ULTRAPAVE

FINAL REPORT
November 1997

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16. ABSTRACT

Premature rutting is a common problem with asphalt concrete pavements, particularly when they are subjected to frequent heavy-axle loading. Producers of asphalt modifiers claim that polymers reduce rutting and other distresses by providing stability and durability to the pavement. This project evaluates and compares two modifiers of a dense graded hot-mix asphalt overlay for performance, cost, and ease of construction.

A styrene-butadiene (vulcanized) binder has been the standard additive used by the Oklahoma Department of Transportation (ODOT) as an AC modifier. It is a thermoplastic polymer blended with liquid asphalt at the refinery before shipping.

ODOT is now testing ULTRAPAVE 70, a new product from Goodyear. This liquid styrene butadiene rubber latex thermoset polymer is shipped directly to the asphalt plant in a tanker and fed into the pugmill or in-line to the drum mixer.

A maintenance overlay contract was awarded for I-40 in Division V, Beckham County and an 8.85 km (5.50 mi) section of the outside eastbound lane was selected as the test site. A 4.15 km (2.58 mi) section was overlaid with the standard thermoplastic polymer mix and a 4.70 km (2.92 mi) section with the ULTRAPAVE 70 mix.

A comparative analysis of the performance of the two mixes found them to be equally effective in reducing rutting. The ULTRAPAVE 70 was, however, a more versatile product which allowed for simpler alternation between modified and unmodified mixes at the batch plant. It is recommended that the use of ULTRAPAVE 70 be permitted on ODOT projects.

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SI (METRIC) CONVERSION FACTORS

Approximate Conversions to SI Units

Symbol	When you know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	25.40	millimeters	mm
ft	feet	0.3048	meters	m
yd	yards	0.9144	meters	m
mi	miles	1.609	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.0929	square meters	m^2
yd^2	square yards	0.8361	square meters	m^2
ac	acres	0.4047	hectares	ha
mi^2	square miles	2.590	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.0283	cubic meters	m^3
yd^3	cubic yards	0.7645	cubic meters	m^3
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.4536	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	degrees Fahrenheit	(°F-32)/1.8	degrees Celsius	°C
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.448	Newtons	N
lbf/in^2	poundforce	6.895	kilopascals	kPa

Approximate Conversions from SI Units

Symbol	When you know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.0394	inches	in
m	meters	3.281	feet	ft
m	meters	1.094	yards	yd
km	kilometers	0.6214	miles	mi
		AREA		
mm^2	square millimeters	0.00155	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.196	square yards	yd^2
ha	hectares	2.471	acres	ac
km^2	square kilometers	0.3861	square miles	mi^2
		VOLUME		
mL	milliliters	0.0338	fluid ounces	fl oz
L	liters	0.2642	gallons	gal
m^3	cubic meters	35.315	cubic feet	ft^3
m^3	cubic meters	1.308	cubic yards	yd^3
		MASS		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.1023	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	degrees Celsius	9/5+32	degrees Fahrenheit	°F
		FORCE and PRESSURE or STRESS		
N	Newtons	0.2248	poundforce	lbf
kPa	kilopascals	0.1450	poundforce	lbf/in^2

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FINAL REPORT

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November 1997

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EXECUTIVE SUMMARY

In the summer of 1994, a 38 mm (1½ in) overlay was constructed on Interstate 40 near Elk City in order to combat a rutting problem. An 8.85 km (5.50 mi) section of the outside eastbound lane was divided into two longitudinal sections. A 4.15 km (2.58 mi) section was overlaid with a standard (thermoplastic) polymerized liquid asphalt mix. The remaining 4.70 km (2.92 mi) was overlaid using a mix modified with an anionic styrene butadiene rubber latex thermoset polymer from Goodyear, ULTRAPAVE 70, intended primarily for asphalt cement and anionic asphalt emulsions.

ULTRAPAVE 70 is blended with the asphalt and aggregate in the pugmill, unlike the thermoplastic polymer which is blended with the liquid asphalt at the refinery. The most significant difference in the two types of additive results from their molecular structures. Thermoplastics can be reshaped when heated while thermosets produce longer chain molecules and will not soften appreciably once the polymerization is complete. The intent is to produce a modifier that will provide the same high temperature characteristics as thermoplastics do, resistance to rutting, along with an improved resistance to the primary low temperature distress, cracking.

