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16. Abstract

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There was no appreciable difference between control and additive sections.

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FINAL REPORT

EVALUATION OF ASPHALT ADDITIVES TO RESIST PERMANENT PAVEMENT DEFORMATION

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Research Scientist

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

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

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ABSTRACT

Many new asphalt additives reportedly improve the stability and flexibility of asphalt concrete, which leads to increased service life. Four polymers (Polybilt 100, Styrelf 13, Downright HM 100L, and Ultrapave 70) and a diatomaceous filler (Celite 292) were incorporated into mixes placed in test sections for a field evaluation and compared to a control section containing hydrated lime. Rut depth, pavement distress, stiffness, and strength were used to evaluate the mixtures. The mixtures containing Polybilt 100, Downright HM 100L, and Ultrapave 70 produced higher values of strength and stiffness than the mixtures containing Styrelf 13 and Celite 292. After 31 months, all sections including the control section are performing well with the maximum rutting less than 0.15 in.

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INTRODUCTION

With an awareness that increased wheel loads and tire pressures are accelerating the deterioration of asphalt pavements, there is an effort to improve paving materials, design procedures, and construction practices to maintain the design service life. After experimentation and some use in Europe, polymer-modified asphalts are now being promoted in the United States (1). Various polymers are claimed to provide benefits such as a reduction in rutting, an increase in fatigue life, a reduction in cold weather cracking, and improved resistance to water damage.

The Virginia Department of Transportation has been approached by many polymer additive suppliers who have requested that their products be used. Since there are no standard tests to evaluate the suitability of polymers, the use of the material in a field test section is the only practical method of evaluation.

PURPOSE AND SCOPE

The purpose of this investigation was to evaluate several polymer additives and a diatomaceous filler that reportedly improve the characteristics of asphalt paving mixes that contribute to the prevention of permanent deformation. The field performance of the test sections was monitored, and laboratory tests were used to evaluate materials that were sampled during construction and cores that were removed periodically after construction.

MATERIALS

Four polymers (Polybilt 100, Styrelf 13, Downright HM 100L, and Ultrapave 70) and a sedimentary deposit filler (Celite 292) were used as additives (see Appendix A). A mix containing 1 percent hydrated lime was used in a control section for comparison. The design information for the S-5 mix is contained in Appendix B.

