Carbon Black Additive in Asphalt

Experimental Project No. 3
WA84-04

WA-RD 198.1

Post-Construction/Annual Report
October 1989

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 198.1		

4. TITLE AND SUBTITLE	5. REPORT DATE
Carbon Black Additive in Asphalt Experimental Project No. 3, WA-84-04	October 1989
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
John Livingston	
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. WA-84-04
	13. TYPE OF REPORT AN PERIOD COVERED
12. SPONSORING AGENCY NAME AND ADDRESS	Post-Construction/ Annual Report
Washington State Department of Transportation Transportation Building, KF-01 Olympia, WA 98504	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

This report describes the construction of an experimental section of asphalt concrete pavement overlay which contained the additive carbon black. A long term evaluation of the overlay seeks to determine if there is a significant difference in performance between it and an adjacent control section of pavement which contains no additive.

Preliminary laboratory results indicate that the viscosity/temperature curve for the carbon black asphalt binder has been altered in a way that the temperature susceptibility of the pavement is decreased.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Carbon black Additive Temperature susceptibility	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None		

CARBON BLACK ADDITIVE IN ASPHALT

SR-290, Spokane Vic.
Flora Road to Idaho State Line

by
John Livingston
Transportation Engineer

Post-Construction/Annual
FHWA Experimental Project No. 3, Asphalt Additives
WA84-04

