

SUMMARY OF RESEARCH ON SNOWPLOWABLE RAISED PAVEMENT MARKERS  
AND RECOMMENDATIONS FOR PLACING MARKERS

by

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

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## SUMMARY

Reduced visibility on the highway due to darkness and adverse weather conditions results in an inability of motorists to readily observe pavement markings. Because raised pavement markers provide increased pavement and roadway delineation, the feasibility of using them has been investigated by the Research Council and the results are summarized in this report. Also, because of the increased use of raised pavement markers by the Department, recommendations for the placement of the markers have been developed and are presented.

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INTRODUCTION

Roadway delineation in the form of painted center-and edge-lines has been used extensively to provide the motorist guidance, regulatory, and warning information. Maximum benefit from the markings is needed under low visibility conditions encountered in nighttime driving. In rainy weather and under night conditions, a water film covers the beads and paint lines and diffuses the illumination from a vehicle's 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 painted lines under such driving conditions, but their use has been limited in areas that experience snow because of the extensive damage they incur from snowplows.

There are, however, methods of placing pavement markers to withstand snowplowing. Markers are placed either below the highway surface in grooves designed to accommodate them or on the surface in specially designed devices which protect them from damage by the snowplow.

INSTALLATION ON I-77

The state of Virginia has had experience with both of these methods of placing the raised pavement markers. In 1976 the Research Council conducted a study to determine the feasibility of using raised pavement markers for roadway delineation during fog, with special attention being focused on the possibility of using the markers for roadway delineation during fog on Interstate 77 at Fancy Gap.<sup>(1)</sup> At that time, consideration was given to various methods of placing the markers and to protecting them from damage by snowplows. The methods included placing the

markers in pavement grooves as shown in Figure 1\* and in surface-mounted steel castings as shown in Figure 2. The steel casting and marker device (Stimsonite Model T99) includes tapered steel ramps which force the snowplow blade to pass over it. The casting, which protrudes approximately 3/4" above the pavement, is attached to the highway by cutting two parallel slots 1/2" wide and 1-1/2" deep into the pavement to receive the keels on the bottom of the casting. The assembly is glued into the slots with an epoxy adhesive.

The study concluded that raised pavement markers would provide sufficient nighttime roadway delineation for vehicle guidance during fog, and that both methods of emplacing the markers would protect them from appreciable damage by snowplows.

The Department decided to install raised pavement markers in steel castings (Stimsonite Model T99) on Interstate 77 at Fancy Gap to guide motorists during inclement weather at night, especially during fog. Markers were placed outside the right and left edgelines on 20' centers. Observation of the markers during a heavy fog (150'-200' visibility) revealed good roadway delineation, with from 5 to 7 markers being visible along the right edgeline. There were some problems, however, with damage from snowplowing; markers were cracked, broken, and torn from the pavement. The particular reason for this damage is not known; however, the loss of 3 or 4 consecutively placed steel castings indicated that the installation procedures might not have been adequate.

#### INSTALLATION ON I-81

In a recently completed study, the Council investigated the use of the groove configuration shown in Figure 3 for protecting the raised pavement markers from snowplow damage.<sup>(2)</sup> The study, which was conducted on Interstate 81, concluded that the method of placing markers in grooves cut in the pavement was feasible as a means of protecting the markers from snowplow damage; however, it was recommended that the markers not be used by the Department for centerline delineation until the cost of installing them could be brought down to an acceptable level.

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\*All figures are attached.

## INSTALLATION AT INTERSTATE 81-581 INTERCHANGE

Subsequent to the installation of the Model T99 type markers on I-77, changes were made in the design of the steel casting to reduce its susceptibility to damage by snowplows. The new casting, designated Model 96, has a lower profile— $7/16$ " above the pavement as opposed to  $3/4$ " for the old model—and can be snowplowed from either direction. In addition to the parallel slots cut in the pavement for the keels, a portion of the area between the keels is cut out to allow the entire marker to be firmly seated into the pavement and glued in place with an epoxy adhesive. Figure 4 shows the pavement cutout without the casting and marker.

With this improved version of the snowplowable casting available, it was decided to install markers at a hazardous location to investigate their durability and reflective qualities.

The site chosen for the installation was the southbound intersection of Interstate 81 and Interstate 581 near Roanoke. The section was chosen because it is an interstate split utilizing a left exit, which is uncommon. Also, this area has a high percentage of trucks and an average annual snowfall of 40".

As noted in Figure 5 the markers were spaced on 40' centers for all edgelines, 80' centers for centerlines, and 20' centers for the gore area and the end of the ramp to I-581 where it narrows. A total of 271 markers were installed. Figure 6 shows a groove being cut in the pavement, and Figure 7 shows the casting and marker in place.

Department personnel and others have made numerous observations of the markers during the night under wet and dry roadway conditions, and their comments on the system have been very complimentary. The only negative comment held the system to be "too bright", which cannot be thought of as a disadvantage. Figures 8, 9, and 10 are night photos of the I-81 mainline, the gore area, and the left exit ramp, respectively, under dry pavement conditions.

Damage to the steel castings and reflective markers after one year of exposure to traffic and approximately 44" of snow is shown in Table 1.

TABLE 1

## DAMAGE TO MARKER AND STEEL CASTING

Total Number of Markers		271.0
Percentage of Castings Damaged		1.1
Percentage of Castings Gone		0.7
Percentage of Markers Damaged:	0% - 10% of face	10.7
	10% - 50% of face	8.5
	50% - 80% of face	3.7
	80% - 100% of face	0.0

Fewer than 1% of the castings were taken out by snowplows. For those castings remaining, all reflecting units remained; however, there was some damage to the units. The damage was in the form of chipping or breaking where a part of the reflecting face was missing. Although portions of the face were missing, the markers were still effective, with only those in the 50% to 80% damage range exhibiting a significant reduction in retroreflectivity. Also, the reflecting units can be replaced at minimal cost. It is noted that the damage shown in Table 1 does not include the normal abrasion and minute chipping caused by traffic.

Overall, it is believed that the system is functioning well; it gives good night-wet retroreflectivity and there has been a minimum of damage to the steel castings and reflecting units. It is thought that use of the raised pavement markers in the snowplow regions of the state is certainly feasible, and that the markers would enhance safety at hazardous locations by adding needed highway delineation.

## RECOMMENDATION FOR PLACEMENT OF RAISED PAVEMENT MARKERS

With the increased emphasis on the use of raised pavement markers by the Department, it is imperative that a criterion or basis for placing the markers be established to ensure uniform and proper placement. Therefore, through a cooperative effort, the Research Council and the Traffic and Safety Division have developed recommendations for the placement of snowplowable, raised, reflective pavement markers.

The recommendations are based on experience in Virginia in the form of research and demonstration projects, along with consideration of placement procedures that have been adopted in other states. However, the raised pavement markers already installed, in addition to projects anticipated in the near

future, should form a basis for a continuing evaluation and refinement of placement procedures. Also, it should be noted that these recommendations are general and there are situations and geometrics which warrant special consideration and marking procedures.

The recommended placement procedures for typical highway situations are given in Figures 11 through 20. Guidelines for the placement of raised markers in construction zones are shown in Figures 21 and 22.

It is noted that the raised markers should be of the same color as the pavement markings they are supplementing. For exit and entrance ramp gore areas, reference is made to Figures 3-11a and 3-12b of the MUTCD for the color of the pavement markings. Also, it is noted that snowplowable markers requiring cuts in the pavement for keels should not be placed on bridge decks as the depth of saw cut is too close to the reinforcing steel. Therefore, when pavement markers are required on bridge decks, surface mounted units using an adhesive should be used. If snowplowability is a problem, the installation procedure whereby markers are placed in special grooves, as shown in Figure 3, may be considered since the groove is only 1/2" deep.

The Appendix contains special provisions for raised pavement markers as furnished by the Construction Division.

Although the author of this report supports the use of raised markers placed in steel casting for protection against snowplowing, there are other methods of marker placement in snowplow areas which hold promise; i.e., there are ways of specially cutting or stamping pavement grooves in which the markers can be placed. The Research Council will continually monitor new placement methods and will attempt to keep abreast of new technology involving the placement of raised pavement markers and keep the Department informed of developments.

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## REFERENCES

1. Shepard, F. D., "Evaluation of Raised Markers for Roadway Delineation", VHTRC 77-R21, Virginia Highway and Transportation Research Council, Charlottesville, Virginia, October 1976.
2. Shepard, F. D., "Evaluation of Recessed, Snowplowable Markers for Centerline Delineation", VHTRC 80-R3, Virginia Highway and Transportation Research Council, Charlottesville, Virginia, July 1979.