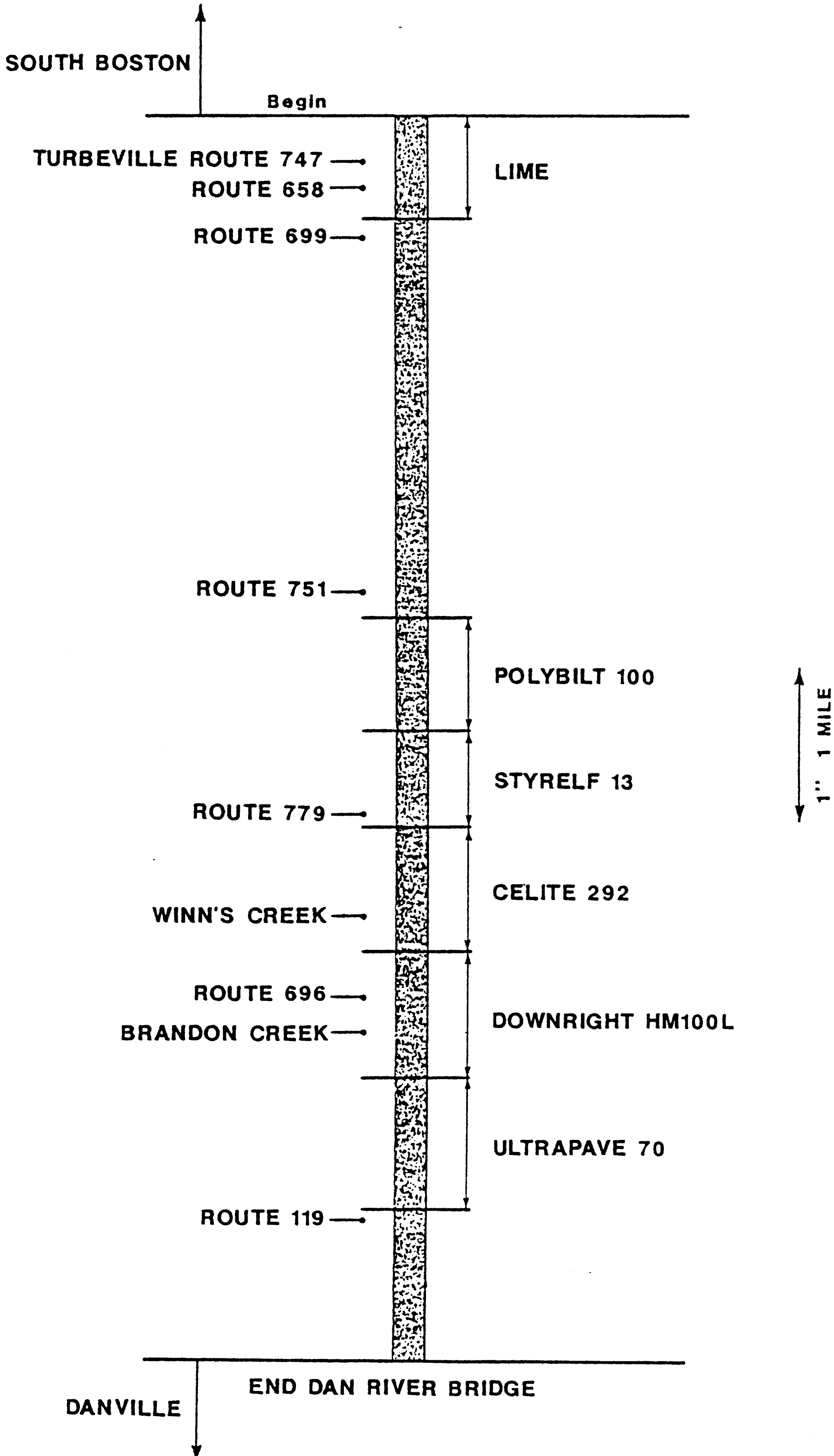

Figure 1. Test sections.

RESULTS

Field Tests

Pavement Core Voids

The void content was periodically determined on the three cores that were removed from each test section for the purpose of strength and modulus testing. Figure 2 illustrates the general decrease of voids during the 31 months of traffic loading. Traffic had reduced the average void content approximately 2 percent since construction. The void content of the sections with hydrated lime and Styrelf was 1 to 2 percent less than the void content of the other sections, although the Downright was approximately 2 percent higher for the last two samplings. Although long-term average trends are valid, individual values must be accepted with caution because of the high variability of test results.

Dynaflect

The deflection data was used to compute the thickness index of the pavement, i.e., the equivalent thickness of asphaltic concrete. The average thickness indices of the sections are listed in Table 1.

Table 1

Thickness Index (in)

Additive	Before Construction	1 Month	8 Months	15 Months	26 Months	31 Months
Lime (control)	10.8	12.5	10.4	11.4	12.8	11.5
Polybilt	6.9	8.0	9.4	10.1	11.3	10.9
Styrelf	9.2	7.0	6.6	9.8	10.9	10.0
Celite	8.4	8.1	8.0	10.6	9.4	10.5
Downright	7.8	9.2	10.6	10.7	11.8	10.4
Ultrapave	7.5	8.5	9.7	11.7	10.8	7.8

Pavement strength was quite variable between test sections as indicated by the thickness indices. The standard deviation of the thickness index within sections was high, typically about 1 to 2 in; therefore, any significant differences between sections was undetectable. The variation of thickness index was influenced primarily by testing variation and by changes in the structural strength of the existing pavement because of environmental effects such as moisture content. The thin, 1.5-in experimental overlays would not produce a measurable effect on the strength of the pavement structure. The average thickness index of the test sections before and after overlaying was 8.4 and 8.9 in, respectively.

Rut Depth

The maximum periodic average rut depths occurring in the right wheel path (RWP) are listed in Table 2. The average rut depths and standard deviations for both wheel paths are contained in Appendix C.

Table 2

Average Rut Depth (RWP) (in)

Additive	0 Month	9 Months	15 Months	26 Months	31 Months
Lime (Control)	0	0	0.05	0.10	0.10
Polybilt	0	0.05	0.05	0.10	0.05
Styrelf	0	0.05	0.15	0.15	0.10
Celite	0	0.05	0.10	0.10	0.05
Downright	0	0.05	0.10	0.10	0.05
Ultrapave	0	0.05	0.15	0.10	0.05

The rut depths were minor for all sections, including the control section containing hydrated lime. The average maximum rut depth was only 0.10 to 0.15 in. The lack of significant rutting may have been because the pavement had been subjected to a relatively light traffic loading (less than 0.5 million total equivalent 18-kip single axle loads).

