FHWA NJ 97002
97 002 1730
97 002 7440

Asphalt Additives and Rut Resistant Pavements

by

Nicholas P. Vitillo

Research Engineer

Prepared by
New Jersey department of Transportation
Quality Assurance, Improvement, and Research
In Cooperation With
U.S. Department of Transportaion
Federal Highway Administration

Notice

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/NJ-97/002		

4. Title and Subtitle	5. Report Date
Asphalt Additives and Rut Resistant Asphalt Pavements	July 1997
	6. Performing Organization Code
7. Author(s) Nicholas P.Vitillo	8. Performing Organization Report No. 97-002-1730 & 97-002-7440
9. Performing Organization Name and Address New Jersey Department of Transportation CN 600 Trenton, NJ 08625	10. Work Unit No.
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address Federal Highway Administration U.S. Department of Transportation Washington, D.C.	13. Type of Report and Period Covered
	14. Sponsoring Agency Code

15. Supplementary Notes

Final Report

16. Abstract

This report describes two studies conducted to evaluate the advantages of using asphalt modifiers to enhance the rut resistance and reduce the cracking of New Jersey's standard asphalt concrete mixes. A variety of asphalt modifiers, stiffer asphalt cements, and aggregate modifications were included in the two studies. These modified asphalt mixes were placed on test sections with widely varying Average Daily Traffic levels and studied for a period of time.

The monitoring of the project produced a mixed set of results. On some sites, both the test sections and the controls performed well and there were no rutting failures and only minimal cracking. When these same additives were used on other sites with different traffic loading conditions, the rutting and cracking were greater than expected.

Recent research efforts connected with the SHRP Superpave Asphalt binder and mixture tests indicate that while modified binders contribute to the performance of the asphalt mix, the contribution is only 20%, while the mixture gradation contributes approximately 80%. We feel that in the future testing of asphalt binder modifications will be evaluated in the SHRP Superpave asphalt binder and mixture test equipment followed by torture tests such as the Georgia Loaded Wheel Tester, Indirect Tensile Tester and Simple Shear Tester.

17. Key Words	18. Distribution Statement
Ashpalt Additives Rutting	No Restrictions

19. Security Classif (of this report)	20. Security Classif. (of this page)	21. No of Pages	22. Price
Unclassified	Unclassified	26	

Form DOT F 1700.7 (8-69)

Table of Contents

List of Figures

1. **Background**:

For the last 10 years, the Department has experimented with various asphalt additives, gradation modifications, and stiffer asphalt cements in order to improve the durability and reduce the rutting of New Jersey's asphalt pavements. This report provides a summary of this research and makes recommendations for the future directions.

2. **Description of Test Sites**: Figure 1 contains a map of New Jersey with the location of the various test sites. Table 1 contains a list of the sites, location, and asphalt mixture modification. The Route 41 and 35 locations contain multiple test sites.

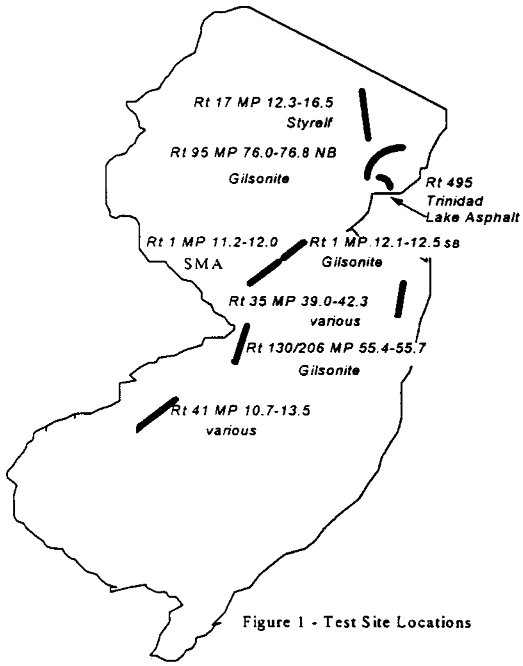


Figure 1 - Test Site Locations

TABLE 1 - Test Sites

Location	Modification
Rt. 17 NB MP 12.3-16.5	Styrelf
Rt. 95 NB MP 76.0-76.8	Gilsonite
Rt. 495 Helix	Trinidad Lake
Rt. 1 SB MP 12.1-12.5	Gilsonite
Rt. 1 MP 11.2-12.0	Stone Matrix Asphalt SMA
Rt. 35 MP 39.0-42.3	Various
Rt. 41 MP 10.7-13.5	Various
Rt. 130/206 MP 55.4-55.7	Gilsonite

Route 41:

The Route 41 test site was constructed in 1983 under the Route 41, Sec 3A contract (Figure 2). This section of Route 41 currently has an ADT between 19,000 to 25,000. The surface course (1 1/2") contains the asphalt material modifications.

This location contains the following test sections:

Section	Treatment
1	Control (I-4) Section
2	Chemkrete
3	Texcrete
4	Solar Laglugel
5	3M - #5990
6	Plus Ride
7	Crushed Gravel

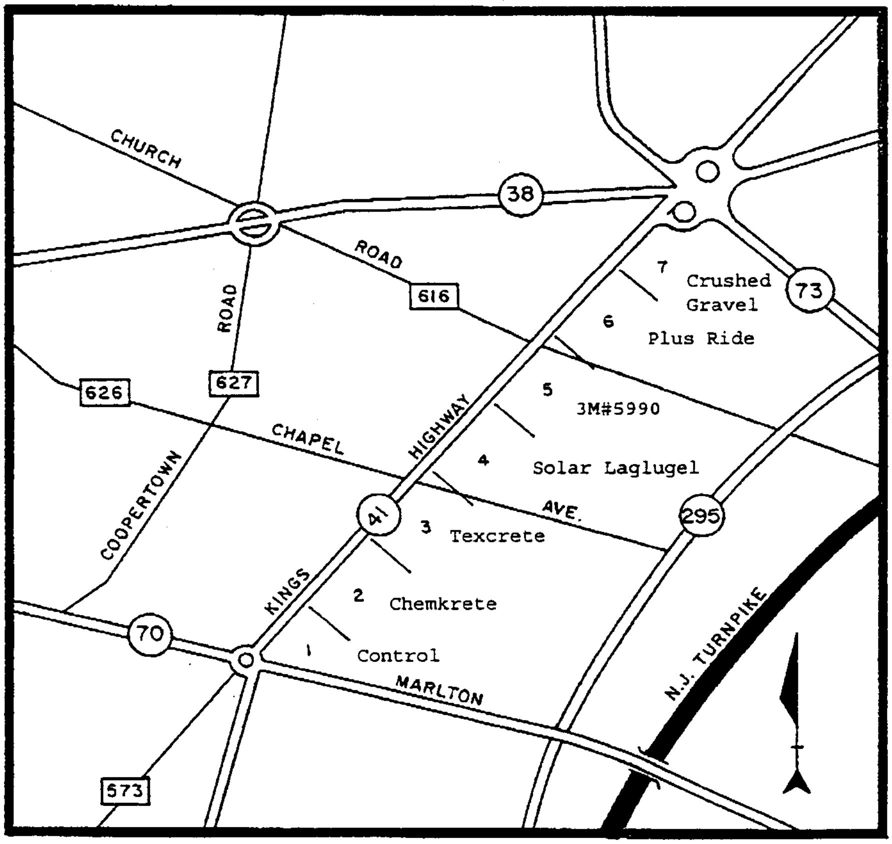


Figure 2

Route 35:

This intersection improvement project on Route 35 was constructed in 1987 (Figure 3). The modifiers used on this project were specifically chosen because of the manufactures' claims of reducing rutting and shoving in the stopping areas. This section of Route 35 in Holmdel, NJ currently has an ADT of 23,000.

