EXPERIMENTAL USE OF RAISED PAVEMENT MARKERS ON I-89 WATERBURY, VERMONT

INITIAL REPORT 85-11

Reporting On Work Plan 82-R-13 & 82-R-15

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

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Date: December 4, 1985

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ABSTRACT

This project evaluates the performance of 59 Stimsonite and 54 Durastone raised pavement markers installed in Central Vermont. Previous reports have shown raised pavement markers to be effective at providing good delineation in night and wet nighttime conditions, and reducing erratic maneuvers at certain geometric highway conditions (1). This experiment was designed to test the snowplowable raised pavement markers in a severe winter environment.

No significant problems were encountered during installation of the Durastone markers. Problems were encountered with the installation of Stimsonite markers.

Both markers were effective in providing nighttime delineation. The Durastone markers out performed the Stimsonite markers in terms of durability and reflector retention.

Many markers sustained damage from snowplowing and winter maintenance operations.

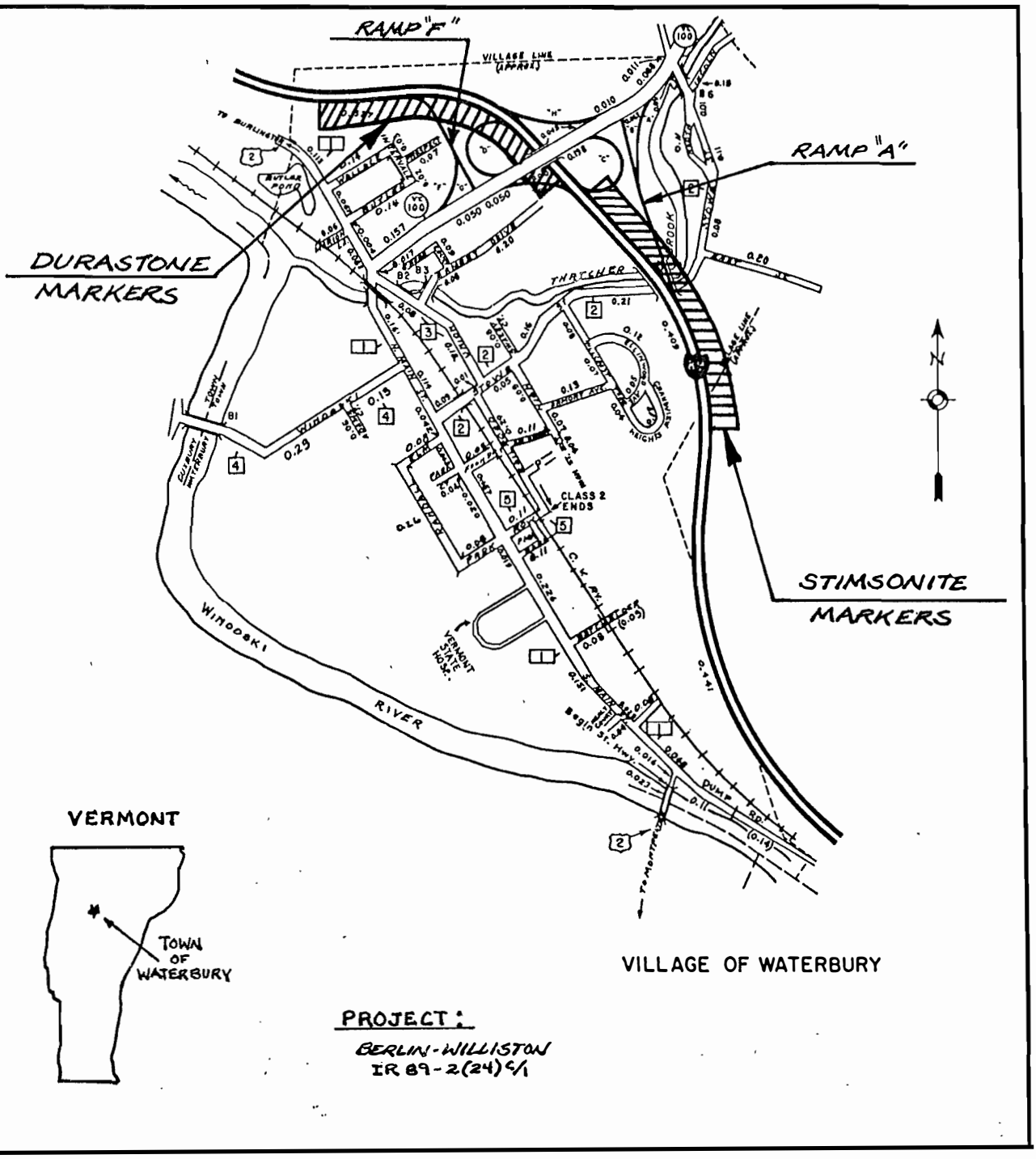
INTRODUCTION

In August of 1983, 113 raised pavement markers were placed at I-89 Interchange #10 in Waterbury, Vermont. Two experimental raised pavement markers were chosen for evaluation, the Stimsonite Model 96 manufactured by the Amerace Corporation, Niles, Illinois and the Durastone marker, manufactured by the Durastone Company, Inc., Lincoln, Rhode Island. The experimental markers were placed in conjunction with the Berlin-Williston I-89-2 (24)C/1 Safety Project. The 59 Stimsonite markers were placed along the centerline of the NB lane and in the gore area of Ramp A between MM 6323± and 6367±. The 54 Durastone markers were placed along the centerline of the SB lane and in the gore area of Ramp F between MM 6418± and 6373±. The experimental test area is shown on the location map on page 3.

