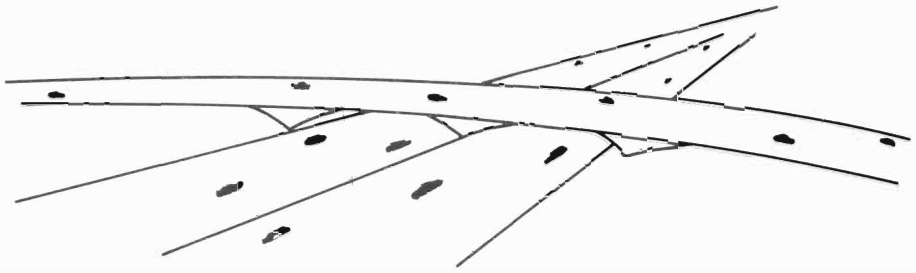

DEPARTMENTAL RESEARCH

Report Number **S S 12.1**

DRIVER COMMUNICATION THROUGH ROADWAY DELINEATION

TEXAS HIGHWAY DEPARTMENT

DRIVER COMMUNICATION

THROUGH ROADWAY DELINEATION

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INFORMATIVE ABSTRACT FOR
"DRIVER COMMUNICATION THROUGH ROADWAY DELINEATION"

This paper investigates the current practices in roadway delineation with particular emphasis on the delineation of freeway exit ramps. The merits and problems associated with current practices particularly in the area of all weather delineators and degree of association with the intended vehicular path through relatively complicated roadway geometrics were investigated. The results of this investigation revealed that the roadside delineator placed above the pavement surface leaves something to be desired in terms of association with an intended vehicular path through a complicated geometric pattern. Reflectorized paint applied to the pavement is good in dry weather, but ceases to be effective under wet night conditions. The use of reflectorized pavement markers was then investigated as these might be used in place of or as a supplement to current delineation. Reflectorized pavement markers having an internal reflective surface were found to be effective under wet night conditions and also maintained an association with the intended path of the vehicle. Also, these markers can be located in areas where a post mounted delineator would be vulnerable to traffic and not practical. A number of patterns of roadway delineation using reflectorized pavement

markers at a freeway exit ramps were studied. The results were that several patterns could be used to advantage and that color code using different colored markers for edge lines, lane lines and ramp gore and edge markings were beneficial but the greatest improvement resulted from positive delineation of the intended vehicular path regardless of the color of the markers. The problems of maintenance of reflectorized pavement markers are discussed with the conclusion that while maintenance is something of a problem, particularly in areas where snow removal is necessary, the advantages of this type of delineation far outweigh the disadvantages.

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INTRODUCTION

Using the term in its very broadest sense, roadway delineation in daylight and in good weather is actually accomplished by the fact that a road has been built. Shaping the terrain into the proper position for vehicular travel in itself delineates the intended path. The color contrast resulting from the materials used often results in even further delineation and marking center lines and other features with paint has been common for many years. As the road becomes more complex, however, and more vehicles travel in close proximity to each other, the need for precisely outlining the path each driver is expected to follow becomes demanding and this need exists at night as well as in the daytime.

Daylight delineation, while requiring careful attention to detail, can be accomplished using currently available materials and methods with reasonable satisfaction. Night delineation, however, requires an entirely different approach and frequently leaves much to be desired. Reflectorized materials of various types have been used with considerable success, and when properly positioned, serve their intended purpose of retro-reflecting the beam from the vehicle headlight back to the driver. Proper positioning of reflectorized devices

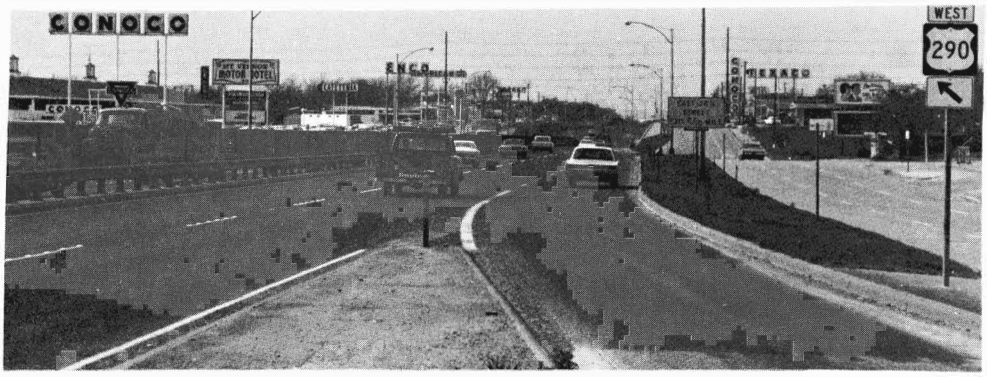
is vital, however, and since many of these materials will not function when covered by a film of water, the driver may be faced with a situation where no effective delineation remains on a wet night.