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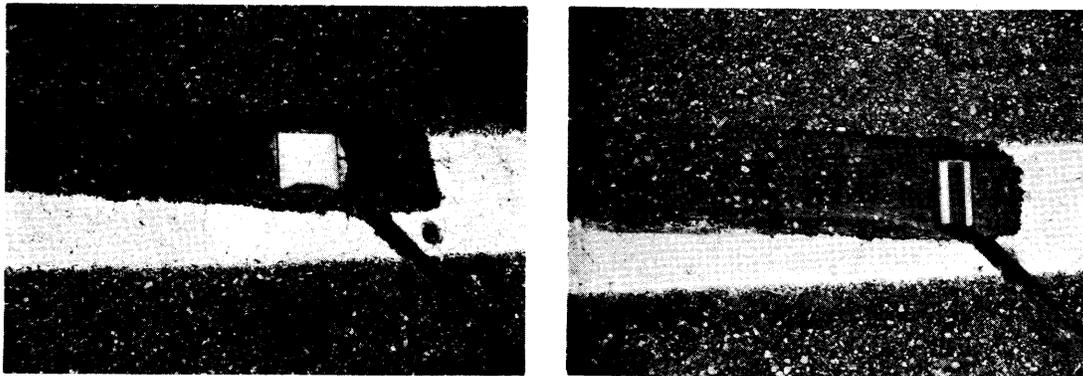
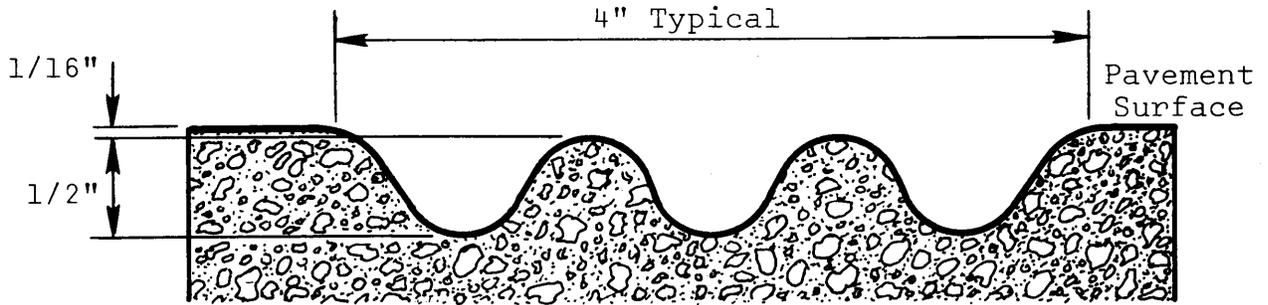


Figure 1. Markers (reflecting unit only) placed in grooves along pavement edge.



Figure 2. T-99 marker placed on shoulder (system III).



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

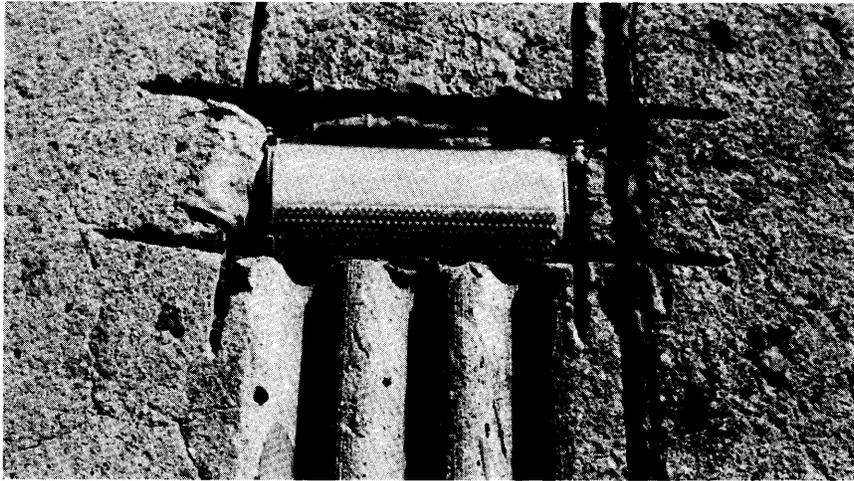


Figure 3. Sketch showing cross section of groove and marker emplaced in pavement.

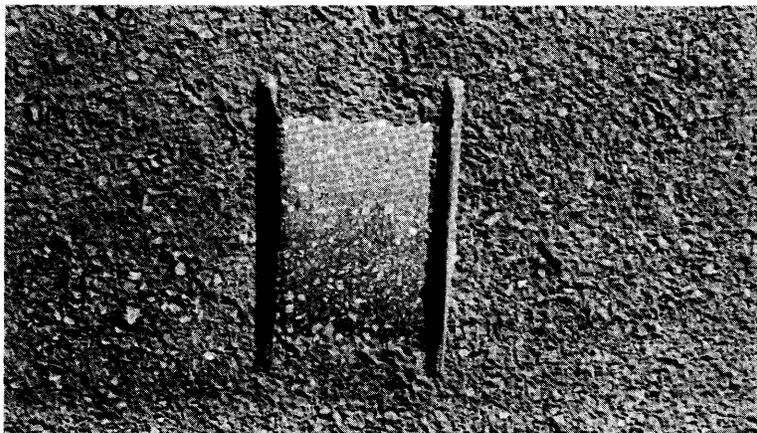
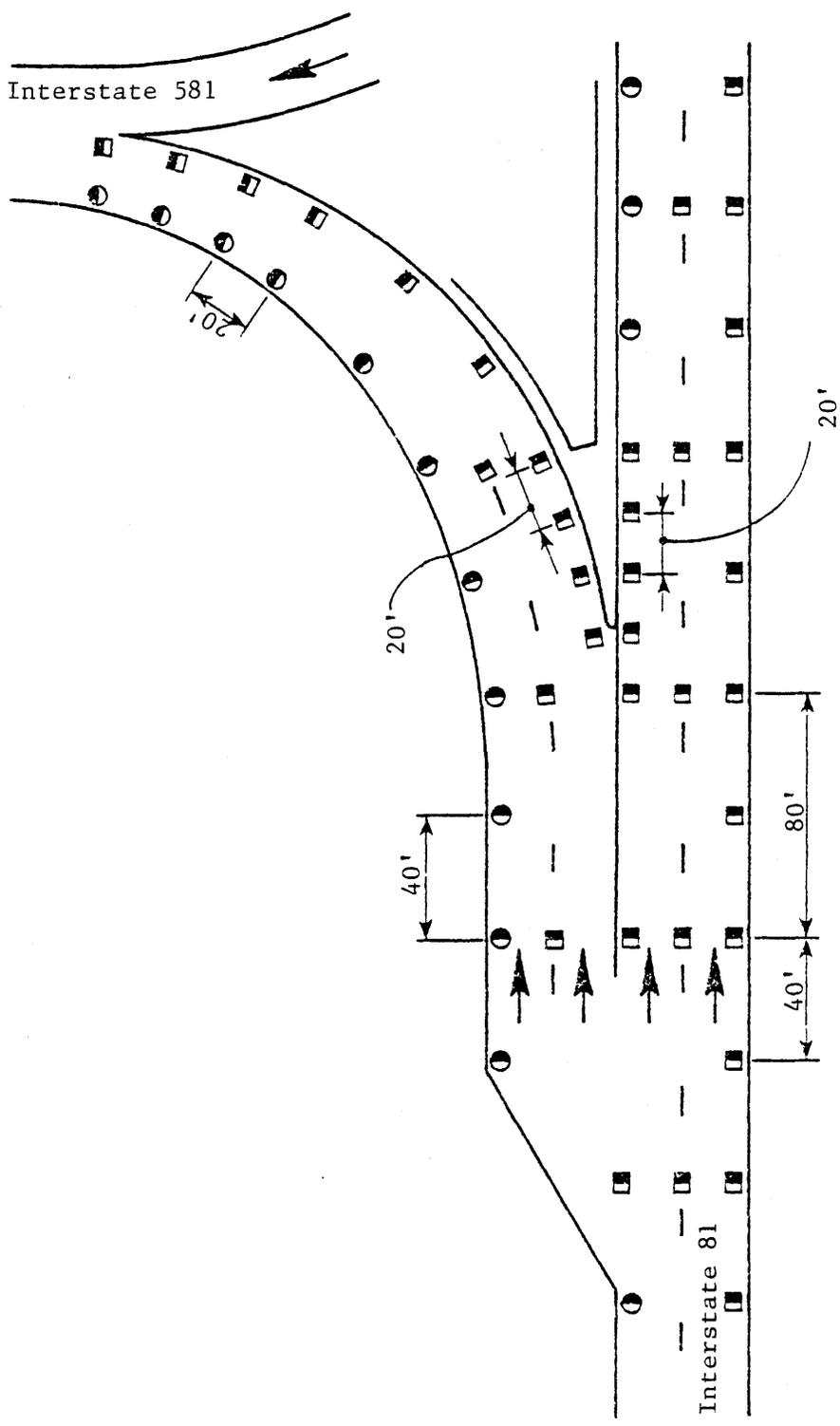


Figure 4. Pavement groove for placement of casting and markers.