Skid Resistance

The skid resistance values measured approximately 10 months after construction (Table 3) were satisfactory. There were no obvious differences between the skid resistance of different sections.

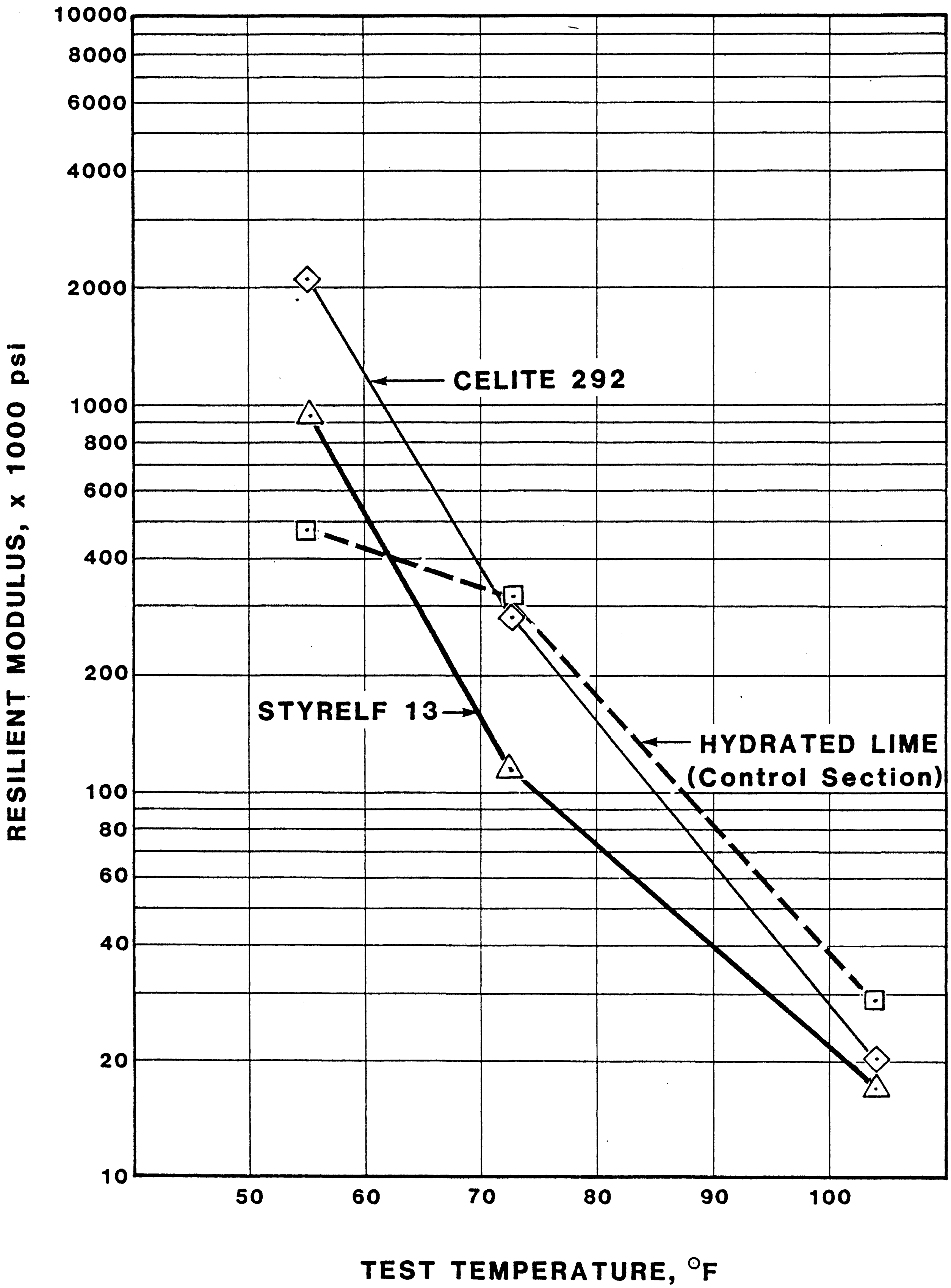

Figure 3. Resilient modulus v. test temperature.