CHAPTER I

CURRENT STATUS OF ROADWAY DELINEATION

A number of examples of delineation currently in use are illustrated in Figure 1. These include such items as lane lines, barrier or no passing lines, pavement edge lines, channelization markings, pavement contrast and hazard markers. Delineation is accomplished by such various means as appearance contrast, paint- either reflectorized or non-reflectorized, pavement markers of various types, roadside delineators and possibly other devices. Relatively standard use and treatment of most of these devices has come about over a period of time and guidelines for their use are provided in the "Manual on Uniform Traffic Control Devices".

Delineation, since it is a relatively inexpensive, versatile and portable device, has been used in many instances in attempts to correct a wide variety of operational problems including basic geometric design deficiencies. These attempts are usually at least partly successful, but delineation of poor geometry



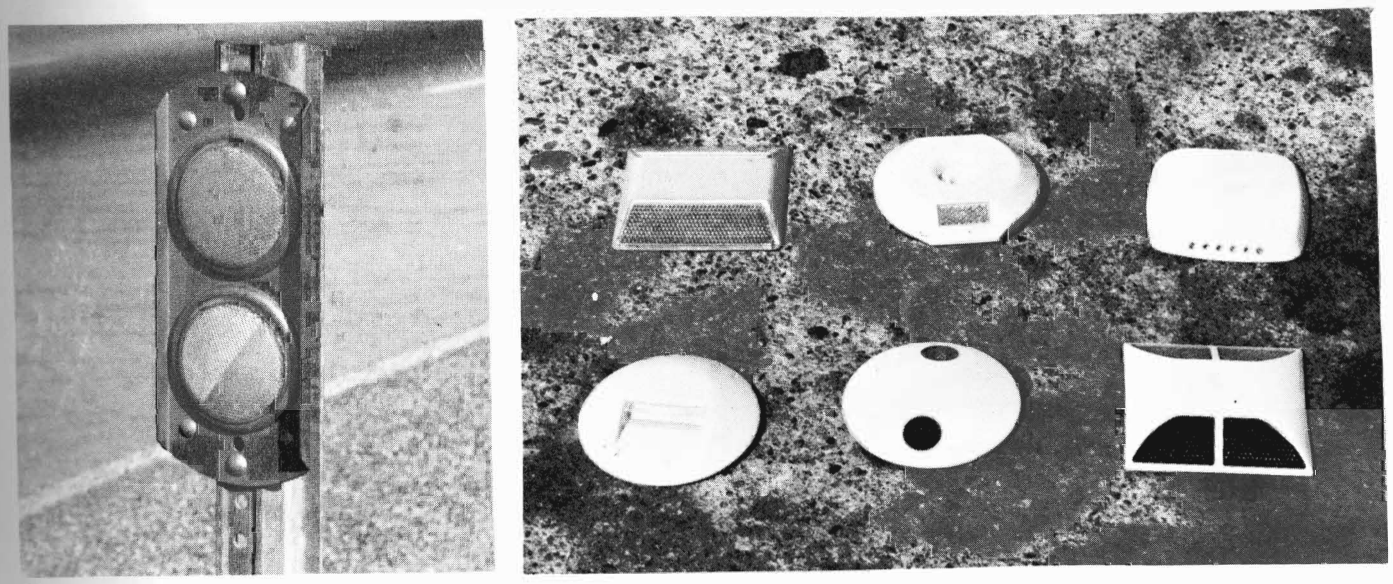


Figure 1

Figure 2

cannot be expected to be a satisfactory alternative to correcting the geometry. As a result of this some very elaborate delineation systems, costly, but inexpensive compared to the cost of revising the roadway geometry, have been installed. The operational improvements resulting from these installations have ranged from satisfactory to completely unsatisfactory. In some cases the problem may have been beyond the scope of correction by delineation, while in other cases the delineation may not have been correctly applied.

