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DEMONSTRATION PROJECT NO. 37

Use of Discarded Tires in Highway Construction

by

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Senior Research Scientist

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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SUMMARY

In August 1978, bituminous surface treatments in which vulcanized rubber was blended with the asphalt cement were placed on two secondary roads by the Sahuaro Petroleum and Asphalt Company and the Whitehurst Paving Company. The work was jointly financed by the Federal Highway Administration and the Virginia Department of Highways and Transportation. The ground rubber from used tires was blended with AC-20 asphalt in amounts ranging from 20% to 22% by weight of the binder, and was applied at a rate of 0.60 to 0.69 gal./yd.^{2} The cover aggregate, No. 68 and No. 78 stone, was applied at a rate in excess of 40 lb./yd.^{2}

The adherence of the stone to the binder was excellent on a section of road that was relatively straight, had a good cross section, and received direct rays of the sun for most of the day. It did not adhere well on a section that had a lot of curves and a poor cross section and was in the shade a good deal of the day.

The surface treatment did an excellent job of sealing cracks. In addition, it arrested and, in some cases, even remedied pavement distortions.

Because the rubberized binder (1) does not flow as regular asphalt does, and (2) can be applied at a relatively high rate, and apparently is effective in sealing cracks, it is believed that it can be used to advantage for sealing pavements and bridge decks.

The drawbacks in using the material are its high cost and the extended time required to blend the rubber and asphalt in the field.

However, because of its performance over the two-year test period, the Department should consider: (1) further experimentation with the material on some badly cracked bituminous pavements, and (2) experimentation with the material as a bridge deck sealant.

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BACKGROUND

Over the years highway maintenance people have been plagued by the problem of cracks developing in asphaltic pavements. Much time and effort have been expended in repairing cracked pavements by one of several methods, including filling the cracks with bituminous materials, skin patching with asphalt and stone, surface treating with asphalt and stone, applying slurry seals, and overlaying with bituminous concrete. While these methods seal the cracks effectively over varying lengths of time, the original cracks eventually reflect through. In an attempt to arrest the development of the cracks and to make economical use of discarded materials, there has been continuing experimentation with blending ground rubber from used tires in the asphalt used in making paving mixtures, the idea being that the rubber improves some of the physical qualities of the asphalt.

The practice of blending rubber in asphalt is not new. In fact, many years ago Virginia and other states experimented with the use of rubberized asphalts in surface treatments [1] and plant mixes.[2] However, they used only about 2% to 5% rubber, whereas the asphalts used in current experiments contains 20% or more rubber. Also, in the past experiments the ground rubber was transformed into a liquid state in the asphalt, whereas today a good portion of it remains as small pellets dispersed throughout the asphalt. Because of the rubber pellets in the binder, a special asphalt distributor that includes an agitating system is required. In the past, one could not distinguish between the regular and rubberized asphalts by visual inspection; and although physical differences could be detected in the laboratory, little if any difference could be noted in the field. On the other hand, it is claimed that the current blend of rubber and asphalt differs greatly in its physical characteristics and will do a much better job of sealing cracks than will regular asphalt.

In light of this claim, when the Federal Highway Administration invited Virginia to participate in Demonstration Project No. 37, which is designed to evaluate the use of rubberized surface treatments to seal cracks, the Department management accepted and asked the Research Council to assist the Maintenance Division in planning, placing, and evaluating the use of the rubberized asphalt.

DESIGN OF EXPERIMENTS

On August 28, 29, and 30, 1978, the Sahuaro Petroleum and Asphalt Company and the Whitehurst Paving Company, under the aegis of the Virginia Department of Highways and Transportation and the Federal Highway Administration, placed rubberized asphalt surface treatments on Route 738 and 684 in Hanover County. (Sahuaro designed the treatments and applied the rubberized asphalt; Whitehurst applied and compacted the stone.) Because the first day's work was completed prior to the arrival of the research team, no records of the condition of the untreated surface other than several photographs were made.

For comparative purposes, the Department planned the placement of test sections consisting of a regular surface treatment, an S-5 bituminous overlay on the existing pavement, and an S-5 bituminous overlay on part of the rubberized asphalt surface treatment. However, because of scheduling difficulties, none of these sections were placed. Therefore, the performance of the rubberized sections has been evaluated on the basis of the ability of the binder to retain stone and to seal cracks; the performance has not been compared to that of other types of remedial treatments. One section of Route 684 was not treated, however, and was used in the evaluation.

