EVALUATION OF RECESSED, SNOWPLOWABLE MARKERS FOR CENTERLINE DELINEATION

by

Frank D. Shepard
Research Engineer

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

Virginia Highway & Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia Department of Highways & Transportation and the University of Virginia)

In Cooperation with the U. S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

July 1979
VHTRC 80-R3

TRAFFIC RESEARCH ADVISORY COMMITTEE

MR. D. B. HOPE, Chairman, District Engineer, VDH&T

MR. R. G. CORDER, Rail Division Administor, VDH&T

MR. L. H. DAWSON, JR., Asst. Traffic & Safety Engineer, VDH&T

MR. J. E. GALLOWAY, JR., Asst. Materials Engineer, VDH&T

DR. JAMIE HURLEY, Assistant Professor of Civil Engineering, VPI & SU

MR. C. O. LEIGH, Maintenance Engineer, VDH&T

MR. R. F. MCCARTY, Safety Coordinator, FHWA

MR. J. P. MILLS, JR., Traffic & Safety Engineer, VDH&T

MR. W. C. NELSON, JR., Asst. Traffic & Safety Engineer, VDH&T

MR. R. L. PERRY, Asst. Transportation Planning Engineer, VDH&T

MR. B. C. PIERCE, District Traffic Engineer, VDH&T

MR. R. N. ROBERTSON, Assistant Head, VH&TRC

MR. F. D. SHEPARD, Highway Research Scientist, VH&TRC

ABSTRACT

The purpose of the evaluation reported here was to determine the feasibility of using raised pavement markers placed in pavement grooves as a guidance aid for motorists during nighttime inclement weather conditions. Emphasis was on the visibility and durability characteristics of the markers as influenced by the method of placing them in pavement grooves.

It was concluded that the method employed for placing these raised markers in the pavement is feasible for use as a means of protecting the marker from snowplow damage while providing guidance for motorists. However, it is recommended that this method of placing raised pavement markers in grooves not be used for centerline delineation until a method of installation is available which will decrease the cost of installing the markers.

EVALUATION OF RECESSED, SNOWPLOWABLE MARKERS FOR CENTERLINE DELINEATION

by

Frank D. Shepard
Research Engineer

INTRODUCTION

Roadway delineation in the form of painted center- and edgelines have been used extensively to provide the motorist guidance, regulatory, and warning information. Maximum benefit from the markings is provided under low visibility conditions encountered in nighttime driving. In rainy weather at night, a water film covers the beads and paint markings and diffuses the headlight beams. Often the result is a drastic reduction in the light reflected from the markings, and thus a reduction in the effectiveness of the guidance function when it is most needed. Raised pavement markers have been used to supplement the regular painted lines under such driving conditions, but their use has been limited in areas that experience appreciable snow because of the extensive damage they incur from snowplows. There are markers specially designed to withstand snowplowing, but even they have been reported to sustain significant damage in states where snowplowing is frequent.(1) Recently, research has indicated that this problem can be avoided by using raised pavement markers in grooves cut into the pavement.(2,3)

Although markers placed in grooves were thought to be an effective means of providing pavement delineation, there were questions concerning the feasibility of their use for this prupose, e.g., questions concerning the placement of the markers in relation to pavement type and grade and the influence of the groove geometry on the amount of light reflected by the marker. To provide answers to these questions, the research reported here was undertaken.

PURPOSE AND SCOPE

The purpose of the evaluation was to determine the feasibility of using raised pavement markers placed in pavement grooves as a guidance aid for motorists during nighttime inclement weather conditions. Emphasis was on the visibility and durability of the markers as influenced by the method of placing them in the pavement grooves. The research was limited to a study of commercially available, corner-cube, raised pavement markers placed on limited access highways.

