Field Evaluation of Snowplowable Raised Pavement Markers on the Vermont Interstate Highway System

Waterbury, Vermont

August 2002
Reporting on Work Plan 2001-R-6
Initial Report

State of Vermont
Agency of Transportation
Materials and Research

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16. Abstract

This report describes the installation and initial performance of snowplowable raised pavement markers (SRPMs) placed as a supplemental pavement marking on the skip line of the interstate highway system in Vermont. Currently, Vermont does not use SRPMs on any of its highway systems. The objective of this study is to evaluate the effectiveness, durability and life cycle costs associated with these devices as a supplemental marking.

Installed in November 2001, this evaluation documents the performance of the Avery Dennison – Stimsonite® brand LifeLite 101 LPCR marker. The performance of the device is evaluated on the durability of the marker - both housing and reflector, delineation quality under various light and weather conditions, and the effect the markers have on snowplow equipment and removal operations.

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INTRODUCTION

Raised pavement markers (RPMs) have been widely used by state transportation departments for several years. Manufactured in different shapes and sizes, these devices are designed to accommodate areas with little or no snowfall as well as those in the snow-belt region. Snowplowable raised pavement markers (SRPMs) differ in design from conventional RPMs by incorporating a lower ramp angle to provide for better plowability and a minimal exposure above the road surface. Although there are several manufacturers of SRPMs, this study evaluated the performance of one make and model, Avery-Dennison – Stimsonite brand LifeLite 101 LPCR markers.

Between 1983 and 1986, Vermont evaluated the performance of two different types of SRPMs. Placed as a supplement to traffic markings, these devices were installed along the center skip line of Interstate I-89 in Waterbury and within the gore areas of the northbound and southbound exit ramps at the Exit 10, Waterbury interchange. The results of this study concluded that these devices provided excellent reflectivity in wet and dry nighttime conditions initially, but declined rapidly after exposure to traffic and typical winter maintenance practices. Since the 1983 installation, the design and installation techniques of SRPMs have been improved upon, warranting another evaluation of their performance.

PRODUCT DESCRIPTION

Avery Dennison - Stimsonite® brand LifeLite 101 LPCR Marker:

Avery Dennison-Stimsonite® brand LifeLite 101 LPCR raised snowplowable pavement markers are a narrow, "H-shaped" device designed with a low ramp angle to provide enhanced traffic marking delineation with better plowability than non-snowplowable markers. The two-component system consists of a nodular iron casting and reflector. The low-profile casting is constructed with two integral center rails that aid in providing protection to the reflector. The overall unit, as shown in Figure 1, measures 10" long by 5.5" wide by 1.76" deep and weighs about 4.9 lbs. When installed, a total of 0.25" protrudes at a sloping angle above the road surface.

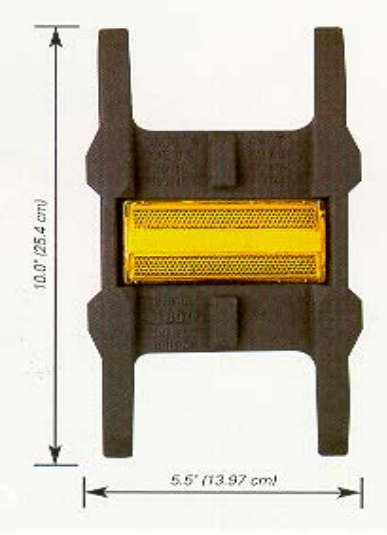

Figure 1. Avery Dennison-Stimsonite® brand LifeLite 101 LPCR Raised Pavement Marker.

Epoplex MA50 Epoxy Adhesive

Epoplex MA50 is a two-component, epoxy polyamine 100% solids adhesive. It is formulated to provide a simple volumetric mixing ratio of one part epoxy resin to one part activator / curing agent. As a heavy-duty bonding compound, it posses high compressive and tensile strengths and minimal shrinkage upon cure, it is recommended specifically for the installation of pavement markers. This product can be used at temperatures between 32^{o}F and 90^{o}F.

