

Effect of Pavement Edge Markings on Traffic Accidents in Kansas

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●RECENT SURVEYS of State Highway Departments indicate wide-spread use of pavement edge markings. Some states have now placed these markings on all major highways. Other states have made steady use of the device on selected highways, based on an anticipated reduction in accidents and fatalities.

Kansas is situated among the latter grouping and beginning in July 1957 placed pavement edge markings on 453 mi of rural highways. No research had been attempted in Kansas prior to this time to determine the effectiveness of this device or of its economic justification. After the initial marking of highway sections, however, "before and after" accident comparisons were compiled. The results of the marking program showed a desirable downward trend on the highway sections so marked.

The study in 1957, included eight study sections totaling 88 mi. The 1958 study included 12 sections totaling 98 mi. Combining both studies showed a 21 percent reduction in total accidents, a 26 percent reduction in the number of personal injuries and a 59 percent reduction in fatalities. In general, most of the highways included in the initial marking program are 2-lane and have bituminous surfaces at least 20 ft wide. It is pointed out that most of the sections had comparatively high initial accident experience rates.

In the fall of 1959, the State Highway Commission in cooperation with the Bureau of Public Roads, undertook a research study of possible motor user benefits to be derived from the use of pavement edge markings. None of the previously marked sections could be used in this research study due to the controlled type of study which was to be undertaken. Therefore, additional highway sections were selected and marked prior to the end of 1959. The objective of this study is to determine what effect these pavement edge markings may have on accident rates.

This report covers the period January 1, 1960, to December 31, 1960.

PROCEDURE

A controlled type of before and after accident comparison study was selected for the survey. Twenty-nine pairs of study sections were selected totaling 384 mi of rural highway that had not been previously edge marked. One-half or 192 mi were selected for the placement of edge markings (marked sections) with the remainder to remain unmarked for the duration of the survey period. The latter are "control" sections, which were employed to cancel out year-to-year variations in accident rates not associated with the edge markings themselves. One section of each pair was selected as the "marked" section with the other being the "control" section and the selection was done by chance, in order to avoid possible bias. The 29 pairs of study sections were distributed throughout the State highway system as shown in Figure 1. It was not possible to include high volume and high accident rate sections in the study because most of these sections had previously been edge marked as part of the regular marking program of the Commission.

SELECTION OF STUDY SECTIONS

Each pair of 29 study sections was located adjacent to each other. The pairs were selected so that traffic and roadway characteristics were uniform in the judgment of the engineer making the selection. In order to maintain study variables to a minimum, the study design characteristics and criteria were established as follows:

1. A bituminous pavement, 20 to 26 ft wide, throughout the study sections.
2. Turf shoulders 1 to 6 ft wide.

3. Traffic volume variation small with a minimum average daily traffic of 1,000 vehicles.

4. Uniform roadside culture in rural areas.

5. A minimum rate of one accident per mile, per year.

6. Total length of each study pair is a minimum of 10 mi with the lengths of the marked and control sections about equal.

7. Sections end at convenient points, such as highway junctions and city limits, to facilitate defining accident location.

8. Centerline and no-passing zone lines were to be in place and maintained in accordance with the Commission's regular marking program.

Initially, about 1,200 mi of highway sections were proposed for inclusion in the study. More detailed investigation showed that many of these sections did not meet the study criteria or were unsuitable for inclusion in the study because of extensive surface repairs, which were undertaken during 1959 or planned for 1960. From this procedure, 29 pairs of marked and control highway study sections totaling 384 mi were selected for inclusion in the study.

Table 1 gives the characteristics of the study sections by the section number shown in Figure 1. It may be seen that the sections are well matched and generally met the established criteria.

Figure 2 shows the study standard for edge marking application. The markings were carried through private driveways but were terminated in advance of intersections with public roads.

Striping of all marked sections was completed prior to December 31, 1959.

Field checking of all marked sections was completed April 27, 1960, to determine where markings had deteriorated by spring edge breakup. Wherever necessary because of line raveling and surface breakup, the edge markings were replaced prior to September 10, 1960, in order that they would retain their maximum effectiveness throughout the study period.

