EVALUATION OF RAISED PAVEMENT MARKERS FOR REDUCING INCIDENCES OF WRONG-WAY DRIVING

by

Frank D. Shepard
Research Engineer

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

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SUMMARY

The research reported here was undertaken to determine the feasibility of using raised pavement markers on interstate off-ramps in such a configuration that the driver will be alerted as a result of viewing an unexpected phenomenon. The results of this preliminary investigation show that the raised pavement marking system, consisting of a pattern of 45 markers, was effective in alerting drivers and would cause a wrong-way driver to realize his mistake and act accordingly. Based on the results of this initial phase, it is recommended that the study be expanded by permanently placing raised markers at two or three interchange off-ramps for further study. It is anticipated that this recommendation will be implemented in the near future.

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INTRODUCTION

The interstate system of highways, because of the safety features it incorporates, is moving high volumes of traffic efficiently and is saving numerous lives each year. However, these facilities have a safety problem generally uncommon to undivided facilities — the problem of wrong-way driving. Studies in Virginia have shown that wrong-way driving accidents account for less than one percent of the total accidents that occur on the interstate system, however, this type of accident is one of the most severe and is responsible for about 11 percent of the fatalities that occur.(1) The studies also have shown that most wrong-way movements occur at night; that the majority begin at interchanges; and that almost 50% of the darkness incidents involve drunkenness.

There are means for preventing a great number of wrong-way maneuvers, including electronic systems for vehicle detection, electronic warning apparatus, and reconstruction of interchanges; however, the high cost and the number of interchanges that would be involved make many of these measures economically unfeasible. Other measures that are not as costly and that are being used include improved signs and pavement markings. Although the number of wrong-way movements at interchanges has been reduced by improvements in signing and pavement markings, the occurrence rates are still relatively high as a result of motorists becoming confused by interchange configurations and of the impaired state of many motorists. In most cases in which motorists make wrong-way maneuvers, whether they are confused, drunk, or just disregardful of the law, they must travel past numerous warning signs and pavement markings.

In an attempt to stop drivers who enter an interchange ramp going the wrong way a means of alerting them to their error is being sought. In view of the fact that a wrong-way driver must fail to see or properly interpret the directional signs, warning signs, and pavement markings placed in the intersection for his guidance, it is obvious that something beyond conventional devices are needed.

A concept which is believed to have merit in further reducing wrong-way accidents involves the placement of raised pavement markers on off-ramps in such a configuration that the driver will be alerted as a result of viewing an unexpected phenomenon. Although such markers have been used for this purpose, they have been placed in the shape of an arrow, transverse line, or other configurations similar to markings normally seen be the motorist.

PURPOSE AND SCOPE

It was the purpose of this preliminary research to determine the feasibility of using raised pavement markers in such a configuration that drivers making wrong-way maneuvers would be alerted to their mistakes and take corrective measures. The investigation was limited to one interstate interchange and only an off-ramp under nighttime conditions was considered.

PROCEDURE

Test Site

The off-ramp at the intersection of Interstate 64 westbound and Route 637 (Ivy Interchange) was used for test purposes. It should be noted that this ramp was the scene of a recent wrong-way driving entry that resulted in an accident causing the death of three persons.

Type and Configuration of Raised Markers

Initially, only one type of raised pavement marker was considered for testing, that being the Stimsonite Type 88 monodirectional red marker.

In the tests, the markers, which possess good reflective qualities, were placed to reflect only the light of a vehicle traveling in the wrong direction. In placing them on the road surface, consideration was given to the following variables:

(1) Various marker configurations or alignment.

(2) Number of markers necessary to be effective.

(3) Length and width of marked section.

(4) Location of marked section with respect to the ramp end, in-place signs, and regular pavement markings.

Evaluation

The evaluation of the raised pavement markers was a subjective one concerned primarily with the visibility characteristics or the attention getting qualities of selected configurations. The sixteen test subjects included research engineers, technicians, state police, a housewife, a student, a lawyer, and three anonymous persons who were using the off-ramp and were asked to participate in the evaluation. The test subjects were shown the test section from a vehicle (lights on high beam and low beam) which entered the off-ramp and proceeded only a short distance before backing out. It should be noted that this procedure did not create a hazard as oncoming vehicles could be seen for a distance of approximately one-half mile (0.80 km), which allowed time for the test vehicle to retreat when an oncoming vehicle was sighted.