PROJECT LOCATION

The test site for the evaluation of the LifeLite 101 LPCR raised pavement markers was located in the southbound lane of Interstate I-89 in Waterbury between mile markers 66.55 and 64.75. As part of the Middlesex-Bolton IM 089-2(26) project, the pavement on this section of interstate highway was milled out 1.5" and resurfaced with a 1.5" bituminous overlay. The paving was completed on November 5, 2001.

INSTALLATION

The Equipment

The equipment used in the installation of the raised pavement markers included a power-driven concrete saw and a pressurized epoxy adhesive system. The concrete saw, shown in Figure 2, is designed with a stack of 18" diameter concrete saw blades bordered by 20" diameter saw blades on each side. With a single plunge, the groove created is in the same configuration as the marker, allowing for a close match for the inset.

Figure 2. Concrete Saw.

The epoxy adhesive system, shown in Figure 3, consisted of two independent pressurized tanks that feed through two independent lines to a disposable plastic application tip. The two components, discernable by color, one white and one black, met at the nozzle and mixed within the spiraled chamber of the application tip producing a gray adhesive material.

Figure 3. Epoxy Adhesive System.

Installation of the Snowplowable Raised Pavement Markers

On November 15, 2001, the installation of the SRPMs commenced along the center skip line of Interstate I-89 in Waterbury. Placed as a supplemental marking to the thermoplastic pavement markings, these devices were located every 80 feet between the skip line. The reflector chosen for this installation was a two-way, two-color device with white visible to the normal direction of traffic and red for anyone traveling the wrong way.

The installation began at 12:15pm on the north end of the project area and proceeded southerly. The average ambient air temperature during the course of the installation was 55^{o} F. At the start of the installation, a problem with a loose drive belt delayed the process for about 15 minutes, but once remedy there were no additional problems with the equipment. The self-driven concrete saw proceeded through the project with one man guiding it, making a plunge cut in the shape of the SRPM housing. A lot of dust was produced from the dry saw process, as shown in Figure 4, creating a visibility issue for a brief period of time.

Figure 4. Sawing Recess for SRPM.

After the groove was cut the area was blown clean with compressed air and the epoxy adhesive was placed covering both the center portion and the legs of the cut out as shown in Figure 5. The two-component epoxy adhesive was heated to 130-140^{o} F to produce a free flowing material. After the adhesive was placed, the marker was immediately set within the cut-out by rocking and working the marker into place then gently stepping on it until the epoxy emerged around the marker as shown in Figures 6 and 7. If an excess amount of epoxy was extruded, a paint scraper was used to smooth-out the material around the marker and, if not, additional epoxy was added. The proper amount of epoxy is essential to keep the marker intact but too much could block or cover the reflective device.

Figure 5. Placing epoxy adhesive.

Figure 6. Setting marker in place.

Figure 7. Securing marker in grooved area.

As the process progressed, with one individual operating the saw and two others applying the adhesive and setting the markers in place, it was discovered that some of the recesses were requiring significantly more epoxy. It was determined that this was the result of the grooves being sawn too deep, likely caused by how the concrete saw was being brought down onto the pavement surface. This was discovered at MM 66.40, at which time the saw was at MM 65.85. The individual operating the saw was informed and modified his practice and those setting the markings concluded that not all the grooved areas between the above mentioned mile markers were effected.

It appeared in general that the majority of the markers received an excessive amount of epoxy, including in front of and in some cases up to the reflector, as shown in Figure 8, and a few others lacked epoxy as shown in Figure 9. No additional problems developed during the installation and the total time required to place the 123 markers was 2 hours 45 minutes.

Figure 8. Excessive amount of epoxy adhesive.

Figure 9. Lack of epoxy adhesive at toe.

