SR-530 Stanwood Vicinity

Plusride and Bonifibers Pavement Evaluation

WA-RD 147.1
September 1987

Washington State Department of Transportation
Planning, Research and Public Transportation Division

in cooperation with the
United States Department of Transportation
Federal Highway Administration

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
WA-RD 147.1		

4. TITLE AND SUBTITLE	5. REPORT DATE
Plusride and BoniFibers Pavement Evaluation: SR-530, Stanwood Vic.	September 1987
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
James L. Anderson	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NO.
Washington State Department of Transportation Transportation Building, KF-01 Olympia, WA 98504	11. CONTRACT OR GRANT NO. GC6560 Task 9
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AN PERIOD COVERED
Washington State Department of Transportation Transportation Building, KF-01 Olympia, WA 98504	Post-Construction and Annual Report
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

Asphalt mixes modified with the addition of reclaimed rubber granules (PlusRide) and polyester fibers (BoniFibers) were used in a 0.12-ft. overlay of a badly distressed section of AC pavement. The distress consisted of transverse and longitudinal cracking which was reflecting through from the underlying old PCC pavement and severe alligator cracking which was an age related fatigue problem. A section of standard Class B dense graded ACP was also put down to serve as a control section for judging performance.

The three sections are to be monitored over a period of three years to determine the effectiveness of the asphalt additive products in preventing the reflection of the distresses noted in the underlying pavement from showing through in the overlay. The first year inspection revealed that the PlusRide section was showing some longitudinal cracking over the old PCC lane edge. The BoniFibers section was also showing the same longitudinal distress over the lane edge of the underlying PCC plus a small amount of transverse cracking.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
asphalt pavement admixtures, rubber, polyester, reflective crack prevention, PlusRide, BoniFibers	

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified		

PLUSRIDE AND BONIFIBERS PAVEMENT EVALUATION

SR-530, Stanwood Vic.

by
James L. Anderson
Transportation Technician

Post Construction and Annual Report
FHWA Experimental Project No. 3, Asphalt Additives

Prepared for
Washington State Department of Transportation
and in cooperation with
U.S. Department of Transportation
Federal Highway Administration

September 1987

DISCLAIMER

The contents of this report reflects the views of the author who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or the policies of the State or Federal Highway Administration. This report does not constitute a standard, specification, or regulation. The Washington State Department of Transportation does not endorse products, equipment, processes or manufacturers. Trademarks or manufacturer's names appear herein only because they are considered essential.

TABLE OF CONTENTS

INTRODUCTION

There are many asphalt additive products available that have been developed to increase the performance of an asphalt pavement. An asphalt mix modified with the addition of reclaimed rubber granules (PlusRide) and one modified with polyester fibers (BoniFibers) are two such additive products.

The PlusRide asphalt is claimed to have the following list of benefits:

I. Elasticity

- A. Good flexibility in cold weather and high resilience to hot weather which results in fatigue resistance and decreased formation of ice layers.
- B. Decreased reflective cracking.

II. Surface Texture

- A. Wear resistant, antiskid surface.
- B. Limits hydroplaning and decreases spray from other cars.
- C. Reflects less light than conventional pavements.

III. Superior Serviceability

The BoniFibers asphalt is claimed to have the following list of benefits.

- A. Increases resistance to reflection cracking.
- B. Reduces the chance of pothole formation.
- C. Helps reduce the chance of thermal cracking.
- D. Retards the formation of ruts.
- E. Uses standard Class B mix where PlusRide requires a special aggregate grading.

This report will summarize the construction information and test results from the first year of exposure to weather and traffic.

STUDY SITE

The project is located in the northwestern portion of Washington on SR-530 as shown on the accompanying vicinity map. The beginning point is at the Skagit-Snohomish county

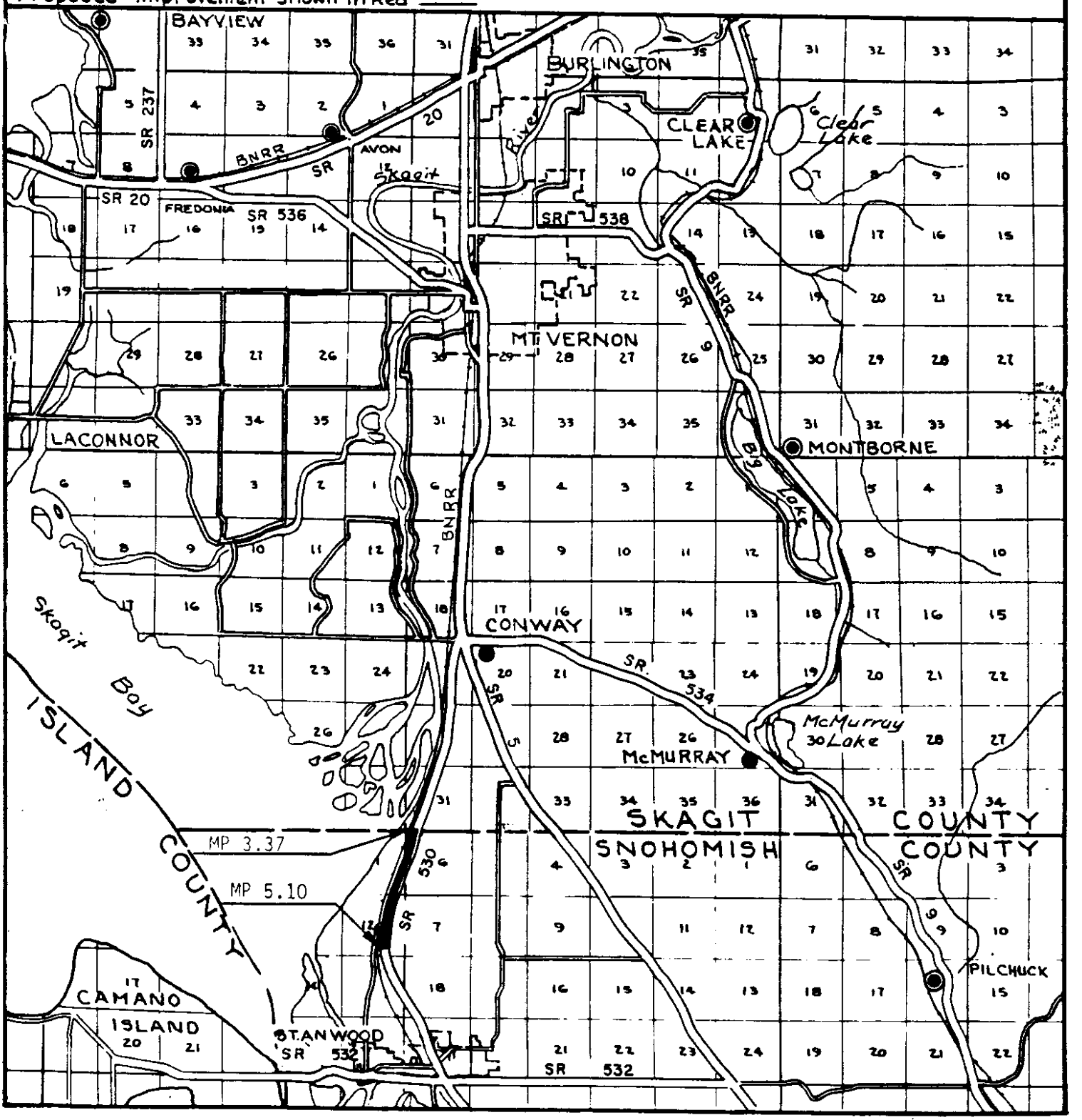
WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

OLYMPIA, WASHINGTON

MAP OF STATE HIGHWAYS

SKAGIT & SNOHOMISH COUNTIES

Proposed Improvement Shown in Red



line, which is M.P. 3.37 and runs South into Snohomish county to M.P. 5.10. This is a secondary highway in a rural area which gets significant extra-wide farm vehicle use.

Rubber Modified Asphalt (PlusRide) and Polyester Modified Asphalt (BoniFibers) were used as a 0.12-ft overlay on SR-530 between Skagit County line and Dahlgren Road in Snohomish County. A conventional overlay of class B ACP was also paved within the same limits. The PlusRide asphalt began at the Skagit County line extending 0.43 miles south with the BoniFibers asphalt beginning at that point and extending another 0.43 miles south. The class B ACP was then placed on the remaining 0.69 miles of the project.

CONSTRUCTION SUMMARY

The paving of the PlusRide asphalt, BoniFibers asphalt, and Class B asphalt was done by Associated Sand & Gravel Company of Everett, Washington. All Seasons Surfacing Corporation of Bellevue, Washington the licensed representative for PlusRide asphalt, provided the technical expertise for the PlusRide portion of the paving. Kapejo Inc., the marketers of BoniFibers, had no technical representative present.

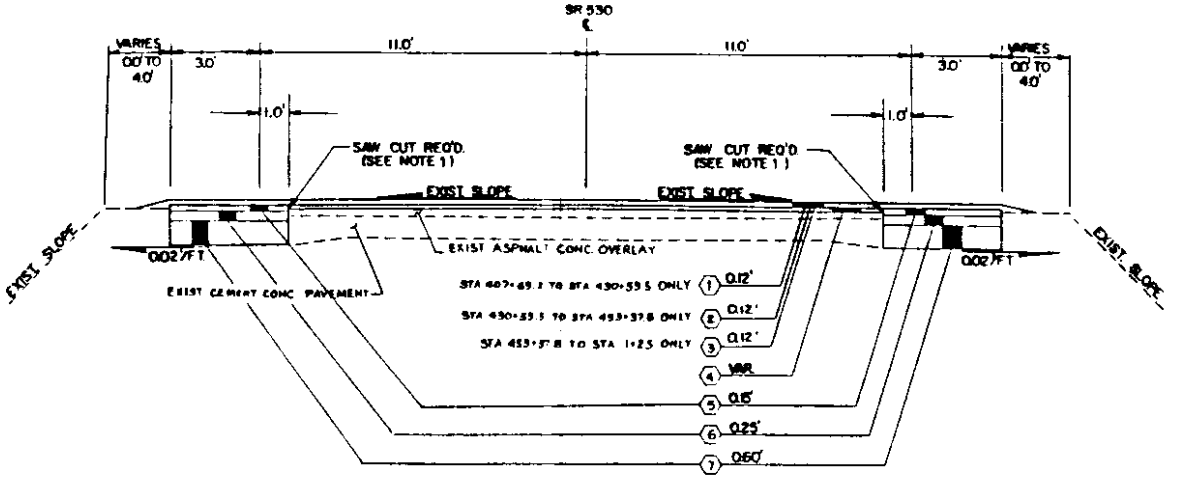
Following is a summary of the construction details for each pavement type. The special contract provisions for the construction of the PlusRide and BoniFibers pavements is located in Appendix A.

