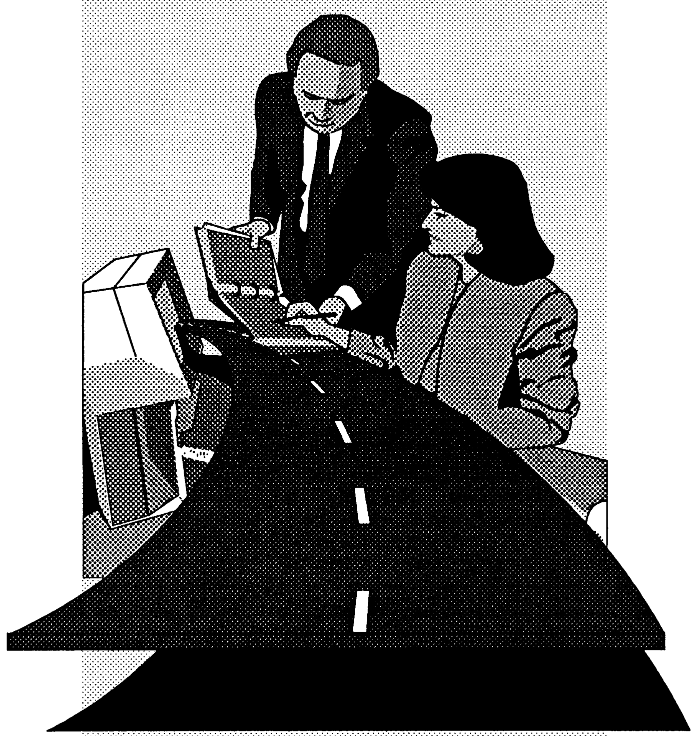
FINAL REPORT

EVALUATION OF A MODIFIED ASPHALT: NOVOPHALT



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Abstract

Because of increased traffic loads and truck tire pressures over the last few years, the rutting of asphalt pavements has worsened. Additives such as polymers are being used in an attempt to improve the performance of these pavements. One such product is Novophalt, which is the registered trademark of an asphalt modified with 4 to 6 percent of a polyolefin polymer, primarily polyethylene. A Novophalt surface mixture was used near an intersection on a new construction project to guard against rutting caused by heavy trucks. This study evaluated the construction and performance of sections of pavement with control and Novophalt mixtures at this location.

The polymer-modified mixture was manufactured, placed, and compacted with no difficulty. Severe ruts developed in both the control and Novophalt sections under stopped traffic near the traffic light. The rutting was found to be caused by a weak base mixture under the Novophalt surface; the rutting under the control mixture was probably also related to the base mixture. No significant rutting occurred in the control and Novophalt sections in the areas not subjected to severe traffic loads. Although the comparison between the control and Novophalt mixtures was vitiated by the performance of the underlying base mixture, the project demonstrated that construction with the Novophalt mixture could be accomplished satisfactorily.

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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

Because of increased traffic loads and truck tire pressures over the last few years, the rutting of asphalt pavements has worsened. Additives such as polymers are being used in an attempt to improve the performance of these pavements. One such product is Novophalt, which is the registered trademark of an asphalt modified with 4 to 6 percent of a polyolefin polymer, primarily polyethylene. A Novophalt surface mixture was used near an intersection on a new construction project to guard against rutting caused by heavy trucks. This study evaluated the construction and performance of sections of pavement with control and Novophalt mixtures at this location.

The polymer-modified mixture was manufactured, placed, and compacted with no difficulty. Severe ruts developed in both the control and Novophalt sections under stopped traffic near the traffic light. The rutting was found to be caused by a weak base mixture under the Novophalt surface; the rutting under the control mixture was probably also related to the base mixture. No significant rutting occurred in the control and Novophalt sections in the areas not subjected to severe traffic loads. Although the comparison between the control and Novophalt mixtures was vitiated by the performance of the underlying base mixture, the project demonstrated that construction with the Novophalt mixture could be accomplished satisfactorily.

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INTRODUCTION

The rutting of pavements has worsened over the last few years because of increased traffic loads and increased tire pressures.[1, 2] Considerable effort is now being made to improve the design procedures and specifications of asphalt concrete in order to cope with these problems. One of the possible solutions to the problem that has received a lot of attention is the incorporation of various asphalt modifiers to improve a mixture's serviceability by changing the characteristics of its binder.

During high summer temperatures, the viscosity of asphalt binders may be reduced to a level that allows the pavement to deform excessively under traffic. Although hard asphalt cements can be used to counteract this problem, this may create a danger of cracking during cold temperatures. A good binder should have a low temperature susceptibility, that is, the change in consistency of the binder with temperature should be as low as possible consistent with adhesive and ductile properties. Rubber and plastic additives are often blended with asphalt cement as a means of reducing the temperature susceptibility of the binder and increasing the flexibility of the asphalt concrete.[3, 4]

Although laboratory tests demonstrate the expected benefits of using such additives, field installations and follow-up performance evaluations are the most reliable method of judging their overall benefits. In 1986, test sections were installed and evaluated in the Lynchburg District. These installations included binders modified with two rubber polymers (styrene-butadiene-styrene, SBS, and styrene-butadiene-rubber, SBR) and one plastic polymer (ethylene vinyl acetate). In 1989, the New Products Committee of the Virginia Department of Transportation asked the Virginia Transportation Research Council (VTRC) to evaluate another plastic polymer in a test section that was constructed in the Salem District. This plastic polymer was a polyolefin (primarily polyethylene) and its performance would not necessarily be expected to be the same as that of the SBS, SBR, or ethylene vinyl acetate because of differences in its chemical composition. This report describes the installation, test results, and performance of the 1989 test section, which used the Novophalt binder containing a polyolefin polymer.

PURPOSE AND SCOPE

The purpose of this study was to evaluate the installation and performance of a test section of asphalt concrete surface mixture containing a polyolefin polymer additive. Construction was observed, and laboratory tests were conducted on samples of the mixture during construction in an attempt to predict its long-term performance. Annual rut depth measurements were also used to measure performance.

METHODOLOGY

Approach

The construction of the installation was observed, and data were collected concerning the equipment used, the construction procedures, the mixture variables (such as mixing and laydown temperature), and the workability. Samples of the materials and mixtures were collected, transported to the laboratory, and tested at a later time.

