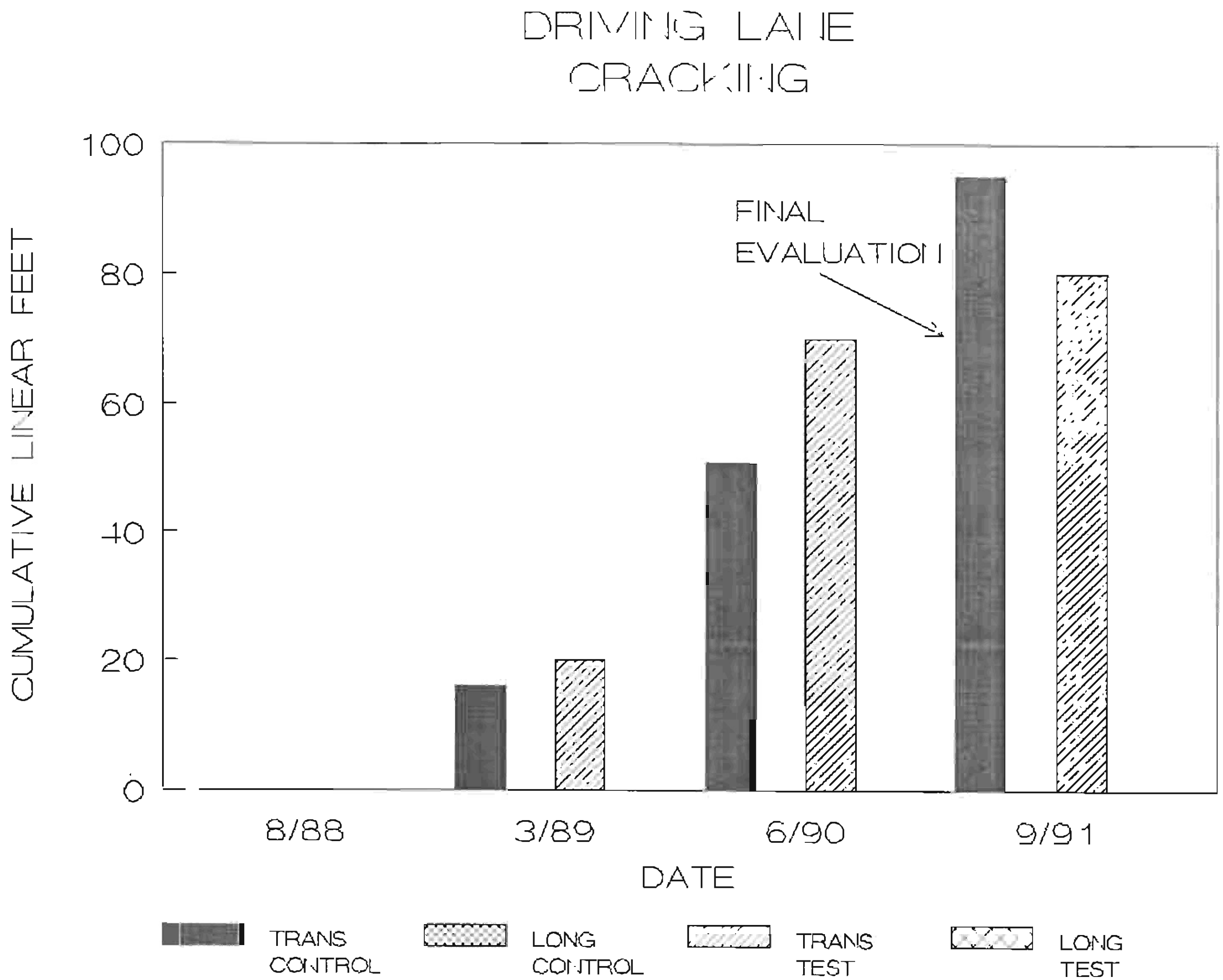

DRIVING LANE
CRACKING
CUMULATIVE LINEAR FEET
0
20
40
60
80
100
FINAL
EVALUATION
8/88
3/89
6/90
9/91
DATE
TRANS
CONTROL
LONG
CONTROL
TRANS
TEST
LONG
TEST

FIGURE 10

V. CONCLUSION

It is very difficult to draw any definitive conclusions in terms of overall pavement performance of the Fiber Pave. The test section which contained the fibers and the control section performed equally well. Both the cracking and rutting at the end of the evaluation for both the test and control sections were minimal. However, with the thickness of the widened section (4-1/2") it is possible that the three year evaluation was not long enough to fully evaluate the pavement's ability to resist cracking.