This report describes the observations made during installation and initial performance through the first 21 months of service.

LOCATION MAP

N.T.S.



R&D 1985

PRODUCT INFORMATION & APPLICATION PROCEDURES PROVIDED BY SUPPLIER (ABRIDGED)

Stimsonite Model 96

Stimsonite Model 96 is a raised, reflective marker consisting of a hardened metal casting with an attached prismatic reflector. The casting has tapered planes shaped to deflect snowplow blades and protect the reflector. The marker is recessed into the pavement and held in place with epoxy bonding compound.

Saw pavement to match bottom contour of marker housing, using a concrete saw fitted with 18" and 20" diameter saw blades. Clean and dry the sawed area, using brush or air blast. Mix and then pour epoxy adhesive into the two outer grooves and the sawed area between the grooves to approximately 3/8" from the roadway surface to insure that a slight amount of adhesive will overflow when the marker is installed. Place the marker into the grooves with the leveling lugs on the marker resting on the pavement and the four leading tips below the surface of the roadway. Allow sufficient time for the epoxy to harden before traffic is allowed.

Durastone

The Durastone is a Highway Surface Reflective Guidance System. The snowplowable system is protected by abrasion resistant steel and pre-cast construction. Its design lets it take a snowplow hit from any angle and the recessed installa-

tion allows plows to ride smoothly over the marker without jumping or causing damage.

A specially set up milling machine (cold planing) cuts the pavement to a preset depth. The pavement groove is cleaned and partially filled with SET-45.

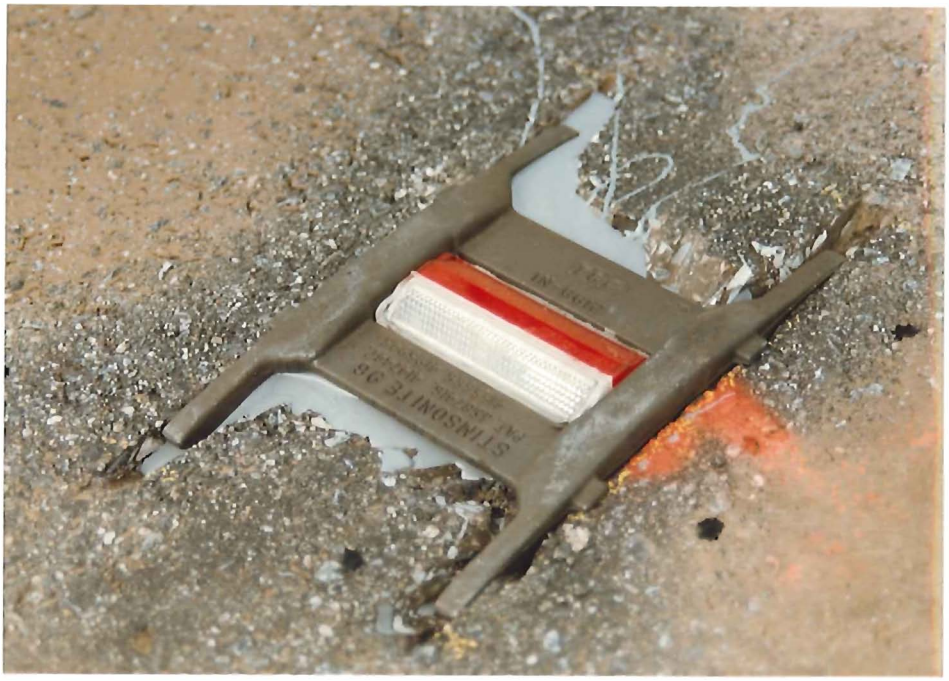
The Durastone marker is pressed into place and measured for proper depth seating. Excess SET-45 is removed and roads are ready for traffic in 45 minutes.