CHAPTER II

DELINEATION REQUIREMENTS

Roads having relatively good geometry require delineation at night, primarily to confirm a relatively normal vehicular path. The material used should be equally effective under all weather conditions, however, and should associate directly with the intended path of the vehicle. The roadside delineator positioned adjacent to the road and 4 1/2 feet above the pavement is effective in bad weather and is relatively satisfactory for delineation of uncomplicated roadway alignments. It is in common use as illustrated in Figure 2. Where alignment is more complex, the roadside delineator, due to the fact that it is positioned 4 1/2 feet above the pavement, and the inability

of a driver to determine depth or distance from the point of observation to the delineator where delineators are relatively close to each other, does not always convey a discernible travel path to the driver. It loses its association with the pavement as illustrated in Figure 3b. The three photographs shown here were taken from the same position on the highway. In daylight (3a) the location of the ramp is obvious and even though the geometrics of the ramp are deficient, the driver can see the area clearly. Where the delineators are the only visible indication of the location of the ramp, as would be the case on a wet night, the driver would very likely be confused by the somewhat jumbled array of delineation shown in the night photograph (3b).

This is the result of the delineators being located in a plane 4 1/2 feet above the pavement and the fact that they do not convey depth perception. It would be possible to develop a delineation pattern using roadside delineators which would convey a correct image but this image would be optimum at only one location along the approach to the ramp and would change as the vehicle approaches.

The reflectorized paint line shown in Figure 4 retains an association with the pavement at night even where alignment is

FIGURE 3(a)

STUDY RAMP NO. 2
IN DAYLIGHT

FIGURE 3(b)

STUDY RAMP NO. 2
AT NIGHT SHOWING
DELINEATORS

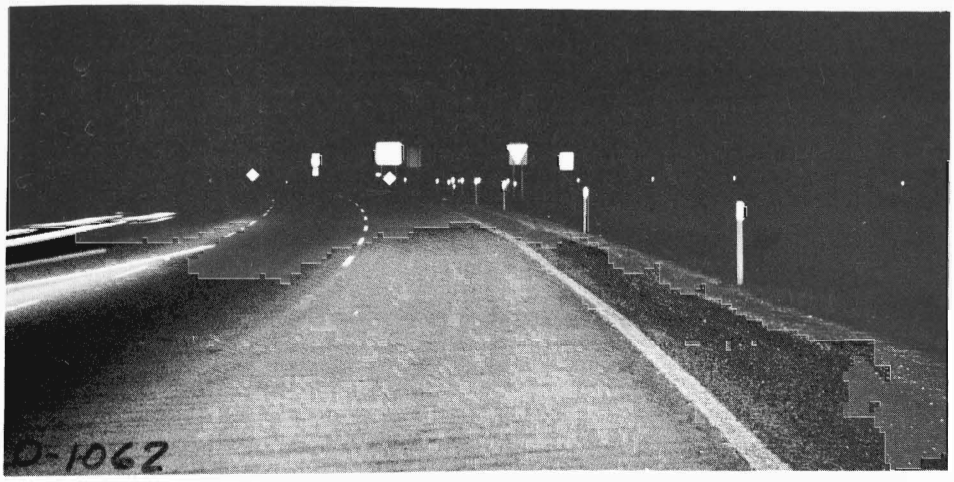


FIGURE 3(c)

