

**PREFORMED,
PATTERNED STRIPING MATERIAL
"Stamark Pliant Polymer Marking Tape"
"Series 5730"
"Series A350"**

Final Report

**OREGON EXPERIMENTAL
FEATURE PROJECT #OR 89-02 A & B**

Douglas Ave. - Parrott Creek Road (Roseburg)
Oregon Highway #234 (SB)
Contract No. 10740

Clackamas/Boring Hwy. - 362nd Dr.
Oregon Highway #26
Contract No. 10726

By

**James S. Rusnak
Research Specialist
and
Scott E. Nodes, P.E.
Research Coordinator**

OREGON STATE HIGHWAY DIVISION
Materials and Research Section
Salem, OR 97310

Prepared for

FEDERAL HIGHWAY ADMINISTRATION
Washington, D.C. 20590

November 1991

ABSTRACT

In 1989, two pavement striping tape materials were placed on two new asphalt pavements. A two-year performance evaluation of the materials has been completed by the Oregon State Highway Division's Materials & Research Section.

On the first project, a **3M Stamark Pliant Polymer Pavement Marking Tape - Series 5730**, was placed on an Oregon dense-graded Class "B" asphalt concrete pavement. Only the skip line was marked with the pavement marking tape. Paint was used to mark the fog line and crosswalk. This area has a high volume of cross traffic, much of which is truck traffic. Over the two year period, the material proved to be durable in that it provided a full service skip line, whereas the painted lines had to be repainted several times. The marking tape material reflectance was below the OSHD standards.

On the second project, **3M Stamark Pliant Polymer Marking Tape - Series A350** (white) and **Series 351** (yellow) were placed on an Oregon open-graded Class "F" asphalt concrete pavement. This area is in a snow zone with a significant amount of studded tire usage during the winter months. Over the two-year period, the marking tape did well in retaining its reflectance, but had bonding problems. Some of the material came up after the first snowfall and had to be replaced.

The recommendations of this study are:

The **Series 5730** pavement marking tape is not recommended for use on Oregon's highways.

The **Series A350** pavement marking tape is not recommended for open-graded pavements on Oregon's highways unless the durability problems can be resolved.

The **Series A350** pavement marking tape should be examined on a dense-graded pavement.

ACKNOWLEDGEMENT

The authors wish to thank the many Oregon State Highway Division employees who had key roles in supplying construction information and follow up field inspections during the evaluation. Special thanks go to Project Managers, John Read and Earl Mershon for providing construction inspection reports and cost information. In addition, a big thanks goes to Ray Cranston, the District 6 maintenance staff, Dave Campbell, the Sandy Section District 2-C maintenance staff, Alan Brooks, and the Crew 02-8009 maintenance staff for their many field inspections. Furthermore, the authors thank Stephanie Swetland and Jo Anne Robison for typing this report.

DISCLAIMER

This document is disseminated under the sponsorship of the Oregon Department of Transportation and the United States Department of Transportation in the interest of information exchange. The State of Oregon and the United States Government assume no liability of its contents or use thereof.

The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official policies of the Oregon Department of Transportation or the United States Department of Transportation.

The State of Oregon and the United States Government do not endorse products of manufacturers. Trademarks or manufactures's names appear herein only because they are considered essential to the object of this document.

This report does not constitute a standard, specification, or regulation.

TABLE OF CONTENTS

1.0 INTRODUCTION	1
1.1 Background	1
1.2 Objective	1
2.0 PROJECT DATA	2
2.1 Oakland-Shady Hwy. (Experimental Features Project No. OR 89-02A) ..	2
2.2 Mt. Hood Hwy. (Experimental Features Project No. OR 89-02B)	3
3.0 RESULTS OF THE 2-YEAR EVALUATION	4
3.1 Durability	4
3.2 Reflectance	5
4.0 MATERIAL COSTS	8
5.0 CONCLUSIONS AND RECOMMENDATIONS	9
5.1 Conclusions	9
5.2 Recommendations	9

