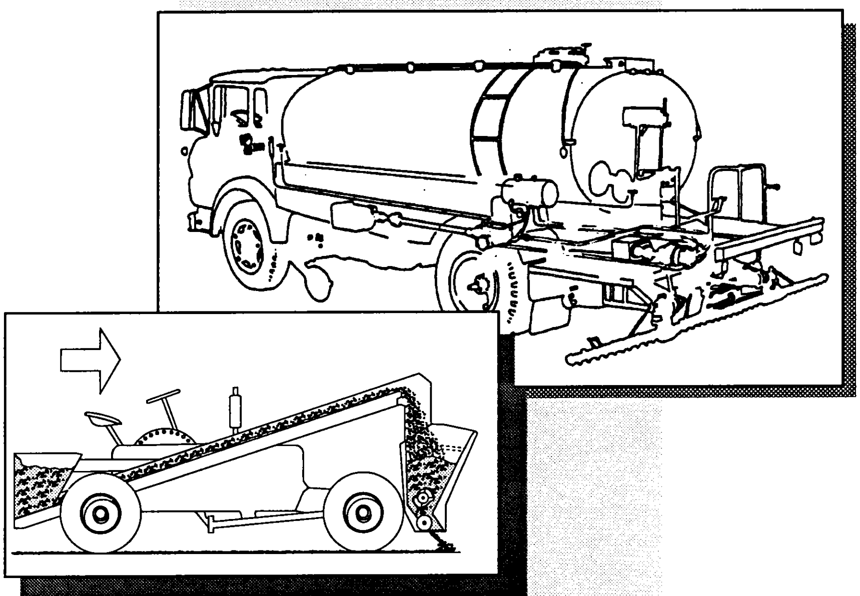
FINAL REPORT

EVALUATION OF MODIFIED SINGLE SEAL SURFACE TREATMENTS



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Supplementary Notes

Abstract

This report describes a field study of a multicourse asphalt emulsion chip seal, designated as a modified single seal. The treatment, already used in North Carolina, consists of an application of emulsion and coarse aggregate followed by another application of emulsion and a final layer of fine aggregate. Sixty sections were placed in three districts in 1986-88, totaling approximately 400 lane-km of surfacing. These sections were evaluated periodically by a team of local operations personnel and research staff. The operations personnel also provided estimates of service life for conventional single chip seals, used for a cost-benefit analysis.

The modified seals performed better and were more cost-effective than conventional surface treatments. Also, the hazard of broken windshields caused by loose aggregate was virtually eliminated on the modified seal treatments.

The report includes recommendations for ensuring that the final product is of high quality. The recommendations include using a pilot vehicle, limiting the speed of construction traffic, using clean dry blot aggregate, applying the coarse aggregate not more than one stone thick, and using the proper nozzles on the asphalt distributor.

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(A Cooperative Organization Sponsored Jointly by the Virginia Department of Transportation and the University of Virginia)

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ABSTRACT

This report describes a field study of a multicourse asphalt emulsion chip seal, designated as a modified single seal. The treatment, already used in North Carolina, consists of an application of emulsion and coarse aggregate followed by another application of emulsion and a final layer of fine aggregate. Sixty sections were placed in three districts in 1986-88, totaling approximately 400 lane-km of surfacing. These sections were evaluated periodically by a team of local operations personnel and research staff. The operations personnel also provided estimates of service life for conventional single chip seals, used for a cost-benefit analysis.

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INTRODUCTION

The term 'surface treatment,' in this report, refers to single or multiple applications of emulsified asphalt and aggregate on the road surface. This is commonly known as chip seal treatment. Traffic on a new surface treatment can whip off the stone due to a lack of adhesion between the aggregate chips and the layer of asphalt applied to the underlying surface. Windshields are sometimes broken, and the exposure of asphalt where aggregate is lost can also cause friction problems. Such surface treatment problems as flushing (excess asphalt), aggregate loss, and windshield damage are quite common.[1] Uncontrollable factors like weather and material properties are known to contribute to these problems. A system that will be somewhat forgiving of adverse paving conditions is needed.

The Virginia Department of Transportation (VDOT) is always looking for better surface treatment technology. Previous studies led to several changes in specifications, improving the quality of conventional surface treatments.[2,3] In 1984 and 1985, Virginia implemented a design method to determine the proper quantities of materials.[4] The method used the flakiness index of the aggregate, as recommended by the Asphalt Institute, and required a minimum surface temperature of 21 C (70 F) for paving. After field experience, several additional changes were made in the late 1980's. The application temperature of emulsion was raised to 71 - 79 C (160 - 175 F) to prevent streaking, and the gradation of the aggregate was changed.

These changes improved surface treatments, but did not eliminate all the problems. In 1986, representatives from the Maintenance Division and the Research Council went to North Carolina to observe the multicourse surface treatments that have been widely used there for several years to minimize surface treatment problems.

The North Carolina multicourse surface treatment consists of an application of asphalt followed by a layer of cover aggregate and a second application of asphalt followed by a blot coat of sand or screenings. Because the prime and seal treatments used in Virginia could be confused with the multicourse treatments, the Virginia designation was changed to "modified seal" in 1988, the term used in this report. Test sections were planned for 1986 and 1987 in the Fredericksburg, Richmond, and Lynchburg Districts to capitalize on North Carolina's success with the multicourse treatments.

PURPOSE

The purpose of this study was to determine the feasibility of using modified seals rather than conventional single surface treatments. One important task was to compare the cost benefit of modified seals with that of conventional surface treatments.

METHODOLOGY

The modified seal was evaluated by placing field test sections and observing their performance. Teams of local evaluators and a member of the research staff evaluated the performance of the treatments and gathered information on the service life and cost of conventional treatments located nearby.

Quantitative evaluations are always preferable, but subjective evaluation was necessary in this study. It was not feasible to construct a control section adjacent to each test section for comparison because of the extraordinary cost involved. Local maintenance personnel furnished information on the average performance and service life of conventional surface treatments subjected to similar levels of traffic in the same general area. This information was used in the cost benefit comparison between the modified seals and conventional treatments.