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

October 1989

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TABLE OF CONTENTS

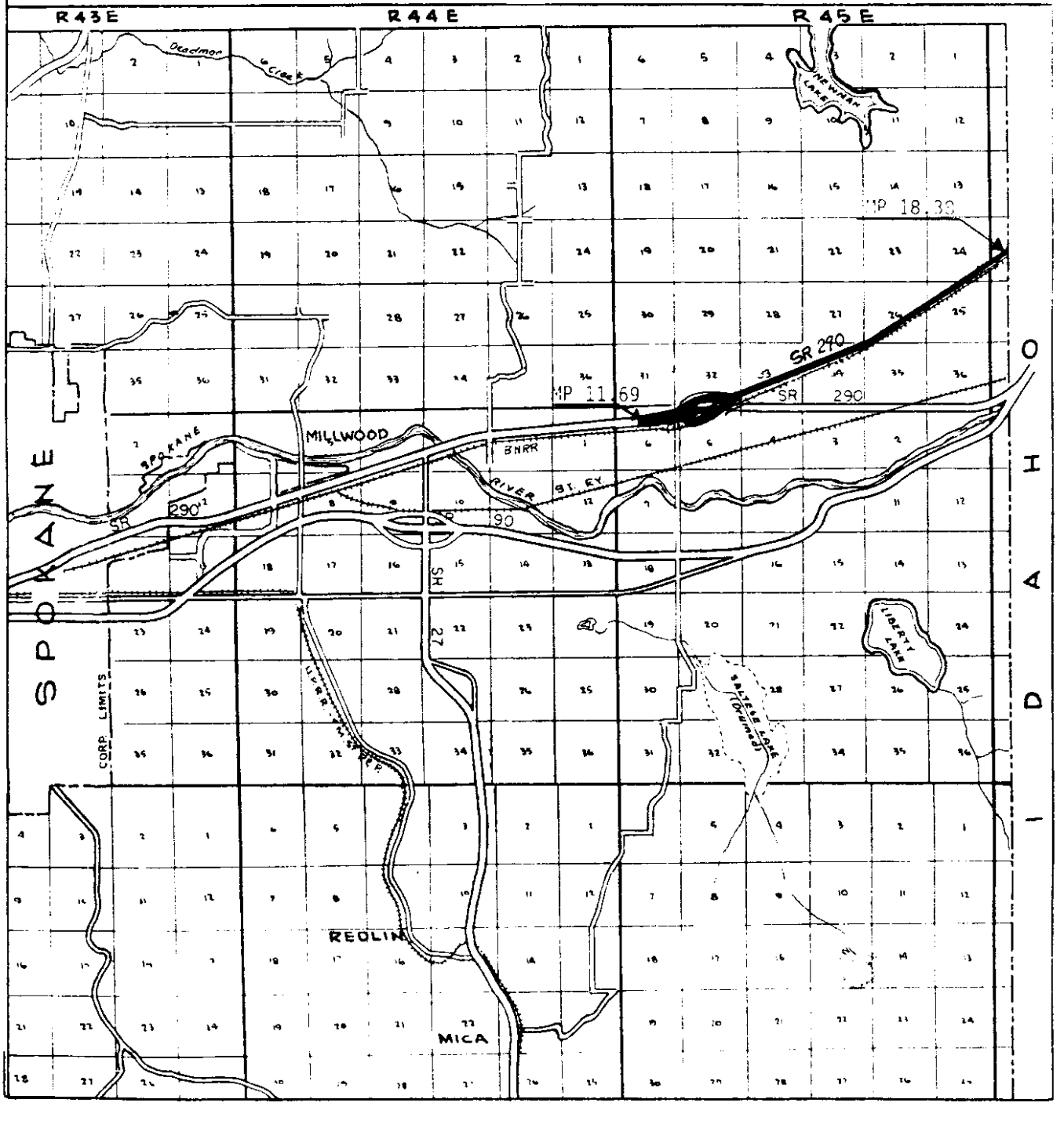
SR 290
FLORA ROAD TO IDAHO STATE LINE

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

OLYMPIA, WASHINGTON

MAP OF STATE HIGHWAYS

SPOKANE COUNTY



OBJECTIVE

Carbon black is one of many asphalt additives said to improve the performance of asphalt pavement. Manufacturers of this product, which has been traditionally used in the rubber industry, claim that carbon black reinforces the asphalt cement binder and reduces the temperature susceptibility of the asphalt pavement. This study will examine these claims by comparing the performance of adjacent sections of an asphalt concrete overlay constructed with and without the carbon black additive.

STUDY SITE

The section of roadway overlaid is located approximately 7 miles east of Spokane on SR-290 as shown on the accompanying vicinity map. The pertinent facts concerning the contact are tabulated below.

Contract Number: 3003
Contract Name: Flora Road to Idaho State Line
Route Number: SR-290
Milepost Limits: 11.69 to 18.38
Number of Lanes: 2 lanes with except of a 1 mile section of 4 lane at beginning of project
Overlay Thickness: 0.15 feet (2 inches)
Project Engineer: R.L. Moore
Contractor: Inland Asphalt Company, Spokane, WA

The carbon black and control sections are located between milepost 11.69 and 12.54 (Construction Station 445+00 to 490+00). SR-290 is four lanes wide in this location as shown on the roadway section sheets in Appendix C. The conventional asphalt pavement overlay is located on the westbound lanes and the asphalt containing carbon black is on the eastbound lanes.

The existing roadway, prior to the overlay, consisted of the following pavement section:

0.58 ft. PCCP
0.25 ft. C.S.T.C.
0.40 ft. ACP
(placed in two separate lifts 0.25 ft. and 0.15 ft.)

All subgrade soils encountered were relatively free draining. Subgrade "R" values ranged from 60 to 79 indicating a surfacing depth of one foot or greater for frost design. Susceptibility to frost is not a consideration due to the free draining nature of the subgrade material. There is enough

surfacing in place to satisfy the frost depth requirements as verified by the low plate deflections of the Falling Weight Deflectometer (FWD) test. The average rainfall for this area ranges from 17 to 19 inches per year. Surrounding terrain is generally flat to only slightly rolling. The existing roadway surface exhibits rutting, longitudinal and block cracking, with some alligator cracking along the lane edges. Alligator cracked areas in the travel lanes have been recently patched by Maintenance forces. Traffic data for this section is as follows:

Traffic Index	6.8
1983 ADT	7,800
1986 ADT	9,298
1996 ADT	15,248
Truck volume	7%

(5% single axle and 2% combinations)

CONSTRUCTION SUMMARY

The paving for this project was performed by Inland Asphalt Company of Spokane, Washington. Inland Asphalt was both the prime contractor and paving contractor. Mr. F. F. Zoeller, of Cabot Corporation, and Mr. Bernard Vallerga, consulting engineer employed by the Cabot Corporation, were present to assist the contractor in the mixing and placement of the special carbon black asphalt.