LEGEND:  
 ■ - one-way clear  
 ○ - one-way yellow

NOTE: - edgeline markers optional.

- The raised markers should be the same color as the pavement markings they are supplementing.

Figure 5. Raised pavement markers placed on I-81 - I-581.

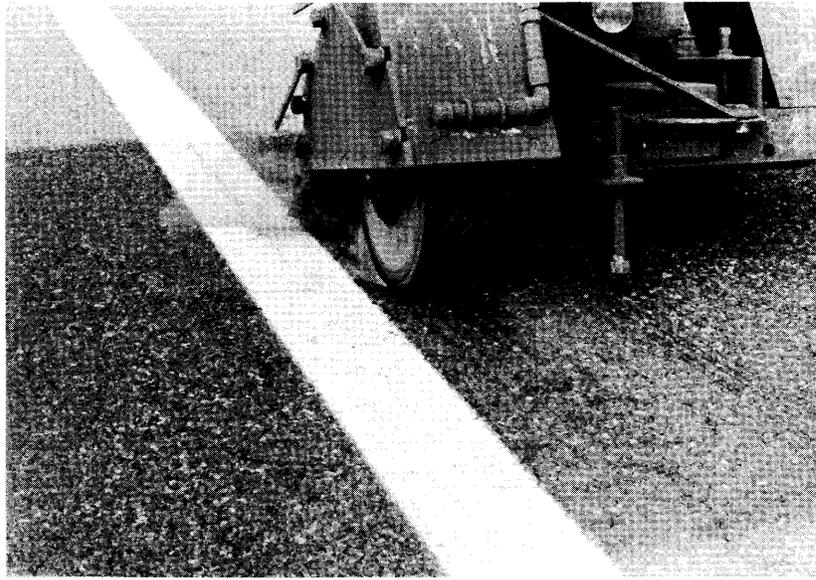


Figure 6. Groove being cut in pavement.

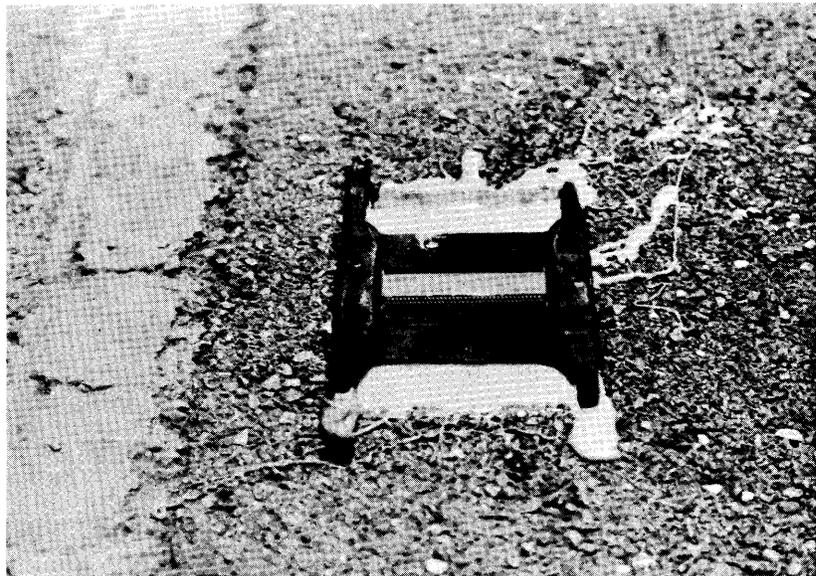


Figure 7. Casting and marker placed in groove.

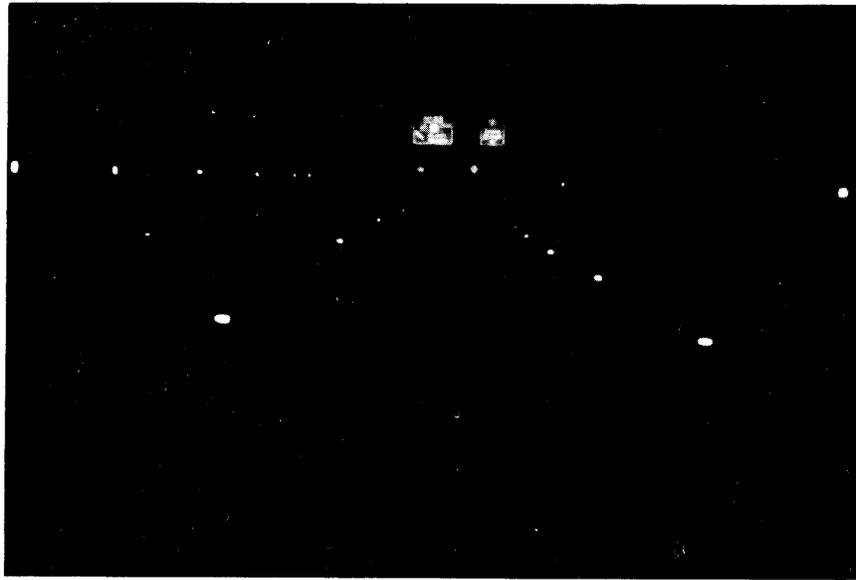


Figure 8. Night photo of raised marker on I-81, mainline.

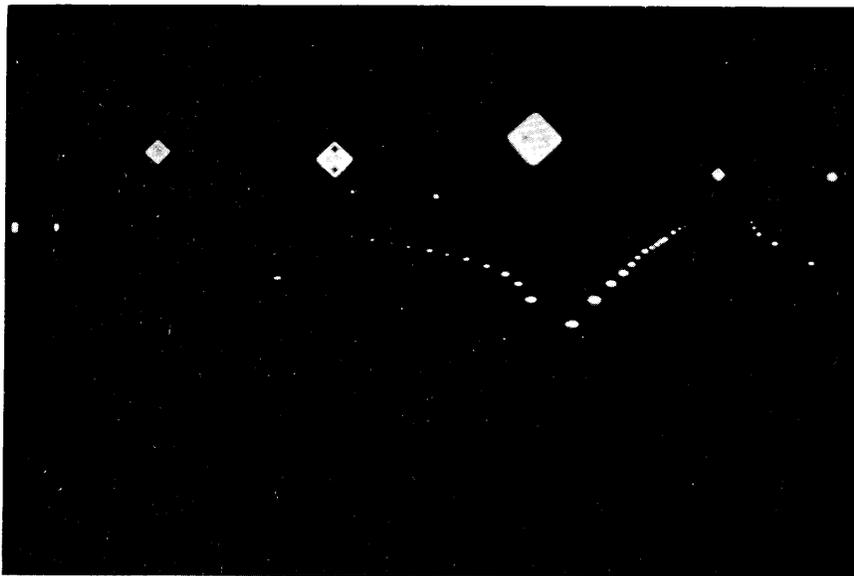


Figure 9. Night photo of raised marker on I-81, gore area.