TESTING

Application Rates

The application rates for the asphalt and aggregate were checked during calibration and construction to ascertain that the correct quantities of materials were being applied. The rates were determined by measuring the amount of material sprayed or dropped on 0.093 m^2 (1.0 ft^2) metal plates placed on the pavement before the distributor and aggregate spreader passed. The rate of asphalt application was determined by:

$$R_{Asp} = 1.08 W_{Asp} M$$

where:

R_{Asp} = Application rate (corrected to 16C), gal/yd^2

W_{Asp} = Weight of emulsified asphalt on plate, lbs

M = Temperature-volume correction factor[5] or by the following equation in metric units:

$$R_{Asp} = 10.8 W_{Asp} M$$

where:

R_{Asp} = Application rate (corrected to 16C), l/m^2

W_{Asp} = Mass of asphalt, kg

M = Temperature-volume correction factor[5]

The aggregate application rate was determined by the formula:

$$R_{Agg} = \frac{W_{Agg}}{A}$$

where:

R_{Agg} = Application rate of aggregate (kg/m^2 or lb/yd^2)

W_{Agg} = Mass (kg) or weight (lb) of aggregate

A = Area of plate (0.093 m^2 or 0.0929 yd^2)

Performance Evaluations

Performance was determined visually by teams of evaluators for each local area. The pavements were rated subjectively as excellent, good, fair, or poor according to the amount of bleeding, cracking, and patching observed. An excellent rating was considered typical for an ideal new surface treatment and poor for a pavement at or near a level needing resurfacing.

Test Sections

Test sections were placed in the Fredericksburg and Richmond Districts in 1986 and 1987 and in the Lynchburg District in 1988. Though there were some problems with the first sections placed in 1986, the early performance was so good that the Fredericksburg District decided to use modified seals instead of conventional surface treatments throughout their district in 1987. All of the sections placed did not serve as test sections even though Research Council personnel were generally present during the construction to offer advice. In 1988, additional test sections were constructed in the Lynchburg District.

Selection and Location

Fredericksburg and Richmond Districts - 1986-87

Ten sections were placed in Lancaster, Middlesex, Mathews, and Gloucester Counties comprising approximately 64 lane-kilometers of pavement in the Fredericksburg District (Appendix A). Twenty sections were placed in Chesterfield County in the Richmond District totaling approximately 48 lane kilometers (Appendix A). The Clover Hill Farm subdivision contained 14 sections and the Plantation Estates subdivision contained 3 test sections.

The test sections were selected by personnel from the Districts, Residencies, Maintenance Division and Research Council. The test sections used different aggregate sources and had a range of traffic volumes. The 30 test sections in the Fredericksburg and Richmond Districts used four different aggregate sources, two supplying granite crushed stone and two supplying rounded river gravel. The highways in the Fredericksburg District covered traffic groups IV - VIII, a range of traffic volumes from 50 to 999 vehicles per day. The highways in the Richmond District covered traffic groups VII - IX, a range of traffic volumes from 400 to 1999 vehicles per day.

Lynchburg District - 1988

The same selection process was used in the Lynchburg District for the 30 sections comprising 288 lane-km (179 lane-miles) in Buckingham and Campbell Counties. Traffic volumes varied, but river gravels were not included in the aggregates. The highways selected in the Lynchburg District included traffic groups IV - IX, a range of traffic volumes of 50 to 1999. Appendix A shows the test section locations for the Lynchburg District.

Materials

Coarse Aggregates

Four aggregate sources were used on the modified seals in Fredericksburg and Richmond Districts. Of these four aggregates, one river gravel and one crushed stone had not performed well when used as surface treatment coarse aggregates in the past. However, in North Carolina NCDOT personnel had found that aggregates with previous histories of poor performance in conventional surface treatments performed well when used in modified seals. The coarse aggregate is totally encapsulated in asphalt by being covered with a blot coat layer that prevents aggregate pick-up and whip-off.

All of the coarse aggregates used in the Fredericksburg and Richmond Districts were No. 8's, whereas the coarse aggregates placed in Lynchburg District were No. 8P's, which had less fine material. The aggregate types and sources are shown in Table 1. The specification ranges for the two gradations are listed in Table 2.

Blot Fine Aggregate

When the original test sections were placed in the Fredericksburg and Richmond Districts, the specifications allowed the final layer of blot material to be grade A, B or F sand. In addition, the No. 10 screenings commonly used in slurry seal mixes were also allowed for the blot layer. Two problems were initially encountered: a dust problem in residential neighborhoods and non-uniform flow of the No. 10 screenings through the aggregate spreader. To alleviate these problems, the amount of fines passing the 75 μm (No. 200) sieve were limited to five percent and the use of No. 10 screenings was discontinued. The specified gradations of the A, B, and F sand that can be used today for blot material are shown in Table 3.

Table 1: Aggregate Data

DISTRICT	AGGREGATE SOURCE	AGGREGATE TYPE
Fredericksburg	Aylett Sand & Gravel Aylett, VA	River Gravel
Fredericksburg	West Sand & Gravel Richmond, VA	River Gravel
Fredericksburg	General Crushed Stone Doswell, VA	Crushed Granite
Richmond	Lone Star Dale Quarry Petersburg, VA	Crushed Granite
Lynchburg	Blue Ridge Mt. Athos Concord, VA	Crushed Granite

Table 2: Aggregate Gradation

AGGREGATE SIZE NO.	PERCENTAGE PASSING SIEVE SIZE				
	* 12.5 ** 1/2	9.5 3/8	4.75 NO. 4	2.36 NO. 8	1.18 NO. 16
8	100	84-100	10-40	MAX.8	MAX.5
8P	100	75-100	5-30	MAX.5	