Class B: The Class B mix was taken from the plant to the jobsite by typical dump trucks with attached trailers. The temperature of the mix was held between 320 °F - 325 °F. A Blaw-Knox paver placed the material on the roadway. Compaction was accomplished with a 10-ton Ingersol-Rand double-drum vibratory roller for breakdown, followed by a Hyster 8-ton single drum with rubber tire vibratory roller for finish rolling. The paving of the Class B portion of the project which included both prelevel and wearing courses was placed in three days, June 21, 25, & 26, 1985. The weather on all three days was clear with an average high of 75 °F and a low of 59 °F.

No construction problems were experienced with the Class B portion of the paving.

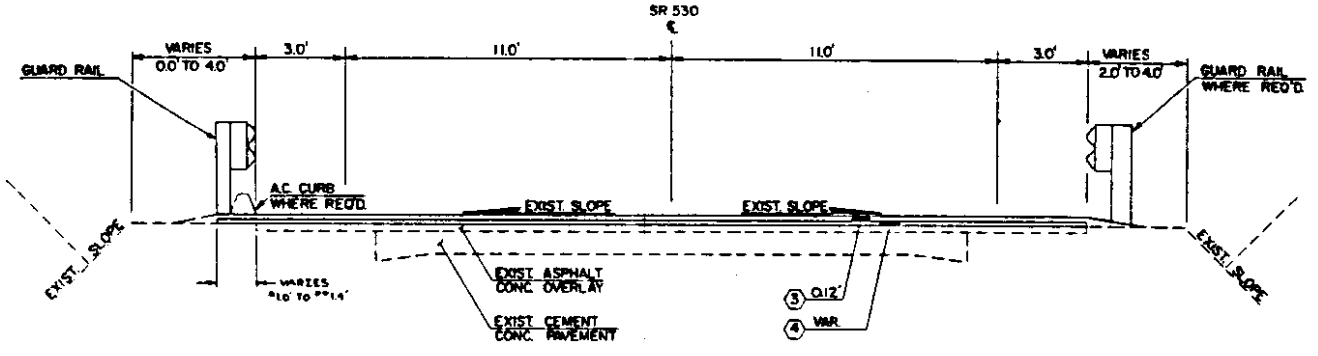
BoniFibers: The BoniFibers were added by hand into the pugmill where it was mixed for 30 seconds. The AR-4000W asphalt was then added and mixed with the aggregate and BoniFibers, the temperature of the mix was held at 325 °F. The BoniFiber mix was transported to the jobsite in Contrail trucks. A Blaw-Knox paver placed the material on the roadway, which was then compacted with a Ingersol Rand DA-50

ROADWAY SECTIONS



ROADWAY SECTION A

407+69.2 TO 1+25



ROADWAY SECTION B

1+25 TO 10+10
* 1+25 TO 2+15 (LT.)
** 2+15 TO 10+10 (LT.)

LEGEND

1. RUBBER MODIFIED ASPHALT CONCRETE PAVEMENT
2. POLYESTER MODIFIED ASPHALT CONCRETE PAVEMENT
3. ASPHALT CONCRETE PAVEMENT CLASS B (WEARING COURSE)
4. ASPHALT CONCRETE FOR PRELEVELING CLASS B (300 TON/LANE MI
5. ASPHALT CONCRETE PAVEMENT CLASS B (BASE COURSE)
6. CRUSHED SURFACING TOP COURSE
7. SHOULDER BALLAST

ALL SURFACING AND PAVING DEPTHS SHOWN ARE COMPACTED DEPTHS.

double-drum vibratory roller for breakdown, followed by a Hyster C625 single-drum vibratory roller for finish rolling. The BoniFibers asphalt was placed in one day, June 28, 1985. The weather was clear with a high temperature of 78 °F and a low of 60 °F.

The problems associated with this portion of the paving were in the mixing procedures at the plant. Because the BoniFibers were added to the pugmill by hand in 10-lb polyethylene bags, a signal system was set up to notify the workman when the bags were to be added. In one instance a signal was missed and one bag was added late, just as the batch was dropped to the flight elevator. This did not allow the fibers to mix in the batch so there were balls of unmixed fibers which had to be hand picked out of the mix. Also there was a delay of approximately two weeks in getting the polyester fiber because of there being only one supplier who is located in Wilmington, Delaware.

PlusRide: The granulated rubber was added at the pugmill by hand. This was mixed for 15 seconds with the aggregate before adding the AR-4000W. The temperature of the mix was held at 325 °F. A Blaw-Knox paver placed the material on the roadway where it was compacted with an Ingersol Rand double-drum vibratory roller for break down, followed by a Hyster 10-12 ton static double-drum roller and a Hyster 8-10 ton static double-drum roller for finish rolling. The PlusRide asphalt was placed in one day, July 12, 1985. The weather was clear with a high temperature of 78 °F and a low of 61 °F.

The problems associated with this portion of the paving were in the testing procedure's at the plant. These procedures had to be modified because of the rubber. For example, to determine the gradation, all the rubber must be removed from the mix. The rubber granules will float on the stripping solvent and need to be skimmed off before drying and gradation testing of the aggregate which is quite time consuming.

ECONOMICS

The bid price for the 645 tons of PlusRide asphalt was $55/ton, for the 645 tons of BoniFibers asphalt was $45/ton, and for the 3,165 tons of Class B asphalt was $27/ton.

TEST RESULTS

A summary of the laboratory test results from all three pavement sections is given in Table 1. A complete listing of all test results is included as Appendix B.

Table 1. Laboratory test results.

TEST	PLUSRIDE	CLASS B	BONIFIBERS
Density	138.2	145.0	143.8
Percent Voids	5.1	4.2	6.5
Stability	6	42	39
Cohesion	60	195	285
140 °F Viscosity	1263	4370	4429
275 °F Viscosity	372	498	494
Penetration	128	38	36
Percent Asphalt	7.8	5.4	6.0

DISCUSSION OF RESULTS

The Hveem stability and cohesion values for the PlusRide are low in comparison with either the Class B or BoniFibers mixes. The cohesion value of the BoniFibers mix is substantially higher than the control section of Class B due to the presence of the fibers. The viscosities of the asphalt in the BoniFibers and Class B mixes are virtually identical whereas the PlusRide viscosities are much lower, especially at the 140 degree F temperature. This is possibly due to less oxidation of the asphalt cement in the pug mill because of the higher percentage of asphalt and resultant thicker asphalt films on the aggregate particles. The resilient modulus values of the PlusRide and BoniFibers cores were lower than the Class B (see Graph 1 and 3, Appendix B). The retained strengths after Lottman conditioning as measured by the resilient modulus test were in approximately the same range for both the Class B and the BoniFibers cores, but were greater for the PlusRide cores (see Graph 2 and 4, Appendix B).

PERFORMANCE EVALUATIONS

Friction Resistance

The following are the friction testing results for the PlusRide, BoniFibers, and Class B asphalt overlays. The friction testing was done the first time on October 10, 1985 approximately three months after construction, and the second time on August 5, 1986.

The following numbers given are the highs, the lows, and the averages for each section on each date tested.

October 10, 1985

	PlusRide	BoniFibers	Class B
HIGH -	42.7	60.6	56.4
LOW -	40.7	50.2	44.5
AVG. -	42.4	56.2	51.9

August 5, 1986

	PlusRide	BoniFibers	Class B
HIGH -	48.3	57.2	54.3
LOW -	42.1	47.7	46.6
AVG. -	44.4	51.1	49.8

Cracking

A survey of the three test sections was done on May 31, 1985, prior to construction, and again on November 20, 1986. The surveys included the mapping and measuring of the total lineal feet of cracking. Following is a summary of each section.

PlusRide: The 1985 pre-construction survey showed a large amount of transverse cracking and places of severe alligator cracking in this section, which was reflected from the underlying old PCCP. No longitudinal cracking was present. The 1986 survey following construction revealed that none of the transverse and alligator cracking had reflected through the PlusRide. A small amount of longitudinal cracking (37

feet total) was present above the edge of the old pavement. This cracking was due to improper shoulder preparation prior to the PlusRide overlay.

BoniFibers: In the 1985 survey this section also showed a large amount of transverse cracking and some longitudinal cracking (50 feet) which was reflected from the old PCCP. In 1986 there was a large amount of longitudinal cracking (544 feet) along the outside edge of the old pavement due to the improper shoulder preparation (see photo, pg.44). Also, 12 feet of the transverse cracking had reflected through the BoniFibers asphalt (see same photo).

Class B: The 1985 survey in this section also showed a large amount of transverse and some longitudinal cracking which was reflected from the original PCCP. The 1986 survey showed 540 feet of longitudinal cracking along the old pavement edge and 64 feet of transverse cracking, of which 43 feet appeared to be caused by thermal expansion. The remaining 21 feet of the transverse cracking occurred over a replaced culvert which may have settled due to improper compaction and resulted in the cracking of the pavement.

Raveling

There is only one place in the PlusRide section that raveling has occurred, Sta. 411+19 (see photo, pg.44). This is possibly due to fact that the asphalt during the laydown is sticky and may have been loosened by the roller during compaction. No other raveling has occurred in any of the other sections.

Rutting

No measurable rutting occurred in any of the sections as of this report.

Deflection Measurements

No post-construction deflection measurements have been taken as of this report.

APPENDIX A

Contract Special Provisions

The stabilometer test value shown in section 9-03.8(2) of the standard specifications is revised to be a minimum of 30 when the asphalt concrete contains 50 percent or more recycled materials.

