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Demonstration Project No. 55

Asphalt Emulsions for Highway Construction

Burlington and Somerset Counties New Jersey

FHWA-DP-55-11

Initial Report

February 1987

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16. Abstract

This report documents the three-year evaluation of a slurry seal study undertaken as part of FHWA Demonstration Project No. 55, "Asphalt Emulsions for Highway Construction".

The objective of this study was to collect information on the design, construction, and performance of a two-course asphalt emulsion slurry seal for mainline surface treatment. The study evaluates the potential extension of useful pavement life of the existing pavement and the adequacy of skid resistance of that material for a three-year period on mainline, moderately traveled bituminous pavements.

Sites on Route U.S. 206, Burlington County and Route I-78, Somerset County were selected for slurry seal applications. A two-course slurry seal of top course (blast furnace slag) and bottom course (3/8 inch stone) was applied to a one and one-half mile section of Route U.S. 206 and two-one mile sections of Route I-78.

The slurry seal application extended the useful pavement life of both sites by three to four years and provided good skid resistance for the period of evaluation.

The slurry seal is a viable alternative for temporary surface improvement on moderately traveled highways. Blast furnace slag aggregate should be used in the surface course of slurry seals. The slurry seal aggregate should be plant-mixed to uniformly blend the coarse and fine gradations. The spreader box should be equipped with stabilizer bars and an auger to uniformly distribute the slurry seal across the roadway.

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Implementation Statement

The information developed during the course of this study has provided the New Jersey Department of Transportation with guidance as to slurry seal construction methods and performance. The work has confirmed that a slurry seal is a viable alternative for temporary surface improvement and skid resistance improvement on moderately traveled bituminous pavements.

Implementation of the study findings will require that the Department's Maintenance and Design units consider the use of slurry seals on a case-by-case basis in accord with the usage guidelines recommended herein.

PREFACE

The practice of using slurry seals for special purpose maintenance overlays has existed for many years in the New Jersey Department of Transportation. However, the construction methods, skid resistance and guidelines for using slurry seals have not been formally documented. This report does just that.

The slurry seals studied in this research used a blast furnace slag aggregate. In the event that this aggregate is not available, a reasonable substitute would be trap rock aggregate, which has been shown in previous skid testing to provide an excellent skid resistant surface. The use of dolomite or limestone aggregates in slurry seal is not recommended since skid resistance testing has shown them to generally exhibit lower skid resistance values.

Since the draft of this report was written, the cost of bituminous concrete has decreased by about 40%. Slurry seals have shown only small cost decreases. Although this obviously alters the relative cost comparisons presented in the report, it does not alter the basic conclusion that a slurry seal can be a viable, quick turn-around procedure for improving skid resistance and temporarily arresting surface distress.

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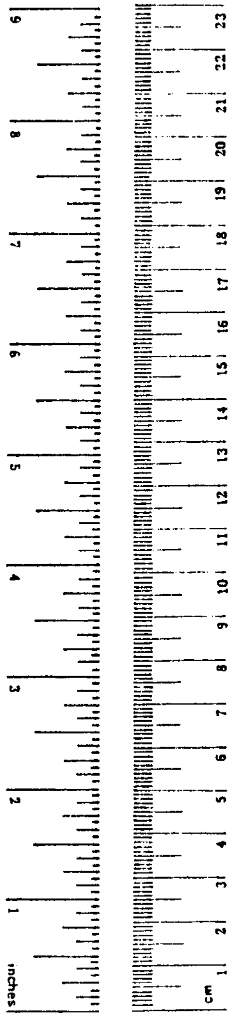
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

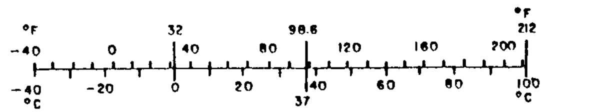
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



Summary and Conclusions

This report documents the three year evaluation of an Asphalt Emulsion Slurry Seal study undertaken as part of the FHWA Demonstration Project No. 55, "Asphalt Emulsions for Highway Construction".

The objective of this study was to collect information on the design, construction and performance of a two-course asphalt emulsion slurry seal on mainline moderately traveled pavements. The study evaluated the durability and skid resistance of the slurry seal, and the potential extension of useful pavement life of the existing pavement.

The two-course slurry seal was constructed under contract with Jersey Slurry Seal Company on Route U.S. 206, Burlington County and Route I-78, Somerset County. The top course slurry seal on both projects was a blend of blast furnace slag and 7.5-13.5 percent by weight of emulsion, applied at 10 lbs. per square yard. The bottom course consisting of 3/8 inch stone and screenings and 6.5-12.0 percent by weight of emulsion, was applied at 15 lbs. per square yard.

As expected, the slurry seal emulsions cured sooner on warm, sunny days than on cloudy, cool days. During the application on Route U.S. 206, the weather was sunny and warm, and the emulsion cured adequately before it was opened to traffic. However, the weather during all of the slurry seal application on Route I-78 was cool and cloudy. On one particularly cool and cloudy day, the highway may have been opened prematurely to traffic.

Pavement condition surveys which were performed prior to the slurry seal application indicated that both routes had oxidation cracks which often occur on highways with low traffic volumes. Benkelman beam rebound measurements indicate that the Route I-78 pavement had not failed structurally. Because there was concern that early cracking on Route I-78 might be a manifestation of structural failure, Benkelman beam measurements were made on that section.

The slurry seal application on the Route U.S. 206 project has increased the useful life of the existing pavement by at least three years. At the conclusion of the study, the slurry seal had delaminated from the underlying surface in 22 areas of four to five square feet each. The delamination is attributed to inadequate mixing of coarse aggregate and fines, and inadequate mixing of the asphalt emulsion, as evidenced by small (1/2-3/4 inch diameter) balls of asphalt at the time of application. The aggregate and fines mixing on the Route U.S. 206 project was done by a front end loader from stock piles of aggregate and fines. On the Route I-78 project, the aggregate and fines were plant mixed which made a more uniform distribution of material resulting in no delaminated areas.

The slurry seal application on the Route I-78 project has appreciably slowed the deterioration of the existing pavement as compared with the adjacent areas. The project has a uniform texture and no areas of delamination. Although reflection cracks have appeared on the surface, the cracks have not been detrimental to the slurry seal surface. The slurry seal application and the bituminous concrete pavement under it have not deteriorated. In contrast, the bituminous pavement which was not treated with the slurry seal has further deteriorated to the point that it now shows serious alligator cracking and dislodged pieces of bituminous concrete.

Thickness measurements on the Route I-78 slurry seal indicate that it was not only thinner than expected (an average of 5/16 inch as compared to an expected value of 3/8" to 1/2"), but highly variable in thickness (range from 1/64 inch to 3/4 inch). This thin, uneven application is attributed to the combination of differential compaction by traffic on days of slow curing and uneven distribution by the spreader box. After three years, the average thickness of the slurry seal was ¼ inch. The thin application of slurry seal was adequate to maintain good skid resistance and retarded pavement deterioration. The application did not fail by wearing away. Essentially, the thickness was not critical for good performances.

Skid resistance tests indicate that the slurry seal application initially increased the skid resistance by approximately 30 percent for both routes. Subsequent data shows that the skid numbers have not significantly changed on either project with the exception of the outside lanes on Route U.S. 206. The blast furnace slag surface course provided a very good skid resistance on both projects. The average skid number of the outside lanes of Route U.S. 206 reflect the lower skid data of the stopping area (200 feet before the intersections) where excessive asphalt from the mix was noted at the time of construction. This excess asphalt, "fatty appearance", is probably the result of too much asphalt in the mix and the friction between the tires and the pavement in the stopping areas. At this time, a corrective overlay is necessary at the intersections to improve skid resistance.

The total in-place bid costs of the two-course slurry seal was 1.75 dollars per square yard in 1982. In contrast, the cost of a 1½ inch thick bituminous concrete surface overlay was 2.43 dollars per square yard in 1982. The bid price of the slurry seal on these projects undoubtedly reflect the relatively long haul distance associated with the aggregates and asphalt emulsion. The present cost of slurry seal is estimated to be about 15 cents less per square yard (1.60 dollars per square yard) for a two course application. The present cost of a 1½ inch bituminous concrete overlay is about 3.25 dollars per square yard. At the current costs, a slurry seal has to provide 3½ years service to be competitive with a bituminous overlay. Since the slurry seal provides at least that and possibly more, the slurry seal is cost effective.

Energy consumption for the slurry seal was compared to the energy consumption for a 1½ inch thick bituminous overlay (1-4 mix). The slurry seal consumed 9,877 BTU per square yard on Route U.S. 206 and 7,719 BTU per square yard on Route I-78. In contrast, installation of a conventional bituminous concrete overlay (I-4 Mix) would have consumed 70,600 BTU per square yard on either route. Essentially, the slurry seal required 86 percent less energy for an overlay and is thus very energy efficient as compared with the bituminous concrete overlay.

The energy consumption of the slurry seal is heavily dependent on the haul distance of materials. It is anticipated that more frequent use of slurry seal would appreciably lower energy consumption costs by encouraging local suppliers to receive and store larger quantities at reduced prices.

Recommendations

1. A two course asphalt emulsion slurry seal is recommended as a maintenance improvement on worn and slippery bituminous pavements to improve skid resistance. In cases of hazardous surface conditions, the slurry seal is a quick remedy which renews the old surface without the need to raise manholes and inlets. The slurry seal can be used effectively on moderately traveled pavements (10,000 AADT) for three to four years. The slurry seal should not be applied at intersections.

2. The slurry seal is recommended for use on structurally adequate bituminous pavements for a temporary surface prior to a major reconstruction and rehabilitation. As an expedient maintenance overlay, the slurry seal will retard further deterioration of an oxidation cracked pavement for three to four years.

