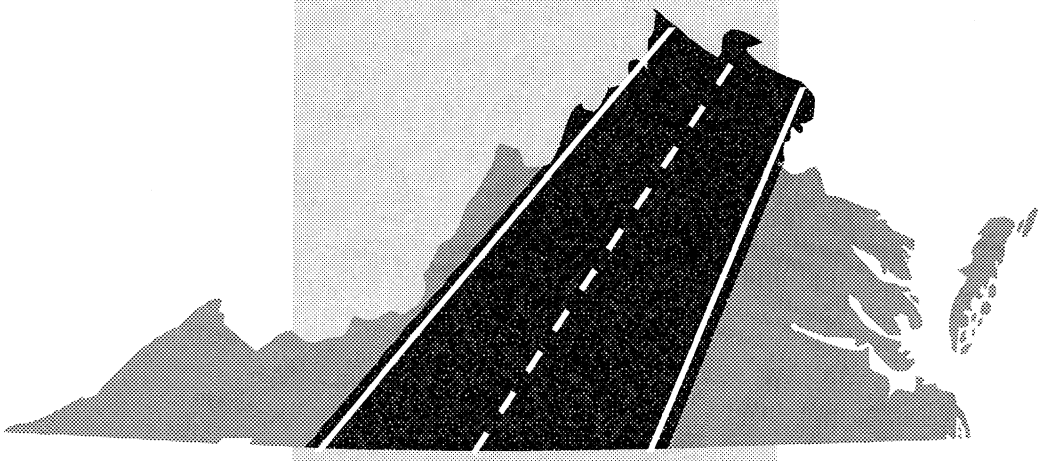
FINAL REPORT

GLASPHALT TEST SECTIONS IN VIRGINIA



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16. Abstract

There is an effort to utilize waste materials in construction processes to diminish the amount placed in landfills. Mixed-color glass, which is not recyclable in the glass industry, has been used in asphalt, but there have been reservations about the durability of a pavement containing glass. The purpose of the project was to install and evaluate field test sections of an asphalt surface mix containing glass, i.e., glasphalt.

Although there were no major problems in constructing the sections, the contractor had a problem obtaining a steady supply of glasphalt from the recycling company. The sections have performed satisfactorily for 2.5 years, but some safety problems have been associated with loose glass raveling from the pavement surface. One report of a child being cut and several reports of cut car tires necessitated a monthly sweeping of the curb and gutter sections during their early life, and one street will be repaved because of these difficulties. Because of these problems, the author recommends that glass not be used in surface mixes, especially in urban areas that are subjected to parking and pedestrian traffic.

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

Virginia Transportation Research Council
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ABSTRACT

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Although no major problems were encountered in constructing the sections, the contractor had a problem obtaining a steady supply of glasphalt from the recycling company. The sections have performed satisfactorily for 2.5 years, but some safety problems have been associated with loose glass raveling from the pavement surface. One report of a child being cut and several reports of cut automobile tires necessitated a monthly sweeping of the curb and gutter sections during their early life; one street will be repaved because of these difficulties. Because of these problems, the author recommends that glass not be used in surface mixes, especially in urban areas subjected to parking and pedestrian traffic.

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GLASPHALT TEST SECTIONS IN VIRGINIA

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INTRODUCTION

The space in approximately 70 percent of the nation's landfills will be depleted by the year 2000.[1] Communities and solid waste disposal companies are searching for ways to dispose of materials that would otherwise have to be placed in landfills. Some waste materials are being used in roadways, including scrap tires, glass, and roofing shingles. Factors other than material properties that affect the interest in using waste materials are environmental issues, legislative activity, economics, material properties, and construction material shortages. Virginia has experimented with approximately 14,000 metric tones of asphalt concrete containing ground scrap tire rubber in an attempt to gain experience in using it and determine whether its use would be economically advantageous.

