Effect of Pavement Edge Marking on Two-Lane Rural State Highways in Ohio

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● IN 1957, the Ohio Department of Highways initiated a program of pavement edge marking on all 2-lane rural state highways which were at least 20 ft wide. No prior research on pavement edge marking in Ohio was available, hence 12 pairs of sections of the programmed edge marking were selected as test samples for a controlled "before-and-after" study on the effects of these markings on the accident patterns. Subsequently, construction changes were made on two pairs of sections and it was discovered that a third pair was a 4-lane highway. These sections were excluded from the study. This resulted in nine pairs of 2-lane sections available for the study.

Each pair of sections consisted of a test section (pavement edge marked) and a control section (pavement not edge marked). These test and control sections were located as nearly as possible adjacent to each other and were selected so that the geometric design characteristics and culture surrounding each of the sections were similar in nature. The volume and character of traffic on each of the sections within a pair was comparable. The section chosen for edge marking within each pair was selected at random—literally by "tossing a coin." This procedure eliminated any bias due to section selection.

One pair of sections was located in each of 9 of the 12 highway department divisions within the state as shown in Figure 1. A total of 116 mi of highway were selected for study including 61 mi of test sections (edge marked) and 55 mi of control sections (not edge marked).

Six pairs of sections were 24 ft wide and the remainder were 20 to 22 ft wide. Pavements less than 20 ft wide were not included in the pavement edge-marking program. Shoulders varied from a curb to 14 ft wide but were generally between 4 and 8 ft wide. Both asphalt and concrete pavements were studied and shoulders were generally cinders or gravel with some grass shoulders and a smaller proportion of bituminous concrete and earth shoulders.

ACCIDENT STUDIES

Analyses were made of all reported accidents on each of the test and control sections both before and after edge marking. In each case, the "before" period was the year 1956. The "after" period was the first full 12-month period following the application of the edge marking. The "after" period began immediately after the placement of the edge marking.

The reported accidents were summarized by location, type of collision, light condition and pavement condition. The number of fatalities and injuries was also recorded.

The accident studies showed that there was a net reduction of 19 percent (Fig. 2) in accidents after the pavement edge marking on the 2-lane rural state highways. This net change was computed as given in Table 1.

TABLE 1

TOTAL NUMBER OF ACCIDENTS BEFORE AND AFTER EDGE MARKING OF 2-LANE RURAL HIGHWAYS IN OHIO

Section	Total Accidents			
	Before Edge Marking	After Edge Marking	Anticipated After	Net Change
	No.	No.	No.	Percent
Test (edge marked)	123	126	156	-19
Control (not edge marked)	132	167		

The control sections (not edge marked) showed an increase of 26.5 percent in the number of accidents between the before-and-after periods: $\frac{167-132}{132} \times 100$. If the test sections (edge marked) had not been treated with edge markings, it may have been expected that the edge-marked sections, also, would have shown an increase of 26.5 percent to 156 accidents: 123 + (123 x 0.265). The difference between the expected number of accidents (156) and the actual number (126) is 30 accidents or a net reduction of nineteen percent: $\frac{30}{156} \times 100$.

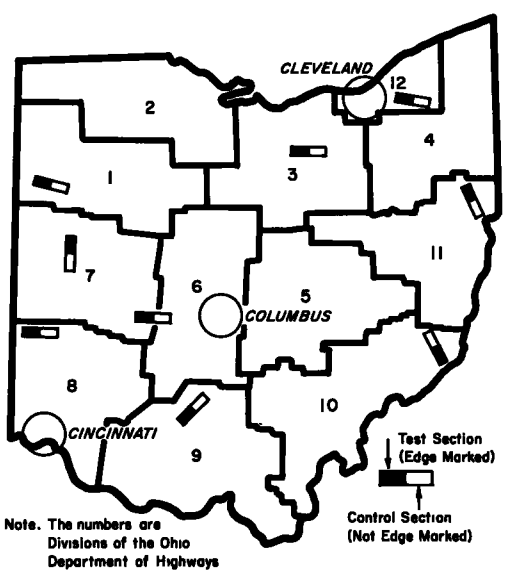

Figure 1. Location of test and control sections for pavement edge marking study on 2-lane rural state highways in Ohio.

Statistical analysis of the data indicates that the significance level of the 19 percent accident reduction is 0.22 if the 2 x 2 chi-square test is employed, and 0.16 if the "t" test is used. In other words, the probability is about 1 in 5 or 6 that a net accident reduction of 19 percent or more could have occurred merely by chance. The "t" test is a slightly more sensitive test than the chi-square test but the difference between it and the chi-square test in this case is very small. There is some question as to whether the "t" test can be applied to these data and therefore it was thought desirable to confine the tests of statistical significance to the chi-square test.