3. The intent of the slurry seal is to provide an alternate overlay procedure to the 1½ inch bituminous overlay under conditions which necessitate an expedient remedial action. Since the quality control of the normal 1½ inch bituminous overlay is significantly better than the slurry seal, it should not be substituted routinely for a bituminous overlay.

4. The slurry seal coarse and fine aggregates should be plant mixed to assure thorough blending and to avoid segregation and resultant washboarding and delamination.

5. Blast furnace slag aggregate should be used in the surface course of a two course slurry seal to ensure improved skid resistance.

6. On future slurry seal projects, the spreader box should be equipped with a hydraulically powered auger to ensure that the mixture is spread uniformly across the spreader box width. Stabilizer bars should be

used to attach the spreader box to the truck. The stabilizer bars will reduce chatter and washboarding.

I. Introduction

In the past several years the NJDOT has used asphalt emulsion slurry seals to correct surface defects on several short sections of pavement. It was observed that the initial skid resistance was improved in the localized areas and the slurry seal provided an acceptable surface for several years.

The need for an inexpensive means to extend the time span between pavement overlays in this period of limited highway maintenance funds necessitates a rehabilitation mechanism such as the two-course slurry seal. Although slurry seal is reportedly able to provide several years of service on low to moderately trafficked roads, there was concern as to the material's skid resistant characteristics and durability on medium volume roads. Previous New Jersey projects have indicated that blast furnace slag aggregate can provide acceptable initial skid resistance.

The Asphalt Emulsion Slurry Seal Study was began in the spring of 1982 under Federal Highway Administration Demonstration Project #55, "Asphalt Emulsions for Highway Construction". This report describes the construction phase, and the monitoring phase, and presents the final conclusions, and recommendations.

The fundamental objective of this project was to collect information on the design, construction and performance of a two-course asphalt emulsion slurry seal for mainline surface treatment. The slurry seal study evaluated the potential increase in useful pavement life by periodically monitoring the wear, durability, and skid resistance of the seal coat over a three year time span.

II. Selection of Slurry Seal Locations

Route U.S. 206, Burlington County and Route I-78, Somerset County were selected for slurry seal applications. The bituminous concrete surface of both routes appeared dry and lifeless with numerous cracks. It was also desirable to enhance the skid resistant properties of the pavement. Neither route showed extensive structural deterioration.

The Route I-78 slurry seal application is essentially not part of the FHWA Demonstration project. However, results will be reported here because they provide additional information for the slurry seal evaluation and also provide comparison with the Route U.S. 206 application.

A. Route U.S. 206, Burlington County

The two-course slurry seal surface treatment was applied on Route U.S. 206 from milepost 26.8 to milepost 28.3 in Springfield Township, Burlington County. A location map is shown in Figure 1. At this location, Route U.S. 206 is a four-lane undivided bituminous concrete highway in a rural area of central New Jersey. The 1980 AADT was 9,800 vehicles, of which less than 10% are heavy trucks. The 1984 AADT was 11,200 vehicles, of which the same percent are heavy trucks.

The existing pavement section consisted of several maintenance overlays over an original bituminous pavement. A pavement condition survey performed in July 1981 indicated numerous longitudinal and map cracks probably caused by oxidation of the asphalt surface. Cracks were approximately 1/8 inch wide and sealed prior to the slurry seal. It was noted by the contractor that small areas of excess crack sealer might adversely affect the slurry seal by bleeding through. Photo #1 shows the pavement surface before slurry seal.

Figure I
Location Map of Route U.S. 206
Slurry Seal Project

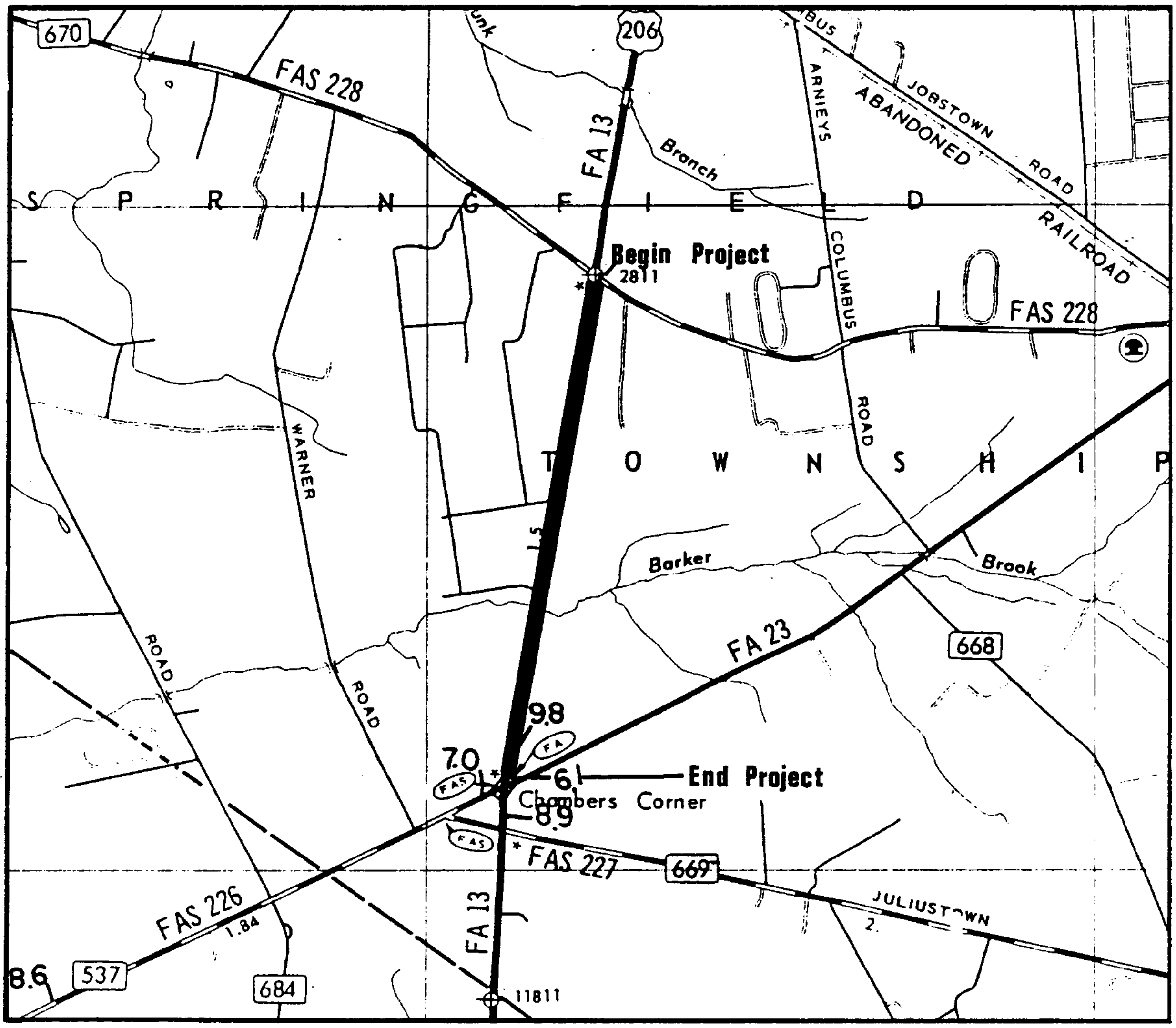


Photo #1

Route U.S. 206 - Surface before slurry seal.
The cracks were sealed during the 1981-82 winter season.

1. Construction Data

The asphalt emulsion slurry seal surface treatment was constructed in accordance with NJDOT "Specifications for Asphalt Emulsion Slurry Seal" (Appendix A). The material sources and aggregate gradations are shown in Figure 2. Prior to construction, the Bureau of Plant and Project Inspection calibrated the slurry seal equipment and sampled the materials. The material sampling results are given in Appendix B. Photo #2 and Photo #3 show the mobile slurry seal unit and application of the slurry seal, respectively.

This slurry seal application consists of a top course (Type II) and a bottom course (Type III). The bottom course of 3/8 inch stone and screenings from Glen Mills, Pennsylvania was mixed at the job site and applied at 15 lbs. per square yard. The job site blending did not provide adequate mixing and resulted in an uneven bottom course surface which created a wavy, uneven surface course. The surface course aggregate was blast furnace slag from Warner Company Morrisville, Pennsylvania, and was applied at 10 lbs. per square yard.

The contractor began application of the bottom course on May 4, 1982 and completed it on May 6. Laydown of the top course was begun on May 10 and completed on May 12. The slurry seal was applied in five 10-foot passes over the 50 foot width of pavement. The contractor applied 44,000 square yards of each course.

The contractor did not perform any special preparation on the old pavement. However, a fine water mist was applied to the old surface prior to the slurry seal application.