Glass can by recycled for glass manufacturing, but it must be color sorted. Mixed-color glass must be disposed of in landfills, and the disposal cost is quite high in some areas. Around 1970, the University of Missouri-Rolla started an extensive research project funded by the Environmental Protection Agency that involved approximately 30 test sections of asphalt concrete containing glass. In a 1994 Transportation Research Board synthesis, only 6 state highway agencies reported any use of glass in asphalt paving, but 10 agencies had performed some research on the utilization of glass.[2] A 1995 Texas report identified five states with specifications for using glass in asphalt.[3] Most pavements have contained less than 15 percent glass in the hot mix, and some have contained only 5 percent. Baltimore, Maryland, was one of the first cities to use glasphalt but recently discontinued its use because of the high cost. New York City continues to use about 5 percent fine sand-sized glass in its mixes.

The performance of building materials is one of the most important aspects engineers must consider. When waste materials are used, their performance should be required to be equal to or better than that of conventional materials. Since glass has a very smooth surface, asphalt may tend not to form a durable, permanent bond, potentially leading to increased stripping. Some early field projects in New York and Baltimore showed stripping, which has been a concern in other studies.[4] A recent technical assistance report showed stripping in many pavements in Virginia, so any addition of a material that causes more stripping would be undesirable.[5] A feasibility study by Hughes in 1990 showed with laboratory tests that stripping of glasphalt may not be a problem. However, the study was limited to one aggregate and used only hydrated lime as an antistripping additive.[6]

In 1992, the Virginia General Assembly passed Senate Bill 469, which directed that a committee be formed to study the use of waste materials. This resulted in the formation of the Recycled Materials in Highway Construction Advisory Committee, composed of representatives of the Virginia Department of Transportation (VDOT), the road construction trade, the waste industry, recycling organizations, the Virginia Department of Waste Management, and local governmental organizations. The committee discussed many materials that could be used in road building and made recommendations to VDOT. Initially, there was considerable interest in using glass in asphalt, and the Asphalt Research Advisory Committee of the Virginia Transportation Research Council (VTRC) directed that a study be conducted on the use of glass in asphalt. The study was to involve installation of a field test section(s) and laboratory work dealing with stripping. The final recommendation of the committee was to consider only the limited use of glass in asphalt pavements because of unknowns concerning performance. This report covers the field test involving glasphalt. The results of the laboratory stripping study will be covered in a separate report.

PURPOSE AND SCOPE

The use of glasphalt has produced mixed opinions regarding the suitability of waste glass as an alterative aggregate source. These reservations have included cost, environmental impact on workers, and susceptibility to premature distress attributable to stripping. This study examined the performance of the test sections. Cost was difficult to assess because of the size of the project and was not included as part of this study. Worker impact was beyond the scope of this study.

The purpose of this phase of the investigation was to install and evaluate test sections of asphalt concrete containing waste glass. Approximately 5,100 metric tons of surface mix were placed on several streets in the same general area. This gave VDOT an opportunity to determine difficulties that might arise in using an unconventional road-building material and provided the contracting industry experience in using glasphalt.

METHODOLOGY

General

The performance of test sections containing glasphalt was observed and recorded. Maintenance practices to yield a satisfactory roadway were necessary on one section and were noted. An attempt was made to give an opinion regarding the reason for the lack of adhesion, which allowed glass particles to ravel from the surface. A preconstruction distress survey of the

underlying surface was invaluable in pointing out whether the distresses on the glasphalt surface reflected the condition of the underlying layer.

Tests

Mix Design

The mixes were designed by the 50-blow Marshall design method in accordance with Virginia Test Method VTM-57.[7]

Density and Air Voids

Density and air void determinations on pavement plugs and cores were made in accordance with ASTM D 2726 and D 3203, respectively.[8]

Stripping Tests

Virginia Test Method VTM-62 was used to determine the predicted stripping susceptibility of the mix placed. The test method is similar to ASTM D 4867, but it does not use a freeze cycle and the mixes are compacted to a target air void content of 7.5 percent instead of 7.0 percent. The specifications required a tensile strength ratio (TSR) of at least 0.9.

Friction Tests

Friction tests were performed on the test sections with a full-scale skid trailer at 64 km/h in accordance with ASTM E 274-90 using a standard smooth tire (E 524-88).

TEST SECTIONS

Seven streets in the Dale City area of Prince William County were paved with glasphalt from August 30, 1994, to September 9, 1994. Locations are shown in Figure 1 and listed in Table 1. The streets were residential, with speed limits less than 56 km/h.