The deflection evaluation showed the Fiber Pave test section to be slightly stronger than the control section; however, the difference is so small that the added cost of the fibers can not be justified. The unit bid price of the mix containing the fibers was approximately 40% greater than that of the standard mix without fibers. This is based on the bids submitted for this project.

VI. IMPLEMENTATION

Based on the lack of significant performance improvement the added cost of fibers cannot be justified.

APPENDIX A

PROJECT SPECIFICATIONS
AND
FIBER PAVE INFORMATION

August 6, 1987

REVISION OF SECTION 403
HOT BITUMINOUS PAVEMENT (GRADING EX AND PATCHING)
COLORADO PROJECT NO. FR 034-2(10)

Section 403 of the Standard Specifications is hereby revised for this project as follows:

Subsection 403.02 shall include the following:

The hot bituminous mix shall conform to the following:

TABLE 403-1

PROPERTY	TEST METHOD	VALUE
Voids (%)	CPL 5105	4-8*
Stability (S)	CPL 5105	37**
Accelerated Moisture Susceptibility Tensile Strength Retained (Lottman)	CPL 5109	60*
Minimum Design Asphalt Content (%)	CPL 5105	5.4*

*** Applied to acceptance of the source or design mix and not on the project-produced material.**

**** See Revision of Section 401.02, Paragraph No. 8.**

If the Contractor elects to use his own source, the results from his trial design mix must comply with the project specifications and at optimum asphalt content must also equal or exceed the stability value, the R_t value, and the strength coefficient obtained from the trial mix design of the available source at optimum asphalt content.

The asphalt cement for this grading shall be AC-10 Fortified.

Subsection 403.03 shall include the following:

When ordered by the Engineer, a tack coat shall be applied between pavement courses.

Hot bituminous pavement shall not be placed between October 1 and April 1 unless otherwise approved by the Engineer.

The Contractor shall use an approved anti-stripping additive.

-continued-

REVISION OF SECTION 403
HOT BITUMINOUS PAVEMENT (GRADING EX AND PATCHING)
COLORADO PROJECT NO. FR 034-2(10)

The Contractor shall arrange his work such that all roadway pavement placed prior to the time paving operations are specified to end for the year shall be to the full thickness required by the plans. The Contractor's progress schedule shall show the methods he intends to use to conform to this requirement.

In Subsection 403.05 delete the last paragraph and replace with the following:

Haul, aggregate, asphalt recycling agent, additives, and all other work necessary to complete the item will not be paid for separately but shall be included in the unit price bid.

Material used for tack coat and asphalt cement for Hot Bituminous Pavement (Grading EX) will be measured and paid for as provided in Section 411.

Asphalt cement for Hot Bituminous Pavement (Patching) will not be paid for separately but shall be included in the unit price bid.

August 6, 1987

REVISION OF SECTION 403
HOT BITUMINOUS PAVEMENT (GRADING EX)(SPECIAL)
COLORADO PROJECT NO. FR 034-2(10)

Section 403 of the Standard Specifications is hereby revised for this project as follows:

Subsection 403.01 shall include the following:

A portion of the hot bituminous pavement on the project will be produced and placed with a polypropylene fiber in the mixture. It will be added to the mixture during production by the Contractor. This experimental product is known as Fiber Pave 3010 and is manufactured by Hercules, Incorporated. It will be placed full width and full depth in Typical Sections A and B from Station 1097+50 to 1107+50.

The Contractor shall have a technical assistant from Hercules on the project during production and placement of this material.

The local supplier for the Hercules Fiber Pave 3010 is Bowman Construction Supply, Inc., 2310 South Syracuse Way, Denver, CO 80231, Telephone: (303) 696-8960.