APPENDICES

APPENDIX A: Permanent Striping Specifications

APPENDIX B: Pavement Mixture Specifications

LIST OF TABLES

TABLE 3.1.A: PHOTOMETRIC TEST RESULTS - SPECIFIC LUMINANCE	6
(Oakland-Shady Highway - Series 5730 (White))	
TABLE 3.1.B: PHOTOMETRIC TEST RESULTS - SPECIFIC LUMINANCE	6
(Mt. Hood Highway - Series A350 (White))	
TABLE 3.1.C: PHOTOMETRIC TEST RESULTS - SPECIFIC LUMINANCE	7
(Mt. Hood Highway - Series A351 (Yellow))	

LIST OF FIGURES

Figure 2.1: Location of Test Section in Roseburg.	2
Figure 2.2: Location of Test Section in Northern Oregon.	3

1.0 INTRODUCTION

1.1 Background

Pavement marking tapes with features such as improved durability and retained reflectiveness continuously enter the market. Often, these tapes are used in place of paint, because tape manufacturers claim the tapes last longer, or provide better reflectance, or do both. If this is true, motorists will be able to see the roadway better at night and in adverse weather. In addition, the road striping crews will benefit, because it lessens the frequency they go out and retrace painted lines, and consequently, frees up equipment and manpower.

Recently, the Oregon State Highway Division (OSHD) evaluated two such reflective pavement marking tapes under experimental feature evaluations (Experimental Features Project No. OR 89-02A and OR 89-02B). Installed on two separate paving projects were 4" wide **Stamark Pliant Polymer Pavement Marking Tape - Series 5730** and 4" wide **Stamark Pliant Polymer Pavement Marking Tape - Series A350**. Both products are manufactured by the 3M Corporation and have been in place for two years.

The **Stamark Pliant Polymer Pavement Marking Tape - Series 5730** is sold as a permanent marking tape that has high durability and is moderately reflective. The material, when used on newly resurfaced roads for striping, carries a 4-year warranty on its adhesion. There is no warranty on its reflectiveness, although OSHD specifications for permanent striping (included in Appendix A) does require that the material have an initial reflectance of 400 millicandelas, retain its durability and retain a minimum reflectiveness of 100 millicandelas for a period of 48 months.

The **Stamark Pliant Polymer Pavement Marking Tape - Series A350** is sold as a highly durable and reflective marking tape. The material carries a 4-year warranty on its adhesion or complete wear through and its reflectiveness. The material is a permanent, preformed, patterned, striping material. It consists of a mixture of polymeric materials, pigments and glass beads that are distributed throughout its base cross-sectional area with a reflective layer of beads embedded into the patterned surface. This reflective layer is intended to improve the striping material's visibility during rainy and night conditions.

1.2 Objective

The objective of this study is to evaluate the performance of the **Stamark Pliant Polymer Pavement Marking Tape - Series 5730** and the **Stamark Pliant Polymer Pavement Marking Tape - Series A350** striping materials after they had been applied to new pavements. This was accomplished by placing and monitoring the striping material on two projects that had different site characteristics, as outlined in the project description portion of this report.

2.0 PROJECT DATA

2.1 Oakland-Shady Hwy. (Experimental Features Project No. OR 89-02A)

The **Stamark Pliant Polymer Pavement Marking Tape - Series 5730** was placed in Southwestern Oregon on the Oakland-Shady Highway (Highway 234, Oregon Route 138). The evaluation section is located within the City of Roseburg between Douglas Avenue and Parrot Creek Road on the southbound side of the couplet. This area has a significant amount of cross traffic from commercial approaches, including log trucks. The Average Annual Daily Traffic (AADT) is 10,000. Winter maintenance activities in this area do exist, but because the area lies in a valley it is protected from many of the winter storms that are more common to other parts of the state.