The test site contains the following test sections:

INTERSECTION	MATERIAL USED
CHERRYTREE FARM ROAD	NB - AGGREGATE MODIFIED SB - AC40
LAUREL AVE (NORTH AND SOUTH BOUND)	EVA
UNION RD. / CENTERVILLE (NORTH BOUND)	GILSONITE
MILLER RD	GILSONITE
POOLE AVE & BETHANY RD (NORTH AND SOUTH BOUND)	CARBON BLACK
HAZLET AVE (NORTH AND SOUTH BOUND)	SBS
HOLMDEL AVE (SOUTH BOUND)	SOLAR LAGLUGEL

Route 17

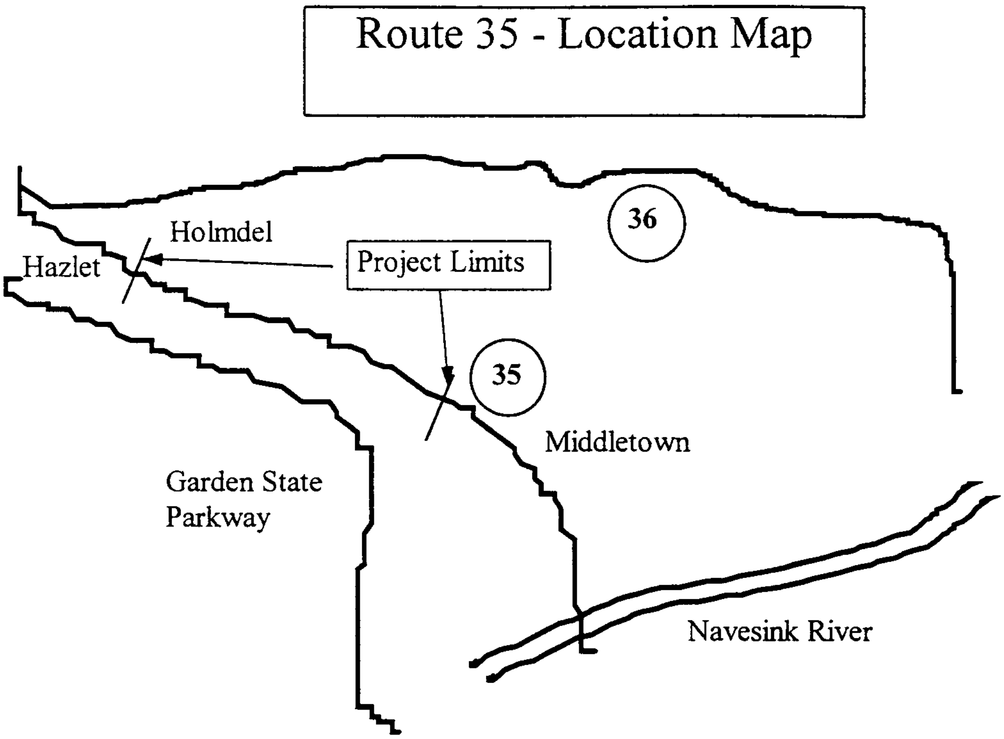
The project on Route 17, section 3F & 5AD, was constructed in 1990. The Styrelf polymer modified asphalt binder was used in the surface course overlay and in the bituminous stabilized base which was reconstructed under the Garden State Parkway bridges. This section of Route 17 currently carries 45,000 ADT.

Route 95

This project on Route 95, section 1AS, was constructed in 1990. The project pavement was constructed to alleviate excessive rutting on the approaches to the George Washington Bridge. The section currently carries an ADT in excess of 87,000. Two inches of rutted material were milled and replaced with 2" of I-2 (Bituminous Stabilized Base Course) and 2" of I-4 (Bituminous Surface Course) with Gilsonite additive.

Route 495 Helix

This project was constructed in 1988 with natural Trinidad Lake asphalt to combat rutting on the approaches to the Lincoln Tunnel. The section carries an ADT in excess of 58,000.


Route 35 - Location Map
36
Holmdel
Hazlet
Project Limits
35
Middletown
Garden State
Parkway
Navesink River

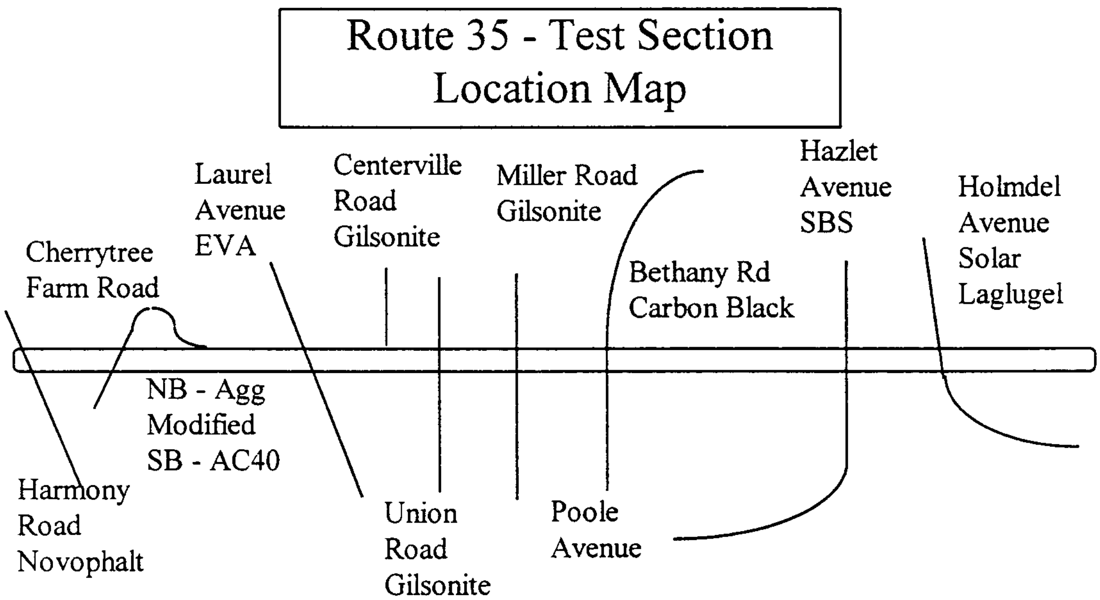

Route 35 - Test Section
Location Map
Laurel
Avenue
EVA
Centerville
Road
Gilsonite
Miller Road
Gilsonite
Hazlet
Avenue
SBS
Holmdel
Avenue
Solar
Laglugel
Cherrytree
Farm Road
Bethany Rd
Carbon Black
NB - Agg
Modified
SB - AC40
Harmony
Road
Novophalt
Union
Road
Gilsonite
Poole
Avenue

Figure 3

Route 1 - Stone Matrix Asphalt (SMA)

This project was constructed on Route 1, section 2J & 3G, in 1992. This was the first installation of this European mix design technology. The section carries an ADT in excess of 28,000.