PROCEDURE

Marking System

The marking system consisted of pavement markers placed in longitudinal grooves cut along the centerline of the highway pavement. The markers were Stimsonite Type T99 units, which are 4 in. (10 cm) wide, 2 in. (5 cm) long and approximately 1/2 in. (1.3 cm) deep. The marker is a standard unit with a special surface having a high resistance to damage by abrasion.

The groove was 4 in. (10 cm) wide and 5 ft. (1.5 m) long with the cross section shown in Figure 1. The 5 ft. (1.5 m) longitudinal groove was placed between the centerline skips with the reflecting unit positioned at the end downstream from traffic. A section 4 in. (10 cm) wide, 2 in. (5 cm) long and 1/2 in. (1.3 cm) deep was cut for the placement of the marker, which was attached using an epoxy adhesive. Also transverse drainage grooves 1/2 in. (1.3 cm) by 1/2 in. (1.3 cm) were cut to carry water and debris from the longitudinal grooves holding the markers. The length of these drainage grooves depended on the pavement slope; however, they were sufficiently long to assure proper drainage.

In addition to the units placed in longitudinal grooves, the experiment included units placed in steel, snowplowable castings, Stimsonite Type T99 that were attached to the pavement surface.

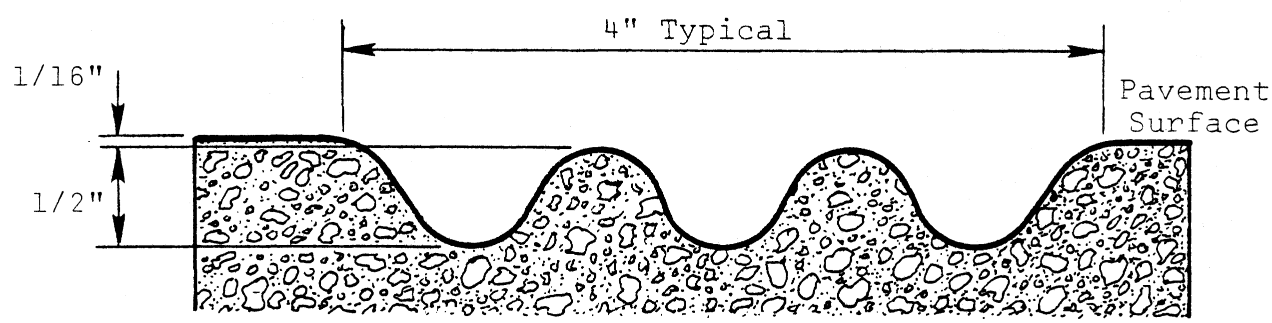

Figure 1. Cross section of groove.
Note: 1 inch = 2.54 cm.

UI 0359

Test Site

The evaluation was conducted on a section of Interstate 81 near Salem. This rural section has an average annual daily traffic of 12,000 vehicles in each direction. It encompasses both bituminous and concrete surfaces and sufficient grades for the observation of the marker systems under a variety of conditions. The average annual snowfall for this area is 24 in. (60.9 cm).

Test Sections

Each test section was 1,600 ft. (487.7 m) long, and the 20 markers were placed at 80 ft. (24.4 m) intervals between alternate centerline skips. The four such installations made were all on a tangent section of roadway. Two were on bituminous pavement and two on concrete; and for each pavement type, one installation was on a positive grade and the other on a negative grade.

In each section, the markers were installed in recessed grooves with peaks extending (a) to the marker face, (b) 2 in. (5.1 cm) from the face, and (c) 2 ft. (60 cm) from the face. Figure 2 shows the variables for each section. The markers in steel, snowplowable castings were placed on the pavement surface at the end of the test sections.