STUDY RAMP NO. 2
AT NIGHT SHOWING
REFLECTORIZED
PAVEMENT MARKERS

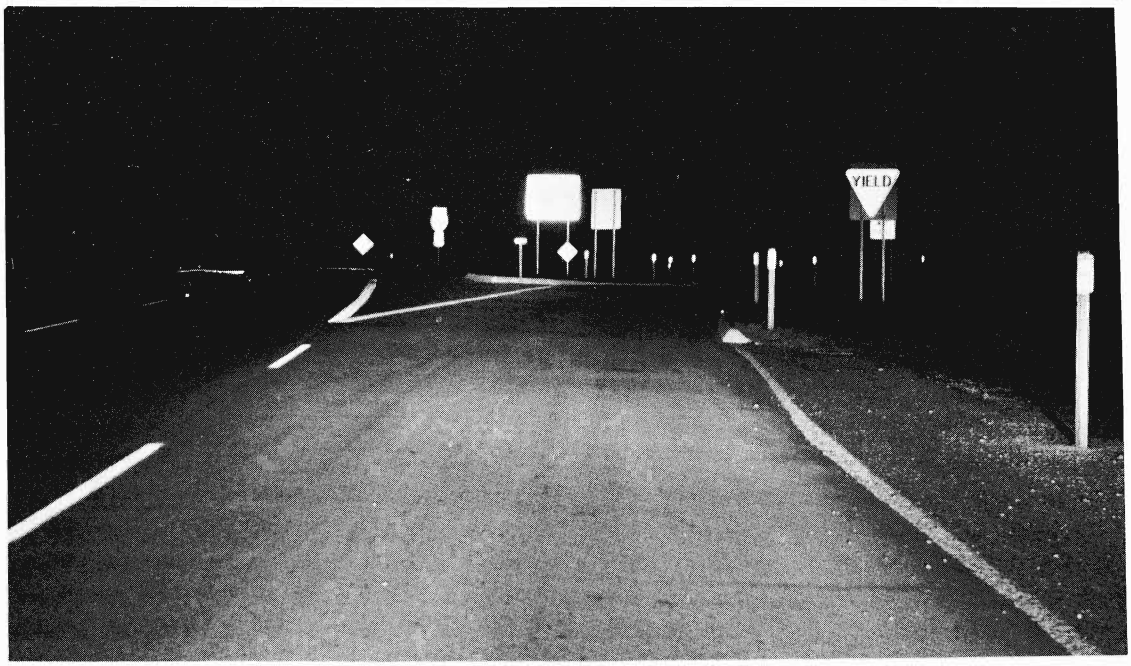


FIGURE 4

complicated, but loses part or all of its reflective ability when it becomes wet and is not as bright as the markers shown in 3c even when dry. Since the pavement is dry a large percentage of the time, the reflectorized paint line does serve a useful purpose and will undoubtedly continue in use, possibly with a supplemental material for the night and wet night conditions. Roadside delineators also are effective under wide range of conditions and can be supplemented where the situation demands.

CHAPTER III

EXPERIMENTATION & DEVELOPMENT

Experimentation on the use of pavement markers for delineating the night travel path on ramps began in January of 1966. A large school parking lot was utilized on which various ramp geometric configurations were laid out by paint lines. These geometric configurations conformed to the Department's standard design for exit ramps.

On one of the nights of the study by a group of engineers, it was raining and had been raining all afternoon. Water had completely covered the ground and almost obscured the visibility of the paint lines. This proved to be an ideal condition in

which to observe and evaluate the raised reflective markers of the various types.

It was concluded that the pavement marker providing an internal reflective element as opposed to an exposed lense had better all-weather characteristics and were brighter.

Other experiments on the use of arrows made with red mono-directional markers for prevention of wrong-way entry at exit ramps were also performed. It was concluded that such arrows should be positioned as close as possible to the end of the exit ramp without protruding onto the frontage road. It was also decided that the arrows should be skewed in order to give the driver approaching the exit ramp a clearer view. In addition to the arrow, a ramp edge line composed of yellow pavement markers and white pavement markers on the lane line were considered effective in delineating the ramp and in an attempt to discourage wrong-way movements.

The next experimentation consisted of placement of various colors, reflective intensity, number and spacing of pavement markers at a typical exit ramp on a 6-lane freeway located in Waco, Texas. Each arrangement was evaluated and photographed from various distances ranging from 275 feet to 1000 feet at approximate height of the driver's eyes with both high beam and low beam headlights.