Route 1 - Gilsonite

This project was constructed on Route 1, section, in 1986. The Gilsonite modified asphalt was placed in the SB direction. The section carries an ADT in excess of 20,000.

Route 130/206 - Gilsonite

This project was constructed in 1986. The section carries an ADT in excess of 17,000.

3. **Special Asphalt Pavement Mixture Modifications**

The following is a description of each Asphalt Mixture or Modifications:

Chemkrete -

Chemkrete is a heavy metal (Manganese)-based additive which was premixed with AC-10 at a rate of one-to-thirty by weight. The manufacture, Lubrizol Corporation, claims that Chemkrete will increase strength and lower temperature susceptibility.

Texcrete -

Texcrete Latex is a synthetic rubber emulsion (69% rubber solids) manufactured by Dow Chemical Corporation. It is added at the pugmill after the AC-20. The latex replaces 3% of the required asphalt cement. Latex rubber is claimed to reduce brittleness, increase toughness and crack resistance, and to improve stability at high temperatures.

Solar Laglugel -

Solar Laglugel is a nylon resin formation supplied by Solar Asphalt of America, Inc. It is preblended with AC-20, and circulated in the AC storage tank (1.33% by weight of the AC-20). Solar Laglugel is formulated to increase rut resistance, improve low temperature flexibility, and resist stripping.

3M - #5990 -

Asphalt Concrete Stabilizing Agent #5990 is manufactured by the 3M Corporation. It consists of a granular polyolefin blend, which was fed at a rate of 8.33 pounds per ton of mixture. It is claimed to increase rutting and wear resistance, and to improve low temperature flexibility.

Plus Ride -

Plus Ride is a proprietary bituminous concrete mixture designed by the All Seasons Surfacing Corporation. It consists of a gap-graded mixture, in which rubber granules, obtained from grinding scrap automobile tires, are substituted for the aggregates omitted from the gap. Three percent rubber (by weight) was incorporated into the bituminous mixture by blending aggregate and rubber in the pugmill prior to adding the AC-20. Plus Ride requires a high percentage of AC-20 to be used in the mixture (7.7%) and is claimed to increase flexibility, durability, skid resistance, crack resistance, and to promote self-deicing of the pavement.

Novophalt -

Novophalt is an Austrian product created by high-shear blending of polyethylene pellets into AC-20 prior to adding to the aggregates. It is claimed to produce mixes that are more rut resistant and have lower temperature susceptibility.

Aggregate Modified Mix -

Aggregate Modified Mix is a slightly coarser modification to the aggregate gradation in the standard I-4 mix.

AC-40 -

The AC-40 section has the standard I-4 aggregate gradation with a stiffer asphalt cement.

EVA -

Ethylene Vinyl Acetate (EVA) is a copolymer that is preblended with AC-20 (4% by weight of AC-20)

Gilsonite -

Gilsonite is a naturally occurring asphalt cement supplied in powder form, which is added to the AC-20, producing a stiffer, more viscous material.

Carbon Black -

Carbon Black is a fine carbon material which is pre-blended with the AC-20 (15% by weight of AC). It is claimed to produce a rut resistant mix.

SBS Co-polymer -

Styrene-Butadiene-Styrene Block Co-polymer is a rubber-like polymer modifier which is premixed with the AC-20 using a high shear blender (6% by weight of AC). The manufacture claims that this reduces temperature susceptibility, provides stiffness in warm weather, yet flexible bituminous mix in cold weather.

Trinidad Lake Asphalt -

Trinidad Lake Asphalt is a natural crushed hard asphalt which is added dry to the asphalt mixture at the plant producing a stiffer asphalt mixture.

Styrelf -

Styrelf is a combination of asphalt cement and block copolymer that are chemically reacted to form a modified asphalt binder that is stiffer in warmer temperatures and more flexible in colder temperatures.

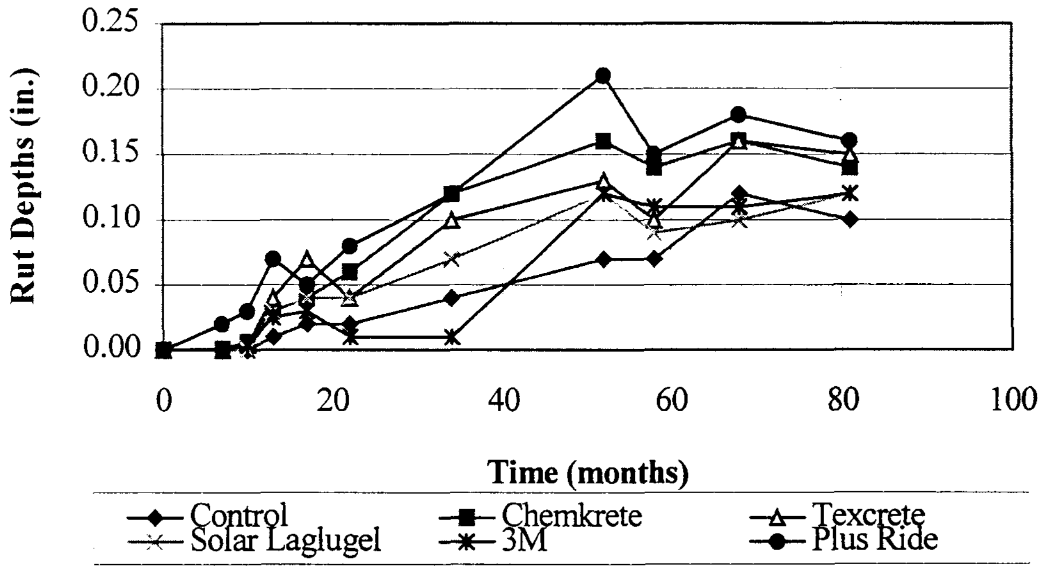
4. Field Test Summary

Route 41: Each of the test and control sections on Route 41 Performed satisfactorily. This may be due to the relatively low AADT and low truck traffic.

All sections exhibited some cracking. The 3M section has the worst level of cracking. Very little rutting has occurred on any test section. The control section (standard NJ DOT mix) performed better than any modified asphalt section for the first five years. Figure 4 is a summary of the rut depths on this project. At the current rate of rut development, most sections will be below 1/2 inch during the pavement's 20 year life.