Prior to viewing the markers the subjects were told only that their opinion of some experimental materials was desired and that they should not be alarmed if certain unexpected maneuvers were made. Note was made of the initial opinions and reactions of each test subject relative to the effectiveness of the marking system. Questions were then asked concerning each subject's thoughts on the effectiveness of the system in preventing wrong-way entries along with any thoughts on number of markers, the shape of the configuration, and the location of the configuration with respect to signs, etc.

Throughout the evaluation all existing pavement markings and signs were unaltered; the only difference was the addition of the raised pavement markers.

RESULTS

Marker Configuration

Based on the author's observations of different marker configurations involving between 20 and 50 markers, two configurations were decided upon for purposes of the evaluation. The length, width, and position of the marked area as shown in Figure 1 were chosen as being suitable for the geometrics of the off-ramp used; however, on other ramps these features might be changed because of different horizontal and/or vertical roadway alignments. The two configurations chosen were the pattern of 45 markers shown in Figure 2 and the irregular placement of 27 markers shown in Figure 3.

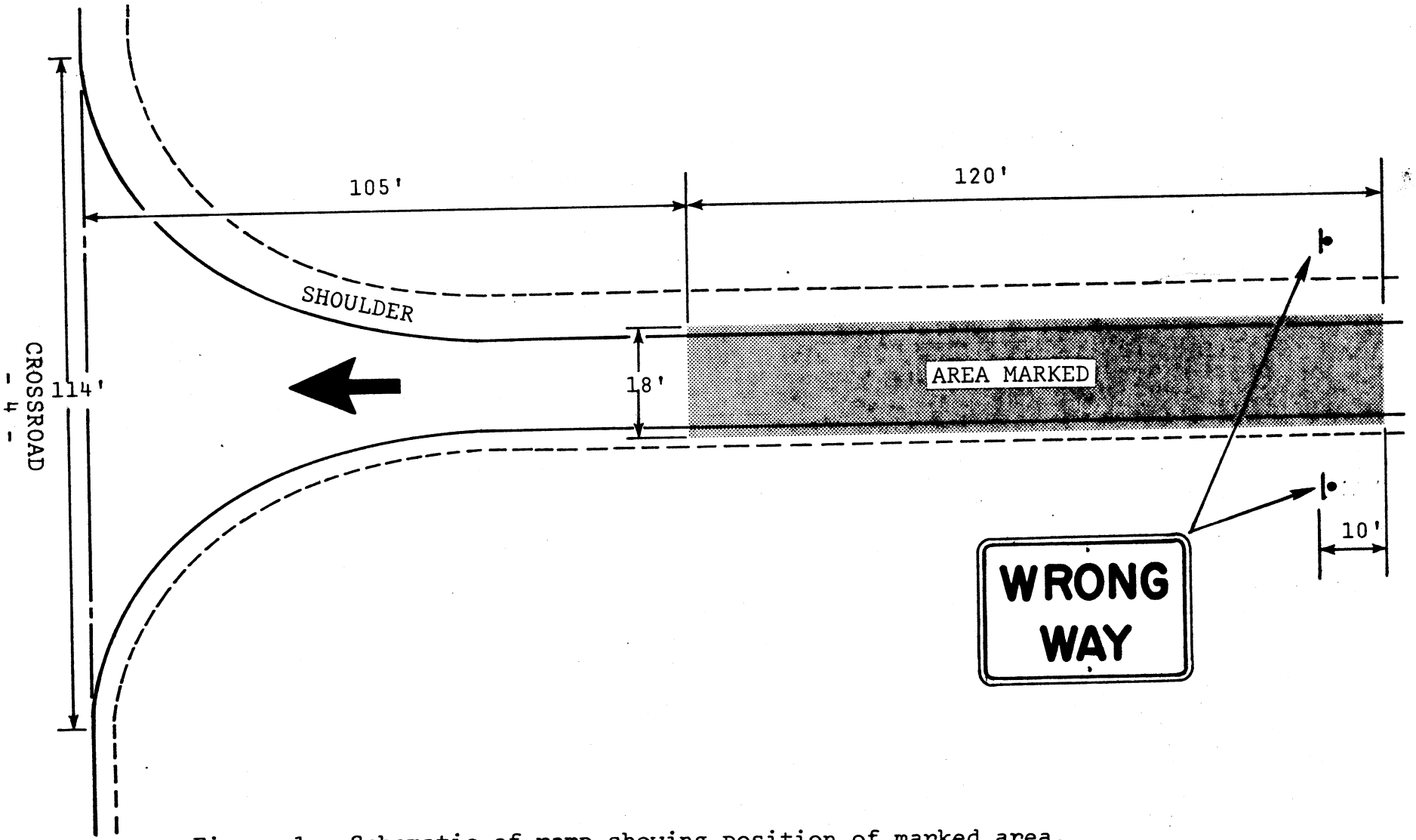


Figure 1. Schematic of ramp showing position of marked area.
Note: 1 foot = 0.30 meters.