COSTS

At the time of installation, the material cost of the Stimsonite® brand LifeLite Model 101LPCR snowplowable raised pavement markers were $16 per marker. The installation cost of the markers, including epoxy adhesive and labor was $22.50 per marker, for an overall total cost of $38.50 per marker.

The delineation of the 1.8-mile skip line at an 80-foot interval, excluding bridge structures, would have totaled $4735.50. For the purposes of this study, a total of 123 SRPMs were supplied to the agency at no cost, making the total cost incurred for the installation $2767.50. Since the installation cost is based on volume, the installation cost per marker was higher than if the scale of the project was larger.

PERFORMANCE

Shortly after the SRPMs' installation it was detected that one of the markers was installed backwards, revealing the "red" side of the delineator. Personnel assigned to the construction project corrected this by removing the reflector and reattaching it in the proper direction. As the result of not having the recommended adhesive available at the time, the delineator at this location became dislodged within a few months as shown in Figure 10.

Figure 10. Dislodged reflector after four months of service.

Initial observations of the SRPMs were favorable in both dry and wet night retroreflectivity. But, over the winter season the effectiveness of most of the reflectors began to diminish. Residual sand and salt build-up on the reflectors from routine winter maintenance was a primary contributor to the loss of reflectivity. In addition, some of the reflectors were damaged, possibly by plow blades and studded tires. After six months, a total of 22 of the 123 reflectors experienced significant damage, as shown in Figure 11, 8 had minor damage, as shown in Figure 12, and one reflector was lost. A summary of each marker's condition is exhibited in Table 1.

Figure 11. Significant lens damage.

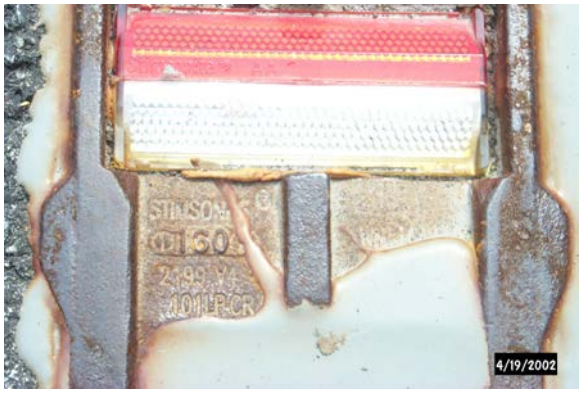

Figure 12. Minor lens damage.

Despite both the low-ramp angle and low profile of the SRPMs, the plow trucks experienced a "jump" of the plow as they passed over each marker. In order to minimize this effect, maintenance personnel modified their plowing techniques in the area to avoid any disturbance. Instead of passing over the SRPMs, they plowed adjacent to them and salted the center portion of the road. This eliminated the jarring impact on the drivers and potential damage on the plow blades. This practice still allowed the maintenance crews to keep the road adequately clean as seen in Figure 13.

Figure 13. Test site area during winter season.

Snowplowable Raised Pavement Markers Model: Avery Dennison (Stimsonite) Model 101LPCR Interstate I-89 SB - Waterbury,VT								
Marker #	Damage	Comments	Marker #	Damage	Comments	Marker #	Damage	Comments
19-Apr-02			19-Apr-02			19-Apr-02		
1			44			87		
2			45	X	Lens Gone	88		
3	X	Lens Damage	46	X	Lens Damage	89		
4			47	X	Lens Damage-Broken	90		
5			48	X	Lens Damage	91	X	Lens Damage
6			49			92		
7			50			93		
8			51	X	Lens Damage	94	X	Lens Damage
9			52			95		
10			53			96		
11			54	X	Lens Damage	97		
12			55			98		
13	X	Lens Damage	56			99	X	Lens Damage
14			57	X	Lens Damage	100		
15			58			101		
16	X	Lens Damage	59			102		
17			60			103		
18			61			104		
19	X	Minor Lens Damage	62			105		
20			63			106		
21	X	Minor Lens Damage	64			107		
22			65	X	Lens Damage	108		
23			66			109		
24	X	Lens Damage	67			110		
25			68			111		
26			69			112		
27			70			113		
28			71	X	Minor Lens Damage	114		
29			72			115		
30			73			116		
31			74	X	Lens Damage-Broken	117	X	Lens Damage
32			75			118	X	Minor Lens Damage
33			76			119	X	Lens Damage
34			77			120		
35	X	Lens Damage	78	X	Lens Damage	121		
36			79	X	Minor Lens Damage	122		
37			80			123	X	Minor Lens Damage
38			81					
39	X	Lens Damage	82					
40			83	X	Minor Lens Damage			
41			84					
42	X	Lens Damage	85					
43	X	Minor Lens Damage	86					