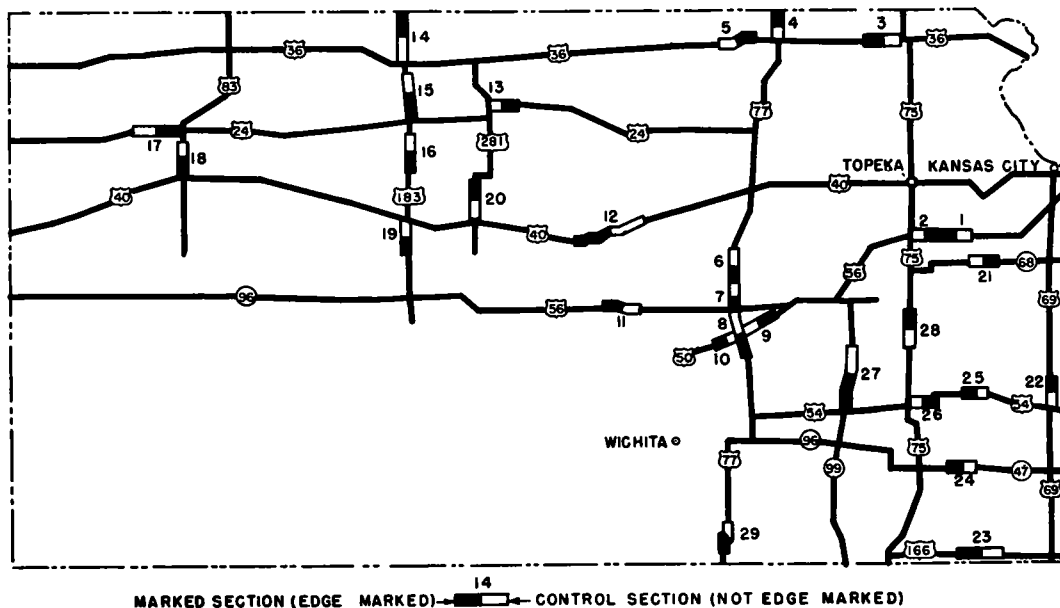


Figure 1. Kansas pavement edge marking study sections.

TABLE 1

SECTION CHARACTERISTICS FOR 2-LANE BITUMINOUS PAVEMENTS WITH TURF SHOULDERS INVOLVED
IN STUDY OF PAVEMENT EDGE MARKINGS AND ACCIDENTS IN KANSAS
(Study Period January 1, 1959 to December 31, 1959 and January 1, 1960 to December 31, 1960)

Section No	Highway Length (mi)		1960 ADT (vehicles)		Pavement Width (ft)		Shoulder Width (ft)	
	Marked	Control	Marked	Control	Marked	Control	Marked	Control
1	6 3	6 4	870	950	24	24	2	2
2	5.1	5 1	1, 218	1, 630	24	24	2	2
3	6 3	6 4	1, 543	1, 650	24	28	6	2
4	5 3	5 9	980	1, 290	26	26	5	5
5	6 5	6 7	2, 323	2, 585	24	24	5	5
6	5 6	5.6	1, 115	1, 245	24	24	6	6
7	5.0	5 0	1, 373	1, 045	22	22	3	3
8	7.6	7.7	995	945	22-24	22-24	4-5	4-5
9	6 6	8.0	1, 810	1, 985	25	24	5	6
10	5.7	4 9	2, 253	1, 735	22	22	8	7
11	6.6	6.6	1, 695	2, 240	26	26	3	3
12	13.3	13.3	1, 339	2, 163	22-24	22-24	4-6	4-6
13	5 5	5.5	1, 523	1, 325	26	26	4	4
14	9 0	8 7	558	688	26	26	6	6
15	8 0	8 0	930	785	24	24	4-6	4-6
16	6.5	6.6	1, 705	1, 250	24	24	5-6	5-6
17	9 0	8.3	2, 225	1, 918	24	24	6	6
18	5.5	4 7	990	740	22	22	3	3
19	6 0	5 4	1, 055	1, 883	22	22	4	4
20	6 8	6.8	700	1, 080	24	24	5	5
21	5.2	5.1	823	1, 045	22	22	4	4
22	5 3	5.3	2, 095	2, 625	20	20	2-3	2-3
23	8 2	8 2	1, 768	1, 528	20-24	20-24	4-6	4-6
24	5 5	5 5	730	750	22-24	22-24	3-6	3-6
25	4.9	4.5	2, 165	2, 300	21	21	2	2
26	5.0	5.1	1, 218	1, 615	25	25	2	2
27	9.6	10.7	710	1, 020	30	24	3	2
28	6.2	5.7	1, 360	1, 618	24	24	2	2
29	6.3	6.3	3, 575	3, 223	22	22	4-6	4-6
Total	192.4	192.0	41, 644	44, 856				