The **3M Series 5730** marking tape was placed over an Oregon's Dense Graded Class "B" Asphalt Concrete Mix, between the intermediate compaction, and final compaction of the top lift. A description of the Class "B" mix can be found in Appendix B. Only the skip line was marked with white pavement marking tape. Paint was used to mark the pavement edge line and crosswalk.

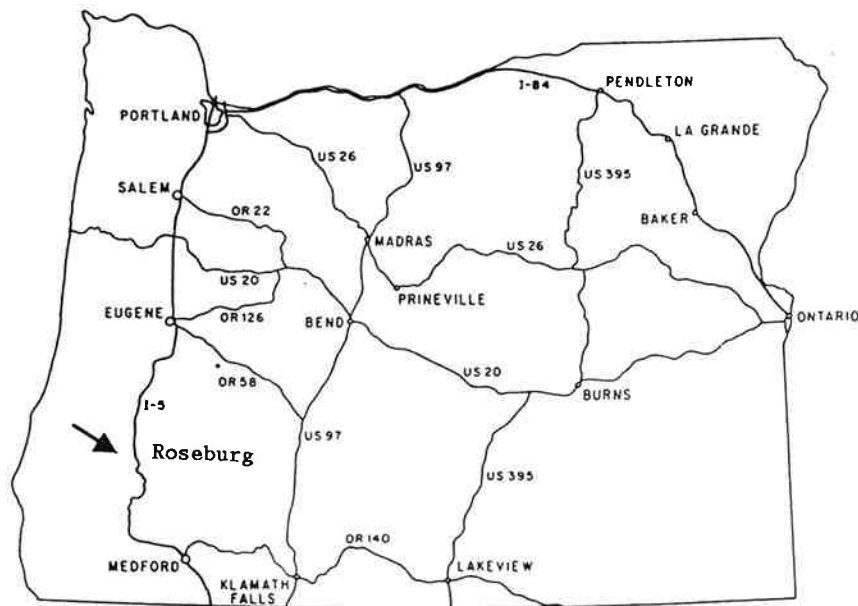


Figure 2.1: Location of Test Section in Roseburg.

2.2 Mt. Hood Hwy. (Experimental Features Project No. OR 89-02B)

The **Stamark Pliant Polymer Marking Tape - Series A350** was placed in Northern Oregon on the Mt. Hood Highway (Highway 26, Oregon Route 26), between MP 19.96 and MP 22.40. The section selected for the evaluation begins three miles northwest of the city of Sandy (See Figure 2.2). This is a rural 5-lane roadway. It is a major access corridor from Portland to Mt. Hood. The AADT is 17,900, with a significant amount of studded tire usage during the winter months. Winter maintenance activities are greater here than in the Western Oregon Valleys.

The 3M marking tape at this location was placed over an Oregon's Open-Graded Class "F" Asphalt Concrete Mix. A description of the Class "F" mix can be found in Appendix B. Both the 3M Series A351 (yellow) and Series A350 (white) marking tapes were used here. The following description will use Series A350 for both Series A351 and Series A350, unless specified otherwise.