The vulcanized ground rubber, furnished in 50-lb. bags, was slowly blended with liquid asphalt type AC-20 to produce the binder. The initial temperature of the asphalt was about 380°F., and during the approximately two hours of blending the temperature was decreased to about 315°F. The percentage of rubber by weight of the binder ranged from 20% to 22%.

In addition to the rubber, 5% by volume of kerosene was introduced into the mixture.

Prior to applying the rubberized binder to the pavement, a light tack coat of asphalt emulsion type CRS-2 of about 0.03 gal./yd.^{2} was applied.

APPLICATION OF SURFACE TREATMENTS

Route 684 Site

The test site on Route 684 is located between Route 1 and the General Crushed Stone Quarry at Verdon; therefore, the majority of the traffic on the road is made up of multi-axle trucks. The eastbound lane leads from the quarry and therefore carries the heaviest loads. The traffic count on the road is 2,482 vehicles a day, but because it is a secondary road, the Department has no breakdown of the traffic by vehicle type. However, since quarry officials report that they load from 450 to 500 trucks per day, it can be estimated that traffic in both directions includes from 900 to 1,000 trucks each day. Further, it can be estimated that 450 to 500 of the 1,241 vehicles in the eastbound lane are heavily loaded trucks.

Because there are few trees along the road and the road runs east-west, the pavement receives a great deal of sunshine and very little shade. The pavement was constructed in the late 1960's of a cement-treated aggregate base with a 2-inch asphaltic concrete surface. This section of road had been covered with a chip seal. Whereas prior to the surface treatment a great deal of the road was in rather good shape, some areas were cracked and isolated areas were rather badly distressed.

The treatment on Route 684 was applied on August 28 and 29. During those two days, the temperature ranged from a high of 96°F. to a low of 75°F., and there was no rain.

On the first day, 2.0 miles of the westbound lane beginning 0.15 mile west of Route 1 was treated. It received 0.60 gal./yd.^{2} of the rubberized binder and was covered with 43 lb./yd.^{2} of No. 68 stone from the General Crushed Stone Company. (The Virginia gradations are shown in Appendix A.[3]) The special distributor shot a uniform coating, and even though 0.60 gal./yd.^{2} is a very heavy application the rubber in the binder eliminated any problems with flow.

The representatives of the Sahuaro Company felt that No. 68 stone were rather large and therefore more binder may be needed to retain the stone; so on the second day, when treating an additional 0.3-mile stretch in the westbound lane and the adjacent 2.6 miles of the eastbound lane, the rubberized binder application was increased to 0.69 gal./yd.^{2} The No. 68 stone was applied at a rate of 48 lb./yd.^{2} Again, the heavy application of binder did not present a problem with flow. On both days the stone adhered well to the binder and there was very little problem with flying stone.

Route 738 Site

The test site on Route 738 has a poor cross section, is quite shaded, and had much less traffic than the site on Route 684. It carries only 671 vehicles a day, relatively few of which are thought to be trucks. There is no record of when the road was constructed.

Since the representatives of the Sahuaro Company had felt the cover aggregate employed on Route 684 was rather large, No. 78 stone was used on Route 738. (The Virginia gradations are shown in Appendix A.[3]) Starting at Route 671 and extending north, a

1.7-mile section of the northbound lane was treated during the afternoon of August 29. The application rates were 0.62 gal./yd.^{2} of binder and 43 lb./yd.^{2} of No. 78 stone.

The remaining 0.3-mile segment in the northbound lane and the adjacent 2.0 miles of the southbound lane were treated on August 30. The application rates were 0.60 gal./yd.^{2} of binder and 43 lb./yd.^{2} of No. 78 stone. Again, the air temperature was quite high; the high and low were 92°F. and 74°F. However, because of several factors, including the poor cross section, extensive shade, and many curves, the stone did not adhere well to the binder. (Figures 14 and 16 given later in the report show sections of the roadway from which most of the stone was lost.) Even though the stone was lost, there was very little flow of the binder.

EVALUATION OF PERFORMANCE

Route 684 Site

The first 0.15 mile of Route 684 after leaving Route 1 was not treated. Figures 1 and 2 are photographs of this untreated pavement. It can be seen in Figure 1 that the eastbound (loaded truck) lane, on the left in the photograph, showed cracking and distortion in 1978. Figure 2, a photograph taken two years later, shows how much the condition worsened.

