Raised Pavement Markers as a Traffic Control Measure at Lane Drops [No. 418]

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ABSTRACT

Raised pavement markers are an effective means of reducing erratic movements at lane-drop locations, particularly under nighttime driving conditions. The cost of raised pavement markers and their installation is nominal (approximately $150 per lane-drop location). It is recommended that raised pavement markers be installed at other lane-drop locations. Markers installed at locations described in this study have not been in place for a sufficient time to determine their durability; however, reports from other states indicate their durability is sufficient to render them economical. If raised pavement markers are installed routinely, steps should be taken to insure they are not damaged by snowplow operations. Rubber-tipped blades have been used successfully in areas with slushy snow or where chemicals are used in conjunction with snowplows.
INTRODUCTION

A previous study conducted by the Division of Research investigated the influence of various traffic control measures on the operational characteristics of lane drops (1). Several standard and experimental traffic control devices were selected for application. No single type of traffic control device was found to be significantly effective in reducing conflicts at all the locations. The purpose of this research was to evaluate the effectiveness of raised pavement markers (not used in the previous study) as a traffic control measure at lane-drop sites. This report is one phase of a research study entitled "Evaluation and Application of Roadway Delineation Techniques." In another phase, an attempt is being made to determine the durability and reflectivity of several types of raised pavement markers over a long period of time. Raised pavement markers have been installed on several test sections and are being monitored by photometer measurements and visual inspection.

Lane drops

A lane drop is defined as a location where the number of lanes provided for through traffic decreases. The broad category of lanes drops has been further subdivided into three more specific classes: lane exits, lane splits, and lane terminations. A lane exit refers to a location where the number of through lanes decreases at an interchange on a multilane roadway. A lane split denotes a major bifurcation of a multilane highway where the level of traffic service provided at the terminus of either fork is approximately equal. A lane termination describes a location where a lane ends.

Raised pavement markers

Raised pavement markers are in use in some states as an integral part of the roadway delineation system. They are being used to supplement as well as to replace paint stripes. In addition, they are being placed on horizontal curves, merge and diverge areas, turning lanes, no-passing zones, and stop approaches (2). These markers have proved to be particularly effective for wet, nighttime and other poor visibility conditions.
A major deterrent to the use of raised pavement markers in snow areas has been marker damage and destruction associated with the use of steel snowplow blades. A study conducted by the State of Washington demonstrated that the rubber-tipped snowplow blade was an effective tool for removing freshly fallen or slushy snows and for protecting raised traffic markers (3). The Federal Highway Administration has requested states in areas where snowfall is common to review their snowplowing and deicing procedures and to carefully consider the use of deicers and rubber snowplow blades so that raised pavement markers could be used (4).

Kentucky receives some snowfall each winter and the seasonal amounts are extremely variable. As a rule, the ground remains covered with snow for only a few days at a time. The average seasonal snowfall at the Lexington weather station for the past 39 years has been 18.5 inches (0.47 meter), with a high of 41.7 inches (1.06 meters) for the 1950-51 season and a low of 2.3 inches (0.06 meter) for the 1949-50 season. Snowplow use varies from an average of 5 to 10 times a year.

Several different types and brands of raised pavement markers have been developed and used by various states. The markers vary in cost, durability, and reflectivity. In this study, five different types of raised pavement markers were used (Figure 1).

**PROCEDURE**

**Locations**

Studies were conducted at five lane-drop locations, each representing one of the three classes of lane drops. The five sites were: (1) a single-lane split at I 75 northbound - I 64 eastbound located east of Lexington, (2) a single-lane split at I 75 southbound - I 64 eastbound located east of Lexington, (3) a single-lane exit without taper on I 75 northbound at the 5th Street exit in Covington, (4) a single-lane exit with taper at I 75 southbound - I 71 southbound in Boone County, and (5) a lane termination at US 27 - 68 (Paris Pike) northbound just north of New Circle Road in Lexington. One of the lane-drop locations is presented in Figure 2.
Data collection

Conflict surveys (consisting of erratic movement and brakelight application counts) and lane volume counts were conducted at each of the lane-drop locations. Observations were made before and after installation of the raised pavement markers at all sites for dry pavement conditions. Data were recorded for six daylight hours and three nighttime hours. Yet nighttime data were collected at one of the sites after installation of the markers to illustrate the relative number of conflicts during wet and dry conditions. Comparable conditions for the before and after data collection periods were necessary to insure conclusive results. By collecting before and after data under dry pavement conditions, the weather variable was eliminated. If data were taken during inclement weather, the visibility would most likely differ between the before and after conditions since the amount and intensity of rainfall would not be identical. Erratic movements were grouped into seven categories: (1) cut across gore area, (2) crowded weave, (3) stopped, (4) slowed drastically, (5) swerved, (6) stopped and backed, and (7) multiple error. The same observer made all conflict surveys in order to eliminate the bias which may result from varying judgments as to what constitutes a conflict. The only exception was the wet nighttime data.

