Final Report on the Minnesota Roadside Study

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● MANY of the findings of the Highway Accident, Access Point, and Advertising Sign Study conducted by Minnesota in 1947 and 1948 were previously presented at the Thirtieth Annual Meeting of the Highway Research Board. The findings presented at that time were, for the most part, summaries of information produced from the preliminary tabulations of the data recorded for the 420 mi. of rural two-lane roadway. Since that time, further investigations of the recorded information have been made to determine the relationship or association that exists between accident occurrence and certain of the roadway characteristics and roadside features. This report will deal with the results of these investigations and summarize the study findings.

As mentioned in the last report, the study originally called for an analysis of accidents which occurred during 1948, but preliminary tabulations revealed that in some instances accident occurrence was insufficient to permit a complete analysis. It was, therefore, decided to include accidents which occurred in 1949 and to compute accident rates on the basis of an annual average for the two-year period.

When adding these 1949 accidents to the study route, it was noted that most of them occurred at locations that were free of accidents in 1948. This observation pointed out the possibility that accidents, at one time or another, may have occurred on every road section included for study. It also accentuated the fact that many of the accidents were not caused by the presence of certain roadway characteristics but were caused by driver behavior, poor mechanical condition of the vehicle, or weather conditions. As a result, every accident rate presented in this report has a component that is not related to roadway characteristics. Since this component was not eliminated, the influence of each roadway characteristic on accident occurrence must be measured by means of the difference between accident rates which include, to a greater or lesser degree, the influence of this component.

Since the most complete information was on the two-lane highways which constituted 82 percent of the study mileage, investigations of this information produced most of the significant relations found to exist between accidents and roadway elements or roadside features.

One of these investigations dealt with accidents on tangent roadways. It seemed a reasonable assumption that short tangent sections, interrupted by curves and intersections, should tend to keep vehicle operators alert and to restrain their speed so that their vehicles are under reasonable control. If this assumption were true, the longer tangent sections, where greater speeds are likely to occur, should have the higher accident rates.

The accident rates for tangent sections of various lengths, together with other pertinent information, are shown in Table 1.

Although accident rates are somewhat lower for the shorter tangents, the rates for the longer tangents are not significantly high enough to validate the original assumption.

Because the assumed effect of long tangents could not be definitely substantiated, the investigation was extended to include curves occurring at the end of these tangents. Of all the curves included, 98 percent were simple curves and the remaining 2 percent were compound curves or reverse curves. For curves adjacent to tangents less than 3 mi. in length, the accident rate was 2.1 accidents per million vehicle miles, while the rate for curves adjacent to tangents more than 3 mi. in length was

TABLE 1

ACCIDENT RATES FOR TANGENT SECTIONS OF SPECIFIED LENGTHS

Section Lengths mi.	Total Mileage	Percent of Mileage	Average Daily Traffic	Accident Rate	Accidents per Mile
Less than 0.5	71	20.9	1,996	1.3	0.97
0.5 to 0.9	57	16.5	2,041	1.4	1.06
1.0 to 1.9	66	19.2	2,085	1.6	1.25
2.0 to 2.9	44	12.7	2,043	1.5	1.12
3.0 or more	105	30.7	2,237	1.5	1.25

2.5 accidents per million vehicle miles. This difference in rates suggests that driver relaxation or inattention, while not emphatically reflected in the rates for long tangents, seems to be reflected in the rate for curves that terminate these sections.

ACCIDENTS RELATED TO SPEED

Accidents as related to speeds at which motorists travel our rural highways are usually mentioned in every discussion on highway safety. To evaluate the effect of speed upon accidents, sections of tangent roadway were grouped according to the speed of travel. The speed of travel used in these computations is referred to as the 85 percentile speed; that is, the rate of speed exceeded by only 15 percent of all motorists using a particular road section. This rate of speed is influenced by posted speed limits as well as design features and other conditions of hazard created by business establishments which populate the rural road margin. The grouping of road sections according to speed of travel is shown in Table 2.

This table shows that, contrary to the popular notion, those sections on which the highest speeds were recorded had the lowest accident rate; and conversely, the sections of lower speed had the highest accident rate. In search of an explanation, a detailed check was made of each section of road, and it was found that the low-speed sections were usually adjacent to urban areas and the high-speed sections were in strictly rural areas.