ACCIDENT REPORTING DATA

With reference to accident reporting, Table 2 indicates an increasing level of accident reporting for the State of Kansas, beginning on January 1, 1958, since the enactment of the Safety Responsibility Act. This increased rate of accident reporting does support the completeness of the accident data used in this survey.

ACCIDENT ANALYSIS

Analyses were made of all reported accidents on each test and control section both before and after edge marking. In this case, the "before" period was the year 1959 and the "after" period was the year 1960.

The accident reports were summarized by number of persons injured and number of persons killed, location, type of collision, light conditions, pavement condition and property damage.

The statistical analysis of the total accident data, compiled and listed in Table 3, shows a 1 percent net increase in over-all accident potential between the two types of study sections. This net increase was computed as follows:

The control sections showed a decrease of 13.5 percent in the number of accidents between the before (1959) and after (1960) periods: $\frac{200-173}{200} \times 100$. If the marked sections had not been treated with edge marking, it may have been expected that the edge marked sections, also, would have shown a decrease of 13.5 percent to 144 accidents: $166 - (166 \times .135)$. The difference between the anticipated total number of accidents on marked sections (144) and the actual number (146) is two accidents or a 1 percent net increase: $\frac{146-144}{146} \times 100$. A chi-square reliability test of the sample data taken

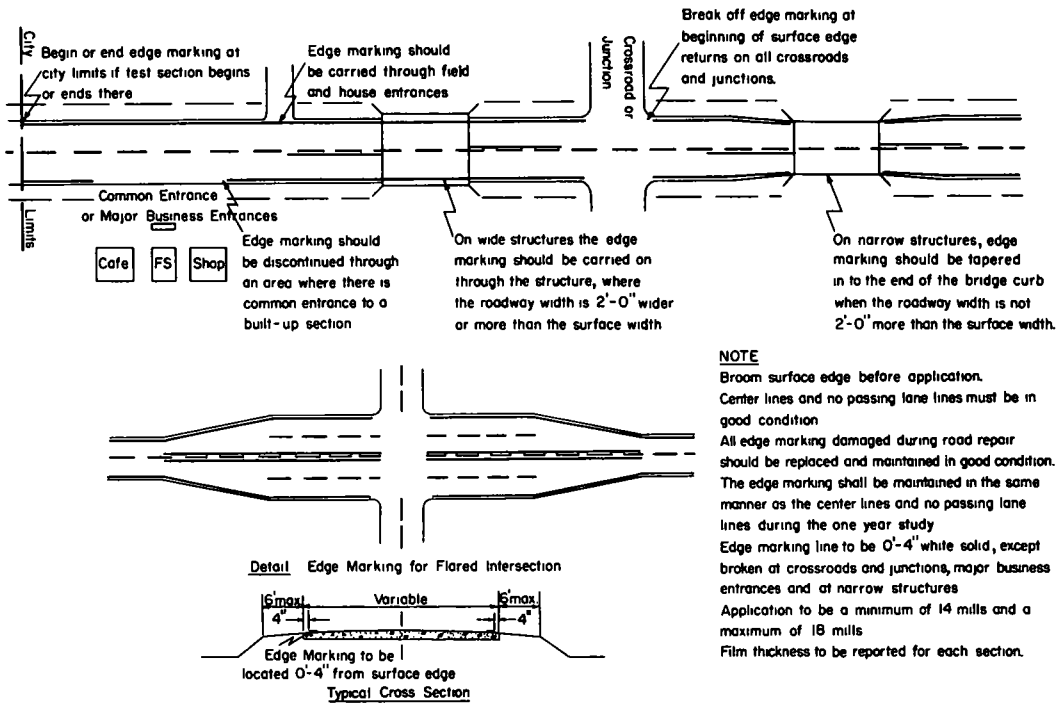


Figure 2. Standard for edge marking application.

separately, shows a significance level greater than 0.25 indicating, as is obvious, that the 1 percent net increase is not statistically significant.