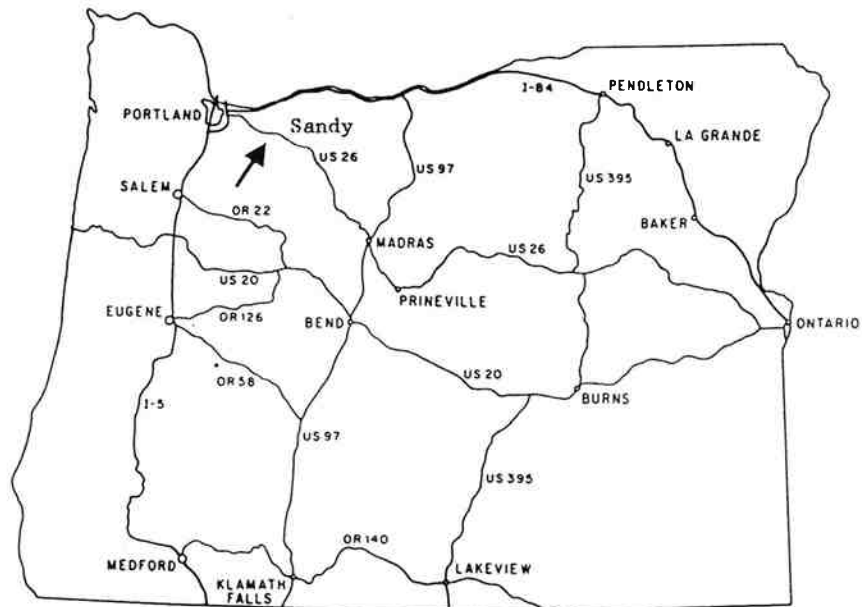


Figure 2.2: Location of Test Section in Northern Oregon.

3.0 RESULTS OF THE 2-YEAR EVALUATION

3.1 Durability

Placement of the **Series 5730** marking tape on the Oakland-Shady Highway Section was completed in September, 1989. A subjective visual evaluation performed by the OSHD District 6 Manager's Office in April, 1990 reported that the marking tape was in good condition after a winter season. There were no reported bonding problems, and the material was very visible during rainy night conditions and looked as reflective as when it was originally installed. At the same time, it was reported that the painted lines in the same area were faded or gone completely.

Another inspection by the District Manager's Office in October, 1990 revealed that the marking tape was still performing well. It was still highly visible with no signs of wear-through or peeling. The material had been down for thirteen months with no maintenance required.

In May, 1991, the District Manager's Office reported that an inspection of the marking tape revealed that it was starting to show a little wear. There was no loss of material due to bonding and it was still highly visible. The material had been down for twenty months with no maintenance required.

A final inspection of the Oakland-Shady Highway Section was made in September, 1991. This marked the end of the 2-year evaluation. Samples of the marking tape were taken from the pavement for final reflective testing. At this time, the material was reported to show signs of wear.

Placement of the **Series A350** pavement marking tape on the Mt. Hood Highway was completed in August, 1989. After one winter, there were several places where the material was not adhering to the pavement. It is not known why this happened. Initially, it was reported to have happened after the first snow plow pass. Representatives from the 3M Corporation along with OSHD Research Unit personnel visited the site to identify the areas. Mostly, this was along the inside of the double yellow refuge lane stripes. There were also some of the white skip lines that were not adhering well; most notably, thirteen of these locations were in the westbound lane at the east end of the project.

In August of 1990, the 3M Corporation replaced the material as called for in their warranty. About 9,000' of 4" wide yellow and 154' of 4" wide white pavement marking material was replaced. During the replacement process, the failed marking tape was removed and a contact cement was applied to the asphalt prior to placing the new pavement marking material. The cement used was SP-44 contact cement with a recommended drying time of 10 to 15 minutes and an application air temperature of 60°F.

After the replacement material was in place, a 3M Technical Service Engineer, performed a pull test on the newly laid yellow marking material. Where it had been primed, it took 7 - 11 lbs. of pull to remove it. Where it had not been primed, it took 3 - 4 lbs. to remove it. The 3M Technical Service Engineer said that the pavement marking material requires a pull test of about 5 lbs. to make it adhere satisfactorily.

One possible explanation for the material not adhering to the pavement was given by the 3M Technical Service Engineer: the pavement is open-graded (Oregon "F" Mix). Thus, when the steel roller rolled the tape down, the material was not depressed into the mat. Normally, the pavement marking material is depressed into the mat in such a way that none of it would stick up above the surface. Since the edges of the tape were exposed, it was easier for snowplows to catch them and tear the edge. This would allow the material to tear further under traffic.

A representative from the City of Sandy reported that the snowfall from the 1989-1990 winter was unusually heavy. This would have resulted in winter maintenance activities in the area.

In September, 1991, a final inspection was performed by the OSHD District Manager's Office, Sandy Section. They reported that some areas of the material were more depressed into the mat than others, depending on traffic patterns, areas of merges and shoulder areas. There were 725' of yellow striping material pulled up by the plows during the 1990-1991 winter season.