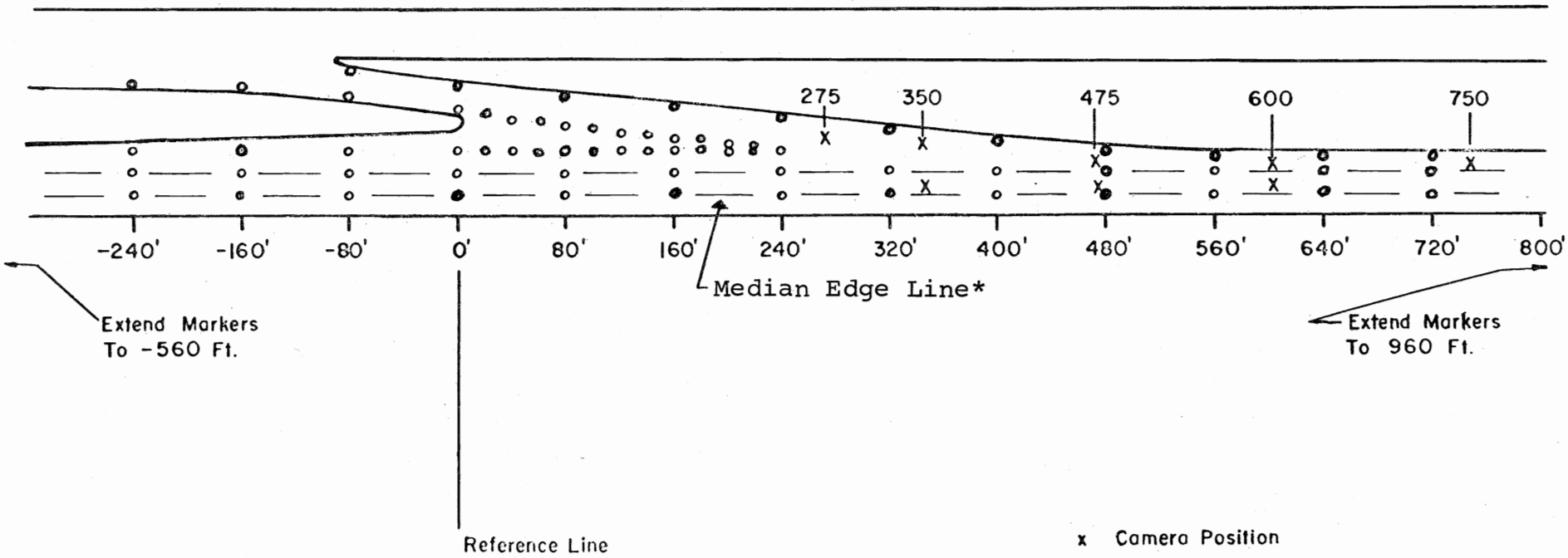
From previous experience it was concluded that all pavement markings such as lane lines and edge lines as well as all proposed pavement markers should be in place before a meaningful evaluation could be made.

Normally the markers are bonded to the pavement by use of an epoxy but for convenience in rearranging same, the markers were not bonded in this experiment. Colors used were white, yellow, and blue mono-directional markers.

The ramp geometry and general arrangement of pavement markers are illustrated in Figure 5 and described in the following paragraph. A conscientious effort was made to use the minimum number of units which could be logically expected to produce satisfactory results.

Arrangement B-1 consisted of a blue ramp edge line beginning 640 feet in advance of the ramp with markers spaced at 80 foot intervals extending down the right side of the ramp. White markers were placed on the lane lines and the median edge line spaced at 80 feet, beginning 960 feet in advance of the ramp and extending 240 feet beyond. The gore of the ramp was delineated by white markers spaced at 20 feet in a "V" type pattern extending 240 feet in advance of the curbed ramp gore. White markers at 80 foot spacing also extended down the left side of the ramp

RAMP GEOMETRY AND GENERAL ARRANGEMENT OF
PAVEMENT MARKERS



* Three lane freeway was delineated as two lane for this experiment

STUDY RAMP NO. 1

FIGURE 5

and at the normal pavement edge some 240 feet beyond the ramp gore.

Arrangement B-2 utilized a like pattern to B-1, except yellow markers were used in lieu of blue markers at the right edge of the ramp.

Arrangement B-2a was similar to B-1 and B-2, except yellow markers were used on either side of the ramp.

Arrangement B-3 was similar to B-2a with exception that the median lane markers were spaced at 160 feet in lieu of 80 feet.

Arrangement B-4 was similar to B-3, except the median lane markers were eliminated entirely.

Arrangement B-5 was similar to B-4, except low intensity markers were used on the median lane at 80 foot spacing.