The bags of carbon black microfiller were added to the pug mill of the C.M.I. 12,000 lb. batch plant just prior to the addition of the AR-4000W asphalt binder. The carbon black was added at a rate of 25 lbs. per ton of mix at a mixing temperature of between 300 F and 315 F. All components were mixed for a total of 45 seconds and then loaded into trucks for the five mile haul to the job.

Paving of both asphalt mixes was accomplished using a Cedar Rapids BSF-520 Track Paver. A tack coat of CSS-1 applied at the rate of 0.04 gal/sy was used on both sections. The compaction train consisted of the following: a Rollo-Pactor pneumatic 10 ton roller for breakdown (2 passes); a Gallion 13.5 ton double drum vibratory roller (2 passes), and a Gallion 13.5 ton double drum vibratory roller with 2 passes vibratory and finishing static. Mat temperatures for the three phases breakdown, intermediate, and finish were 280 F, 240 F, and 185 F, respectively. Compaction was monitored with a nuclear densometer. The paving operation for the carbon black was completed on August 22, 1985 with the Class B asphalt being completed the following day. Weather conditions for the two days of paving ranged between nighttime lows of 47 F and daytime highs of 85 F.

ECONOMICS

The unit contract bid price for the Class B Asphalt containing carbon black was $34.00/ton for the 1,350 tons used. The bid price for the Class B Asphalt was $ 24.00/ton and a total of 18,650 tons was used.

PERFORMANCE EVALUATION

Friction Resistance

Initial friction tests were performed in October 1985, two months after the completion of the paving. The friction values on the entire job ranged from 42 to 61 with an average of 54. In October 1988, friction tests were again run to compare with the post-construction tests. The control section of Class B asphalt ranged from 30 to 43 with a average of 38, while the carbon black section had a range of 32 to 39 with an average of 36. The data indicates that the control section is just slightly better on the average than the carbon black section. Both sections, however show a substantial decrease in friction numbers since construction, although each section remains above the recommended minimum for friction resistance.

Fatigue

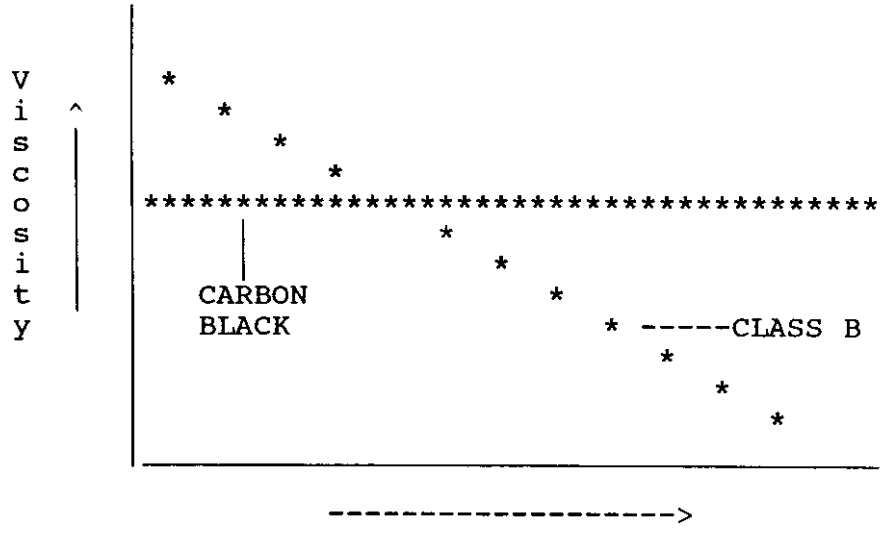
Crack mapping of the underlying PCC pavement was done on both the control section and carbon black section prior to overlaying. At the present time neither section has shown any reflection cracking.

Density

There were no problems attaining required densities in the control section, but there were problems in the carbon black section. The compaction records for the carbon black section indicated that the pavement achieved only 89.9 % compaction with a specification requiring 92 %. The asphalt content was increased from 5.5% to 5.7%, but this did not result in any increase in the density as measurement on the overlay with the nuclear gauge. After the paving was completed, a new gage correction factor was calculated using the densities of the cores taken from the project . Using it, the corrected densities came up to 91.7%, which is within the tolerance limits of the specifications.