Subsection 403.02 shall include the following:

The hot bituminous mix shall conform to the following:

TABLE 403-1

PROPERTY	TEST METHOD	VALUE
++Voids, percent	CPL 5105	3-6
Stability, minimum	CPL 5105	37
Strength Coefficient, minimum	CPL 5105	.44
Accelerated Moisture Susceptibility		
Tensile Strength Retained, minimum	CPL 5109	70
Minimum Design Asphalt Content	CPL 5105	5.8

++Voids criteria are for design mix approval only. They are not to be considered as a specification for production samples.

The asphalt cement for this grading shall be AC-10 (Fortified).

The top lift of the hot bituminous pavement shall not contain any reclaimed material.

-continued-

REVISION OF SECTION 403
HOT BITUMINOUS PAVEMENT (GRADING EX)(SPECIAL)
COLORADO PROJECT NO. FR 034-2(10)

Job Mix Formula - The formula shall include a minimum of 0.3 percent by weight polypropylene fiber. It may be necessary to increase the percentage of bituminous binder nominally 0.3 percent over that in a standard mix to accommodate the fiber surface area. The job mix formula shall be submitted for approval prior to manufacture.

Materials

Fiber - The fiber shall meet the following requirements:

Material:	Polypropylene
Denier:	4 ± 1
Length:	10 ± 2 mm
Crimps:	None
Tensile Strength (PSI) - ASTM D882-83, Method A:	40,000 psi, minimum
Specific Gravity:	0.91 (typical)
Moisture regain at 70°F and 65% RH 1000 hrs:	0.1% (typical)
Acid resistance - 95% Nitric acid solution for 1000 hours at 70°F:	90% tensile strength retained
Alkali resistance - 40% NaOH solution for 1000 hours at 70°F:	100% tensile strength retained

(Fiber Pave 3010 meets the above requirements.)

Subsection 403.03 shall include the following:

Mixing - The mixing plant shall be a weight-batch or continuous-mix type hot plant operated to produce a mixture within the job-mix formula. The aggregate shall be heated to a temperature no higher than 290°F. The polypropylene fiber shall be added to the heated aggregate. If a batch plant is used, the fibers shall be bagged in proper size bags to match the drop capacity of the batch plant. If a pug or continuous asphalt plant is used, the fiber supplier shall supply a fiber feed system to accurately feed the proper quantity of fibers for the plant's production rate. The aggregate and fiber shall be mixed sufficiently to obtain a homogeneous mixture before combining with the asphalt. The asphalt temperature shall not exceed 300°F.

Transportation of Bituminous Mixture - Each load of mixture shall be protected from the weather to prevent loss of heat. Mixtures having temperatures greater than 290°F or less than 245°F at the laydown machine will be rejected.

-continued-

REVISION OF SECTION 403
HOT BITUMINOUS PAVEMENT (GRADING EX)(SPECIAL)
COLORADO PROJECT NO. FR 034-2(10)

Treatment of Underlying Surface - Prior to applying the tack coat and laying a bituminous course, the underlying surface shall be cleaned of loose and foreign matter.

When ordered by the Engineer, a tack coat shall be applied between pavement courses.

Hot bituminous pavement shall not be placed between October 1 and April 1 unless otherwise approved by the Engineer.

The Contractor shall use an approved anti-stripping additive.

The Contractor shall arrange his work such that all roadway pavement placed prior to the time paving operations are specified to end for the year shall be to the full thickness required by the plans. The Contractor's Progress Schedule shall show the methods he intends to use to conform to this requirement.

In Subsection 403.05 delete the last paragraph and replace with the following:

Haul, aggregate, Hercules Fiber Pave 3010, additives, and all other work necessary to complete the item will not be paid for separately but shall be included in the unit price bid.

Material used for tack coat will be measured and paid for as provided for in Section 411.

August 6, 1987

REVISION OF SECTION 410
PLANT MIXED SEAL COAT (TYPE A)
COLORADO PROJECT NO. FR 034-2(10)

Section 410 of the Standard Specifications is hereby revised for this project as follows:

Subsection 410.02 shall include the following:

The Plant Mix Seal Coat shall conform to the following:

TABLE 410-1

PROPERTY	TEST METHOD	VALUE*
Index of Retained Strength (IRS)	CPL 5104	50
Minimum Design Asphalt Content (%)	CPL 5105	7.0%

*Applied to acceptance of the source or design mix and not on the job-produced material.

The asphalt cement for this type shall be AC-20R.