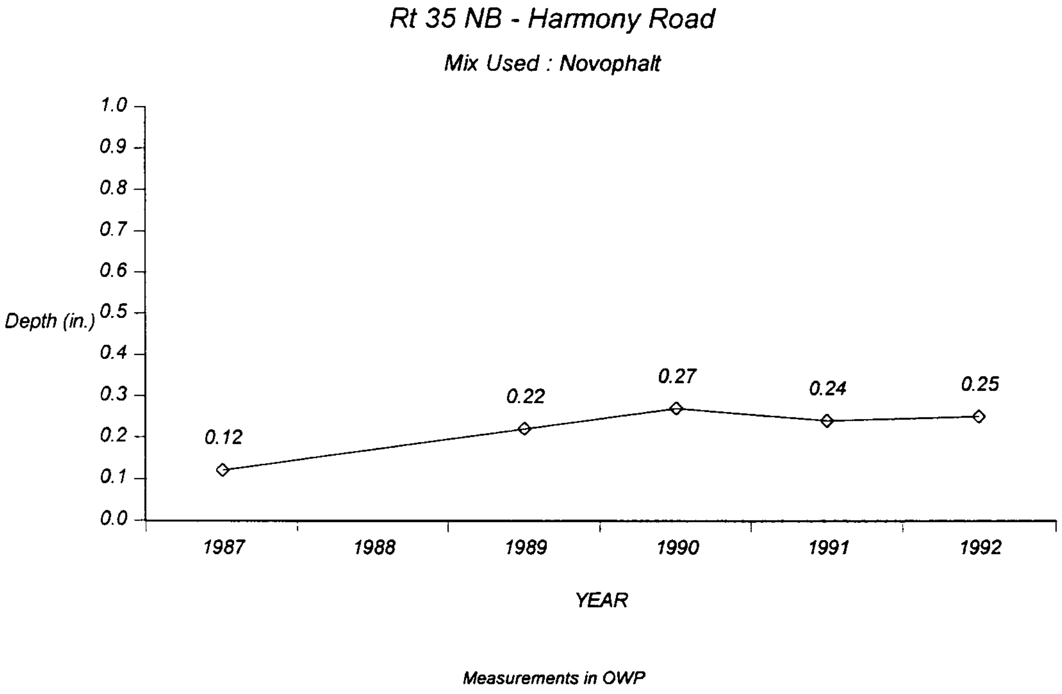
Figure 4 - Summary of Rt. 41 Rut Depths

[All Sections]



Route 35: The main goal of this project was to evaluate rut resistant asphalt mixtures. Figures 5-11 are a summary of the rutting history of each section. All sections showed greater than expected rutting levels. Carbon Black had significant levels of rutting. The aggregate modified and AC-40 mixtures also had more rutting than the other modified asphalt sections.

The Novophalt, EVA, Gilsonite, and Aggregate modified sections showed significant levels of longitudinal cracking. There was little transverse cracking in any section. The Solar Laglugel section developed significant flushing and bleeding.


Rt 35 NB - Harmony Road
Mix Used : Novophalt
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Depth (in.)
0.12
0.22
0.27
0.24
0.25
1987
1988
1989
1990
1991
1992
YEAR
Measurements in OWP

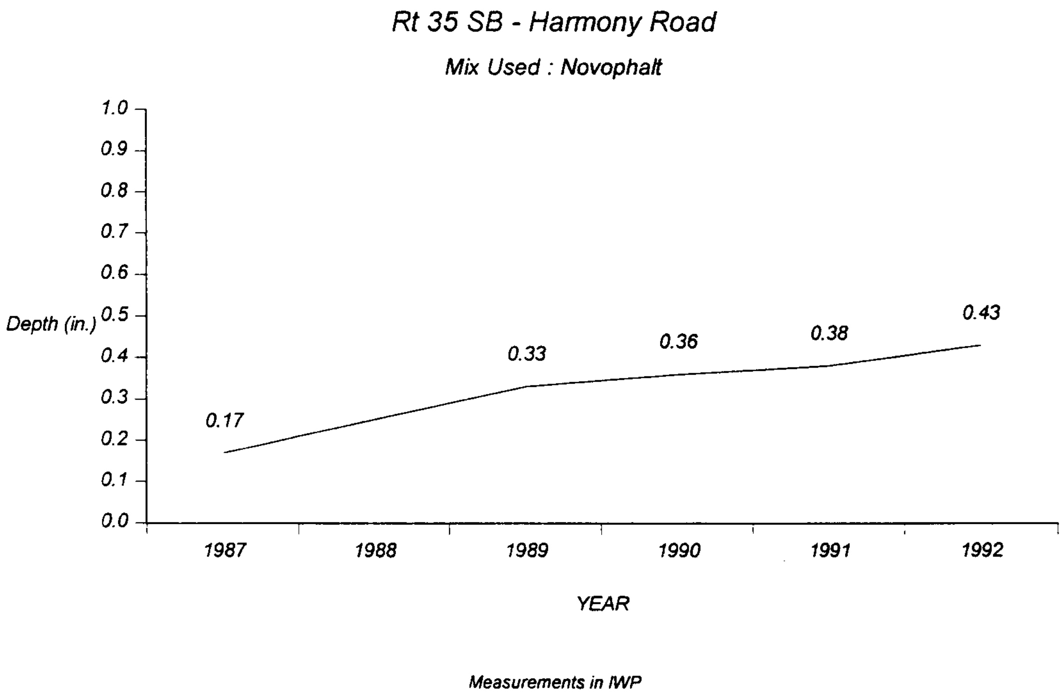
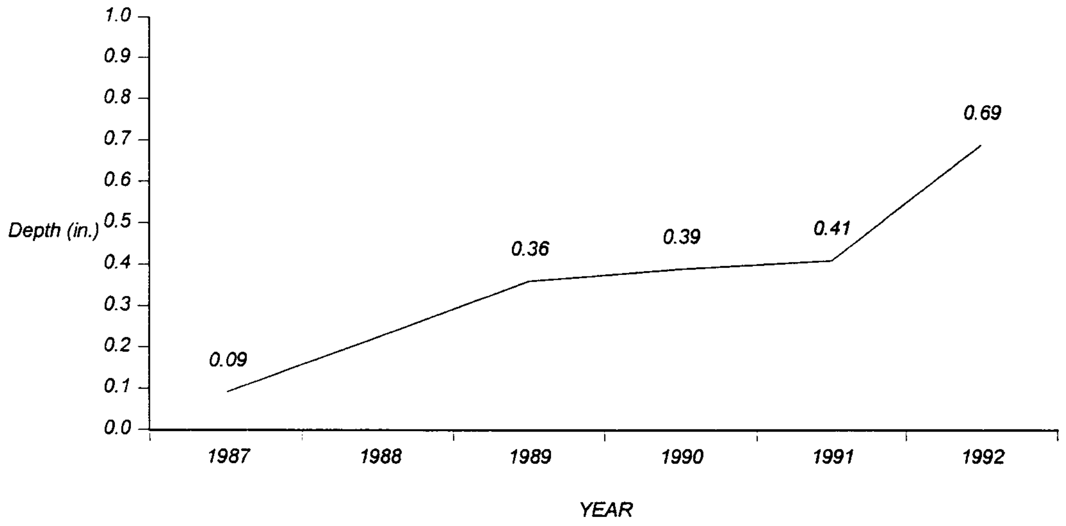

Rt 35 SB - Harmony Road
Mix Used : Novophalt
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Depth (in.)
0.17
0.33
0.36
0.38
0.43
1987
1988
1989
1990
1991
1992
YEAR
Measurements in IWP