INSTALLATION OBSERVATIONS

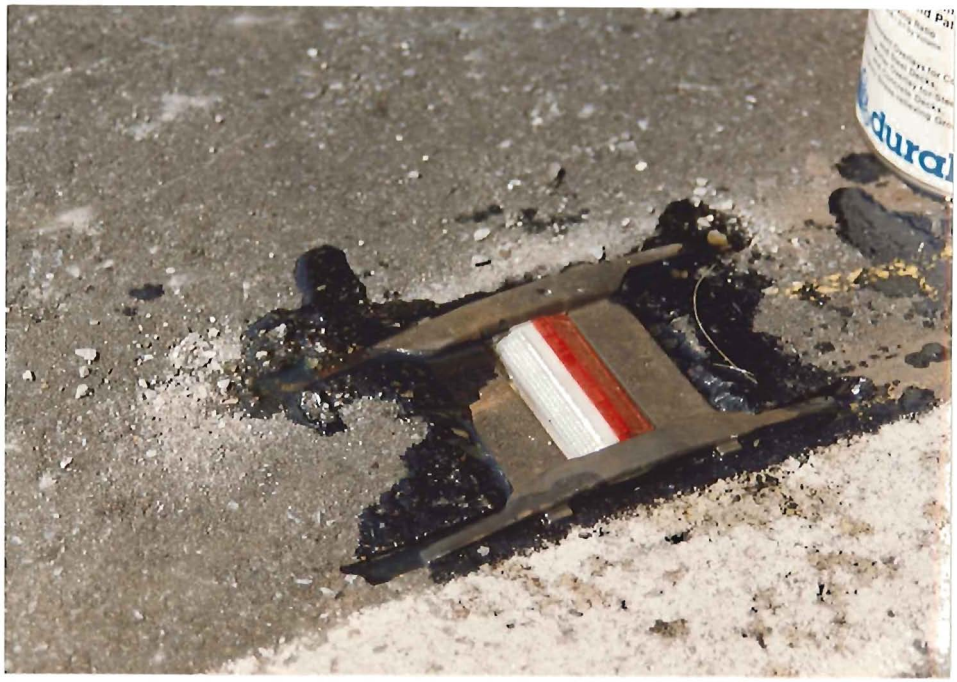
On August 5, 1983, workers began the installation of Stimsonite raised pavement markers on centerline of the northbound lanes of I-89 in Waterbury. All holes were cut using a hand-held concrete saw (rather than the larger 65 HP pavement saw with specifically designed saw head). The channels for the legs or ramps were cut first, then the mid-section of the hole was cut and shaped.

The proper depth saw cut was difficult to obtain, due to lack of previous experience. In many instances, cuts would be made, saw removed, marker tried in cut, only to discover that additional sawing was required. Often the holes for marker legs would be too long and the hole too deep. Photos showing the sawing operation and the hole prior to filling with epoxy can be seen on the following page.

After sawing was completed, the holes were cleaned using compressed air. Initially the two part epoxy was mixed using one gallon of each part which presented a problem. Within eight minutes, the mixture reached its critical point, became too hot and began to set up. A second smaller batch was mixed using one quart measurements which allowed for most of the epoxy to be used before it set up. Overall, the epoxy proved difficult to work with because of the grade and superelevation of I-89 in this area. A small amount of epoxy was poured into the hole prior to installation of the marker. When the marker was pressed into the hole, the epoxy would flow to the low side, as shown in the photograph below:



An attempt to remedy the problem by adding epoxy to the high side often caused it to run out onto the pavement. This problem was encountered on many of the markers as shown in the photograph on the following page.