Research, Development, & Technology Transfer was asked to evaluate the performance of ULTRAPAVE 70 as compared to the styrene-butadiene (vulcanized) binder currently used by the Oklahoma Department of Transportation (ODOT). At that time, the contract had already been let and construction was under way. The mix design was Type BH for both overlays and each used AC 20. Similar construction methods were used for the application of both mixes.

A comparative analysis of the performance of the two mixes found them to be equally effective in reducing rutting. The ULTRAPAVE 70 was, however, a more versatile product which allowed for simpler alternation between modified and unmodified mixes at the batch plant.

INTRODUCTION

Producers of asphalt modifiers claim that polymers reduce rutting by providing stability and durability to the pavement (1). This project evaluates and compares two modifiers of a dense graded hot-mix asphalt overlay for performance, cost, and ease of construction.

A styrene-butadiene (vulcanized) binder has been the standard additive used by t e Oklahoma Department of Transportation (ODOT) as an AC modifier. It is a thermoplastic polymer blended with liquid asphalt at the refinery before shipping.

ODOT is now testing ULTRAPAVE 70, a new product from Goodyear. This liquid styrene butadiene rubber latex t ermoset polymer is shipped directly to the asphalt plant in a tanker and fed into the pugmill or in-line to the drum mixer. It is intended primarily for asphalt cement and anionic asphalt emulsions.

BACKGROUND

Thermoplastic and thermosetting polymers have differing properties as a result of their molecular structures. Polymerization refers to the process of combining relatively simple molecules to form a more complex molecule of higher molecular weight. In thermo*plastic* polymers this process has been carried out as far as it will go during mixing at the asphalt plant. In thermo*setting* polymers the reaction is not completed until the modifier is introduced to the mix in the pugmill and the polymerizing temperature is reached, resulting in a cross-linked three dimensional polymer.

The existing pavement was composed of a fine aggregate bituminous base, a Type B dense graded mix binder, and an open graded friction surface course. Rutting was the primary distress addressed by the new overlay although the pavement also e hibited depressed transverse cracks and raveling.

The procedures for laying down and rolling the mixes were similar. Since both mixes included polymers, both required break down rolling with a pneumatic roller. The tires required extra lubrication to avoid a problem with sticking to the mat.

The ULTRAPAVE 70 mix met ODOT specifications for plant mix asphalt concrete pavement with latex modified asphalt cement [ODOT Special Provision 708-8(a-b) 91S] shown in Appendix A.

LOCATION

The test site is located on I-40, a four lane divided interstate highway in Beckham county, near Elk City. (See Figure 1 for Location Map.) The project begins at mile post 34.09 and extends 9.44 km (5.87 mi) east to mile post 39.96. Section I is 4.15 km (2.58 mi) long and was constructed with the ODOT standard vulcanized AC binder. Section II is 4.70 km (2.92 mi) long and was constructed with the ULTRAPAVE 70 latex AC binder.