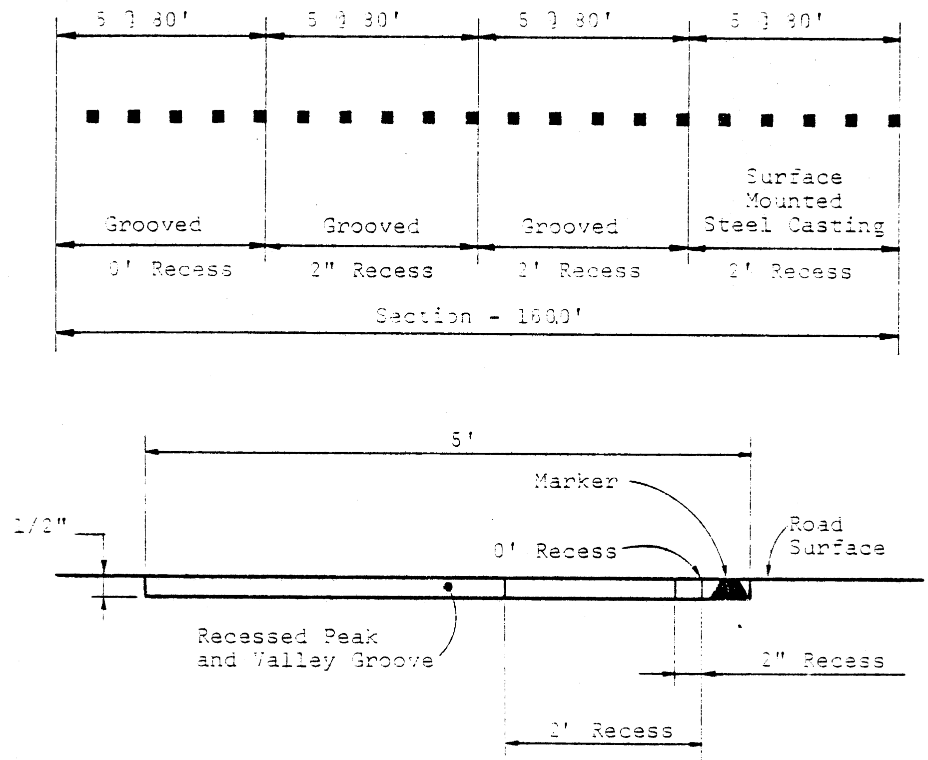

Figure 2. Variables included in each section.

0360

Installation

The recessed groove in the stope of the cross section in Figure 1 was cut with a concrete saw modified to accommodate a special diamond-drum cutter assembly as shown in Figure 3. Figure 4 shows a groove being cut while Figure 5 shows the groove. The 2 in. x 4 in. (5 cm x 10 cm) rectangular area for the marker, shown in Figure 6, was cut with a hand-held concrete saw and impact hammer. Sufficient material was removed so that the marker, once epoxied in place, was flush with the pavement surface as shown in Figure 7. Surface-mounted steel castings, as shown in Figure 8, were installed in the manner normally recommended by the manufacturer.

All installations were made in November and December 1977.