The typical construction procedure consisted of the slurry seal application beginning in early morning (between 8-9 o'clock) and being

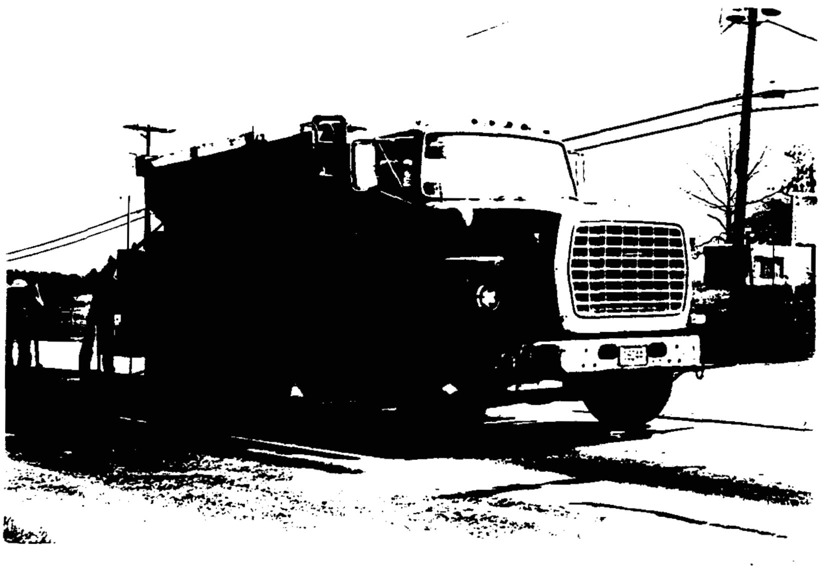


Photo #2

Mobile Slurry Seal Unit

The paving unit contains separate storage for the asphalt emulsion and aggregate. These materials are mixed in the truck and applied by the spreader box at the rear of the truck.

Photo #3

Application of the Slurry Seal

The mixed slurry seal is fed into the spreader box where it is applied to the road by squeegee action.

completed before noon. The paved surface remained closed to traffic until 4 o'clock. During most of the construction, the weather conditions were warm and sunny. On sunny, warm days, the emulsion cured sooner than it cured on cloudy, cool days. Essentially, the contractor opened the road when he felt that the pavement had adequately cured, which was usually about 4 o'clock.

The application rate of asphalt emulsion slurry seal surface treatment was recorded by the resident engineer for each day's application. The highest rate was 17,244 square yards per day for top course and 16,956 square yards per day for bottom course. An average day's application was 14,500 square yards for Route U.S. 206. The mobile slurry seal unit applies material at 2 linear feet per second or about 2.2 square yards per second (10 feet wide).

Figure 2

Material Gradation and Supplier

Route U.S. 206, Burlington County

Type II - Slurry Seal - Top Course

Screening - Warner Company, Morrisville, Pa. (Slag)

Mineral Filler - Co Play Cement (Portland cement) Local supply

Water - Local supply

Asphalt Emulsion - Windsor Service, Inc., Reading, Pa. (Type CSS-1H)

Type III - Slurry Seal - Bottom Course

Screening - General Crushed Stone, Glen Mills, Pa.

3/8 inch Stone - General Crushed Stone, Glen Mills, Pa.

Mineral Filler - Co Play Cement (Portland cement) Local supply

Water - Local supply

Asphalt Emulsion - Windsor Service, Inc., Reading, Pa. (Type CSS-1H)

The combined aggregate and mineral filler conforms to the following gradations:

Sieve Size	Type II Percent Passing	Type III Percent Passing
1/2"	100	100
3/8"	100	90-100
#4	85-100	70-90
#8	65-90	45-70
#16	45-75	28-50
#30	30-55	19-34
#50	18-35	12-25
#100	10-21	7-18

The finished surface at the signalized intersections in the stopping areas of the inside lane in the southbound direction and the outside lane in the northbound direction appeared darker than other stopping areas. The darker asphalt was located in the stopping areas where traffic is channelized at the intersection. The darker asphalt appears "fatty" but the surface was gritty and aggregate projected through the asphalt. An additional application was placed in these specific areas. Photo #4 and Photo #5 show the finished surface without darker (fatty) areas.

2. Skid Resistance

Skid resistance tests were made with the Department's skid tester one week after the slurry seal application and at two week intervals, thereafter. Beginning in August 1982, skid tests were made on one to two month intervals as conditions warranted.

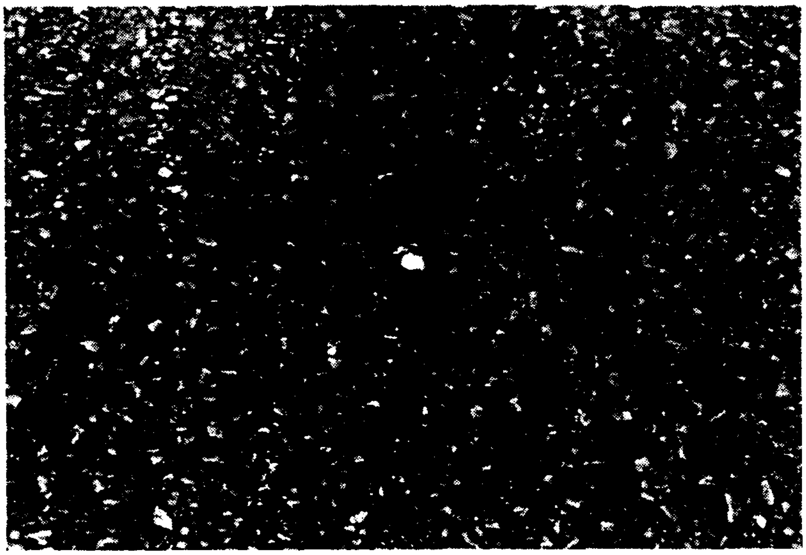


Photo #4

Typical Close-up of the Finished Surface

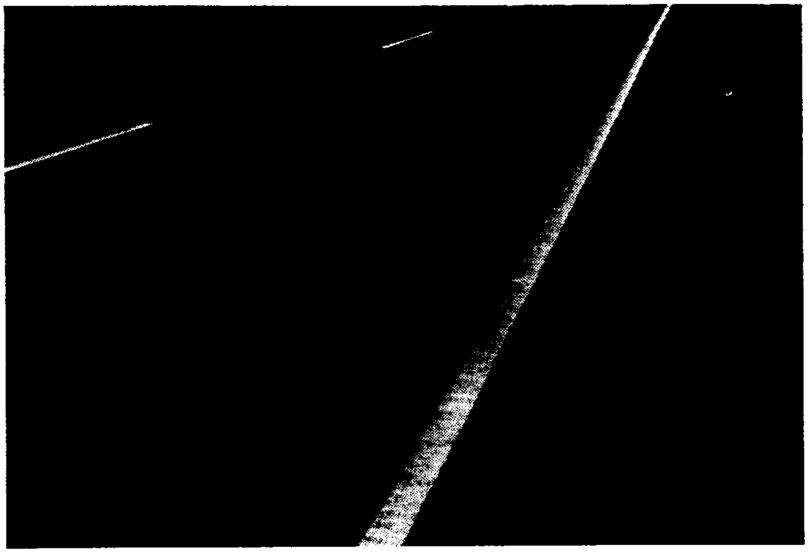


Photo #5

Finished Surface - Route U.S. 206

The average skid numbers (SN) of the skid resistance tests on the slurry seal are shown in Table 1. Before the application of the slurry seal, the 1980 average skid resistance (SN) was 40. Immediately after the application of slurry seal, the average skid resistance (SN) was 52, which is an improvement of 30 percent.

The average skid test data in Table 1 shows that skid data for the outside lane, northbound and southbound have decreased from the original measurements. Although the final measurements show good skid resistance, a decreasing trend is noted for that data. Crack sealer from the original pavement surface bleed through the slurry seal and probably contributed to the reduction in skid resistance. Skid resistance data for both northbound and southbound, inside lanes also shows a small decrease from the original measurements. The average skid number recorded in November 1985 is 47.

Table 1

Skid Resistance Tests

Route U.S. 206, Burlington County
(Average SN Value)

Date	Northbound Outside Lane	Northbound Inside Lane	Southbound Outside Lane	Southbound Inside Lane
May 21, 1982	50	54	53	52
June 4, 1982	53	54	51	52
June 25, 1982	51	47	47	49
July 9, 1982	50	54	51	51
Aug. 27 1982	39	51	45	50
Oct. 27, 1982	43	51	47	50
Nov. 19, 1982	38	49	43	47
Dec. 2, 1982	43	55	47	52
May 6, 1982	48	55	49	53
July 25, 1983	45	56	51	54
Aug. 19, 1983	38	44	46	54
Sept. 22, 1983	45	59	48	55
April 9, 1984	44	59	48	55
June 25, 1984	41	56	46	52
Oct. 23, 1984	42	57	44	54
March 26, 1985	45	54	49	53
July 15, 1985	39	54	51	52
Oct. 7, 1985	42	52	46	50
Nov. 12, 1985	42	52	46	49

This value is 15% greater than the measurements recorded on the old surface.

3. Surface Appearance

During construction of the slurry seal, uneven distribution, "washboarding", of the material was noted as it left the spreader box, which was hung from the rear of the truck. The slurry seal material is discharged from a truck mounted mixing plant into an attached spreader box that applies the slurry seal by a squeegee-type action. The washboarding was caused primarily by the inadequate on-site job mixing of coarse aggregate and fines. The squeegee's action on the segregated mix as it left the unsupported spreader box compounded the effect. By supporting the spreader box with stabilizer bars, the washboarding reportedly could be eliminated on future jobs. As the surface aged with traffic the wash-boarding decreased in severity.

Since construction, the slurry seal project was monitored monthly for overall surface appearance and cracking. The slurry seal showed initial surface delamination in the fall of 1984, about 2½ years after construction. At the present, the slurry seal has delaminated from the underlying surface in 22 areas of four to five square feet each. The material delamination is probably due to pockets of inadequately mixed asphalt emulsion, coarse aggregate and fines as discussed above. The overall surface texture is moderately coarse, but shows considerable variation with some smooth areas at the intersection either end of the project. The smooth texture is attributed to the consolidation of the slurry seal due to the stopping action of traffic rather than excessive wear.

In certain isolated areas, the slurry seal appears "fatty" which is attributed to the bleeding through of crack sealer that was applied to the original pavement prior to the slurry seal application. Some fine cracks have reflected into the slurry seal application from the original pavement in these areas. At this time, the cracks are not detrimental to the pavement surface. However, in time the cracks may allow water to penetrate into the base course and cause pavement distress.