ASPHALT CONCRETE PAVEMENT
(August 16, 1982)

This work shall consist of plant-mixed asphalt concrete placed on the prepared surface in accordance with these special provisions and the applicable requirements of section 5-04 of the standard specifications.

The Contractor shall have the option of utilizing asphalt concrete removed under this contract, if any, or old asphalt concrete from an existing stockpile, or supplying all new materials in the production of the asphalt concrete pavement or any approved combination of the foregoing. If removed from an existing stockpile, the old asphalt concrete to be used must be uniform in gradation, asphalt content, and asphalt viscosity. If not from an identified and approved source, the aggregates must meet degradation and hardness requirements. Should the Contractor elect to use 10% or less of recycled materials, the recycled materials need not be uniform as long as the asphalt concrete meets the specifications for the class specified.

If asphalt concrete planings or old asphalt concrete are utilized in the production of asphalt concrete, they shall be sized prior to entering the mixer so that a uniform and thoroughly mixed asphalt concrete is produced in the mixer. If there is evidence of the old asphalt not breaking down during the heating and mixing of the asphalt concrete, the Engineer may elect to modify the maximum size entering the mixer. No contamination by deleterious materials will be allowed in the old asphalt concrete used.

The new paving asphalt (AR-4000W) shall meet the specification requirements listed in section 9-02.1(4) of the standard specifications.

The gradation for the new mineral aggregate used in the production of the asphalt concrete shall be the responsibility of the Contractor, and when combined with recycled material, if any, the combined material shall meet the gradation specification requirements for the specified Class ACP as listed in section 9-03.8(6) of the standard specifications or as shown in these special provisions. The new mineral aggregate shall meet the general requirements listed in section 9-03.8(1) of the standard specifications and shall meet the appropriate Fracture and Sand equivalent requirements as listed in section 9-03.8(2) of the standard specifications.

The recycling agent selected by the Contractor shall meet the specification requirements listed elsewhere in these special provisions for the grade he selects.

When old asphalt concrete is proposed for inclusion in the mix (either from materials obtained from this project or an existing stockpile), the Contractor shall submit his design for approval, including representative samples taken in the presence of the Engineer, and the approximate proportions of the various materials (old asphalt concrete, new aggregate, recycling agent, new paving asphalt) to be used. Upon tentative approval of approximate proportions proposed by the Contractor, the materials will be proportioned together for a job mix design. Approval of the mix design shall be based upon meeting the specification requirements of section 9-03.8(2) of the standard specifications for the specified Class ACP or as shown in these special provisions. In addition, for mix design approval, the blend of recovered paving asphalt plus recycling agent and additional paving asphalt shall meet the requirements for AR-4000W in accordance with section 9-02.1(4) of the standard specifications. The Contractor shall allow 15 working days for this approval and design once the material has been received at the Materials Laboratory. Additional time may be required if the proportions will not make an adequate design, as determined by the Engineer, or if the Contractor requests more than one rejuvenator or paving asphalt source approval. The Contractor is also advised that production of the asphalt concrete shall not commence until the job mix design has been established.

Asphalt concrete pavement Class *** B *** will be measured by the ton with no deduction being made for the weight of the paving asphalt or any other component of the mixture.

For the purpose of asphalt cement adjustment computations and paving asphalt revision quantities, if any, the new paving asphalt and recycling agent, if any, will be measured by the ton with the quantity determined from production data. The State reserves the right to make random checks of the gross and tare weights of the transport equipment at the time of delivery, as well as measuring the paving asphalt volume in the storage tank prior to and after the deposit from the transport vehicle.

The unit contract price(s) per ton for *** "Asphalt Conc. For Preleveling Cl. B Incl. Paving Asphalt" and "Asphalt Concrete Pavement Class B Incl. Paving Asphalt" *** shall be full compensation for furnishing all labor, equipment, tools and materials, including the cost involved with the furnishing of recycling agent, if any, and the furnishing of paving asphalt, necessary to produce and place the asphalt concrete pavement as specified.

RUBBER MODIFIED ASPHALT CONCRETE PAVEMENT

This work shall consist of placing Plusride Asphalt on those portions of the roadway shown in the plans.

Plusride Asphalt is a patented process licensed by:

All Seasons Surfacing Corporation
1017 NE 4th Street, Suite No. 1
Bellevue, WA 98004
(206) 454-3830

The Contractor shall arrange to have a technical representative of All Seasons Surfacing Corporation on the project while Plusride is being mixed or placed.

The rubber modified asphalt concrete shall consist of granulated rubber added to the aggregate phase of an asphalt concrete mixture.

The standard specifications for asphalt concrete shall be applicable except for the following:

Materials

The materials used in this rubber modified asphalt concrete shall have the following properties:

Asphalt

The asphalt shall be AR-4000W conforming to section 9-02.1(4) of the standard specifications. The percent of asphalt required in this mixture shall be between 7.5 and 9.5 percent.

Granulated Rubber

The granulated rubber and cord fibers shall be ground from rubber tires and shall meet the following gradation:

Sieve	Percent Passing by Weight
1/4	100
No. 4	76-100
No. 10	28-42
No. 20	16-24

Aggregate

The aggregate shall meet the general requirements of section 9-03.8(1) of the standard specifications and in addition shall meet the following specifications:

Sieve	Percent Passing by Weight
5/8	100
3/8	60-80
1/4	30-44
No. 10	20-32
No. 30	13-25
No. 200	8-12

Fracture 75% minimum
Sand Equivalent 45 minimum

Mineral filler is usually required to meet the minimum 200 material requirements.

Blending and Mixing

A representative sample of the total paving mixture, which meets the mix requirements, shall be produced prior to producing the mix for the project paving.

The construction requirements set forth in section 5-04.3(1)B of the standard specifications shall be supplemented by the following:

The amount of granulated rubber shall be determined by a method which uniformly feeds the mixer within ± 0.15 percent.

The components of the rubber modified asphalt concrete shall be combined in the following order and proportions:

1. Add mineral aggregate
2. Add rubber granules at 3.0 percent by weight of the total mix (60 lb/ton)
3. Mix for 15 seconds
4. Add the design asphalt content
5. Mix normal time

The construction requirements set forth in section 5-04.3(1)D of the standard specifications shall be supplemented by the following:

Granulated rubber introduced into the mixer shall be drawn from storage bins by a continuous mechanical feeder which will uniformly feed the mixer within ± 0.15 percent.

The plant shall be equipped with a heat shield or other means to prevent the open flame from coming in contact with the granulated rubber.

The first sentence of the third paragraph of section 5-04.3(8) of the standard specifications is deleted and the following substituted:

> The temperature of the mix at discharge shall be between 325% F. and 360% F. for batch plants or between 300% F. and 325% F. for drum mixer plants.

Mix Design

The Contractor shall submit to the Engineer a rubber modified asphalt concrete mix design that has been agreed to by the patent holder.

Job Mix Tolerances

All mix furnished for the project shall conform to the approved job-mix formula within the following ranges of tolerances:

Sieve Size	Percent Passing
3.8" or 1/4"	± 6
No. 10 or No. 30	± 4
No. 200	± 2
Gap Grading Percent	± 4
Asphalt Percent	± 0.4
Rubber Percent	± 0.15*

*Not determinable by extraction testing.

The plant shall be equipped to feed mineral filler into the mix within an accuracy of 0.5 percent.

Spreading and Finishing

Section 5-04.3(9) of the standard specifications is deleted and replaced with the following:

> The mixture shall be laid upon an approved surface, spread and struck off to the grade and elevation established. Special care must be taken to obtain a good joint as it may be difficult to hand rake this material. Asphalt pavers complying with section 5-04.3(3) shall be used to distribute the mixture.
>
> A CSS-1 tack coat shall be applied and shall consist of 0.06-0.08 gallon/square yard of retained asphalt. The spraying temperature shall be from 70% to 140% F.
>
> On areas where irregularities or unavoidable obstacles make the use of mechanical spreading equipment impractical, the paving may be done with other equipment or by hand.

Compaction

Asphalt rollers and compaction procedures shall conform with the standard requirements and supplemented with the following:

Breakdown compaction should begin immediately behind the paving machine. However, some delay may be required to prevent roller pickup. The roller drums must be kept well watered and a wetting agent may be necessary to decrease the occurrence of roller pickup.

Breakdown compaction shall be accomplished using a 10-12 ton vibratory or static steel roller. The roller must apply a minimum force of 250 pounds per linear inch of drum width to the pavement surface.

An 8-10 ton tandem steel roller shall be used for finish rolling. Finish rolling of the mat shall continue until the temperature of the mat has dropped below 140%F or until elastic movement under the roller is no longer observed.

The proper rolling procedure shall be established with a control strip to determine equipment and number of coverages necessary to obtain the target density. The target density, as a percentage of maximum theoretical density, shall be 95% to 98% (2% to 5% air voids).

Measurement

Section 5-04.4 of the standard specifications is supplemented with the following:

Measurement of the rubber modified asphalt concrete will be by the ton and will include the granulated rubber, the asphalt cement and any other component of the mix.

Payment

Section 5-04.5 of the standard specifications is supplemented with the following:

The unit contract price per ton for "Rubber Modified Asphalt Concrete Pavement" shall be full compensation for furnishing all labor, equipment, materials, supplies, and royalties (if any) required in the construction of this material as specified.

POLYESTER MODIFIED ASPHALT CONCRETE PAVEMENT

This work shall consist of mixing, placing and compacting asphalt concrete that has had polyester fibers introduced at the time of mixing.

The polyester fibers are produced by:

KAPEJO, INC.
115 Valley Road
Wilmington, DE 19804

The polyester fibers shall be added at the plant prior to the beginning of the asphalt charge. The standard specifications for asphalt concrete shall be applicable along with the following:

Polyester Fibers
The polyester fibers shall be BoniFibers "B" as follows:

Average Length	0.25 inch
Average Diameter	0.0008 inch ± 0.0001
Specific Gravity	1.32 to 1.40
Melt Temperature	480% F minimum
Ignition Temperature	1000% F minimum
Tensile Strength	75,000 p.s.i. ± 5,000 p.s.i.
Break Elongation	33 percent ± 9 percent

Aggregate
The aggregate shall meet the requirements of section 9-03.8 of the standard specifications for asphalt concrete pavement Class B.