* Metric (mm)
** U. S. Sieve Series

Table 3: Blot Fine Aggregate Gradation

SIEVE	PERCENTAGE PASSING SIEVE SIZE							
	* 9.5 ** 3/8	4.75 NO. 4	2.36 NO. 8	1.18 NO. 16	0.600 NO. 30	0.300 NO. 50	0.150 NO. 100	0.075 NO. 200
A	100	94-100	80-100	49-85	25-59	8-26	MAX.10	MAX.5***
B	100	94-100	100	94-100			MAX.10	MAX.5***
F	100	84-100	60-100	40-84	11-49	MAX.26	MAX.10	MAX.5***

* Metric (mm)
** U. S. Sieve Series
*** Limited to 5 percent only for modified seals

Asphalt

A cationic rapid-set emulsion, type CRS-2, was used on all of the test sections. Only one change was made in the emulsion during the time of test section placement: new temperature requirements for application were adopted, as discussed in the Introduction. Samples of the asphalt emulsion were obtained from the suppliers and tested in the VDOT Materials Division lab in accordance with the test requirements shown in Table 4 as specified in Section 210.02 of the 1994 *Road and Bridge Specifications*[6] to ensure compliance.

Table 4: Asphalt Emulsion Specifications

TEST TYPE	REQUIREMENT	
Viscosity, Saybolt Furol, s, @ 122 F (50 C)	Min 100	Max 400
Storage Stability Test 24 Hour %		Max 1.0
Classification Test	Passes	
Particle Charge Test	Positive	
Sieve Test, 20 Mesh		Max 0.2
Distillation:		
Oil distillate, by volume of emulsion, %		Max 3
Residue, %	Min 65	

Construction

All test sections were placed by private contractors. The asphalt distributor and self-propelled aggregate spreader were calibrated before starting construction on each section to ensure a proper rate of application. During placement of each test section, periodic quantity checks were made to confirm that the equipment remained calibrated and proper quantities of aggregate and emulsion were being placed.

Application rates

The North Carolina specifications called for the first application of asphalt and aggregate on a single modified seal to be placed at 0.90 l/m^2 (0.20 gal/yd^2) and 9.8 kg/m^2 (18 lbs/yd^2). The specified application rates for the components of the second layer (the blot layer) were 0.77 l/m^2 (0.17 gal/yd^2) of emulsion and 6.5 kg/m^2 (12 lbs/yd^2) of fine aggregate.

The NCDOT maintenance superintendent noted that the actual application rates were somewhat below those in the specifications. Therefore, the rates that Virginia specified for the single modified seal were 0.77 l/m^2(0.17 gal/yd^2) and 8.1 kg/m^2 (15 lbs/yd^2) for the first application of emulsion and coarse aggregate respectively and 0.68 l/m^2 (0.15 gal/yd^2) and 5.4 kg/m^2 (10 lbs/yd^2) for the second application of emulsion and blot material. The NCDOT maintenance superintendent also noted that, depending on the climatological conditions, the actual quantity of blot material placed was sometimes less than 6.5 kg/m^2 (12 lbs/yd^2). When temperatures were cooler, especially during spring and fall, the blot material was sometimes placed at as little as 3.3 kg/m^2 (6 lbs/yd^2).

General Construction Technique

The construction technique for placing the modified seal is similar to that for conventional surface treatments. The modified seal is rolled with a steel wheel roller instead of the commonly used rubber-tired roller, and adequate traffic control is of the utmost importance until the fine aggregate blot coat is placed. Within a week of construction, the modified seal may be swept to remove any loose aggregate or excess blot material.

Good traffic control ensures minimal loss of coarse aggregate in cases where traffic must travel on the surface before the application of the blot layer. The asphalt emulsion is applied in two applications, and the first application of 0.77 l/m^2 (0.17 gal/yd^2) does not ensure enough asphalt to hold the single layer of coarse aggregate in place. If traffic is allowed to run at normal speeds on the new treatment while there is still only a light application of asphalt, much of the aggregate could be whipped off before the final blot coat is placed. A pilot vehicle should be used to keep all traffic, including haul-trucks, off the new treatment or to limit their speed to 24 km per hour (15 miles per hour) until the final application of asphalt and blot material is placed.

Steel wheel rollers were used because the NCDOT required them and because previous Research Council experience indicated that the steel wheel roller embedded the aggregate better than the pneumatic tire roller and also left a smoother riding mat for the traveling public. The final layer of blot material helps prevent the loss of aggregate in any depressed areas that may be bridged over and not seated well by the steel wheel roller.

Construction Observations

Even though much valuable information was gained from the NCDOT personnel, much more was learned during the placement of the test sections in 1986 and 1988 and the learning process still continues. The modified seal is not immune to problems although it does offer a significant improvement in surface treatments.

Traffic Control

On the original test sections in the Fredericksburg District, the first application of asphalt emulsion and cover aggregate was placed on both lanes before placing the final layer of blot material. This meant that traffic had to be placed on one lane before the blot layer was applied. Traffic was controlled with a pilot vehicle to less than 24 km/hr (15 miles/hr) until the final layer of asphalt and blot material was placed. It was learned that by completing one lane with both the coarse aggregate and blot layers before subjecting it to traffic, the coarse aggregate was less likely to be dislodged, because the coarse aggregate was completely surrounded by asphalt and also protected by the blot layer aggregate. Consequently, the 1988 *Special Provisions* specified that one lane would be completed with fine aggregate blot material before beginning the adjacent lane. Also, because of damage from construction trucks when the speed was uncontrolled, the speed is now limited to 15 miles per hour (24 km per hour).