Number of Markers with Housing Damage	0	0%
Number of Markers with Lens Damage	30	24%
Minor Damage	8	7%
Significant Damage	22	18%
Number of Markers with Missing Lenses	1	1%

Table 1. Condition of Snowplowable Raised Pavement Markers after 5 Months

SUMMARY

A two-year AASHTO National Transportation Product Evaluation Program (NTPEP) study on the performance of SRPMs was conducted between 1998 and 2000 on an Ohio test deck. Located on the Franklin County Interstate, Route 270, this evaluation reported on the field performance of four SRPMs. In addition to a field review, the Georgia Department of Transportation provided some laboratory test results on each of the markers. The criteria for test site required a pavement structure in good condition, an average annual daily traffic greater than 20,000, a minimum snowfall of 25 inches per year controlled with plowing, salt, and grits, and a speed limit of 50 to 75 miles per hour (Ohio, 5). During the two-year period, this site met these criteria with the first winter being harsher then the second.

The NTPEP study based its evaluation on a sample of one hundred markers, fifty on a portland cement concrete and fifty on asphalt concrete pavement. One of the markers in this study is the Stimsonite 101LPCR, as is being reviewed in this report. For the purpose of comparison, only the values for the markers placed on asphalt concrete pavement is reported within. The field performance of the markers was rated on a scale of 1 to 5, with the higher number representing the best performance. The results were recorded on nine separate days throughout the two-year period. These results were summarized in five groups of 10 markers each. Table 2 is a collective summary of each marker type's performance near the one-year and two-year period. More detailed information on each group's performance on each of the nine days and a description of the rating system is presented in Appendix A.

NTPEP Study -Ohio Test Deck (1998-2000)

Manufacturer/ Model	Pavement	Age (Days)	Housing Average	Lens Average	Visibility Average
Stimsonite, No. 94	Asphalt	365	4.2	4.1	3.2
Stimsonite, No. 101LP	Asphalt	365	4.2	4.4	4.0
Stimsonite, No. 101LPCR	Asphalt	365	4.1	4.4	3.4
Hallen, Ironstar	Asphalt	282	4.0	3.6	1.0
Stimsonite, No. 94	Asphalt	731	4.0	2.5	2.1
Stimsonite, No. 101LP	Asphalt	731	4.0	2.7	3.1
Stimsonite, No. 101LPCR	Asphalt	731	4.0	2.6	2.5
Hallen, Ironstar	Asphalt	648	4.0	1.2	0.3

Rating: 5 = Excellent 4 = Good 3 = Fair 2 = Poor 1 = Missing or damaged beyond repair

Table 2. NTPEP Study – Evaluation of SRPMs on Asphalt Concrete Pavement.

This study indicates that after one-year, the condition of the housing and lens of the Stimsonite LPCR101 SRPMs are good, but the overall visibility is fair. In the second year, the housing continued to remain in good condition with both the lens and visibility performance declining to a rating of fair to poor condition. Comparing the results of this NTPEP study's first year data and the field performance of the SRPMs on I-89 we can conclude the performance is similar.