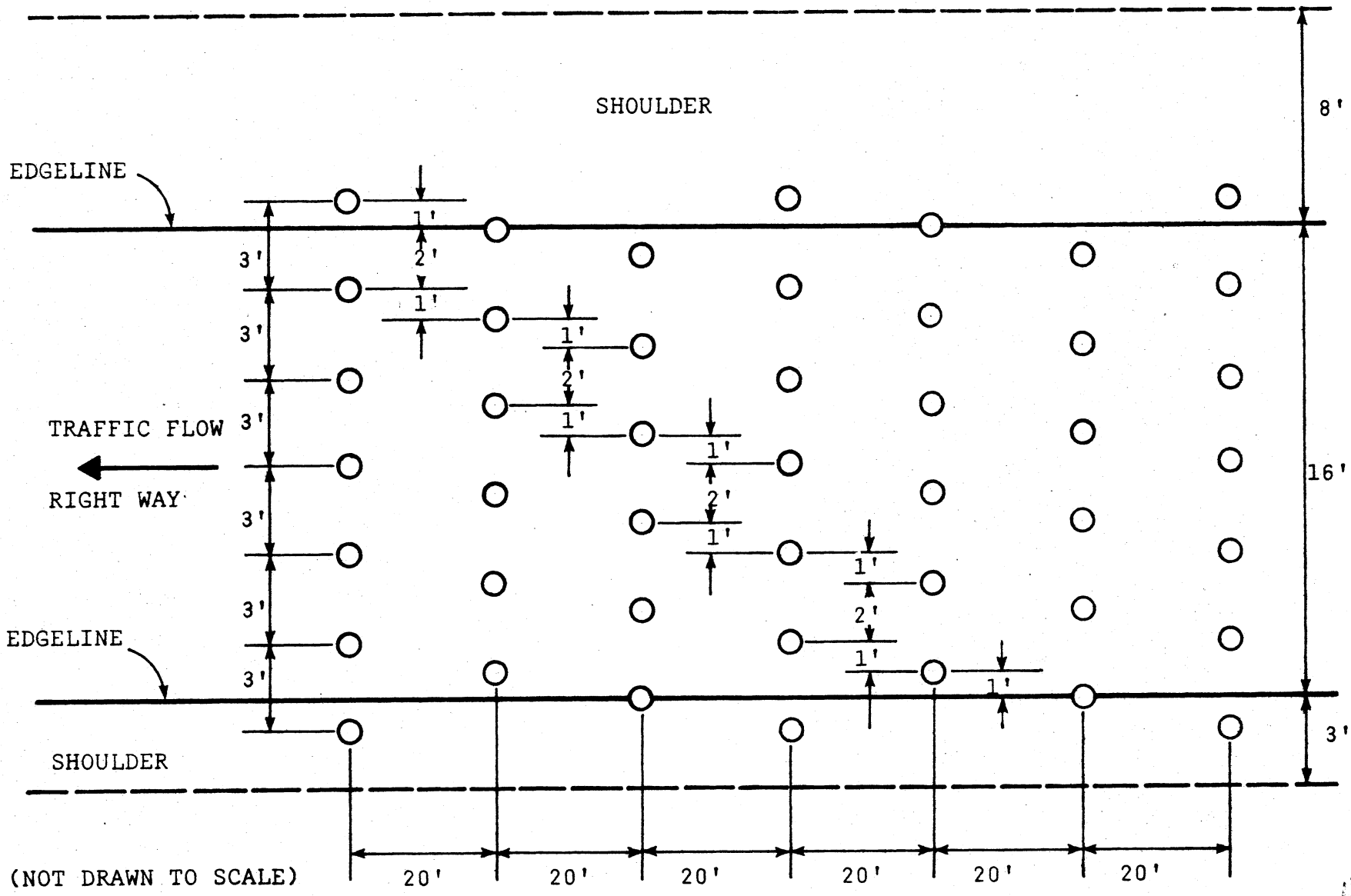


Figure 2. Configuration No. 1 — Forty-five markers in set pattern.
Note: 1 foot = 0.30 meters.