Figures 3 and 4 are photographs of the eastbound lane in an area covered by the rubberized asphalt treatment. While it can be seen that the edge of the pavement was skin patched sometime during the two years between the times the pavement was photographed, it is obvious that the surface treatment arrested the cracking.

Figures 5 and 6, also photographs of the eastbound lane, vividly show the effectiveness of the surface treatment in sealing cracks and arresting deterioration.

Similar examples are shown in the pairs of photographs in Figures 7 and 8, 9 and 10, and 11 and 12. These photographs clearly show that the rubberized asphalt treatment effectively arrested the pavement cracking and partially healed the pavement distortion. The mechanism by which the distorted areas were partially healed is not known. It is speculated that the treatment sealed the surface to prevent the entry of moisture into the base, while the moisture already present was sufficient to permit gradual compaction and rearrangement of the base by traffic.

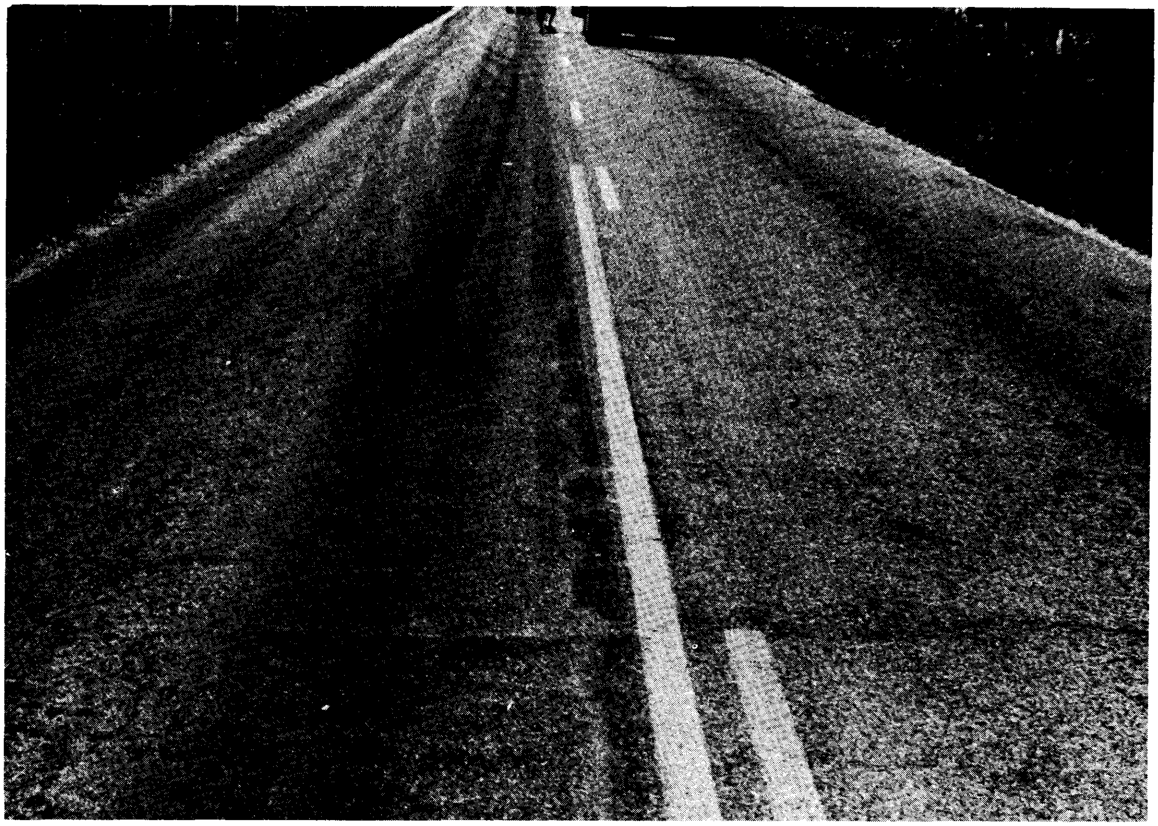

Figure 1. Untreated pavement in August 1978.

Figure 2. Same untreated pavement in August 1980.