Crew members of the OSHD have stated that the tape pavement marking material is more visible in adverse weather than paint pavement marking material.

3.2 Reflectance

Reflectance testing was performed by OSHD Materials Lab personnel in accordance with the testing procedures of the American Society for Testing and Materials (ASTM) D 4061. The photometric quantity measured is specific luminance, SLO, at an angle of 86.5, and is expressed in millicandelas per square meter per lux.

The OSHD Specification U648000.01 states that permanent striping tape materials used as longitudinal marking must meet specific, initial requirements, and retain a minimum reflectance value of 100 millicandelas for four years. A copy of the OSHD specifications is in Appendix A.

Table 3.1 summarizes, by project, the initial reflectivity as required by OSHD Specification U648000.01, the required minimum retained reflectance value according to U648000.01 Replacement Obligation, and the reflective test results of each striping material after it had been in service for two years. Initial reflectance testing was performed using material prior to placement. The materials used for the final evaluation tests were taken from the road surface of each project two years after installation.

In summary, after two years of service, the white **Series 5730** striping material, used on the Oakland-Shady Highway section, failed to retain a minimum reflectance of 100 millicandelas as specified in OSHD specifications. The **Series 350** striping material, used on the Mt. Hood Highway section, did well in retaining its reflectance for the same time period.

TABLE 3.1.A: PHOTOMETRIC TEST RESULTS - SPECIFIC LUMINANCE

**Oakland-Shady Highway
"SERIES 5730"
OSHD - Reflectance Values (White)**

	Initial Required Reflectance	Retained 4-Year Reflectance Requirements	Evaluation After 2-Years In Service Reflectance
Entrance Angle Degrees	86.5	86.5	86.5
Observation Angle Degrees	1.0	1.0	1.0
*Specific Luminance [(MCD. Ft.-2)1FC1]	400 Required *300 Actual	100	80 (Failed)
*Expressed as millicandelas per square foot per footcandle *The "Series 5730" never met the required 400.			

TABLE 3.1.B: PHOTOMETRIC TEST RESULTS - SPECIFIC LUMINANCE

**Mt. Hood Highway
"SERIES A350"
OSHD - Reflectance Values (White)**

	Initial Required Reflectance	Retained 4-Year Reflectance Requirements	Evaluation After 2-Years In Service Reflectance
Entrance Angle Degrees	86.5	86.5	86.5
Observation Angle Degrees	1.0	1.0	1.0
*Specific Luminance [MCD. Ft.-2)1FC1]	400	100	400 (Pass)
*Expressed as millicandelas per square foot per footcandle			

TABLE 3.1.C: PHOTOMETRIC TEST RESULTS - SPECIFIC LUMINANCE

**Mt. Hood Highway
"SERIES A351"
OSHD - Reflectance Values (Yellow)**

	Initial Required Reflectance	Retained 4-Year Reflectance Requirements	Evaluation After 2-Years In Service Reflectance
Entrance Angle Degrees	86.5	86.5	86.5
Observation Angle Degrees	1.0	1.0	1.0
*Specific Luminance ((MCD. Ft.-2)1FC1))	300	100	200 (Pass)
*Expressed as millicandelas per square foot per footcandle			

4.0 MATERIAL COSTS

No cost analysis has been performed because the Series 5730 tape failed the reflectance test and the Series 350 failed the durability tests. In cost analysis terms, this results in a null value to the OSHD.

Costs for the striping tape material and costs estimates for paint marking material are being included for general comparison.