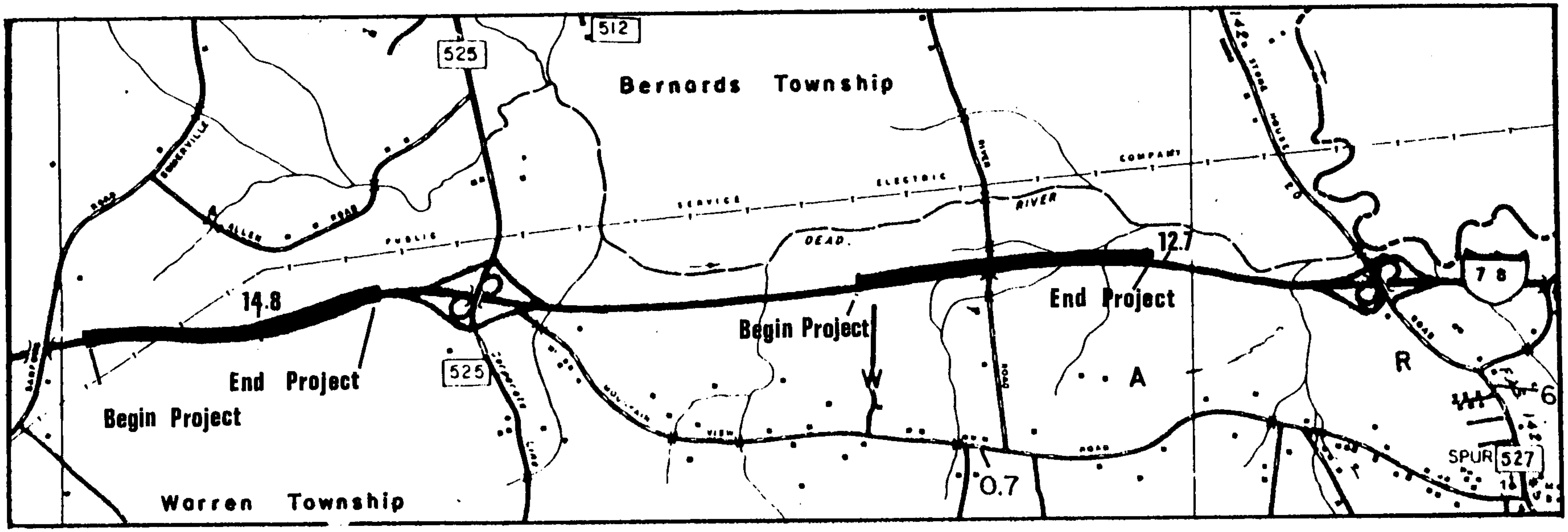
B. Route I-78, Somerset County

The two-course slurry seal was applied on Route I-78 eastbound from milepost 32.6 to milepost 33.6 and from milepost 35 to milepost 36 in Bernards Township and Warren Township, Somerset County. A location map is shown in Figure 3. The eastbound road section is three lanes (6 lane divided highway) of bituminous concrete in a rural area of northern New Jersey. The 1979 AADT and the 1984 AADT were 14,800 and 17,100 respectively. This section has few heavy trucks.

The original pavement was built in 1971 and consists of 4 inches bituminous surface course (Fine Aggregate Bituminous Concrete), 4 inches bituminous-stabilized base course, 4 inches quarry-processed stone base course, 8 inches macadam base course, and 12 inches granular subbase.

The initial pavement condition survey which was performed in August 1981 indicated numerous transverse, longitudinal and map cracks. Most cracks were approximately ¼ inch wide, and are attributed to oxidation of the asphalt top course. Photo #6 shows the oxidation cracks of the pavement surface before the slurry seal application.

Figure 3
Location Map for Route I-78
Slurry Seal Project



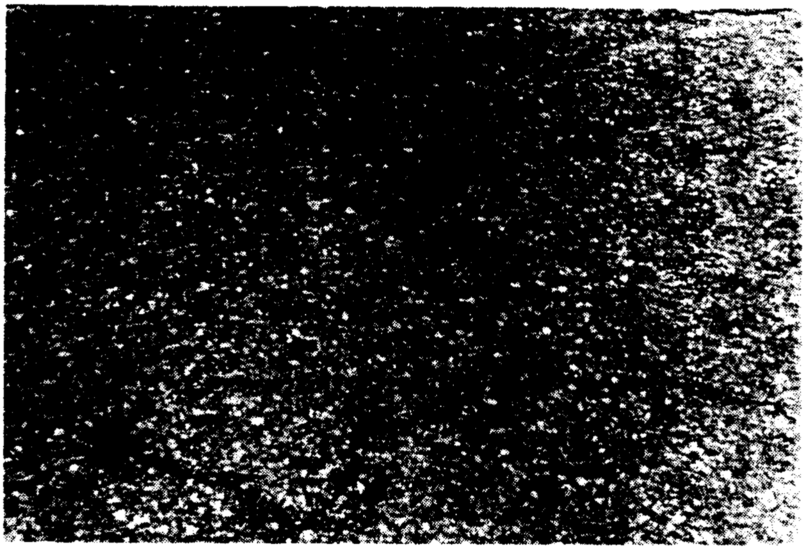


Photo #6

Route I-78 - Surface before Slurry Seal
The cracks are attributed to age harding of the bituminous surface.

1. Construction Data

The slurry seal surface treatment on Route I-78 was constructed in accordance with the NJDOT "Specifications for Asphalt Emulsion Slurry Seal" (Appendix A). The material sources and aggregate gradations are shown in Figure 4. The Bureau of Plant and Project Inspection sampled materials. The material sampling results are given in Appendix B.

The bottom course of 3/8 inch stone and screenings was plant mixed material from Limestone Products, Lafayette, New Jersey. The plant mixed material provided a more uniform bottom course which resulted in a more uniformly distributed surface course. The surface course aggregate was blast furnace slag from the Warner Company, Morrisville, Pennsylvania.

The contractor began application of the bottom course on May 17, 1982 and completed it on May 20. The top course placement began on May 25 and was completed on June 2. The slurry seal was applied 38 foot wide in three

Figure 4

Material Gradation and Suppliers

Route I-78, Bernards and Warren Townships

Type II - Slurry Seal - Top Course

Screening - Warner Company, Morrisville, Pa. (slag)

Mineral Filler - Co. Play Cement (Portland cement) Local supply

Water - Local supply

Asphalt Emulsion - Windsor Service, Inc., Reading, Pa. (Type CSS-1H)

Type III - Slurry Seal - Bottom Course

Screening - Limestone Products, Lafayette, N.J.

3/8 inch Stone - Limestone Products, Lafayette, N.J.

Mineral Filler - Co. Play Cement (Portland cement) Local supply

Water - Local supply

Asphalt Emulsion - Windsor Service, Inc. Reading, Pa. (Type CSS-1H)

The combined aggregate and mineral filler conforms to the following gradation:

Sieve Size	Type II Percent Passing	Type III Percent Passing
1/2"	100	100
3/8"	100	90-100
#4	85-100	70-90
#8	65-90	45-70
#16	45-75	28-50
#30	30-55	19-34
#50	18-35	12-25
#100	10-21	7-18

10-foot passes and one 8-foot pass. A total of 45,643 square yards of each course was placed.

The average daily rate of slurry seal on Route I-78 was comparable to that on the Route U.S. 206 project (12,000 vs. 14,500 square yards per day). However, the overall progress of the work was constantly hampered by weather conditions.

Rainy weather postponed construction on May 21 and 24, and halted construction on May 27 after one pass was made on the center lane. Cloudy weather slowed curing on May 19 and 20 when the center and outside lanes of the bottom course were slurry sealed, and for all days of the top course slurry sealing except June 2.

2. Thickness

Level and rod elevations at one foot intervals were taken on six cross-sections of Route I-78 to determine slurry seal thickness characteristics. The average thickness measurements are shown in Table 2. After construction, the overall average thickness was 0.30 inch (less than 5/16 inch). The average thickness after 3 years service was 0.22 inch (about ¼ inch).

While no minimum total thickness was specified for the slurry seal--materials' quantities being controlled by application rates (weight) rather than thickness -- the observed average thickness was certainly less than expected. In a properly applied treatment, we would have expected a finished thickness of at least 3/8 to 1/2 inch. However, the initial thin slurry seal surface was not detrimental to the overall pavement condition.

As is further indicated in Table 2, the thickness of the slurry seal was highly variable. In particular, the cross section measurements indicate a thickness range from 0.012 inch (less than 1/64 inch) in the

Table 2

Slurry Seal Thickness

Cross Section Measurements: Route I-78

Station	0+00	1+00	2+00	3+00	4+00	5+00
Initial Average Thickness ($\bar{X}$) (inches)	0.29	0.22	0.29	0.22	0.36	0.41
Final Average Thickness ($\bar{X}$) (inches)	0.20	0.20	0.15	0.20	.31	0.36
Average Decrease in Thickness	.09	.02	.14	.02	.05	.05

right wheelpath of the outside lane to 0.71 inch (nearly 3/4 inch) at the edge of the inside shoulder. The initial average slurry seal thickness in the wheelpaths was 0.19 inch (approximately 3/16 inch). The final average slurry seal thickness in the wheel paths was 0.12 inches (approximately 1/8 inch).

The uneven slurry seal thickness can probably be attributed to slow curing. Consistently cloudy, humid weather was experienced during the Route I-78 slurry seal application. Slurry seal application made under those weather conditions exhibited a spongy condition which was attributed to slow curing. Essentially, the road may have been opened prematurely to traffic causing differential compaction.