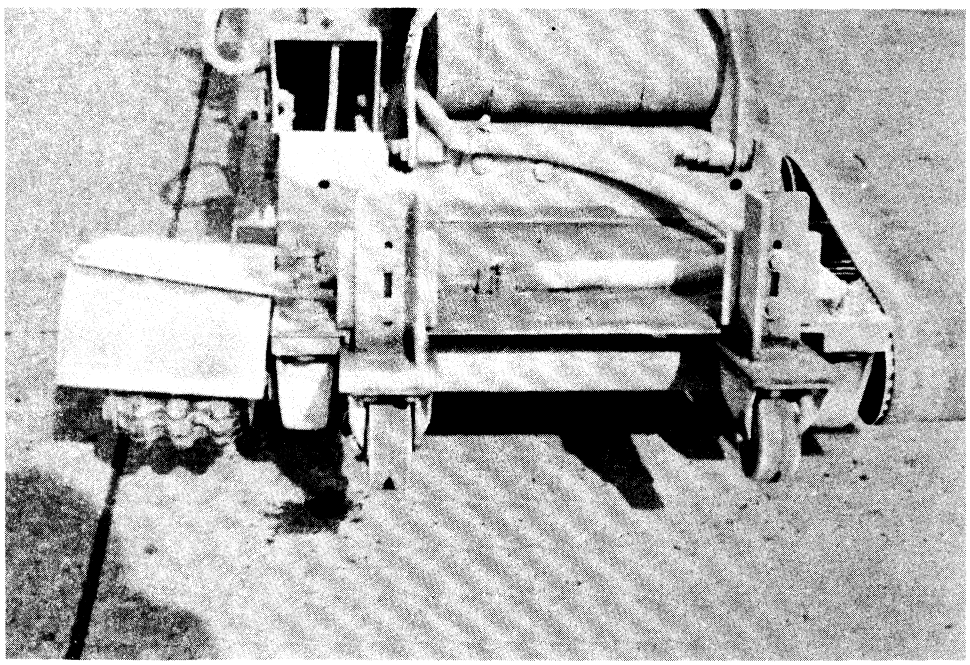

Figure 3. Concrete saw modified to accommodate special diamond drum cutter.

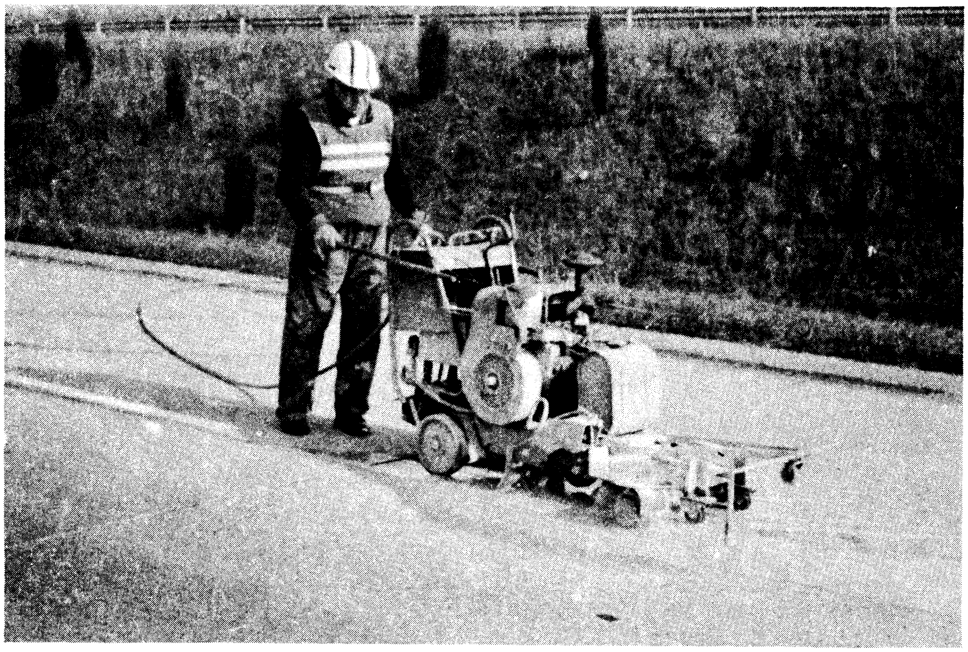

Figure 4. Cutting groove in pavement.

Figure 5. Finished groove.