Lab Test Results

The results from the testing of the mix samples taken during paving and the core samples taken from the finished pavement are shown in Appendix D. The problem encountered in reaching density with the carbon black mix is supported by the lab results which show a 1-3 pounds per cubic foot difference between the carbon black and Class B. The percent voids also indicate that the Class B was compacted to a higher density than the carbon black mix. A graphic representation (not to scale) of the viscosity versus temperature relationship is shown below. The carbon black pavement has lower viscosities at lower temperatures and higher viscosities at higher temperatures when compared to the Class B pavement. The carbon black pavement is softer and less susceptible to cracking at lower temperatures and, at the same time, is harder and thus less susceptible to flushing and rutting at higher temperatures.



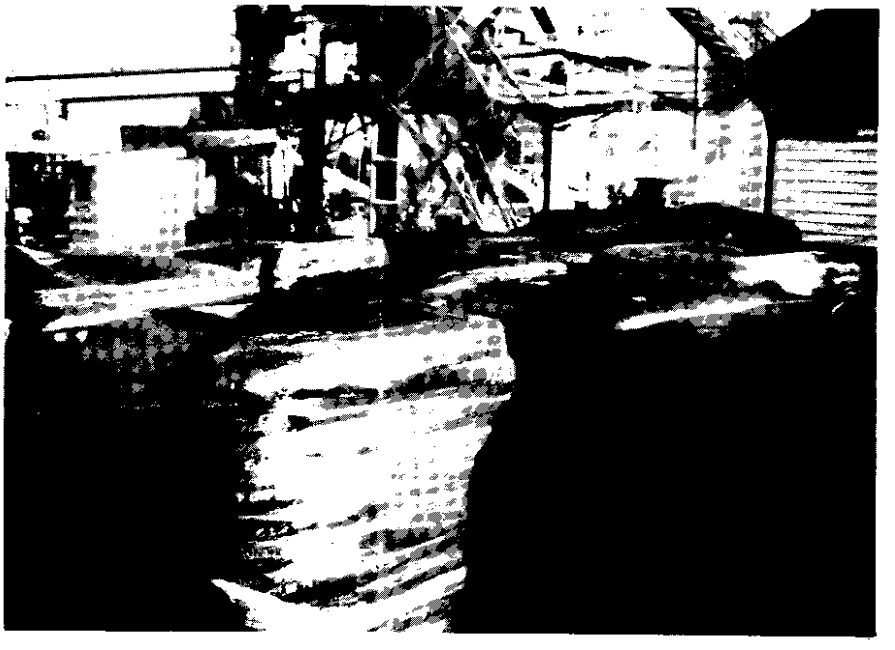
CONCLUSIONS

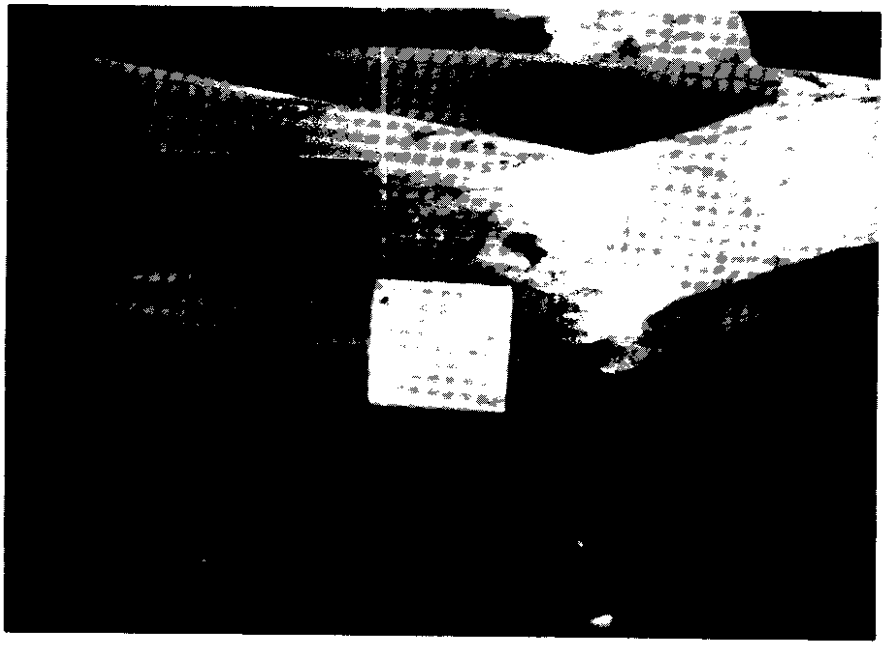
The two study sections are performing equally after two years of service. The viscosity results indicate a real difference in the temperature susceptibility of the two sections, however, it may take several years before any measurable differences in performance are noted. A time extension is being requested so that the expected performance variations between the two sections can be captured and reported.

