

Evaluation of Snowplowable Markers

FHWA-TS-82-222

October 1982



U.S. Department
of Transportation
**Federal Highway
Administration**



REPRODUCED BY
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SPRINGFIELD, VA. 22161

FOREWORD

This Tech Share report summarizes the results of a study to evaluate available snowplowable markers under similar traffic and snowplowing operations. The report should be of interest to traffic and maintenance engineers responsible for installing and maintaining roadway delineation systems.

Research for improved and practical delineation materials is included in the Federally Coordinated Program of Highway Research and Development in Project 11, "Traffic Lane Delineation Systems for Adequate Visibility and Durability."

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1. Report No. FHWA-TS-82-222		2. Government Accession No.		3. Recipient's Catalog No. PB8 3 187229	
4. Title and Subtitle Evaluation of Snowplowable Markers				5. Report Date October 1982	
				6. Performing Organization Code	
7. Author(s) J. G. Pigman and K. R. Agent				8. Performing Organization Report No. UKTRP-82-7	
9. Performing Organization Name and Address Kentucky Transportation Research Program College of Engineering University of Kentucky Lexington, Kentucky 40506				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No. KYP-79-206	
12. Sponsoring Agency Name and Address Kentucky Department of Transportation State Office Building Frankfort, Kentucky 40622				13. Type of Report and Period Covered Final	
				14. Sponsoring Agency Code	
15. Supplementary Notes Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration. Study Title: Field Evaluation of Snowplowable Pavement Markers					
16. Abstract The objective of this study was to evaluate available snowplowable markers under similar traffic and snowplowing operations. There were five different markers tested which included the following: 1) Stimsonite 96, 2) Dura-Brite, 3) recessed, 4) Kingray, and 5) Prismo Roadstud. The Stimsonite 96, Dura-Brite, and recessed markers were found to be acceptable snowplowable markers. All three of these markers were found to have adequate reflectivity during both dry and wet nighttime conditions. This reflectivity was maintained over the test period and the markers proved to be durable when subjected to snowplow operations. However, considering all available input, the recessed marker is the most functional and cost-effective.					
17. Key Words Snowplowable Markers Installation Reflectivity Durability			18. Distribution Statement No restriction. This document is available to the public from the National Technical Information Service, Springfield, Virginia 22161.		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 41	22. Price

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INTRODUCTION

Many reasons can be given to support the need for efficient roadway delineation systems; however, all are related to the safety aspects of the highway which may improve and simplify the driving task. Much of the research and development has been directed at the problem of providing adequate delineation during wet nighttime and other poor visibility conditions when most pavement markings are least effective.

Major emphasis was placed on the problem of wet-nighttime visibility when Congress created a pavement-marking demonstration program and a special research and development program as part of the 1973 Federal-Aid Highway Act. Specifically, Section 206 (a) authorizes the Secretary of Transportation "to develop new traffic control materials, devices, and related delineators to assist the traveling public during adverse weather and nighttime driving conditions."

Raised pavement markers have proven to be an effective delineation treatment during wet-nighttime and poor visibility conditions, especially so in states outside the "snowbelt." However, the problems resulting from snowplowing are particularly severe and marker applications are limited. Even in a border state such as Kentucky, where over one million raised pavement markers have been installed, only one winter of heavy snow and resultant snowplowing can destroy a significant part of the installations.

In an attempt to provide wet-nighttime delineation using the concept of raised pavement markers, considerable effort has been devoted to developing snowplowable pavement markers. The most widely used and most successful approach to development of a snowplowable marker has been to retain the reflective unit of a raised pavement marker and attempt to protect it from snowplows. Usually the reflective unit is encased or surrounded by a material which is resistant to snowplow blades. Consistently mixed results, particularly with regard to cost-effectiveness of the markers, have been the rule in almost all experimental and

large-scale installation projects.

Several types of snowplowable markers have been field tested in the past few years. These tests have been conducted independently under different field conditions. The objective of this study was to evaluate all available snowplowable markers under similar traffic and snowplowing operations.

BACKGROUND

This project was originally designed to compare the durability of the Stimsonite 96 (Figure 1) and Konelite (Figure 2) markers. However, other markers were added to the evaluation as a result of the desire to include all available snowplowable markers. Problems with development and production of the Konelite marker delayed installation. Considering the time requirements of this project, it was decided that the Konelite marker was not going to be available for installation and evaluation. Following is a description of the Konelite marker:

The Konelite marker is a five-piece unit, housed in a can molded of A.B.S. plastic. A molding of synthetic rubber, a collar-like precision-molded piece, fits over the can to seal out moisture and dirt. It is held in place on the can by a ring of Lexan that incorporates slots which lock into a groove in the can. It holds the lens of Lexan and the lens cover. During operation, the lens is depressed by vehicle tires or a snowplow blade into the body of the marker which, in theory, would make the marker snowplowable. The lens is wiped and cleaned by the rubber molding each time it is depressed.

A recent survey of the use of snowplowable markers found that the vast majority of existing markers were the Stimsonite marker -- either the Stimsonite 96 model or the older Stimsonite 99 model (1). This marker consists of an iron casting with an attached prismatic retroreflector. Both ends of the castings

are shaped to deflect a snowplow blade. This marker has been evaluated (2, 3, 4) but had not been compared directly with other markers.

The survey found that several states are experimenting with a recessed marker (1). This installation involves placing a regular or low-profile raised marker into a groove cut into the pavement so the top of the marker is flush with the pavement surface. A recessed marker was included in this study using a regular raised marker in the groove. Some installations have involved a groove with a cross section which had several peaks and valleys (5, 6). However, this study used a full-width groove similar to installations in Tennessee and South Carolina. The Stimsonite 911 marker (Figure 3) was installed in the groove.

In an effort to include all other available snowplowable markers in the test, various manufacturers were contacted. As a result, two additional markers were included in the original installation, and a small number of another marker was installed shortly thereafter. The new markers were the Dura-Brite (Figure 4), Kingray (Figure 5), and Prismo (Figure 6). The Dura-Brite marker includes a steel frame set in pre-cast concrete. The replaceable reflector is mounted between the two steel runners which protrude above the pavement surface. The runners are shaped so that the marker can be plowed at an angle. The Kingray marker involves placing the reflective lens in an insert which is depressed in an outer sleeve when struck by a tire or snowplow. The Prismo roadstud is a diecast aluminum marker which provides an anchor stem for additional durability.

A few other potential snowplowable markers were investigated. However, the development or marketing of these markers had either stopped, or was progressing so slowly that they were not available for testing.

The lane delineation survey also obtained information about installation costs (1). The average cost of numerous installations of Stimsonite markers was approximately \$16 per marker but a more accurate current cost would be about \$20

per marker when installed in large quantities. Cost data was not available for the Dura-Brite at the time of the survey but estimates place the cost of this marker to be similar to the Stimsonite. No cost figures are available for large installations of the Kingray marker but its cost would not be less than that of the Stimsonite or Dura-Brite. The most inexpensive snowplowable marker installed to date has been the recessed marker with reported costs per marker in the \$8 to \$9 range. These costs compare to a cost of approximately \$3 per marker for a regular, raised pavement marker.

INSTALLATION

Four of the test marker types were installed in December 1980. The fifth type, the Prismo roadstud, was installed by the manufacturer in January 1981. A contract was awarded for the installation of 150 each of the Stimsonite 96, recessed, Dura-Brite, and Kingray markers. The contract was for \$31,371.12 or \$52.29 per marker. Installation of such a small number of markers resulted in this extremely high cost. Fifty-two of the Prismo markers were installed at no cost by the manufacturer.

A copy of the contract for installation of these markers is included in the Appendix. These installation specifications give a detailed description of each marker, specific installation instructions, and detailed drawings. Also included is similar information for the Prismo roadstud.

Two test locations were selected. Both locations were four-lane divided highways. One location (US 68 in Fayette County) had a portland cement concrete pavement while the other (US 27 in Jessamine and Garrard Counties) had a bituminous pavement. The following criteria were used when selecting the test locations.

1. The roadway could be plowed with any type of snowplow blade which is used in normal snowplow operations.
2. A minimum AADT of 15,000 was

preferable.

3. Part of one test section should be in a high weave area.
4. Test sections should not have roadway lighting.

The markers were only to be installed on skip lines.

All snowplow operations were performed with a steel blade. In the past, rubber-tipped blades have been used on roadways with raised markers. Also, virtually all multi-lane highways in Kentucky which did not have roadway lighting have had raised markers added. This meant that the snowplowable markers had to replace regular raised markers. For practical reasons, isolated, short sections of multi-lane highways had to be found for the test installation since maintenance personnel could not be expected to use a different snowplow blade for a short section of a long multi-lane highway. Arrangements were made with maintenance personnel to assure that the two short sections of highway would be plowed with the normal blade (a steel blade).

Both test sections were in areas with no roadway lighting. The Fayette County location was adjacent to an interchange and contained several access points which generated a significant amount of lane changing. The 1980 AADT of the Fayette County location was 16,400 while the AADT at the Jessamine-Garrard County location was 7,000. The Jessamine-Garrard County location included a section with a substantial grade. Markers were placed on both the uphill and downhill grade. The old, regular markers were removed prior to installation of the snowplowable markers.

In general, the installation pattern involved alternating the markers so that every fourth or fifth marker was the same. The exception was one direction at the Fayette County location where several of each marker type (22 or 23) were placed together. This was done so that a comparison between the number of markers visible in a line could be made. Also, a regular Stimsonite 911 marker was placed in the pattern in one direction at the Fayette County location. All markers were installed at a 40-foot spacing. A

description of the pattern and spacing of markers used in the installation is in the APPENDIX.

Installation of each of the markers required either a saw cut or a drilled hole in the pavement. The cuts for the Stimsonite 96, recessed, and Dura-Brite markers were made using diamond-tipped sawblades. The Kingray and Prismo markers required drilling holes in the pavement. The average times for cutting or drilling, installing the marker, and for the adhesive material to dry are given in Table 1. Sawing or drilling time for the Stimsonite 96, recessed, and Prismo markers should be representative of larger installations. However, sawing and drilling time for the Dura-Brite and the Kingray, in particular, would be less on larger installations where better procedures could be used.

Times to install the markers in the prepared cut would also be less in a large scale operation. The time to install the markers was highest for the Kingray markers and shortest for the recessed markers. The factor which contributed most to the higher time to install the Kingray marker was a requirement that the marker be held in position until the bitumen hardened enough such that the marker would not rotate out of alignment. The longest drying times were for the Stimsonite 96 and recessed markers where epoxy was used. Much shorter drying times were found for the Kingray and Prismo markers which used a bituminous material and for the Dura-Brite marker which used a material called SET-45 (a magnesium phosphate cement). Photographs showing the sawing or drilling operation, the finished cut, and the installed marker are given in the APPENDIX for each marker.