Uneven distribution of slurry seal material by the spreader box is another possible cause of the uneven slurry seal thickness. As discussed previously, the slurry seal material is discharged from a traveling mixing plant into an attached spreader box that applies the slurry by a squeegee-type action. The spreader box is a sectioned steel frame. Four or five people with shovels stand on the frame to distribute the slurry seal within the spreader box. Spreader boxes may be equipped with hydraulically powered augurs to move the slurry within the box and spread it uniformly across the spreader box width (Reference 1).

3. Skid Resistance

Skid resistance tests were made with the Department's skid tester one week after the final slurry seal application. The 1980 skid test survey (before the slurry seal) indicates that the average skid resistance (SN) was 41. The average SN of the slurry seal measurements are shown in Table 3. The average initial skid resistance (SN) on the slurry seal was 53 which is a 30 percent improvement from the original surface.

Table 3

Skid Resistance Tests

Route I-78, Somerset County

(Average SN)

Eastbound

Date	Outside Lane	Center Lane	Inside Lane
June 11, 1982	52	54	51
July 26, 1983	55	55	57
Aug. 22, 1983	47	57	62
Sept. 23, 1983	55	59	63
June 25, 1984	46	56	62
Oct. 23, 1984	54	59	65
April 1, 1985	54	60	64
Sept. 20, 1985	51	54	61

The average skid numbers (SN) of the skid resistance tests on the slurry seal are shown in Table 3. The numbers show a normal seasonal variation and suggest that the final skid numbers of the slurry seal have not changed from the initial skid numbers.

4. Surface Appearance

Pavement condition surveys were conducted periodically over the three-year evaluation to analyze pavement cracking, and surface appearance. No delamination and no "fatty" areas such as on the Route U.S. 206 project were noted on the Route I-78 project. Reflection cracks were noted on the surface shortly after construction. These cracks were less than 1/8 inch wide and were not detrimental to the pavement surface. In contrast to the moderately rough surface texture of the Route U.S. 206 application, the Route I-78 slurry seal has a sharp texture throughout the project. The typical cracking and texture on the slurry seal is shown in Photo #7.

The untreated (no slurry seal application) pavement surface which is before and after the slurry seal section on Route I-78 was periodically monitored for cracking and pavement deterioration. The deterioration of this pavement progressed to severe alligator cracking where pieces of bituminous concrete became loose. Photo #8 shows typical alligator cracking and loose bituminous concrete. This cracking is characteristic of pavement failure which requires rehabilitation and resurfacing. The slurry seal application delayed the occurrence of this condition for three-four years.

III. Evaluation of Structural Adequacy

Slurry seal applications are recommended by the International Slurry Seal Association for the restoration of pavement surfaces and for the improvement of skid resistance. Slurry seal does not provide structural strength to the pavement. Therefore, slurry seal is not recommended for applications to pavements with failed base courses.

Three sites on the proposed slurry seal sections of Route I-78 were tested with the Benkelman beam to evaluate the structural adequacy. Fifteen rebound measurements were made at each site. The average rebound measurements for Route I-78, prior to the slurry seal application, are shown in Table 4. For the purpose of comparison, Table 4 also contains

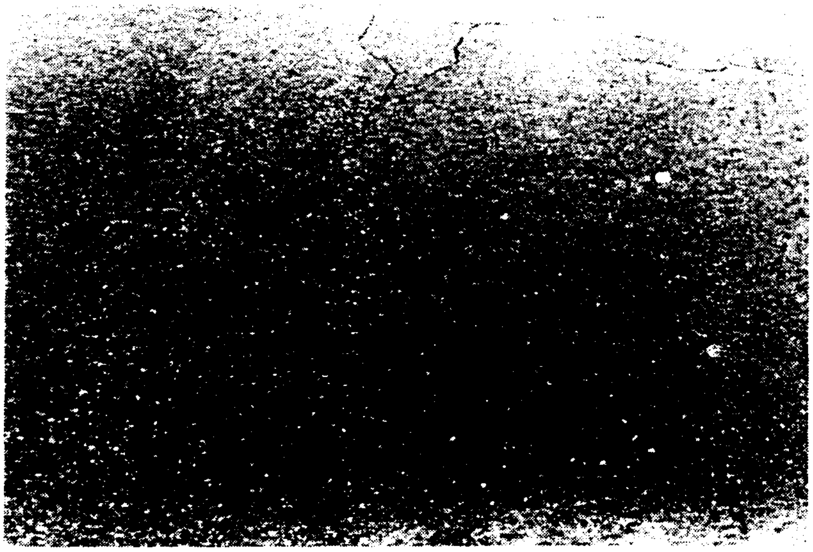


Photo #7

Typical Cracking on the Slurry Seal - Route I-78 Project

Table 4

Evaluation of Structural Adequacy

Route I-78 - Slurry Seal Application

Average Rebound Measurements

Location	Route I-78 Slurry Seal Area, Fall #1	Route I-78 Slurry Seal Area, Fall #2	Route I-78 Slurry Seal Area, Fall #3	Route I-80 Experimental Pavement*, Fall Test Section 1E	Route I-80 Experimental Pavement*, Fall Test Section 1W
Mean (inches)	0.013	0.010	0.014	0.014	0.013
Standard Deviation (inches)	0.002	0.002	0.003	0.001	0.004

*Benkelman beam average rebound measurements, outside lanes, outside wheelpath, October 1979.

Photo #8

Route I-78
Surface not covered by slurry seal at three years after the slurry seal application.

Benkelman beam measurements obtained on the Route I-80, Experimental Pavement. (Reference 2)

The pavement section for certain of the Route I-80 test sections are very similar to the Route I-78 slurry seal area. In particular, Route I-80 test sections consist of 4 inches bituminous top course, 6 inches dry bound macadam base course, 6 inches quarry processed stone and 14 inches granular subbase. These sections have a significantly higher AADT than the I-78 slurry seal sections and a higher percentage truck traffic, resulting in greater accumulated 18 kip loadings. In 1979 when the 0.014 inch and 0.013 inch rebound measurements (Table 4) were taken, analysis of the test data did not indicate structural failure. The 0.010 inch, 0.013 inch and 0.014 inch average rebound measurements on Route I-78 are similar to the Route

I-80 measurements. Therefore, the Route I-78 pavement is considered to be structurally adequate for the moderate traffic of that route.

IV. Cost of Alternate Materials

The bid price of Type III slurry seal was 95 cents per square yard and the Type II slurry seal was 80 cents per square yard, for a total slurry seal bid price of 1.75 dollars per square yard. The cost of a typical 1½ inch thick bituminous concrete surface course overlay in 1982 was 2.43 dollars per square yard. It follows then, if the slurry seal is to be cost effective in comparison to a thin overlay, it must provide a serviceable, skid resistant surface for more than five years, assuming an average life of seven years for a 1½ inch bituminous concrete overlay. (1.75 dollars per sq. yd./5 yrs. = 2.43 dollars per sq. yd./7 yrs.).

The 1986 cost of two course slurry seal seal is estimated to be 1.60 dollars per square yard and the 1986 cost of a 1½ overlay is about $3.25 dollars per square yard. Under these cost conditions the slurry seal has a 3½ year breakeven point.

The cost of the bituminous concrete mix does not include salvage costs and recycling costs. The salvaged bituminous concrete is a credit to the total cost. The recycling and milling costs become a debit. These costs must be considered on a job by job basis because the costs are variable. In consideration of these costs, the total life cycle cost relationship would probably benefit the slurry seal.

The haul distances for slurry seal aggregate and asphalt emulsion on these projects increased the bid price. For example, the crushed stone aggregates for the slurry seal on Route U.S. 206 were hauled from Glen Mills, Pennsylvania, which was 45 miles from the job. The blast furnace slag was hauled from Morrisville, Pennsylvania, which was 25 miles from the job. The crushed stone aggregate for the slurry seal on Route I-78 was hauled from Lafayette, New Jersey, which was 25 miles from the job. The blast furnace slag was hauled from Morrisville, Pennsylvania, which was 43 miles from the job. The asphalt emulsion was hauled from Reading, Pennsylvania, which was a distance of 86 and 75 miles for Route I-78 and Route U.S. 206 respectively.

V. Environmental Considerations

The New Jersey Department of Environmental Protection regulates the use of emulsified asphalt by the New Jersey Administrative Code - Title 7, Chapter 27, Subchapter 16.7. The article is as follows:

A. No person shall cause, suffer, allow or permit the use of cutback asphalt or emulsified asphalt containing volatile organic solvents (VOS) unless:

   1. The material is applied during the periods January 1 through April 15 or October 15 through December 31; or
   2. The use is solely as a penetrating prime coat; or
   3. The emulsified asphalt contains no greater than 8 percent VOS by volume and is used for mixed in-place construction; or
   4. The material is cold-mix, stockpile material used for pavement repairs; or
   5. The user can demonstrate that there are no emissions of VOS from the asphalt under conditions of normal use.

The Type CSS-1H Asphalt Emulsion which was used in the Route I-78 and U.S. 206 projects meets these regulations in that it contains less than the maximum allowed volatile organic solvents. The absences of VOS reduces atmospheric pollution.

VI. Energy Consumption

An analysis was made to compare the energy requirements of the slurry seal mix with a conventional New Jersey bituminous concrete mix. The energy consumption of the various operations for manufacturing, processing and placing of the asphalt emulsion slurry seal and bituminous concrete was taken from contractor records and from the Asphalt Institute's publication "Energy Requirements for Roadway Pavements." The complete energy analysis is shown in Appendix C.