Blending and Mixing
The construction requirements set forth in section 5-04.3(1)B of the standard specifications shall be supplemented by the following:

The polyester fibers shall be added at the rate of five (5) pounds per ton of mix. They shall be added in unopened bags directly in to the mixer along with the dried aggregate at the beginning of the dry-mix cycle. The fibers shall be mixed with the aggregate for at least 30 seconds prior to the introduction of the asphalt. A minimum of 30 seconds mixing time shall follow the introduction of the asphalt.

The construction requirements set forth in section 5-04.3(1)C and 5-04.3(1)D of the standard specifications shall be supplemented by the following:

The polyester fibers shall be added at a rate which will produce mix having five (5) pounds of fiber per ton. The fibers shall be introduced using a metered vane-feeder before the addition of the asphalt, or if there is an opening for feeding recycled material, the fibers shall be added continuously in the specified proportions at that opening. Fibers shall not be added with the aggregate before the aggregate is dried.

Measurement

The requirements set forth in section 5-04.4 of the standard specifications are supplemented by the following:

Measurement of the polyester modified asphalt concrete will be by the ton and will include the polyester fibers, asphalt cement, blending sand and any other component of the mix.

Payment

The unit contract price per ton for "Polyester Modified Asphalt Concrete Pavement" shall be full compensation for furnishing all labor, equipment, materials, supplies and royalties (if any) required for the construction of this material as specified.

PAVING ASPHALT REVISION
(January 18, 1982)

Should the amount of new paving asphalt and recycling agent, if any, incorporated into the mix vary by more than $\pm$ 0.3 percent of the amount determined from the mix design when shown elsewhere in these special provisions, an adjustment in payment shall be made. If there is no asphalt content shown in the special provisions, or if the Contractor furnishes aggregates for a job mix design that require a different asphalt content than that shown in the special provisions, a new asphalt content shall be established and used to calculate the adjustment varying from the job mix design by more than $\pm$ 0.3 percent. The adjustment in payment (plus or minus) shall be based on the average refinery prices as defined elsewhere in these special provisions. A new contract item, Paving Asphalt Revision, will be established for material varying from the appropriate mix design by more than $\pm$ 0.3 percent.

FEATHERING ASPHALT CONCRETE PAVEMENT
(November 2, 1981)

Where directed by the Engineer, the Contractor shall feather the asphalt concrete pavement overlay in a manner to produce a smooth riding connection to the existing pavement.

Asphalt concrete pavement Class *** B and Rubber Modified Asphalt Concrete Pavement ***, utilized in the construction of the feathered connections to existing pavement, shall be modified by eliminating the coarse aggregate from the mix at the Contractor's plant or the commercial source from which the Contractor obtains the mix or by raking the joint on the roadway, to the satisfaction of the Engineer.

All costs and expenses in connection with providing, placing and feathering the asphalt concrete pavement shall be incidental to and included in the unit contract price per ton for *** "Asphalt Concrete Pavement Class B Incl. Paving Asphalt" and "Rubber Modified Asphalt Concrete Pavement" ***.

APPENDIX B

Quality Control Test Results

CLASS B

Field Lab Extraction Results

Sieve Size	Sample #1 (Ext.)	Sample #2 (Ext.)	Sample #3 (Ext.)	Sample #4 (Q.W.)	Contract Spec's
5/8"	100	100	100	100	100
1/2"	98	97	96	97	90 -100
3/8"	84	82	84	84	75 - 90
1/4"	69	65	66	68	55 - 75
#10	42	39	41	40	32 - 48
#40	19	18	19	18	11 - 24
#80	9	10	10	9	6 - 15
#200	5.6	5.8	5.9	5.8	3 - 7
% Asphalt	5.4	5.5	5.4	5.4	4.0 - 7.5
Sand/Silt	7.5	6.7	6.9	6.9	5.5 -10.5

CLASS B

H.Q. Lab Mix Sample Test Results

	(Ave. of 8)	(Range)
Density	151.7	151.3 - 152.4
% Voids	2.1	1.7 - 3.0
Stability	42	37 - 46
Cohesions	195	159 - 229
Gradation		
5/8"	100	100
1/2"	96	94 - 98
3/8"	83	82 - 84
1/4"	66	63 - 68
#10	40	38 - 43
#40	20	18 - 23
#80	10	9 - 10
#200	5.8	5.2 - 6.2
Sand/Silt	6.9	6.3 - 7.5
% Asphalt	5.3	4.9 - 5.8
140 ^{0}F Viscosity	2921	2606 - 3411
	(Ave. of 3)	
275 ^{0}F Viscosity	436	432 - 441
Penetration	50	46 - 54

CLASS B

H.Q. Core Sample Test Results

	(Ave. of 5)	(Range)
Density	145.0	144.2 - 146.5
% Voids	4.2	3.2 - 4.7
Gradation		
5/8"	100	100
1/2"	97	95 - 98
3/8"	85	80 - 88
1/4"	69	66 - 74
#10	42	39 - 45
#40	20	18 - 24
#80	10	9 - 11
#200	6.0	5.4 - 6.2
Sand/Silt	6.9	6.6 - 7.4
% Asphalt	5.4	5.3 - 5.9
140^0F Viscosity	4370	3867 - 4768
275^0F Viscosity	498	454 - 589
Penetration	38	35 - 41
Resilient Modulus		
MR @ 41^0F (.05 sec.)	1.23×10^6	8.77×10^5 - 1.54×10^6
(.10 sec.)	1.26×10^6	1.04×10^6 - 1.52×10^6
MR @ 77^0F (.05 sec.)	3.07×10^5	2.44×10^5 - 3.74×10^5
(.10 sec.)	2.06×10^5	1.57×10^5 - 2.39×10^5
(Lottman Conditioned)		
MR @ 77^0F (.05 sec.)	2.56×10^5	1.98×10^5 - 3.16×10^5
(.10 sec.)	1.79×10^5	1.30×10^5 - 2.43×10^5

PLUSRIDE

Job Mix Design

Sieve Size	Percent Passing	Tolerance
5/8"	100	
3/8"	67	± 6
1/4"	38	± 6
#10	26	± 4
#30	18	± 4
#200	8	± 2
% Asphalt	7.5	± 0.4
% Rubber	3.0	± 0.15

Field Lab Extraction Results

Sieve Size	Sample #1 (extraction)	Sample #2 (quickwash)	Contract Specifications
5/8"	100	100	100
3/8"	76	75	60 - 80
1/4"	37	48	30 - 44
#10	21	27	20 - 32
#30	14	16	13 - 25
#200	6.7	7.1	8.0 - 12.0
% Asphalt	7.2	---	7.5 - 9.5

PLUSRIDE

H.Q. Lab Mix Sample Test Results

	(Ave. of 5)	(Range)
Density	141.7	139.7 - 144.8
% Voids	2.7	1.8 - 4.2
Stability	6	3 - 9
Cohesions	60	48 - 85
Gradation		
5/8"	100	100
3/8"	75	72 - 77
1/4"	41	34 - 46
#10	25	18 - 32
#30	17	12 - 24
#200	6.9	4.4 - 10.5
Sand/Silt	3.7	3.1 - 4.4
% Asphalt	7.7	6.6 - 8.5
140^0F Viscosity	1098	1022 - 1650
275^0F Viscosity	367	286 - 462
Penetration	106	96 - 119

PLUSRIDE

H.Q. Core Sample Test Results

	(Ave. of 5)	(Range)
Density	138.2	135.6 - 139.5
% Voids	5.1	4.2 - 6.9
Gradation	(Ave. of 10)	
5/8"	100	100
3/8"	78	72 - 80
1/4"	39	37 - 51
#10	25	20 - 30
#30	16	13 - 19
#200	6.3	4.6 - 7.8
Sand/Silt	4.0	2.8 - 5.2
% Asphalt	7.8	6.2 - 9.8
140^0F Viscosity	1263	402 - 2090
275^0F Viscosity	372	253 - 484
Penetration	128+	76 - 250+
Resilient Modulus		
MR @ 41^0F (.05 sec.)	9.67×10^5	6.35×10^5 - 1.22×10^6
(.10 sec.)	8.85×10^5	4.41×10^5 - 1.23×10^6
MR @ 77^0F (.05 sec.)	1.17×10^5	3.74×10^4 - 1.77×10^5
(.10 sec.)	8.32×10^4	2.38×10^4 - 1.51×10^5
(Lottman Conditioned)		
MR @ 77^0F (.05 sec.)	1.13×10^5	2.86×10^4 - 2.01×10^5
(.10 sec.)	7.79×10^4	1.68×10^4 - 1.57×10^5

BONIFIBERS

Field Lab Extraction Results

Sieve Size	Sample #1 (extraction)	Sample #2 (quickwash)	Contract Specifications
5/8"	100	100	100
1/2"	96	98	90 - 100
3/8"	80	81	75 - 90
1/4"	62	65	55 - 75
#10	39	39	32 - 48
#40	18	19	11 - 24
#80	8	10	6 - 15
#200	4.4	6.0	3 - 7
% Asphalt	5.6	---	4.0 - 7.5
Sand/Silt	8.9	6.5	5.5 - 10.5

BONIFIBERS

H.Q. Lab Mix Sample Test Results

	(Ave. of 5)	(Range)
Density	149.9	149.4 - 150.4
%Voids	2.5	2.0 - 3.2
Stability	39	33 - 45
Cohesions	285	139 - 363
Gradation		
5/8"	100	100
1/2"	96	94 - 98
3/8"	83	80 - 86
1/4"	65	62 - 68
#10	40	37 - 44
#40	21	19 - 25
#80	10	9 - 10
#200	5.5	4.9 - 5.8
Sand/Silt	7.3	6.4 - 8.0
% Asphalt	5.4	5.1 - 5.6
140^0F Viscosity	6029	3089 - 13,994
	(Ave. of 3)	
275^0F Viscosity	487	472 - 511
Penetration	36	21 - 55