Branscome Paving Company of Manassas, Virginia, produced and placed approximately 5,100 metric tons of the glasphalt surface mix. Greenwood Drive did not receive glasphalt on the eastbound/southbound lane from Granby Road to Glendale Road. A conventional SM-1 mix was

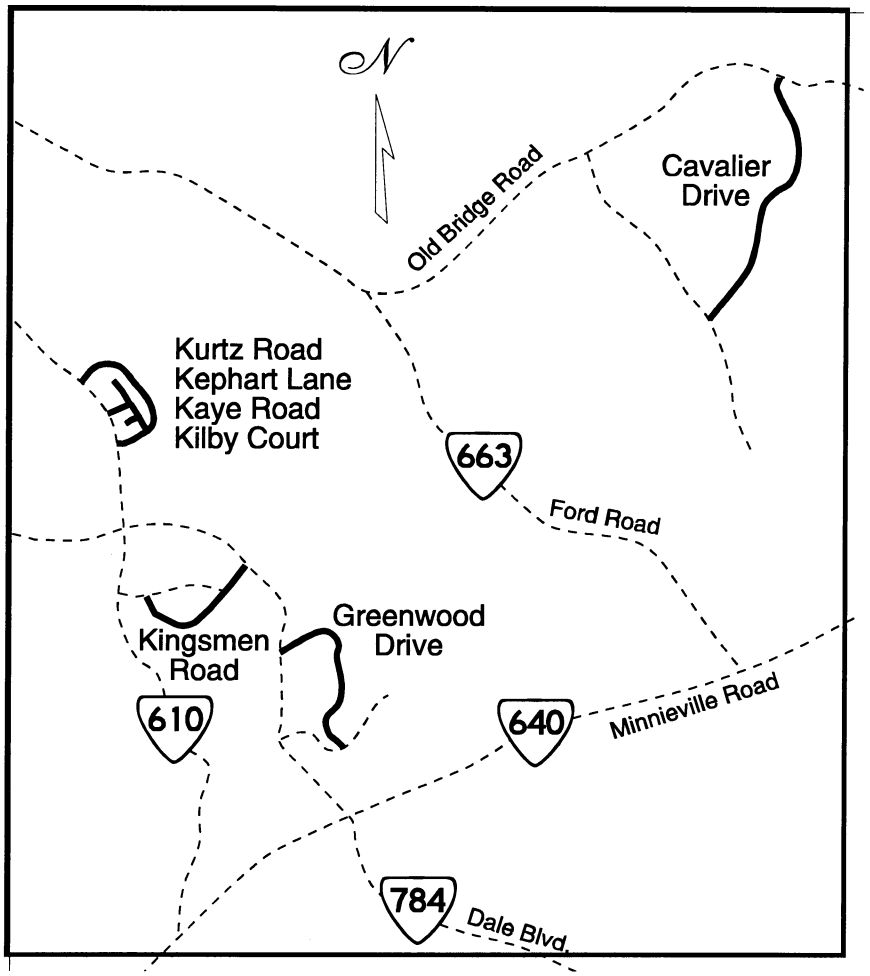

Figure 1. Location of Test Sections

Table 1. Locations of Test Sections

Street	From	To	Distance, km	Date Paved
Cavalier Dr.	Old Bridge Rd.	Smoketown Rd.	1.52	8/30/94
Kingsman Rd.	Dale Blvd.	Kilbane Rd.	0.79	9/7-8/94
Kurtz Rd.	Delaney Rd.	Delaney Rd.	0.88	9/8/94
Kephart Ln.	Kurtz Rd.	Dead end	0.37	9/8/94
Kaye Rd.	Delaney Rd.	Kephart Ln.	0.09	9/8/94
Kilby Ct.	Kephart Ln.	Dead end	0.07	9/8/94
Greenwood Dr.	Dale Blvd.	Glendale Rd.	1.06	9/9/94

used instead. All streets had concrete curb and gutter and accommodated vehicle parking for residents except Cavalier Drive, which had stone shoulders. A variable depth of asphalt was milled on the edge of the streets with curb and gutter to keep the pavement surface below the gutter. A detailed distress survey was performed before paving in which patches, cracks, and any other distresses were mapped.