The energy consumption which was calculated for the slurry seal was 9,877 BTU per sq. yd. for the Route U.S. 206 project and 7,719 BTU per sq. yd. for the Route I-78 project. A conventional bituminous concrete mix for either project would expend 70,600 BTU per sq. yd. If the slurry seal is to be energy effective, as compared to an average life of seven years for a 1½ inch bituminous concrete overlay it must provide a serviceable, skid resistant surface for approximately one year. (70,600 BTU per sq. yd./7yrs. = 9,877 BTU per sq. yd./1yr. and 70,600 BTU per sq. yd./7yrs. = 7,719 BTU per sq. yd./0.8 yrs.)

The energy consumption of the slurry seal is heavily dependent on the haul distance of materials. It is anticipated that increased use of slurry seal would appreciably lower energy consumption and costs by encouraging local suppliers. At this time, few local quarries are supplying blended stone for the slurry seal. Also, the asphalt emulsion came from Windsor Supply in Reading, Pennsylvania, which was the closest available supplier.

The frequent use of slurry seal would also encourage local suppliers of asphalt emulsion.

An energy analysis of slurry seal versus cutback asphalts was not considered because environmental restrictions on emissions do not allow the use of cutbacks in New Jersey. Since NJDOT uses a 1½ inch overlay of bituminous concrete for both resurfacing and skid resistance improvements, the energy analysis of bituminous concrete was felt to be appropriate for comparison with the slurry seal emulsion.

VII. Estimate of Service Life

The average service life in New Jersey of a 1½ inch bituminous concrete overlay is seven years with moderate traffic. The bituminous concrete overlay usually fails by rutting, raveling, cracking and loss of skid resistance. The average service life of the two-course slurry seal was estimated initially to be three to four years with moderate traffic. The estimate was based on previous experience with short maintenance repairs on state jobs and experience from county jobs.

Based on a qualified opinion, the performance to date (from May 1982 to the present) shows that this service life estimate to be conservative. Although a corrective overlay at the stopping areas is needed on the Route U.S. 206 project, the overall appearance and skid resistance will continue to be acceptable for an additional one or two years. Furthermore, the overall appearance and skid resistance of the Route I-78 project will continue to be acceptable for two or more years.

APPENDICES

VIII. References

1. "A Basic Asphalt Emulsion Manual," Asphalt Emulsion Manufacturers Association, Washington, D.C. February 1979.
2. Baker, R.F., "Experimental Pavement Project - Status Report," NJDOT, September, 1981.

August 10, 1979 Appendix A

ASPHALT EMULSION SLURRY SURFACE

The work to be performed and the materials to be supplied under this contract shall comply with the current requirements of the New Jersey Department of Transportation Standard Specifications for Road and Bridge Construction - 1961, except as amended, modified or supplemented herein, and which Standard Specifications are hereby made a part of these Supplementary Specifications.

The following is added to Division 3:

3.6.1. - Description

The work to be performed shall consist of the application of an asphalt emulsion slurry seal coat applied in two courses, at the locations, to the widths and lengths, all as shown on the plans or in the schedule included herewith, together with all other incidental work provided herein.

Additional instructions supplementing and made a part of these requirements shall specify the gradation (Type II or Type III Slurry) for each course.

3.6.2. - Materials

The Slurry Surface shall be prepared from materials conforming to the appropriate articles of Division 8 of the Standard Specifications, and/or as modified below, as follows:

(A) Asphalt Emulsion shall meet the current specifications of the American Association of State Highway and Transportation Officials for Cationic Emulsified Asphalt, Grade CSS-1h, except that the penetration of the distillation residue shall be 40-100.

(B) Aggregate shall be Trap Rock meeting the quality requirements set forth in the Standard Specifications and within the gradation ranges set forth below.

When aggregates of different gradations must be blended to obtain the proper gradation required for the Slurry Seal operation, the various sizes to be blended shall be of like character. All blending shall be done through a bituminous concrete, stabilization or other approved plant that will provide a complete and uniform mixture of the ingredients.

(C) Mineral Filler shall be Portland Cement meeting the requirements of the Standard Specifications.

(D) The combined aggregate and mineral filler shall conform to the following gradation or gradations:

Sieve Size	Type II Percent Passing	Type III Percent Passing
1/2"	100	100
3/8"	100	90-100
No. 4	85-100	70-90
8	65-90	45-70
16	45-75	28-50
30	30-55	19-34
50	18-35	12-25
100	10-21	7-18
200	5-15	5-15

(E) Water shall be potable and free from harmful soluble salts.

(F) Selection of materials for various uses and the approximate rate or percentage of each by weight in the Slurry Surface mix shall be in accordance with the following:

Material	Grade	Slurry Type	Rate or Percentage
			Asphalt Content
Emulsion	Cationic, Grade CSS-1h	II	7.5% - 13.5%
		III	6.5% - 12%
Aggregate	Washed Trap Rock Screenings	II	Minimum-10 lbs./S.Y.
	Blend of Washed Trap Rock Screenings and coarse Broken Stone	III	Minimum-15 lbs./S.Y.
Mineral Filler	Portland Cement	Either Type	1% - 3%
Water			As per Design Formula

Note: All materials requirements are based on dry weight of the aggregate.

3.6.3. - Methods of Construction

(A) Vehicular traffic control at the job site and protection of the work in progress shall be the responsibility of the contractor in cooperation with the contracting agency.

(B) Preparation of existing surface, including patching, crack filling, removal of vegetation and other foreign material, and cleaning and sweeping shall be completed by the contracting agency unless otherwise provided herein.

(C) The materials going into the Slurry Surface mix shall be proportioned in accordance with the design formula based on those materials. This formula shall be approved by the engineer prior to the start of any work. No change in the type or source of any ingredients shall be permitted without the submission and approval of a new design. A complete laboratory analysis and test report shall be submitted by the contractor before the job starts.

(D) Stockpiling and handling of aggregates shall be in accordance with Article 8.5.3. of the Standard Specifications.

(E) Samples of the aggregate, the emulsion and the mineral filler going into the mix shall be furnished to the engineer by the contractor during the progress of the work.

(F) All equipment, tools and machines used in the performance of this work shall be maintained in satisfactory working order at all times.

1. Slurry Mixing Equipment - The slurry mixing machine shall be a continous flow mixing unit designed to accurately deliver predetermined proportions of aggregate, asphalt emulsion, mineral filler and water to a mixing chamber, and of discharging the thoroughly, uniformly mixed product complying with the design formula, on a continuous basis. The aggregate shall be prewetted immediately prior to mixing with the emulsion. The mixing unit of the mixing chamber shall be capable of thoroughly blending all ingredients together without violent action.

The machine shall also be equipped with a water pressure system and fog type spray bar adequate for completely fogging the surface preceding the slurry spread with a maximum application of 0.05 gallons of water per square yard.

Sufficient machine storage capacity to properly mix and apply a minimum of ten tons of slurry shall be provided. A certified calibration chart of the emulsion tank shall be carried on the machine at all times.

The slurry machine must have been calibrated prior to commencing operations. The amount of each material proposed to be used on the contract - the aggregate, the asphalt emulsion and the mineral filler - shall be separately determined by the calibration, and these quantities must meet the requirements of the approved design formula.

2. Slurry Spreading Equipment - Attached to the mixer machine shall be a mechanical type squeegee distributor box having flexible material in contact with the road surface to prevent loss of slurry from the distributor. The box shall be so maintained as to prevent loss of slurry on varying grades and crowns by adjustments to assure uniform spread. There shall be a steering device and a flexible strikeoff. The spreader box shall be designed to apply varying widths of slurry. It shall be kept clean, and buildup of asphalt on the box shall not be permitted.

3. Auxiliary Equipment - Hand squeegees, shovels and all other necessary equipment shall be provided to perform the work in a proper manner.

(G) Application of the Slurry Surface

1. Weather Limitations - The Slurry treatment shall be applied only when the existing surface is dry or slightly damp without the existence of any free water, and when the pavement temperature is above 40°F., and the atmospheric temperature is above 50°F., unless otherwise authorized by the engineer.

2. Mixing and Spreading - The contractor shall apply the respective types specified in the proper order.

The pavement surface shall be fogged with water directly preceding the spreading of each course. The mixture shall be of the proper consistency when deposited on the surface and no additional elements shall be provided. Total mixing time shall not exceed four minutes. A sufficient amount of seal mix shall be carried in all parts of the spreader at all times so that complete coverage of the pavement is obtained. No lumping, balling or unmixed aggregate shall be permitted. No segregation of the emulsion and aggregate fines from the coarse aggregate will be allowed. If coarse aggregate settles to the bottom of the mix, the unsatisfactory material shall be removed from the pavement. No excessive breaking of the emulsion shall be allowed in the spreader box.

The second course shall not be applied until the engineer has given his approval, but in no case sooner than twenty-four hours after completion of the first course.

3. Joints - No excessive build-up or unsightly appearance shall be permitted on either longitudinal or transverse joints.

4. Hand Work - Hand squeegees or other tools approved by the Engineer shall be used to spread the Slurry mix in areas not accessible to machine spreading. Care must be exercised in this operation to make sure no unsightly appearance is created by the handwork.

The mix used in this operation must be uniform with no broken emulsion and without excess water.

5. Curing - It is anticipated that each course may be opened to traffic within 3 hours, but not until the engineer has given his approval.

Where possible, parking shall be prohibited for twenty-four hours after the work is finished.

3.6.4. - Quantity and Payments

Measurement and payment for Asphalt Emulsion Slurry Surface shall be on a square yard basis for each area completed and accepted by the engineer. When required by the engineer, certified tickets must be submitted covering the quantities of emulsion, aggregate and cement as determined by the job formula and as specified below.

Form LB-9 2/75

NEW JERSEY DEPARTMENT OF TRANSPORTATION
Trenton, New Jersey

SERIAL NO.