Arrangement B-6 was similar to B-5, except blue markers were used on the median lane at 80 foot spacing.

After observing the delineation, the most profound realization of the diagnostic team was the observed difference between a freeway ramp with reflectorized markers and one without. In the experiment, arrangement B-3 with yellow markers at both the left and right edges of the ramp was considered the preferable

design by the group. However, arrangement B-2a, B-5 and B-6 were also considered excellent.

The reasons for these choices were as follows:

1. Edge lines and lane lines were clear and well defined.
2. The exit ramp became distinguishable to the driver sooner.
3. There is little chance of mistaking the exit ramp marking for the lane marking.
4. All of the above mentioned features exist with little or no improvement in arrangements B-2a, B-5, and B-6 but at the expense of considerably more markers.

One objection to arrangement B-3 was the possibility of a driver confusing the yellow markers at an exit ramp with those used in a hazard zone.

Following this work, in July of 1968 another exit ramp on Interstate Highway 35 in Waco was permanently delineated by markers which have remained in place since that time with little or no maintenance necessary. Figure 6 shows the pattern utilized which consisted of blue markers spaced at 20 feet at both the right and left edges of the ramp proper, yellow markers at the

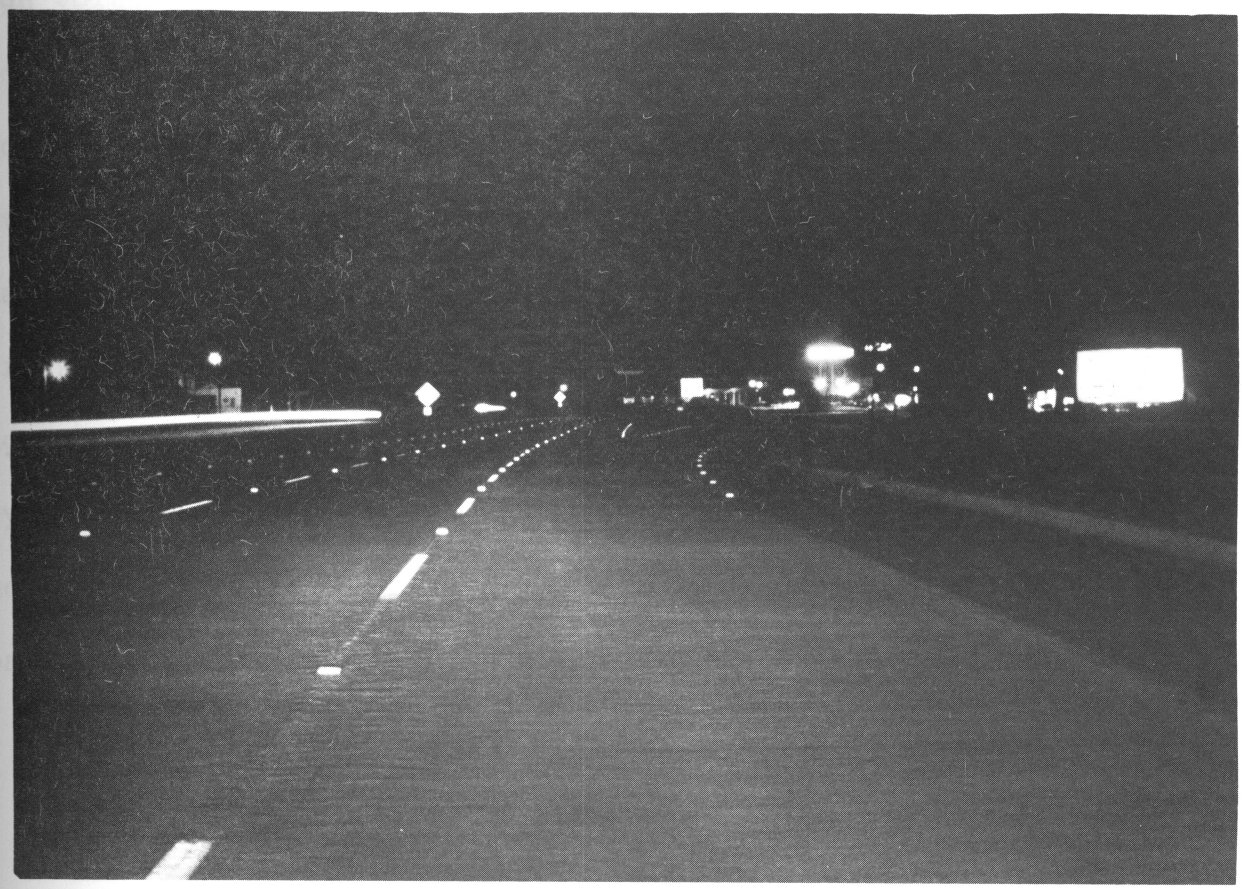


FIGURE 6