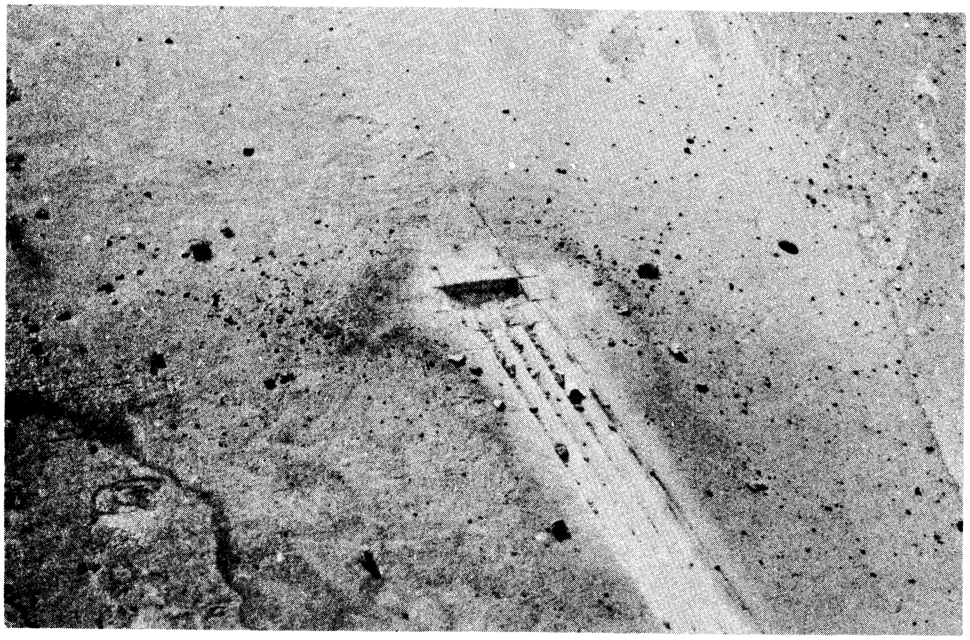

Figure 6. Rectangular area for emplacing marker.

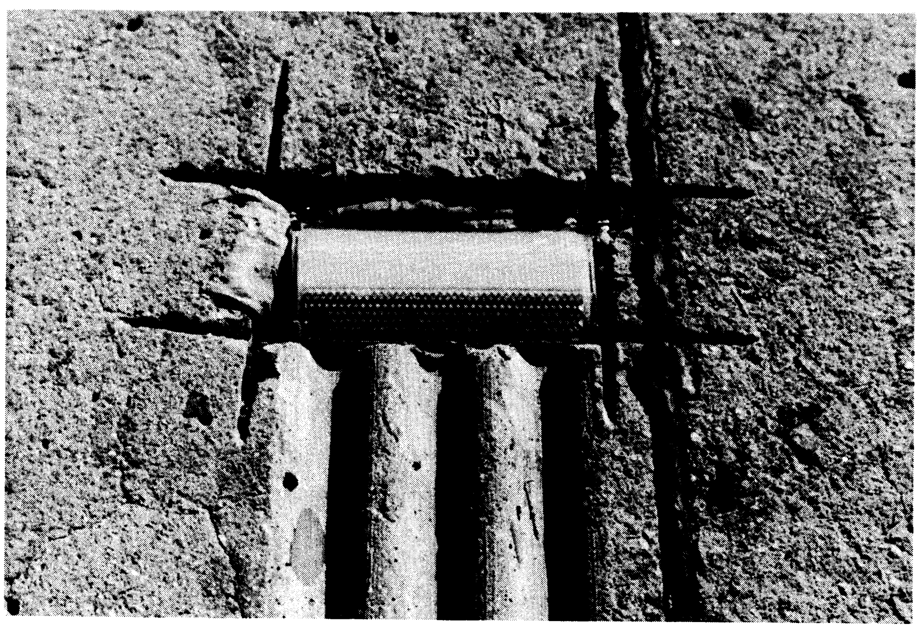

Figure 7. Marker emplaced in concrete pavement.