Oakland-Shady Highway Section "Series 5730"

Project length = 0.90 mile

Striping Tape Material

Material Cost	= \$0.75/linear foot
Bid Price (materials and installation)	= \$2.55/linear foot (930 linear feet installed)
Contractor Total Cost for Tape	= \$2,371.50

Paint Marking Material

Initial Paint Striping	= \$0.14/linear foot skip line
Trace Paint Striping	= \$0.05/linear foot of skip line

Mt. Hood Highway Section "Series A350"

Project length = 2.44 miles

Striping Tape Material

Material Cost	= \$1.05/linear foot
Bid Price (materials and installation)	= \$1.75/linear foot (88,312.3 linear feet installed)
Contractor Total Cost for Tape	= \$154,546.50

Paint Marking Material

Initial Paint Striping	= \$0.17/linear foot (88,312.3/lin. ft x 2 applications)
Trace Paint Striping	= \$0.05/linear foot of skip line (section has 8 lines x 2.44 miles)

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The **Series 5730** pavement marking tape did not meet OSHD specifications for reflectance, but it did meet the durability requirements.

The **Series A350** pavement marking tape satisfied the OSHD specifications for reflectance, but did not satisfy the OSHD specifications for durability.

The initial cost of pavement marking tape (**Series 5730 or Series A350**) is significantly higher than the typical pavement marking paint used by the OSHD.

5.2 Recommendations

The **Series 5730** pavement marking tape is not recommended for use on Oregon's highways.

The **Series A350** pavement marking tape is not recommended for open-graded pavements on Oregon's highways unless the durability problems can be resolved.

The **Series A350** pavement marking tape should be examined on a dense-graded pavement.

APPENDIX A
PERMANENT STRIPING SPECIFICATIONS

APPENDIX A

U64800.01 (4-13-89)

Oregon State Highway Division
Specifications for Permanent Striping

PERMANENT STRIPING

Scope - The Contractor Shall provide permanent pavement striping on this project according to the enclosed detail and the following specifications:

General - The preformed patterned markings shall consist of white or yellow films, with glass beads incorporated to provide immediate and continuing retroreflection.

All material must be precoated pressure sensitive adhesive, with coated paper backing for easy removal of backing papers; a primer may be used to precondition the pavement surface.

The pavement markings shall be capable of application on new, dense and open-graded asphalt concrete wearing courses during the paving operation in accordance with the manufacturer's instructions. The striping tape shall be applied before public traffic is allowed on the freshly paved surface. It shall be inlaid in the fresh surface during final rolling of the mat.

After application, the markings shall be immediately ready for traffic.

Materials - The preformed markings shall be capable of the adhering to asphalt concrete or portland cement concrete. The markings shall be highly durable retroreflective pliant polymer materials designed for longitudinal and word/symbol markings subjected to high traffic volumes and severe wear conditions such as shear action from crossover or encroachment on longitudinal configurations, such as edge lines, barrier lines and lane lines. The white and yellow markings shall retain their color throughout their effective performance life.

Skid Resistance - The surface of the materials shall provide an initial average skid resistance value of 45 BPN when tested according to ASTM E 303.

Solvents and Primers - The Contractor must identify proper solvents and/or primers, where necessary, to be applied at the time of application, and recommendations for application that will assure effective product performance.

Shelf Life of Material - The preformed markings shall be suitable for use for one year after the date of receipt when stored in accordance with the manufacturer's recommendations.

Replacement Obligation - For a period of 48 months from date of installation, regardless of ADT, the Contractor shall provide replacement material for any tape used as longitudinal marking which (1) fails to retain the minimum reflectance values of 100 millicandelas, or (2) fails due to loss of adhesion or complete wear through. (Reflectance measured at 86.5 entrance angle, observation angle 1.0, minimum after 4 years = 100 millicandelas).

Initial Reflectance - The white and yellow markings shall have the following initial minimum reflectance values as measured in accordance with the testing procedures of ASTM D 4061. The SLO, and shall be expressed as millicandelas per square foot per footcandle [(MCD > FT.-2)1FC-1]. The metric equivalent shall be expressed as millicandelas per square meter per lux. The test distance shall be 50 ft. (15 m) and the sample size shall be a 2.0' x 2.5' rectangle (0.61 m x 0.76 m).