RESULTS

The results consisted of an evaluation of the reflectivity and durability of the markers. The markers were evaluated for a 15-month period after installation. Day and night inspections were conducted quarterly. Additional inspections were made after snowplow

operations. There was no significant snowfall requiring snowplows in the first winter so a snowplow test on wet pavement was made over a portion of the test installation. There were snowplow operations during the second winter resulting in the markers being subjected to a total of from six to eight snowplow passes. The visual inspections were supplemented with photographs.

Reflectivity

Nighttime observations were made immediately after installation and then on a quarterly basis. Photographs were taken during each inspection. Comparisons could be made between markers installed in the various patterns as described in the APPENDIX.

The first inspection, immediately after installation, of the four original markers found all markers to be very effective. A photograph taken in December 1980 at the Jessamine County, southbound installation enables a comparison of reflectivity (Figure 7). Observations of the Prismo markers showed that this marker was also effective. While the Prismo marker was not as reflective as the others, it still provided adequate delineation and was particularly effective on curved sections.

Results of the periodic nighttime evaluations of reflectivity showed that most of the marker types maintained their reflectivity very well during the test period. Photographs of the long sections of markers installed at the Fayette County, northbound installation are shown in Figures 8-11. Photographs were taken during nighttime inspections on the dates shown in the figures. The photographs given here show the markers at the beginning and ending of the test period. The test period was 16 months. The Prismo marker is not shown because the markers placed on the section with a continuous pattern were removed by snowplows shortly after installation. The only marker that suffered a substantial loss of reflectivity was the Kingray marker. This loss of reflectivity apparently resulted from dirt and water penetrating the clean air space behind the lens resulting in the

lens having a "foggy" appearance (Figure 12). The loss of reflectivity occurred after only a few months. The manufacturer indicated that this problem was overcome by increasing the weld zone of the lens to the backplate and by improving the flow of polypropylene material. However, new markers with this improved feature were not available for testing.

Installing the markers in the alternating pattern allowed comparisons of relative reflectivity. Photographs taken at the Garrard County, southbound installation at periodic intervals during the evaluation period show a comparison of all five markers (Figure 13). The Kingray marker had lost its visibility. The Prismo marker was the least reflective of the other markers. The remaining marker types (Stimsonite 96, Dura-Brite, and Recessed) demonstrated similar reflectivity.

A photograph of the Fayette County, southbound installation gives a comparison of the Stimsonite 96, recessed, and Dura-Brite markers with a regular Stimsonite 911 marker placed on the pavement surface (Figure 14). It was shown that each of these three snowplowable markers had a reflectivity similar to the regular, raised pavement marker.

Observations during wet, nighttime conditions were made, and the same general conclusions were found. Particular attention was paid to whether the groove in which the recessed marker was placed would fill with water during wet weather conditions. If this occurred, a loss of reflectivity would result. In all but heavy rains, the groove remained relatively dry due to the effect of vehicles passing and the water being vacuumed or blown out. The groove did maintain a level of water for a short time during heavy rains but this only caused a problem when the geometry of the roadway was such that the marker was on the downhill end of a groove. Overall, it appears that there is no significant problem with the groove becoming filled with water during wet weather conditions.

The visibility of the recessed markers during snow and ice conditions was also observed. After a snowplow

operation, the groove would be filled with snow and ice. The snow and ice would usually melt in a relatively short period of time and the resulting water would be swept from the groove by traffic. Some inspections found the groove to be partially filled during these conditions. Approximately the top third of the marker would be cleansed by tires but the bottom portion would be obscured. This reduced nighttime visibility but the markers could still be seen. Overall, the conclusion was reached that the recessed marker remained adequately effective during snow and ice conditions.

In April 1982, after 16 months in service, the reflective lenses of three each of the Stimsonite 96, Dura-Brite, and recessed markers were removed from the field sites for laboratory tests. These reflectors would have initially met Kentucky's reflectivity requirements for a highly reflectorized marker. The minimum specific reflectivity requirement, for a silver-white lens at a 0.2 degree divergence angle and 0 degree incidence angle, is 2.7 candlepower/footcandle/unit marker. Laboratory tests found the average specific reflectivity for the markers after slightly over one year in service, given in terms of candlepower/footcandle/unit marker, was 2.5 for the recessed reflector, 2.1 for the Dura-Brite reflector, and 1.3 for the Stimsonite 96 reflector. The Dura-Brite and Stimsonite 96 use the same reflector. These readings are in agreement with the observed durability of the reflectors in these markers. The lenses in the recessed and Dura-Brite markers received very little damage while the Stimsonite 96 had some minor damage. This would be related to the higher profile of the Stimsonite 96 marker. Nighttime observations showed that all three of these markers maintained very good reflectivity after 16 months in service.

Durability

Evaluation of the durability of the markers involved two areas. First, an effort was made to determine the effect of

traffic on marker durability and second, the effect of snowplow operations was evaluated. Most of the markers were not snowplowed for slightly over one year after installation, enabling an assessemnt of the effect of traffic on their durability.

Traffic Wear - Photographs of the various markers after almost one year in service are given in Figures 15-20. These photographs were taken prior to the second winter and therefore, show the effects of traffic wear only. The summary of marker damage which follows applies to the effect of approximately one year of traffic wear with no snowplow damage.

The recessed marker is shown in Figure 15. This marker demonstrated good durability. Minor damage to the top of the lens was found at seven markers (five percent). Inspections during the year found that the groove remained relatively free of debris. Approximately the top one-half of the lens remained clean. The bottom one-half was not cleaned well by tires. Also, the abrasive coating on the top one-half of the lens was chipped more than the other snowplowable markers.

The Dura-Brite marker is shown in Figure 16. The durability of the Dura-Brite marker to traffic wear was found to be good. The lens remained clean with less chipping to the abrasive coating than the other markers. In some instances, the adhesive holding the lens covered part of the lens as shown. This was caused by using butyl tape which was too thick. The thickness of this tape has since been reduced by the manufacturer. It was also noted that the lens was loose in two markers.

The durability of the Stimsonite 96 marker after being subjected to traffic was also found to be good (Figure 17). Minor damage to the lens was noted on 13 markers (nine percent). As shown in Figure 17, this damage was minor and did not adversely affect reflectivity. The lens remained clean with minor chipping of the abrasive coating.

Several problems were found with the Kingray marker (Figure 18). The bitumen material holding the marker cracked and, in many instances, a large amount of this

material was lost. This reduced the bond of the marker to the pavement. A possible reason for the loss of bitumen was failure to heat the hole to a sufficiently high temperature during the installation process. Six (four percent) of the markers were found to be missing after almost one year in service. The lens also tended to remain dirty because tires would depress and not clean the lens. A rain was necessary to clean the lens. Since the lens did depress upon impact, it sustained less abrasive damage to the lens surface than the other markers. About 15 percent of these markers had damage either to the lens or marker. All but two of the markers still recoiled as designed.

The Prismo markers at the Fayette County site were removed by snowplows but observations of the markers at the Garrard County site were made (Figure 19). Five of the markers (17 percent) were missing. The remaining markers were generally in good condition. Several had minor damage to some of the glass lenses.

Twenty Stimsonite 911 markers were installed at the Fayette County site as a comparison to the snowplowable markers. After almost one-year, one of these markers was missing and one had major damage to the lens. There was significant chipping of the abrasive coating on the markers but they generally remained in good condition (Figure 20).

Snowplow Damage - During December 1981 and January 1982, there were between six and eight snowplow passes over the various test sections of markers (Figure 21). A steel blade was used during all operations. The only other snowplow tests were made during January 1981 when two passes were made northbound at the Fayette County location on a wet pavement. In the January 1981 test, the Prismo markers were removed and there was damage to three (14 percent) of the Kingray markers, while the Stimsonite 96, Dura-Brite, and recessed markers proved to be snowplowable with no damage.

Following is a summary of the performance of the markers as a result of the snowplow operations during December 1981 and January 1982. The final inspection was conducted in April 1982

after approximately 16 months in service. As shown in Figure 22, the recessed marker was filled with snow after the snowplow operations, but the snow melted and the marker was visible again within a few hours (Figure 23). The recessed marker sustained no additional damage as a result of snowplowing. Neither the Stimsonite 96 or Dura-Brite markers sustained any damage to either the lens or the marker housing unit from the snowplowing. The final inspection found 13 Stimsonite 96 markers and one Dura-Brite marker with minor damage to the lens which was the result of traffic wear. Also, in two of the Dura-Brite markers, the lens was missing.

The Prismo marker was found to not be snowplowable. The snowplow sheared the marker off the pavement at the top of the anchor stem. Virtually every Prismo marker which was snowplowed was removed. Also, all of the regular Stimsonite 911 markers which were placed on top of the pavement were severely damaged.

The Kingray markers were also damaged by the snowplow operations (Figure 24). Even before the snowplows were used, several of the Kingray markers were either missing or damaged. An inspection after the snowplow operations revealed that 71 Kingray markers (47 percent) were missing, 43 (29 percent) were severely damaged, and 20 (13 percent) were moderately damaged. Only 11 percent were undamaged, and these remaining markers still recoiled as designed.

Another feature of the markers relative to snowplowing was their interference with snowplow operations. This involved discomfort to the snowplow operator resulting from the jolt of hitting the marker as well as damage to the snowplow blade. The Stimsonite marker, which had the highest profile above the pavement, caused the most interference. The snowplow blade would jump several inches above the pavement after striking a Stimsonite marker. The lower profile Dura-Brite marker caused less interference. The Kingray and the recessed, in particular, caused no interference. The test section was not long enough to show damage to the snowplow blade but potential for such damage was

demonstrated.

SUMMARY

Installation

All of the markers were installed with relatively few problems. The Stimsonite 96 marker required the shortest saw or drill time. The lengthy drilling time for the Kingray marker would be shortened substantially with better equipment. A more efficient procedure for installing the Dura-Brite markers has been developed by the manufacturer but was not used because of the small installation. The time to install the markers was highest for the Kingray markers and shortest for the recessed markers. The Stimsonite 96 and recessed markers required longer adhesive drying times because they used epoxy.

Reflectivity

The Stimsonite 96, recessed, and Dura-Brite snowplowable markers maintained their reflectivity over the evaluation period and each of these markers provided very good delineation. While the Prismo marker was less reflective than these markers, it maintained its reflectivity and provided good delineation. The Kingray marker suffered a severe loss of reflectivity. A subjective rating of the reflectivity of these markers found the Stimsonite 96 marker as the best overall. The reflectivity of the recessed marker varied somewhat with roadway geometry but could be rated as second. The fact that the Dura-Brite marker was a lower profile marker (rising only 0.25 inch above the pavement surface) resulted in a slightly lower reflectivity and a subjective rating of third. However, the Dura-Brite marker still provided more than adequate delineation, and the low profile of this marker provides some durability advantages. A new Stimsonite marker which was recently introduced is also a low profile marker and will probably be similar to the Dura-Brite in reflectivity.