right and left pavement edges spaced at 20 feet, and white markers on the lane lines spaced at 40 feet. Although the markers are probably more numerous than necessary, the ramp is well delineated and operation has been very satisfactory during this one year of service.

At the present time a sizable number of bi-directional marker units of the type illustrated in Figure 7 are in place, primarily on high volume freeways as lane lines with the reverse side being red on the assumption that a driver entering the freeway in the wrong direction might note his error and take proper corrective action. Figure 8 indicates the standard plan sheet for installation of ceramic traffic buttons, pavement markers and arrows. These buttons and markers may be used on any multi-lane highway where added visibility is considered necessary. Wrong-way arrows are used at all exit ramps to two-way frontage roads and other exit ramps where ramp terminals are near the cross-road or where there has been wrong-way entry experience.

CHAPTER IV

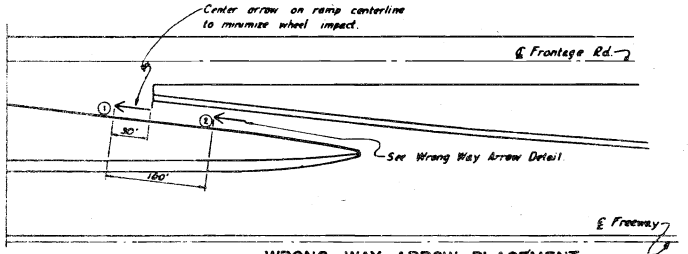
TENTATIVE CONCLUSIONS

Although the experimentation in this area to date has been somewhat limited, several conclusions can be drawn. Probably the most important of these would be that a form of delineation

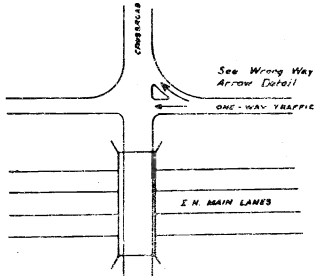
FIGURE 7

SMOOTH SURFACE, RETRO-REFLECTIVE UNITS WITH INTERNAL REFLECTING SURFACE

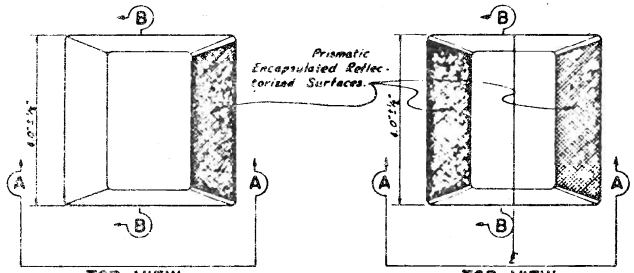
Reflectorized arrow(s) not to exceed two shall be placed on all exit ramps within the limits of the project. Location of arrow 1 shall be as shown. A second arrow shall be placed at location 2.