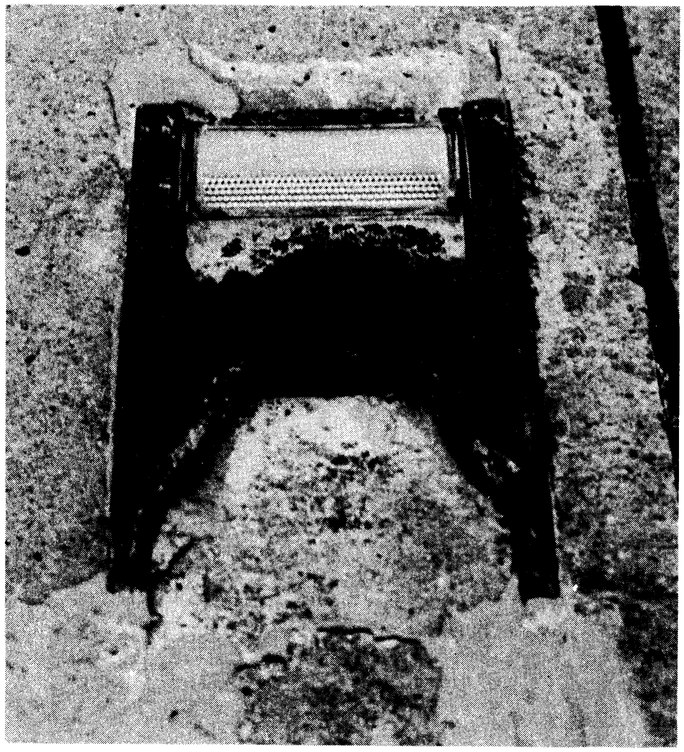

Figure 8. Steel casting and marker on pavement surface.

EVALUATION

The evaluation of the marking systems was a subjective one concerned primarily with the durability of the markers and with the visibility characteristics under clear and inclement weather conditions at night.

Durability

The durability of the installations was noted by observing damage to the markers and the recessed grooves. Damage was rated subjectively in terms of the estimated percentage of the marker's face that was found to be intact, i.e., free from scratches, chipping, etc. The ratings were then averaged for each variable within each test section; namely, the distance of the peak of the groove from the marker face. Any chipping, deterioration, etc., of the grooves was also noted.

Visibility

The visibility characteristics of the markers at each installation were subjectively evaluated by the author and a technician by noting the distances at which they could be seen at night under dry and wet conditions. Also a comparison of the visibilities of the systems was made by rating the systems on a scale of 0 to 10, with 10 denoting the brightness or degree of retroreflection of a new and unobstructed marker positioned on the road surface and 0 a marker that had completely failed. All observations were made from a vehicle approaching the marking system with both high-and low-beam headlights.

Debris Buildup

Any accumulation of debris within a groove was noted along with its proximity to the marker. The influence of any debris on the visibility of the marker was also noted.

RESULTS

Durability

The estimates of the percentages of marker surfaces remaining intact, which were derived from visual inspections, are shown in Table 1. It is noted that all damage to the markers placed in grooves resulted from normal traffic contact and not snowplowing; however, those placed in steel castings exhibited damage from snowplows.

Table 1

Percentage of Marker Faces Intact

Test Section	Distance--Peak to Marker			Steel Casting
	0	2"	24"	
Bituminous + Grade	76	74	71	73 (3 missing)*
Concrete + Grade	92	91	86	90 (4 missing)
Bituminous - Grade	85	84	72	60 (3 missing)
Concrete - Grade	94	88	83	73 (1 missing)

* missing refers to reflectors rather than castings

Most of the damage to the markers placed in grooves was in the form of surface cracking. Figure 9 shows an example of the damage sustained by the markers. There was very little chipping or breaking of the marker face that would cause complete loss of reflective qualities for that portion damaged.