APPENDIX A

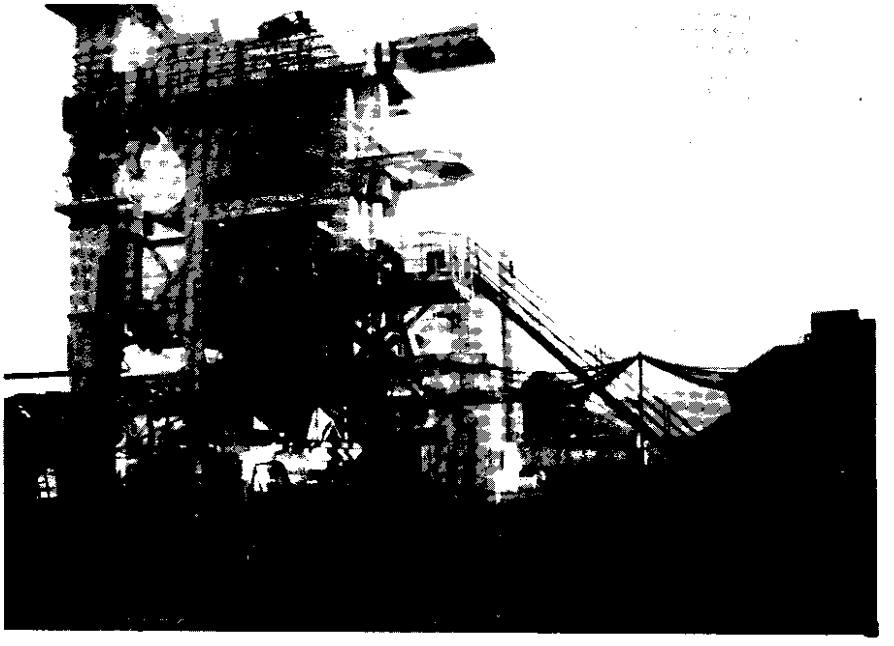
Photographs

CARBON BLACK AS DELIVERED TO PLANT

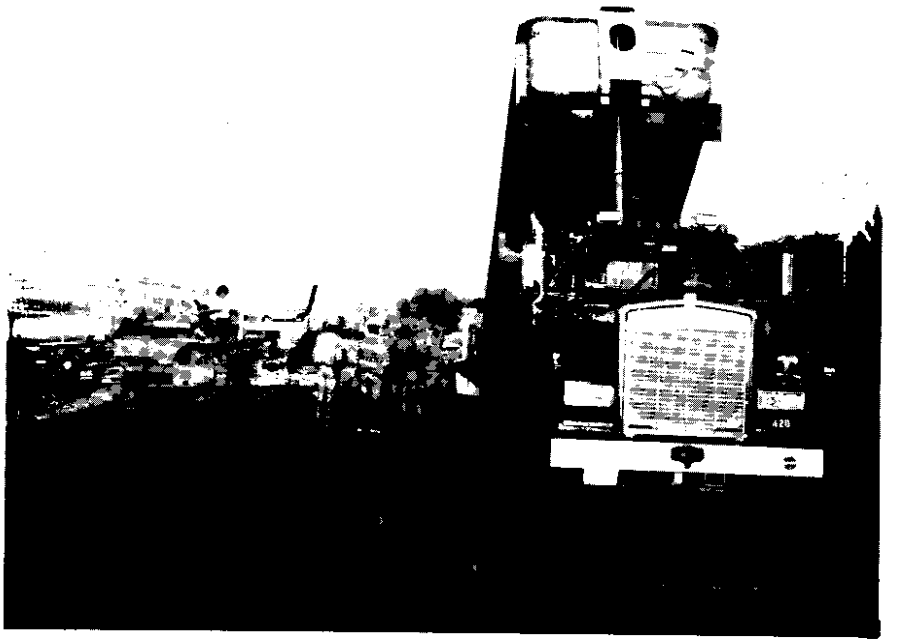


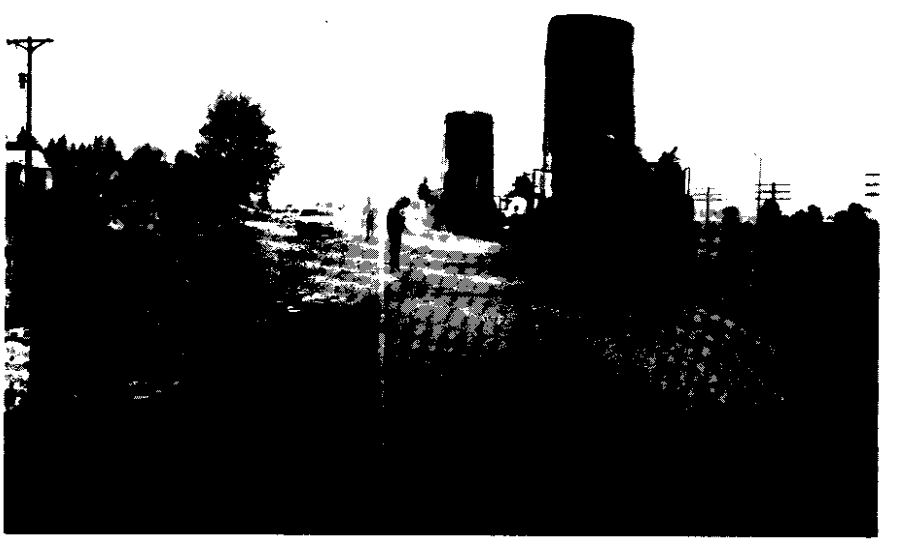


PLANT OPERATIONS



STREET OPERATIONS





STREET OPERATIONS
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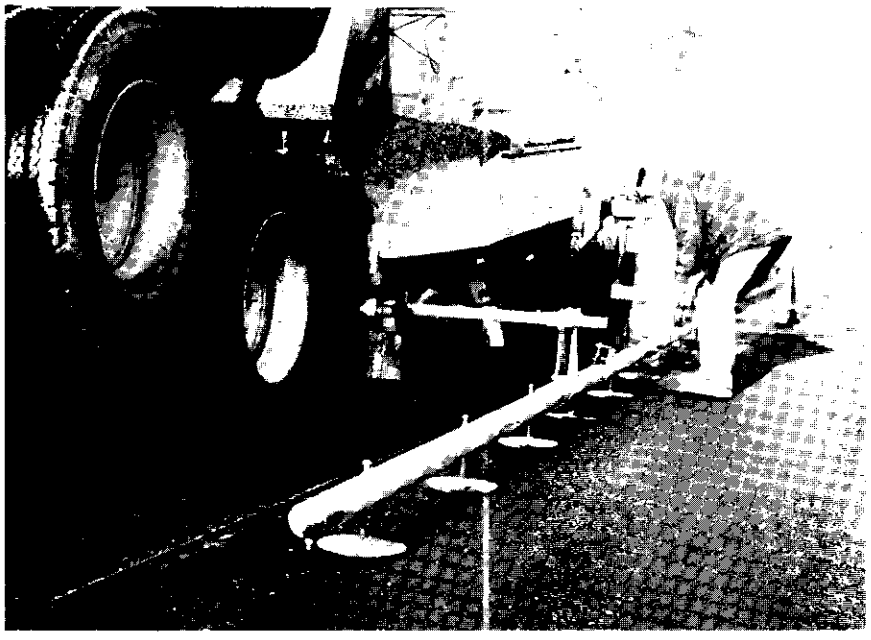


APPENDIX B

Material Specifications

MATERIALS SPECIFICATIONS

MODIFIED ASPHALT CONCRETE PAVEMENT

This work shall consist of placing asphalt concrete that contains a carbon black additive on those portions of the roadway shown in the plans and designated by the Engineer

A carbon black producer is:

Cabot Corporation
Concord Road
Billercia, MA 01821
(617)663-3455

The Contractor shall arrange to have a technical representative of the carbon black supplier on the project while the carbon black is being mixed or placed.