BONIFIBERS

H.Q. Lab Core Sample Test Results

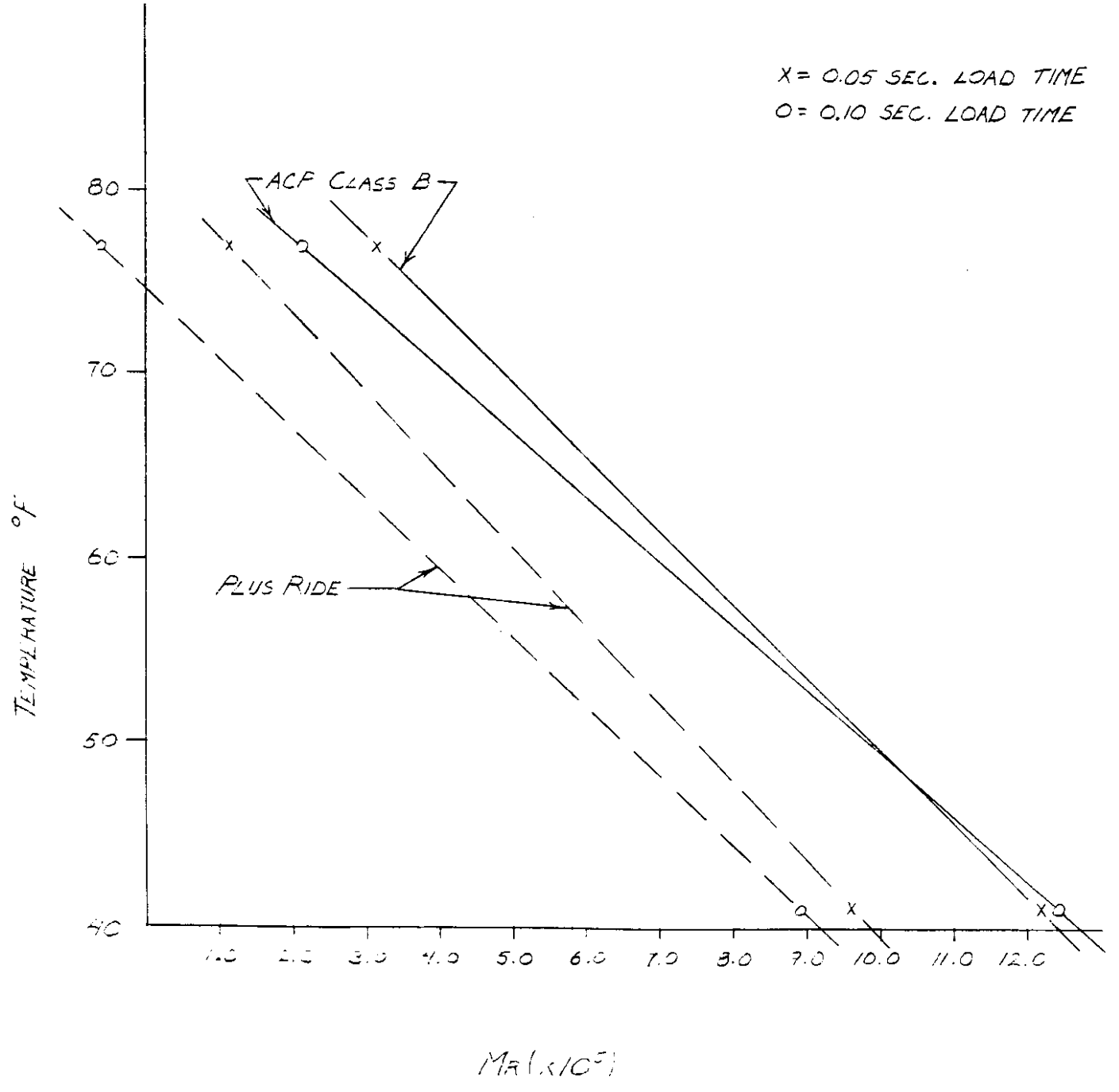
	(Ave. of 5)	(Range)
Density	143.8	138.5 - 147.7
% Voids	6.5	3.9 - 10.0
Gradation		
5/8"	100	100
1/2"	97	94 - 99
3/8"	83	80 - 87
1/4"	67	65 - 70
#10	41	38 - 45
#40	21	18 - 23
#80	10	9 - 12
#200	5.5	4.3 - 6.8
Sand/Silt	7.5	6.6 - 8.8
% Asphalt	6.0	5.2 - 6.7
140^0F Viscosity	4429	3834 - 4800
275^0F Viscosity	494	460 - 518
Penetration	3	33 - 40
Resilient Modulus		
MR @ 41^0F (.05 sec.)	1.00×10^6	6.01×10^5 - 1.52×10^6
(.10 sec.)	1.01×10^6	5.25×10^5 - 1.36×10^6
MR @ 77^0F (.05 sec.)	2.55×10^5	2.18×10^5 - 3.42×10^5
(.10 sec.)	1.68×10^5	1.52×10^5 - 2.08×10^5
(Lottman Conditioned)		
MR @ 77^0F (.05 sec.)	2.34×10^5	1.55×10^5 - 3.39×10^5
(.10 sec.)	1.45×10^5	9.88×10^4 - 1.95×10^5