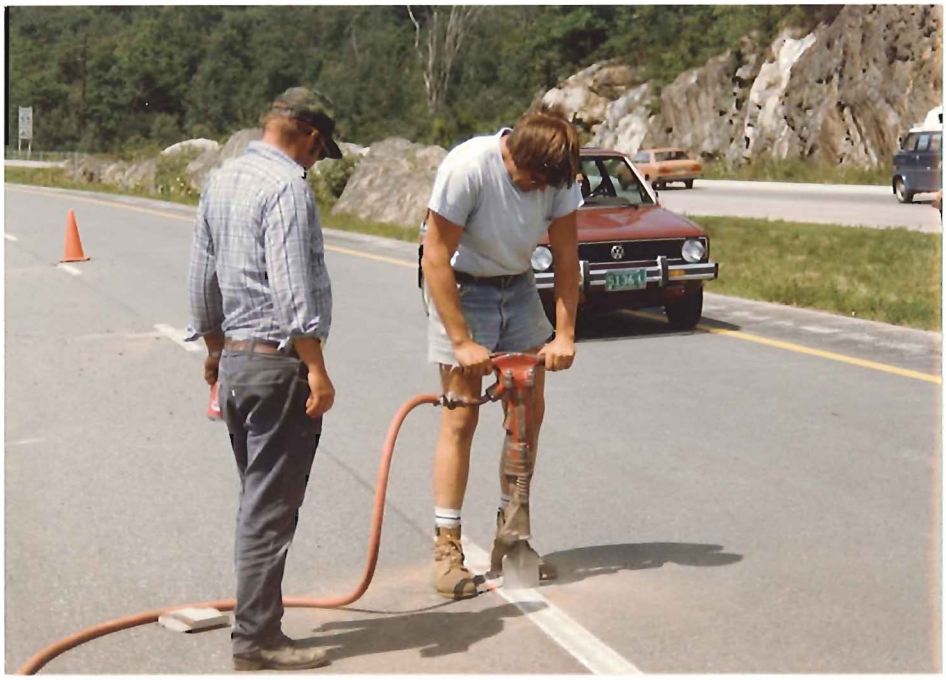


Because of the problem encountered with the first batch of epoxy, the contractor used up the Stimsonite Adhesive and had to use an alternate material. The material used was also a two part epoxy and had greater problems in terms of flowing with the superelevation. The Flex-O-Crete material was used to install six markers, at which point the resident engineer stated that the material was unacceptable. The original epoxy (Stimsonite Epoxy Adhesive #2203-01) had to be reordered and was used for the remaining markers.

On August 8, 1983, the remaining Stimsonite markers were installed. Holes which had been previously cut were distorted during traffic exposure and required reshaping with a hammer. This did not cause any significant problems. There are 45 markers located on centerline betwen MM 6323± and 6367± and 14 in the gore area of Ramp A.

On August 9, 1983, workers began the installation of Durastone raised pavement markers on the centerline of the southbound lanes of I-89 in Waterbury. All holes were cut using a hand-held concrete saw. Two cuts were made along each side and a jack hammer fitted with a spade type blade was used to remove the pavement. The following photograph shows an example of the sawing operation.

The photograph below shows the removal of pavement using the jack hammer after the two saw cuts are made.



The hole was blown clean with compressed air and then moistened using a pail of water and a six inch brush. SET-45 patching material was used to hold the markers in place. A small amount of material was placed into the hole and the marker was dipped into the bucket of water then placed in the hole and pressed into place using a template. The template was provided by the manufacturer. The following photographs show examples of installation procedures.

When the marker was pressed into the pavement with the template or leveling tool, the patching material would flow up around the sides of the marker. The excess patching material was then smoothed out or removed using a trowel. Caution was needed to mix the SET-45 properly in order to avoid a mix which was too wet, causing the marker to sink below the pavement surface.

Workers commented that they preferred working with the Durastone markers over the Stimsonite. Installation of the Stimsonite was found to be slower because the legs, or protector ramps, required more careful sawing operations as compared to the rectangular shaped Durastone marker. In addition, the epoxy used with the Stimsonite demonstrated very poor workability. Because of the rapid cure time, workers had to rush while using the epoxy, therefore found it difficult to do a neat job. These conditions were compounded by the tendency for the epoxy to flow with the grade as discussed previously.