Routine tests such as asphalt viscosity, extraction, aggregate gradation, and Marshall were conducted on the materials and mixtures. The Virginia Department of Transportation's materials laboratory at Salem also performed extraction, gradation, and Marshall tests as part of their routine operation. Other tests, such as gyratory shear, creep, resilient modulus, and indirect tensile, were performed at VTRC's laboratory. Strength and stiffness results were compared between the normal control mixture and the Novophalt mixture to try to predict whether one was more resistant than the other to permanent deformation under traffic. High strength and stiffness (modulus) should indicate more resistance to deformation, although susceptibility to other types of distresses such as cracking might be increased.

Field tests included the annual measurement of profiles from which rut depths were computed and the taking of cores on which air voids were determined. Because the amount of voids in a mixture affects the durability of asphalt pavement, the amount of voids was measured in each section. The more important considerations concerning the satisfactory use of an additive are whether pavements can be constructed successfully with the mixtures containing the additive, whether the performance is satisfactory, and whether the performance is cost-effective. These items were used to gage the acceptability of Novophalt.

Description of Test Section

The test installation was included as part of a new construction project (6220-011-104, C-501) and is located at the intersection of Route 220 and Route 11 in the Salem District. It consisted of two sections of surface mixture (the control) and two sections of surface mixture containing Novophalt, which is a modified asphalt binder. In order to equalize the effect of traffic on both mixes, the sections were placed in a checkerboard fashion (see Figure 1). The typical cross section for the pavement is shown in Figure 2. The rate of application of the surface mixture was specified as 89.6 kg/m^2 (165 lb/yd^2), which is equivalent to a thickness of 38 mm (1.5 in). The specified thickness of the asphalt base course was 152 mm (6.0 in).

Mixture Designs

A 75-blow Marshall compactive effort was used for the design of the control and Novophalt surface mixtures. The design parameters are shown in Table 1. The binder for the control mixture was an AC-20 asphalt cement, and the binder for the experimental mixture was an AC-20 asphalt cement modified with 5 percent polyolefin (Novophalt). The base mixture design is also contained in Table 1. All mixtures contained 1 percent of hydrated lime as an antistripping additive. The sources of the materials are listed in Table 2.

Construction

The test sections were constructed December 5 and 6, 1989, by Adams Construction Company of Roanoke in the sequence shown in Figure 3. Sections 1 and 2 were placed on December 5, and the remaining sections were placed on December 6. Although the paving was done in December, the air temperature was more than 10°C (50°F) at all times.

A special blending unit was furnished by the Novophalt supplier at the asphalt concrete plant to blend the asphalt cement and the polymer. No special equipment was required to place the mixtures. Compaction was accomplished with a 10.9 Mg (12-ton) 3-wheel breakdown roller and a 7.3- to 9.1-Mg (8- to 10-ton) vibratory finish roller operated in the static mode.

The temperatures of the control and Novophalt mixtures averaged 154°C (310°F) to 157°C (315°F) in the truck at the site and approximately 121°C (250°F) on the mat surface behind the breakdown roller. These temperatures were obtained with an infrared thermometer, which measures the surface temperature; therefore, the temperature of the mixtures below the surface was slightly higher.