APPENDIX C

Resilient Modulus Graphs

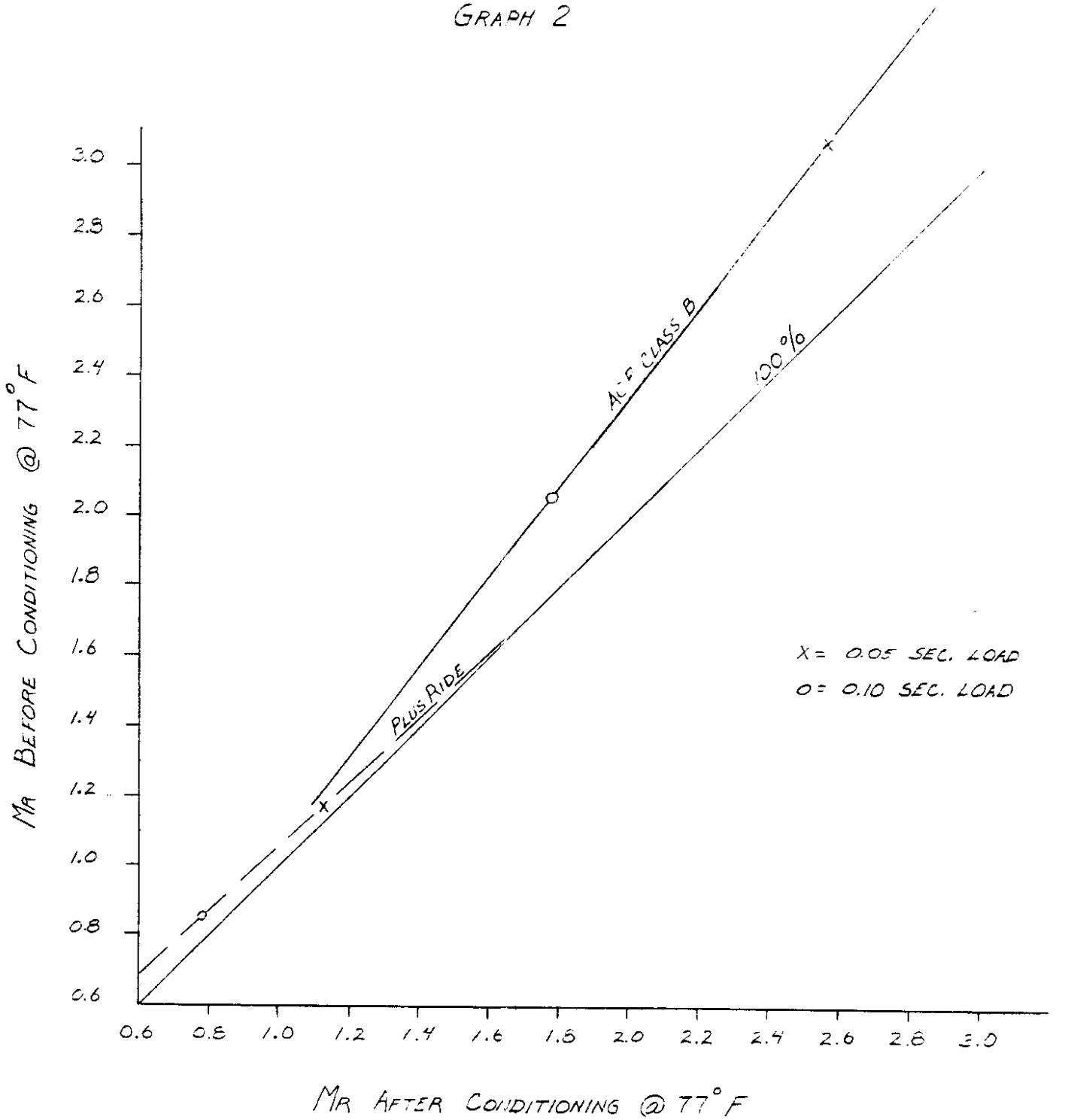
Resilient Modulus
Plus Ride

Graph 1



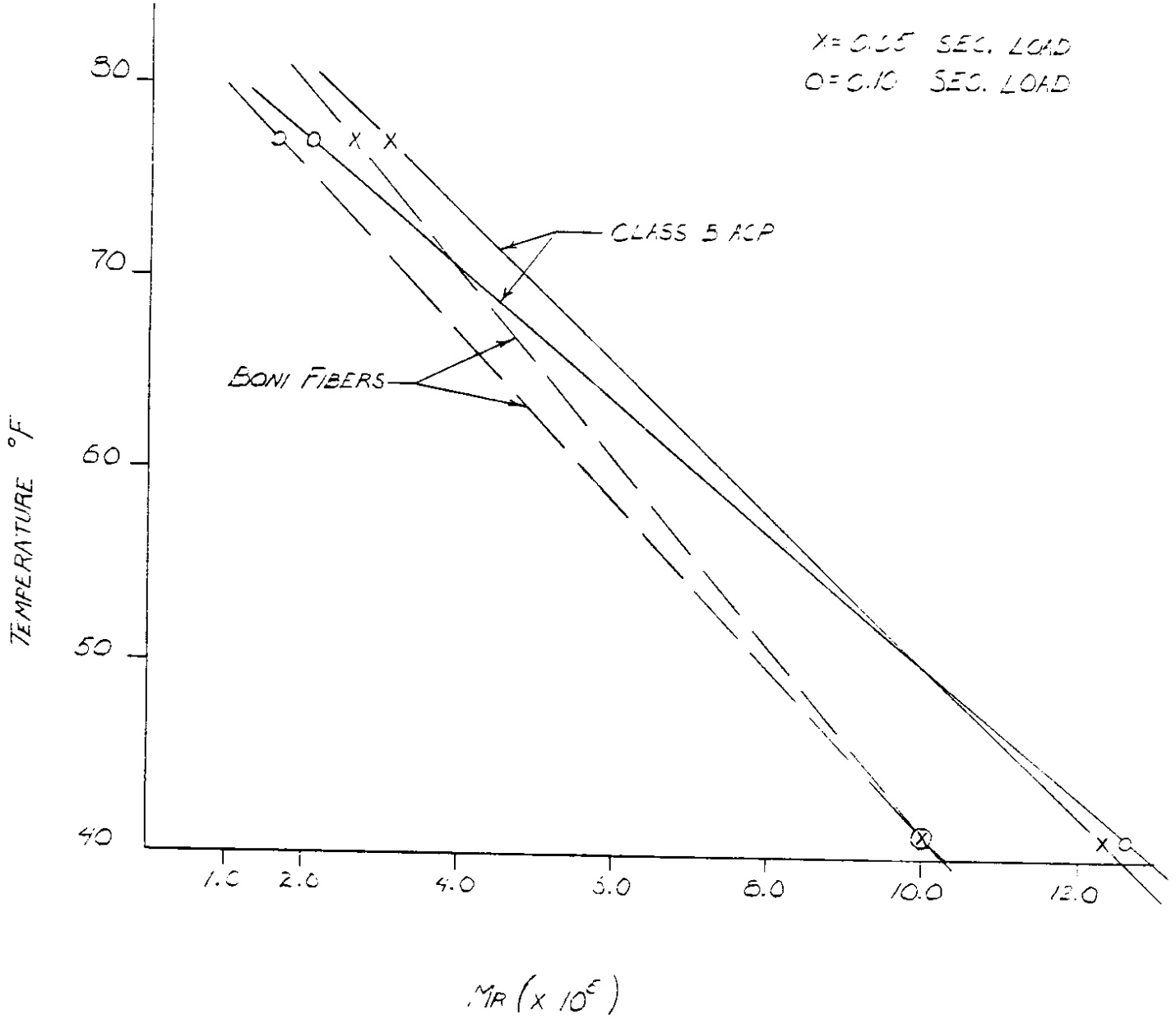
Resilient Modulus
Plus Ride

Graph 2



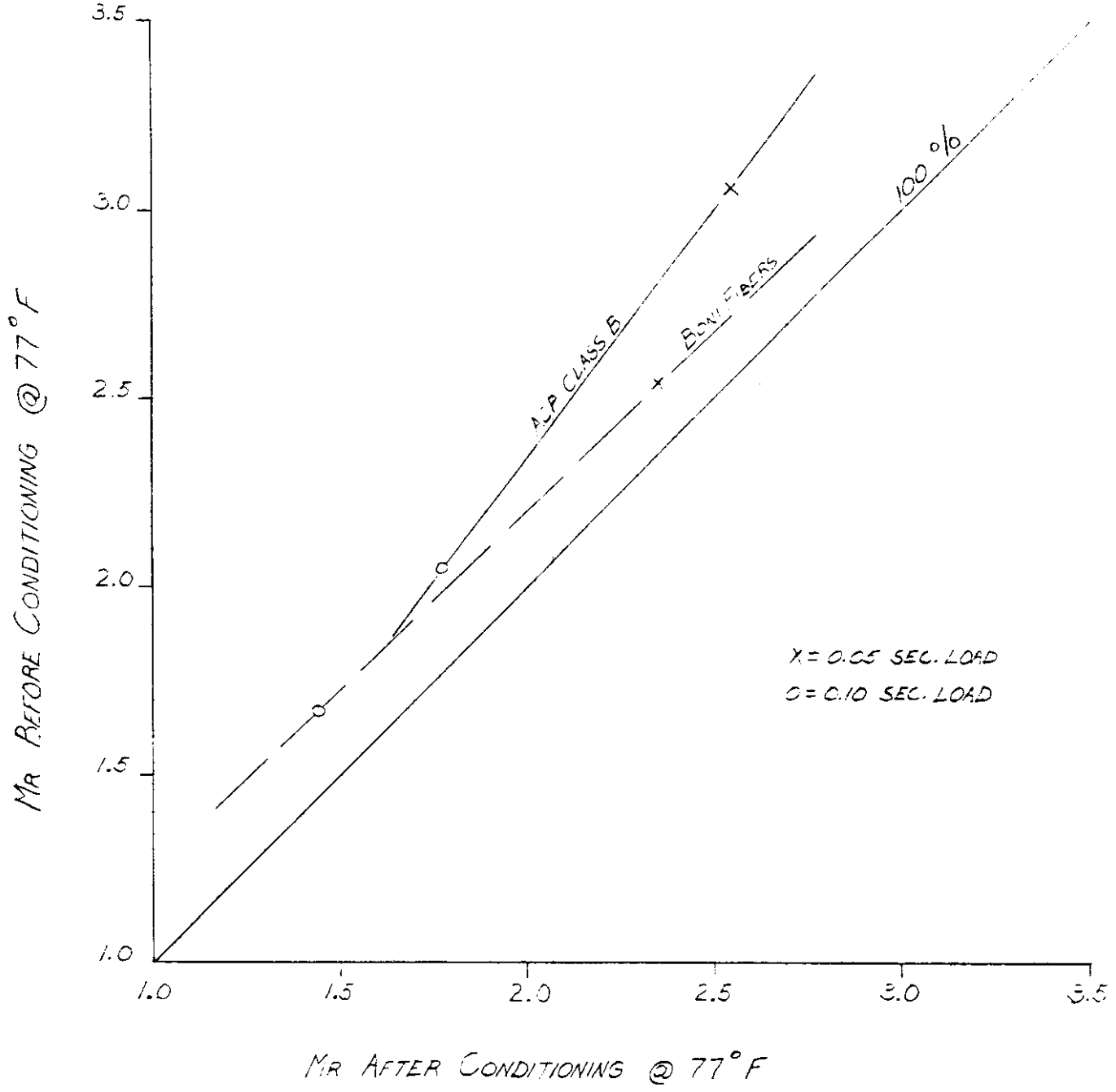
RESILIENT MODULUS
BONI FIBERS

GRAPH 3



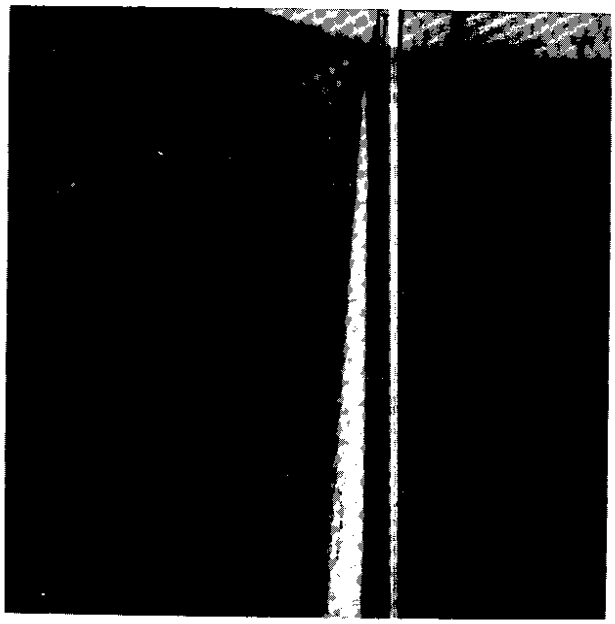
RESILIENT MODULUS
BOW FIBERS

SCALPH 4



APPENDIX D

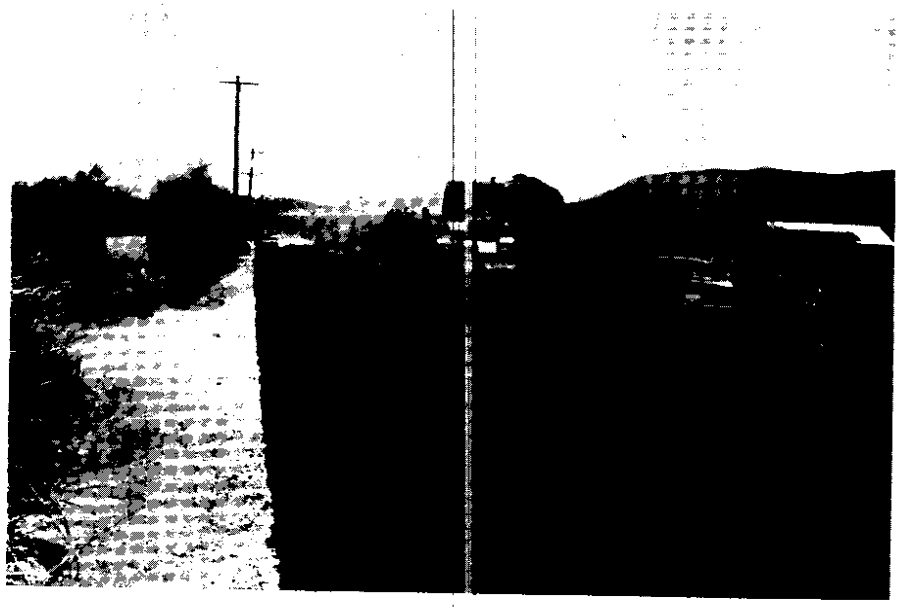
Photographs



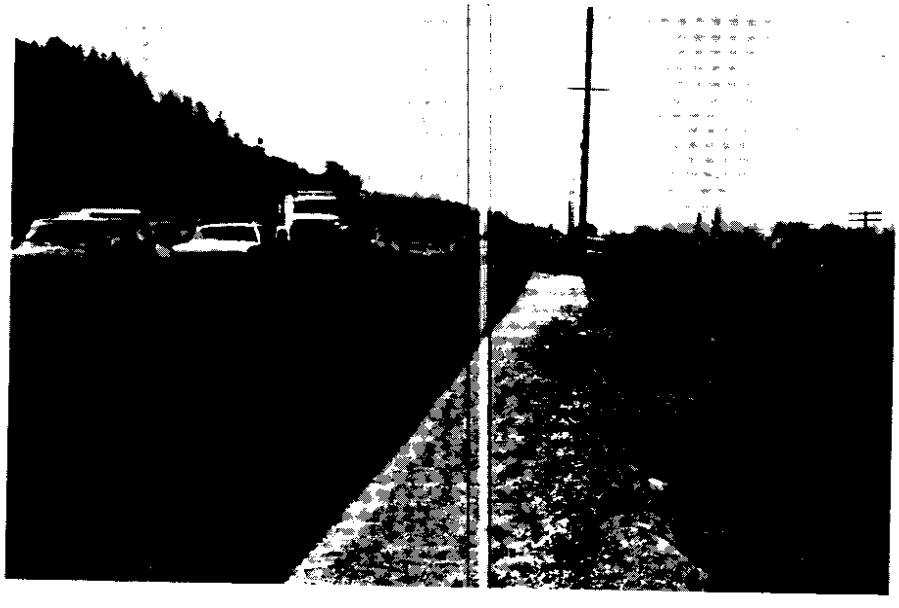
Condition of pavement before construction of overlays.