BECKHAM COUNTY

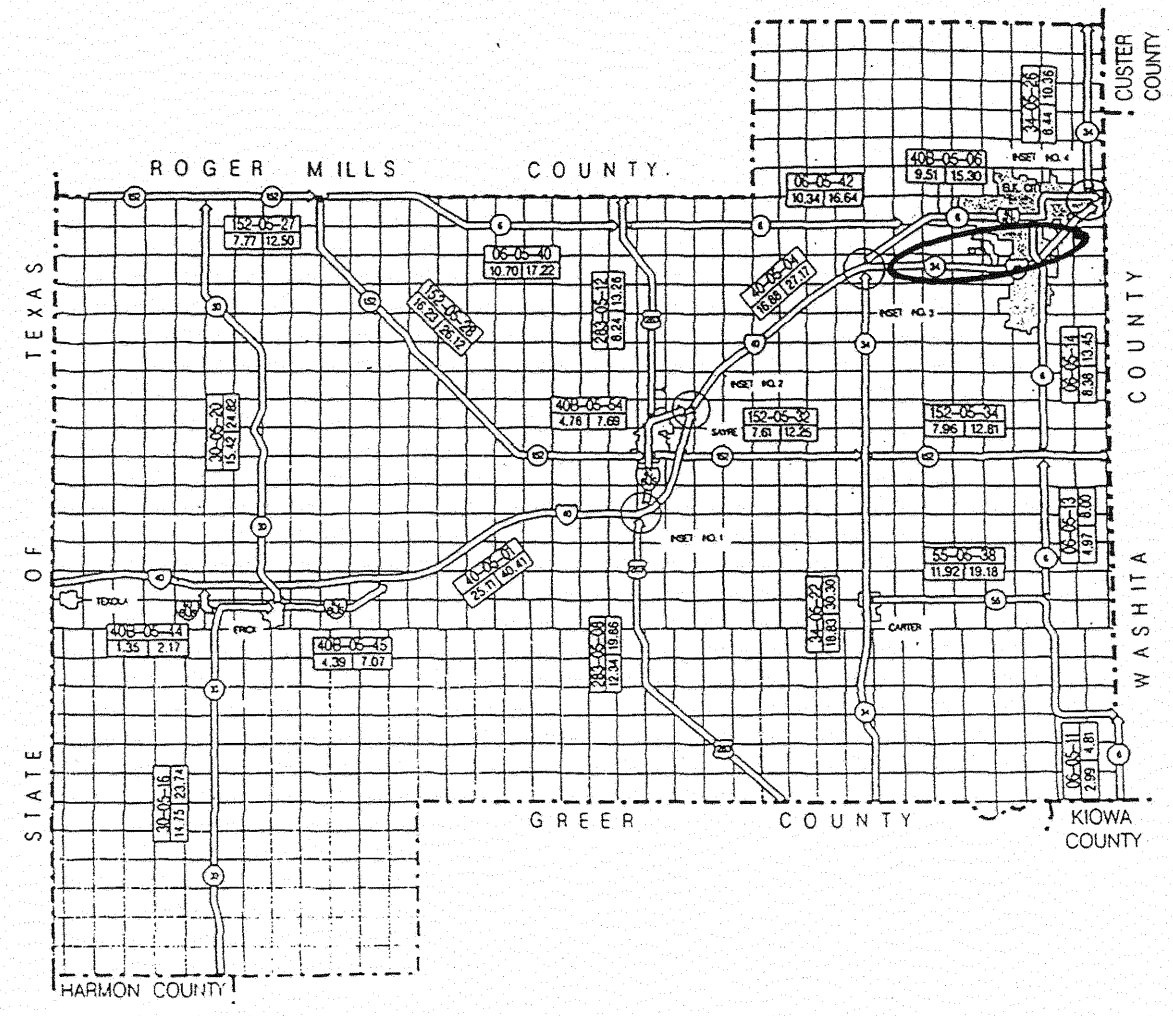

Figure 1. LOCATION MAP.

CONCLUSIONS

The constructability of the overlay modified with a thermoset polymer, ULTRAPAVE 70, was essentially equal to that of the one modified with a thermoplastic polymer. The same construction methods were employed with each mix and no problems were encountered.

The difference in the way each polymer is added to the mix creates some significant considerations concerning storage and batching procedures. Because a thermoset polymer, such as ULTRAPAVE 70, is stored in a separate container at the batch plant, the actual mixing procedure can be delayed for prolonged periods without the need for heating or other special treatments of the additive. And, since the polymer is injected directly into the pugmill, the operator can quickly alternate between modified and unmodified b tches with the simple flip of a switch.

The final investigation was completed in March 1996. It consisted of a Flexible Pavement Condition Survey and rut depth measurements. Readings were taken every 0.32 km (0.2 mi) for cracking, raveling, and bleeding. Cracking was the most dominant of these accounting for over 80% of the observed distresses. Both sections received a Condition Rating of 88 (Good).

Rut depth measurements were taken every 0.16 km (0.10 mi). The greatest rut depth on either section was 7.6 mm (0.3 in). Over 70% of the lanes in both sections showed no discernable rutting. Rut depth measurements and Condition Ratings appear in Appendix B.