Neither the total number of persons killed and injured nor the number of persons injured (when analyzed separately) was significantly changed after edge marking (Table 4). The number of persons killed, however, showed a net reduction, significant at the 0.07 level. In reviewing the benefits of the edge marking program, certain accident categories were affected to a large and significant degree and these are discussed in detail.

Accidents at Access Points Reduced

As shown in Table 5 and Figure 3, there was a 46 percent net decrease in the number of accidents at intersections and driveways after edge marking of 2-lane rural State highways with a corresponding significance level of 0.04.

Using a marked vs control comparison of accidents not located at intersections and driveways, a 27 percent net increase in accidents in 1960 is found, compared to the same period in 1959 as shown in Figure 3. This net change has a low level of significance, however, 0.17. In other words the net increase of 27 percent could easily have occurred by chance alone.

These findings are consistent with a recent study reported by Musick (1) for Ohio highways. In the latter study, a net reduction of 63 percent in accidents at access points was reported—statistically significant at the 0.01 level. The number of accidents occurring between access points was not significantly changed.

Further analyses of both the Ohio study and the present one showed that these comparisons are similar for both day and night conditions.

To explain these findings, it has been suggested that pavement edge markings encourage drivers to look farther ahead and thus become aware of vehicles about to enter or leave the highway at points of access. Another explanation is that the gap in edge markings at intersections makes drivers aware that there is an intersection ahead. Carefully planned research is needed to test one or preferably both of these theories.

TABLE 2
ACCIDENT REPORTING DATA BEFORE
AND AFTER PASSAGE OF SAFETY RE-
SPONSIBILITY ACT IN KANSAS

Year	No. of Statewide Accidents	No. of Fatalities	Ratio of Fatalities to Accidents
1956	25,435	683	1 to 37
1957	26,481	585	1 to 45
1958 ^a	45,080	554	1 to 81
1959	46,173	367	1 to 81
1960	40,044	512	1 to 78

^aSafety responsibility act effective
January 1, 1958.

TABLE 3

TOTAL NUMBER OF ACCIDENTS BEFORE AND AFTER PAVEMENT EDGE
MARKING OF TWO-LANE RURAL STATE HIGHWAYS IN KANSAS

Section	No of Total Accidents		No of Total Accidents Anticipated After Marking	Net Change (%)	Significance Level
	1959	1960			
Marked	188	146	144	+1	0.25+
Control	200	173	-	-	-

Other Comparisons

Table 6 summarizes several other comparisons. The various types of collision showed no significant change in accidents except for turn collisions and "other" or miscellaneous types.

Figure 4 and Table 6 show that daytime accidents were reduced 18 percent and night accidents increased 42 percent. Neither net change was statistically significant, however.

A more detailed analysis of the two light conditions by the three types of surface condition showed no significant change for any combination except that night accidents on dry pavements increased 72 percent with a significance level of 0.08.

Analysis of combinations of various light condition by various types of collision showed few significant changes. The net decrease in turn collisions was due entirely to daylight data, and a 67 percent reduction in turn collisions during daytime conditions occurred, significant at the 0.04 level. Turn collisions at

TABLE 4

TOTAL FATALITIES AND INJURIES BEFORE AND AFTER PAVEMENT EDGE
MARKINGS OF TWO-LANE RURAL STATE HIGHWAYS IN KANSAS

Section	No. of Total Fatalities and Injuries		No. of Total Fatalities and Injuries Anticipated After Marking	Net Change (%)	Significance Level
	1959	1960			
Marked					
Killed	5	4	18	78	0.07
Injured	105	100	77	+30	0.25+
Total	110	104	90	+16	0.25+
Control					
Killed	4	15	-	-	-
Injured	136	100	-	-	-
Total	140	115	-	-	-

night were not significantly changed. The increase in "other collisions" was due principally to night data. In addition, fixed object collisions increase significantly (0.04 level) at night.