SRPMs installed on Vermont's interstate in 1983 experienced significantly more damage than those tested in this study resulting in 93% of the markers exhibiting some type of damage after its first winter season (Houston, 14). One of the two SRPM markers evaluated in this study was a Stimsonite model, but with a higher profile. Hence, it is probable that the redesigned lower-profile units contributed a more successful performance of the device.

FOLLOW UP

The SRPMs will continue to be monitored over the next four years. Subjective field evaluations, photographic documentation, and public feedback will continue to be collected. Reflectors will be replaced as needed and all costs associated with these devices, including their maintenance will be reported.

REFERENCES

Houston, E.C., "*Experimental Use of Raised Pavement Markers on I-89*," Initial Report 85-11. State of Vermont, Agency of Transportation, Montpelier, VT. December 1985.

Ohio Department of Transportation et al, "*Second Year and Final Field Evaluation of Plowable Raised Pavement Markers (SRPMs)*," Report 00 NTPEP 208. AASHTO's National Transportation Product Evaluation Program, Washington, D.C. January 2001.

Appendix A

The following two tables are averages of the above data:

Summary Asphalt

NTPEP Sample	Manufacturer/Model		Rating Number	Date	Age Days	Lab .2/0 R(i)Avg	Lab .2/20 R(i)Avg	Housing Avg	Lens Avg	Dirty Avg cd/lx	Clean Avg cd/lx	Visibility Avg	Comments
RPM-98-4	Stimsonite, No. 94	Asphalt	Rating 1	9/1/98	0			5.0	5.0		0.641	5.0	
RPM-98-4	Stimsonite, No. 94	Asphalt	Rating 2	11/23/98	83			5.0	5.0	0.084	0.689	3.2	
RPM-98-4	Stimsonite, No. 94	Asphalt	Rating 3	3/2/99	182			4.3	4.0	0.127	0.604	3.6	
RPM-98-4	Stimsonite, No. 94	Asphalt	Rating 4	6/2/99	274			4.6	4.6	0.099	0.372	2.4	
RPM-98-4	Stimsonite, No. 94	Asphalt	Rating 5	9/1/99	365			4.2	4.1	0.170	0.632	3.2	
RPM-98-4	Stimsonite, No. 94	Asphalt	Rating 6	12/7/99	462			4.0	3.3	0.161	0.706	3.1	
RPM-98-4	Stimsonite, No. 94	Asphalt	Rating 7	3/13/00	559			4.0	1.9	0.019	0.499	2.4	
RPM-98-4	Stimsonite, No. 94	Asphalt	Rating 8	6/5/00	643			4.0	2.6	0.083	0.345	3.2	
RPM-98-4	Stimsonite, No. 94	Asphalt	Rating 9	9/1/00	731			4.0	2.5	0.028	0.279	2.1	
RPM-98-5	Stimsonite, No. 101LP	Asphalt	Rating 1	9/1/98	0	0.5	0.2	5.0	5.0		0.557	5.0	
RPM-98-5	Stimsonite, No. 101LP	Asphalt	Rating 2	11/23/98	83			5.0	5.0	0.271	0.508	4.0	
RPM-98-5	Stimsonite, No. 101LP	Asphalt	Rating 3	3/2/99	182			4.3	4.1	0.195	0.347	3.8	
RPM-98-5	Stimsonite, No. 101LP	Asphalt	Rating 4	6/2/99	274			4.5	4.4	0.393	0.589	4.0	
RPM-98-5	Stimsonite, No. 101LP	Asphalt	Rating 5	9/1/99	365			4.2	4.4	0.428	0.747	4.0	