Durability

Considering only traffic wear, the

Kingray and Prismo markers were the only markers which experienced any significant damage. The Dura-Brite and recessed markers received the least amount of damage. The Stimsonite 96 sustained minor damage to the lens in a few markers.

Evaluation of the snowplow operations revealed that the Stimsonite 96, Dura-Brite, and recessed markers qualify as snowplowable markers. None of these three markers sustained any noticeable damage as a result of the limited number of snowplow operations. The Prismo markers were found to not be snowplowable. The Kingray markers sustained significant damage as a result of snowplow operations.

Another factor which should be considered is the relative snowplowability of the markers. The concept used in the design of the Stimsonite 96 and the Dura-Brite markers is to retain the reflective unit of a raised pavement marker and attempt to protect it by using a snowplow-resistant encasement. However, it was found that an encasement sufficiently sturdy to resist snowplow damage will likely interfere with snowplow operations because of severe vibrations and plow blade damage. Of the markers evaluated in this study, only the recessed and Kingray markers would present a sufficiently low profile (or characteristics which cause them to function like low profile) to not interfere with snowplow operations.

RECOMMENDATIONS

The Stimsonite 96, Dura-Brite, and recessed markers should be considered as acceptable snowplowable markers. All three of these markers were found to have adequate reflectivity which was maintained over the test period and proved to be durable when subjected to snowplow operations. However, considering all available input, the recessed marker is recommended as the most functional and cost-effective. This recommendation is based on the following characteristics of the recessed marker: 1) ease of installation; 2) high retention of reflectivity; 3) durability when subjected to snowplow operations; 4) relative cost

of the marker and its installation; and 5) lack of interference with normal snowplow operations. Specifications for an installation contract of snowplowable markers could allow for use of any of these three markers (Stimsonite 96, Dura-Brite, and recessed), but, considering available cost data, the recessed marker should provide the lowest cost.

Further development of less expensive markers which are easier to install is warranted with emphasis on a low-profile marker. The new low-profile Stimsonite snowplowable marker and a recessed marker using a low-profile marker, rather than the regular marker, should be included in any future evaluations. Also warranted is the development of more cost-effective methods to install existing markers.

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TABLE 1. INSTALLATION TIMES

TYPE OF MARKER	TIME			
	SAW OR CONCRETE	DRILL BITUMINOUS	INSTALL MARKER	ADHESIVE DRY
Stimsonite 96	12 seconds	9 seconds	1 minute	1 hour
Recessed	40 seconds	25 seconds	20 seconds	1 hour
Dura-Brite	40 seconds	25 seconds	1.5 minutes	15 minutes
Kingray	12 minutes	6 minutes	5 minutes	10 minutes
Prismo	1.5 minutes	1.5 minutes	30 seconds	10 minutes

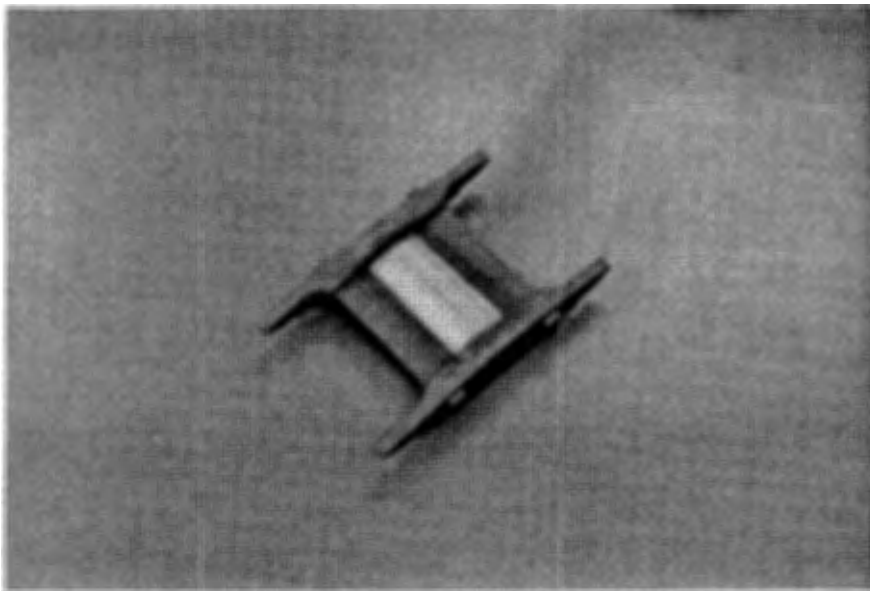


Figure 1. Stimsonite 96 Marker.

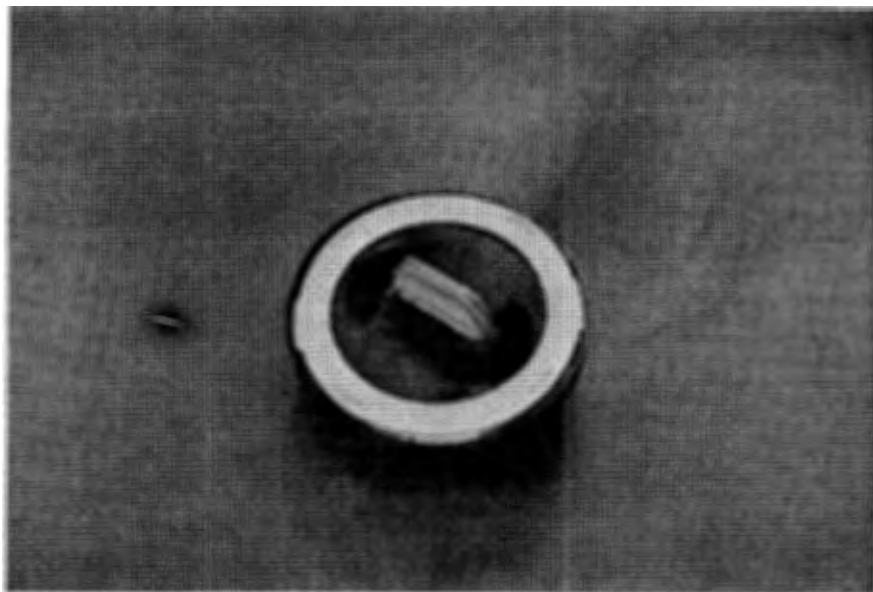


Figure 2. Konelite Marker.

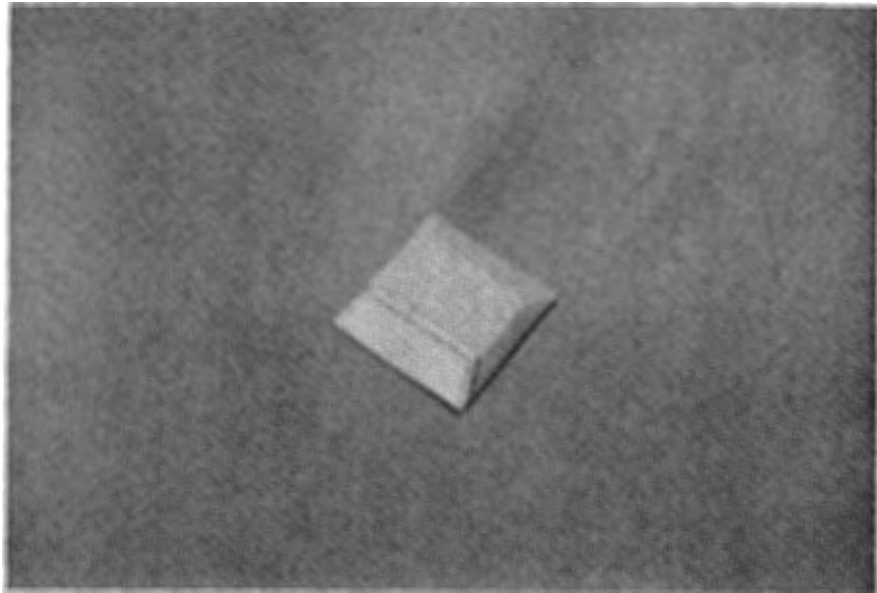


Figure 3. Stimsonite Marker Used as Recessed Marker.

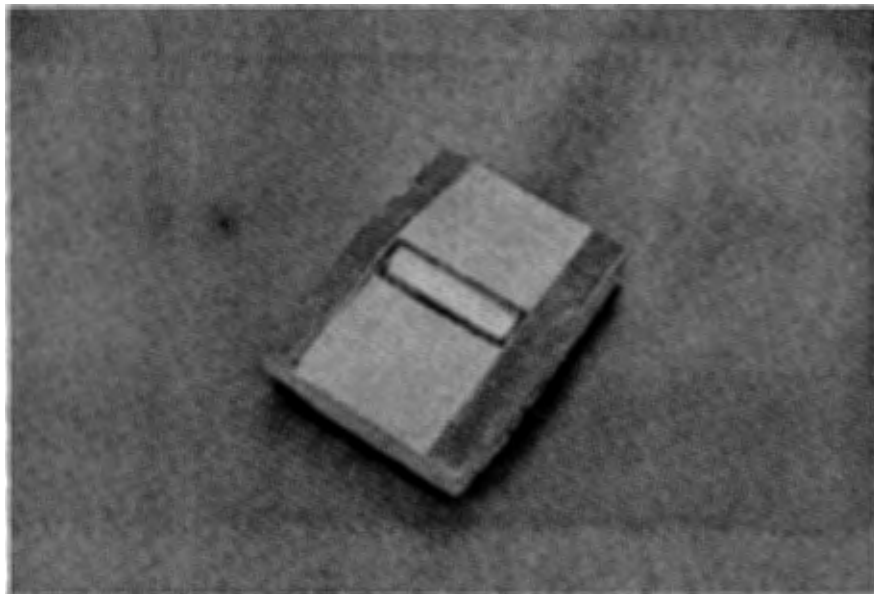


Figure 4. Dura-Brite Marker.

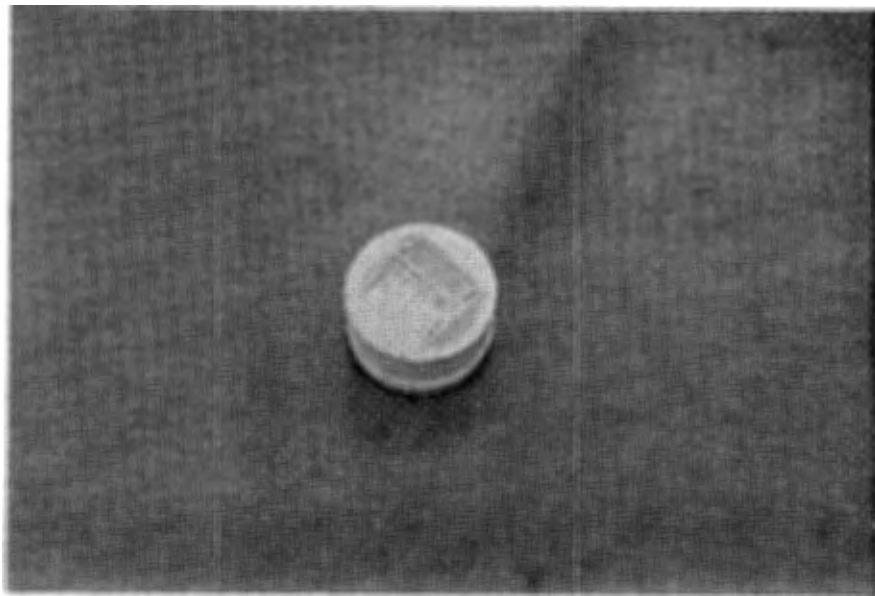


Figure 5. Kingray Marker.