REPORT OF ANALYSIS OF AGGREGATE

Appendix B

CHARGED TO: **Slurry Seal Contract #1 (1981) Route 206 & Route I-78**

PROPOSED USE **Slurry Seal Aggregate**

KIND OF MATERIAL **Slag** SIZE TYPE **II** CLASS

PRODUCER **Warner Company** LOCATION **Morrisville, PA**

PLANT LOCATION

SAMPLE TAKEN FROM	Jobsite			
QUANTITY REPRESENTED	100 Tons			
MARKS ON SAMPLE				
SAMPLED BY	R. Dimmick			
DATE TAKEN	5-19-82			
DATE REC'D. AT LAB.				
SEAL NO.				
LAB. SERIAL NO.				

REPORTED TO

QualityControl
H.Kinderman
Region #1

SIZE OF OPENING SQUARE	TOTAL PERCENT PASSING			REQUIRED Min.	REQUIRED Max.
4"					
3½"					
3"					
2½"					
2"					
1½"					
1"					
¾"					
½"	100			100	
3/8"	100			100	
No. 4	94			85	100
No. 8	71			65	90
No. 16	51			45	75
No. 30	34			30	55
No. 50	23			18	35
No. 100	14			10	21
No. 200	8.8			5	15
REFLECTANCE					
LIQUID LIMIT					
PLASTICITY INDEX					
ABSORPTION					
SODIUM SULFATE LOSS					
SOFT PART. AND/OR LITHO.					
% CRUSHED PART.					
MICA					

REMARKS: **Sample run at Region #1 Headquarters-Clinton, NJ.**

Complies.

Form LB-9 2/75

NEW JERSEY DEPARTMENT OF TRANSPORTATION
Trenton, New Jersey

SERIAL NO.

REPORT OF ANALYSIS OF AGGREGATE

CHARGED TO: Slurry Seal Contract No. 1 (1981) Route 206 & Rt. I-78

PROPOSED USE Slurry Seal Aggregate

KIND OF MATERIAL #10 SIZE TYPE III CLASS

PRODUCER Limestone Products LOCATION Lafayette, NJ

PLANT LOCATION

SAMPLE TAKEN FROM	Jobsite			
QUANTITY REPRESENTED	150 Ton			
MARKS ON SAMPLE				
SAMPLED BY	J.Mason			
DATE TAKEN	5-17-82			
DATE REC'D. AT LAB.				
SEAL NO.				
LAB. SERIAL NO.				

REPORTED TO

Quality Control
H. Kinderman
Region #1 File

SIZE OF OPENING SQUARE	TOTAL PERCENT PASSING			REQUIRED Min.	REQUIRED Max.
4"					
3½"					
3"					
2½"					
2"					
1½"					
1"					
¾"					
½"	100			100	
3/8"	100			90	100
No. 4	78			70	90
No. 8	51			45	70
No. 16	37			28	50
No. 30	27			19	34
No. 50	18			12	25
No. 100	11			7	18
No. 200					
REFLECTANCE					
LIQUID LIMIT					
PLASTICITY INDEX					
ABSORPTION					
SODIUM SULFATE LOSS					
SOFT PART. AND/OR LITHO.					
% CRUSHED PART.					
MICA					

REMARKS: Sample run at Region #1 Headquarters-Clinton, NJ.

Complies.

New Jersey Department of Transportation

ANALYSIS OF MISCELLANEOUS MATERIALS

Field Evaluation

Serial No.

harged To: Slurry Seal Contract No 1 (1981)

ype of Material: Mineral Filler

roposed Use: Asphalt Emulsion Slurry Surface

roducer: Co Play Location:

lant Location:

				REPORTED TO
ample Taken From	Stock (Bags) at job site			
uantity Represented	100 Bags			
arks on Sample	FE-RT-5			
mpled By	R. Tobb			
rade Specified				
ot No. Shipped From				
bmitted on Inspector's Daily Report No.				
ate Taken	5-3-82			
ate Received at Laboratory				
al Number				
aboratory Serial No.				

TESTS	ANALYSES (Req. #3)		REQUIRED MIN.	REQUIRED MAX.
PASS 50	100		95	100
PASS 200	99.2		75	100

REMARKS:

12/77

Page 6

NEW JERSEY DEPARTMENT OF TRANSPORTATION
Trenton, New Jersey

REPORT OF ANALYSIS OF AGGREGATE

Field Evaluation

SERIAL NO.

CHARGED TO: Slurry Seal Contract No 1 (1981)

PROPOSED USE: asphalt Emulsion Slurry Surface

KIND OF MATERIAL: Screenings SIZE TYPE CLASS

PRODUCER: General C. Stone LOCATION: Glen Hills Pa.

PLANT LOCATION

SAMPLE TAKEN FROM	Stockpile at job site			
QUANTITY REPRESENTED	50 Tons			
MARKS ON SAMPLE	FE-RT-2			
SAMPLED BY	R. Todd			
DATE TAKEN	5-3-82			
DATE REC'D. AT LAB.				
SEAL NO.	—			
LAB. SERIAL NO.	—			

REPORTED TO

SIZE OF OPENING SQUARE	TOTAL PERCENT PASSING		Req. #3	REQUIRED Min.	REQUIRED Max.
4"					
3 ½"					
3"					
2 ½"					
2"					
1 ½"					
1"					
¾"					
½" ✓			100		
3/8" ✓			100		
No. 4 ✓			99.1		
No. 8 ✓			79.8		
No. 16 ✓			56.7		
No. 30 ✓			41.6		
No. 50 ✓			28.6		
No. 100 ✓			15.7		
No. 200 ✓			7.0		
PLASTICITY INDEX					
ABSORPTION					
SODIUM SULFATE LOSS					

REMARKS:

12/77

NEW JERSEY DEPARTMENT OF TRANSPORTATION

Trenton, New Jersey

REPORT OF ANALYSIS OF AGGREGATE

SERIAL NO.

Field Evaluation

CHARGED TO: Slurry Seal Contract No 1 (1981)

PROPOSED USE Asphalt Emulsion Slurry Surface

KIND OF MATERIAL Coarse Agg SIZE 3/8" TYPE CLASS

PRODUCER General Cr. Stone LOCATION Glen Mills Pa

PLANT LOCATION

REPORTED TO

SAMPLE TAKEN FROM	Stockpile at job site				
QUANTITY REPRESENTED	80 Tons				
MARKS ON SAMPLE	FE-RT-1				
SAMPLED BY	R. Tott				
DATE TAKEN	5-3-82				
DATE REC'D. AT LAB.	—				
SEAL NO.	—				
LAB. SERIAL NO.	—				

SIZE OF OPENING SQUARE	TOTAL PERCENT PASSING		Agg. #3	REQUIRED Min.	REQUIRED Max.
4"					
3 ½"					
3"					
2 ½"					
2"					
1 ½"					
1"					
¾"					
✓ ½"			100		
✓ 3/8"			91.8		
✓ No. 4			31.9		
✓ No. 8			5.4		
✓ No. 16			2.8		
✓ No. 30			2.3		
✓ No. 50			2.1		
✓ No. 100			2.0		
✓ No. 200			1.8		
PLASTICITY INDEX					
ABSORPTION					
SODIUM SULFATE LOSS					

REMARKS:

6-9 12/77

NEW JERSEY DEPARTMENT OF TRANSPORTATION
Trenton, New Jersey

SERIAL NO.

REPORT OF ANALYSIS OF AGGREGATE

Field Evaluation

CHARGED TO: Slurry Seal Contract No 1 (1981)

PROPOSED USE Asphalt Emulsion Slurry Surface Type II

KIND OF MATERIAL Slag SIZE TYPE CLASS

PRODUCER Warner Co. LOCATION Morrisville Pa.

PLANT LOCATION

SAMPLE TAKEN FROM	Stockpile @ job site				
QUANTITY REPRESENTED	30 tons				
MARKS ON SAMPLE	FE-RT-4				
SAMPLED BY	R Pete				
DATE TAKEN	5-3-82				
DATE REC'D. AT LAB.	–				
SEAL NO.	–				
LAB. SERIAL NO.	–				

REPORTED TO

SIZE OF OPENING SQUARE	TOTAL PERCENT PASSING		Rt. 1, #3	REQUIRED Min.	REQUIRED Max.
4"					
3½"					
3"					
2½"					
2"					
1½"					
1"					
¾"					
½"			100		
3/8"			100		
No. 4			93.8		
No. 8			72.4		
No. 16			52.3		
No. 30			36.2		
No. 50			23.9		
No. 100			14.9		
No. 200			9.5		
PLASTICITY INDEX					
ABSORPTION					
SODIUM SULFATE LOSS					

REMARKS:

.8.9 12/77

NEW JERSEY DEPARTMENT OF TRANSPORTATION

Trenton, New Jersey

SERIAL NO.