RPM-98-5	Stimsonite, No. 101LP	Asphalt	Rating 6	12/7/99	462			4.0	3.3	0.289	0.641	3.5	
RPM-98-5	Stimsonite, No. 101LP	Asphalt	Rating 7	3/13/00	559			4.0	3.4	0.193	0.763	3.7	
RPM-98-5	Stimsonite, No. 101LP	Asphalt	Rating 8	6/5/00	643			4.0	3.6	0.213	0.485	3.9	
RPM-98-5	Stimsonite, No. 101LP	Asphalt	Rating 9	9/1/00	731			4.0	2.7	0.125	0.413	3.1	
RPM-98-6	Stimsonite, No. 101LPCR	Asphalt	Rating 1	9/1/98	0	0.5	0.2	5.0	4.9		0.465	5.0	
RPM-98-6	Stimsonite, No. 101LPCR	Asphalt	Rating 2	11/23/98	83			5.0	4.9	0.225	0.423	3.4	
RPM-98-6	Stimsonite, No. 101LPCR	Asphalt	Rating 3	3/2/99	182			4.2	4.0	0.169	0.316	3.8	
RPM-98-6	Stimsonite, No. 101LPCR	Asphalt	Rating 4	6/2/99	274			4.6	4.4	0.226	0.395	2.9	
RPM-98-6	Stimsonite, No. 101LPCR	Asphalt	Rating 5	9/1/99	365			4.1	4.4	0.356	0.681	3.4	
RPM-98-6	Stimsonite, No. 101LPCR	Asphalt	Rating 6	12/7/99	462			4.0	3.3	0.248	0.578	3.2	
RPM-98-6	Stimsonite, No. 101LPCR	Asphalt	Rating 7	3/13/00	559			4.0	3.6	0.143	0.700	3.3	
RPM-98-6	Stimsonite, No. 101LPCR	Asphalt	Rating 8	6/5/00	643			4.0	3.4	0.197	0.450	3.2	
RPM-98-6	Stimsonite, No. 101LPCR	Asphalt	Rating 9	9/1/00	731			4.0	2.6	0.093	0.385	2.5	
RPM-98-15	Hallen, Ironstar	Asphalt	Rating 1	9/1/98									
RPM-98-15	Hallen, Ironstar	Asphalt	Rating 2	11/23/98	0	0.3	0.2	5.0	5.0	0.123	0.383	5.0	
RPM-98-15	Hallen, Ironstar	Asphalt	Rating 3	3/2/99	99			4.0	3.8	0.082	0.246	2.4	
RPM-98-15	Hallen, Ironstar	Asphalt	Rating 4	6/2/99	191			4.1	4.3	0.048	0.131	0.8	
RPM-98-15	Hallen, Ironstar	Asphalt	Rating 5	9/1/99	282			4.0	3.6	0.050	0.171	1.0	
RPM-98-15	Hallen, Ironstar	Asphalt	Rating 6	12/7/99	379			4.0	2.9	0.083	0.293	1.0	
RPM-98-15	Hallen, Ironstar	Asphalt	Rating 7	3/13/00	476			4.0	1.1	0.007	0.120	0.6	
RPM-98-15	Hallen, Ironstar	Asphalt	Rating 8	6/5/00	560			4.0	1.3	0.037	0.113	1.6	
RPM-98-15	Hallen, Ironstar	Asphalt	Rating 9	9/1/00	648			4.0	1.2	0.016	0.091	0.3	

Housing:
5 = Excellent, Completely intact, in "Like New" condition, good adhesion
4 = Good, Minor scrapes/scratches visible on close examination of surfaces
3 = Fair, Some cuts but none larger than 10 mm
2 = Poor, Some cuts larger than 10 mm
1 = Very Poor, Showing significant wear, no longer protecting reflector
0 = Missing or damaged beyond use

Lens:
5 = Excellent, Completely intact, in "Like New" condition
4 = Good, Minor scrapes/scratches visible on close examination of surfaces
3 = Fair, Some abrasion, none greater then 5 mm
2 = Poor, Some large cuts/cracks/chips greater than 5 mm
1 = Very Poor, Showing significant wear, significant discoloration
0 = Missing or damaged beyond use