Installations

A different type of raised pavement marker was used at each of the five lane drops. The type of marker and the lane drop at which it was used are as follows:

1. Ray-O-Lite (regular) -- I 75 northbound - I 64 eastbound, east of Lexington;
2. Ray-O-Lite (replaceable lens) -- I 75 southbound - I 64 eastbound, east of Lexington;
3. Stimsonite -- I 75 northbound - 5th Street exit in Covington;
4. Permark -- I 75 southbound -- I 71 southbound in Boone County; and

The markers were applied using a two-component epoxy. Surfaces were prepared prior to application of the epoxy by scrubbing with a wire brush. Traffic was maintained during application, but traffic cones were used to prevent vehicles from touching the markers until the epoxy had hardened.

Markers outlined the gore area as well as the edgelines. The markers started approximately 1100 feet (335 meters) in advance of the gore and continued approximately 150 feet (45 meters) past the base of the striped gore area. At the Paris Pike location, markers were placed on the right edgeline as well as the left side of the section where the two lanes merged into one. A schematic which provides details of the marker arrangement at one of the study locations is shown in Figure 3.
Data analysis

Erratic movement and brakelight rates were calculated. Rates before and after installation of the markers were calculated for both daytime and nighttime conditions and for the total study period. Rates were obtained by dividing the number of erratic movements or brakelight applications by the applicable traffic volumes and expressing this quotient as a percentage. Statistical tests were then used to determine whether a significant difference existed between the before and after conflict and brakelight rates (5).

RESULTS

Erratic movement rates, brakelight rates, and average hourly volumes for all five lane-drop locations were calculated, and the data before and after installation of the raised markers were summarized by total study period, daytime conditions, and nighttime conditions, respectively.

Results of the statistical analysis of the difference between the before and after conflict and brakelight rates are presented in Table 1. The words "increase" and "decrease" mean that the particular erratic movement or brakelight rate difference was found to be statistically significant at the 95-percent confidence level. Reference should be made to the research report from which this paper was written if more detailed information is desired (6).

A statistically significant decrease in the total erratic movement rate occurred in nearly all cases. Exceptions were I 75 NB at the 5th Street exit under daytime conditions and Paris Pike under nighttime conditions. There was not a significant increase in any type of erratic movement at any of the locations. From Table 1, it can be seen there was a significant decrease in the total erratic movement rate for daytime, nighttime, and combined conditions. It should be noted that, while the erratic movement rate decreased for all conditions, the nighttime rate showed the greatest decrease. There was a total reduction in the overall erratic movement rate of 27 percent (from 2.07 to 1.52). This resulted from a 20 percent reduction (from 2.15 to 1.71) for daytime conditions and a 44 percent reduction (from 1.78 to 0.99) for nighttime conditions. This indicated the raised pavement markers were particularly effective in reducing erratic movement rate for nighttime conditions.

A study of brakelight rates produced different results. Some locations showed a significant increase while others showed a significant decrease. From Table 1, it can be seen that no significant change occurred in the total brakelight rate.
At the I 75 northbound - I 64 eastbound site, wet, nighttime data were collected. A comparison was made of the nighttime data for dry-before, day-after, and wet-after conditions. Results indicate that the wet-after, nighttime erratic movement rate decreased by 29 percent from the dry-before, nighttime rate and increased by 25 percent from the dry-after, nighttime rate. Neither the reduction nor the increase in erratic movement rates was significant at the 95·percent confidence level. The increase in erratic movements was somewhat expected due to the larger number of conflicts which occur during wet, nighttime conditions -- that is, when visibility is generally and otherwise impaired.

Cost of the raised pavement markers and their installation was relatively inexpensive compared to their potential benefits (Table 2). The average cost was approximately $150 per lane-drop location.

Reflectivity test results at the 0.5-degree divergence angle on the five soft-white markers are summarized in Table 3. The comparative reflectivity measurements indicate that two distinct categories of markers were used. All markers used were monodirectional with white reflective lens. The Stimsonite and Ray-O-Lite markers have highly reflective prismatic reflectors which are considerably larger in area than those of the Permark and Safety Guide markers. The Permark and Safety Guide markers have less reflectivity. The Permark marker has an acrylic rod-lens reflector, and the Safety Guide marker has a reflective strip consisting of ten glass beads. The Stimsonite and Ray-O-Lite markers had a specific reflectivity five or six times greater than Permark and Safety-Guide. There were no conclusive results which indicated that the lower reflectivity of the Permark and Safety-Guide markers affected their ability to reduce conflicts. Since the five types of markers were installed at different lane-drop locations, a valid comparison between marker types is not available. The markers have not been installed for a sufficient period of time to justify a complete evaluation of their durability. With the exception of the Ray-O-Lite (replaceable lens), all markers appear to have sufficient durability. The Ray-O-Lite (replaceable lens) marker failed to remain intact under traffic and has since been discontinued by the manufacturer.

CONCLUSIONS

The objective of this study was to determine the effectiveness of raised pavement markers as a traffic control measure at lane drops. The following are the major conclusions which were drawn from the analyses:
1. Raised pavement markers are an effective means of reducing erratic movements at lane-drop locations.