The standard polymer hot mix section exhibited reflective transverse cracking over long intervals. A small amount of raveling and an occasional pop-out lowered the rating from "Superior" to "Good." Spot bleeding was also noted.

In the ULTRAPAVE section, reflective transverse cracks were more widely spaced (30 m to 46 m [100 ft to 150 ft]). The depressed nature of these cracks managed to lower the rating of this section because they created a rougher ride. Half of the rut readings were between 5.1 and 7.6 mm (0.2 and 0.3 in), a few more than in the standard polymer section. However, rutting of such low magnitude did not adversely affect the evaluation. The slight difference in rutting of the two sections was attributed to the difference in underlying materials. The standard polymer section was originally constructed with 130 mm (5 in) of Type B over 180 mm (7 in) of fine aggregate bituminous base (FABB) and the ULTRAPAVE 70 section with 38 mm (1½ in) of Type B over 280 mm (11 in) of FABB.

No rutting was attributed to the non-plastic subgrade soil.

COST ANALYSIS

Modifying hot-mix asphalt with ULTRAPAVE 70 costs about $3.00/ton. This figure compares favorably to the $3.00/ton to $4.00/ton cost of modifying with a vulcanized polymer.

RECOMMENDATIONS

The ULTRAPAVE 70 performed at least as well as the ODOT standard polymer in this trial and appears to be an acceptable alternative to the standard. As such, it is recommended that the use of ULTRAPAVE 70 be a permitted option when a polymerized AC is required.

REFERENCES

1. "Specifiers Guide to Asphalt Modifiers," Roads & Bridges, May 1988, page 69.

2. English and Cassidy, Principals of Organic Chemistry, McGraw-Hill, New York, 1956, Second Edition.

APPENDICES

APPENDIX A

ODOT SPECIAL PROVISION FOR LATEX ASPHALT MODIFICATION

OKLAHOMA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISIONS
FOR
PLANT MIX ASPHALT CONCRETE PAVEMENT
WITH
LATEX MODIFIED ASPHALT CEMENT

These Special Provisions revise, amend, and where in conflict, supercede applicable sections of the Standard Specifications for Highway Construction, Edition of 1988 and the Supplemental thereto, Edition of 1991.

411.01 DESCRIPTION. (Add the following)

The plant mix asphalt concrete specified shall contain styrene butadiene rubber latex (latex) as an asphalt modifier.

411.04 CONSTRUCTION METHODS. (c) MIXING (Add the following)

The Latex shall be added to the paving mix at the mixing plant. The asphalt delivery pipe line shall contain an in-line blender. The in-line blender shall provide preblending of the liquid asphalt and the latex. The in-line blender shall provide for both the injection of the latex and a method for sampling the mixed material (sampling valve).

The Latex delivery system shall be integrated into the mixing plant control system. The plant mixing control system shall provide for delivery of latex and asphalt at prescribed rates shown in the job mix formula. The control system shall provide for separately accumulated totals of asphalt cement and latex delivered to the asphalt paving mixture.

708.03(a) ASPHALT MATERIALS. (Add the following)

The latex modified asphalt shall meet the requirements shown in the following table:

		TYPE LMA	TYPE LMB
Penetration 77 Deg.F 100g,5 Sec.	AASHTO T-49	70 min.	50 min.
Viscosity 140 Deg.F,Poises	AASHTO T-202	1600 min.	4000 min.
Viscosity 275 Deg.F,cst.	AASHTO T-201	2000 max.	3500 max.
Ductility 39.2 Deg.F,5 cpm,cm	AASHTO T-51	50 min.	30 min.
Flash Point Deg.F	AASHTO T-48	450 min.	450 min.
Solubility * %	AASHTO T-44	99 min.	99 min.
Toughness 77 Deg.F,20 ipm,in-lbs.		110 min.	110 min.
Tenacity 77 Deg.F,20 ipm,in-lbs.		75 min.	75 min.

* To be performed on asphalt cement prior to adding latex.