This investigation also revealed that the 101 mi. in the high-speed group had comparatively few intersections, access points, and advertising signs; they also had low traffic volumes. In fact, this mileage seemed to have the ideal conditions necessary for an accident-free record. From these ideal conditions it appears that the 1.0 accident rate is perhaps the minimum rate that can be expected when accidents of all types are considered and the traffic volumes on the road range from 1,500 to 2,000 vehicles per day.

The sections on which the low speeds occurred were most often found to be adjacent to urban areas, and the low speeds recorded are believed to be a result of deceleration on the part of motorists approaching the urban area and by other motorists who, on leaving the urban section, had not, as yet, attained cruising speeds usually associated with rural highways. These deceleration and acceleration actions undoubtedly tend to maximize the difference in speeds between successive vehicles and thus create friction which usually increases the accident potential on any road section.

Since most of the sections having a low 85 percentile speed were adjacent to urban areas and the sections having a high 85 percentile speed were, for the most part, strictly rural, an investigation was made of the number of access points located on each section.

The number of access points per mile and the accident rates for the various speed groups are presented in Table 3.

This apparent relationship between access points per mile and accident rates casts another element of doubt on the assumption that speed in itself is a major cause of accidents.

TABLE 2

ACCIDENT RATES FOR TANGENT SECTIONS IN SPECIFIED SPEED GROUPS

Speed Groups mph.	Mileage	Percent of Mileage	Average Daily Traffic	Accident Rate
30 to 34	4	1.0	2,437	2.4
35 to 39	6	1.6	2,149	2.5
40 to 44	14	4.2	2,553	1.4
45 to 49	35	10.1	2,229	2.0
50 to 54	183	53.6	2,264	1.6
55 to 59	101	29.5	1,681	1.0

Time does not permit a detailed review of more of the findings that resulted from other investigations of information obtained on the curve and tangent sections of the study routes, and therefore, accident occurrence as related to intersections, another roadway element selected for study, will now be discussed.

ACCIDENTS AT INTERSECTIONS

The assigning of an accident to an intersection was determined by the location where the initial cause of the accident occurred. For example, an intersection accident would be created if a motorist lost control of his car when avoiding another vehicle in the intersection, and in so doing, collided with a third vehicle, perhaps at a point well removed from the intersection.

In classifying intersections, it was found that a few had no provision for traffic control, a few had more than 10 percent cross traffic and some had intersectional volumes in excess of 5,000 vehicles per day. A summary of the many possible groupings showed that 96 percent of the intersections had volumes less than 5,000 vehicles per day, less than 10 percent cross traffic and were provided with standard "Stop" signs for traffic controls. Further comment regarding intersections will be confined to these 593 intersections.

In this investigation, intersections were first segregated as to type and then further classified as to intersectional volume. When this grouping was completed, the average accident rate for intersections in each grouping was computed. A comparison of these rates is made in Table 4.

TABLE 3

ACCIDENT RATES AND FREQUENCY OF ACCESS POINTS FOR TANGENT SECTIONS IN SPECIFIED SPEED GROUPS

Speed Group mph.	Mileage	Percent of Mileage	Average Daily Traffic	Access Points per Mile	Accident Rate
30 to 39	10	2.6	2,256	27.4	2.5
40 to 49	49	14.3	2,324	13.8	1.8
50 to 59	284	83.1	2,057	8.8	1.4

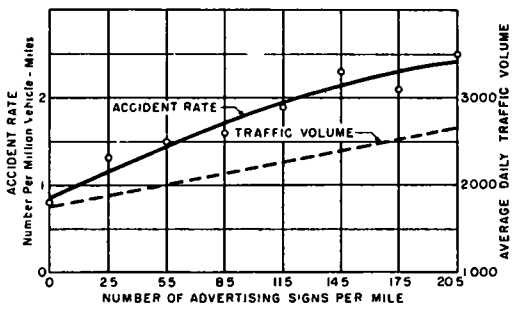

Figure 1. Accident Rates for Various Frequencies of Advertising Signs.