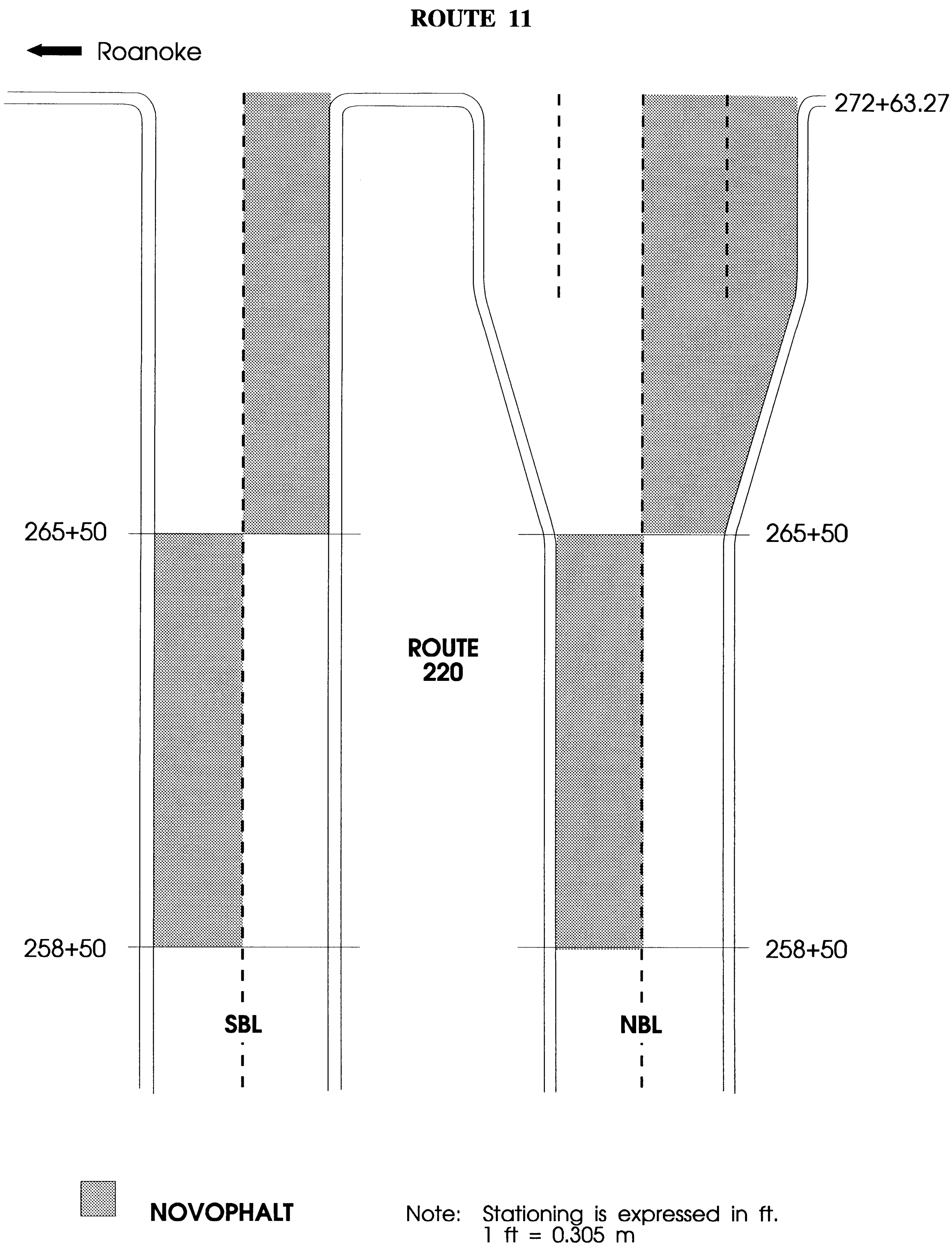
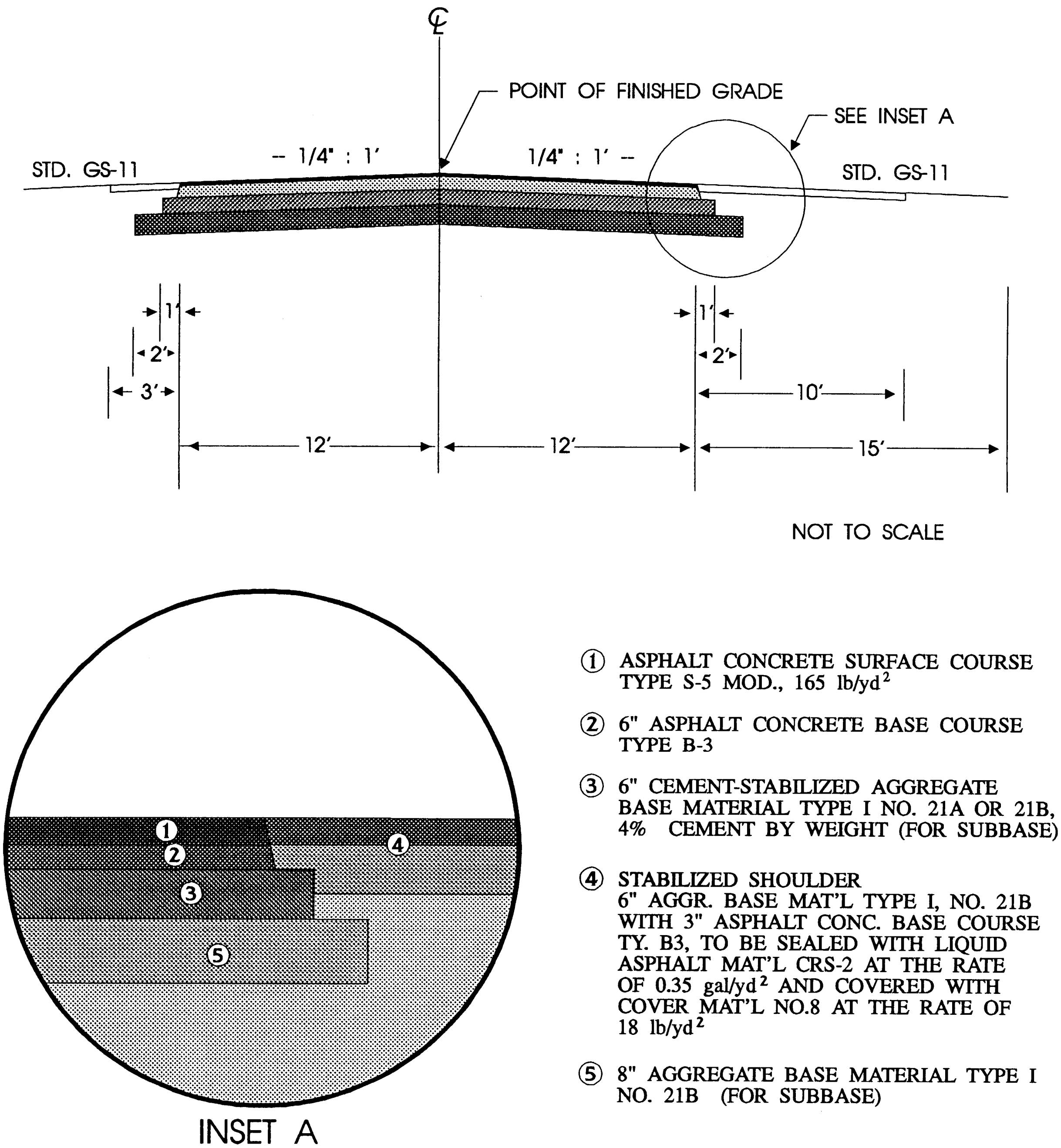


Figure 1. Location of test sections.



Metric conversion: 1 in = 25.4 mm 1 lb/yd^2 = 0.543 kg/m^2
1 ft = 0.305 m 1 gal/yd^2 = 4.528 l/m^2

Figure 2. Typical pavement cross section.

Table 1
MIXTURE DESIGN

Sieve	% Passing	
	Surface	Base
37.5 mm (1 1/2 in)		100
19 mm (3/4 in)		69-77
12.5 mm (1/2 in)	97-100	
4.75 mm (#4)	53-61	38-46
2.36 mm (#8)		25-33
600 mm (#30)	20-26	
75 mm (#200)	4.2-6.2	3.9-5.9
Asphalt (percentage)	4.9-5.5	4.1-4.7

Table 2
SOURCES OF MATERIALS

Materials	Supplier	Location
Surface Mixture		
50% #8s	Danville Vulcan Materials	Danville, Va.
20% Sand	Eden Sand Co.	Eden, N.C.
30% #10s	Martinsville Stone Co.	Fieldale, Va.
1.0% Hyd. Lime[a]	Virginia Lime Co.	Ripplemead, Va.
5.2% AC-20	Fuel Oil & Equipment Co.	Roanoke, Va.
5% Polyolefin[b]	Novophalt America Inc.	Sterling, Va.
Base Mixture		
30% B-3 Coarse Agg.	Blue-Ridge Stone	Blue Ridge, Va.
30% #68s	Blue-Ridge Stone	Blue Ridge, Va.
40% #10s	Blue-Ridge Stone	Blue Ridge, Va.
1% Hyd. Lime	Virginia Lime Co.	Ripplemead, Va.
4.4% AC-20	Fuel Oil & Equipment Co.	Roanoke, Va.

a. By weight of aggregate.
b. By weight of asphalt cement.