As shown in Table 7, a net increase in amount of property damage of 44 percent or nearly \$50,000 resulted after pavement edge markings.

The substantial increase in property damage on the marked sections bears some explanation. This increase was caused by four accidents. Two accidents involved trains and large trucks at railroad crossings, and two involved large truck accidents. These four accidents caused a total of \$69,050 property damage. If the

TABLE 5

TOTAL NUMBER OF ACCIDENTS AT INTERSECTIONS AND DRIVEWAYS BEFORE AND AFTER PAVEMENT EDGE MARKINGS OF TWO-LANE RURAL STATE HIGHWAYS IN KANSAS

Section	No of Total Accidents		No of Total Accidents Anticipated After Marking	Net Change (%)	Significance Level
	1959	1960			
Marked	52	38	70	-46	0.04
Control	41	55	-	-	-

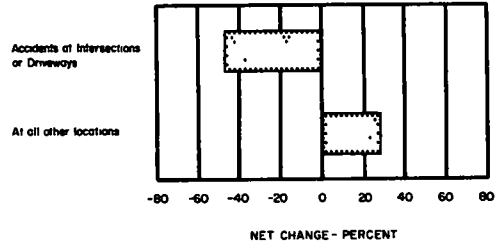


Figure 3. Net change in accidents by location after edge marking of two-lane rural State highways in Kansas.

TABLE 6

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

Item	Net Change (%)	No. of Accidents ^a	Significance Level ^b
Total Accidents	+1	685	0.25+
Persons Killed and Injured	+16	469 ^c	0.25+
Location			
At Access Points	-46	186	0.04
Between Access Points	+27	499	0.17
Type of Collision			
Pedestrian	d	1	0.25+
Turn	-60	72	0.06
Angle	-58	28	0.25+
Rear-end	-31	151	0.25+
Head-on	-11	27	0.25+
Sideswipe	-6	50	0.25+
Other collision	+326	33	0.03
Non-collision	+6	22	0.25+
Fixed objects	+6	44	0.20
Run off road	+34	257	0.23
Light condition			
Day	-18	421	0.25+
Night	+42	264	0.15
Pavement Condition			
Dry	+4	471	0.25+
Wet	0	119	0.25+
Ice	+3	95	0.25+

^aRefers to the total sample and includes both edge marked and control sections for the year before and the year after edge marking.

^bIndicates the probability that the net change could have occurred merely by chance. A significance level of 0.04; for example, indicates that there are only four chances in 100 that a "net change" as great or greater than that shown could have occurred merely by chance.

^cRefers to number of persons killed and injured.

^dTotal sample is too small to warrant computing net change.

TABLE 7

TOTAL PROPERTY DAMAGE BEFORE AND AFTER PAVEMENT EDGE MARKING OF TWO-LANE RURAL STATE HIGHWAYS IN KANSAS

Section	Total Property Damage (\$)		Total Property Damage Anticipated After Marking(\$)	Net Change (%)
	1959	1960		
Marked	103,700	159,900	111,100	+44
Control	112,300	120,300	-	-

costs of these four accidents conformed more nearly to the average costs of all accidents involved in the study, there probably would be only a slight increase in property damage costs on the marked sections over the control sections in 1960.

CONCLUSIONS

The significant conclusions from this study are:

1. On two-lane rural State highways in Kansas, the use of pavement edge markings resulted in a reduction in the number of fatalities.
2. There was no significant change in number of persons injured or in total number of accidents.
3. Accidents at intersections and driveways were significantly reduced during both daytime and nighttime conditions. Accidents between access points were not significantly changed.
4. The turning collisions associated with access points were reduced during daytime conditions.

ACKNOWLEDGMENT

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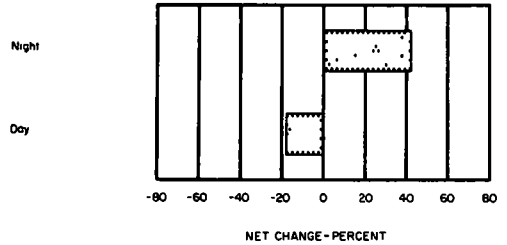


Figure 4. Net changes in accidents during daylight and darkness hours after edge marking of two-lane rural State highways in Kansas.