POST CONSTRUCTION OBSERVATIONS

The experimental markers were surveyed periodically for nighttime reflectivity and detailed daytime surveys were performed on April 12, 1984 and May 29, 1985.

Each experimental marker unit was assigned a reference number and plotted on a location plan for consistent and accurate performance monitoring.

Damage or performance categories were developed to ensure uniform ratings when surveys are conducted. The system was designed to record the performance of the actual plastic reflector insert itself, unless otherwise noted. The fourth category, "severe", does address the structural housing if damage is enough to hinder reflectivity. The rating system is as follows:

REFLECTOR DAMAGE

1) OK - No appreciable damage.

2) Slight - (SL) - Small chips (10%-25% of surface are affected) or cracks, reflector still functioning.

3) Moderate - (M) - Some loss of reflector (26% to 75% of surface area affected) surface area may still be functioning.

4) Severe - (S) - Reflector damaged (76% of surface area or greater) no longer functioning. Structural housing may also be damaged or missing.

During the winter of 1983-84 the markers received 599 passes with a snowplow. A survey was conducted on April 12, 1984, to determine damage from winter exposure. The following chart shows the results:

ONE WINTER OF EXPOSURE

- 04/12/84 Survey Results -

	DURASTONE		STIMSONITE	
Rating	Number Of Markers	Percent	Number Of Markers	Percent
OK	25	46	4	7
Slight	19	35	10	17
Moderate	6	11	29	49
Severe	4	7	16	27

A similar pattern was found when the markers were surveyed on May 29, 1985, after two winters (21 months) in place. The second winter, plows passed over the markers 571 times for a combined total of 1170 hits or passes by the snowplow over the 21 month period. Results from the survey can be seen in the chart which follows:

TWO WINTERS OF EXPOSURE

- 05/29/85 Survey Results -

OK	12	22	3	5
Slight	20	37	7	12
Moderate	7	13	24	41
Severe	15	28	25	42

After two winters of exposure, it is apparent that of the two raised pavement markers evaluated in this report, Durastone has been more resistant to traffic and or, snowplow damage.

The Stimsonite markers experienced rapid degradation of the plastic reflector unit as compared to the Durastone. It is believed that the higher profile above the pavement surface (ave. 3/8") of the Stimsonite marker allows for greater damage. The Durastone utilized the same Stimsonite reflector, but with its lower profile (ave. 1/4") the marker has demonstrated far better reflector retention and protection.

The high profile above pavement surface of the Stimsonite markers also caused problems with the plowing operations. Snowplow drivers commented that it was an inconvenience to plow over the markers and it was necessary to slow down to 15 mph when plowing the area. The carbide tip of the plow blade was damaged after 34 hours of use when normally 140 hours time of plowing is expected. Even plowing at 15 mph, half the normal speed, the plow blade would still jump and in some cases leave a windrow of snow behind the marker. This problem was more prevalent in the gore area as shown in the photograph on the following page.

With two winters of exposure the protector ramps of both markers are showing wear. The plows are causing section loss which decreases the height of protection over the plastic reflector unit. In the case of the Durastone marker, some of the ramps have worn (up to about 1/8") down low enough so that the concrete behind the reflector is being worn also. This condition appears to be limited to markers which were set too high at the time of installation. If the wear continues it may be a concern in the future, but is not a problem at this time.

Currently, there are 15 Durastone markers with "severe" damage, three of which are damaged beyond use. The Stimsonite markers have 25 with "severe" damage, one of which was ripped from the pavement. In all of the cases, it is apparent that the markers were set too high during installation, which allowed the plows to damage them severely.

The markers were placed along the centerline of the roadway adjacent to the pavement joint. When the pavement cracked it subsequently contributed to a decrease in performance and in some cases breaking up of the SET-45 material. Patching will be needed at some point in the future.

In terms of reflectivity, both markers provided excellent initial delineation in both wet and dry night conditions. The Stimsonite markers were the better of the two, probably due to the high profile. The maintenance drivers also commented on the effectiveness of both markers, particularly in rainy conditions. The level of performance has dropped off considerably since the installation however (especially with Stimsonite).