Sequence of Operations

On the test sections in the Clover Hills Subdivision (Richmond District), the contractor and inspector misunderstood the instructions for the construction technique and placed the first layer on all of the subdivision roads during one week. The second layer of asphalt and blot material was not placed on the subdivision roads until the following week. Despite the low traffic speed, quite a bit of the aggregate was whipped loose from the asphalt mat, either because of traffic running on the surface treatment before the final layer of blot material was applied or because the dust affected the adhesion of the No. 8 aggregate. The loose aggregate could not be swept from the pavement without dislodging some of the embedded aggregates before the blot layer was placed. Because of the loosened aggregate, the second layer of asphalt was applied slightly heavier than normal at 0.86 l/m^2 (0.19 gal/yd^2), in hopes of salvaging the treatment. It helped to some extent, but some areas failed or spalled (Figure 1).

Application of Emulsion

During the initial placement of the modified seal test sections, slight streaking occasionally occurred even when the distributors were calibrated properly. When the test sections were placed in the Lynchburg District, construction had to be delayed until severe streaking (Figure 2) could be eliminated.

Figure 1. Spalled area in Clover Hills Subdivision.

Figure 2. Severe streaking.

The Etnyre Distributor Manufacturers said the streaking was caused by using the wrong spray nozzle. The standard nozzles shipped on the Etnyre Distributor are designed to spray the asphalt from 0.91 l/m^2 (0.20 gal/yd^2) to 2.0 l/m^2 (0.45gal/yd^2). This falls outside of the range needed for the modified seal. It was suggested by the Etnyre Company that a nozzle designed to spray from 0.45 l/m^2 (0.10 gal/yd^2) to 1.6 l/m^2 (0.35 gal/yd^2) should be used to obtain the proper quantities without streaking. The nozzles are shown in Figure 3. The nozzle with the large inner diameter is the standard nozzle and the nozzle with the small inner diameter is the one that was recommended when placing the modified seals.

Application of Coarse Aggregate

Another problem was the application of the aggregate more than one layer thick. Spalling tended to occur when there was more than one layer, whether due to spillage or because the application rate was not controlled properly. The application of only 0.68 l/m^2 (0.15 gal/yd^2) of asphalt emulsion was not enough to lock several layers of coarse aggregate in place. Figures 4 and 5 show a spalled area shortly after placement and one year after placement.

Application of Fine Aggregate Blot Material

Although it was not necessarily a problem in rural areas, dusty blot aggregate sometimes caused undesirable dust in residential neighborhoods. However, when the blot material was too wet it would not spread uniformly. This problem caused construction delays to apply additional material and also resulted in a poor job of blotting the second layer of asphalt. Figures 6 and 7 show wet blot material being placed and a section of pavement after placement.

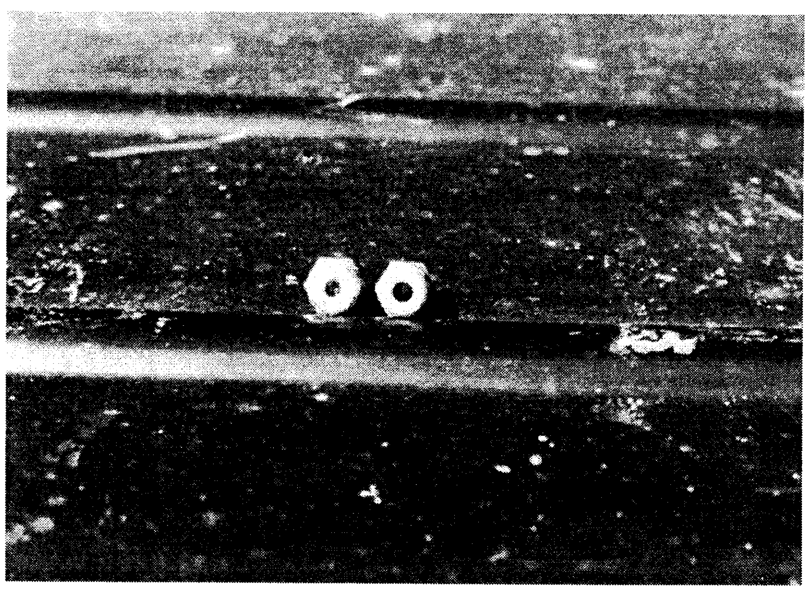

Figure 3. Standard and modified seal distributor nozzles.

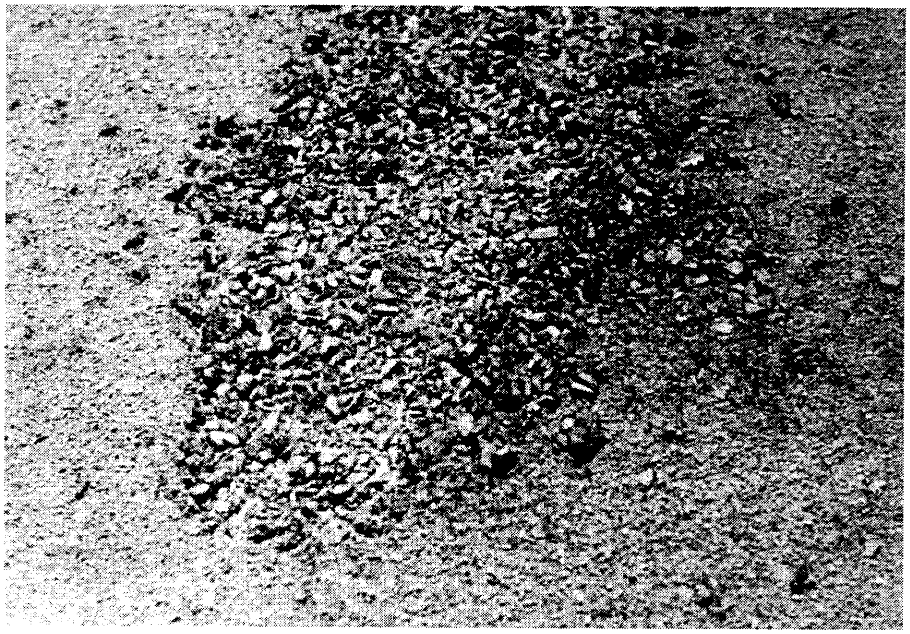

Figure 4. Beginning of a spall.