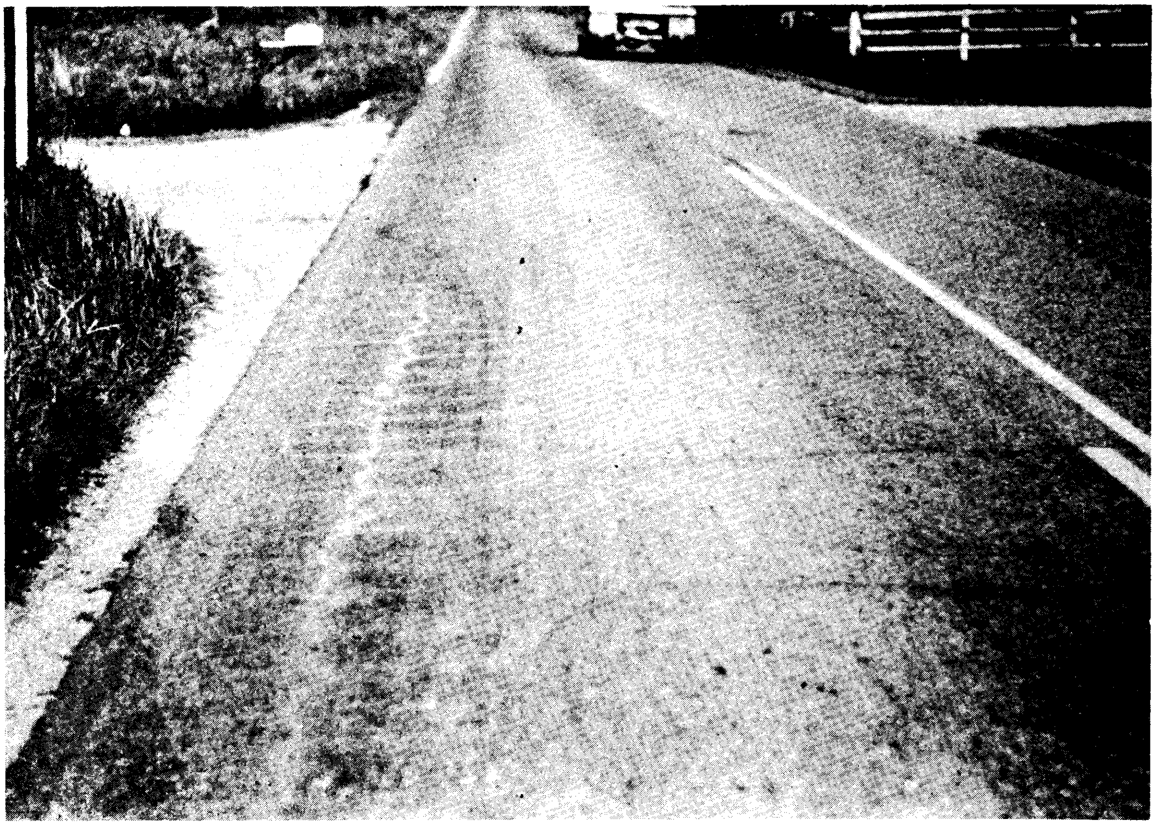

Figure 3. Pavement before treatment in August 1978.