The carbon black shall be added at the plant immediately prior to the beginning of the asphalt charge.

The standard specifications for asphalt concrete are supplemented by the following:

Carbon Black
The carbon black shall be added in pellet form and shall meet the following requirements:

Carbon Black: The carbon black shall be of HAF grade meeting the requirements of ASTM D1765.

Maltenes: The maltenes oil shall be a high flash point hydrocarbon meeting the requirements of ASTM D2226, Type 103.

The carbon black and the maltenes oil shall be mixed at weight ratios of 92:8 and shall be rolled into pellets by equipment suitable for this purpose. The resulting pellets shall be of a hardness that will allow handling without breading but still permit them to be readily broken down and completely dispersed when added to hot asphalt and mixed vigorously.

Size Requirements

Sieve	Percent Passing
No. 4	98 - 100
No. 16	5 - 60
No. 100	0 - 10

Section 5-04.3(1)B of the standard specifications is supplemented by the following:

The carbon black microfiller shall be added at the rate 25 pounds per ton of mix to the pug mill during the hot-mixing cycle of the batch-type plant immediately prior to the addition of the asphalt cement unless otherwise directed by the Engineer. The material is to be added to the pug mill as received, sack included. Bags shall be charged into the pug mill by the Contractor in any manner acceptable to the Engineer. Fifteen pounds of asphalt cement will be withheld from the established design content for every 25 pounds bag of carbon black microfiller added to the batch.

Section 5-04.3(1)D of the standard specifications is supplemented by the following:

Carbon black, which is to be added to the asphalt concrete mixture being produced in a drum mix plant, shall be temporarily stored in a separate silo. If the carbon black is packaged in intermediate bulk containers (approximately 900 pounds), as small surge tank should be sufficient to maintain consistent feed to the drum. The material shall be metered out of the storage silo through a vane feeder. The rate of feed of the carbon black shall be 25 pounds per ton of mix. The carbon black shall be pneumatically conveyed into the rear of the drum mix plant. It shall be discharged in the immediate vicinity of the asphalt cement discharge point so that the carbon black is completely coated with asphalt cement before it comes in contact with the aggregate in the drum. The point of carbon black discharge shall be protected from direct exposure to the burner exhaust gases by a means of a shield or cover on the upstream side of the entry point to prevent the carryout of the material before it is completely coated with asphalt cement.

Section 5-04.3(8) of the standard specifications is supplemented by the following:

Mixing time shall be a minimum of 45 seconds per batch to allow for complete breakdown of the pellets and through dispersal of the carbon black particles into the asphalt binder.

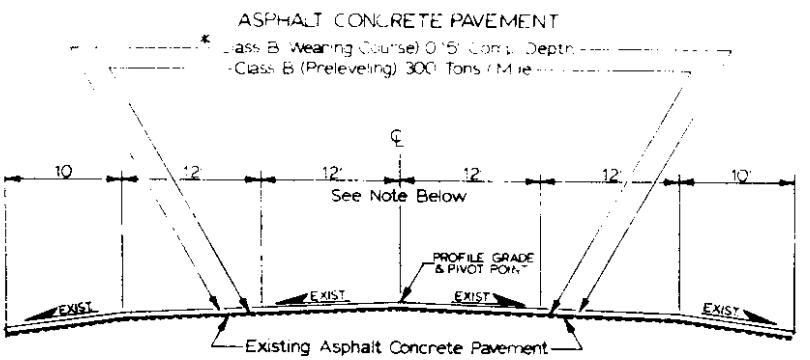
Section 5-04.4 of the standard specifications is supplemented by the following:

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

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

APPENDIX C

Roadway Section



ROADWAY SECTION A

Sta 445+00.00 to Sta 495+28.40

Note: Sta 490+00.00 to Sta 495+28.40 See Detail This Sheet

* Wearing Course Shall Be 0.15' Comp. Depth Modified Asphalt Concrete Pavement from Sta. 445+00.00 to Sta. 490+00.00 for Right Lanes and Right Shoulder Only.