Figure 5. The same spall 1 year later.

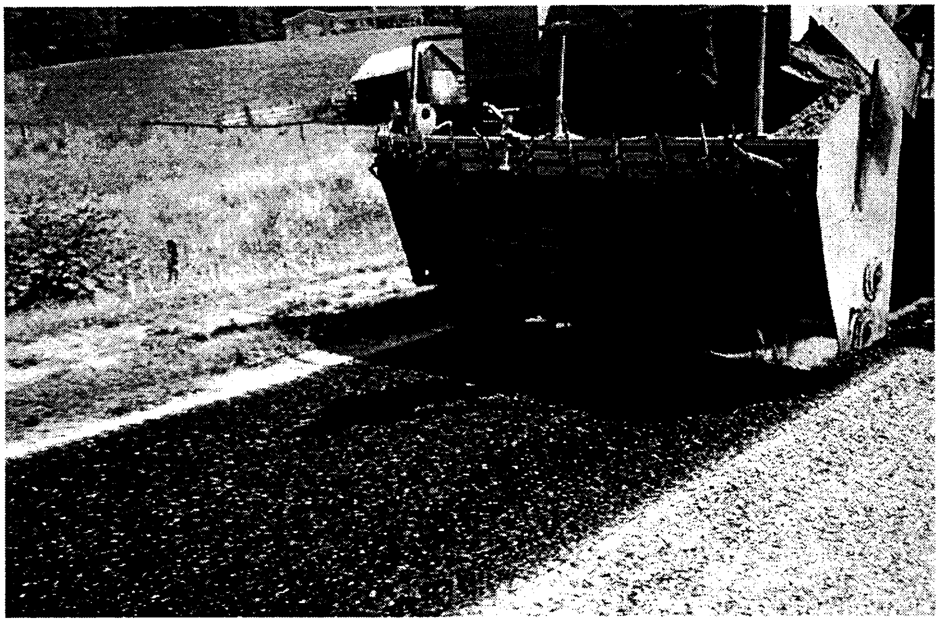

Figure 6. Wet blot material being placed.

Figure 7. Wet blot material after placement.

When the blot material was not placed uniformly, additional blot material was sometimes necessary. To ensure that the second layer of asphalt is properly blotted, the *Special Provisions* (Appendix B)[7] now state that the blot material has to be placed uniformly. This gives the inspector the right to require the contractor to use more than the specified amount of 5.4 kg/m^2 (10 lbs/yd^2) to get coverage, if necessary.

RESULTS OF TEST SECTION EVALUATIONS

The test sections in the Fredericksburg and Richmond Districts were visually evaluated by personnel from the Maintenance Division and Research Council periodically after construction. The evaluations in the Lynchburg District were performed by Lynchburg District personnel from the Materials Section and Residencies and Research Council personnel.

The 1986 test sections placed in the Fredericksburg and Richmond Districts were not evaluated before construction, but were evaluated after construction periodically from 1988 through 1991. No adjustments due to surface conditions or traffic level were made in the quantity of emulsion that was applied. The Lynchburg District test sections were evaluated before construction and the asphalt quantities were adjusted according to roadway and traffic conditions. Periodic evaluations were continued through 1991. A summary of the final evaluations is presented in Table 5. Note that 93 percent of the sections retained at least a "good" rating with 37 percent receiving an "excellent" rating after at least 3 years of service. Only one section received a poor rating. The condition of the existing roadway contributed to the poor performance of this section.

In addition to the evaluation team, the Maintenance Managers in the Fredericksburg Residency summarized how they and their Superintendents thought the modified seals were performing in 1992. Mr. W. W. Womack, Assistant District Materials Engineer in Lynchburg District, also solicited comments from Residency personnel. The summary and comments appear in Appendix C.

Table 5: Summary of Final Evaluations by District and County

DISTRICT	COUNTY	TOTAL SITES	OCCURRENCES BY CATEGORY			
			EXCELLENT	GOOD	FAIR	POOR
Fredericksburg	Lancaster	2		2		
Fredericksburg	Middlesex	3	2		1	
Fredericksburg	Mathews	2	2			
Fredericksburg	Gloucester	3	2			1
Lynchburg	Buckingham	19	12	7		
Lynchburg	Campbell	11	3	6	2	
Richmond	Chesterfield	20	1	19		
TOTAL		60	22	34	3	1

COST COMPARISON

To compare the modified seal to the conventional type of surface treatment, it was necessary to use the original cost of each system and estimate the service life. When the first modified seals were placed in 1986, the cost was only $0.036/m^2 ($0.03/yd^2) more than the conventional surface treatment.

Since the first test sites of modified seal were placed in Fredericksburg and Richmond Districts in 1986 and in the Lynchburg District in 1988 the prices have fluctuated somewhat, but the average price has only been $0.084/m^2 ($0.07/yd^2) higher than the conventional type surface treatment. The average prices experienced by VDOT for the two types of treatments for the last several years are shown in Table 6.

Table 6: Surface Treatment Prices

MODIFIED SINGLE SEAL	CONVENTIONAL
$0.44 * ($0.37) **	$O.41 ($0.34)

* Cost Per Square Meter
** Cost Per Square Yard

Based on the performance evaluations of the modified seal test sections, the expected life is estimated to be 4 to 7 years with an average life of 5.5 years. According to VDOT personnel the average life of conventional surface treatments historically has been 3 to 5 years. Based on an average life of 5.5 years for the single modified seal and 4 years for the conventional surface treatment, the annual cost is $0.080/m^2 ($0.067/yd^2) per year for the modified seals and $0.102/m^2 ($0.085/yd^2) per year for the conventional surface treatments. The annual unit cost for the modified seal is approximately 20 percent less than the cost of the conventional surface treatment when service life is considered.