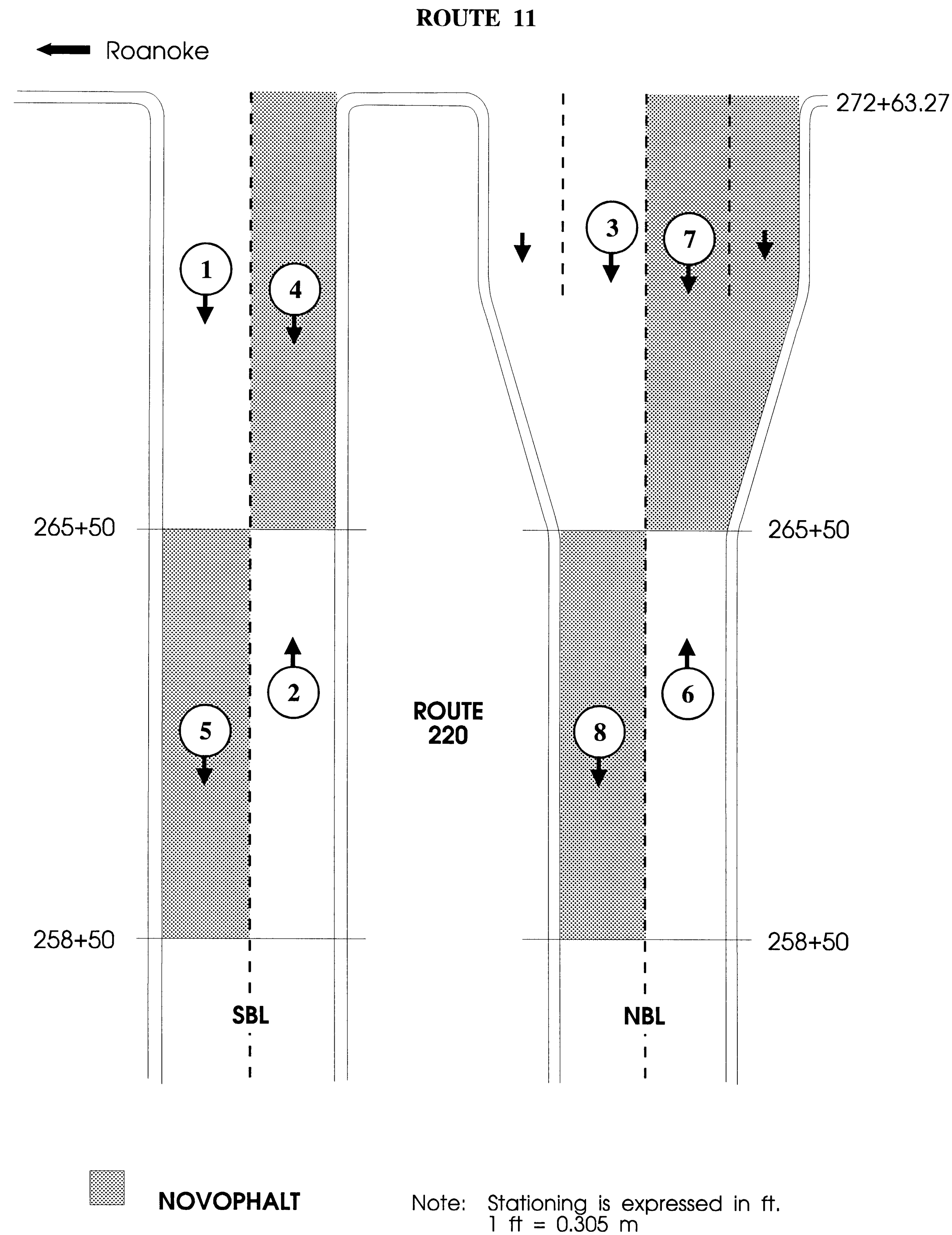


Figure 3. Paving sequence.

RESULTS

Laboratory Tests

Viscosity Tests

The viscosity of the binders was determined at 60°C (140°F) and at 135°C (275°F) according to ASTM test methods D2171 and D2170,[5] respectively. The results listed in Table 3 show that the addition of the polymer increased the viscosity of the binder at both 60°C (140°F) and 135°C (275°F) to approximately 150 percent of the original values. The increased viscosity should make the asphalt concrete mixture less susceptible to permanent deformation during high summer temperatures.

Extraction and Gradation Tests

Reflux extraction and gradation tests were performed on samples of plant mixture according to test methods ASTM D2172[5] and AASHTO T30-84.[6] The results of tests by VTRC and by the Virginia Department of Transportation's Salem District Materials Laboratory are listed in Table 4. The gradation of both mixtures is slightly finer than the design gradation. For unknown reasons, the Novophalt mixture tested by VTRC had a much larger amount of material passing the 75 µm (No. 200) sieve. This discrepancy could have resulted from sampling and/or testing variability.

Marshall Tests

Marshall tests were performed on samples of plant mixture according to ASTM D1559[5] using a 75-blow compactive effort. Determinations were made for voids in the total mixture (VTM), voids filled with asphalt (VFA), voids in the mineral aggregate (VMA), and stability (see Table 5). Table 5 also includes the Virginia specifications and design criteria suggested by the Asphalt Institute. The Marshall properties of both mixtures were within all criteria with the exception of the VFA for the control mixture, which was high. A high VFA indicates that the mixture possibly contained too much binder.

Table 3
VISCOSITY OF BINDERS

Binder	Viscosity			
	60°C Pa·s	(140°F) (P)	135°C $m^2/s \times 10^{-6}$	(275°F) (cSt)
AC-20	188.6	(1,886)	410	(410)
Novophalt	476.1	(4,761)	1,018	(1,018)

Table 4
GRADATION OF MIXTURES SAMPLED DURING CONSTRUCTION

Sieve	Job Mix	% Passing			
		Tests by Research Council		Tests by Salem District[a]	
		Novophalt	Control	Novophalt	Control
12.5 mm (1/2 in)	100.0	100.0	100.0	100.0	100.0
9.5 mm (3/8 in)	—	94.8	93.0	95.0	95.0
4.75 mm (#4)	57.0	59.2	49.5	57.5	59.0
2.36 mm (#8	—	43.2	36.6	41.5	43.0
600 mm (#30)	23.0	27.6	23.2	25.0	25.5
300 mm (#50)	—	19.7	16.5	17.0	17.5
150 mm (#100)	—	14.0	11.3	11.0	11.0
75 mm (#200)	5.2	9.4	6.7	6.2	6.8

a. Average of two tests per mixture.