	<u>White</u>	<u>Yellow</u>
Entrance Angle	86.5 - 86.0	86.5 - 86.0
Observation Angle	1.0 - 0.2	1.0 - 0.2
Specific Luminance	400 - 700	300 - 500

Measurement - The quantity of permanent pavement striping will be measured for payment by the linear foot of striping placed and accepted.

Payment - The accepted pay quantity will be paid for at the contract unit price per linear foot for the item "Permanent Striping", which payment will be full compensation for furnishing and placing the material, including all labor, tools and equipment necessary to complete the work as specified.

APPENDIX B
PAVEMENT MIXTURE SPECIFICATIONS

APPENDIX B
PAVEMENT MIXTURE SPECIFICATIONS*

BROADBAND LIMITS

Sieve Size Passing	Class "B"	Class "F"
1"	99-100	99-100
3/4"	90-98	85-96
1/2"	75-91	60-71
1/4"	50-70	17-31
NO. 10	21-41	7-19
NO. 40	8-24	-
NO. 200	2-7	1-6
Asphalt Cement**	4-8	4-8
Mineral Filler		0.5-1.5

*Oregon State Highway Division
 Supplemental Standard Specifications
 September 1989
 Section 403.12

**Percent of total mix (by weight)

2.0 PROJECT DATA

2.1 Oakland-Shady Hwy. (Experimental Features Project No. OR 89-02A)

The **Stamark Pliant Polymer Pavement Marking Tape - Series 5730** was placed in Southwestern Oregon on the Oakland-Shady Highway (Highway 234, Oregon Route 138). The evaluation section is located within the City of Roseburg between Douglas Avenue and Parrot Creek Road on the southbound side of the couplet. This area has a significant amount of cross traffic from commercial approaches, including log trucks. The Average Annual Daily Traffic (AADT) is 10,000. Winter maintenance activities in this area do exist, but because the area lies in a valley it is protected from many of the winter storms that are more common to other parts of the state.

The **3M Series 5730** marking tape was placed over an Oregon's Dense Graded Class "B" Asphalt Concrete Mix, between the intermediate compaction, and final compaction of the top lift. A description of the Class "B" mix can be found in Appendix B. Only the skip line was marked with white pavement marking tape. Paint was used to mark the pavement edge line and crosswalk.

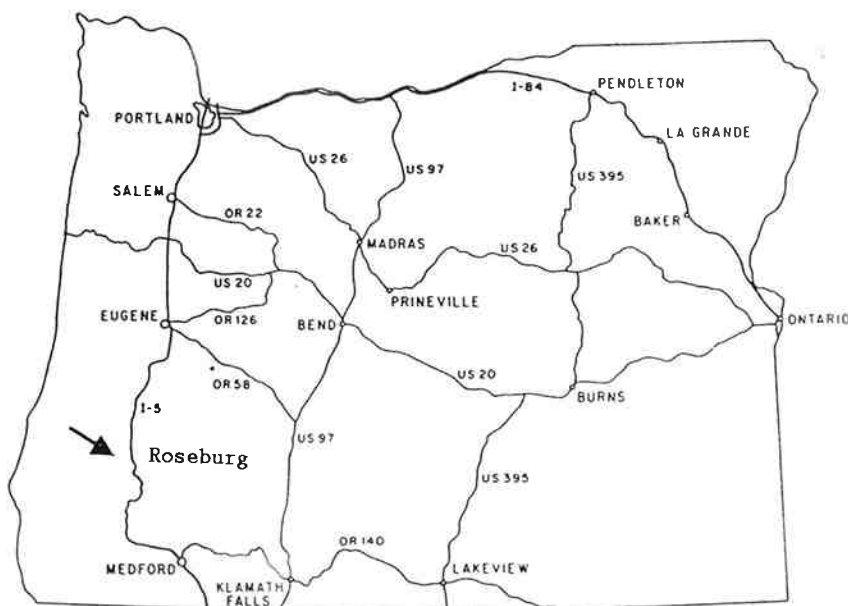


Figure 2.1: Location of Test Section in Roseburg.