Addition of PlusRide granulated rubber to the pug mill.

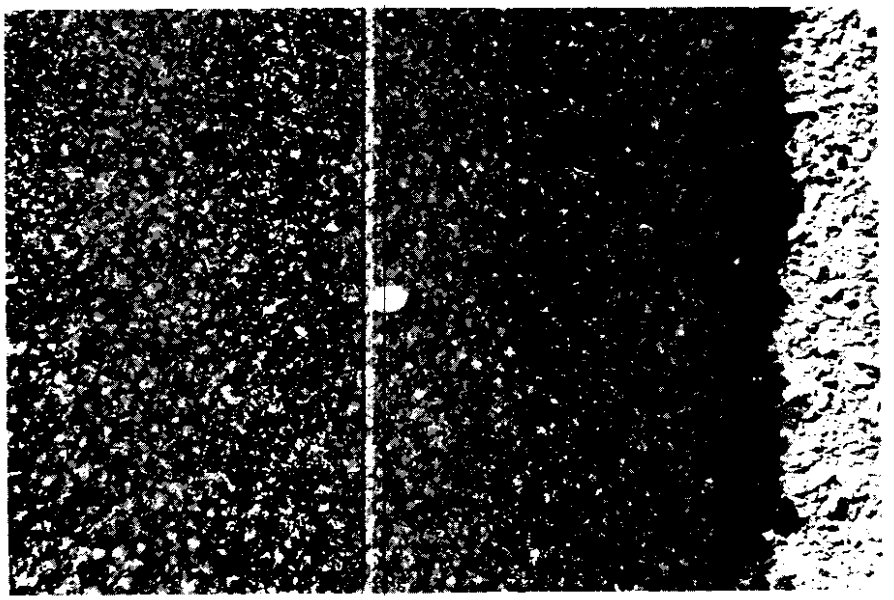
Paving PlusRide asphalt mix.



Rolling PlusRide asphalt mix.

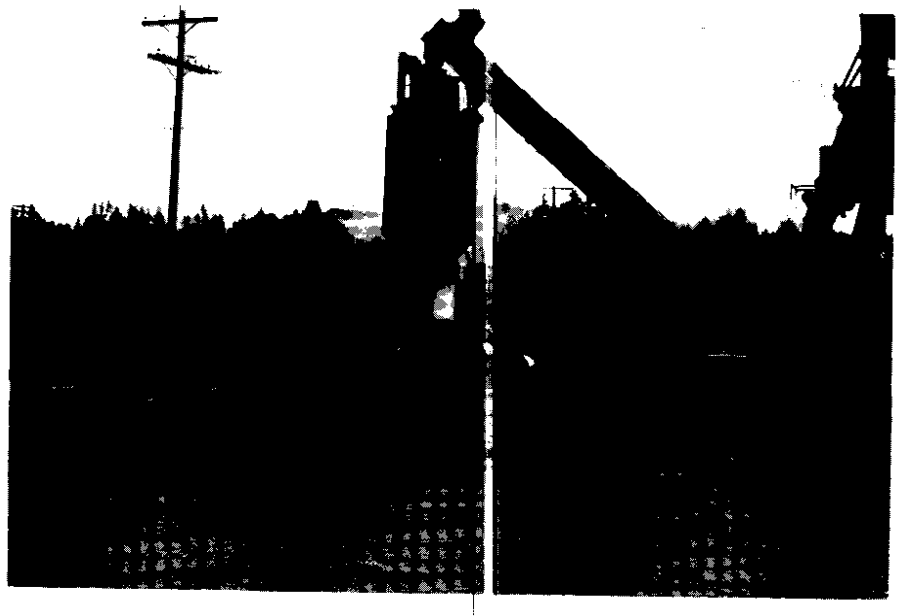


Finished PlusRide asphalt pavement.

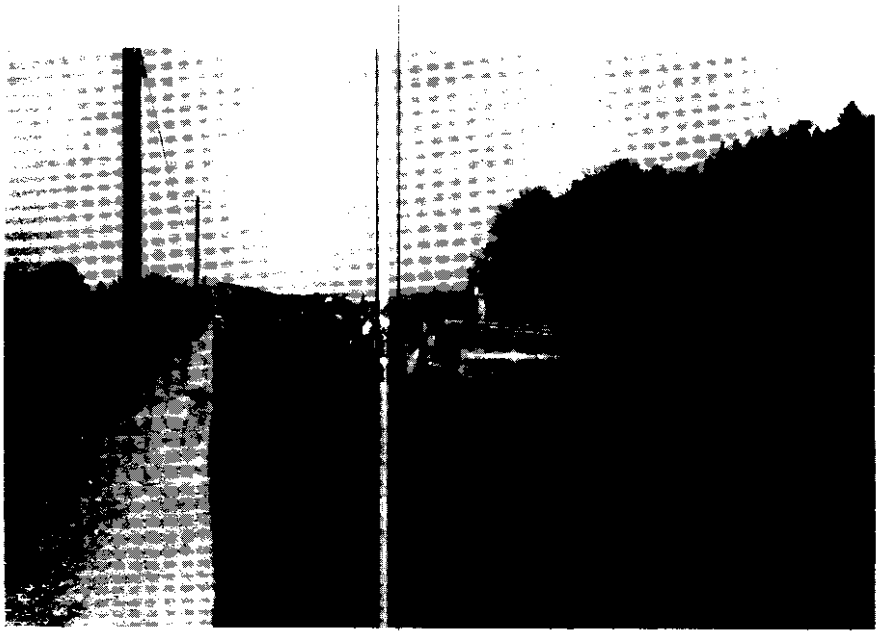


Close-up of PlusRide asphalt pavement.

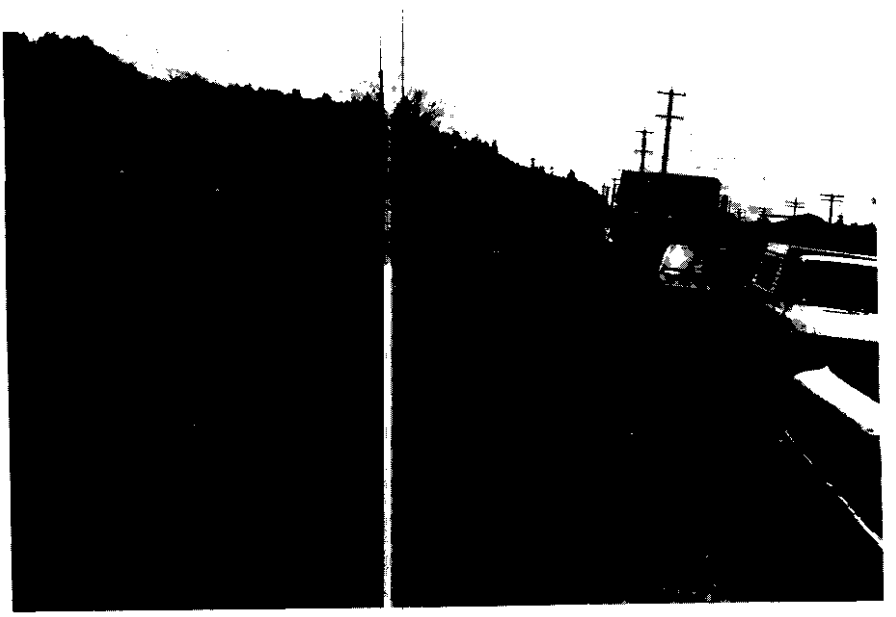
Pug mill where BoniFibers were added to the mix.



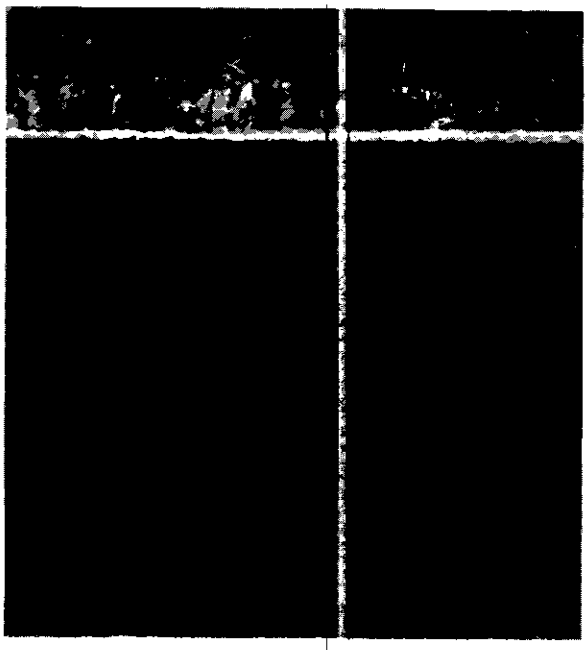
BoniFibers asphalt mix being loaded into contrail trucks for transport to the jobsite.