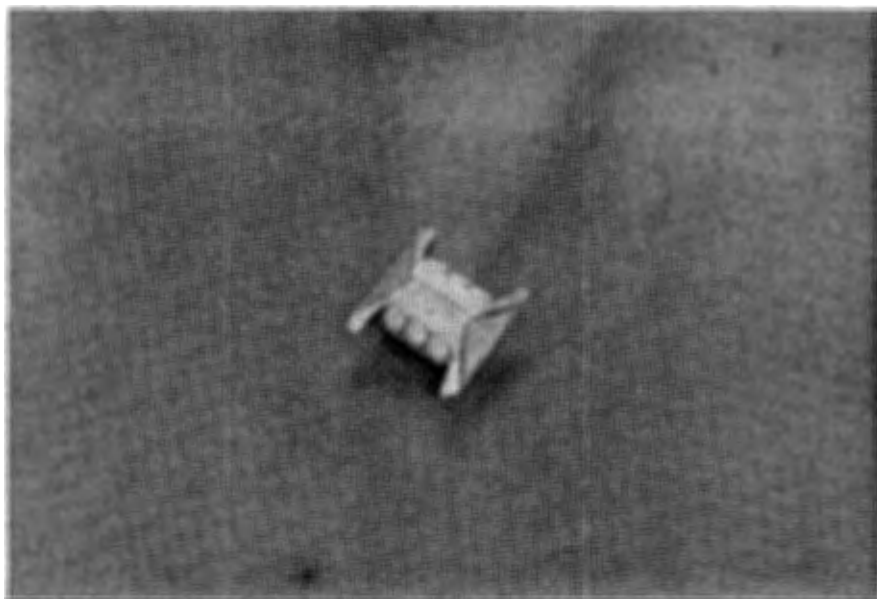


Figure 6. Prismo Marker.



Figure 7. Photograph Taken in December 1980 at the Jessamine County Southbound Installation (Pattern of Markers is Recessed, Dura-Brite, Stimsonite 96, and Kingray).



December 1980



April 1982

Figure 8. Photographs of Section of Dura-Brite Markers (Fayette County, Northbound Installation).



December 1980

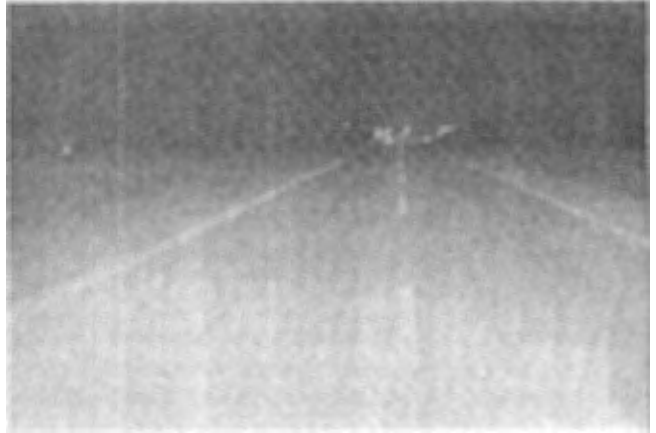


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Figure 9. Photographs of Section of Kingray Markers (Fayette County, Northbound Installation).



December 1980



April 1982

Figure 10. Photographs of Section of Recessed Markers (Fayette County, Northbound Installation).



December 1980



April 1982

Figure 11. Photographs of Section of Stimsonite 96 Markers (Fayette County, Northbound Installation).

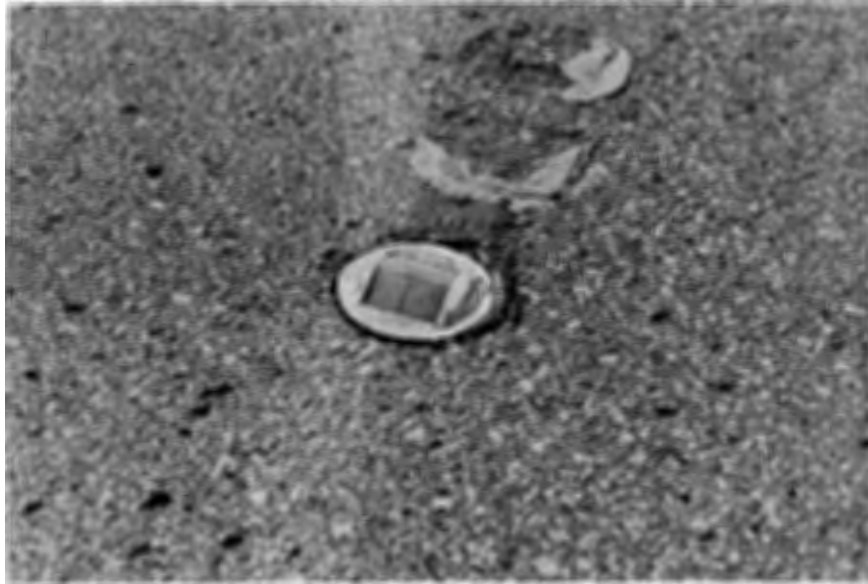


Figure 12. "Foggy" Appearance of Kingray Lens.



June 1981



April 1982

Figure 13. Photographs Taken at the Garrard County, Southbound Installation (Order of Markers is Kingray, Stimsonite 96, Dura-Brite, Recessed, and Prismo).



Figure 14. Photograph Taken at the Fayette County, Southbound Installation (Order of Markers is Kingray, Stimsonite 911, Stimsonite 96, Recessed, and Dura-Brite).

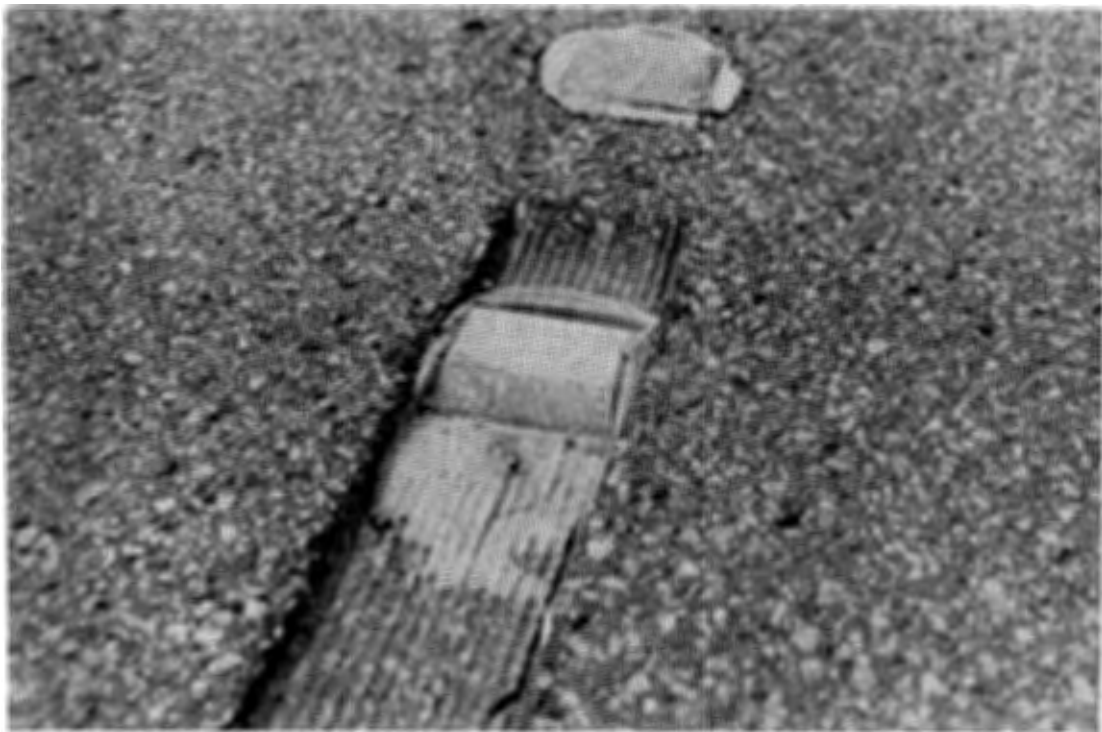


Figure 15. Recessed Marker after Approximately One Year in Service (Before Snowplowing).

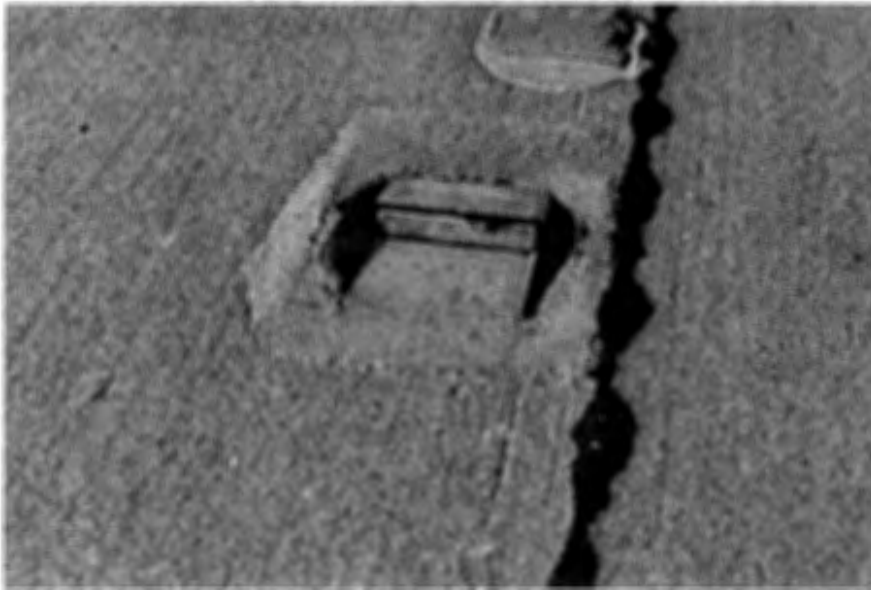


Figure 16. Dura-Brite Marker after Approximately One Year in Service (Before Snowplowing).



Figure 17. Stimsonite 96 Marker after Approximately One Year in Service (Before Snowplowing).