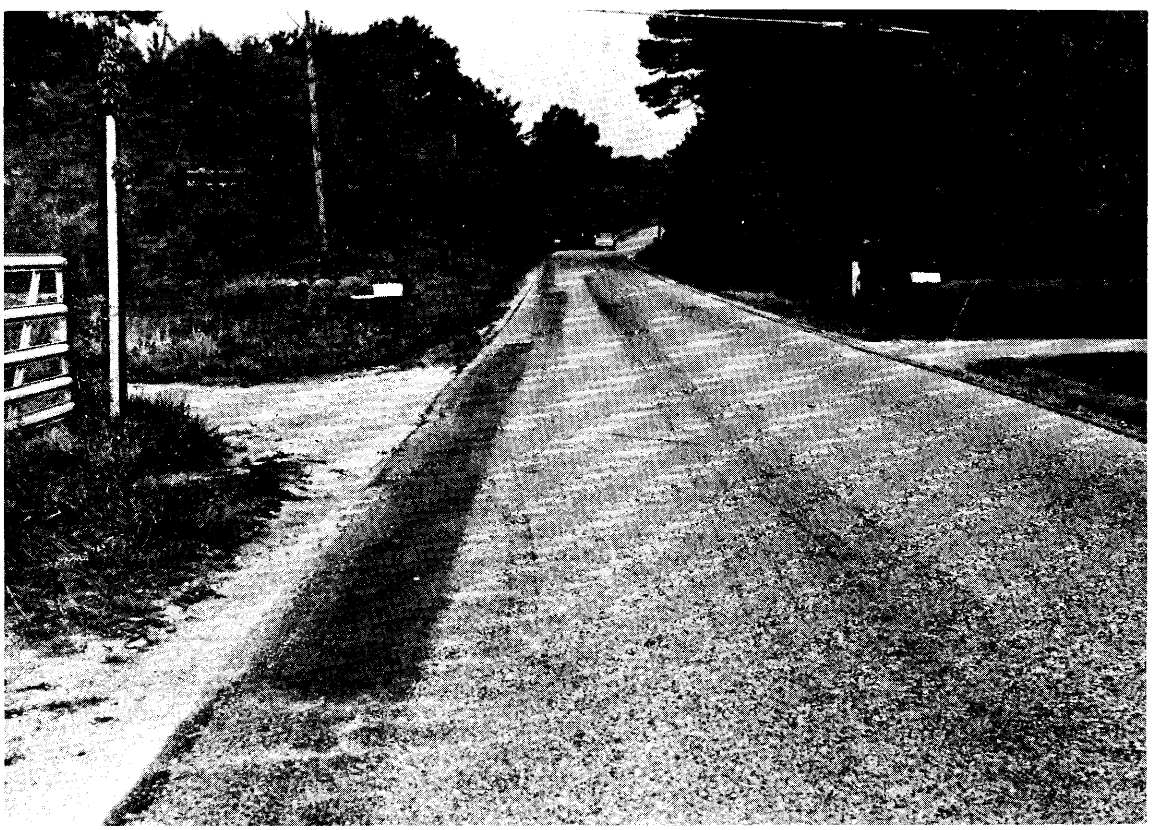

Figure 4. Same pavement two years after surface treatment.

Figure 5. Before rubberized surface treatment in August 1978.

Figure 6. Same pavement two years after surface treatment.

Figure 7. Pavement section before surface treatment in August 1978.

Figure 8. Same pavement two years after treatment.

Figure 9. Before treatment in August 1978.

Figure 10. Two years later.

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Figure 11. Before treatment in August 1978.

Figure 12. Two years later.

Route 738 Site

As previously mentioned, at the site of the experiment, Route 738 is a lower class road than Route 684. It has a lot of curves and a poor cross section, and is shaded a great deal of the time. These conditions, coupled with the fact that the rubberized binder is more viscous than regular asphalt, led to the loss of a great deal of the cover stone. Since the viscosity of the binder in shaded areas rises more rapidly than that of the binder subjected to the sun's rays, it would be prudent to employ special precautions when using the rubberized binder in the shade. Figures 13 and 14 are photographs of an area before treatment and two years afterwards. The type of cracking is different from that shown in the photographs of Route 684, but the treatment was just as effective, even with the loss of cover stone. Mention should be made that although much of the cover stone was lost from this road within several days, the rubberized asphalt did not flow and become tacky as regular asphalt does, even in the very hot weather.

Figures 15 and 16 also show the effectiveness of the binder in sealing cracks.

Because the rubberized binder does not flow as regular asphalt does, can be applied at a relatively high rate, and apparently is effective in sealing cracks, it is believed that it can be used to advantage for sealing pavements and bridge decks.

The drawbacks in using the material are its high cost and the extended time required to blend the rubber and asphalt in the field.