2. No significant change in brakelight rates resulted from the installation of raised pavement markers.

3. While the raised pavement markers proved to be generally effective under both daytime and nighttime conditions, the reduction in erratic movements under nighttime conditions was the major benefit derived.

4. The cost of the raised pavement markers and their installation was nominal, and their use at any lane-drop location is recommended.

5. Conclusions concerning the long-term durability of the raised pavement markers are not appropriate on the basis of only limited exposure to traffic. However, experience in other states suggests that some markers possess the desired characteristics to make them economically feasible.

6. Studies have shown that rubber-tipped snowplow blades have been used successfully. The potential benefits of raised pavement markers at the types of locations investigated herein indicate that overall safety provided the driving public would be enhanced by utilization of raised pavement markers. It is recommended that use of steel snowplow blades be discontinued on a trial basis where raised markers have been installed.

7. Since different marker types were used at each of the lane-drop locations, it was not possible to compare their relative effectiveness.

REFERENCES

1. Cornette, D., Operational Characteristics of Lane Drops, Kentucky Department of Highways, Division of Research, August 1972.


6. Pigman, J. G.; and Agent, K. R., Raised Pavement Markers as a Traffic Control Measure at Lane Drops, Kentucky Bureau of Highways, Division of Research, August 1972.
Figure 1. Types of Raised Pavement Markers
Figure 2.  I-75 NB - I-64 EB Lane Split
Figure 3. Arrangement of Raised Pavement Markers at I 75 NB - I 64 EB Lane Split East of Lexington (61 Markers Installed)
Table 1. Significant erratic movement and brakelight rate differences -- summary for all locations

<table>
<thead>
<tr>
<th>Erratic Movement</th>
<th>DAYTIME CONDITIONS</th>
<th>NIGHTTIME CONDITIONS</th>
<th>TOTAL STUDY PERIOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut Across Gore</td>
<td>DECREASE</td>
<td>DECREASE</td>
<td>DECREASE</td>
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<tr>
<td>Crowded Weave</td>
<td>DECREASE</td>
<td>DECREASE</td>
<td>DECREASE</td>
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<tr>
<td>Swerve</td>
<td>DECREASE</td>
<td>DECREASE</td>
<td>DECREASE</td>
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<tr>
<td>Slowed Drastically</td>
<td>DECREASE</td>
<td>DECREASE</td>
<td>DECREASE</td>
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<tr>
<td>Stopped</td>
<td>DECREASE</td>
<td>DECREASE</td>
<td>DECREASE</td>
</tr>
<tr>
<td>Stopped and Backed</td>
<td>DECREASE</td>
<td>DECREASE</td>
<td>DECREASE</td>
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<tr>
<td>Multiple Error</td>
<td>DECREASE</td>
<td>DECREASE</td>
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<tr>
<td>Total</td>
<td>DECREASE</td>
<td>DECREASE</td>
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<table>
<thead>
<tr>
<th>Brakelight Rate</th>
<th>DAYTIME CONDITIONS</th>
<th>NIGHTTIME CONDITIONS</th>
<th>TOTAL STUDY PERIOD</th>
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<tr>
<td>Median Lane</td>
<td>DECREASE</td>
<td>DECREASE</td>
<td>DECREASE</td>
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<tr>
<td>Middle Lane</td>
<td>INCREASE</td>
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<tr>
<td>Shoulder Lane</td>
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<td></td>
<td></td>
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<tr>
<td>Total</td>
<td></td>
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Table 2. Summary of materials and installation costs

<table>
<thead>
<tr>
<th>TYPE OF MARKER</th>
<th>NUMBER USED</th>
<th>UNIT PRICE (Dollars)</th>
<th>MARKER COST PER LANE-DROP LOCATION (Dollars)</th>
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</thead>
<tbody>
<tr>
<td>Ray-O-Lite (regular)</td>
<td>61</td>
<td>1.28</td>
<td>78.08</td>
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<tr>
<td>Ray-O-Lite (replaceable lens)</td>
<td>57</td>
<td>1.00</td>
<td>57.00</td>
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<tr>
<td>Stimsonite</td>
<td>79</td>
<td>1.045</td>
<td>82.56</td>
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<td>Permark</td>
<td>63</td>
<td>0.45</td>
<td>28.35</td>
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<tr>
<td>Safety Guide</td>
<td>41</td>
<td>0.60</td>
<td>24.60</td>
</tr>
</tbody>
</table>

Installation Costs for the Five Lane-Drop Locations (includes epoxy, site preparation, placement of markers)

- Epoxy - 3 gallons · $42.00
- Labor - $420.00

Total Cost = $734.00

Table 3. Summary of reflectivity tests

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SPECIFIC REFLECTIVITY*</th>
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<tbody>
<tr>
<td>Stimsonite 88</td>
<td>1.9</td>
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<tr>
<td>Ray-O-Lite (regular)</td>
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<tr>
<td>Ray-O-Lite (replaceable lens)</td>
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<tr>
<td>Permark</td>
<td>0.36</td>
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<tr>
<td>Safety Guide</td>
<td>0.30</td>
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</table>

*Candlepower per foot candle (1.08 lux) per unit reflector (at 0-degree incidence angle)