Although ordinary maintenance was not monitored in this study, it would probably be less for the modified seal than for the conventional surface treatment. The application of blot material develops a thicker surface with less chance of raveling and failure than a conventional treatment. Lower maintenance costs would make the modified seal even more cost-effective than the conventional surface treatment. There may be additional savings from reducing the number of broken windshields by using the modified seal.

MODIFIED DOUBLE SEAL

The modified double seal has been used on some jobs but it was not evaluated as an experimental section. The double seal treatment consists of two alternating applications of asphalt and coarse aggregate followed by a single application of asphalt and fine blot aggregate.

The second application of asphalt and coarse aggregate is 0.77 l/m^2(0.17 gal/yd^2) and 8.1 kg/m^2(15 lb/yd^2) respectively.

Performance appeared to be superior to both modified single seals and conventional surface treatments. The cost was approximately 50 percent higher than conventional surface treatment, but it may have future potential for special situations -- for instance, where the traffic volume is too high for either conventional treatments or modified single seals, or when the existing surface is severely deteriorated.

CONCLUSIONS

1. The performance of modified seals was superior to the performance of conventional surface treatments.

2. Modified seals were more cost-effective than conventional surface treatments.

3. Modified seals eliminated the hazard of loose aggregate breaking automobile windshields.

4. Proper equipment and construction techniques, such as using the correct distributor nozzles and applying the correct thickness of coarse aggregate, were essential for success.

RECOMMENDATIONS

The experience gained in this study will result in improvements to the modified seal process. Some recommendations for future work dealing with equipment, materials, and the construction process are:

- Use a pilot vehicle to keep traffic off of the surface until the blot layer is applied.
- Construction traffic should be limited to 24 km/hr (15 mile/hr).
- Use clean dry blot aggregate to minimize dust problems in residential areas and non-uniform spreading.
- Use the proper distributor nozzles to apply the emulsion uniformly.
- Do not apply coarse aggregate in excess of one stone thick, to prevent spalling.

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The authors thank Mr. James G. Browder, Jr. in the Fredericksburg District and Mr. Everett Covington in the Richmond District for their help in making the initial field tests possible, and the personnel from these two districts who selected and monitored the treatments. Thanks also go to Mr. John McEwen, Mr. Dale Grigg, and Mr. W. W. Womack from the Lynchburg District for their cooperation, and to their personnel who selected and monitored the test sections constructed in 1988. Thanks also are extended to Mr. Arthur J. Wagner of the Research Council, who devoted countless hours to the success of this project.

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APPENDIX A

LOCATION OF MODIFIED SEAL TEST SECTIONS

Table 7: Fredericksburg District -- Location of Modified Seal Test Sections

COUNTY	ROUTE	FROM	TO
Lancaster	675	Rt. 200	Rt. 778
Lancaster	612	.05 mi. S. Rt. 604	Dead End
Middlesex	631	Rt. 33	Rt. 709
Middlesex	632	Rt. 633	Dead End
Middlesex	606	Rt. 17	Rt. 17
Mathews	622	Rt. 621	Rt. 623
Mathews	642	Rt. 643	Dead End
Gloucester	604	Rt. 3	Rt. 605
Gloucester	605	Rt. 3	1.0 mi. E. Rt. 3
Gloucester	605	1.0 mi. E. Rt. 3	6.4 mi. E. Rt. 3

Note: 1 mi. = 1.6 km.

Table 8: Richmond District -- Location of Modified Seal Test Locations

COUNTY	ROUTE	FROM	TO
Chesterfield	710	Rt. 637	Rt. 640
Chesterfield	1587	Rt. 609	Rt. 144
Chesterfield	706	Rt. 144	Rt. 619
Chesterfield	Clover Hill Farm Subdivision (14 test sections)		
Chesterfield	Plantation Estates Subdivision (3 test sections)		

Table 9: Lynchburg District -- Location of Modified Seal Test Sections

COUNTY	ROUTE	FROM	TO
Buckingham	600	Rt. 15 N. Intersection	Rt. 15 S. Intersection
Buckingham	601	Rt. 604	Rt. 655
Buckingham	602	.05 mi. N. of Rt. 56	Rt. 658 Intersection
Buckingham	604	Rt. 601	Rt. 56
Buckingham	607	Rt. 646	Rt. 662
Buckingham	617	Cumberland Co. Line	Rt. 667
Buckingham	617	Rt. 667	.05 mi. S. of Rt. 615
Buckingham	621	Rt. 15	Rt. 600
Buckingham	628	1.0 mi. S. of Rt. 711	Rt. 60
Buckingham	632	Rt. 60	Rt. 650
Buckingham	633	Rt. 609	Rt. 635
Buckingham	633	Rt. 640	.05 mi. N. of Rt. 774
Buckingham	633	Rt. 15	Rt. 600
Buckingham	639	Rt. 633 S. Intersection	1.05 mi. N. of Rt. 633
Buckingham	640	S. Rt. 638	Rt. 636
Buckingham	648	Rt. 649	1.15 mi. S. of Rt. 649
Buckingham	648	1.15 mi. S. of Rt. 649	Rt. 60
Buckingham	671	Rt. 677	Rt. 676
Buckingham	683	Rt. 15	Rt. 608
Campbell	601	Rt. 756	Rt. 600
Campbell	618	Rt. 643	Rt. 645
Campbell	646	Rt. 1715	Rt. 606
Campbell	650	Rt. 501	Rt. 615
Campbell	651	Rt. 650	Rt. 652
Campbell	652	Rt. 501	Rt. 648
Campbell	656	Rt. 606	Rt. 24
Campbell	656	Rt. 24	Rt. 460
Campbell	660	Rt. 24	Rt. 662
Campbell	667	Rt. 1030	Dead End
Campbell	749	Rt. 40	Rt. 618

APPENDIX B

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
ASPHALT SURFACE TREATMENT (CLASS "C" SCHEDULE)

September 21, 1994

I. DESCRIPTION

This work shall consist of the application of a single or multiple course of asphalt surface treatment in accordance with the *Road and Bridge Specifications* and this provision.