Figure 5

Rt 35 NB - Cherrytree Farm to Palmer Road

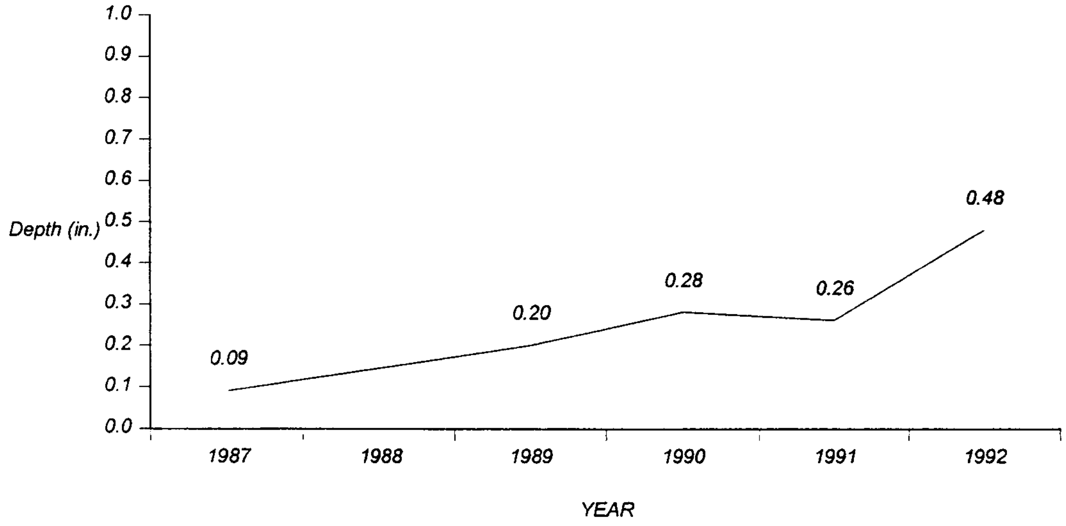
Mix Used : Aggregate Modified



Measurements in IWP - Center Lane

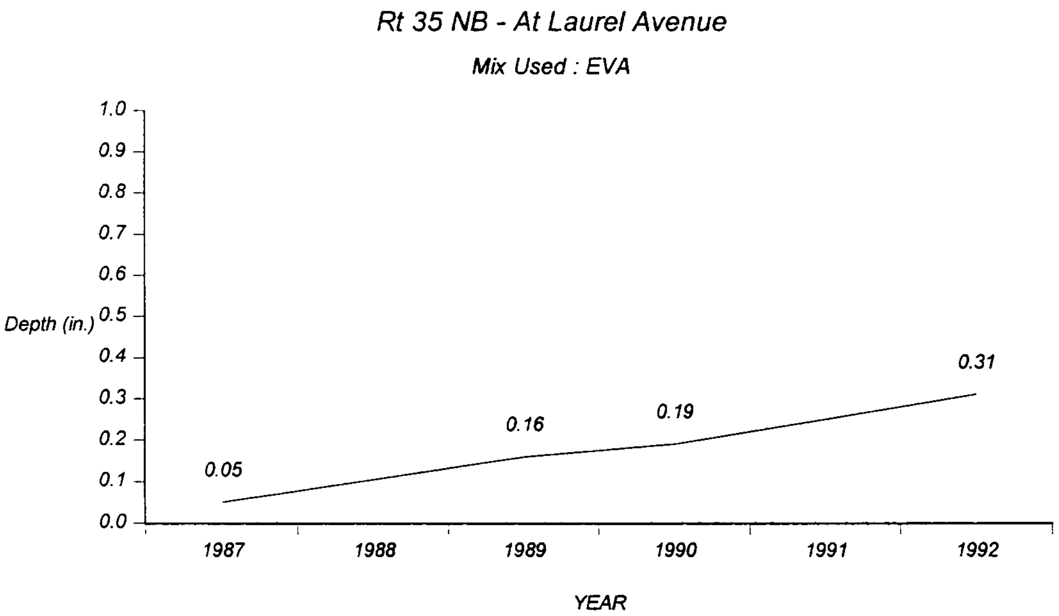
Rt 35 SB - Cherrytree Farm to Palmer Road