Subsection 410.03(b) shall be revised as follows:

The second sentence shall be changed to read as follows: A tack coat will be required and shall be applied in accordance with Section 407.

In Subsection 410.05 delete the last paragraph and replace with the following:

Haul, aggregate, asphalt recycling agent, additives, and all other work necessary to complete the item will not be paid for separately but shall be included in the unit price bid.

Material used for tack coat will be measured and paid for as provided in Section 411.

August 6, 1987

REVISION OF SECTION 411
BITUMINOUS MATERIALS
COLORADO PROJECT NO. FR 034-2(10)

Section 411 of the Standard Specifications is hereby revised for this project as follows:

Subsection 411.04 is deleted and replaced with the following:

Bituminous materials will be measured as follows: Asphalt cement will be measured as a percentage of the weight of the total mix in which the asphalt cement was used. The percentage will be obtained by averaging the values of all the field acceptance tests run to determine asphalt content for the item. The percentage will be converted to tons of asphalt cement by multiplying the accepted tons of paving mix (Item 403, 410, etc.) by the average value of the field acceptance tests. Emulsified asphalt and liquid asphaltic materials will be measured by the gallon. The pay quantity for emulsified asphalt shall be the number of gallons before dilution with water.

August 6, 1987

REVISION OF SECTION 703
AGGREGATES
COLORADO PROJECT NO. FR 034-2(10)

Section 703 of the Standard Specifications is hereby revised for this project as follows:

Subsection 703.10 shall include the following:

The job mix formula for Plant Mixed Seal Coat (Type A) shall be as follows:

Passing 1/2" sieve	100%
Passing 3/8" sieve	97-100%
Passing #4 sieve	40%
Passing #8 sieve	14%
Passing #200 sieve	5%

In Subsection 703.10, first paragraph, delete the second and third sentences and replace with the following:

100% by weight of the particles retained on the No. 4 sieve shall have at least two fractured faces when tested in accordance with Colorado Procedure 45. Aggregate passing the No. 4 sieve shall be the dust of fracture of crushing rock larger than 1/2 inch.

The aggregates shall have a percentage of wear of not more than 35 when tested in accordance with AASHTO T-96.

HERCULES

FIBER PAVE®

POLYPROPYLENE FIBER FOR HIGHWAY APPLICATIONS

GENERAL PRODUCT INFORMATION

Fiber Pave™ is a short-length polypropylene fiber designed for use as an asphalt reinforcement. This nonhazardous fiber has been engineered to increase the pavement service life of conventional highway paving, patching, crack sealing, and seal coating applications.

Polypropylene is made from propylene (an unsaturated, flammable hydrocarbon, and colorless gas) obtained in the refining of petroleum. It is polymerized (the joining of like molecules) to form a complex molecule that is a very light, chemical and moisture resistant thermoplastic resin in flake form.

To produce fiber, the polypropylene flake is combined with stabilizers and other additives, then heated and extruded through dies to produce filaments. The filaments are gathered together then reheated and stretched to orient the molecules. The amount of stretching controls the fiber strength, elongation, and diameter. During the stretching process, a finish, selected to promote adhesion between the fiber and various types of asphalt, is applied. The axially-oriented fiber is then cut to the desired length and packaged.

Fiber Pave polypropylene fibers are water-insoluble and remain dimensionally stable with changes in humidity. They are also highly durable and offer excellent chemical, weather and abrasion resistance. Most importantly, because polypropylene and asphalt are derived from petroleum, they are chemically compatible and a strong bond forms between the asphalt and polypropylene fiber.

The addition of Fiber Pave to asphalt provides a matrix that is more ductile and stronger than many other treatments. Fiber Pave disperses readily in either hot or cold-mix systems and can be processed in and applied with conventional equipment.

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APPENDIX B

PHOTOGRAPHS

Photo 1

This photo shows the existing pavement and widened sections.