RTFOR or TFOT Residue:

Viscosity 140 Deg.F,Poises	AASHTO T-202	8000 max.	12000 max.
Ductility 39.2 Deg.F,5 cpm,cm	AASHTO T-51	25 min.	10 min.

708.04 COMPOSITION OF MIXTURES. (a) Asphalt Mix Design And Initial Job-Mix Formula (Add the following)

Prior to developing the job-mix formula, the amount of latex to be added shall be determined by the asphalt cement or latex supplier. Samples of the proposed latex and asphalt shall be mixed to a smooth and homogenous blend and be evaluated to meet the specified properties. This shall be repeated until the proper amount of latex is determined that will impart the properties specified above.

Samples of the required blended latex and asphalt cement, shall be furnished to the laboratory for completion of the job-mix formula. Additional samples of the latex, asphalt and aggregates shall be furnished the Materials Engineer along with the proposed job-mix formula for approval.

(b) Plant Produced Mixtures (Add the following)

The amount of latex in the mix shall be determined from the readings of the metering devices in the delivery system and shall be within plus or minus 5% of the amount of latex shown in the job-mix formula.

APPENDIX B

TEST RESULTS

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STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
200 N.E. 21ST STREET
OKLAHOMA CITY, OK 73105-3204

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RES. & DEV. DIV.

SOILS AND FOUNDATIONS BRANCH

Report No. 2-5010-09813
Account No. 313930

Report on Sample of Soil

Job Piece No. 01946(26)

Project No. SPR-0010(020)

Sample Received at Laboratory April 7 , 1997 County Beckham Division 5

Received on Project _____ Sampled on _____, 1997 By

From Roadway Identification (Shown Below) Quantity

Project Manager Wilson Brewer Address Research Div., OKC

Contractor _____ Tested By SOILS AND FOUNDATIONS BRANCH

Source of Material

Examined for Soil Classification Test for INFORMATION

Laboratory No.		#4990	#4991
Sample No.		Polymer #1	Polymer #2
Sieve Size	**Required (% Passing)**	**Found**	**Found**
No. 10 / 2.00mm	–	100	100
No. 40 / .425mm	–	99	97
No. 200 / .75mm	–	32.3	59.0
L.L.	–	NP	NP
P.I.	–	NP	NP
AASHTO Class	–	A-2-4(0)	A-4(0)

DESCRIPTION: #4990-SM SILTY SAND
#4991-ML SANDY SILT

c: Materials File
Division Research
Project Mgr.: Wilson Brewer
Curt Hayes
Soils & Foundations Branch
Bookkeeping

Transmitted April 23, 1997

J. D. Telford, P.E.
Materials Engineer

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APR 23 1997

Figure 2. SOIL REPORT - POLYMER SECTION.

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DH-Form 1-L
Rev. 9/95

STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
200 N.E. 21ST STREET
OKLAHOMA CITY, OK 73105-3204

SOILS AND FOUNDATIONS BRANCH

Report No. 2-5010-09812
Account No. 313930

Report on Sample of Soil

Job Piece No. 01946(26) Project No. SPR-0010(020)

Sample Received at Laboratory April 7 , 1997 County Beckham Division 5

Received on Project Sampled on , 1997 By

From Roadway Identification (Shown Below) Quantity

Project Manager Wilson Brewer Address Research Div., OKC

Contractor Tested By SOILS AND FOUNDATIONS BRANCH

Source of Material

Examined for Soil Classification Test for INFORMATION

Laboratory No.		#4988	#4989
Sample No.		Latex 1	Latex 2
Location		Roadway	Roadway
Sieve Size	**Required (% Passing)**	**Found**	**Found**
No. 10 / 2.00mm	–	100	100
No. 40 / .425mm	–	93	88
No. 200 / .75mm	–	41.5	71.8
L.L.	–	NP	32
P.I.	–	NP	15
AASHTO Class	–	A-4(0)	A-6(9)

DESCRIPTION: #4988-SM SILTY SAND
#4989-CL LE N CLAY W/SAND

c: Materials
Division Research
Project Mgr.: Wilson Brewer
Curt Hayes
Soils & Foundations Branch
Bookkeeping

Transmitted April 23, 1997

J. D. Telford, P.E.
Materials Engineer

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Figure 3. SOIL REPORT - LATEX (ULTRAPAVE) SECTION.