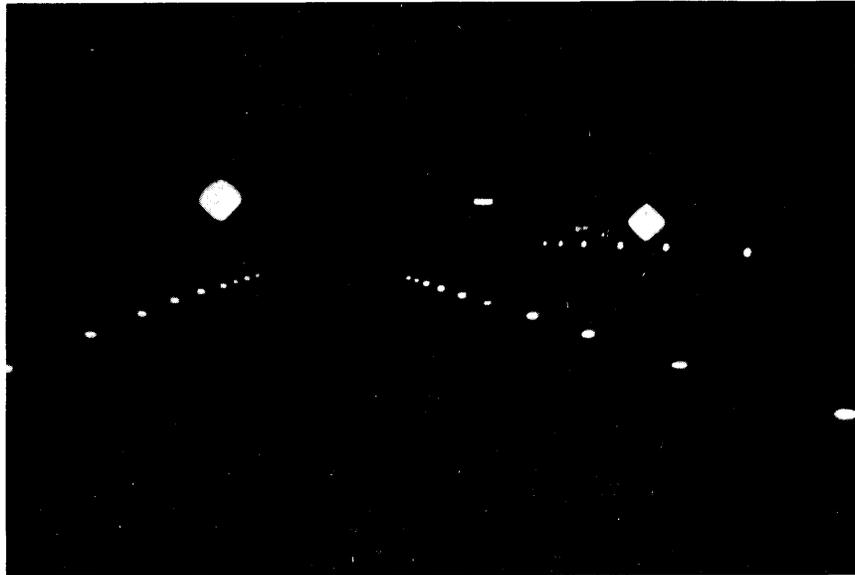


Figure 10. Night photo of raised marker on I-81, left exit ramp.

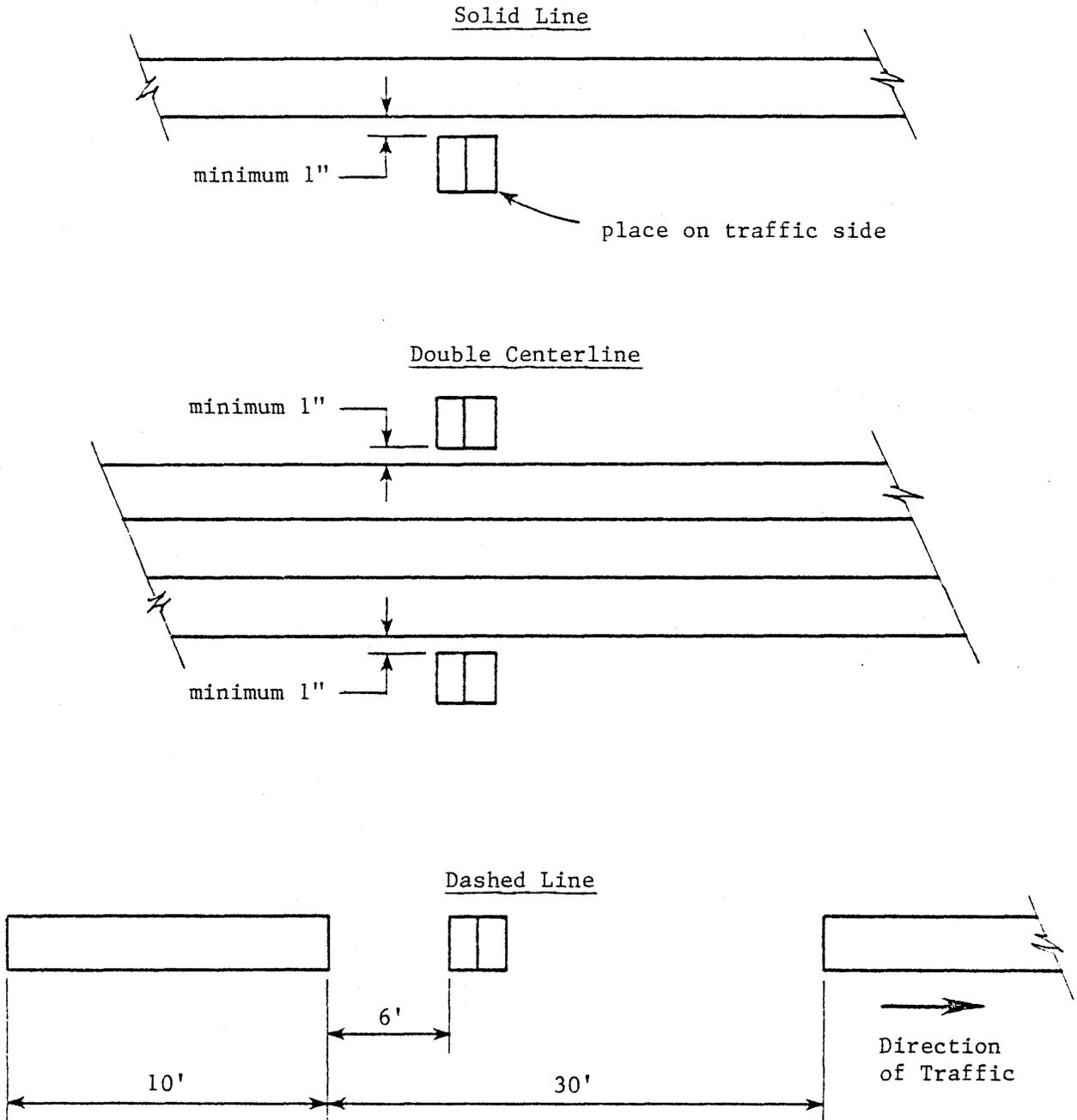
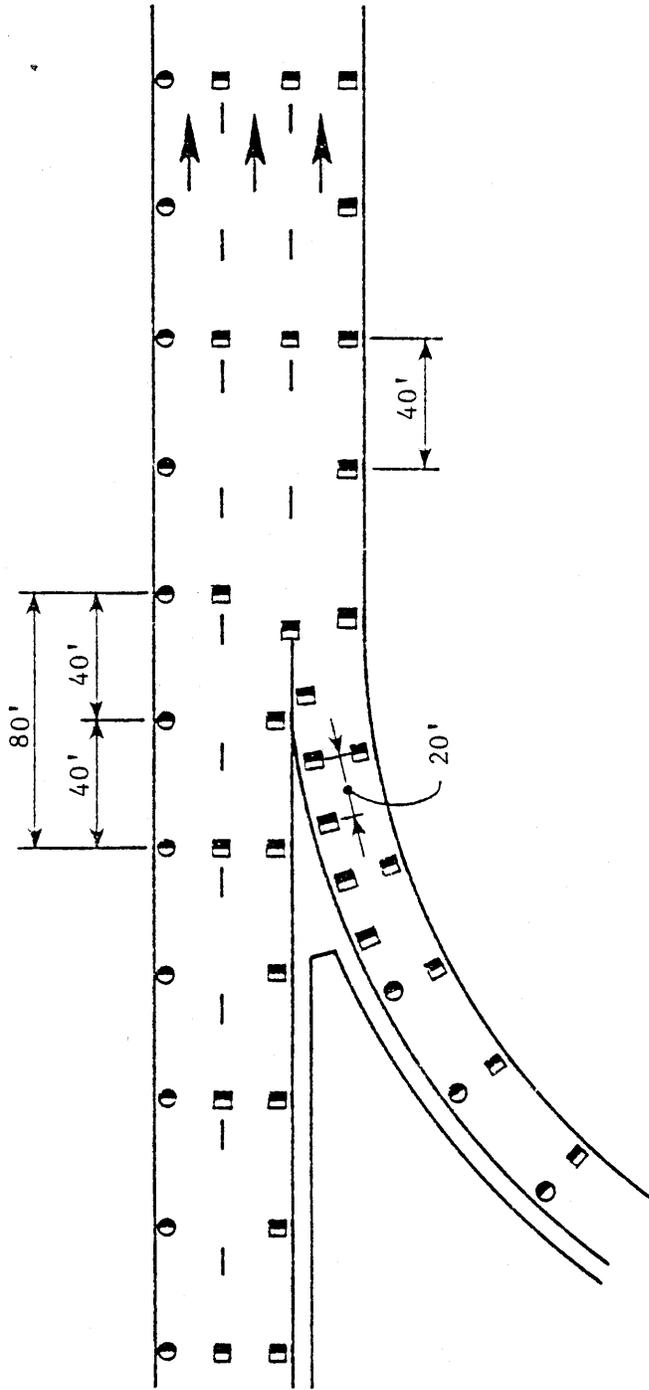


Figure 11. Placement of plowable raised pavement markers relative to centerlines and lane lines.