Materials

Two SM-1 surface mixes containing glass were produced: one containing recycled asphalt pavement (RAP) with no natural sand, identified as the RAP mix, and another containing natural sand with no RAP, identified as the virgin mix. The sources of materials and design gradations are listed in Tables 2 and 3, respectively. As shown in Table 2, 15 percent glass was used in both mixes.

Table 2. Sources of Materials

Percentage of Material		Material	Source
Rap Mix	Virgin Mix		
20	28	No. 8's	Bull Run Stone, Manassas, Va.
15	26	No. 10's	Bull Run Stone, Manassas, Va.
35	21	Manufactured sand	Bull Run Stone, Manassas, Va.
---	10	Natural sand	Solite Corp., Fredericksburg, Va.
15	15	Glass	Metro Recycling Corp., Fairfax, Va.
15	---	RAP	Branscome Paving Co., Manassas, Va.
		AC-20	Sun Oil, Cockpit Point, Va.
---	1.0	Antistrip HP Plus	ARR-MAZ Products, Winter Haven, Fla.
1.2	---	Antistrip Kling Beta 2000	SCAN Roads, Waco, Tex.

Construction

Branscome Paving Company used a drum plant of 270 metric tons per hour to make the mixes. They used a Blaw-Knox PF-500 paver, a 9-metric-ton breakdown tandem steel wheel roller, and a 5-metric-ton finish steel wheel roller for placement.

Ambient temperatures were moderate, ranging from 28 to 30 C for daily highs and from 14 to 16 C for daily lows. Cavalier Drive was paved the first day, August 30, 1994. Paving was then delayed until September 7, 1994, to obtain an adequate supply of glass from Metro Recycling Corporation. Metro did not have enough of the mixed glass available to meet the demands of the contractor, and the cost was high when compared with conventional aggregates.

Table 3. Average Gradation and Marshall Results of Field Samples

	RAP Mix			Virgin Mix		
Sieve, mm	**Design**	**VTRC**	**Contractor**	**Design**	**VTRC**	**Contractor**
Gradation						
19.0		100.0				100.0
12.5	100.0	99.9	100.0	100.0	100.0	99.9
9.5	96.3	96.1	96.7	96.6	95.8	96.7
4.75	74.4	76.0	76.8	73.4	72.3	71.6
2.36	---	49.6	50.1	---	49.0	47.5
1.18	---	33.4	33.4	---	34.1	33.4
0.60	20.7	23.6	23.2	22.9	23.9	23.2
0.30	13.9	16.1	16.0	14.1	15.6	15.5
0.75	6.3	6.3	6.3	6.1	6.2	6.6
% AC	5.9 & 5.7*	5.9	6.0	5.3	5.2	5.4
Marshall						
VTM	4-8	4.1	4.8	4-8	6.0	5.2
VMA	>17	16.7	17.7	>17	17.3	17.7
VFA	65-80	75.3	73.0	65-80	65.4	71

*Decreased to 5.7 percent after the first day.

No major problems were encountered the first day. Some plastic bottle tops in the glass were observed in the pavement, and the temperature of the mix was increased from approximately 145 to 154 C to determine if the plastic would melt. Because the plastic was still visible at the higher temperatures, the temperature was returned to the normal operating temperature.

RESULTS

Average extraction gradation results and Marshall results of field samples are provided in Table 3. There was good agreement between the gradation results of the contractor and VTRC.

Generally, the gradations of the material produced for both mixes were several percentage points finer than the mix design gradations. The asphalt content for the mix containing RAP was decreased after the first day because it was felt that the Marshall air voids might be too low. The air void content design for this mix was 6.0 percent, and the average Marshall results for production samples were approximately 4.5 percent.

Eleven cores were taken from the RAP mix pavement and 6 were taken from the virgin mix pavement after the compaction rolling was completed. The average air void content was 10.5 and 12.8 percent for the RAP and virgin pavements, respectively. The slightly higher pavement void content of the virgin mix was expected because the field Marshall void content results of the virgin mix were higher than those of the RAP mix. It is likely that the virgin mix could have tolerated and benefited from a higher asphalt content.