Mix Used : AC40

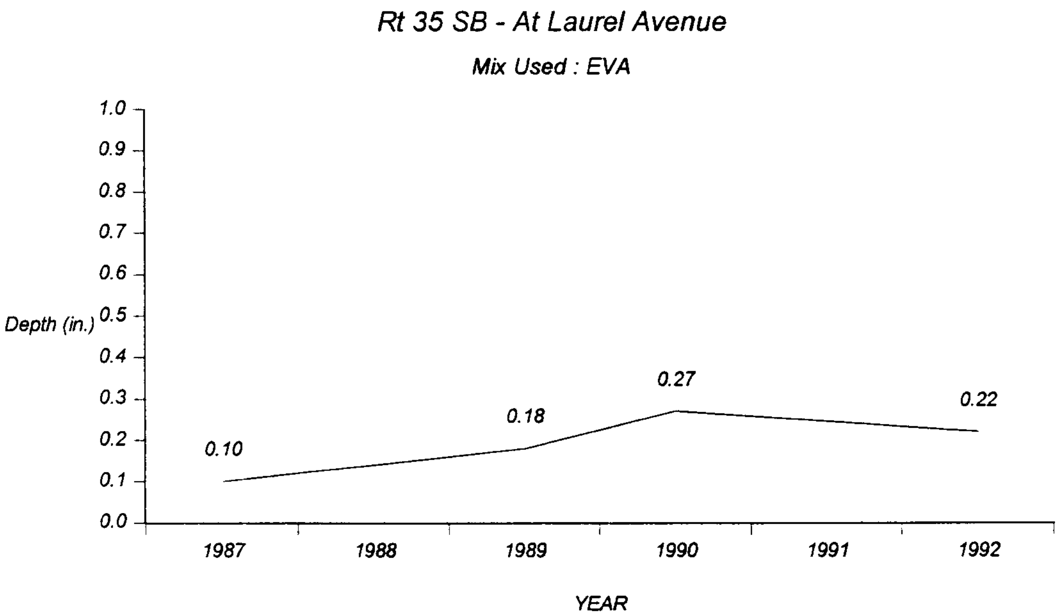


Measurements in IWP

Figure 6

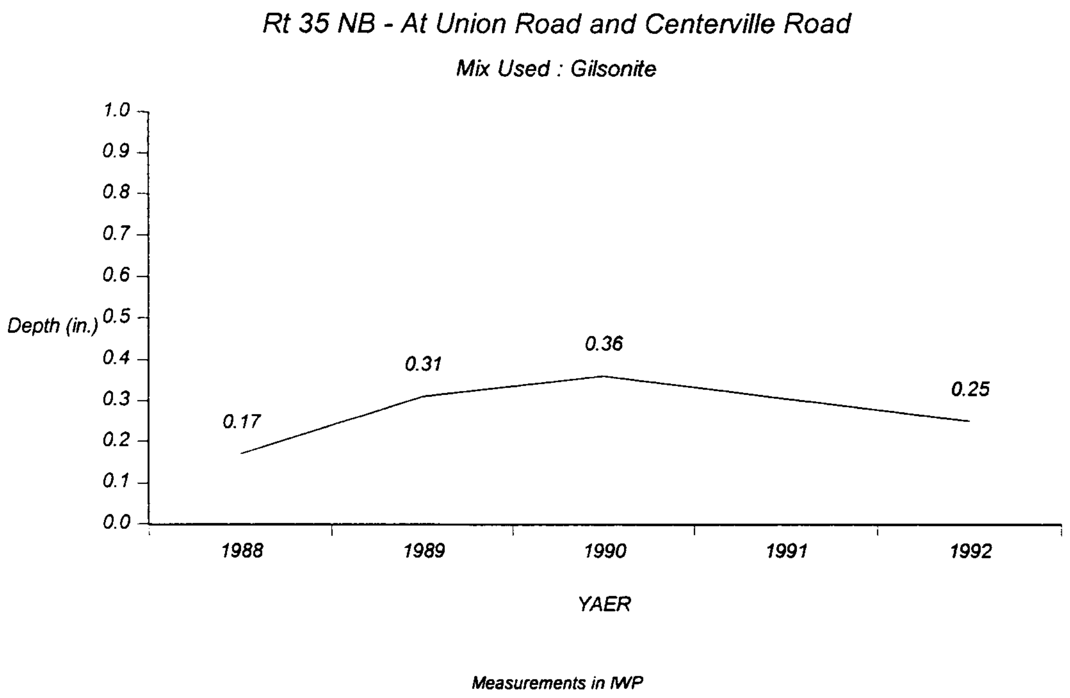


Measurements in Center Lane, OWP

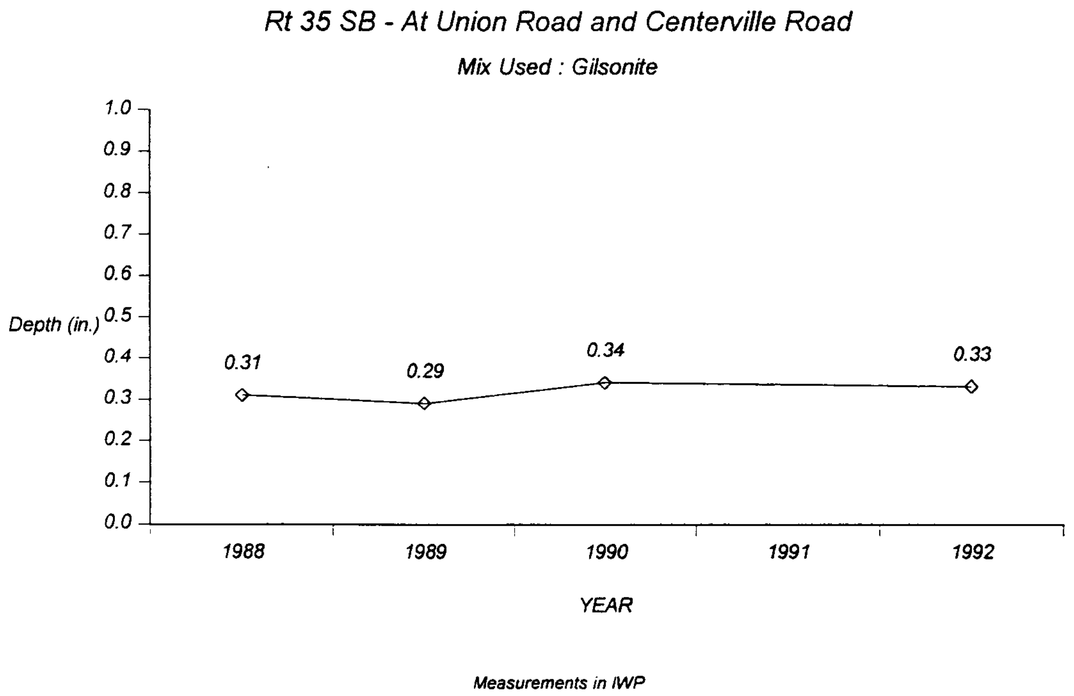


Measurements in Center Lane, IWP

Figure 7

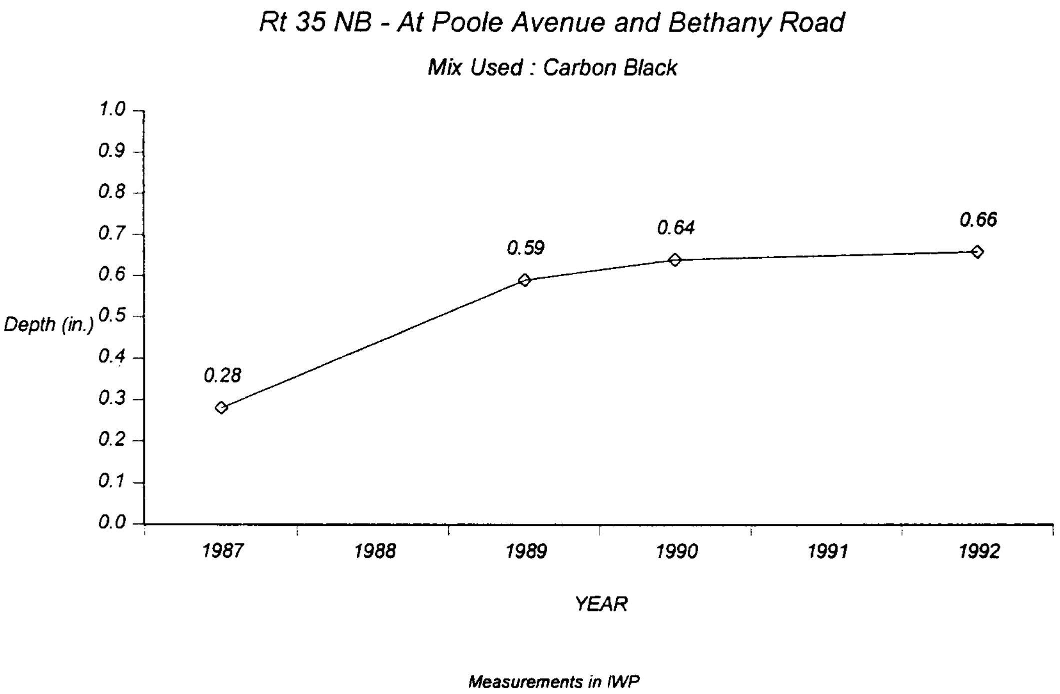


Rt 35 NB - At Union Road and Centerville Road
Mix Used : Gilsonite
Depth (in.)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.17
0.31
0.36
0.25
1988
1989
1990
1991
1992
YAER
Measurements in IWP



Rt 35 SB - At Union Road and Centerville Road
Mix Used : Gilsonite
Depth (in.)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.31
0.29
0.34
0.33
1988
1989
1990
1991
1992
YEAR
Measurements in IWP

Figure 8


Rt 35 NB - At Poole Avenue and Bethany Road
Mix Used : Carbon Black
Depth (in.)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.28
0.59
0.64
0.66
1987
1988
1989
1990
1991
1992
YEAR
Measurements in IWP