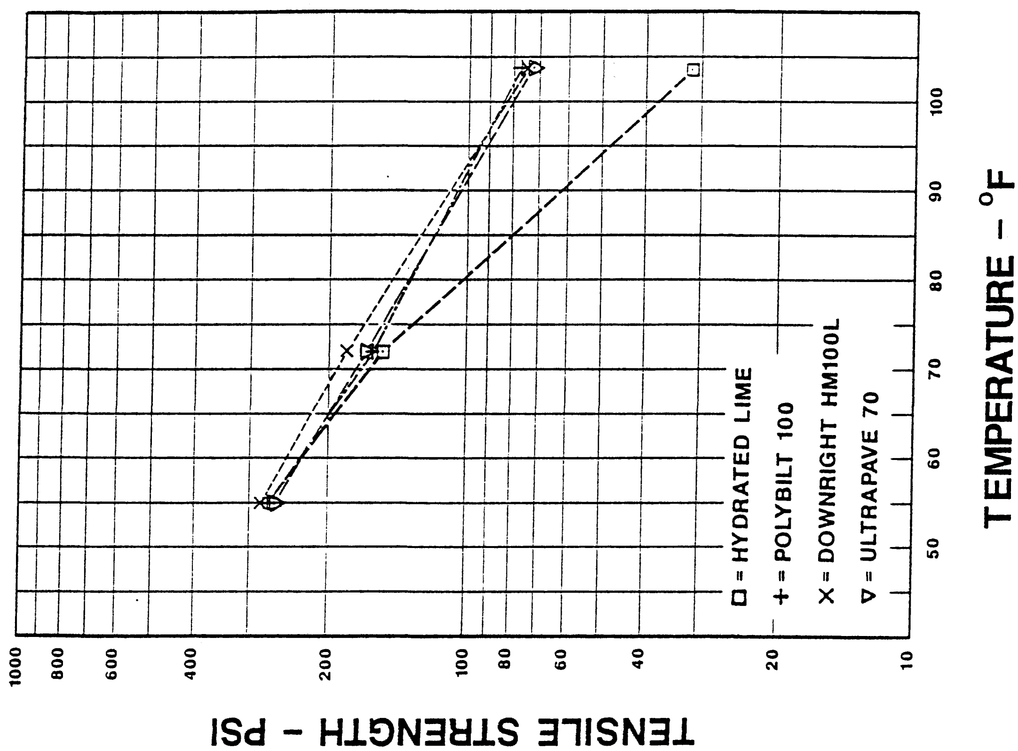

Figure 5. Indirect tensile strength v. test temperature.