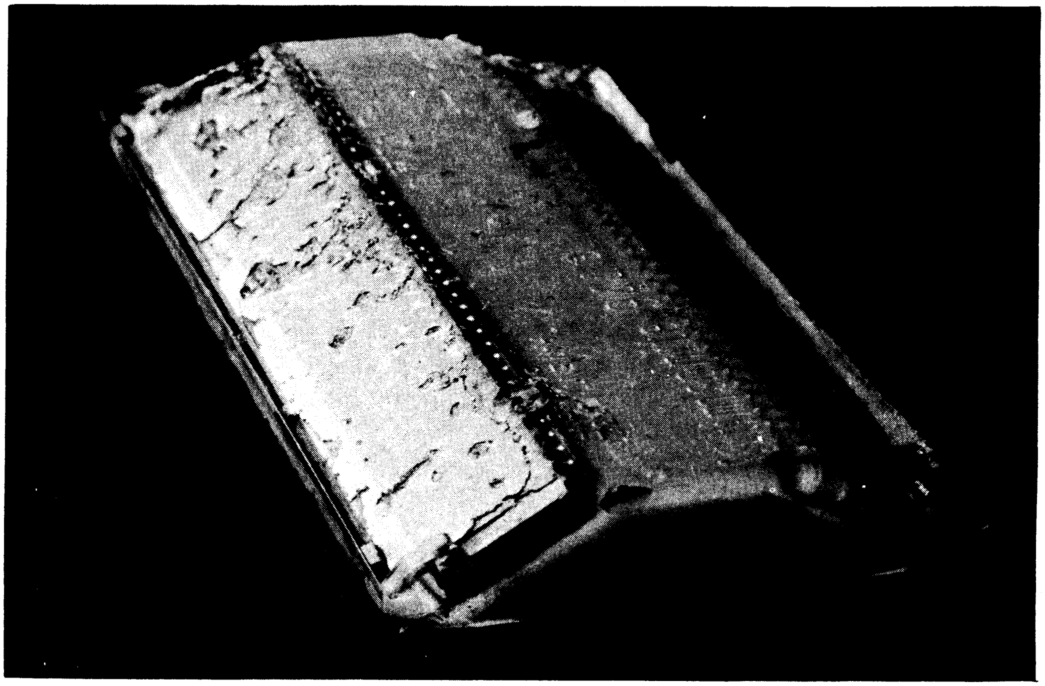

Figure 9. Example of damage to marker face.

Those markers emplaced in bituminous surfaces showed more damage than those in concrete surfaces. The reason for this is not known; however, it could possibly be attributable to the loose gravel noted on the bituminous surfaces. Of the installations on bituminous pavements, the one on the positive grade exhibited more damage than that on the negative grade. For the installations of concrete pavements, there was little difference.

In all cases, damage increased with distance from the marker face to the start of the peaks, ostensibly because the groove peaks protect the marker face from traffic.

For all installations, markers placed in the steel castings had more damage than those placed in grooves, with an overall loss of 55%. Fifteen percent of the castings were gone and 25% were damaged or cracked, all as a result of damage by snowplows. These castings were the old model Stimsonite T-99 markers.

There was no evidence of the grooves being damaged by either snowplows or traffic. Also no buildup of debris was seen in the grooves cut in front of the marker or those cut for drainage.

Visibility

In the evaluation of visibility it was very difficult to distinguish any differences between variables within each marker installation and differences between installations, primarily because of nonuniformity of highway grades; therefore, the visibility results are limited to an estimate of the number of markers visible and an overall rating for each installation. All markers were exposed to traffic for 20 months. This time period encompassed two winters with a total snowfall of 90 in. (228.6 cm), which is 21 in. (53.3 cm) above the expected average of 24 in. (61.0 cm) per year. For each site, during dry conditions approximately 5 to 6 markers were visible with vehicle lights on low beam and 10 to 11 markers with the lights on high beam. For wet conditions at night, approximately the same number of markers were visible with low beams as were visible with high beams. It is noted that markers were placed 80 ft. (24.4 m) apart and that this observation includes only those markers placed in grooves. Those markers placed in castings were visible from further distances than those in grooves. This finding would be expected because placement on the road surface exposed the entire marker face for retroreflection, regardless of its distance from the vehicle.