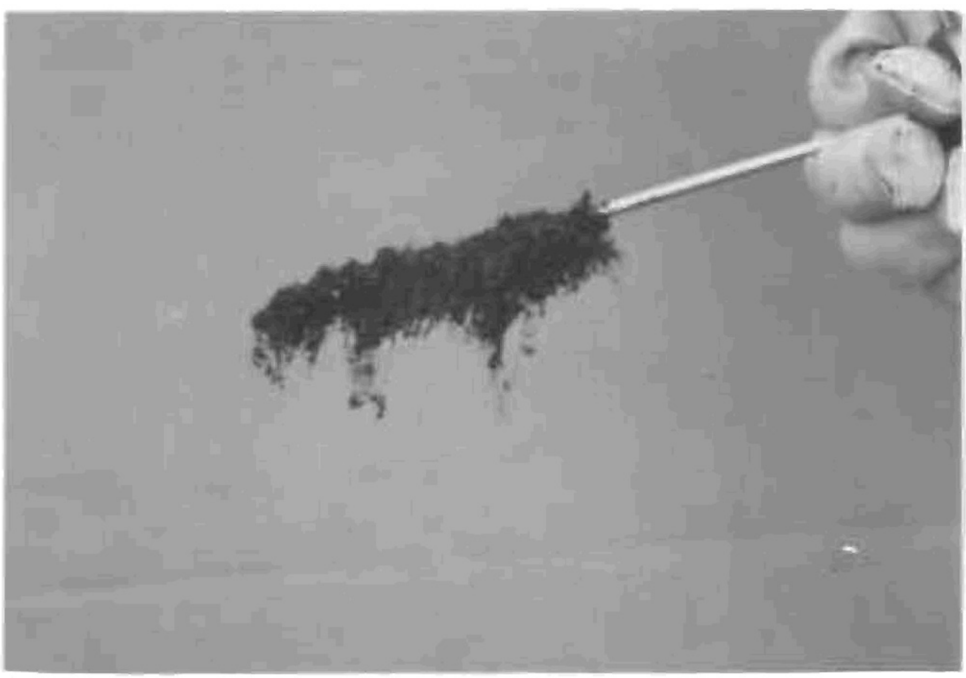

Photo 2

This photo shows the "fuzzy appearance of the mix containing the fibers.

Photo 3

The pneumatic roller picked up pieces of the mat during the rolling process.

Photo 4

This photo shows the condition of the concrete roadway prior to construction. This condition was typical throughout the project.

Photo 5

The cracking pattern in 1992 is similar to the cracking pattern on the original concrete pavement.

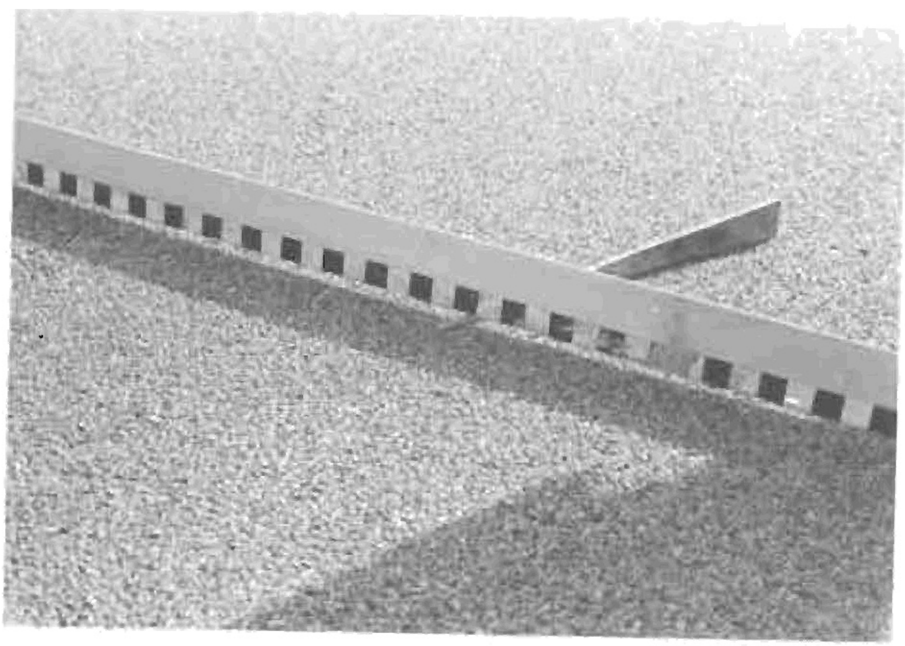

Photo 6

Following the three year evaluation rutting in the test and control sections was minimal.

Photo 7

This photo shows a sympathy crack found in the widened asphalt section.