II. DEFINITION OF TERMS

Seal treatment is defined as one application of asphalt material and one application of cover aggregate.

Modified single seal is defined as two applications of asphalt material, one application of cover aggregate and one application of blot fine aggregate.

Modified double seal is defined as three applications of asphalt material, two applications of cover aggregate and one application of blot fine aggregate.

III. MATERIALS

The Contractor shall demonstrate the compatibility of the asphalt emulsion and cover aggregate (excluding the blot seal) prior to construction of the surface treatment. This testing shall be conducted in accordance with VTM-65 in the presence of the Engineer for each asphalt and aggregate combination. In addition, the Contractor shall conduct the compatibility test at least once a week on stockpiled materials and as additional tests are deemed necessary by the Engineer. All compatibility test results shall be submitted to the Engineer. All material combinations shall pass the compatibility test unless waived in writing by the Engineer.

During the life of the project, if excessive loss of cover aggregate occurs the Engineer may suspend work in accordance with Section 108 of the Specifications until the problem is corrected.

(a) **Asphalt Materials** shall conform to Section 210 of the Specifications except as revised herein.

CRS-2 shall be rapid setting cationic emulsified asphalt when tested in accordance with AASHTO T59, Testing Emulsified Asphalt. CRS-2 shall meet the requirements of type II coating ability.

RC-250 when permitted during the period of May 1 to October 1 shall meet the requirements of Type I coating ability. When permitted during the period of October 1 to May 1 the requirements of Type II coating ability shall apply.

CRS-2L (Latex Modified Asphalt) shall meet the physical requirements of asphalt material Type CRS-2, modified herein. A minimum of 2.5% (by weight) of styrene-butadiene rubber (SBR) solids shall be incorporated into the emulsified asphalt. The latex modified emulsified asphalt shall be homogeneous and shall conform to the following requirements.

TESTS	Min.	Max.
Visc. Saybolt Furol, 122 F, sec.	100	100
Storage Stability Test, 24 hr.	--	1.0
Classification Test	Passes	
Particle Charge Test	Positive	
Sieve Test, 20 Mesh, %	--	0.2
Distillation:		
Oil distillate, by volume of emulsion, %	--	--
Residue, %	65	--
Tests on Residue from Distillation:		
Penetration, 77 F, 100 g, 5 sec.	100	250
Ductility, 77 F, 5 cm/min, cm	100	--
Softening Point, F, (AASHTO T53-89)	100	--
* Elastic Recovery	50	--

* Elastic Recovery Test: Condition the ductilometer and samples to be treated at 50 F. Prepare the brass plate, mold and briquette specimen in accordance with AASHTO T51. The molds shall be the non-tapered type used for Force Ductility Testing. Keep the specimen at the specified test temperature of 50 F for 85-90 minutes. Immediately after conditioning, place the specimen in the ductilometer and proceed to elongate the sample to 20 cm at a rate of pull of 5 cm/min. After five minutes, clip the sample approximately in half by means of scissors or other suitable cutting device. Let the sample remain in the ductilometer in an undisturbed condition for one hour. At the end of this time period, retract the half sample specimen until the two broken ends touch. At this point note the elongation (E) in cm. Calculate the percent recovery by the following formula:

$$\% \text{ Recovery} = \frac{20 - E}{20} \times 100$$

Modifiers shall not be post-added to the finished emulsion. All modifiers shall be incorporated during the milling process (co-milled) at the manufacturing facility.

The contractor shall provide written certification of the test results.

(b) **Cover Material** - Aggregate shall conform to Section 203 of the Specifications. Crushed stone shall only be used on roads of Traffic Groups VI and above unless the surface treatment consists of modified single seal treatment or modified double seal treatment. Aggregates shall not be used within 24 hours of washing. Aggregate from more than one source shall not be furnished for a specified route or a group of sub-division routes unless permitted by the Engineer.

The following modifies the material as defined in Section 203 of the Specifications:

Designation	**Modification**
N	Non-polishing material only
L	Lightweight
G	Washed gravel only

Note: Where 8N is specified, it shall meet the gradation requirements of No. 8P.

IV. CONSTRUCTION METHODS

The Contractor shall use one steel wheel roller and one pneumatic-tire roller on modified single seal, modified double seal and seal treatments using CRS-2L asphalt material in a sequence approved by the Engineer. These treatments shall be subjected to a minimum of one complete pass of each type of roller on either the cover aggregate or the blot seal coat.

(a) **Seal Treatment**: When seal treatment is specified, the Contractor shall protect the cover aggregate from traffic until the asphalt material has sufficiently cured to carry traffic without damage to the treatment.

The rate of application shall be in accordance with VTM-66. The rate application for the cover aggregate and asphalt emulsion shown in the contract are approximate and the actual rate shall be determined by the Contractor and approved by the Engineer.

After the roadway has been treated and cured, the Contractor shall lightly broom the surface to remove any excessive aggregate in accordance with Section 312.04 of the Specifications and as directed by the Engineer. Brooming shall be performed in such manner as to not damage the embedded material.

(b) **Modified Single Seal and Modified Double Seal Treatments**: When modified single seal and double seal treatments are specified the Contractor shall lightly broom the surface to remove any excessive aggregate in accordance with Section 312.04 of the Specifications and as directed by the Engineer. Brooming shall be performed in such manner as to not damage the embedded material.

No traffic, including delivery trucks, shall be allowed on modified seal treatments until after the blot coat material has been placed and rolled.

1. **Modified Single Seal Treatment**

    a. Approximately 0.17 gal/sq. yd of asphalt material, type as specified, shall be applied to the existing surface immediately followed by an application of approximately 15 lbs./sq. yd of aggregate size no. 8P. The aggregate shall be spread uniformly (one aggregate deep) over the treated surface.