Both the TSR and boiling tests were used to attempt to predict the stripping susceptibility of the mixes. Table 4 lists the results of the TSR test. The average TSR of field samples was

slightly less than the TSRs obtained from design tests. The specification required a TSR of at least 0.90, but only the design value for the RAP mix met that criterion. Quite often, the production TSR is greater than the design TSR, and it was anticipated that this would be the case here, but it was not. The fact that the TSR of the virgin mix was lower than that of the RAP mix could have been caused by two factors: a lower asphalt content and the presence of natural sand. The variation of TSR production tests was low, being comparable to the variation expected from multiple tests on a single sample by one laboratory.[10] The low variation of the additive introduction had little effect on the TSR.

Table 4. Stripping Test Results

		No. Tests	Average TSR	Standard Dev.
RAP mix	Field samples	10	0.83	0.03
	Design	1	0.90	---
Virgin mix	Field samples	3	0.76	0.03
	Design	1	0.85	---

Some stripping was visible on the glass particles when the boiling tests were performed. Four of 13 samples, representing both the RAP and virgin mixes, showed slight signs of stripping. VDOT's criterion for the boil test is that no stripping be visible.

Friction tests were performed approximately 2 weeks after construction. The average friction number for the RAP mix on Cavalier Drive was 40 and that for the virgin mix on Kingsman Road was 38. Both of these numbers were adequate, being above 20.

Field Performance

A visual field inspection of the sites was performed in the fall of 1995, approximately 1 year after construction. Very little reflection cracking was present, and the surface was in excellent condition. There were loose glass particles on the side of the street where automobiles parked and in the gutter for the streets with curb and gutter. The force of rainwater in the gutter had caused small piles of glass particles to be deposited at some locations. Some glass particles were also visible along the stone shoulder on Cavalier Drive.

A second field inspection in March 1997 indicated much less visible loose glass. Some loose particles were observed in the lane next to the curb where automobiles parked, but only a negligible amount was in the concrete curb. More reflection cracking was visible on all streets. Cavalier Drive had less cracking than the other streets but originally had fewer distresses in the surface that was overlaid. Although glass particles had raveled from the surface on all of the streets as evidenced by the loose particles nearby, the raveling was not evident on the surface of the pavement. No discernible difference was observed between the performance of the two mixes. The mixes were performing well on all streets.

The local VDOT residency office was contacted to ascertain their experience with maintaining the glasphalt sections.[11] There were several complaints from residents of Kingsman Road. One person reported that a child had been cut, and there were several reports of cut automobile tires. After the initial complaints during the first year, the street was swept monthly for 6 months to remove loose glass. The streets in this area are routinely swept every 6 months to remove sand and trash. It seemed that Kingsman Road had more loose glass than the other streets. The results of the TSR stripping test were lower for this mix (virgin mix), which might indicate a greater tendency to strip and ravel. In addition, the fact that the asphalt content was lower than that of the mix placed on the other streets might have contributed to the loss of glass particles. Because of complaints by a few residents, the street will be milled and repaved in 1997.

CONCLUSIONS

- Glasphalt can be designed and constructed without technical problems. Availability of an adequate supply of glass was a problem on this particular project.

- The lab tests performed on samples taken during construction indicated that stripping might be a problem, but not a major problem. The raveling of some glass particles from the surface indicated some lack of adhesion, possibly resulting from stripping. With the exception of raveling, no evidence of stripping was evident.

- Stripping tests indicated that the virgin mix was more prone to stripping than the RAP mix, possibly because of the lower asphalt content and presence of natural sand.

- Raveling of glass from the pavement surface resulted in loose glass particles, which were a safety hazard on one street. Glass that was crushed to a smaller size (less than 9.5 mm) probably would not have posed the same safety problem but might have suffered more damage because of stripping.

- Except for loose glass, the performance of the glasphalt was satisfactory.

RECOMMENDATION

- Do not use glasphalt in an asphalt surface mix because of the safety hazard with loose glass particles, especially in an urban area with curb and gutter.

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