2.2 Mt. Hood Hwy. (Experimental Features Project No. OR 89-02B)

The Stamark Pliant Polymer Marking Tape - Series A350 was placed in Northern Oregon on the Mt. Hood Highway (Highway 26, Oregon Route 26), between MP 19.96 and MP 22.40. The section selected for the evaluation begins three miles northwest of the city of Sandy (See Figure 2.2). This is a rural 5-lane roadway. It is a major access corridor from Portland to Mt. Hood. The AADT is 17,900, with a significant amount of studded tire usage during the winter months. Winter maintenance activities are greater here than in the Western Oregon Valleys.

The 3M marking tape at this location was placed over an Oregon's Open-Graded Class "F" Asphalt Concrete Mix. A description of the Class "F" mix can be found in Appendix B. Both the 3M Series A351 (yellow) and Series A350 (white) marking tapes were used here. The following description will use Series A350 for both Series A351 and Series A350, unless specified otherwise.

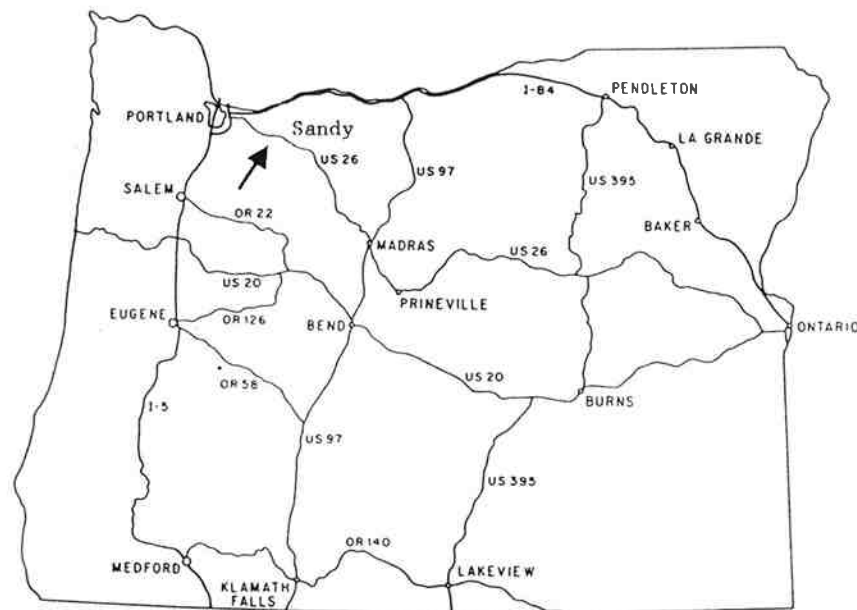


Figure 2.2: Location of Test Section in Northern Oregon.

OREGON STATE HIGHWAY DIVISION

Research Report User Survey

Please evaluate the research report by answering the following questions. After you have answered the questions, please return this form to:

Research Unit
Oregon State Highway Division
800 Airport Road SE
Salem, OR 97310

Report Title: **"Preformed, Patterned Striping Material," Final Report**

Your Name & Organization (optional): _____

Date you completed this survey: _____

- 1) Which elements of the report did you read (circle all that are applicable)?

A) Abstract.	D) Conclusions & Recommendations.
B) Introduction.	E) References.
C) Body.	F) Appendices.

- 2) Did you find the report useful?

A) Very useful.	C) Somewhat useful.
B) Useful.	D) Not useful.

- 3) How will you use the information in this report?

A) As reference.	C) To implement recommendations.
B) Will use recommendations in other research.	D) Will not use recommendations; Why?

- 4) Implementation of the recommendations will result in the following estimated savings:

A) None.	D) Large.
B) Small.	E) Increased cost with increased benefits.
C) Medium.	

- 5) How do you rate the technical content of the report?

A) Excellent.	D) Poor.
B) Good.	E) Don't know subject well enough to judge.
C) Fair.	

- 6) If you have additional comments, please provide them below.