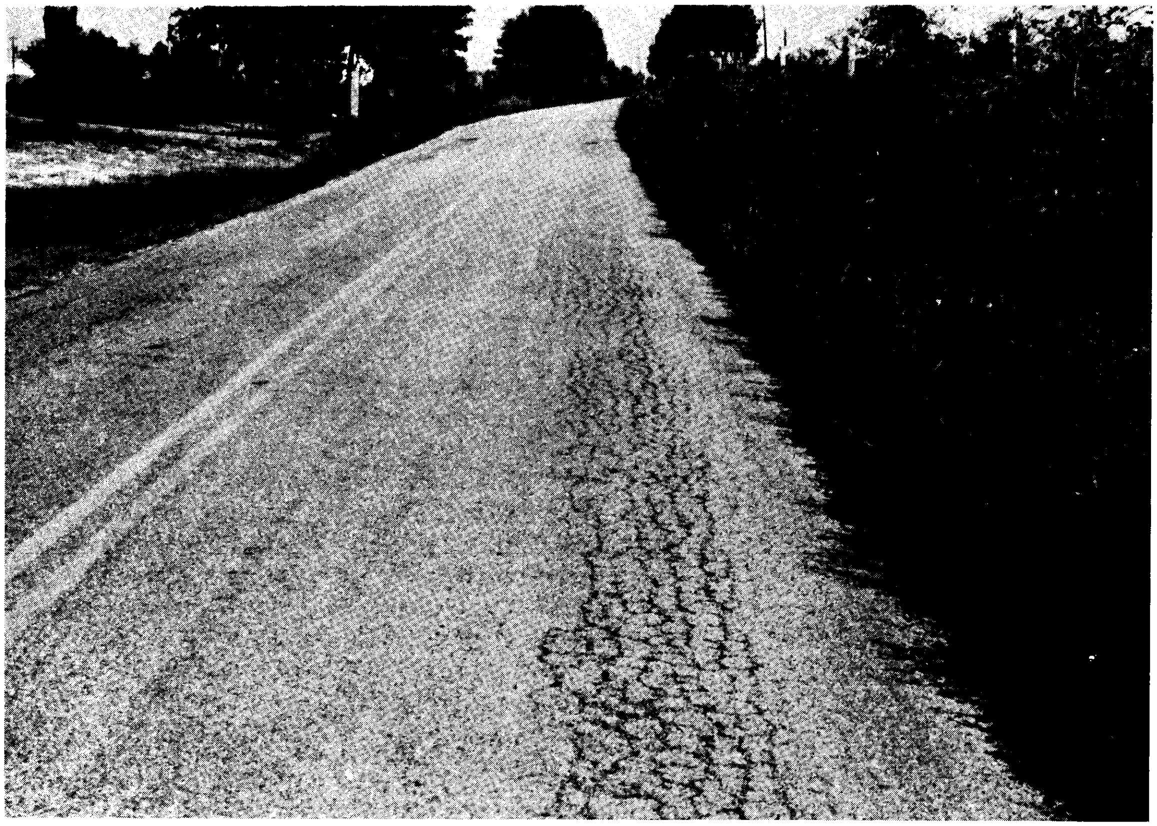

Figure 13. Before treatment in August 1978.

Figure 14. Two years afterwards.

Figure 15. Before treatment in August 1978.

Figure 16. Two years afterwards.

COST COMPARISON

As part of the project, consideration was given to the cost of applying the rubberized asphalt surface treatment relative to the costs for the conventional systems used in Virginia for rehabilitating pavements; i.e., those of regular surface treatments, slurry seals, and plant mix overlays. Based on 1978 data, the costs for these various types of treatment are shown in Table 1.

Table 1

1978 Costs For Types of Pavement Rehabilitation

Type	$Cost/yd.^2$
Surface treatment	$0.28
Slurry seal	0.40
Rubberized surface treatment	1.18
S-5 plant mix overlay (1-in.) [a]	1.36

[a] Appendix B gives mix designs for bituminous concretes. (3)

As can be seen, the cost of the rubberized surface treatment is relatively high. Some of this cost is probably due to the experimental nature and the smallness of the project, but much of it is due to the inclusion of the rubber, the need to use a special distributor, and the time required to blend the rubber and the asphalt. It is well known that the relatively low cost of regular surface treatments results from the very high productivity that can be maintained. To a lesser extent, this also applies to slurry seals and plant mix overlays. As expertise is gained in applying rubberized asphalt surface treatments, productivity may be increased.

CONCLUSIONS

The adherence of the stone to the binder was excellent on the site that was relatively straight, had a good cross section, and received direct rays of the sun for most of the day. It did not adhere well on the section that had a lot of curves, a poor cross section, and was in the shade a good deal of the day.

The treatment did an excellent job of sealing cracks. In addition, it arrested and, in some cases, even remedied pavement distortions.

Because the rubberized binder does not flow as regular asphalt does, can be applied at a relatively high rate, and apparently is effective in sealing cracks, it is believed that it can be used to advantage for sealing pavements and bridge decks.

The drawbacks in using the material are its high cost and the extended time required to blend the rubber and asphalt in the field.