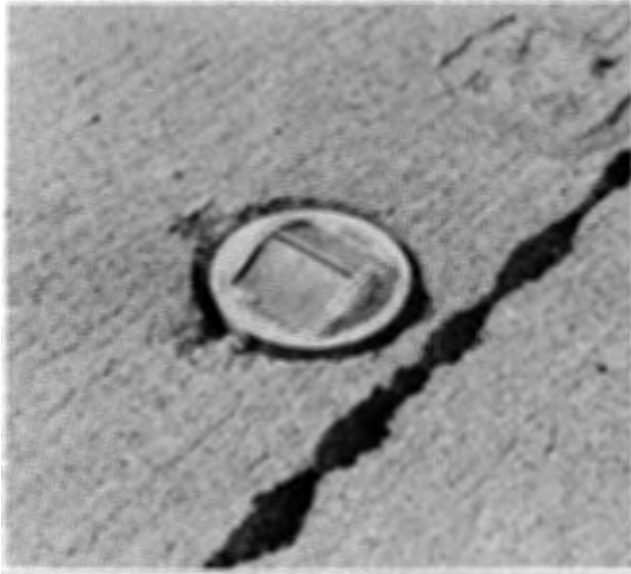


Figure 18. Kingray Marker after Approximately One Year in Service (Before Snowplowing).



Figure 19. Prismo Marker after Approximately One Year in Service (Before Snowplowing).

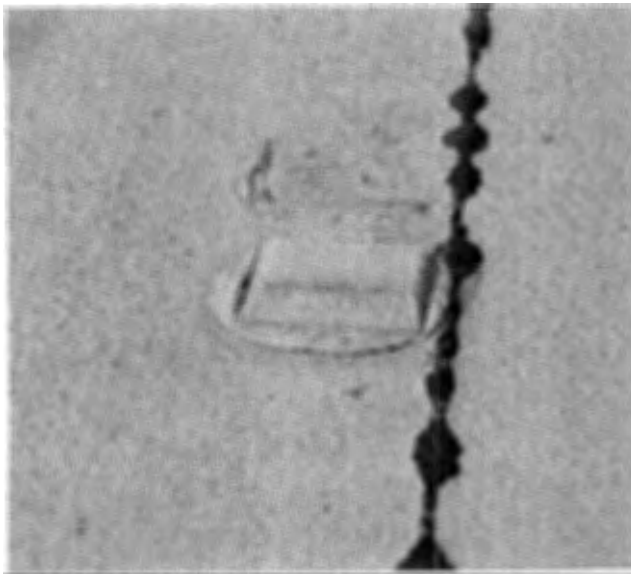


Figure 20. Stimsonite 911 Marker after Approximately One Year in Service (Before Snowplowing).



Figure 21. Snowplow Operation at Fayette County Location (US 68).

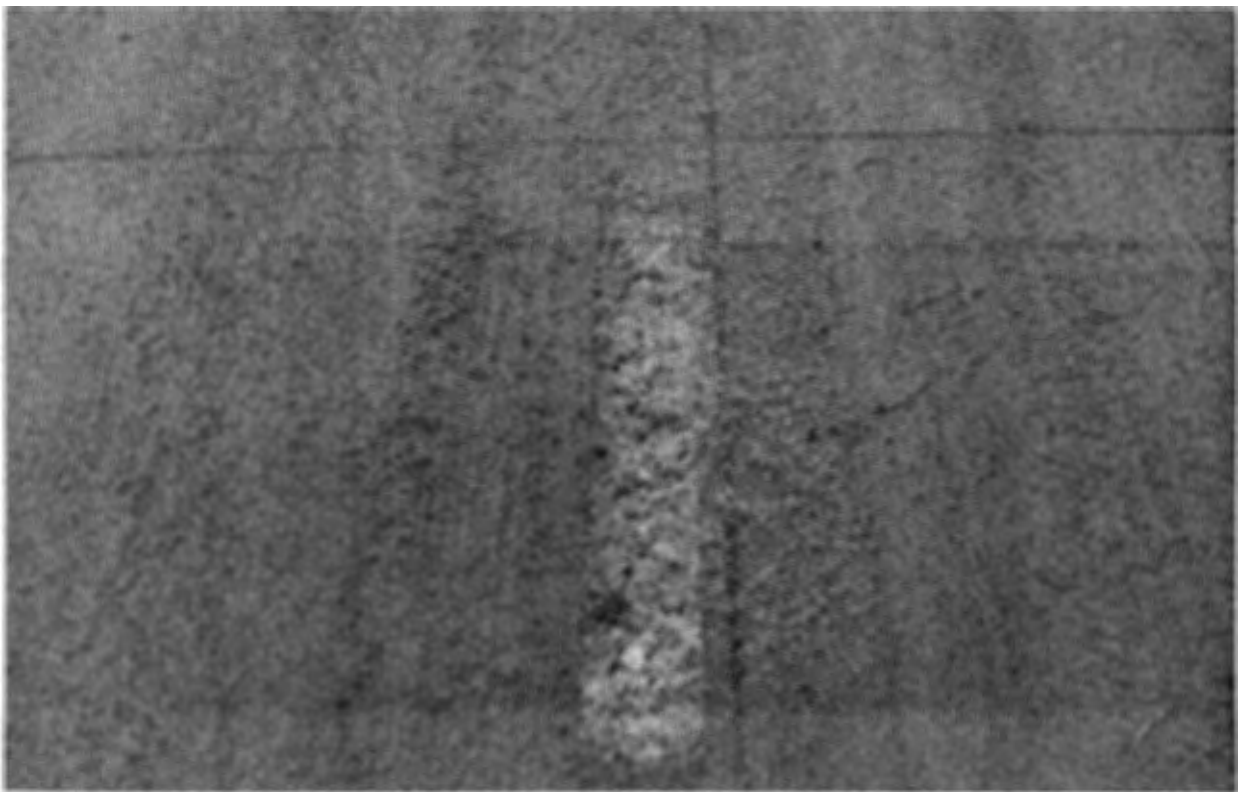


Figure 22. Recessed Marker Immediately after Snowplow Operation.

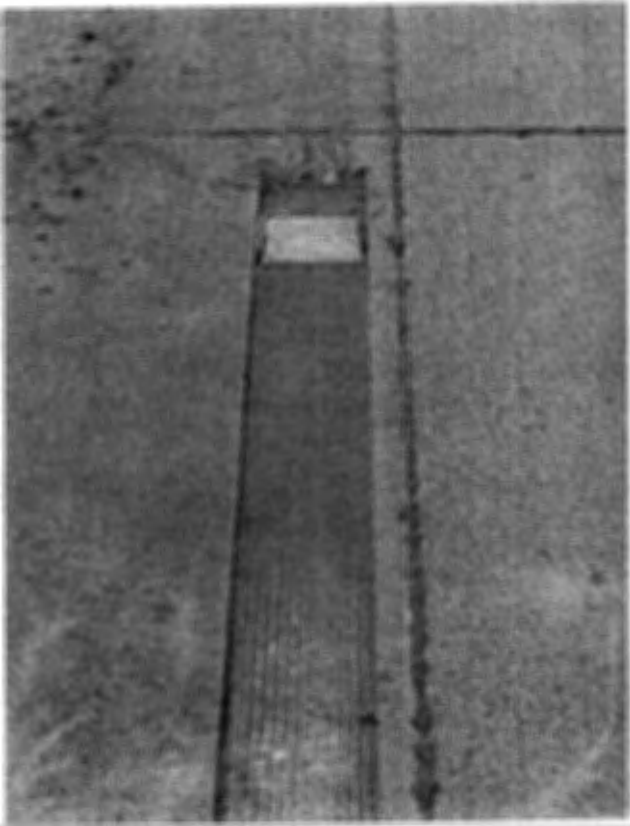


Figure 23. Recessed Marker a few Hours after Snowplow Operation.



Figure 24. Damage to Kingray Marker by Snowplow.

APPENDIX
INSTALLATION SPECIFICATIONS AND PHOTOGRAPHS

CONTRACT FOR INSTALLATION OF KINGRAY,
STIMSONITE, RECESSED, AND
DURA-BRITE MARKERS

I. Description

This work shall consist of furnishing and placing snowplowable pavement markers at locations as directed by the Engineer.

The snowplowable markers shall conform to the requirements for Type A, Type B, Type C, or Type D markers as designated herein. Markers shall be approved by the Bureau (Kentucky Bureau of Highways) before installation. One brand of markers shall be used throughout the project for each type of marker required.

The markers shall be mono-directional, silver-white and shall be installed only on the skip lines in the pattern designated by the Engineer.

II. Requirements

Markers will be classified as Type A, Type B, Type C, or Type D. For each type, the designated marker is listed below. In addition, the dimensions of each type are shown on the attached detailed drawings (Figures A-1 through A-4).

- TYPE A Marker - KINGRAY, International Roadstud, MK7;
American Highway Sign Company;
East Longmeadow, Massachusetts
- TYPE B Marker - STIMSONITE, Life-Lite 96;
Amerace Corporation;
Niles, Illinois
- TYPE C Marker - STIMSONITE, Type 911;
Amerace Corporation;
Niles, Illinois
- TYPE D Marker - DURA-GLOW (DURA-BRITE) Pavement Marker;
Durastone Company;
Lincoln, Rhode Island

III. Construction Methods

A. General

Before work begins, the Contractor shall furnish to the Engineer copies of each manufacturer's written recommendations for preparation of the pavement surface and installation of the markers. All work shall be performed in accordance with the manufacturer's recommendations, and the requirements listed hereinafter.

Any damage to the pavement caused by the grinding, drilling, or sawing of recesses for the markers shall be repaired by the Contractor at no cost to the Bureau.

The recesses in which the markers are to be installed shall be free of dirt, grease, oil, moisture, loose or unsound layers, or any other materials that would reduce the bond of the adhesive. Cleaning shall be done by sandblasting.

The markers shall be installed so that every fourth marker is the same type unless directed otherwise. (Note: The description of the pattern of markers used in the installation is given in Table A-1.)

The installed markers shall be protected from traffic for the time necessary to allow the adhesive to set sufficiently to prevent displacement of the marker by traffic.

(Note: Photographs showing the sawing or drilling operations, the finished cut or hole, and the installed marker for these four markers are shown in Figures A-5 through A-8.)

B. Type A Markers (Figures A-1 and A-5)

1. The depth of the hole must not exceed 60mm since it is imperative that the reflector flange is installed flush with the road surface. This is to insure that the self cleansing mechanism will operate optimally and that a "dirt trap" is not produced.

2. The markers shall be set in bitumen furnished or recommended by the marker manufacturer. The softening point of the bitumen is 115 degrees C. The temperature of the bitumen for installation is not critical; however, it

is important for the bitumen to have a low viscosity before being poured into the hole. The bitumen should then flow up and around the sides of the reflector leaving a slightly raised housing unit.

3. After the hole is drilled, loose material shall be removed and the depth of the hole checked by inserting a marker.

4. The hole shall then be heated with a flame gun for a few seconds to ensure that the hole is dry and that the bitumen cools evenly.