LEGEND:

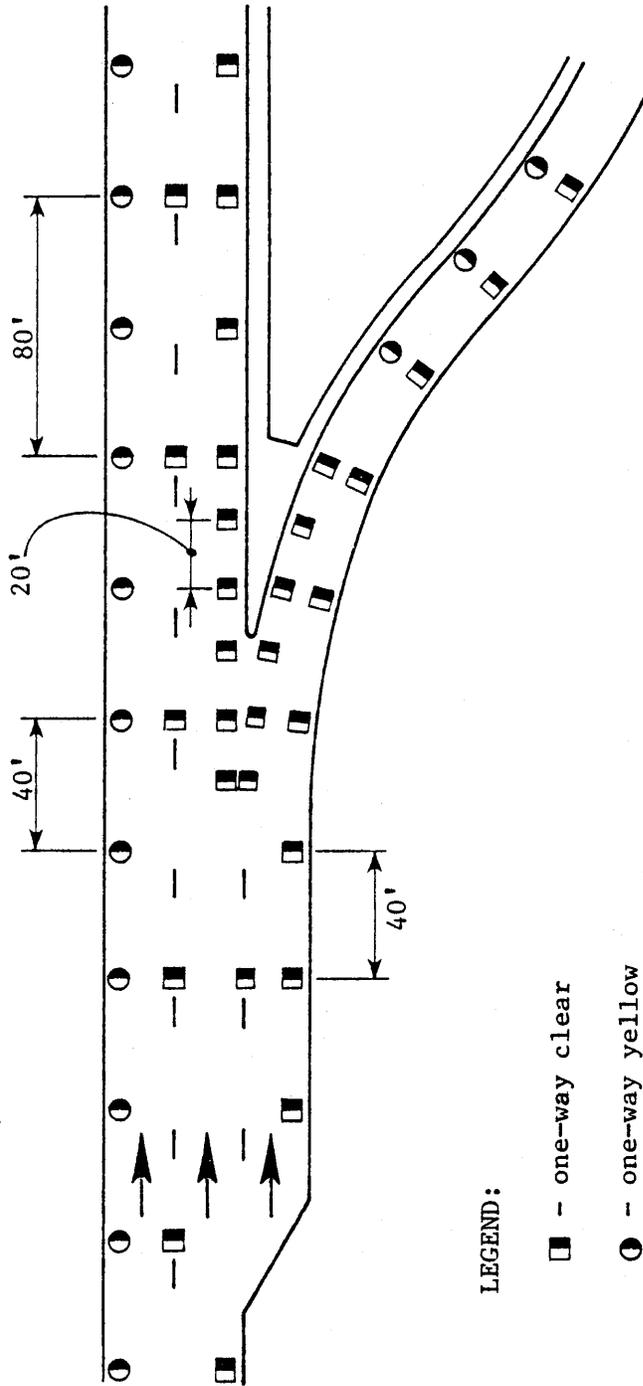
■ - one-way clear

● - one-way yellow

NOTE: - edgeline markers optional.

- The raised markers should be the same color as the pavement markings they are supplementing.

Figure 12. Typical section entrance ramp.



LEGEND:

▭ - one-way clear

● - one-way yellow

NOTE: - edgeline markers optional.

- The raised markers should be the same color as the pavement marking they are supplementing.

Figure 13. Typical section exit ramp.

LEGEND:

▣ - one-way clear

○ - one-way yellow

NOTE: - edgeline markers optional.

- The raised markers should be the same color as the pavement marking they are supplementing.

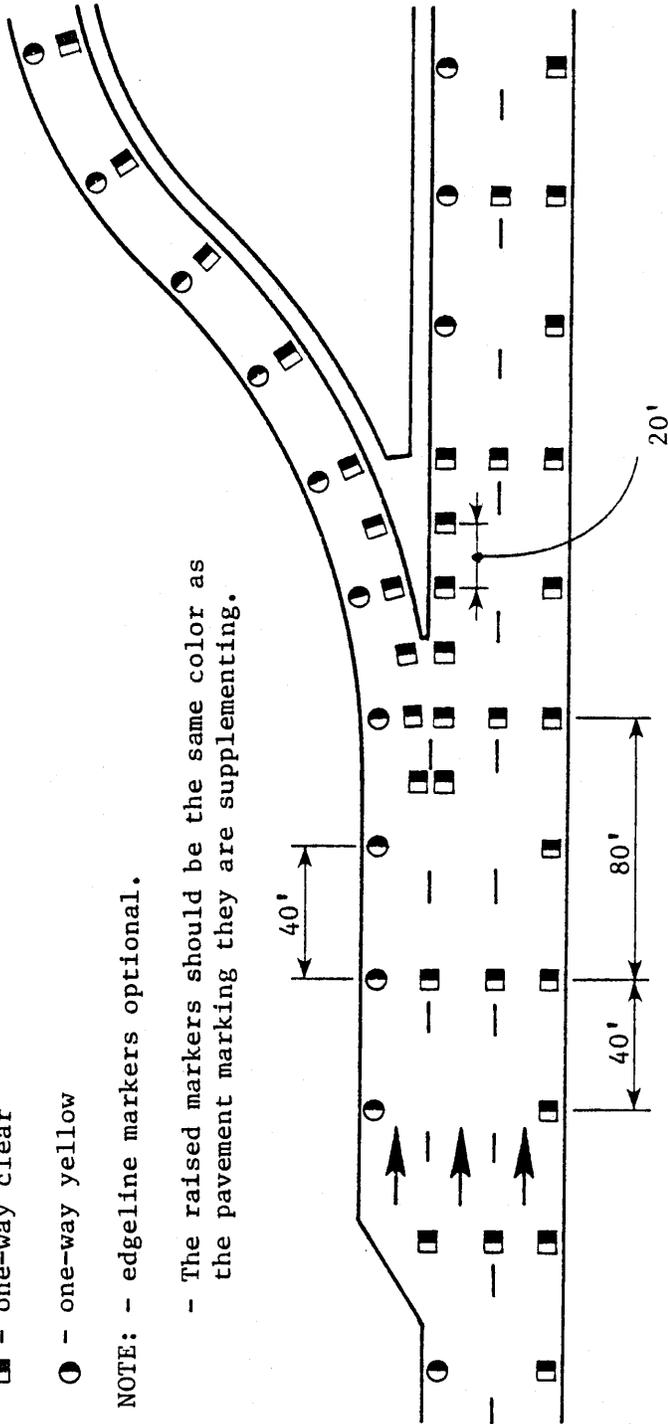


Figure 14. Typical section - left exit ramp.

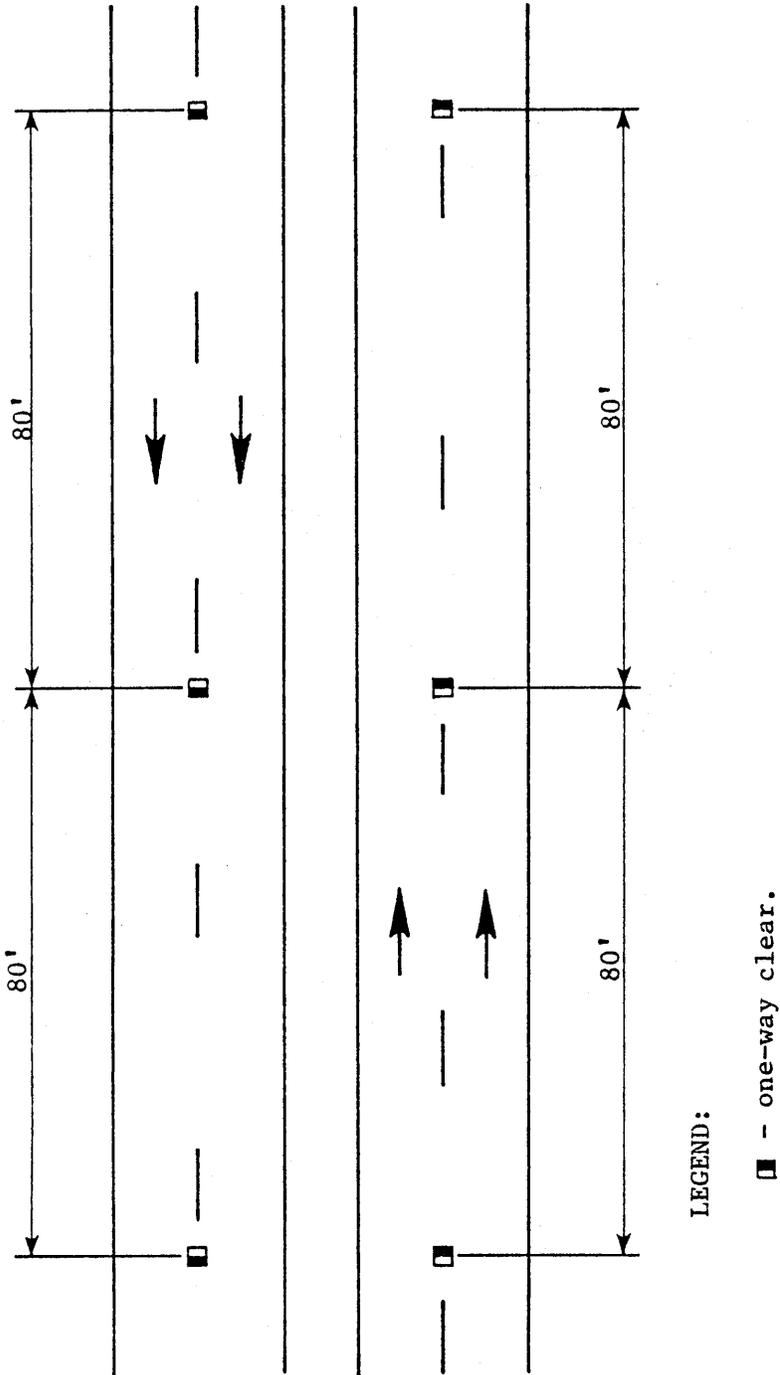


Figure 15. Typical section of 4-lane divided highway.