Table 5
MARSHALL LIMITS AND RESULTS OF TESTS ON PLANT MIXTURES

	VTM (%)	VFA (%)	VMA (%)	Stability N (lb)
Virginia DOT	4-8[a]	60-75[a]	—	—
Asphalt Institute	3-5[b]	—	>14.5	>6,675 (1500)
Control Mixture	3.2	80.2	16.3	18,100 (4060)
Novophalt Mixture	4.5	71.9	15.9	16,400 (3690)

a. Production limits.
b. Design limits.

Pavement Voids

A determination of the specific gravity of cores removed from each section was performed according to AASHTO T166-83[6] to obtain VTM results (see Table 6). There was no significant difference at a 95 percent confidence level between the average VTM of the control sections (10.8 percent) and the average VTM of the Novophalt sections (10.2 percent). The variability of VTM within some sections is higher than normal, possibly because such short sections were involved. As mentioned previously, the gradations of samples tested by the Research Council and the Salem District Materials Lab differed significantly for the Novophalt mixture, which was one of the sections with a high variability of VTM.

Table 6
VTM IN CORES TAKEN AFTER CONSTRUCTION (%)

Section	$\bar{x}$[a]	s[b]
1. Control	8.9	0.65
2. Control	12.9	1.11
3. Control	9.9	2.09
6. Control	11.3	1.84
4. Novophalt	8.4	2.28
5. Novophalt	10.6	1.65
7. Novophalt	9.2	2.43
8. Novophalt	12.6	0.98

a. Average.
b. Standard deviation.

Gyratory Shear Test

The gyratory testing machine (GTM) was used to test the mixtures according to ASTM D3387.[5] An initial gyratory angle of 1° and a vertical pressure of 827 kPa (120 psi) (using the oil-filled mode of operation) was employed to give strength, compaction, and strain information. The specimens were compacted until the rate of compaction decreased to 16 kg/m^3 (1 pcf) per 100 revolutions, which simulates the maximum compaction that the mixture will be subjected to under traffic. The three properties used to characterize the mixtures were air voids, shear strength, and gyratory stability index (GSI). According to the developer of the equipment, the air voids should be greater than 3 percent, the shear strength should be greater than 260 kPa (38 psi), and the GSI, which is an indicator of whether the mixture will undergo plastic deformation, should be less than 1.1.

The results of the GTM tests are presented in Table 7. The predicted VTM for the control pavement after traffic was less than allowable, which indicates a potential for overdensification and bleeding. The shear strength for the

Table 7
RESULTS OF GTM TESTS

Mixture	Shear Strength kPa (psi)	GSI	VTM (%)
Suggested Limits	>260 (38)	<1.10	>3.0
Control	270 (39)	1.10	2.5
Novophalt	220 (32)	1.07	3.7

Novophalt mixture was less than allowable. The GSI result of the control mixture was 1.1, which is the maximum allowable value; therefore, this sample may have been rich in asphalt or fines, which apparently act as an asphalt extender in this mixture. These results indicate that both the control mixture and the Novophalt mixture had some deficiencies that could lead to future overdensification and instability in the pavement.

Compression Creep Test

Compression creep tests were performed on specimens that were 64 mm (2.5 in) thick and 102 mm (4 in) in diameter that were prepared on the GTM to simulate the VTM of the pavement immediately after construction. The tests were conducted at 40°C (104°F) using an axial loading of 207 kPa (30 psi) for 60 min. The specimens were preloaded for 2 min, unloaded, and allowed to rest for 5 min before the test load was applied. Axial deformation was recorded in order to develop a strain-time curve. After 60 min, the load was removed, and the recovered deformation was recorded for an additional 60 min. The primary properties of interest were stiffness modulus after 60 min of loading and unrecovered axial strain after 60 min of relaxation.

The creep test results are listed in Table 8. The modulus is a measure of the ability of the mixture to resist deformation under static loading, and the unrecovered strain is a measure of the inability of the mixture to rebound completely from deformation when the load is removed. There was no significant difference at a 95 percent confidence level in the average values for the two mixtures; therefore, no difference in the ability of the mixtures to resist slow-moving loads is predicted by this test.

Resilient Modulus and Indirect Tensile Tests

"The resilient modulus is the ratio of repeated stress to corresponding recoverable strain during loading."[7] The resilient modulus test, which is a dynamic test, produces results that represent the moduli of asphalt under a moving traffic load better than tests with static or slow loading.

Table 8
CREEP TEST RESULTS

Mixture	Modulus at 60 min kPa (psi)	Unrecovered Strain (%)
Control	46,000 (6,670)	0.200
Novophalt	53,800 (7,810)	0.128

The resilient modulus test at 40°C (104°F) was performed with the Schmidt device (ASTM D4123)[5] using the same specimens that were used in the creep test. The moduli were computed using the following formula:

$$MR = P(\mu + 0.273)/tD,$$

where: *MR* is the resilient modulus kPa (psi); *P* is the applied load N (lbf); μ is Poisson's ratio (assume 0.35); *t* is the thickness of specimen m (in); *D* is the horizontal deformation m (in).

The indirect tensile strengths were determined using the same specimens as used in the previous two tests. The tests were performed at 40°C (104°F) and at a vertical deformation rate of 51 mm/min (2 in/min). The strength was computed by the formula:

$$S_T = 2P_u/td,$$

where: P_u is the ultimate applied load required to fail the specimen N (lbf); *t* is the thickness of specimen m (in); and *d* is the diameter of specimen m (in).

The resilient moduli and indirect tensile strengths are listed in Table 9. There was a significant difference at a 95 percent confidence level between the averages of resilient modulus for the two mixtures and also between the averages of indirect tensile strength. The higher values for the Novophalt mixture indicate a tendency of the Novophalt mixture to resist deformation better than the control mixture.