SEVERITY OF ACCIDENTS REDUCED

Figure 2 shows a computed net reduction of 37 percent in fatalities and injuries after edge mark-

TABLE 2

FATALITIES AND INJURIES BEFORE AND AFTER EDGE MARKING OF 2-LANE RURAL HIGHWAYS IN OHIO

Section	Fatalities and Injuries			
	Before Edge Marking	After Edge Marking	Anticipated After	Net Change
	No.	No.	No.	Percent
Test (edge marked)				
Killed	3	5		
Injured	93	85		
Total	96	90	143	-37
Control (not edge marked)				
Killed	6	8		
Injured	86	129		
Total	92	137		

ing. The computation of this net reduction is given in Table 2.

The before-and-after comparison on the edge-marked sections shows a decrease in the total number of injuries and fatalities in the "after" period. The control sections showed a marked increase in the number of fatalities and injuries in the "after" period, actually, a 49 percent increase. If the control sections are used as the base, then the net reduction appears to be approximately 37 percent.

The results showed that the net reduction of 37 percent in the number of persons killed and injured after pavement edge marking was significant at the 0.02 level employing the 2 x 2 chi-square test. In other words, there was only a remote possibility that this reduction occurred by chance.

A comparison of the injury and fatality frequency (that is, the number of injuries and fatalities per accident) shows that the edge-marked sections decreased from 0.78 to 0.71 while the control sections increased from 0.70 to 0.82 during the corresponding period.

ACCIDENTS REDUCED AT ACCESS POINTS

Accidents occurring at access points such as intersections, alleys, and driveways, decreased 24 percent in the period after the edge marking was applied. In the corresponding period, accidents at these locations on the "control" sections showed an increase of 106 percent. Assuming that the control establishes the normal pattern of increase for all sections, then the apparent effect of the edge marking

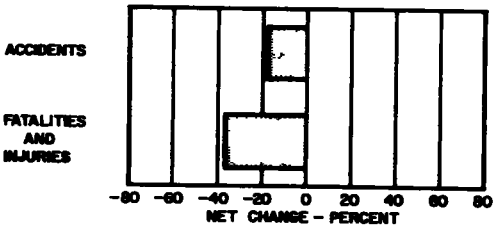

Figure 2. Net change in accidents and fatalities and injuries after edge marking of 2-lane rural state highways in Ohio.

would be a reduction of approximately 63 percent as shown in Figure 3.

No specific reason could be established to relate edge marking to the reduction in accidents at intersections, alleys, and driveways. A theory has been advanced that edge marking may encourage drivers to watch the pavement edge further in advance of the vehicle and, consequently, to be more aware of vehicles entering the roadway from side roads and driveways. With this "increased vision ahead," the driver has more time to react to intersectional friction.

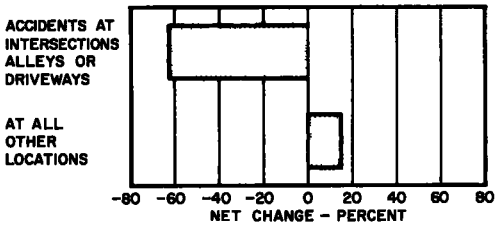

Figure 3. Net change in accidents by location after edge marking of 2-lane state highways in Ohio.

Accidents at locations other than intersections, alleys, and driveways showed an 18 percent increase after edge marking as compared to the before period. Because accidents increased only 3 percent on the comparable control sections, the net increase in accidents was approximately 15 percent (Fig 3). Further analysis showed that there was a significant net accident reduction in accidents at access points during both day and night conditions although the net reduction was greater at night. There was no significant change in accidents between access points during either day or night conditions.

NIGHT ACCIDENTS REDUCED

Figure 4 shows a comparison of accidents according to the time of day. During the before period, the edge-marked sections showed 56 percent of the accidents occurring in daylight hours and 44 percent in darkness hours. The control sections showed 53 percent of the accidents during daylight hours and 47 percent in darkness hours. The sections were assumed to be comparable in the percentage distribution of day and night accidents.

After the edge marking was applied to the test sections, these sections showed a 19 percent increase in the number of day accidents whereas the control sections showed a 29 percent increase. This would seem to indicate that edge marking has a favorable effect on daylight vehicle operation. The difference was not statistically significant, however.

When the edge marking was applied to the test sections, the night accidents on these sections showed a 19 percent decrease whereas the control sections recorded an increase of 25 percent. The net decrease in night accidents is then approximately 35 percent and is significant at the 0.11 level.

In addition, the ratio of night-to-day accidents on the marked sections showed a significant change. Before the edge markings were applied to the test sections, 44 percent of the accidents occurred during darkness, whereas after the edge markings were applied, only 34 percent of the accidents occurred during these hours. For the same period, the control sections showed no significant change in the percentage of accidents taking place at night.