APPENDIX D

Test Reports

MIX SAMPLE TEST RESULTS

	CLASS B		CARBON BLACK	
	Ave. of 14	Range	Ave. of 14	Range
Density	148.9	147.3 - 151.7	149.4	148.1 - 150.9
Rice Density	154.3	153.0 - 154.7	154.6	153.3 - 155.9
% Voids	3.5	1.4 - 4.8	3.4	1.7 - 5.5
Gradation				
5/8"	100	100	100	100
1/2"	98	96 - 99	97	96 - 99
3/8"	84	79 - 90	83	79 - 87
1/4"	65	58 - 73	65	61 - 70
#10	35	31 - 40	36	31 - 38
#40	14	11 - 17	14	11 - 19
#80	8	4 - 10	9	7 - 11
#200	5.1	4.0 - 6.7	5.8	4.7 - 7.8
Sand/Silt	6.9	5.5 - 8.7	6.2	4.9 - 7.3
% Asphalt	5.5	5.2 - 5.7	5.7	5.2 - 6.3
Stability	40	37 - 45	37	27 - 44
Penetration	52	40 - 57	54	39 - 65
140^0 F Viscosity	2534	2133 - 3697	9236	1986 - 20584
275^0 F Viscosity	386	357 - 464	620	369 - 1056
Lottman Load	742	480 - 1330	926	620 - 1340

CORE SAMPLE TEST RESULTS

	CLASS B		CARBON BLACK	
	Ave. of 6	Range	Ave. of 6	Range
Density	145.7	143.7 - 148.5	142.8	140.1 - 144.9
Rice Density	154.3		154.6	
% Voids	5.6	3.8 - 6.9	7.6	6.3 - 9.4
Gradation				
5/8"	100	100	100	100
1/2"	98	97 - 99	98	97 - 98
3/8"	86	85 - 88	82	80 - 84
1/4"	69	65 - 72	64	60 - 66
#10	36	34 - 38	34	33 - 35
#40	15	14 - 16	14	13 - 16
#80	10	8 - 11	9	8 - 11
#200	6.1	5.6 - 6.8	6.2	5.0 - 7.6
Sand/Silt	6.0	5.6 - 6.6	5.6	4.6 - 6.7
% Asphalt	5.7	5.6 - 5.9	5.9	5.1 - 6.3
Penetration	55	45 - 68	66	56 - 72
140^0 F Viscosity	2580	1710 - 4670	7188	2430 - 16920
275^0 F Viscosity	363	333 - 395	1386	620 - 3520
Resilient Modulus				
@ 41^0 F (.05 sec)	1.08×10^6	1.38×10^6 - 7.52×10^5	1.05×10^6	1.15×10^6 - 9.26×10^5
(.10 sec)	9.40×10^5	1.08×10^6 - 6.23×10^5	9.96×10^5	1.15×10^6 - 8.78×10^5
@ 77^0 F (.05 sec)	1.61×10^5	1.84×10^5 - 1.35×10^5	1.96×10^5	2.56×10^5 - 1.60×10^5
(.10 sec)	1.02×10^5	1.20×10^5 - 8.02×10^4	1.32×10^5	1.72×10^5 - 1.05×10^5
Mottman Conditioned				
@ 77^0 F (.05 sec)	1.52×10^5	1.76×10^5 - 1.03×10^5	1.47×10^5	1.90×10^5 - 1.12×10^5
(.10 sec	8.89×10^4	1.18×10^5 - 6.32×10^4	9.92×10^4	1.31×10^5 - 7.38×10^4

COMPACTION CONTROL

	Percent of Rice Density				
Class B	89.9	92.6	92.4	92.2	92.0
Carbon Black	89.9	92.4	91.6		