Field Tests

The transverse profile of each section was measured with a Dipstick Road Profiler immediately after construction and again after being under traffic for one summer to determine the rutting that was taking place. The Dipstick Profiler is an electronic device that is walked across the pavement to measure the profile of the surface.

Table 9
RESILIENT MODULUS AND INDIRECT TENSILE STRENGTH

	Resilient Modulus kPa (psi)		Indirect Tensile Strength kPa (psi)	
Mixture	$\bar{X}$	s	$\bar{X}$	s
Control	480,000 (70,000)	15,000 (2,100)	360 (52)	16 (2.3)
Novophalt	820,000 (119,000)	149,000 (21,600)	460 (67)	41 (5.9)

The profiles of the sections adjacent to the intersection were measured 12 m (40 ft) from the intersection, and those for the sections farthest from the intersection were measured at midsection.

The rut depth of the sections farthest from the intersection was generally less than 5 mm (0.2 in), which is not considered to be a problem. However, rut depths were greater in the sections in the northbound lane near the intersection. This increased rutting was to be expected because the traffic stops here for the light. The northbound traffic lane that contained the Novophalt mixture had rutting approaching 25 mm (1 in), which is severe. Although the traffic was not counted, it was observed that this lane was subjected to much more truck traffic than the other lanes.

Some additional tests were conducted to try to determine where the rutting was occurring and its cause. Five cores were removed from both the Novophalt and control sections near the intersection (Figure 4). The thickness of the layers was measured, and the gradation was determined for both the surface and base mixtures using the extracted aggregate.

Figure 5 shows the thicknesses of the surface and base layers from the cores that were removed from the Novophalt and control sections, and Tables 10 and 11 list the average thickness and estimated rutting, respectively. Two observations can be made from the graph: (1) the surface and base layers were thicker in the control section than in the Novophalt section, and (2) most of the rutting appeared to be confined to the base mixture in the Novophalt section. The estimate for rutting of the asphalt concrete layers was based on the assumption that the stabilized stone base had not rutted.

The estimated rutting was less than 2.5 mm (0.1 in) for the surface layer in the Novophalt section, but it averaged 20 mm (0.8 in) in the base layer. The estimated rutting was negligible for both the surface and base layers in the control section. These estimates compare favorably with the total rutting that was measured with the Dipstick Profiler. These tests showed that the rutting was primarily confined to the base layer of asphalt concrete, which was surprising. Asphalt base layers are generally found to be very stable, and the occurrence of rutting in this layer is very unusual. The thickness of the surface layer and base layer in the control section was slightly greater than the specified thickness, but the thickness of the asphalt concrete layers in the Novophalt section was appreciably less than the specified thickness.

Extraction and gradation tests were performed on the cores to try to determine why excessive rutting occurred. The Novophalt mixture was much finer than the specifications allowed, and the excessive amount of material passing the 75–μm (No. 200) sieve would have tended to make the mixture overly dense and susceptible to rutting. The air voids (Table 12) were much lower in the Novophalt surface mixture than in the control mixture. The air voids had decreased from approximately 10 percent to about 3 percent in the

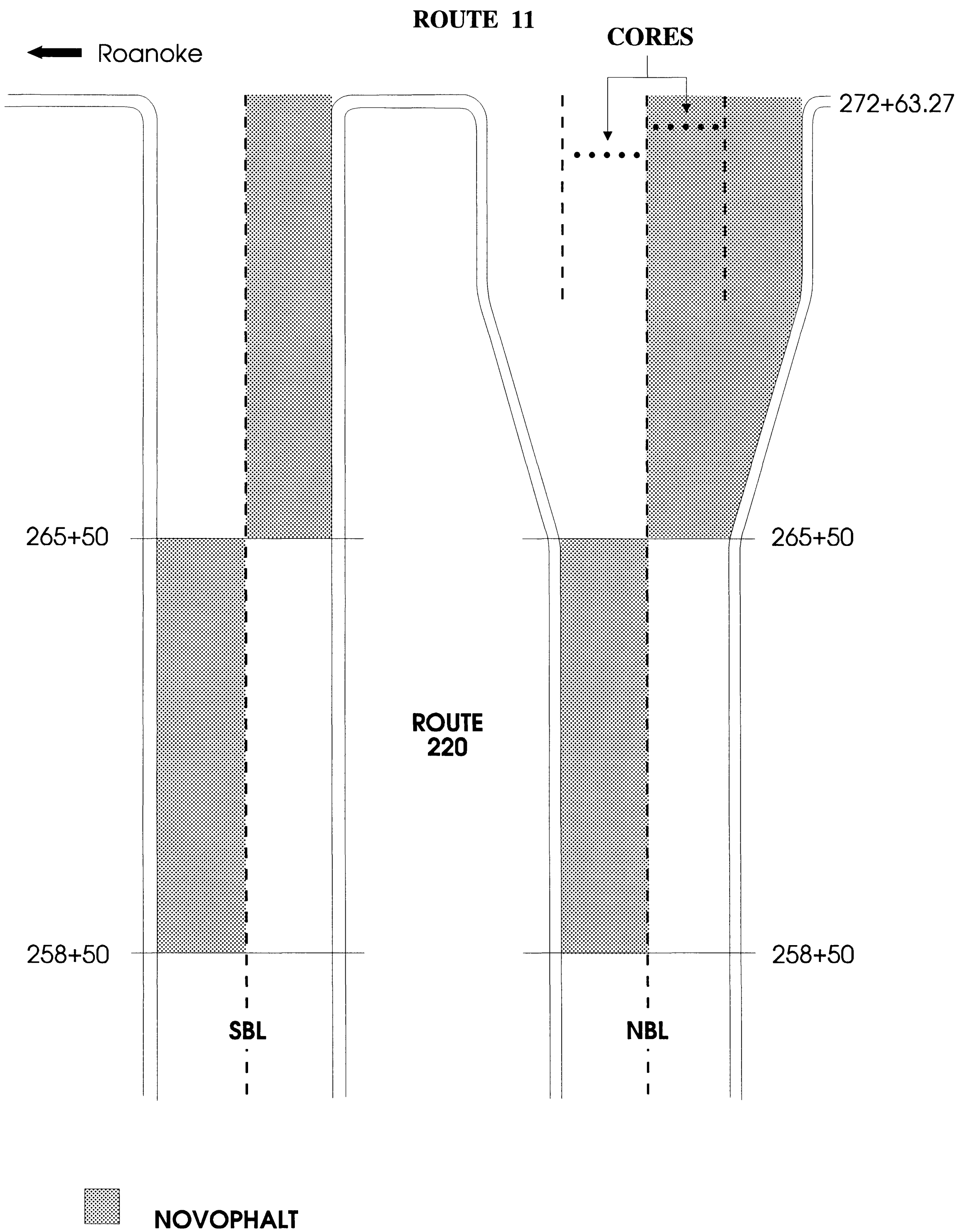


Figure 4. Location of cores.