5. Apply primer recommended by the marker manufacturer to the sides, bottom and lip of the hole with a brush. The primer is a bitumen/naptha liquid that ensures a permanent seal and bond between the road surface and the bitumen. Do not apply a naked flame to the primer, since it is petroleum based and highly flammable.

6. Pour in small amount of bitumen (experience governs this, but initially pour in to an approximately 1-2 cm depth).

7. Insert the marker, pushing down, so as to make sure it is well sealed and that bitumen flows up the side of the reflector. Place the reflector face so that it is aligned at right angles to oncoming traffic and hold for a few seconds. Next, pour in additional liquid bitumen so as to ensure that the bitumen produces a complete seal around the circumference of the reflector. After cooling (depending on how good the hole fit is), the bitumen may shrink. The shrinkage should be topped up.

C. Type B Markers (Figures A-2 and A-6)

1. Type B markers shall be installed by inserting the two keels on the casting into parallel slots sawn into the pavement in accordance with details shown on the attached drawing.

2. The epoxy adhesive shall be mixed by combining components A and B in a ratio of 1:1 by volume. The epoxy adhesive requires that the mixing operation and placing of the pavement markers be done rapidly. Any mixed batch that becomes so viscous that it cannot be readily extruded from under the marker under light pressure shall not be used. The adhesive shall be maintained at 60 degrees F to 80 degrees F

before mixing. Any heating of the epoxy shall be by the application of indirect heat. The adhesive shall not be heated above 120 degrees F.

The adhesive used to bond the pavement marker to the pavement shall be a two-component, standard-set-type epoxy available from the Amerace Corporation (Signal Products Division), 7542 North Natchez Avenue, Niles, Illinois, or other material recommended or approved by the marker manufacturer.

3. Before applying the epoxy adhesive, the slots shall be brushed or blown clean of loose material and shall be dry. The cleansed slots shall be filled with epoxy adhesive. The keels of the pavement marker casting shall be hand placed into the slots in such a manner as to assure that the tips of the snowplow deflecting surface(s) are below the pavement surface. Also, the four lugs on the keels of the two-way plowable casting shall be in contact with the pavement.

4. After the epoxy has hardened, any rust or foreign matter shall be removed from the surface of the casting on which the reflector is to be attached. The recessed attachment area shall then be painted with Stimsonite Adhesive Primer or equal in accordance with the manufacturer's instructions. The adhesive primer shall be furnished by the Contractor. The release paper shall then be peeled from the butyl adhesive bottom of the reflector, and the reflector shall be inserted into the recessed attachment area and pressed into place until a firm bond has been made with the casting. The contractor shall press the reflector into place by the application of a 1,000-2,500 pound load for three seconds minimum or another procedure acceptable to the Engineer. The prismatic reflector may be attached in the field or in the shop. (Note: In this test installation, the reflector was installed by the manufacturer).

5. Pavement surfaces shall be maintained in a clean condition until markers are placed. All excess adhesive shall be removed from the reflective lens of the marker. If adhesive or foreign matter cannot be removed from the

reflective lens, the lens shall be replaced.

D. Type C Markers (Figures A-3 and A-7)

1. The Contractor shall grind a groove in the pavement 40 inches long by 4 inches wide by 3/4 inch deep. The cross-section of the groove will vary depending on placement of the marker as directed by the Engineer.

2. The Type C markers shall be placed in the center of the 40-inch groove or at some other position specified by the Engineer. (Note: For installations being evaluated in this study, the marker was placed near the far end of the groove farthest from approaching traffic, as shown in Figure A-3). The marker shall be installed in the groove with an epoxy adhesive such that the top of the marker is flush with the pavement surface. The adhesive bed shall be placed in an amount equal to the bottom of the marker, and in sufficient quantity to cause excess to be forced out around the entire perimeter of the marker.

3. The epoxy adhesive shall be mixed by combining components A and B in a ratio of 1:1 by volume. The epoxy adhesive requires that the mixing operation and placing of the pavement markers be done rapidly. Any mixed batch that becomes so viscous that it cannot be readily extruded from under the marker under light pressure shall not be used. The adhesive shall be maintained at 60 degrees F to 80 degrees F before mixing. Any heating of the epoxy shall be by the application of indirect heat. The adhesive shall not be heated above 120 degrees F.

The adhesive used to bond the pavement marker to the pavement shall be a two-component, standard-set-type epoxy available from the Amerace Corporation (Signal Products Division, 7542 North Natchez Avenue, Niles, Illinois), or other material recommended or approved by the marker manufacturer.

4. Pavement surfaces shall be maintained in a clean condition until markers are placed. All excess adhesive shall be removed from the reflective lens

of the marker. If adhesive or foreign matter cannot be removed from the reflective lens, the marker shall be replaced.

E. Type D Markers (Figures A-4 and A-8)

A recess shall be cut into the pavement, and the markers permanently installed at the locations directed by the Engineer. The dimensions of the recess shall be as recommended by the marker manufacturer. The marker shall be installed to the depth as shown in the detailed drawing. The adhesive used to install the marker shall be a product furnished, recommended, or approved by the marker manufacturer. (Note: After the hole is cut, it is wet and the adhesive material (SET-45) is placed in the hole. For installations being evaluated in this study, the marker was positioned correctly using a template which was provided by the manufacturer).

IV. Sampling

For the purpose of sampling, a shipment shall consist of the amount of material received in one delivery even though it may represent only partial delivery of the contract quantities. Samplings shall be made from at least five, widely separated and indiscriminately chosen packages of like materials included in the shipment. Samples shall be submitted for reflectivity, color, and other testing deemed necessary.

All material shall be approved before use. Adhesives will be accepted based on visual inspection by the Engineer on the project.

V. Packaging

All materials shall be suitably and substantially packaged and shall have the name and address of the manufacturer or vendor, contract or purchase order number, kind of material, trade name, and net

contents plainly marked on each package.

VI. Basis of Payment

Each marker will be paid for at the contract unit price for "Type A, B, C, or D Snowplowable Pavement Markers", which payment shall include all labor, equipment, adhesive, and all materials, services, and traffic controls necessary to complete the work. Markers not installed in an acceptable manner shall be removed and replaced in a satisfactory manner at the contractor's expense.

DESCRIPTION OF PRISMO MARKER

The fifth marker tested, the Prismo Roadstud, was installed by the manufacturer. Fifty-two of these markers

were installed. A detailed drawing of this marker is given in Figure A-9.

The marker is made of diecast aluminium LM6. The size of the head is 100mm x 100mm x 18mm and the anchorage is 40mm long with a 30mm diameter. The marker is diecast in aluminium as one complete integral unit. The weight is 0.24 kg. A one-way marker has 3 reflectors with each reflector containing seven bi-convex glass lenses. The marker is manufactured by Prismo Universal Limited in England.

The installation procedure involves drilling a hole 45mm deep with a 32mm diameter and setting the anchor in suitable bituminous grout. Photographs showing the drilling operation, finished hole, and installed marker are shown in Figure A-10.

TABLE A-1. PATTERN OF MARKERS USED IN INSTALLATION

FAYETTE COUNTY INSTALLATION

Southbound (20 markers of each type with every fifth marker the same)

ORDER

Stimsonite 96
Recessed
Dura-Brite
Kingray
Stimsonite 911

Northbound (Several of each marker type placed together; 22 markers in a row of Dura-Brite, Kingray, Recessed, and Stimsonite 96 and 23 Prismo)

JESSAMINE COUNTY INSTALLATION

Southbound (Space every fourth marker - 36 of each type except 37 grooved)

ORDER

Recessed
Dura-Brite
Stimsonite 96
Kingray

Northbound (Space every fourth marker - 7 of each type except 6 Recessed)

ORDER

Kingray
Dura-Brite
Stimsonite 96
Recessed

GARRARD COUNTY INSTALLATION

Southbound (Space every fifth marker - 28 of each type except 29 Prismo)

ORDER

Kingray
Stimsonite 96
Dura-Brite
Recessed
Prismo

Northbound (Space every fourth marker - 37 of each type)

ORDER

Kingray
Dura-Brite
Stimsonite 96
Recessed

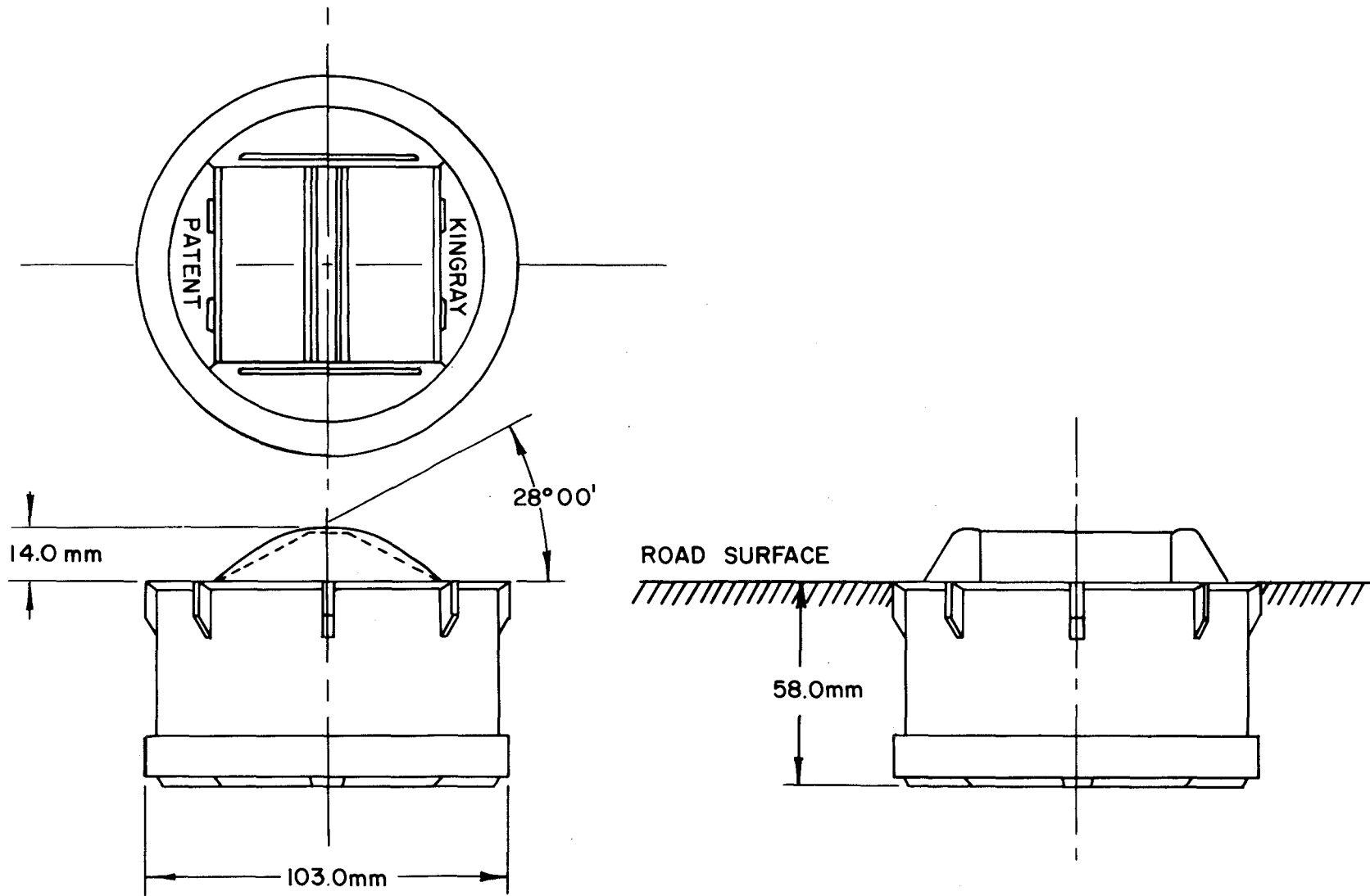


Figure A-1. Detail of Type A Marker (Kingray).