ADVANTAGE OF EMPLOYING CONTROL SECTIONS

One other point might well be highlighted for the benefit of future "before-and-after studies" of this type. If a simple noncontrolled "before-and-after" study had been made, employing test sections only, the results would have indicated that accidents increased 2 percent as a result of edge marking, and injuries and fatalities decreased 6 percent. However, by the use of control sections the net effect was shown to be a reduction of 19 percent in the number of accidents and 37 percent in the number of fatalities and injuries after edge marking had been installed. This comparison points up the value of using control sections in studies of this type wherever possible.

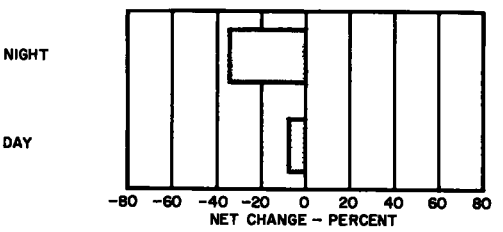

Figure 4. Net change in accidents during daylight and darkness hours after edge marking of 2-lane rural state highways in Ohio.

ADDITIONAL STUDIES

Although the idea of pavement edge marking is not new, the early adoption of this principle and rapid acceptance by the motorists in Ohio has foreclosed the possibility of much research on the subject and the continuance of any extensive "controlled before-and-after studies" in Ohio. However, it is anticipated that the department of highways will continue to study the use of edge marking on narrower highways and the effects of these lines on driver behavior and accident patterns.

SUMMARY

Table 3 summarizes the principal findings of this study. Items 1 and 2 were calculated as given in Tables 1 and 2, respectively. The remaining items were computed in a similar fashion. Table 3 gives:

1. The net reduction of 37 percent in fatalities and injuries due to the edge marking was significant at the 0.02 level employing the 2 x 2 chi-square test.
2. The reduction of night accidents of 35 percent was significant at the 0.11 level using the chi-square test.
3. At intersections, alleys, and driveways there was a significant reduction in accidents, and the angle-type collisions which are associated with intersections, alleys, and driveways were also reduced significantly.

All other comparisons were not significant at the 0.10 level by employing the 2 x 2 chi-square test. The "net changes" in accidents for these comparisons are not considered reliable because they could easily have occurred by mere chance. A reduction in accidents which has a significance level of 0.10 indicates that there is only one chance in ten that a "net change" as great or greater than that shown could have occurred merely by chance. This level of significance was considered the minimum acceptable for this study. It may be noted that the significance level for night accidents was 0.11—a marginal value.

TABLE 3

NET CHANGE IN ACCIDENTS AFTER EDGE MARKING OF 2-LANE RURAL HIGHWAYS IN OHIO SUBDIVIDED BY LOCATION, TYPE OF COLLISION, LIGHT CONDITION AND WEATHER

Item	Net Change (%)	No. of Accidents 1/	Significance Level 2/
1. Total accidents	-19	548	0.22
2. Persons killed and injured	-37	415 3/	0.02
3. Location:			
At intersections, alleys, driveways	-63	177	0.01
Between intersections, alleys, driveways	+15	371	0.25+
4. Type of collision:			
Pedestrian	4/	5	0.25+
Turn	4/	10	0.25+
Angle	-83	51	0.01
Rear-end	-21	210	0.25+
Head-on	4/	14	0.25+
Sideswipe	- 6	42	0.25+
Other collision	+ 8	57	0.25+
Non-collision	+ 6	159	0.25+
5. Light condition:			
Day	- 8	311	0.25+
Night	-35	233	0.11
6. Pavement condition:			
Dry	-24	285	0.25+
Wet	-12	119	0.25+
Ice	- 1	75	0.25+
Not stated	-33	69	0.25+

1/ The number of accidents refers to the total sample and includes both edge-marked and control sections for the year before and the year after edge marking.

2/ The significance level indicates the probability that the net change could have occurred merely by chance. A significance level of 0.01, for example, indicates that there is only one chance in 100 that a "net change" as great or greater than that shown could have occurred merely by chance.

3/ The number 415 refers to the number of persons killed and injured.

4/ Total sample is too small to warrant computing net change.

CONCLUSIONS

The significant conclusions from this study are:

1. On 2-lane rural highways in Ohio, the use of pavement edge mark-

ings resulted in a significant reduction in fatality and injury-causing accidents.

2. Accidents at intersections, alleys, and driveways were significantly reduced but accidents between access points showed no significant change.

3. The only type of collision to show a significant change (a substantial reduction) was the angle collision which is associated with access points.

4. There was no significant change in day accidents; night accidents were reduced but the change was marginal as far as statistical significance is concerned.