RECOMMENDATIONS

In light of the above conclusions based on the performance of the rubberized surface treatment test sections over the two-year test period, the Department should consider:

1. Further experimentation with the material on some badly cracked bituminous pavements.
2. Experimentation with the material as a bridge deck sealant.

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REFERENCES

1. Mahone, David C., "Report on the Installation of Experimental Rubberized Surface Treatments," Virginia Council of Highway Investigation and Research, Charlottesville, Virginia, February 1960.

2. Sheppe, R. L., and T. E. Shelburne, "Progress Report No. 1 on Field Experiments With Powdered Rubber in Sand Asphalt (F-1) Surface Course," Virginia Council of Highway Investigation and Research, Charlottesville, Virginia, July 1949.

3. Virginia Department of Highways and Transportation Road and Bridge Specifications, Commonwealth of Virginia, Richmond, Virginia, 1978.

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APPENDIX A

TABLE II-5

SIZES OF COARSE AGGREGATES—Open Graded

Va. Size No.	Amounts Finer Than Each Laboratory Sieve (Square Openings*), Percentage by Weight														
	4	3½	3	2½	2	1½	1	¾	½	⅜	No. 4	No. 8	No. 16	No. 50	No. 100
1	Min. 100	95 ± 5		43 ± 17		Max. 15		Max. 5							
2			Min. 100	95 ± 5		43 ± 17		Max. 15	Max. 5						
3					Min. 100	63 ± 17		Max. 20	Max. 5						
357					Min. 100		60 ± 20		20 ± 10		Max. 5				
5						Min. 100	95 ± 5	58 ± 17	Max. 15	Max. 5					
56						Min. 100	9 ± 5	58 ± 17	25 ± 10	Max. 15	Max. 5				
57						Min. 100	95 ± 5		43 ± 17		Max. 7	Max. 3			
68							Min. 100	95 ± 5		48 ± 17	Max. 20	Max. 8	Max. 5		
7								Min. 100	95 ± 5	57 ± 17	Max. 15	Max. 5			
78								Min. 100	95 ± 5	60 ± 20	Max. 20	Max. 8	Max. 5		
8									Min. 100	92 ± 8	25 ± 15	Max. 8	Max. 5		
9										Min. 100	92 ± 8	25 ± 15	Max. 10	Max. 5	
10										Min. 100	92 ± 8				20 ± 10

*In inches, except where otherwise indicated. Numbered sieves are those of the U.S. Standard Sieve Series.

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APPENDIX B

TABLE II-12
BITUMINOUS CONCRETE MIXTURES
(Design Range)

TYPE	Percentage by Weight Passing Square Mesh Sieves*										Percent Bitumen	Mix Temperature (At Plant)
	1½	1	¾	½	⅜	No. 4	No. 8	No. 30	No. 50	No. 200		
S-1						100	94-100	69-77	38-49	2-6	8.5-10.5	210-280°F
S-2					100	91-100	69-77	26-34	16-24	4-8	9.5-12.0	210-280°F
S-3					100	88-100	79-87	36-44	21-29	5-9	6.5-10.5	210-220°F
S-4				100		76-90		31-39	16-24	4-8	5.5-9.5	210-280°F
S-5				100		53-67		19-27		4-8	5.0-8.5	210-280°F
S-8				100	85-100	15-32	0-7			0-0.5	6.0-12.0	210-260°F
I-1		100	88-100		86-100	81-95	74-82	39-47	20-28	4-8	5.0-7.5	210-280°F
I-2		100			63-77	43-57			6-14	2-6	4.5-8.0	210-280°F
B-1		100	88-100			78-92	71-79	41-49	22-30	2-6	3.0-6.5	210-280°F
B-2	100		56-70			21-35	16-24			1-5	4.0-6.0	210-220°F
B-3	100		73-85			38-48	28-35			2-6	4.0-7.0	210-280°F
C-1				100	92-100	70-75	50-60	28-36	15-20	7-9	6.0-9.0	210-300°F
CB-1	55-85	45-75		15-25		0-2					2.5-4.0	305-345°F
P-1					100	86-100	76-84	36-44	21-29	5-7	6.5-9.5	145-155°F
P-2				100	83-97	53-67	41-49	19-27	9-17	4-8	6.5-8.5	145-155°F
P-3			100		63-77	38-52	24-32			1-5	5.5-7.5	145-155°F

*In inches, except where otherwise indicated. Numbered sieves are those of the U. S. Standard Sieve Series.

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