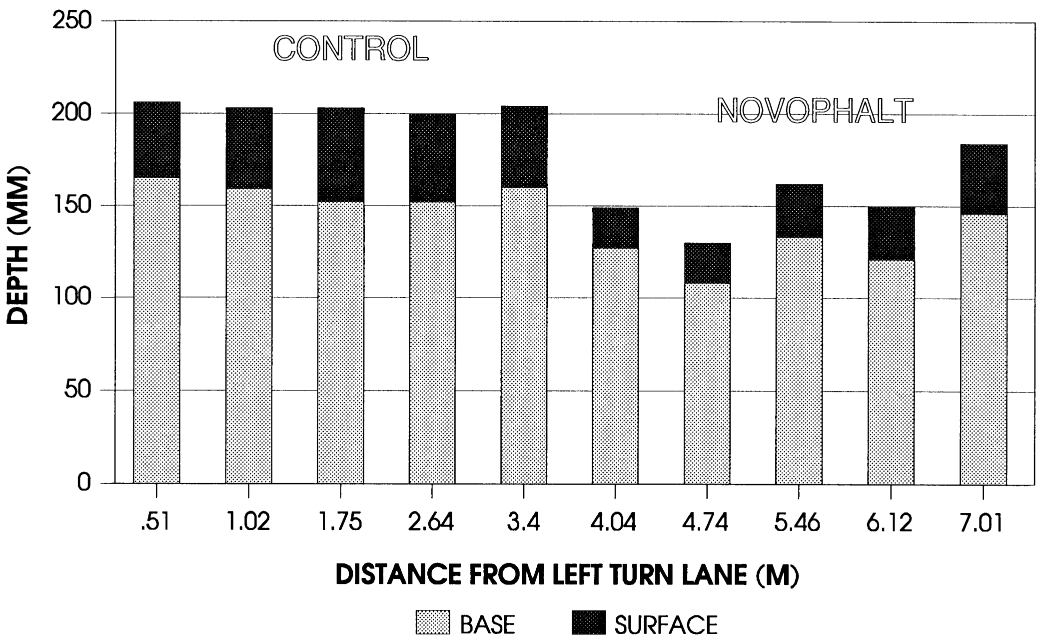


Figure 5. Thickness of cores removed in February of 1991.

Table 10
AVERAGE THICKNESS FROM CORES

	Control Section		Novophalt Section	
	Base	Surface	Base	Surface
Designed thickness mm (in)	152 (6.0)	38 (1.5)	152 (6.0)	38 (1.5)
Avg. measured thickness mm (in)	157 (6.2)	46 (1.8)	127 (5.0)	28 (1.1)

Table 11
RUTTING (mm [in])

	Surface		Base		Total	
	OWP[a]	IWP[a]	OWP	IWP	OWP	IWP
Cores						
Control	0	0	0	—	0	0
Novophalt	2.5 (0.1)	2.5 (0.1)	18 (0.7)	23 (0.9)	20 (0.8)	25 (1.0)
Dipstick						
Control[b]					5 (0.2)	5 (0.2)
Novophalt					25 (1.0)	25 (1.0)

a. Outside wheel path (OWP); inside wheel path (IWP).
b. Measurements were closer to intersection than location of cores.

Table 12
VTM IN CORES IN 1991(%)

Section	Surface Mixture	Base Mixture
Control	5.8	6.3
Novophalt	3.1	3.4

Novophalt mixture and to about 6 percent in the control mixture. Even though the air voids were low in the Novophalt mixture, it is possible that the additive was helping to alleviate rutting. Additives such as polymers tend to make the mixture more elastic and less susceptible to permanent deformation; however, they should not be considered a cure-all for poor mixture gradation. The control mixture was also finer than the specifications allow; however, the material passing the 75–µm (No. 200) sieve was not as high as in the Novophalt mixture, and significant rutting had not occurred. The base mixture under both surface mixtures was much finer than the design gradation, and the asphalt content was also about 0.5 percent higher than specified. Both of these occurrences may have resulted in mixtures with low air voids and instability. In fact, the air voids of the cores from the base mixture were low. The air voids of the base mixture under the Novophalt mixture were 3.4 percent (which is very low), whereas the voids of the base mixture under the control mixture were considerably higher (6.3 percent). The low air voids under the Novophalt were probably caused by a concentration of heavier traffic loads (more trucks) in that lane combined with less-than-desirable base mixture properties.

The rut depths estimated from the last dipstick profiles, which were obtained in September of 1992, are shown in Figure 6. The average rut depth immediately before the traffic light of the northbound travel lanes and left turn lane have continued to increase annually. The maximum and average of both wheel paths for the Novophalt section in the traffic lane was 46 mm (1.8 in) and 36 mm (1.4 in), respectively. In fact, the rutting was so severe that a temporary repair was necessary before winter to fill the ruts and prevent a place for water to collect and freeze. The rutting of the control mixture has increased to an average of 10 mm (0.4 in) and 18 mm (0.7 in) in the northbound passing lane and turn lane, respectively. It is not known why the rutting was slightly worse in the turn lane; however, it may be because that lane may be subjected to more slow-moving heavy truck traffic than the passing lane carrying through-traffic.

It was hoped that some differences in rut depths would develop between the other control and Novophalt sections. However, it is obvious from Figure 6 that there is no significant difference between the rut depths of the other sections. The rut depth of all of these sections is less than 6 mm (0.25 in), which is considered satisfactory.