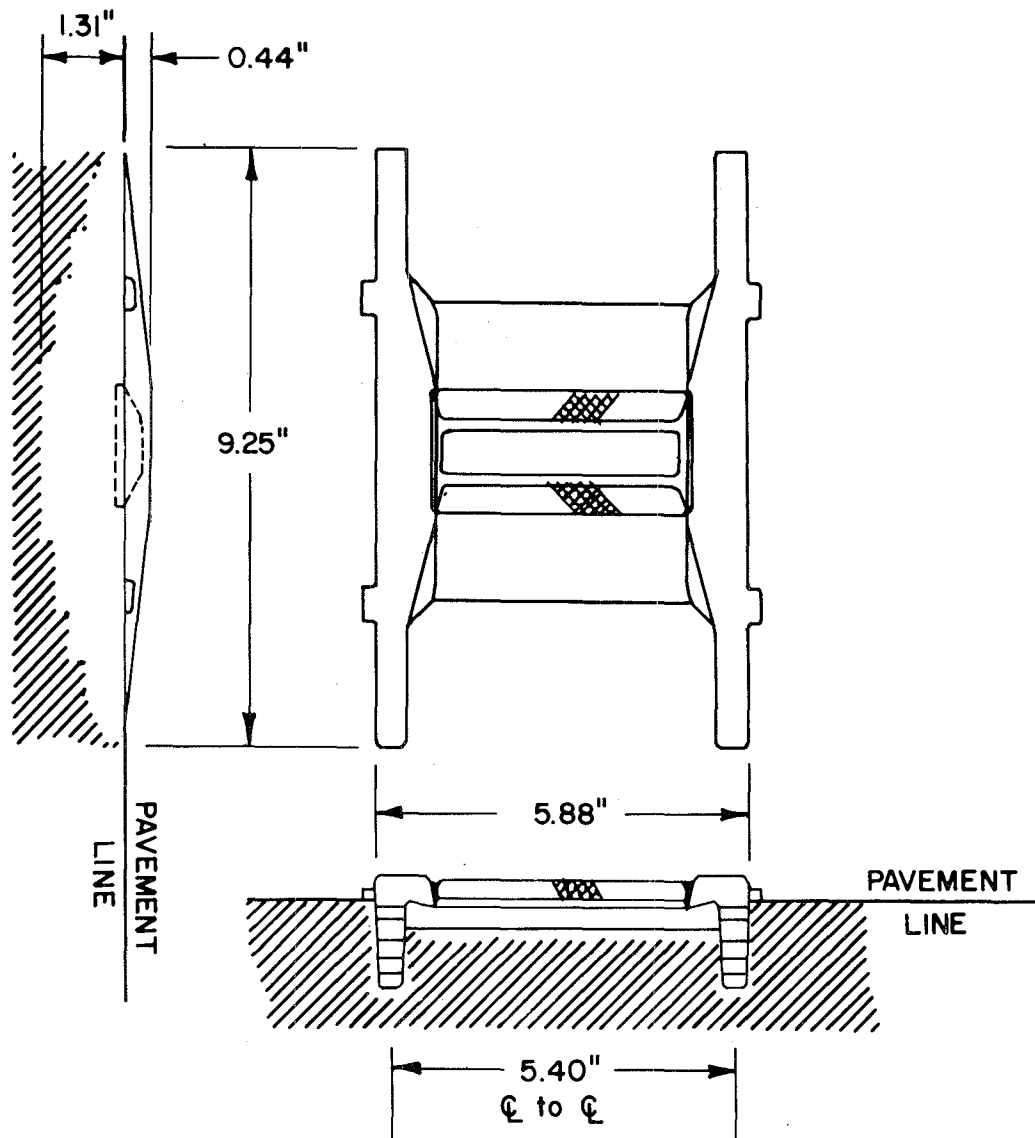


Figure A-2. Detail of Type B Marker (Stimsonite 96).

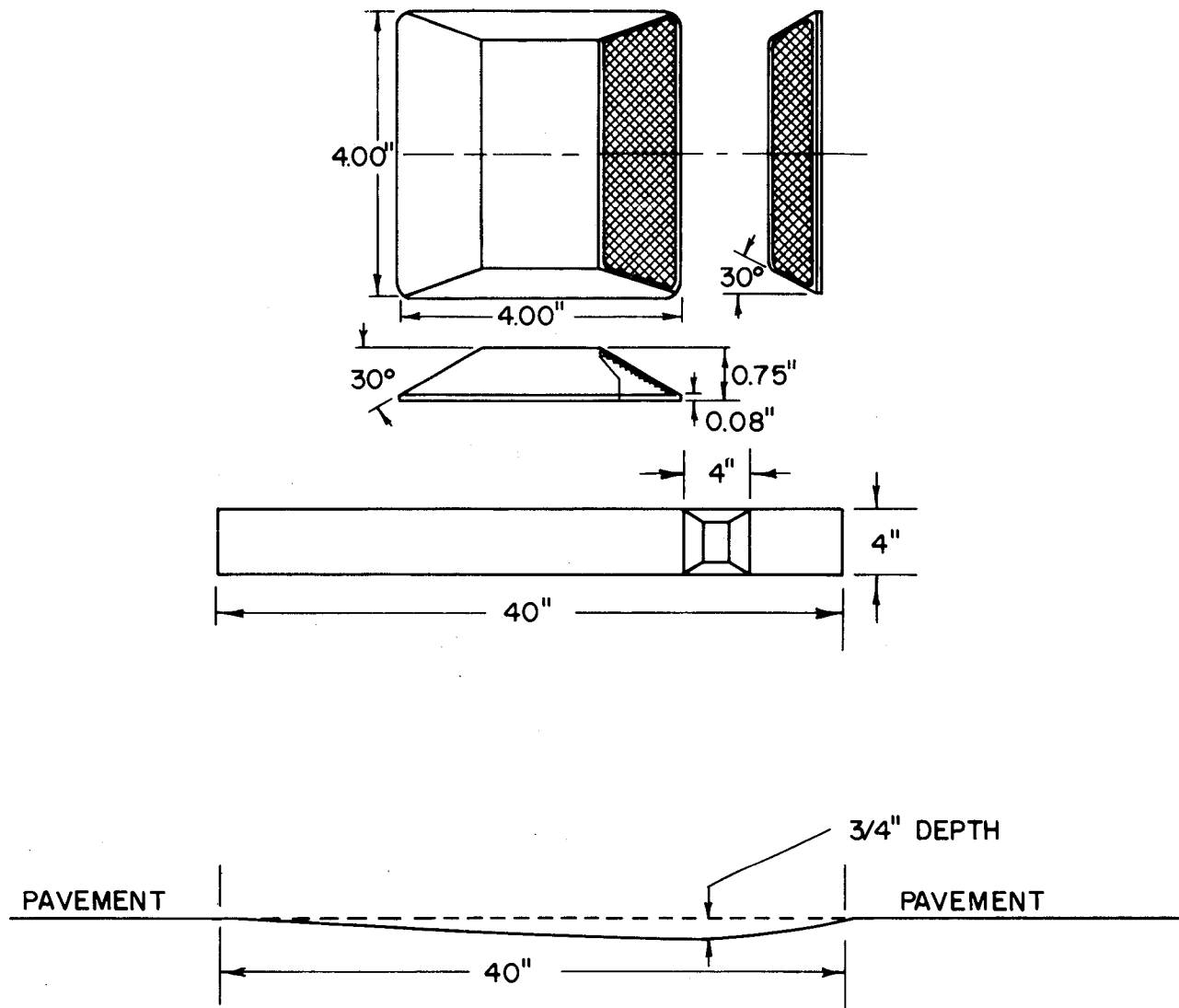
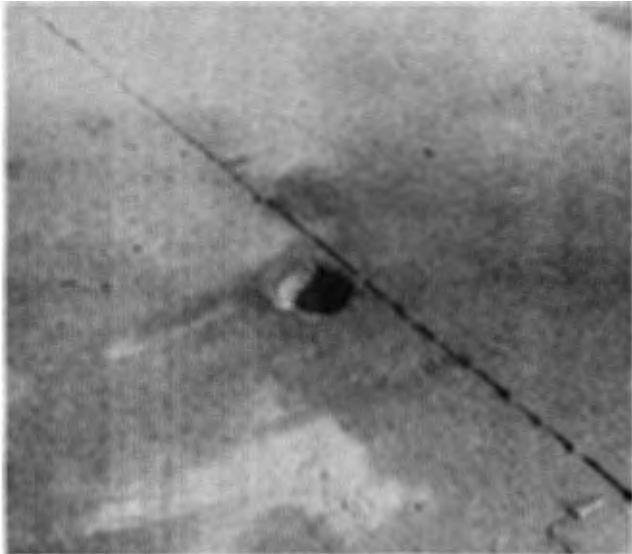


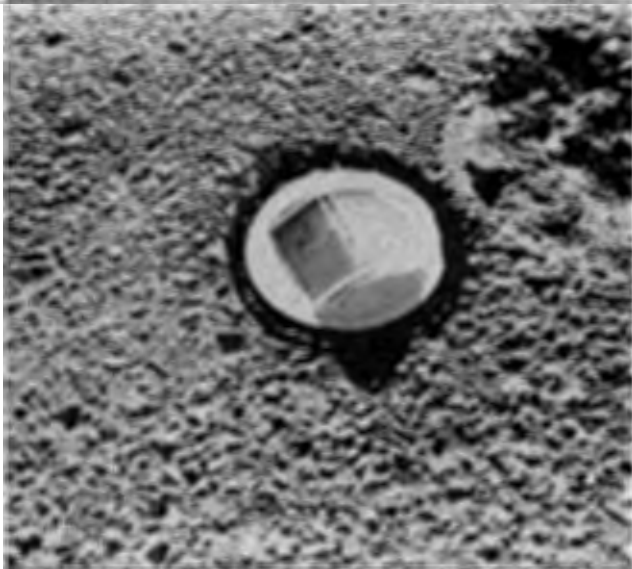
Figure A-3. Detail of Type C Marker (Recessed) and Sawed Groove



Drilling



Finished Hole



Installed Marker

Figure A-5. Installation of Kingray Marker.