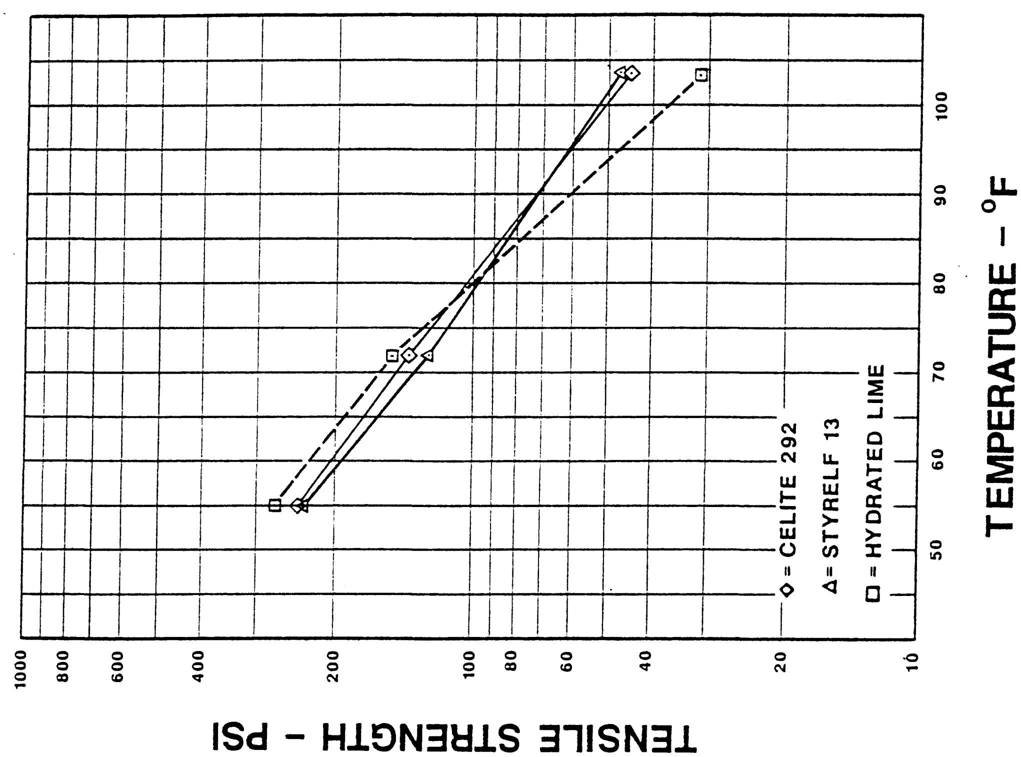

Figure 6. Indirect tensile strength v. test temperature.

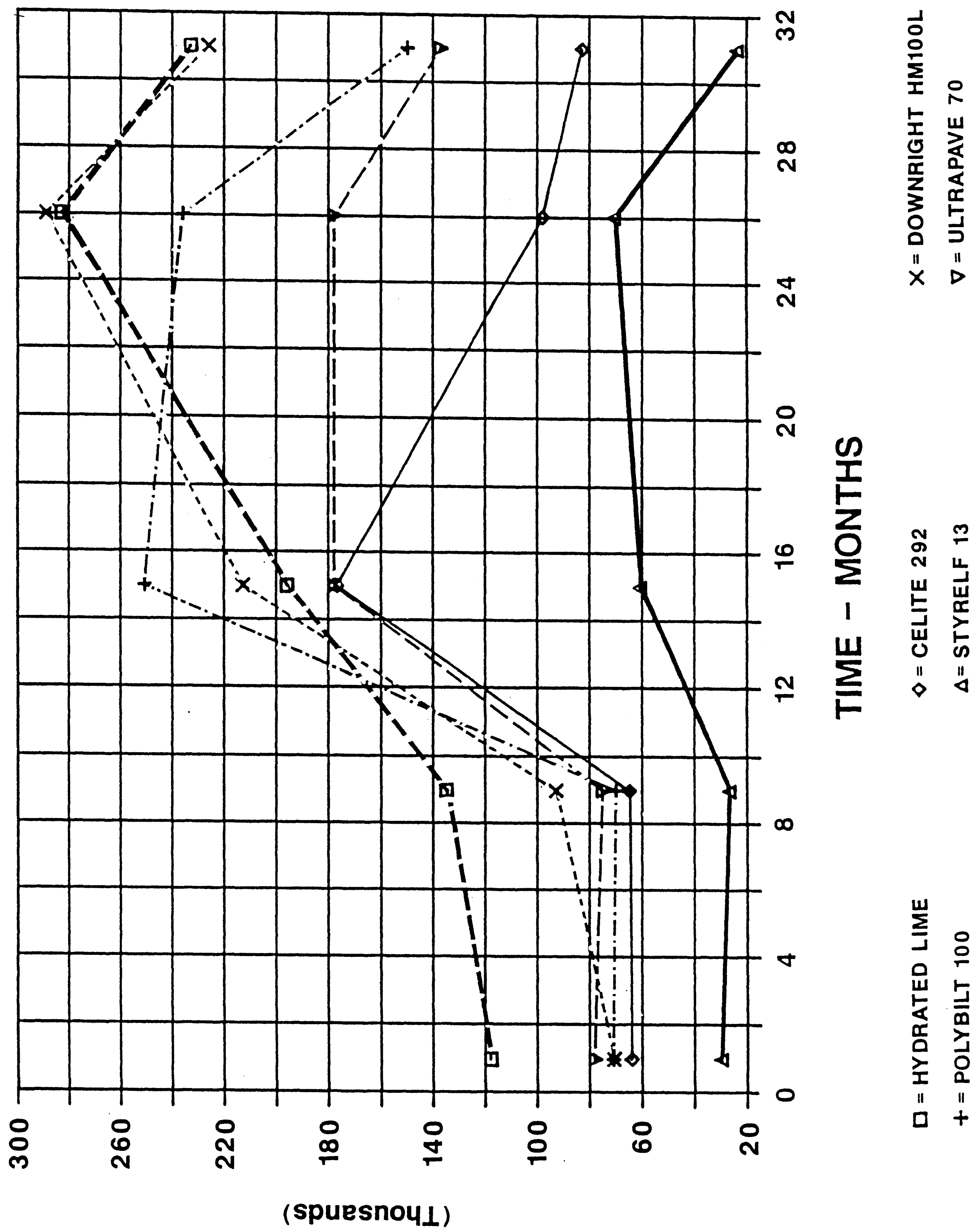

Figure 7. Resilient modulus v. months.