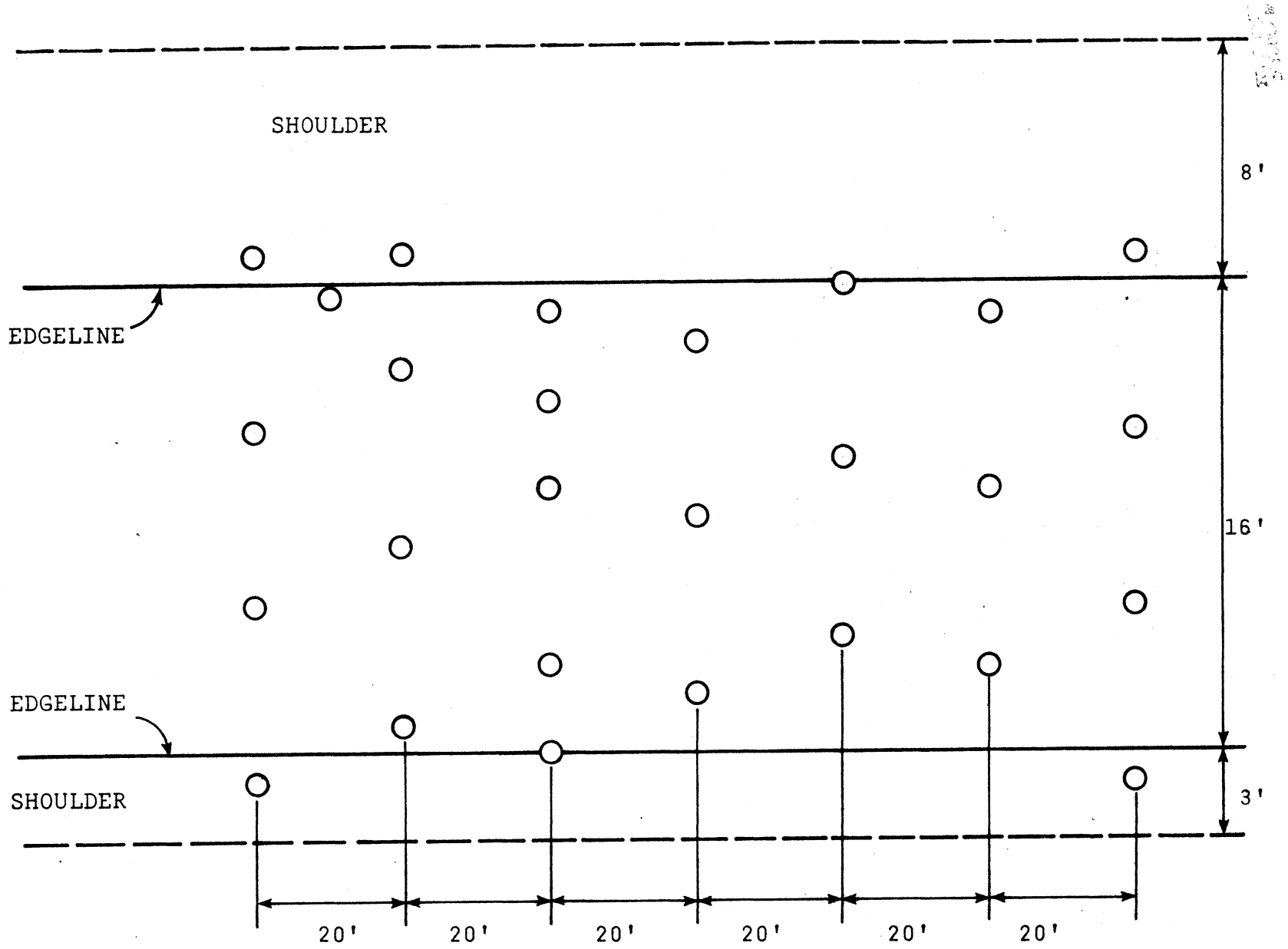


Figure 3. Configuration No. 2 — Twenty-seven markers in irregular placement.
Note: 1 foot = 0.30 meters.