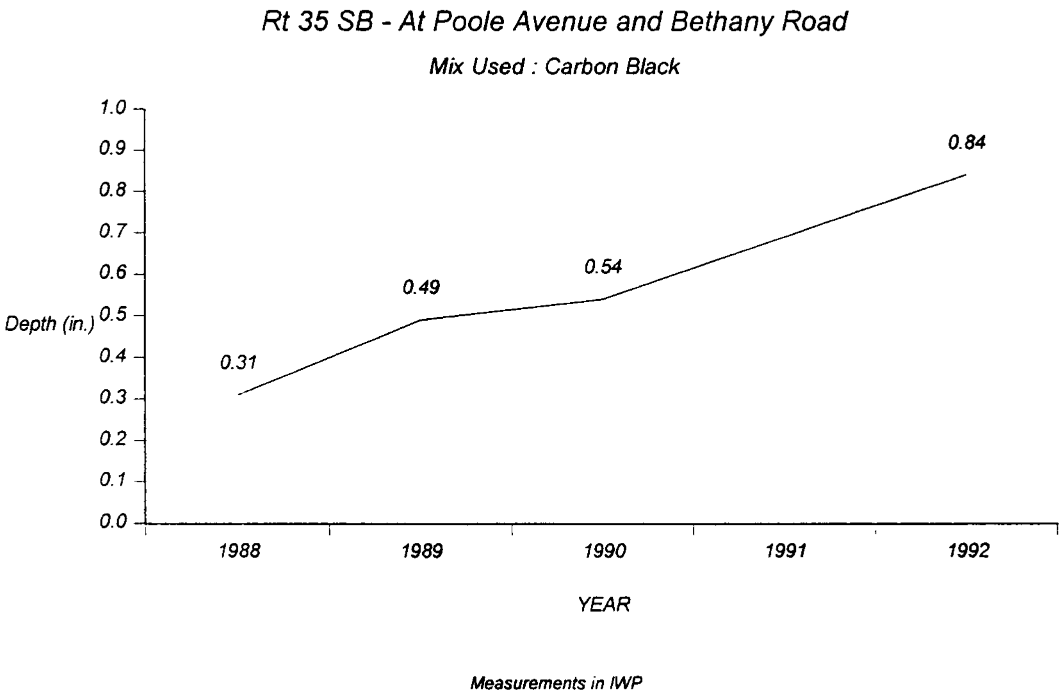
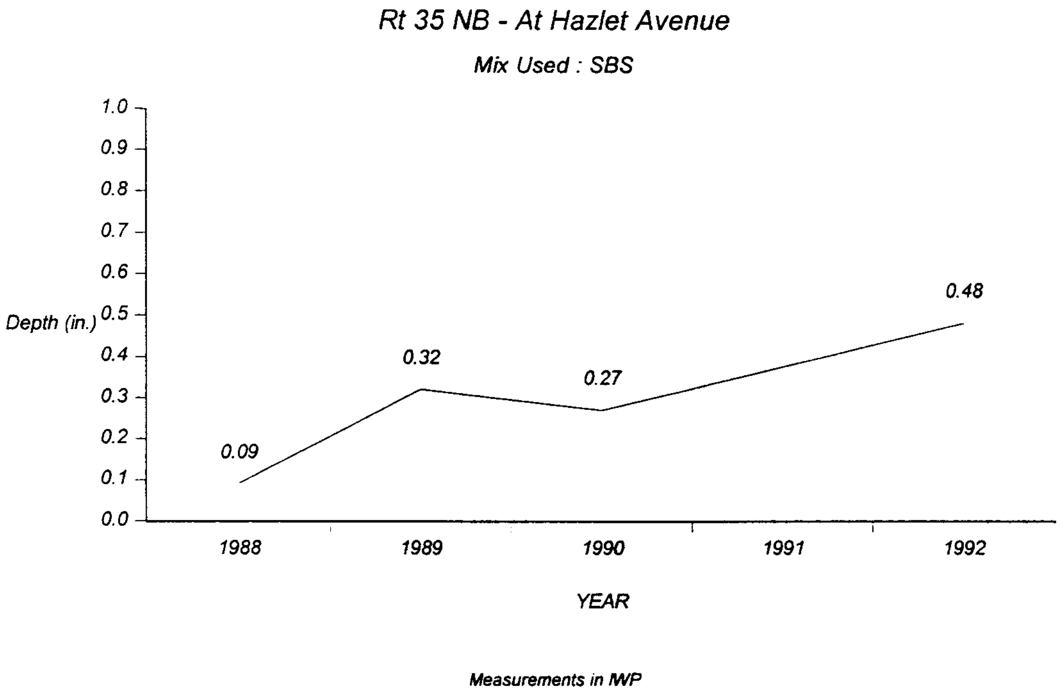

Rt 35 SB - At Poole Avenue and Bethany Road
Mix Used : Carbon Black
Depth (in.)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.31
0.49
0.54
0.84
1988
1989
1990
1991
1992
YEAR
Measurements in IWP

Figure 9


Rt 35 NB - At Hazlet Avenue
Mix Used : SBS
Depth (in.)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.09
0.32
0.27
0.48
1988
1989
1990
1991
1992
YEAR
Measurements in IWP

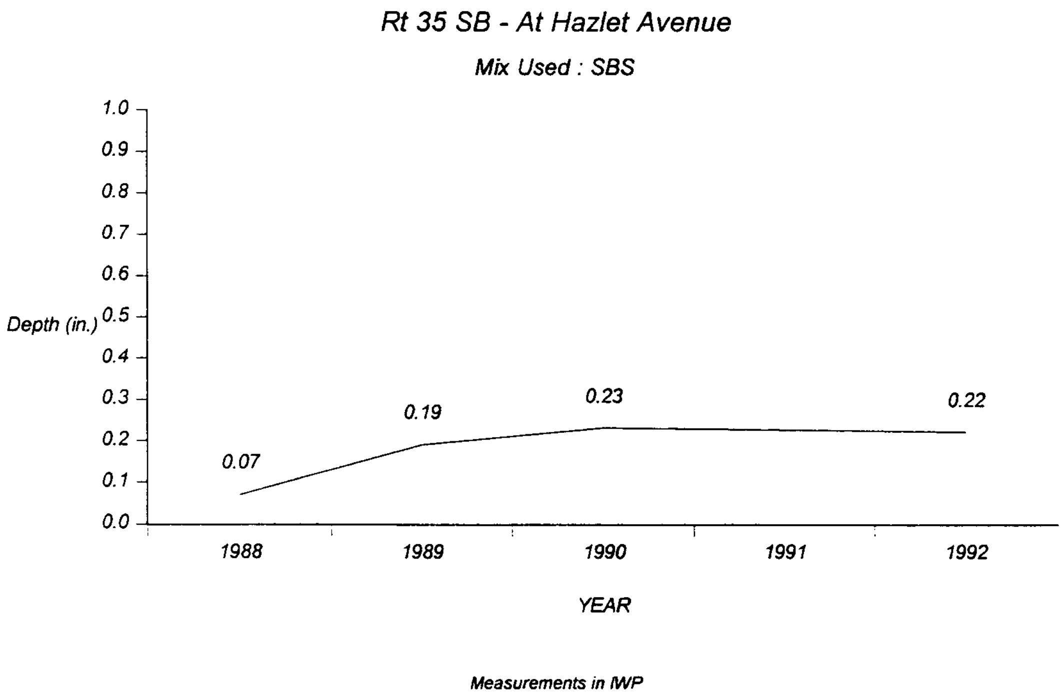

Rt 35 SB - At Hazlet Avenue
Mix Used : SBS
Depth (in.)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.07
0.19
0.23
0.22
1988
1989
1990
1991
1992
YEAR
Measurements in IWP