Based on the rating system described in this report, reflectors with "ok" and "slight" are still considered effective. The effectiveness or performance of reflectors with a "moderate" rating has been decreased overall and reflectors with a "severe" rating are considered not effective.

The replacement of reflector units with "severe" ratings in the future will be monitored for inclusion in the next report. The current cost of reflectors as quoted by the manufacturer in July of 1985 should be approximately $4.00 each, including adhesive. This price does not include labor. The damaged reflectors will need to be removed and the old adhesive scraped off prior to placement of the new units. Markers which have

severe housing damage (3 Durastone and 1 Stimsonite) will need complete replacement and installation with new units. Some of the markers with "moderate" ratings will need reconditioning also.

COST INFORMATION

A total of 113 raised pavement markers were installed at a cost of $30.00 each during 1983.

The following cost is based on quotes from the manufacturer in June of 1985.

The Stimsonite Model 96, two-way, two color markers sell for $12.96 each. The epoxy is sold by the gallon at a cost of $27.56, which will install approximately 15 markers for a combined cost of $14.80, for materials.

The Durastone marker sells for $8.00 each. A 50 lb. bag of SET-45 costs approximately $15.00 and will install 10± markers for a combined cost of $9.50, for materials.

Installation of the markers could be expected to have a total cost of $35.00 for the Stimsonite and $18.00 for the Durastone. These figures indicate a slight increase in cost for the Stimsonite and a significant decrease for the Durastone marker.

DISCUSSION

After two winters of exposure the Durastone raised pavement markers have out performed the Stimsonite raised pavement markers. Survey results show that 83% (49 markers) of the Stimsonite markers experienced moderate to severe damage after two winters in place (manufacturer states that this is the maximum performance that can be expected in this environment) as compared to 41% (22 markers) of the Durastone markers. In addition, the Durastone markers were easier to install and less of an interference to snowplow drivers due to their lower profile. Both models provided excellent wet and dry night visibility, but the damage or reflector loss was far less with the Durastone. These factors combined with lower relative cost make the Durastone marker acceptable for additional trial use as snowplowable markers.

Future installations of the Durastone marker should be done so that the marker is offset from the pavement joint and painted centerline by 4". This will help prevent breaking of the SET-45 as the pavement joint cracks. In addition, it will be easier for paint crews to do striping without fear of painting over the markers. Since the installation described in this report, the Durastone Company has developed a new procedure for cutting the holes. A Ditch-Witch trench excavator fitted with a small carbide tip drum can cut precise holes at a rate of 90 holes per hour. This procedure is highly recommended by the company because of the cost saving of faster

installation and a better fitting hole which will enhance performance. Maintenance of both markers will be monitored for evaluation and inclusion in the final report.

SUMMARY

* The Stimsonite and Durastone markers provided excellent night and wet-night delineation initially.
* The Stimsonite markers were difficult and messy to install due to spillage of the bonding epoxy.
* The raised profile of the Stimsonite pavement markers causes inconvenience to snowplow drivers and causes damage to the plow blades.
* The Stimsonite marker sustained significant damage during the first winter of service resulting in a reduction in the delineation provided.
* The Durastone marker presented no significant problems during installation.
* The SET-45 used to install the Durastone markers is breaking up and will need reconditioning.
* The Durastone marker has demonstrated better durability than the Stimsonite marker, which in turn has resulted in better delineation.
* The steel housing protector ramps of both products are showing signs of wear from snowplow operations.

RECOMMENDATION

The lower relative cost and satisfactory performance of the Durastone marker make it acceptable for additional trial use as a snowplowable marker.

REFERENCES

(1) "Effect of Raised Pavement Markers on Traffic Performance", William L. Mullowney, New Jersey Department of Transportation, 1982*

"Snowplowable Raised Reflective Pavement Markers at Hazardous Locations in New Jersey", Christopher R. Graf and Arthur W. Roberts, New Jersey Department of Transportation, 1979*

"Evaluation of Raised Snowplowable Pavement Markers", Gary F. Gurney, Prasanta K. Gupta, William G. Roth, Research Report 84, New York State Department of Transportation, 1984.

"Traffic Delineation, Work-Zone Protection, and Winter Maintenance", Transportation Research Record 933, Jerry L. Graham, and Kennth R. Agent, 1983, pp. 18-23

* Reports done in cooperation with U.S. D.O.T., F.H.W.A.