The 120 ft. (36.58 m) marked sections started approximately 105 ft. (32.00 m) from the end of the ramp and extended 10 ft. (3.05 m) past the wrong-way signs. This placement gave the motorist a chance to turn completely into the off-ramp before crossing the marked section. Also, it was felt that the ending of the marked section in the vicinity of the wrong way signs would help call attention to the signs.

Subject Questioning

The subjects were asked four basic questions concerning the system and its effectiveness, and the results of each question are presented separately as follows:

Question 1 — Was the marking system effective in attracting attention, creating bewilderment?

In responding to this question, all of the test subjects said that they thought the marking system was effective in attracting attention and that it did create bewilderment. No one thought that the marking system would not have attracted their attention and made them realize they were driving in the wrong direction.

Question 2 — Does the marking system help call attention to the "Wrong-Way" signs?

Eighty-six percent of the test subjects said the marking system was effective in directing attention to the "wrong-way" signs; 7% were uncertain; and another 7% said the system would not be effective in this regard.

Question 3 — Would the marking system be effective in causing a wrong-way driver to realize his mistake and react accordingly?

This question is similar to question 2, however, it was included because the marking system is visible before a full turn is made into the off-ramp, and the driver is thereby warned before the wrong-way sign becomes noticeable. Ninety-four percent of the subjects thought the marking system would lead to corrective action by the driver, while the other 6% said it would not.

Question 4 — Which marker configuration would be most effective in preventing wrong-way entries onto the interstate?

Given the choice between configurations 1 and 2, all of those viewing both configurations thought configuration 1, consisting of 45 markers in a set pattern, was the most effective.

In addition to the responses to the above questions, each subject's initial reactions to the marking system were obtained. A tabulation of the findings showed that 33% of the subjects were obviously surprised by the presence of the marking system while 67% showed no noticeable reaction. However, upon subsequent questioning the latter group did indicate that they had experienced a degree of unexpectedness upon initially viewing the markers.

After initial questioning, the test subjects were asked to comment on the location of the marked section with respect to the ramp end and in-place signs, and to make any other comments or suggestions they might have concerning the marking system. Approximately 85% of the subjects thought the marking system was generally in the location to be most effective. Various suggestions were made for improvements, however, these were not within the scope of the project and are not included in this report.

DISCUSSION OF RESULTS

It is realized that a degree of bias can be expected when testing subjects in the manner described in this report; however, since this research was intended as a first step in determining the feasibility of using raised pavement markers to alert wrong-way drivers, a subjective evaluation was deemed to be appropriate. The effect of the marking system on intoxicated or drowsy drivers cannot be surmised from the results of this evaluation nor can the reactions of passengers to the markings be inferred. However, if only a small number of the subjects, all of whom thought the system to be effective, would actually have been prevented from going the wrong way, the system should be seriously considered because of its simplicity and low cost.

A statistical analysis was not used in this study because the subjects' reaction to the marking system soon became apparent. This early establishment of the reaction also explains the low number of test subjects used in the evaluation.

It should be noted that although the test subjects were expecting to see some type of experimental material, most of them indicated that they had expected to be shown something other than the pavement markers and therefore the appearance of the markers was unexpected.

The configuration lengths, widths, and pattern considered in this research were selected based on the particular geometries of the off-ramp studied and may, therefore, be different from other locations.

CONCLUSIONS

The following conclusions were derived from this study:

(1) The raised pavement marking system was effective in alerting drivers as a result of their viewing an unexpected phenomenon.

(2) The marking system did help call attention to the in-place Wrong-Way signs and was thought to be effective in causing a wrong-way driver to realize his mistake and act accordingly.

(3) A configuration consisting of 45 markers was preferred over a configuration with approximately one-half this number of markers. It was felt that the Wrong-Way signs should be toward the far end of the marker configuration as a wrong-way driver would view the system.