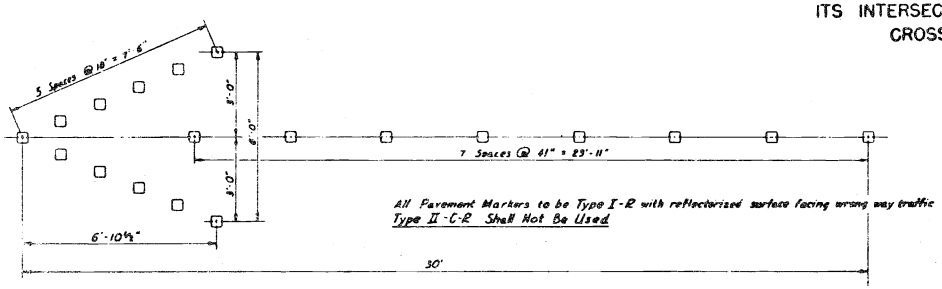


WRONG WAY ARROW PLACEMENT ON EXIT RAMPS

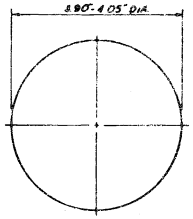


WRONG WAY ARROW PLACEMENT ON ONE-WAY EXIT RAMP AT ITS INTERSECTION WITH A CROSSROAD

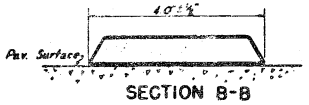




WRONG WAY ARROW DETAIL



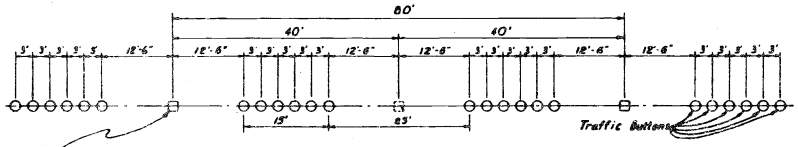
TOP VIEW



Minimum area of markers shall be not less than 12.5 square inches.

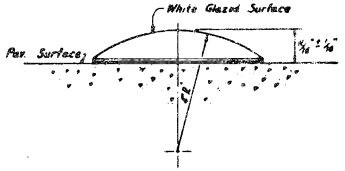
Marker shown is for illustrative purposes only and is not intended to specify any particular product.

PAVEMENT MARKERS (REFLECTORIZED) Types I & II



Pavement Marker Type II-C-R, crystal face toward normal traffic, red face toward wrong way traffic, shall be spaced on 80' centers except on vertical curves, grades over 2%, horizontal curves, and on continuously illuminated sections of highway where they may be placed on 40' centers if deemed necessary by the engineer.

TRAFFIC BUTTON AND PAVEMENT MARKER LANE LINE DETAIL



TRAFFIC BUTTONS

TEXAS HIGHWAY DEPARTMENT
TRAFFIC BUTTONS
(NON - REFLECTORIZED)
&
PAVEMENT MARKERS
(REFLECTORIZED)
FOR LANE LINES AND WRONG WAY ARROWS

INTERSTATE AND OTHER CONTROLLED ACCESS HIGHWAYS
TB & PM-66

ORIGINAL DRAWING DATE 7-26-66

FIGURE 8

which continues to be effective on a wet night is of considerable benefit to the motorist under these adverse conditions. The reflectorized pavement marker serves this purpose and is also effective in good weather. This would be by comparison with reflectorized paint which is good in dry weather, but probably not as bright as the reflectorized markers. By way of comparison with the roadside delineator, the reflectorized pavement marker retains its association with the pavement and the intended path of the vehicle more effectively than does the roadside delineators and the reflectorized pavement marker can be positioned in vulnerable areas such as ramp gores, where it would be impossible to locate delineators on posts.

While the vertical and horizontal alignment of the pavement and ramp have a considerable influence on this, the reflectorized markers present a continually reasonable perspective of the ramp to the driver as he approaches the exit point. This is important on all ramps but particularly when dealing with existing ramps with deficient geometrics.

In connection with the color and delineation pattern where edge lines, lane lines and ramp delineation are all concerned; several general conclusions can be drawn. The most impressive of which would be the contrast between the reflectorized pavement

marker and other forms of delineation. It is most impressive, however, to the driver approaching or leaving an area delineated with pavement markers on a wet night when reflectorized markers are the only form of delineation which remain effective. All of the patterns observed were good. It is undoubtedly desirable to use color as a means of imparting information to the driver but the visible outline of the intended vehicle path, regardless of the color, leaves little to be desired.

Maintaining markers of this type in the area traveled by vehicles is not without problems. Failures usually occur within the pavement rather than within the marker and are more frequent on asphaltic concrete surfaces than on portland cement concrete. In most cases the marker pulls one eighth to one sixteenth of an inch of pavement out with it as illustrated in Figure 9.

The use of markers in areas where extensive snow removal operations are necessary may present problems which are insolvable at this time. Markers have been designed for use in areas of this type and may prove to be satisfactory but practical experience is limited at this time.

FIGURE 9