Figure 10

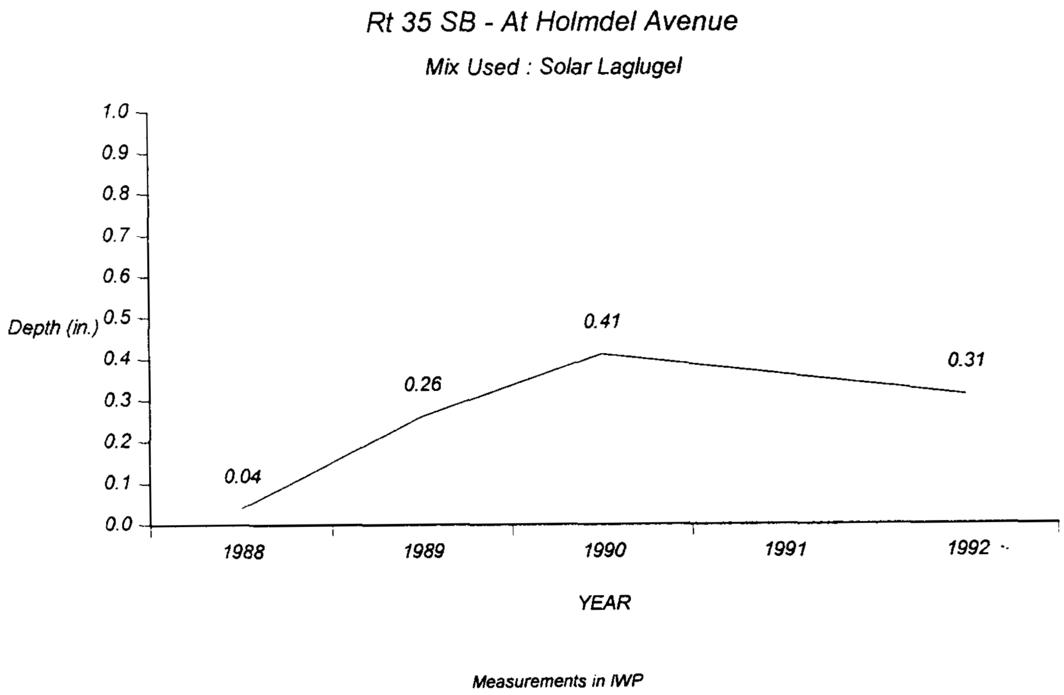

Rt 35 SB - At Holmdel Avenue
Mix Used : Solar Laglugel
Depth (in.)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.04
0.26
0.41
0.31
1988
1989
1990
1991
1992
YEAR
Measurements in IWP

Figure 11

Route 17: The project on Route 17 contained a reconstructed pavement section, and a resurfacing using the Styrelf additive and a control section using the Department's standard I-4 mix. The section that was reconstructed shows the least rutting (0.1 inch) The section that was milled and resurfaced with Styrelf and the control shows approximately 0.25 inches of rutting.

Route 95 NB: The Route 95 project was a result of a severe rutting problem at the approaches of the George Washington Bridge. The ruts were in excess of 3 inches. The Gilsonite additive used on the section produces a hard asphalt mixture. The test section has developed approximately) 0.15 inches of rutting. The control section on the project has slightly greater than 0.2 inches of rutting. The Gilsonite section does show slightly more cracking that the control.

Route 495 HELIX: This project has extremely high AADTs with many trucks and busses. This traffic mix justified the expense of the Trinidad Lake asphalt mix. The section has approximately 0.2 inches of rutting

Route 1 (SMA): This European mix has been placed on this section of Route 1 twice. The first installation resulted in flushing and high rutting after the first very hot summer. There were a number of problems with the first mix design and construction practices that caused the initial failure. The initial problems included differences in the specific gravity of NJ's coarse aggregate and the specific gravities used in the development of the FHWA Sample specification and aggregate degradation of the mix after compaction. After modifing the initial specification to correct these problems, NJ DOT was able to modify the mix design. The revised mix design specification was used in the new SMA application. This section will be monitored through the PMS database. It currently has some slight rutting.

Route 1 SB - Gilsonite: This project contained a Gilsonite mix as an overlay. The mix developed excessive cracking and approximately 0.7 inches of rutting.

Route 130/206 NB - Gilsonite: As with the Route 1 section, this section developed excessive cracking and over 0.8 inches of rutting.

5. **Costs:** The following is a summary of the cost of the various mixes and controls for the projects. Note that the costs shown were the project costs for each material. The variation in costs are due to the year of placement, the experimental nature of the special additives, and the relatively small quantities of the special mixes.

Material	**Tonnage**	**Cost** (per ton)
Route 41:		
AC-20 Control	-	$25.39
AC-40	1200	39.00
Texcrete	600	47.00
Chemkrete	600	30.48
Solar Laglugel	400	36.99
3M	600	87.90
Route 35:		
Gilsonite	600	$43.00
Carbon Black	650	54.00
SBS	1150	49.00
Solar Laglugel	600	45.00
EVA	1100	45.00
Novophalt	1750	39.00
Route 17:		
Styrelf	300	45.00
Control	300	33.60
Route 95		
Gilsonite	300	43.00
Control	-	34.80
Route 495		
Trinidad Lake Asphalt	5900	85.00
Route 1 (SMA)	4000	54.66

6. **Conclusions and Recommendations:** The examination of Asphalt additives or modifiers in most cases did not make a substantial difference in the performance of the asphalt mixture. The field trials of the various mixes is a time consuming procedure that does not always produce repeatable results. The mixes that produced harder asphalt mixes that minimized rutting for the most part produced mixes with more cracking. In the future, our examination of asphalt additives should distinguish between mixes for new bituminous construction, first and second generation overlays on concrete pavements and first and second generation overlays on bituminous pavements.

Some of the Department's current modifications of mix gradation and restriction to crushed stone mixes will probably result in mixes that are more rut resistant. The use of mechanistic pavement overlay design procedures, deflection testing, and the use of new SHRP Superpave asphalt binder and mixture tests should facilitate the development of mixes that perform in a satisfactory manner.

The new asphalt binder and asphalt mixture test methods developed through SHRP may prove to be a more reliable and timely method of comparing or evaluating asphalt mixes with and without modifiers. The need for more rut resistant and durable mixes especially in high traffic and slow moving traffic areas will require a continuing search and evaluation of the asphalt modified binders. The SHRP Superpave asphalt binder performance graded system will provide an additional laboratory tool to assess the enhancements to the properties of the AC without the long term field trials. The use of these tests will provide valuable data for the new pavement design procedures and long term evaluation through the use of the Department's PMS as a feedback tool.

References

1. Kathleen T. Diringer and Joseph Smith, "Asphalt Additives Study-Construction Report", Research Report, New Jersey Department of Transportation, February 1985.

2. Nicholas P. Vitillo, "Mechanistic Pavement Overlay Design Procedures", Research Report, New Jersey Department of Transportation, November 1992.

3. Robert L. Dunning, "Polymers in Asphalt", SHRP A-003B

4. AASHTO-AGC-ARTB Joint Committee, Task Force 31 Report, "Guide Specifications Polymer Modified Asphalt

5. Joseph Smith, Eillen Connolly, and Scott Seabridge, "Experimental Rut-Resistant Test Sections - Route 35 Intersection Improvements", Materials Reserch Report, New Jersey Department of Transportation, April 1988.

6. Joseph Smith, Eillen Connolly, and Scott Seabridge, "Experimental Rut-Resistant Test Sections - Route 41", Materials Reserch Reports, New Jersey Department of Transportation, October 1985, February 1997, and May 1988.

7. Eileen Connolly, "Evaluation Plan - NJ SMA - Rt. 1", Materials Research Report, New Jersey Department of Transportation, August 1993.

8. Eileen Connolly, "Stone Matrix Asphalt - Rt. 1, Section 2J & 3G", Materials Research Report, New Jersey Department of Transportation, February 1993.