RECOMMENDATIONS

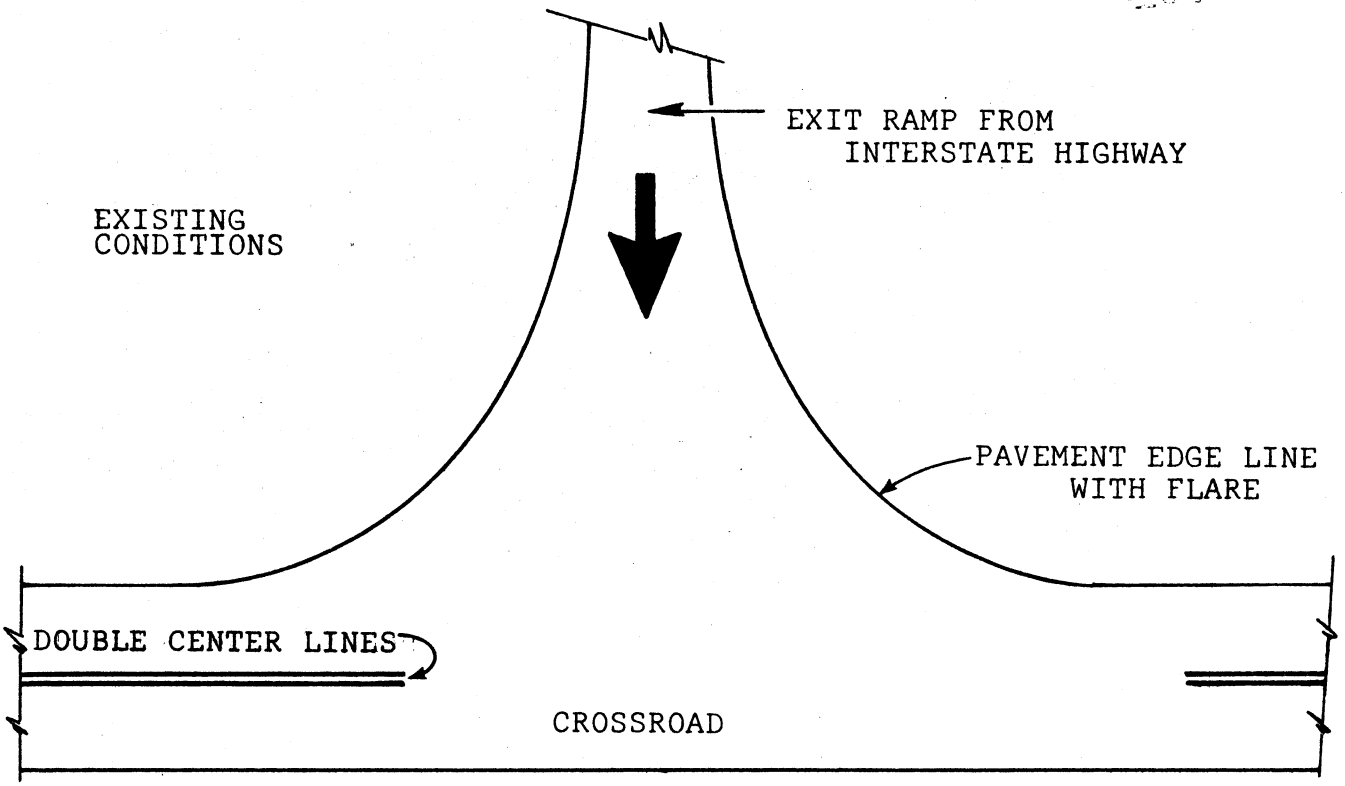
The working plan for this study noted that the research would be conducted in three phases, with the execution and design of each subsequent phase being dependent upon the results of the preceding one. Based on the results of this initial phase, which have indicated that the selected raised pavement markers exhibit good attention getting characteristics, it is recommended that the study be expanded by permanently placing raised pavement markers at two or three interchange off-ramps for further study. It is anticipated that this recommendation will be implemented in the near future.

SPECIAL OBSERVATIONS

In conducting the study the author made several observations that were not within the scope of this research, but that are thought to be important in considering the problem of wrong-way driving.

It is most important that once a wrong-way driver is alerted as a result of the raised pavement marking system he be given means to recognize his mistake and correct it. The Wrong-Way signs placed on the shoulder approximately 215 ft. (65.53 m) from the end of the ramp were erected for this purpose; however, these signs were not highly effective, although they were within the required specifications. This opinion was confirmed by replacing the 30" x 30" (76.20 cm x 76.20 cm) Wrong-Way signs with 48" x 48" (121.92 cm x 121.92 cm) signs having high intensity facing material and placed closer to the ramp, yet within the specification distance. The larger, brighter signs were judged by the test subjects to be definitely more effective in giving information to the wrong-way driver who had been confronted with the experimental marking system. This is particularly important in view of a recent study[2] which indicated that intoxicated drivers require significantly brighter signs than do sober drivers and the higher reflectance signs can significantly ameliorate the degrading influence of alcohol impairment on sign reading ability.