REPORT OF ANALYSIS OF AGGREGATE

Field Evaluation

CHARGED TO: Slurry Seal Contract No 1 (1981)

PROPOSED USE Asphalt Emulsion Slurry Surface Type III

KIND OF MATERIAL 3/8's & Screenings Blend SIZE TYPE CLASS

PRODUCER General G. Stone LOCATION Glen Mills Pa

PLANT LOCATION

SAMPLE TAKEN FROM	Stockpile at job site			
QUANTITY REPRESENTED	80 tons			
MARKS ON SAMPLE	FE-RT-3			
SAMPLED BY	R. Tall			
DATE TAKEN	5-3-82			
DATE REC'D. AT LAB.	-			
SEAL NO.	-			
LAB. SERIAL NO.	-			

REPORTED TO

SIZE OF OPENING SQUARE	TOTAL PERCENT PASSING		Req #3	REQUIRED Min.	REQUIRED Max.
4"					
3 ½"					
3"					
2 ½"					
2"					
1 ½"					
1"					
¾"					
½"			100	100	
3/8"			98.2	90	100
No. 4			84.8	70	90
No. 8			64.6	45	70
No. 16			44.9	28	50
No. 30			32.9	19	34
No. 50			22.1	12	25
No. 100			12.4	7	18
No. 200			5.0	5	15
PLASTICITY INDEX					
ABSORPTION					
SODIUM SULFATE LOSS					

REMARKS:

TYPE —

3/8's SCREEN. BIN GRADATIONS ACTUAL

SIEVE SIZE	~~BIN NO 5~~ 28.0 %		BIN NO 4 %		BIN NO 3 70.0 %		BIN NO 2 %		BIN NO 1 %		FILLER 2.0 %		THEOR COMB	SPEC	
	% Pass.	% Batch	% Pass.	% Batch	% Pass.	% Batch	% Pass.	% Batch	% Pass.	% Batch	% Pass.	% Batch		Min.	Max.
2"															
1½"															
1"															
¾"															
½"	100	28.0			100	70.0					100	2	100	100	
3/8"	91.8	25.7			100	70.0					100	2	97.7	90	100
# 4	31.9	8.9			99.1	69.4					100	2	80.3	70	90
# 8	54	1.5			79.8	55.9					100	2	59.4	45	70
# 16	2.8	0.8			56.7	39.7					100	2	42.5	28	50
# 30	2.3	0.8			41.6	29.1					100	2	31.9	19	34
# 50	2.1	0.6			28.6	20.0					100	2	22.6	12	25
# 100	2.0	0.6			15.7	11.0					100	2	13.6	7	18
# 200	1.8	0.5			7.0	4.9					94.2	1.9	7.3	5	15

BLENDED STOCKPILE GRADATIONS

SIEVE SIZE	SIZE NO ___ ___ %		SIZE NO ___ ___ %		SIZE NO ___ 98 %		SIZE NO ___ ___ %		SIZE NO ___ ___ %		FILLER 2 %		THEOR COMB	SPEC	
	% Pass.	% Batch	% Pass.	% Batch	% Pass	% Batch	% Pass	% Batch	% Pass	% Batch	% Pass	% Batch		Min.	Max.
2"															
1½"															
1"															
¾"															
½"					100	98					100	2	100	100	
3/8"					98.2	96.2					100	2	98.2	90	100
# 4					84.8	83.1					100	2	85.1	70	90
# 8					64.6	63.3					100	2	65.3	45	70
# 16					44.9	44.0					100	2	46.0	28	50
# 30					32.9	32.2					100	2	34.2 *	19	34
# 50					22.1	21.7					100	2	23.7	12	25
# 100					12.4	12.2					100	2	14.2	7	18
# 200					5.0	4.9					94.2	1.9	6.8	5	15

* @ max of spec.

SLAG BIN GRADATIONS

SIEVE SIZE	BIN NO. 5 ___ %		BIN NO. 4 ___ %		BIN NO. 3 98.0 %		BIN NO. 2 ___ %		BIN NO. 1 ___ %		FILLER 2.0 %		THEOR COMB	[illegible]	
	% Pass.	% Batch	% Pass.	% Batch	% Pass	% Batch	% Pass	% Batch	% Pass.	% Batch	% Pass	% Batch		Min.	Max.
2"															
1½"															
1"															
¾"															
½"					100	98.0					100	2	100	100	
3/8"					100	98.0					100	2	100	100	
# 4					93.8	91.9					100	2	93.9	85	100
# 8					72.4	71.0					100	2	73.0	65	90
# 16					52.3	51.2					100	2	53.2	45	75
# 30					36.2	35.5					100	2	37.5	30	55
# 50					23.4	22.9					100	2	24.9	18	35
# 100					14.9	14.6					100	2	16.6	10	21
# 200					9.5	9.3					99.2	1.9	11.2	5	15

STOCKPILE GRADATIONS

SIEVE SIZE	SIZE NO ___ ___ %		SIZE NO ___ ___ %		SIZE NO ___ ___ %		SIZE NO ___ ___ %		SIZE NO ___ ___ %		FILLER ___ %		THEOR COMB.	[illegible]	
	% Pass.	% Batch	% Pass.	% Batch	% Pass	% Batch	% Pass	% Batch	% Pass	% Batch	% Pass	% Batch		Min.	Max.
2"															
1½"															
1"															
¾"															
½"															
3/8"															
# 4															
# 8															
# 16															
# 30															
# 50															
# 100															
# 200															

Form AD-40 (A) 11/78

NEW JERSEY DEPARTMENT OF TRANSPORTATION

MEMORANDUM

TO: F. Palise, Project Engineer, Region 3

FROM: D. Sessa, Principal Engineer, Region 3

SUBJECT: Calibration of Slurry Seal Mobiles
Slurry Seal Contract No. 1(1981)

DATE: 5-4-82

TELEPHONE NO.: Ext 356 -

On May 3, 1982, myself and R. Toth witnessed the calibration of three slurry seal mobiles at the contractor's yard at the intersection of Route 206 and Route 537 in Mount Holly, N.J. These trucks are to be used for the upcoming Slurry Seal Contract No. 1 (1981) project.

Listed below is the data collected on that day:

1. For mix Type III

Truck No.	Avg. % Emulsion vs. Agg.	Gear Ratio	Recommended Range
566	13.8%	25:19	13 - 17%
554	15.4%	25:25	13 - 17%
511	14.5%	25:18	13 - 17%

2. For mix Type II

Truck No.	Avg. % Emulsion vs. Agg.	Gear Ratio	Recommended Range
511	18.0%*	25:16	15 - 18%
566	16.5%	25:17	15 - 18%
554	17.8%	25:25	15 - 18%

* Recommended gear ratio on this truck be changed to 25:17 to reduce emulsion/aggregate ratio. Contractor will obtain larger gear before project begins.

ORIGINAL SIGNED
D. A. SESSA

D. A. Sessa

DAS:js

cc: T. Corcoran
R. Kenderman (Resident Engineer)
Job File
Engineering Staff
File

Appendix C

A. Energy Analysis for Conventional No. 4 MABC Mix

Materials	BTU/Ton
Mfg. asphalt cement	587,500
Haul 20 mi. x 2 @ 5040 BTU/Ton mi.	201,600
	789,100
Mfg. tack coat	498,870
Haul 20 mi. x 2 @	201,600
	700,470
Crushed Stone @ 70,000 BTU/Ton - 71%	49,700
Sand @ 15,000 BTU/Ton - 22%	3,300
Mineral Filler @ 70,000 BTU/Ton - 7%	4,900
Haul 10 mi. x 2 @ 4,270 BTU/Ton mi. 1.025 (2.5% moisture 1.025)	87,535
	145,435

Mix Composition

Asphalt Cement 5.5% @ 789,100 BTU/Ton	43,400
Aggregate 94.4% @ 145,435 BTU/Ton	137,436
	180,836

Plant Operations

Heat and dry aggregate 1.67 gal./Ton (139,00 BTU/Gal. #2 F.O.)	232,130
Store asphalt cement	6,400
Cold Feed	4,730
Dryer and exhauts	4,770
Mixing Plant	3,920
	251,950

Paving and Hauling

Haul 20 mi. x 2 @ 4270 (Mix)	170,800
Haul 20 mi. x 2 @ 5040 (Tack Coat)	201,600
Tack Coat (.25 gal/S.Y.)	43,624
Spread and Compact Mix	16,700
	432,724
Total BTU/Ton	865,510

Energy for Bituminous Concrete Mix

Route U.S. 206 - 44,000 S.Y.
3,589 Tons

865,510 BTU/Ton X 3,589 Ton / 44,000 S.Y. = 70,600 BTU/S.Y.

Route I-78 - 45,643 S.Y.
3,723 Tons

865,510 BTU/Ton x 3,723 Tons / 45,643 S.Y. = 70,600 BTU/S.Y.

B. Energy Analysis for Asphalt Emulsion Slurry Seal

Materials	Route I-78 BTU/Ton	Route U.S. 206 BTU/Ton
Mfg. asphalt emulsion (1980 BTU/Gal. x 241 gal/ton)	477,180	477,180
Haul to Job 86 mi. x 2 @ 5040 BTU/ton mi.	866,880	
Haul to Job 75 mi. x 2 @ 5040 BTU/ton mi.		756,000
	1,344,060	1,233,180
Mfg. Portland cement	7,570,000	7,570,000
Haul to Job 13 mi. x 2 @ 4270 BTU/ton mi.	111,020	
Haul to Job 3 mi. x 2 @ 4270 BTU/ton mi.		25,620
	7,681,020	7,595,620
Crushed Stone	70,000	70,000
Haul to Job 25 mi. x 2 @ 4270 BTU/ton mi.	213,500	
Haul to Job 45 mi. x 2 @ 4270 BTU/ton mi.		384,300
	283,500	454,300
Water truck Haul 5 mi. x 2 @ 5040 BTU/ton mi.	50,400	50,400
Mix Composition		
Asphalt emulsion 9.25%	124,326	114,069
Cement 2%	153,620	151,912
Aggregate 88.75%	251,606	403,191
Water 5%	2,520	2,520
	532,072	671,692

Application

Front end loader	4,375	4,375
Slurry Seal Mobile Unit		
394 gal. x 125,000 BTU/Gal/570 tons		86,404
458 gal. x 125,000 BTU/Gal/550 tons	104,090	
	108,465	90,779
Total BTU/Ton	640,537	762,471

Energy for Slurry Seal Project

Route U.S. 206
762,471 BTU/Ton x 570 tons / 44,000 S.Y. = 9,877/S.Y.

Route I-78
640,537 BTU/Ton x 550 tons / 45,643 S.Y. = 7,719 BTU/S.Y.

*Represents total energy used by the Slurry Seal mobiles on the Slurry Seal Project.

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