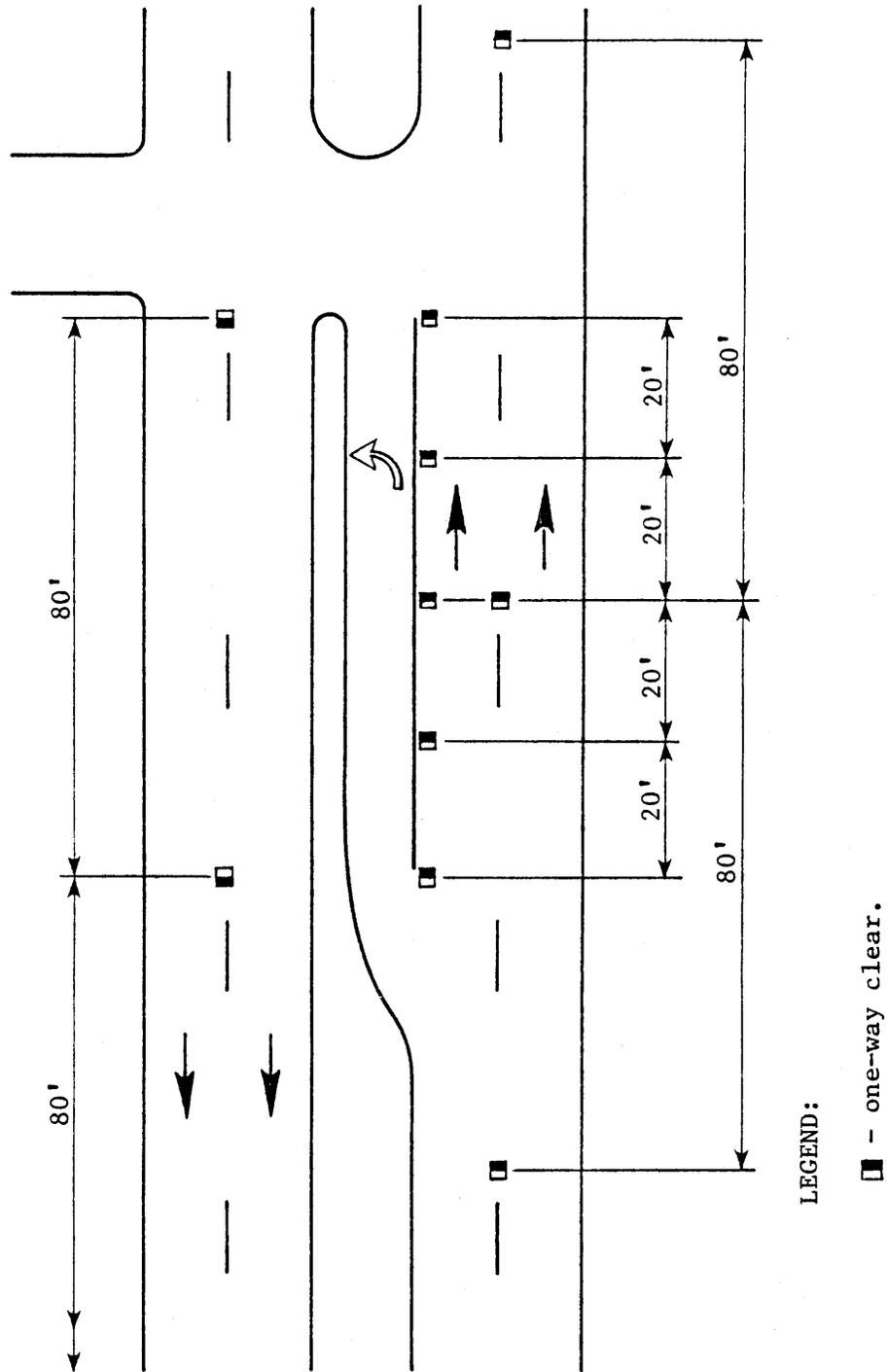


Figure 16. Typical section of 4-lane divided highway.

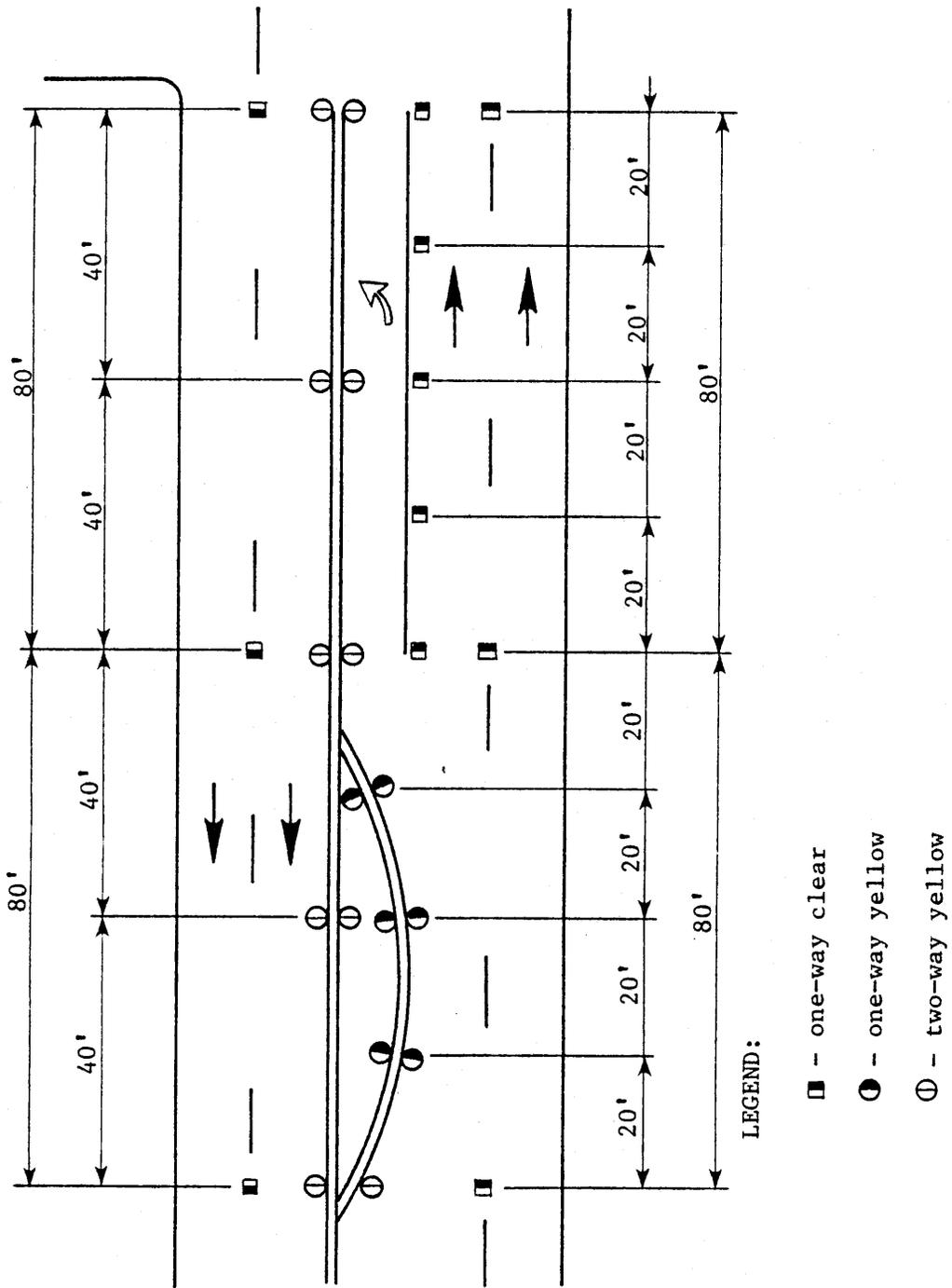


Figure 17. Typical section of 4-lane undivided highway.