Sawing



Finished Cut

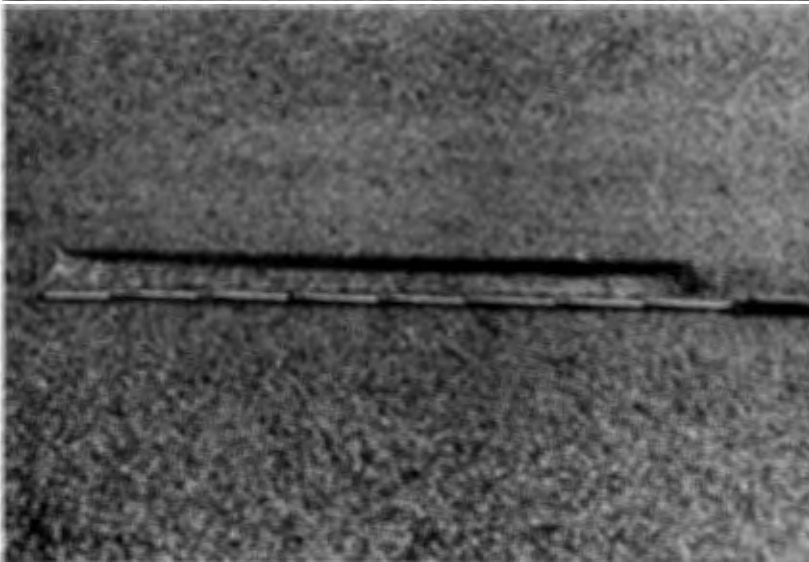


Installed Marker

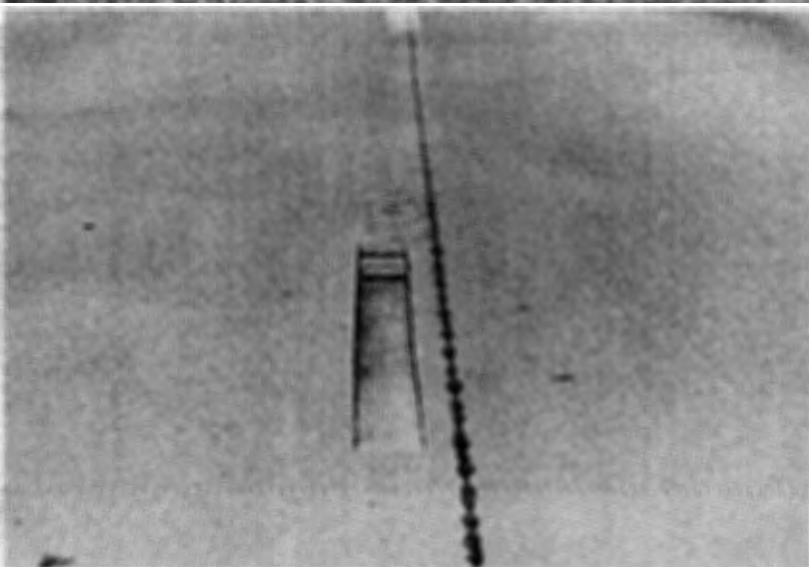
Figure A-6. Installation of Stimsonite 96 Marker.



Sawing Groove



Finished Groove



Installed Marker

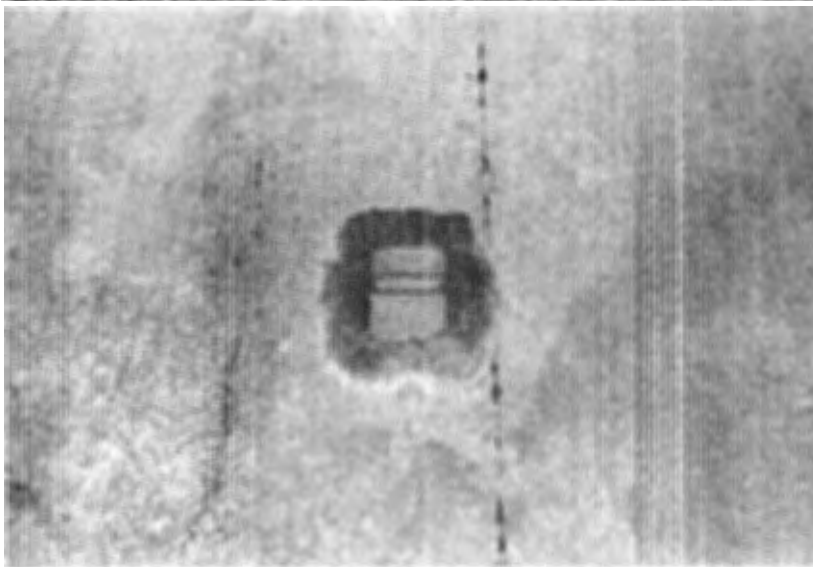
Figure A-7. Installation of Recessed Marker.



Sawing



Finished Cut



Installed Marker

Figure A-8. Installation of Dura-Brite Marker.

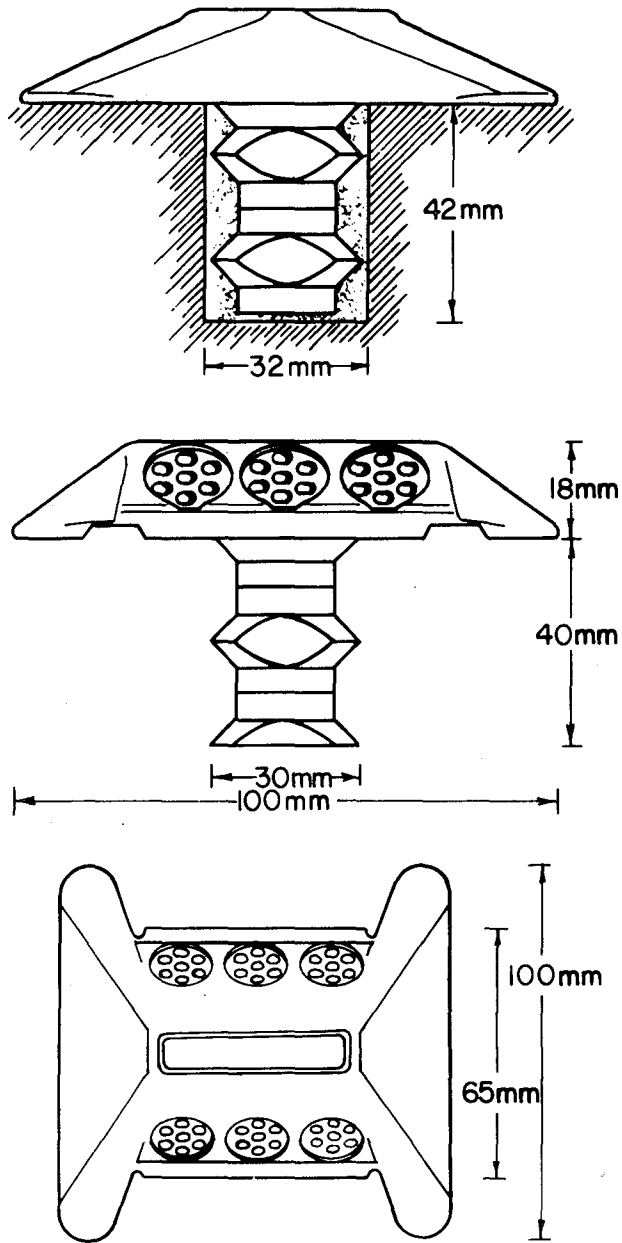
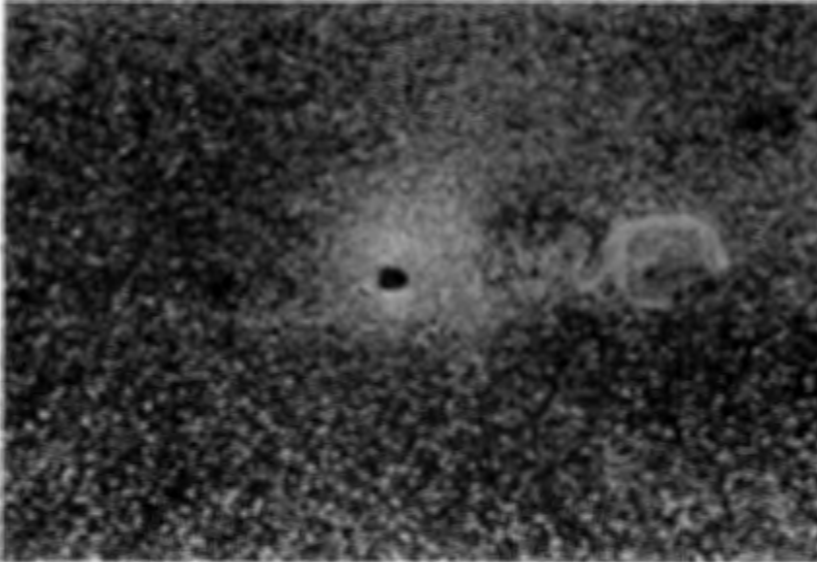


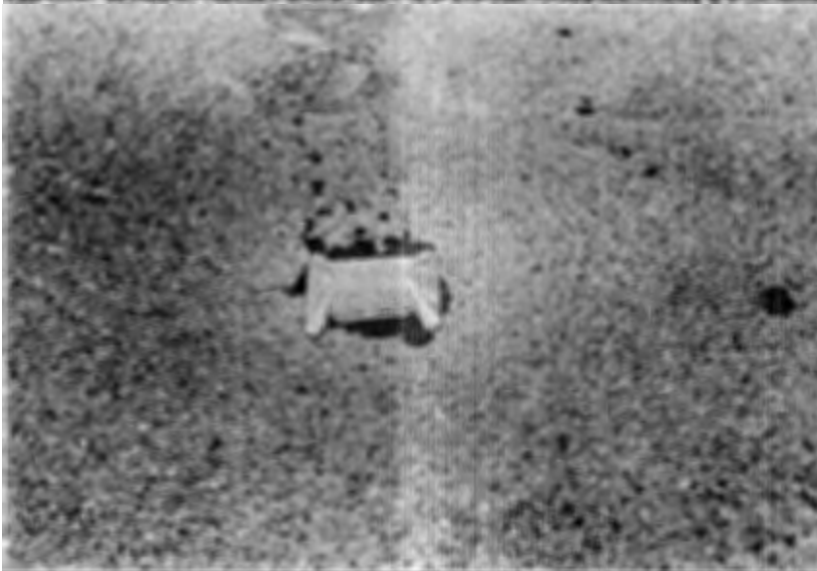
Figure A-9. Detail of Prismo Roadstud.



Drilling



Finished Hole



Installed Marker

Figure A-10. Installation of Prismo Marker.