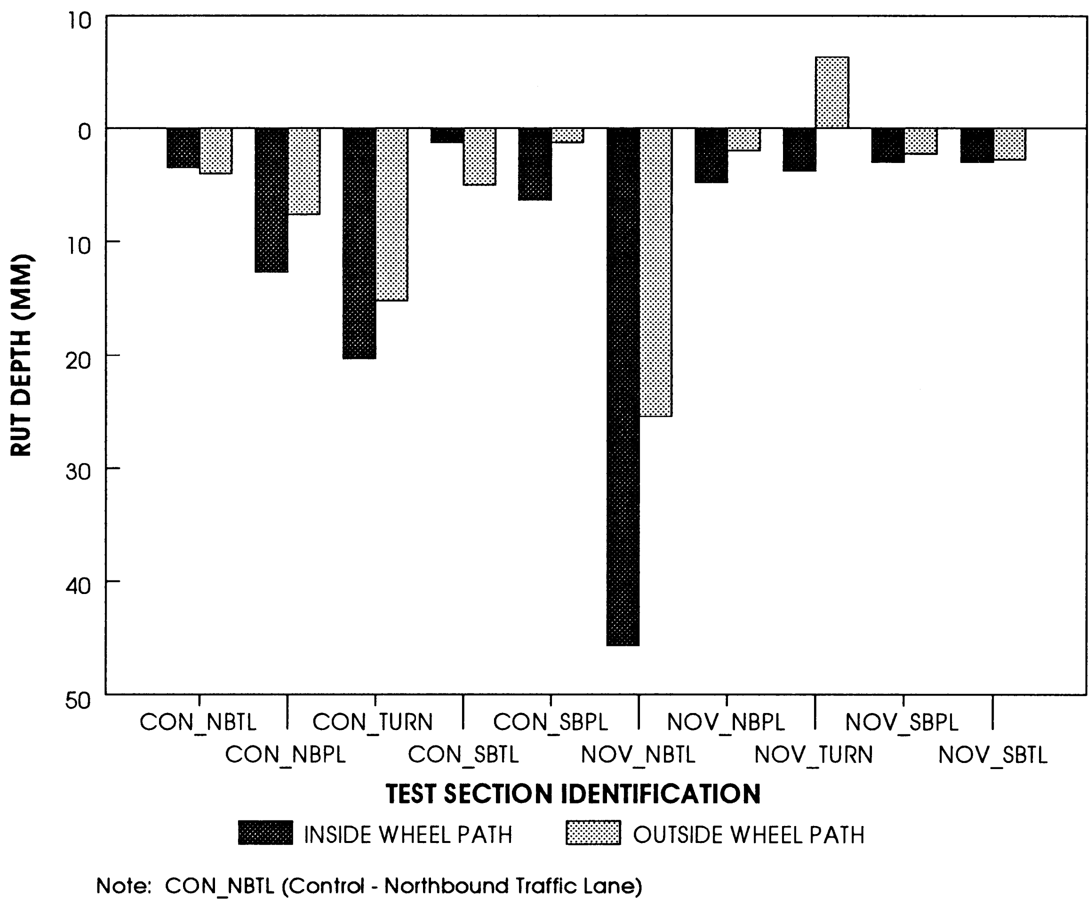


Figure 6. Rut depth as of September 1992.

The typical added cost for using a Novophalt binder rather than a conventional asphalt cement is approximately $5 to $6 per ton of mixture. Based on an average cost of $25 to $30 per ton of mixture, an increase in service life of 20 percent would have to be realized to offset the additional cost. No cost-benefit analysis was attempted because of the lack of good performance data.

DISCUSSION

Construction of the test sections went smoothly. The only exception to normal construction practice that was required for the Novophalt mixture was a special unit to blend the asphalt cement and polymer. However, slightly higher-than-normal mixing and compacting temperatures were used as recommended by the supplier.

The gradations of extracted samples of mixtures taken during construction were finer than specified, especially for the Novophalt mixture tested by the Research Council. Although the air voids of cores taken soon after construction were approximately 10 percent, the air voids of cores taken in 1991 adjacent to the stop light had dropped significantly (3 to 6 percent). The initial high air voids may indicate that more compactive effort during construction would have yielded densities closer to the densities after 1 year of traffic. It is certainly desirable to obtain as much of the ultimate density as possible with compaction equipment rather than with traffic.[8] The air voids were also variable from section to section, indicating a lack of good quality control. Admittedly, quality control is more difficult for short sections as in this project than for longer routinely constructed sections.

Low shear strength, high GSI, and low predicted voids in the tests with the gyratory testing machine indicated possible problems with both mixtures. Resilient modulus and indirect tensile tests showed that the Novophalt mixture may have been slightly better than the control mixture; however, creep tests did not show an appreciable difference between the two mixtures.

Rut depths 10 months after construction in the Novophalt section in the northbound traffic lane near the intersection were excessive; therefore, additional cores were taken and analyzed in an attempt to determine the cause of the problem. The majority of the rutting appeared to be confined to the base layer. Extraction and gradation tests reveal that the gradation of the base mixture under both the control and the Novophalt mixtures is finer than the specifications required, and the asphalt content is about 0.5 percent higher than specified. Both of these undesirable mixture properties probably contributed to the overdensification and rutting in the base mixture. The voids in the base mixture have decreased to approximately 3 percent in the Novophalt section where rutting has occurred.

It appears that the rutting that has occurred was caused by the base mixture and not the experimental Novophalt surface mixture. After the severe rutting was discovered in the sections near the traffic light, it was anticipated that rutting differences between the control and Novophalt sections might develop in sections away from the traffic light and still provide a valid comparison of the surface mixtures; however, this has not occurred.

Even though it was impossible to reach definitive conclusions about the performance of the Novophalt surface mixture under severe traffic loads, there was no difference in the rut depths of sections subjected to less severe loading. Unfortunately, additives such as Novophalt are used only in cases with severe loading; therefore, our results do not help to determine whether Novophalt may be useful.

An interesting observation is that a strong surface mixture will not cover up a weak base. It is imperative to remedy weak bases and supporting layers when making repairs.

CONCLUSIONS

1. A pavement mixture containing a binder of asphalt modified with a polyolefin polymer, Novophalt, was constructed with no difficulty.
2. Because of excessive rutting caused by a weak asphalt base mixture, it was not possible to determine whether the Novophalt mixture had the potential to perform better than the control mixture.

RECOMMENDATION

Based on the fact that the placement of the mixture containing Novophalt was unproblematic, it is recommended that it be tried in additional field tests as the need for modified binders occurs.

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