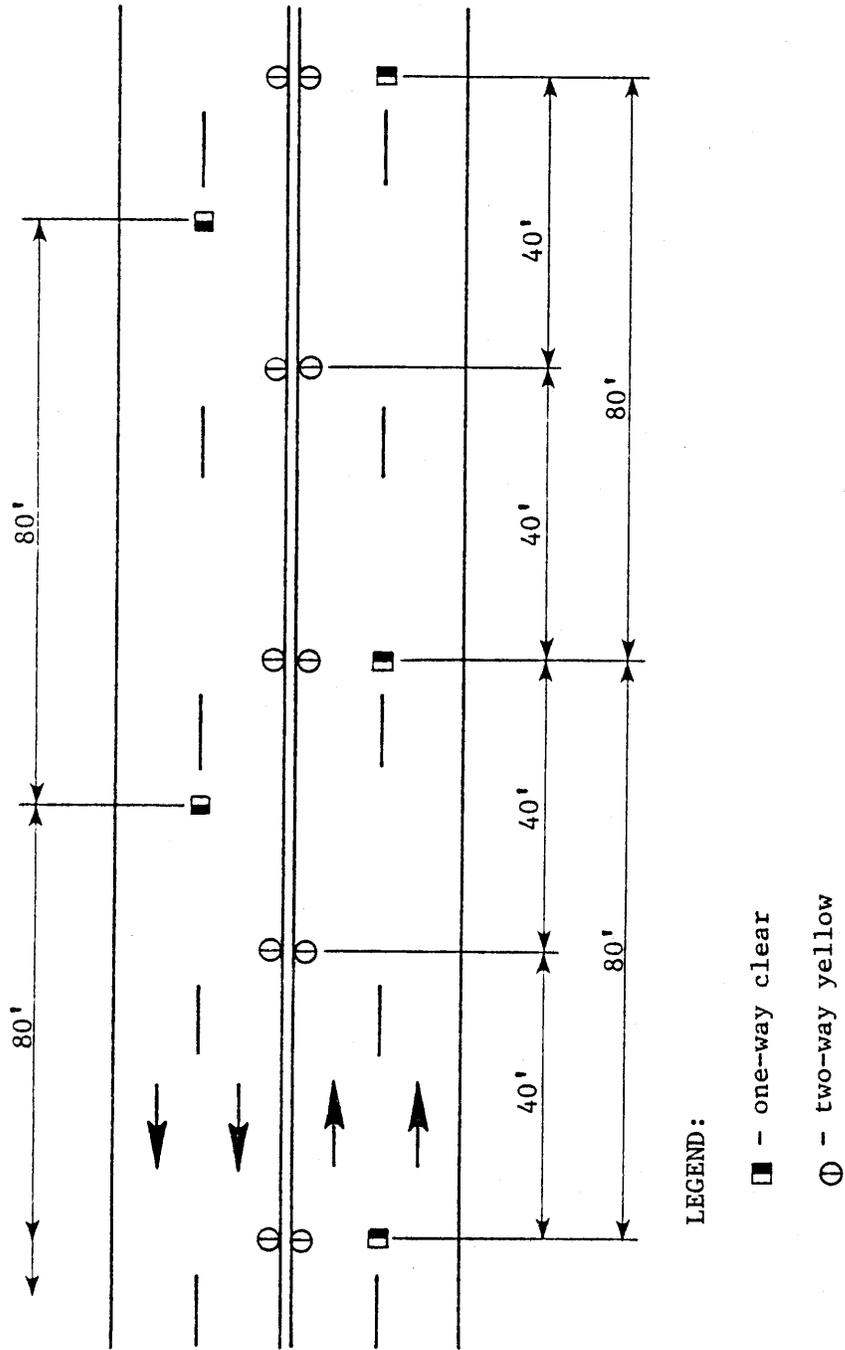
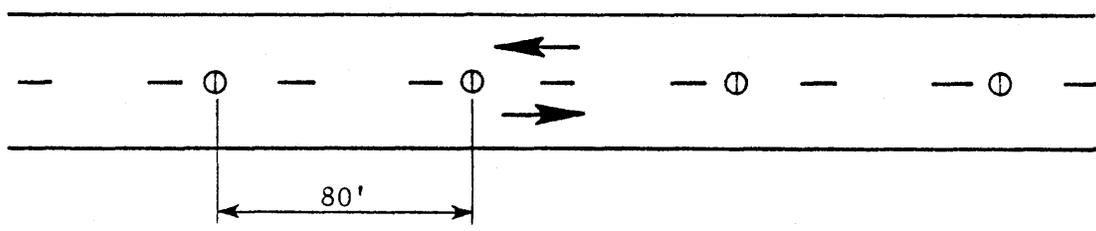
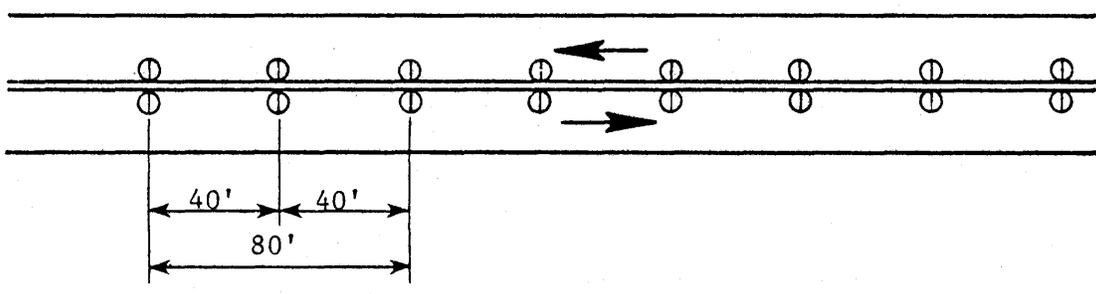


Figure 18. Typical section of 4-lane undivided highway.

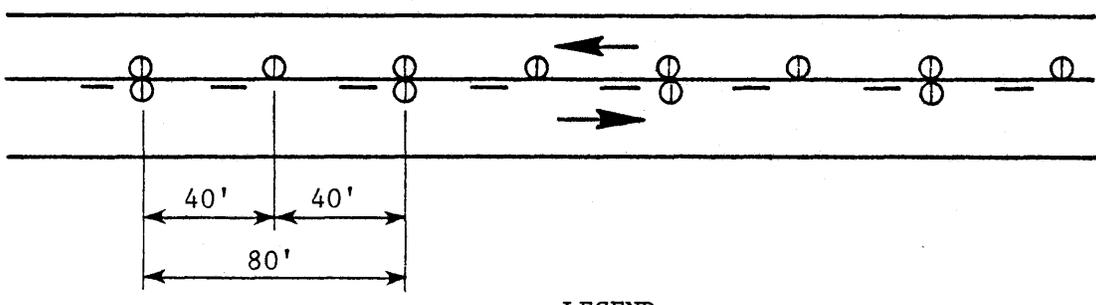
(a) passing permitted both directions



(b) passing prohibited both directions



(c) passing permitted one direction



LEGEND:

⊕ - two-way yellow

Figure 19. Typical 2-lane highway.