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

WORK PLAN FOR CATEGORY II EXPERIMENTAL PROJECT RAISED PAVEMENT MARKERS WORK PLAN 82-R-13

OBJECTIVE OF EXPERIMENT

To compare the durability and performance of a proprietary raised pavement marker with that of a competitive product and the standard traffic paint used for roadway delineation.

PROJECT

Berlin - Williston IR 89-2(24) C/1

PROJECT LOCATION

Beginning at a point approximately 0.285 mile northwesterly of the Montpelier-Berlin Town Line and extending 31.153 miles to the Williston interchange.

EXPERIMENTAL WORK LOCATION

At interchange 10, Waterbury, on the centerline of the northbound lane and along gore areas of Ramp A (northbound off ramp).

MATERIALS TO BE USED

Stimsonite Model 96 snowplowable, raised pavement markers manufactured by Amerace Corporation, Signal Products Division, 7542 North Natchez Avenue, Niles, Illinois 60648. Phone: (312) 647-7717

APPLICATION PROCEDURE

The installation shall be made as recommended by the manufacturer.

CONTROL SECTION AND TREATMENT

Traffic paint applied along gore areas and the centerline of the northbound on-ramp and raised pavement markers placed along gore areas and the centerline of the northbound off-ramp of interchange 10.

COST

Fiftynine (59) markers required at an estimated cost of $30.00 each for a total cost of $1770.00.

DATE OF INSTALLATION

Prior to October 1, 1982.

DURATION OF STUDY

The project will be evaluated for the length of time required to obtain valid conclusions on the performance of the experimental and control materials.

SURVEILLANCE

The experimental and control materials shall be monitored during installation and visually inspected each spring and fall for the duration of the study. The surveillance shall include the following:

Durability of the raised markers.
Delineation performance under varied light and weather conditions.
The effect of raised markers on snow removal operations.
The effect of raised markers on snowplow blades.
Accident data before and after installation.
Photographic documentation of the life of both experimental and control materials.

REPORTS

An initial report covering the installation and initial observations through the first winter season and a final report drawing conclusions on the effectiveness of the experimental material shall be submitted to the Federal Highway Administration.

Materials & Research Division
Agency of Transportation
July 13, 1982

Reviewed by:

R. F. Nicholson, P.E., Materials & Research Eng.

Date: July 14, 1982

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

WORK PLAN FOR CATEGORY II EXPERIMENTAL PROJECT RAISED PAVEMENT MARKERS WORK PLAN 82-R-15

OBJECTIVE OF EXPERIMENT

To compare the durability and performance of a proprietary raised pavement marker with that of a competitive product and the standard traffic paint used for roadway delineation.

PROJECT

Berlin - Williston IR 89-2(24) C/1

PROJECT LOCATION

Beginning at a point approximately 0.285 mile northwesterly of the Montpelier-Berlin Town Line and extending 31.153 miles to the Williston interchange.

EXPERIMENTAL WORK LOCATION

At interchange 10, Waterbury, on the centerline of the southbound lane and along gore areas of Ramp F (southbound off-ramp).

MATERIALS TO BE USED

Durastone raised pavement markers manufactured by Durastone Company, Inc., P.O. Box 303, Lincoln, R.I. 02865. Phone: (401) 723-7100.

APPLICATION PROCEDURE

The installation shall be made as recommended by the manufacturer.

CONTROL SECTION AND TREATMENT

Traffic paint applied along gore areas and the centerline of the southbound on-ramp and raised pavement markers placed along gore areas and the centerline of the southbound off-ramp of interchange 10.

COST

Fiftyfour (54) markers required at an estimated cost of $30.00 each for a total cost of $1620.00.

DATE OF INSTALLATION

Prior to November 1, 1982.

DURATION OF STUDY

The project will be evaluated for the length of time required to obtain valid conclusions on the performance of the experimental and control materials.

SURVEILLANCE

The experimental and control materials shall be monitored during installation and visually inspected each spring and fall for the duration of the study. The surveillance shall include the following:

Durability of the raised markers.
Delineation performance under varied light and weather conditions.
The effect of raised markers on snow removal operations.
The effect of raised markers on snowplow blades.
Accident data before and after installation.
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