Reference is made to a report by Vaswani[3] in which the following recommendations were made: (1) Use a 24-inch (60.96 cm) stop line across the exit ramp with its edge on the side of the crossroad in line with the crossroad pavement edgeline; and (2) if possible remove the flared end of the exit ramp, which provides an easier right-hand turn into the off-ramp, or improve it by marking the pavement at the flared corners. It is felt that these two recommendations could have been successfully applied to the particular ramp considered in this study in view of the large flares and existing pavement markings. Suggested improvements are shown in Figure 4.



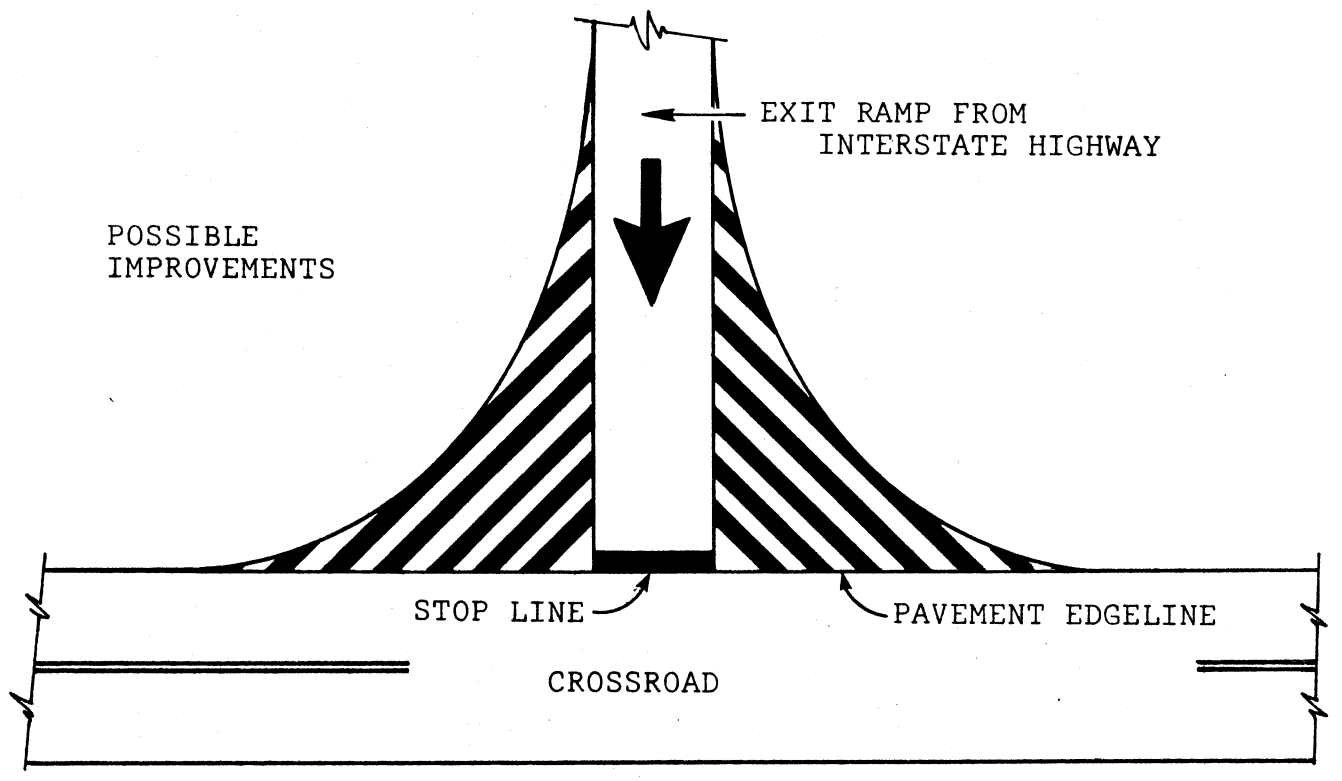


Figure 4. Suggested improvements to off-ramp.

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2. Hicks, John A., "An Evaluation of the Effect of Sign Brightness on the Sign Reading Behavior of Alcohol Impaired Drivers," Traffic and Transportation Center, University of South Carolina, Columbia, South Carolina.

3. Vaswani, N. K., "Measures for Preventing Wrong-Way Entries on Highways", VHRC 72-R41, Virginia Highway Research Council, Charlottesville, Virginia, June 1973.