all mixes--with the exception of the hydrated lime mix--contained chemical antistripping additive. The cost information from Table 4 shows that the experimental additives add approximately 20 to 70 percent to the basic cost of the asphalt concrete at the hot mix plant. It is estimated that the cost of mix in-place was increased approximately 10 to 35 percent. Based on the lack of significant rutting in the control mix as well as the experimental mixes, the use of additives was not justified for this volume of traffic. Additives may be justified at other locations if the service life is increased to offset the additional cost or if proper service can not be achieved by any other method.

CONCLUSIONS

1. All test sections are performing satisfactorily; there are no discernible differences between additives.

2. Laboratory tests indicate that the mixes containing Polybilt, Downright, and Ultrapave were stiffer than the mixes containing Styrelf and Celite and have the potential to be more resistant to deformation.

3. Considerable stripping was evident in the pavement cores containing Celite.

4. Additives were not cost effective on this project because traffic was not severe enough to cause significant rutting in the conventional control mix.

ACKNOWLEDGMENTS

The author would like to thank Resident Engineer, J. D. Barkley II, and his staff for their help during construction and for providing timely traffic control for periodic field testing. Thanks are extended to the Lynchburg District Materials Lab personnel for their cooperation during construction and for coring the sections periodically.

The contractor, APAC-Virginia, Inc., was especially helpful in making the installation of the test sections go smoothly and providing production information.

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1. Terrel, Ronald L. and Walter, Jean L. 1986. Modified asphalt pavement materials--the European experience. In Proceedings: Association of Asphalt Paving Technologists technical sessions, 482-518. Clearwater Beach, Florida: Association of Asphalt Paving Technologists.

2. Maupin, G. W., Jr. 1987. Installation report: Evaluation of asphalt additives. VTRC Report 87-R29. Charlottesville, Va.: Virginia Transportation Research Council.

3. Annual Book of ASTM Standards: Volume 04.03. 1988. Philadelphia, Pa.: American Society for Testing and Materials.

APPENDIX A

ADDITIVES

Table A-1

Additives Used in Test Sections

Additive	Supplier
Polybilt 100	Exxon Chemical Co.
Styrelf 13	Elf Aquitaine Asphalt
Downright HM 100L	Dow Chemical, U.S.A.
Ultrapave 70	Textile Rubber & Chemical Co., Inc.
Celite 292	Manville Corp.

Polybilt 100 is a translucent solid that can be blended with the asphalt cement or can be added directly into the pugmill in preweighed plastic bags as it was in this installation. It is claimed that it will reduce rutting in the pavement while maintaining the pavement flexibility; also, it may improve the adhesion of the asphalt to the aggregate.

Styrelf is a polymerized asphalt cement that is used as the binder in asphalt concrete; it reportedly increases resistance to rutting, increases flexibility at low temperatures, alleviates stripping problems, and decreases age hardening.

Downright HM-100L and Ultrapave 70 are styrene/butadiene rubber latexes. These materials are supposed to reduce shoving and rutting, increase flexibility, and increase the cohesion and adhesion of the asphalt-aggregate mix. Some of their physical properties are listed in Table A-2.

Table A-2

Properties of Latexes

	Downright HM-100L	Ultrapave 70
Butadiene/Styrene monomer ratio	76/24	76/24
Solids Content (% by weight)	69	69
Weight per gallon at 77^{o}F (lb)	7.9	7.9
Brookfield Viscosity (cps) (Model RVT, #3 Spindle at 20 RPM)	700	1500

Celite is a chalky sedimentary deposit composed of the skeletal remains of single cell aquatic plants called diatoms. It has been hypothesized that the unique particle shapes interlock within the asphalt film to help transfer stress between aggregate particles. It is believed to stabilize the mix and prevent rutting and shoving. Its physical and chemical properties are listed in Table A-3.