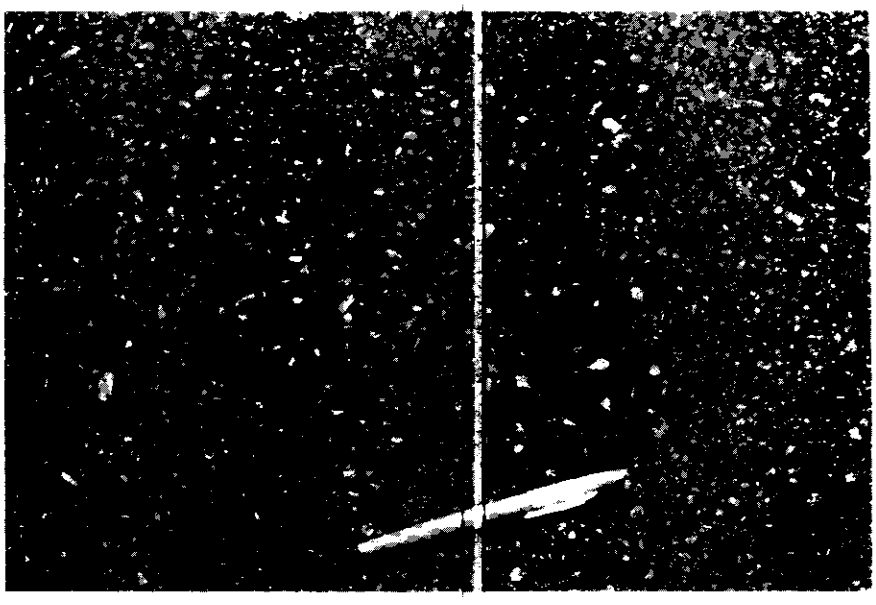
Breakdown rolling of BoniFibers asphalt mix with an Ingersol Rand DA-50 Vibratory Roller. Location is M.P. 4.15.



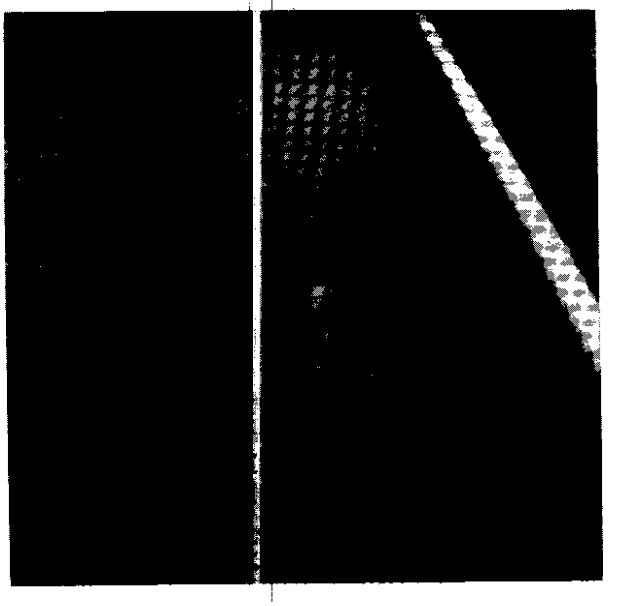
Finish rolling of BoniFibers asphalt mix with Hyster C-625 Vibratory Roller. Location is M.P. 4.20.



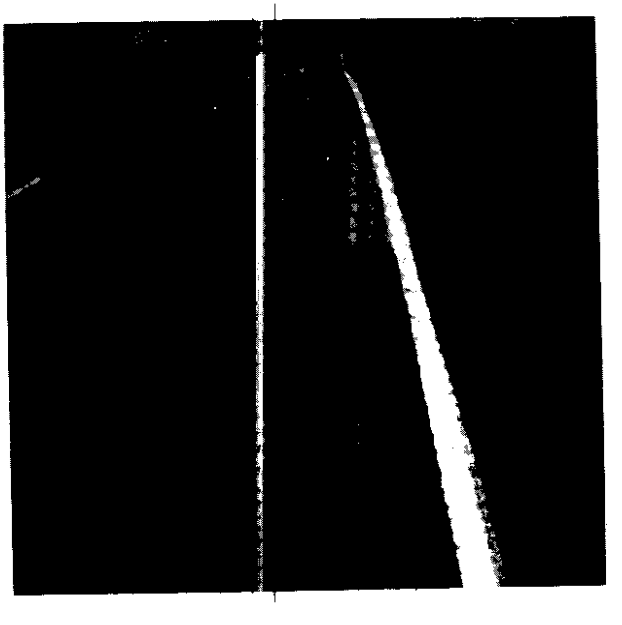
Finished BoniFibers asphalt pavement.



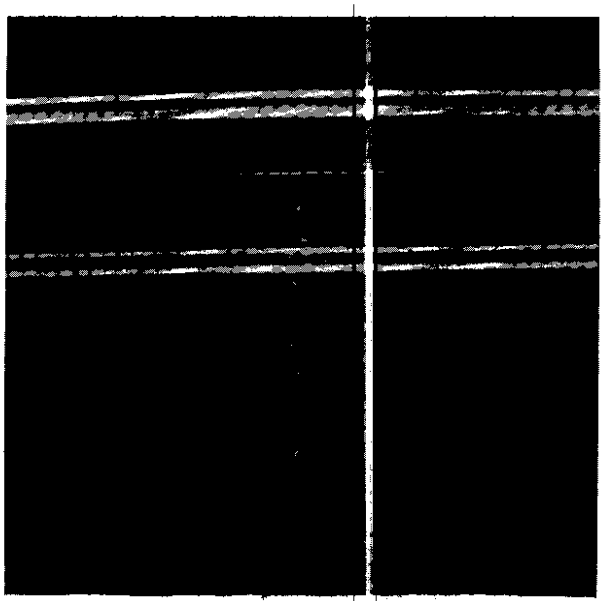
Close-up of BoniFibers asphalt pavement.



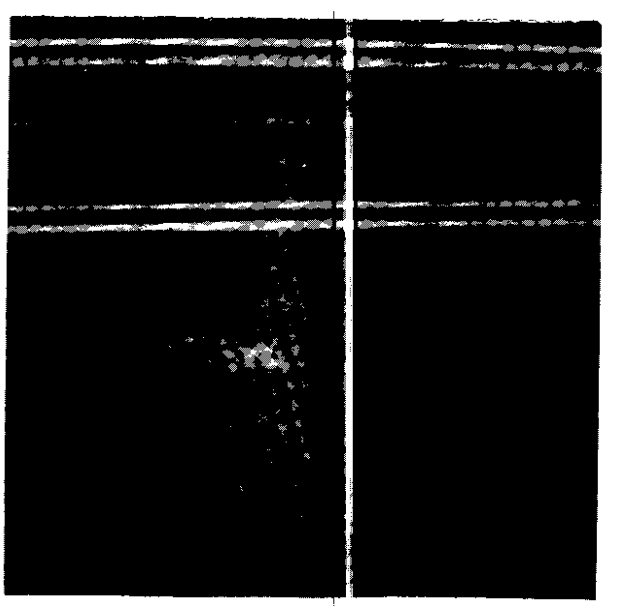
Ravelling of PlusRide asphalt pavement.
Location is approximately M.P. 3.44.



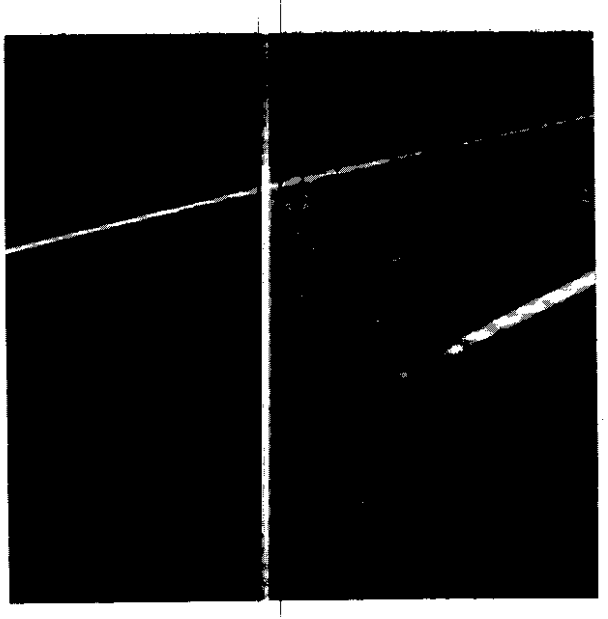
Typical cracking along old pavement edge in BoniFibers section



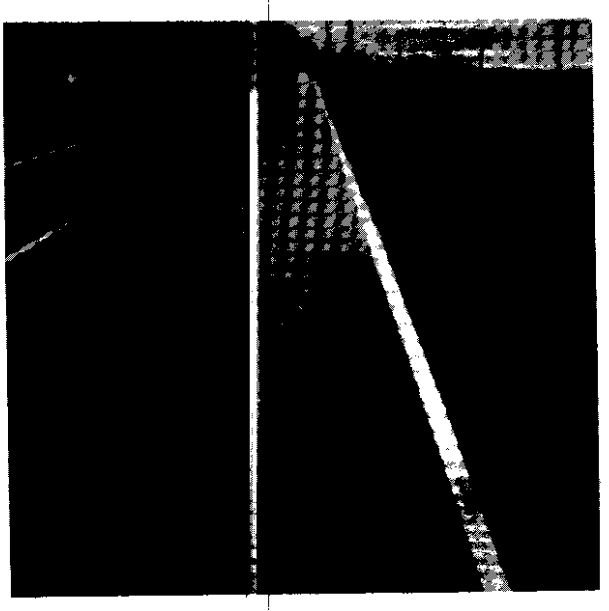
Transverse cracking in standard Class B section at M.P. 4.97.



Transverse cracking in standard Class B section at M.P. 4.99.



Transverse cracking in standard Class B section at M.P. 4.72.



Typical longitudinal cracking along old pavement edge in standard Class B section.