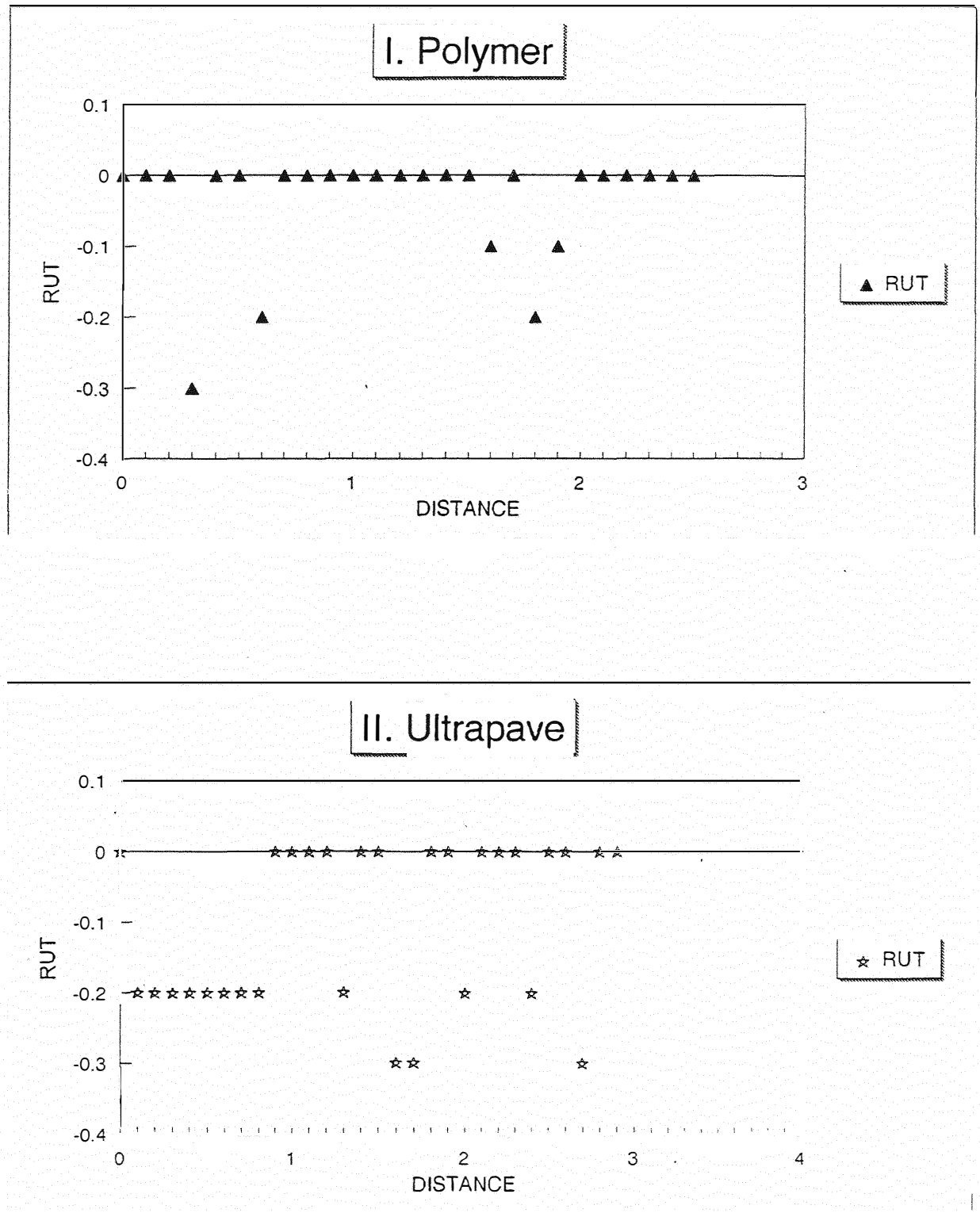

Figure 4. RUT MEASUREMENT GRAPHS.