APPENDIX B

MIX DESIGNS

The preliminary mix design for the S-5 mix was performed by the contractor, APAC-Virginia, Inc., and approved by the Virginia Department of Transportation (Table B-1).

Table B-1

Preliminary Mix Design

Sieve	% Passing
1/2"	100
#4	58 ± 4
#30	20 ± 3
#200	4.4 ± 1
A.C.	5.7 ± 0.3

60% No. 8 crushed stone - Vulcan Materials, South Boston
25% No. 10 crushed stone - Vulcan Materials, South Boston
15% No. 10 washed crushed stone - Vulcan Materials, South Boston

Froehling and Robertson, Inc., an independent testing laboratory, was retained by APAC-Virginia as specified in the highway maintenance contract to perform Marshall designs for each mix containing a different additive. Design data for each mix indicated that the asphalt content should have been appreciably higher than the preliminary asphalt content design of 5.7 percent, with the exception of the mix using Polybilt 100. It was thought that the mix with Celite 292 might require more asphalt than the conventional mix. The Marshall design was duplicated in the Research Council laboratory for the mixes with Celite 292 and Ultrapave 70 as a check. The results indicated that the preliminary asphalt content of 5.7 percent provided a sufficient quantity of asphalt to attain desirable void content levels. It is possible that the aggregates may have varied between the times that the different designs were performed, thereby accounting for differences in the design asphalt contents. It was decided to use 5.7 percent asphalt in the field mixes but to increase the asphalt content of the mix with Celite to 5.9 percent, as recommended by the Celite representative. The control mix containing hydrated lime contained 5.6 percent asphalt cement.

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APPENDIX C

SUMMARY RUT MEASUREMENTS

VIRGINIA TRANSPORTATION RESEARCH COUNCIL

SUMMARY RUT MEASUREMENTS

Rt. 58 South Boston, VA.

	MIX 1 Lime		MIX 6 Polybilt		MIX 7 Celite	
	Traffic Lane		Traffic Lane		Traffic Lane	
	LWP	RWP	LWP	RWP	LWP	RWP
	---	---	---	---	---	---
Initial			0.00 (0.04)	0.00 (0.03)	-0.05 (0.04)	0.00 (0.03)
1 Month			-0.05 (0.06)	-0.05 (0.05)	-0.10 (0.06)	0.00 (0.02)
9 Month	0.00 (0.05)	0.05 (0.05)	0.00 (0.05)	0.05 (0.05)	0.00 (0.05)	0.05 (0.05)
15 Month	0.05 (0.06)	0.05 (0.04)	0.00 (0.05)	0.05 (0.08)	0.00 (0.06)	0.10 (0.04)
26 Month	0.00 (0.05)	0.10 (0.03)	-0.05 (0.04)	0.10 (0.02)	0.00 (0.07)	0.10 (0.05)
31 Month	-0.10 (0.09)	0.10 (0.04)	-0.05 (0.06)	0.05 (0.04)	-0.10 (0.06)	0.05 (0.03)

	MIX 8 Styrelf		MIX 9 Downright		MIX 10 Ultrapave	
	Traffic Lane		Traffic Lane		Traffic Lane	
	LWP	RWP	LWP	RWP	LWP	RWP
	---	---	---	---	---	---
Initial	0.00 (0.02)	0.00 (0.03)	-0.05 (0.04)	0.00 (0.02)	-0.05 (0.04)	0.00 (0.03)
1 Month	-0.05 (0.07)	0.00 (0.03)	-0.05 (0.10)	0.00 (0.04)	-0.05 (0.04)	0.00 (0.02)
9 Month	0.00 (0.05)	0.05 (0.05)	0.00 (0.05)	0.05 (0.05)	0.00 (0.05)	0.05 (0.05)
15 Month	0.05 (0.08)	0.15 (0.05)	0.00 (0.08)	0.10 (0.04)	0.00 (0.06)	0.15 (0.04)
26 Month	0.05 (0.09)	0.15 (0.06)	0.00 (0.05)	0.10 (0.07)	0.05 (0.05)	0.10 (0.05)
31 Month	0.00 (0.10)	0.10 (0.06)	-0.05 (0.07)	0.05 (0.07)	0.00 (0.04)	0.05 (0.05)

First set numbers, rut measurements
Second set numbers ( ), standard deviation
- numbers, = hump