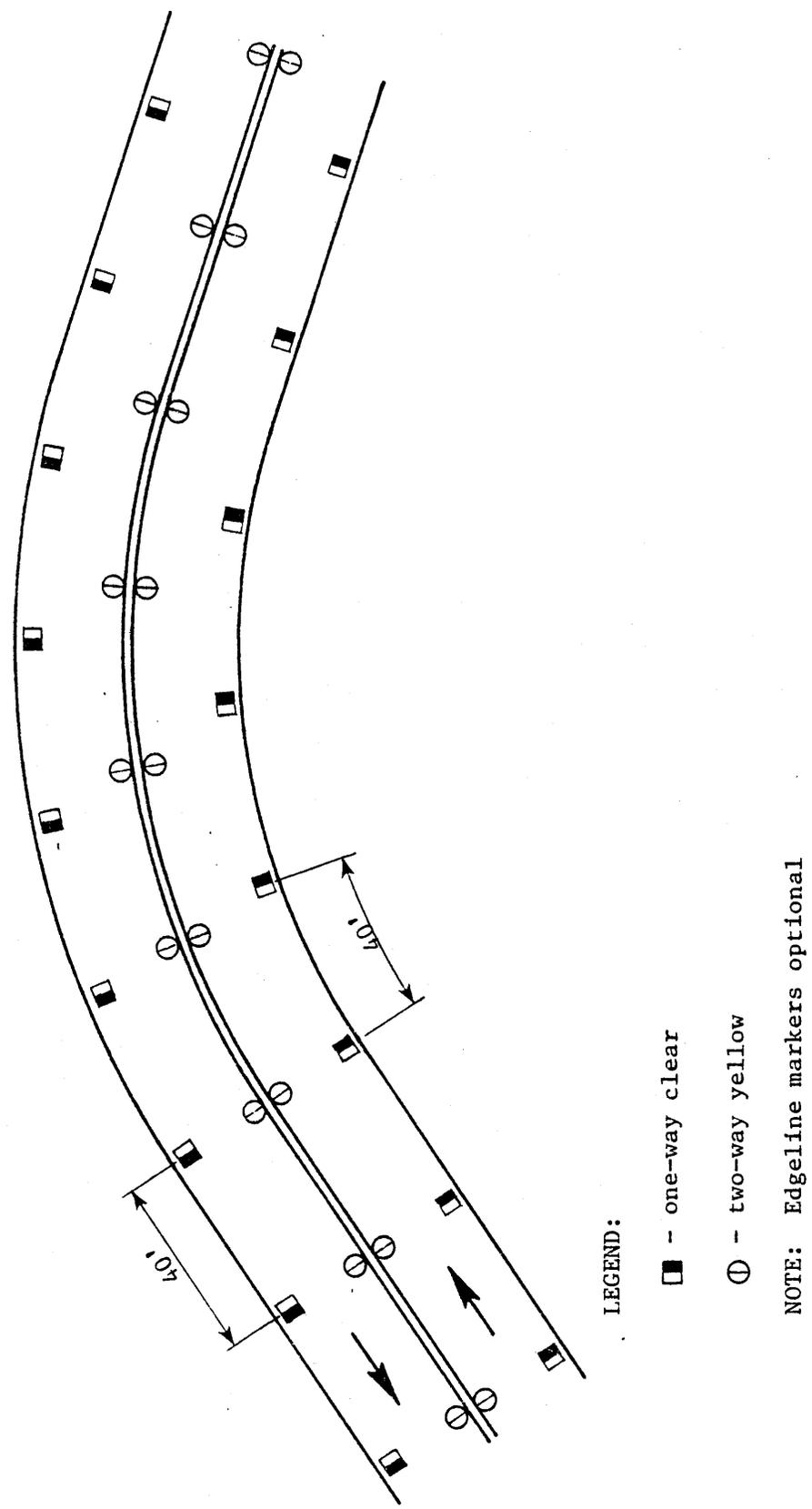
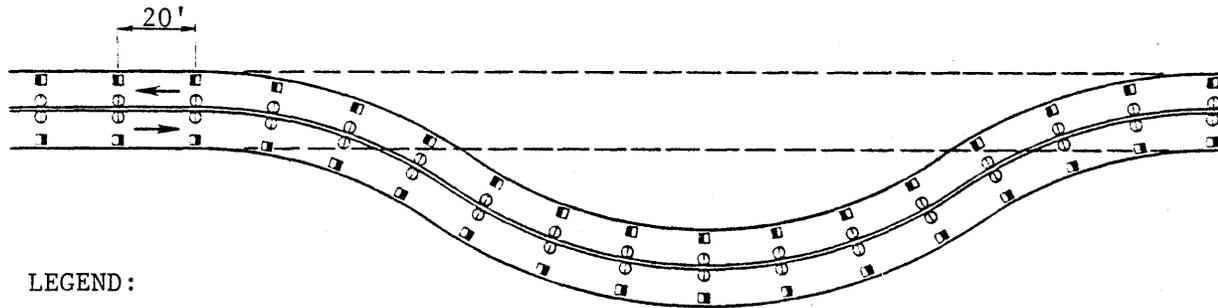


Figure 20. Typical section of horizontal curve on 2-lane highway.

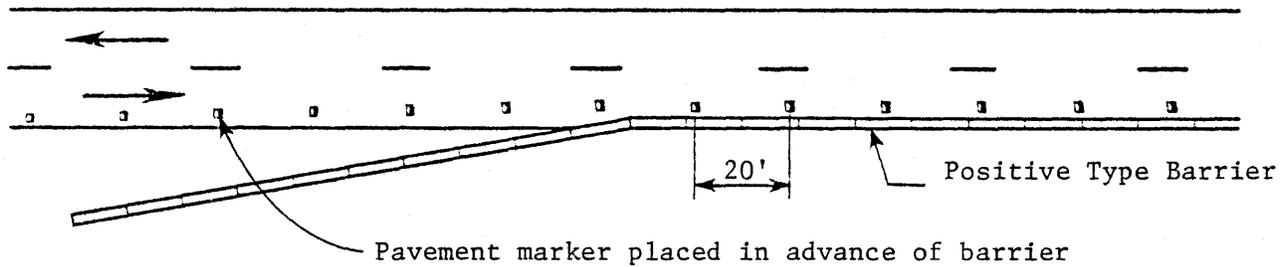


LEGEND:

- - one-way clear
- - two-way yellow

NOTE - The raised markers should be the same color as the pavement markings they are supplementing.  
 - Raised marker spacing should be a function of speed.

Figure 21. Typical placement of raised marker for highway detour.



LEGEND:

- - one-way clear

NOTE - The raised marker should be the same color as the pavement markings they are supplementing.

Figure 22. Placement of raised marker in conjunction with concrete barrier.

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APPENDIX

VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION  
SPECIAL PROVISION FOR  
SNOW PLOWABLE RAISED PAVEMENT MARKERS

December 14, 1979

I. DESCRIPTION:

This work shall consist of furnishing and installing snow plowable raised pavement markers with steel casting and double replaceable prismatic retro-reflectors in accordance with this provision and in reasonably close conformity with the dimensions and alignment shown on the plans or established by the Engineer. The forward and rear noses of the casting shall be shaped to deflect snowplow blades. The bottom of the casting shall include two parallel keels designed to fit into parallel slots cut into the road surface.

II. MATERIALS:

Overall dimensions of the raised pavement markers shall be approximately 9" long by 6" wide and 2" high.

- (a) Steel castings shall conform to ASTM A536, hardened to 52-54RC, and shall weigh approximately 4-1/2 pounds. Keels shall be approximately 3/8 inch thick by 1-1/4 inch in depth and shall have notched edges.
- (b) Reflectors shall consist of prismatic acrylic shell conforming to Federal Specification L-P-380, Type I, Class 3, and filled with tightly adherent potting compound. Each reflector face shall have a minimum reflecting surface of 1.6 sq. in. The slope of reflecting surfaces shall be 30°.

III. INSTALLATION:

Raised pavement markers shall be installed by cutting two parallel grooves into the pavement of the depth and dimensions recommended by the Manufacturer. Grooves shall be cut with 18" and 20" diameter saw blades to match the curvature of the steel casting bottom and keels. Keel surfaces shall be free of scale, dirt, oil, grease or any other contaminant which might reduce bonding.

The casting keels shall be bonded in the saw cut grooves in a manner as recommended by the Manufacturer with Type EP-2 epoxy adhesive for portland cement concrete pavement, with Type CTE epoxy adhesive for bituminous concrete pavement or with an equivalent epoxy adhesive as approved by the Engineer. The bottom middle portion of the casting and the noses of the casting shall be installed flush with the pavement surface. The installed height of the raised pavement marker shall be approximately 1/2" above the pavement surface.

The top of reflectors shall be mounted flush with the top of the casting. The front reflector shall be yellow or silver, as indicated on the plans, and the back reflector shall be red, except when otherwise specified on the plans.

IV. METHOD OF MEASUREMENT:

Snow plowable raised pavement markers will be measured in units of each, complete-in-place.

V. BASIS OF PAYMENT:

Snow plowable raised pavement markers will be paid for at the contract unit price per each, which price shall be full compensation for furnishing and installing steel castings with double prismatic retro-reflectors, for saw cut and epoxy adhesive, and for all materials, labor, tools, equipment and incidentals necessary to complete the work.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
Snow Plowable Raised Pavement Marker	Each

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