Night Visibility:
5 = Excellent, completely intact, Bright, in "Like New" condition
4 = Good, Clearly visible from greater than 100 m
3 = Fair, Some loss in reflectivity, barely visible from 100 m
2 = Poor, Significant loss of reflectivity, visible from 50 m
1 = Very Poor, Significant loss of reflectivity, barely visible, discoloration
0 = Missing or totally Nonreflective

** Night visibility will be conducted during complete darkness by viewing the RPMs at 122 meters from a typical automobile using low-beam headlights.

NTPEP Rating System for SRPM Field Performance

Appendix B

Approved Date 10/23/01
Planning & Programming Engineer
Federal Highway Administration

Prepared By: Theresa C. Gilman
Date: August 24, 2001
Revised: October 15, 2001

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH SECTION

WORK PLAN FOR
CATEGORY II EXPERIMENTAL PRODUCT

FIELD EVALUATION OF SNOWPLOWABLE RAISED PAVEMENT MARKERS ON THE VERMONT INTERSTATE HIGHWAY SYSTEM

Work Plan No. WP 2001-R-6

OBJECTIVE OF STUDY:

To evaluate the effectiveness, durability and life cycle cost of snowplowable raised pavement markers (SRPMs) on Vermont's Interstate Highway System. The product used in this study will be Avery Dennison's Model 101LPCR.

LOCATION:

As part of the Middlesex-Bolton AC IM 089-2(26) project, snowplowable raised pavement markers shall be placed along a 2.1 mile section in Waterbury between MM 66.60 – 64.50 southbound on Interstate I-89, where the existing OGFC is scheduled for replacement. SPRMs will be added to the skip line only, in addition to the durable pavement markings. Following the latest edition of the MUTCD, markers shall be located 80 feet apart.

MATERIAL:

Snowplowable raised pavement markers (SRPMs) are a low-profile marker designed with a low angle ramp for better plowability. Avery Dennison Model 101LPCR will be installed for this evaluation. Markers shall be placed on the roadway only, excluding bridges. Installation will be done in accordance with the manufacturer's recommendations and shall be adhered with an epoxy bonding agent. Installation is expected to take place with ambient temperatures in the 40s to 50s.

Signs will be placed at the beginning and end of the test area informing the public of the beginning and end of the test site location.

COST:

The manufacturer's representative estimates the cost of the markers and installation to be $30-37 per marker, of which $14 to $21 per marker is the installation cost. For the 2.1 mile section, the manufacturer is supplying the devices at no cost resulting in an estimated total installation cost of about $1800 to $2000. Costs associated with the installation of the SPRMs will be paid for under RSCH003-352.

SURVEILLANCE AND TESTING:

Research personnel will monitor the installation of the markers and visually inspect them each spring and fall for the duration of the study. Additional periodic investigations may be done to evaluate product performance in varied conditions. The surveillance shall include the following:

- Durability of the snowplowable raised pavement markers (SRPMs).
- Delineation performance under various light and weather conditions.
- The effect of SRPMs on snow removal operations, as well as the effect of plowing operations on the SRPMs.
- The effect of SRPMs on snow plow blades and adjacent pavement.
- Photographic documentation on the products' performances.

Research personnel will coordinate with District 6 in order to establish a mechanism for tracking maintenance costs and repair activities for the duration of the study. Such costs will be incorporated in the results in order to determine the life cycle cost of SRPMs.

DURATION OF THE STUDY:

The duration of the study will be for a period of five years.

REPORTS:

An initial report shall be prepared to include the installation and initial observations through the first winter season. A final report shall be completed at the end of the fifth year, after the evaluation is complete. Interim reports may be published if warranted.

Agency of Transportation
Materials and Research Division

Date: 16 Oct 2001

Reviewed By:

Robert F. Cauley, P.E.
Materials & Research Engineer