A rating of 8, which is definitely considered to be in the effective range, was given the markers in the grooves on the four test sections. Some markers were brighter than others; however, the rating took into account the relative retroreflectivity of all markers. Also, where the grooves of the peaks extended to the marker face, a silhouette of the peaks could be seen on the face of the nearest 2 or 3 markers; however, beyond that point, the marker brightness "washed out" this pattern and the marker appeared as a bright spot. As expected because of their exposure on the surface, the markers placed in castings achieved a slightly higher rating.

Observations of the markers after a snow revealed an accumulation of salt residue along the bottom of all markers, with those markers with the peaks extending to the marker face having a greater portion of the face covered. While protecting the face, the peaks also prevent the cleaning of the face by traffic. It is noted, however, that during the warmer months observations revealed very little dirt accumulation regardless of the peak location. Also, it is noted that although residues may accumulate on the marker face, that portion of the face behind the peak is unavailable for retroreflectivity since it is blocked from the vehicle lights by the peak.

It is not known how much influence the peaks have on the amount of light reflected. This amount is affected by many variables, including the distance of the peak of the groove from the marker face and the position of headlights relative to the marker. The results obtained within the scope of this research were inadequate for determining the exact relationship between durability and retroreflectivity as a function of the distance from the groove peak to the marker face. The anticipated life of the marking system should be longer than the 20 months the markers have been in place; so observations relating to this relationship should be continued.

COST

The primary purpose of this project was to determine the feasibility of placing raised pavement markers in pavement grooves as a means of protecting the markers from snowplowing while providing guidance for motorists during nighttime inclement weather. Cost was not a primary consideration, but as with other facilities, it should be commensurate with need. For the installations reported on here it is estimated that the cost per in-place marker was approximately $40. This cost includes the price of the marker and adhesive plus labor and equipment. Although this cost could be reduced by improving the method of cutting the groove where the marker is placed and through better coordination for large installations, the cost for the procedure described in this report is prohibitive. It is the author's understanding that research is under way by the FHWA for the fabrication of a prototype of a machine which will simultaneously cut a groove and epoxy the marker into place while moving. It is hoped that this anticipated process will make the concept of placing markers in grooves economically feasible.

The concept of placing a groove in the pavement as new plant mix is being placed might be investigated as a means of economically securing a groove for marker placement. Grooves could possibly be stamped in the pavement by rollers, etc.

CONCLUSIONS

Based on results of approximately 20 months, including two severe winters, of exposure to traffic, the method of placing raised markers in grooves cut in the pavement is feasible as a means of protecting the marker from snowplow damage. All markers installed in grooves were still intact and provided an acceptable level of retroreflectivity.

As the distance from the start of the peak and valley groove to the marker face decreased, the marker durability increased slightly.

Over half of the markers installed in steel casting were gone, with 15% of the castings missing. The remaining markers exhibited better reflective qualities than did those placed in grooves. It is noted that the type of casting used has been replaced on the market by an improved model.

RECOMMENDATIONS

It is recommended that the method of placing raised pavement markers in grooves not be used by the Department for centerline delineation until an improved method of installation is available which will decrease the placement cost to an acceptable level.

Surveillance of the installation should continue for the purpose of gathering additional information on marker durability and visibility over time for both protected and unprotected marker faces.

REFERENCES

1. Shelly, T. L., and Rooney, H. A., Development and Evaluation of Raised Traffic Lane Markers: 1968 to 1971, Research Report M & R No. 635152 Materials and Research Department, California Division of Highways, October 1971.

2. Bryden, J. E., Allison, J. R., and Gurrey, G. F., Grooved Stripes for Plow-Resistant Wet-Night Lane Delineation; Phase II, FHWA-RD-76-131, August 1976.

3. Shepard, F. D., Evaluation of Raised Pavement Markers for Roadway Delineation During Fog, Virginia Highway & Transportation Research Council, October 1976.

0370