    The aggregate shall be rolled immediately at least once over with self-propelled roller of an approved design. When a continuous uninterrupted modified single seal treatment train method is employed, rolling of the initial aggregate course may be omitted.

    b. Immediately after the seal coat has been rolled in accordance with IV.(b).a., a blot seal coat consisting of approximately 10 lbs/sq. yd. of fine aggregate. The fine aggregate shall be Grading A, B, or F natural or manufactured in accordance with Section 202 of the Specifications, except that the material shall have no more than 5% passing the No. 200 sieve by washed analysis. An increase in the application rate for blotter material may be necessary when using natural sand and if the desired results are not achieved with this material, the Engineer may require the use of manufactured sand. Fine aggregate from more than one source shall not be used intermittently. The fine aggregate shall be applied by the use of a self-propelled aggregate spreader of approved design. At least 48 hours after the blot coat application, the roadway surface shall be lightly broomed as directed by the Engineer.

2. **Modified Double Seal Treatment**

    a. Two applications of asphalt material and cover aggregate shall be applied in accordance with Section IV.(b)1.a., except that at least one complete pass shall be made with the roller after each aggregate application.

    b. A blot coat shall be applied in accordance with IV.(b)1.b.

The application temperature for liquid asphalt material shall conform to Table III-1 of Section 310 of the Specifications, except that the minimum application temperature for CRS-2 and CRS-2 shall be 160 F.

(c) **Maintenance, Protection, and Performance of the Work** - The Contractor shall be responsible for the maintenance and protection of the seal treatment on the roadway for a period of 48 hours after application.

The Contractor shall exercise control of the delivery and application of the surface treatment materials to prevent damage to the roadway surface. The speed of the delivery equipment and pilot truck shall be limited to a maximum 15 mph. The maintenance and protection shall include, but not be limited to, the placement of signs; the use of flaggers and pilot trucks; and placement of additional asphalt and aggregate material. In the event a failure occurs prior to acceptance, the Contractor shall repair or replace the failed treatment as directed by the Engineer.

V. EQUIPMENT

(a) Asphalt Distributors and Aggregate Spreaders

1. Distributors and spreaders shall be calibrated by the Contractor in the presence of the Engineer prior to placing surface treatment to ensure even and accurate spray and aggregate distribution.

2. Asphalt distributors shall be equipped with proper spray nozzles including end nozzles for the application rate specified so as to provide uniform coverage throughout the width of the application.

(b) Rollers

1. One steel wheel roller and one pneumatic-tire roller shall be used on modified single seal, modified double seal and seal treatment using CRS-21 asphalt material. The steel wheel roller weight shall be between 6 and 8 tons for the tandem type and between 8 and 10 tons for the three wheel type.

2. Two pneumatic-tire rollers shall be used on the conventional type seal treatment.

VI. MEASUREMENT AND PAYMENT

Liquid asphalt material for seal treatment will be measured and paid for in accordance with Section 313 of the Specifications.

Aggregate for seal treatment will be measured and paid for in square on a plan quantity basis, which price bid shall include furnishing and applying aggregate, protection of the asphalt surface treatment, and all incidentals necessary to complete the work. Authorized increases or decreases to the plan quantity will be adjusted in accordance with Section 109 of the Specifications.

Modified single seal and modified double seal treatments will be measured and paid for in square yards on a plan quantity basis, which price bid shall include all cost for furnishing and applying liquid asphalt material and cover aggregate, protection of the asphalt surface treatment and all incidentals necessary to complete the work. Authorized increases and decreases to the plan quantities will be adjusted in accordance with Section 109 of the Specifications.

Brooming, when requested by the Engineer, will be paid at a rate of $20.00 per hour for each power broom required. The price shall include power broom, operator, fuel, maintenance, traffic control, and all incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Aggregate (type)	Square Yard
Modified Single Seal	Square Yard
Modified Double Seal	Square Yard

Appendix C
Residency Comments

Warsaw Residency

1) Modified treatments last longer.
2) No broken windshields.
3) Only problem was contractor placing too much sand.
4) Generally contractor did a very good job.
5) Asphalt adjustments still need to be made to reduce flushing.
6) Think that the modified seal is the best surface treatment ever used by the department.

Saluda Residency

1) Much better surface treatment.
2) Last longer (5 years plus).
3) No complaints of flying stone.
4) No broken windshields.
5) Overall, very satisfied with the modified seal.
6) Prefers crushed stone over river gravel; however, thinks that the finished product is the same for both.

Fredericksburg Residency

1) Longevity is much better with modified seals and makes the additional cost worthwhile.
2) Modified seals seem to eliminate flushing problems better than the conventional surface treatments.
3) Usually eliminates streaking problems.
4) Almost no public complaints.
5) Final surface looks better after 2 to 3 weeks when the sand wears off.
6) Prefers crushed stone over river gravel because of a better surface texture.
7) Prefers manufactured sand rather than natural sand because it can be placed at lower quantities than the natural sand.
8) Very well satisfied with the product.

Bowling Green Residency

1) Eliminates construction problems usually present with the river gravels.
2) Virtually eliminates broken windshield claims.
3) Reduces/eliminates flushing problems.
4) No flying stone.
5) Extends the life of surface treatments from 3-4 years to 5-8 years.

6) Even with the increased cost, we're sold on the benefits of the modified seal and plan to continue to use them.

Lynchburg District

Summary of Lynchburg Districts comments by Mr. W. W. Womack, Assistant District Materials Engineer. The benefits of this technique -- improved surface texture and aggregate retention and the virtual elimination of vehicle damage claims -- far outweigh the one drawback of dust complaints in highly populated areas. We have found that by using a double modified seal on cracked oxidized asphalt concrete pavement, its service life can be extended for 2 to 3 years before an overlay is required.

In summary, we are well pleased with the modified seal and intend to continue recommending its use for our future schedule advertisements with the possible exception of excluding it from subdivision areas where we are considering an alternate treatment (Cape Seal Slurry, or No. 9 aggregate blot material) to resolve the dust problem.