It is apparent that traffic volumes have the greatest effect on accident frequency at the four-way intersections. Of particular interest is the difference in accident rates for the two types of intersections in corresponding traffic volume groups. When the traffic volumes at the two types of intersections are between 1,000 and 1,500 vehicles, there is no difference in the accident rates but, as the volumes increase, the accident rates at four-way intersections increase progressively until volumes of 3,000 to 3,500 vehicles are reached; and for this volume group the rate for four-way intersections is approximately 3.3 times the rate for three-way intersections having the same intersectional volumes.

This suggests that it is decidedly more dangerous to cross both directional lanes of traffic in a single maneuver than to merge with the two traffic streams as is done at three-way intersections.

The two types of intersections were grouped according to their location on curve and tangent sections of roadway and the computed accident rates again were higher for four-way intersections. Higher accident potential at intersections on curves was also indicated.

Considerable information regarding frequency, location, size, and shape of advertising signs was presented in the previous paper and will not be repeated. Other investigations have been made, however, of accidents and advertising signs.

In order to establish and attempt to measure the relation that might exist between signs and motor vehicle accidents, all road sections were grouped according to the frequency of signs per mile of road, and average accident rates for the road sections in each sign group were computed. The trend of accident rates thus obtained is shown on Figure 1.

This shows that as the number of signs per mile of road increases, there is a corresponding increase in accident rate. When a second trend line was computed to show the average traffic volume for road sections in each of the same sign groups, it was found that the sections with the greatest frequency of signs also had the highest traffic volume.

To obtain a measure of the association between accident rate and sign frequency, two statistical tests were applied to the data. The first produced a correlation coefficient of 0.97 and the second produced a standard error of estimate of 0.13. The results of these two tests practically eliminates the probability that this association is due to chance. It may be assumed that an increase in the number of signs per mile will be accompanied by a corresponding increase in accident rate.

While other investigations were made and results of lesser significance obtained, time does not permit a recital of these activities.

MAJOR FINDINGS

The four-lane, divided highways had the lowest accident rate of all types of highway studied and are therefore presumed to be the safest. Conversely, the three-lane highways, which had the highest accident rate, may be presumed to be the most dangerous.

The disproportionately lower accident rates for low traffic volume roads and intersections make apparent the fact that traffic volumes influence accident rates.

Other conditions being equal, two-lane highways with 18-ft. pavement were found to be more dangerous than two-lane highways having surface widths of 20 ft. or more.

Short tangent sections, interrupted by curves and intersections, had accident rates that were not appreciably different than those for long tangent sections.

TABLE 4

COMPARISON OF ACCIDENT RATES AT THREE-WAY AND FOUR-WAY INTERSECTIONS BY SPECIFIED TRAFFIC VOLUME GROUPS

Intersectional Volume	Three-way Intersections (Acc. Rate [a])	Four-way Intersections (Acc. Rate [a])	Ratio
1,000 to 1,499	2.6	2.6	1.0
1,500 to 1,999	2.2	3.6	1.6
2,000 to 2,499	1.9	4.5	2.4
2,500 to 2,999	2.1	5.4	2.6
3,000 to 3,499	2.1	7.0	3.3

[a] 10 Million vehicles per year.

Curve sections at the ends of long tangents had higher accident rates than were found on curves at the ends of short tangent sections.

Tangent sections of two-lane highways in strictly rural areas had relatively low accident rates, even though these were the high-speed sections of the study route. These low rates may be attributed to the low frequency of intersections and access points as well as the low traffic volumes occurring on these rural roads.

Restrictive sight distances caused by vertical curves on tangent roadways having traffic volumes of less than 5,000 vehicles per day are not particularly dangerous when they are properly identified by signs and striping.

Curves with restrictive sight distances produced an average accident rate twice the rate for tangent sections with restrictive sight distances. This average was also twice as great as that for curves with adequate sight distances.

The accident rate for curves of 7 deg. and over was found to be nearly four times the rate for curves of less than 3 deg.

Four-way intersections had consistently higher accident rates than three-way intersections when taken either as a group or by comparable intersectional volumes or by percent of cross traffic. When the cross traffic was more than 10 percent, the accident rate was six times the rate at three-way intersections and eight times the rate at four-way intersections at which there was less than 10 percent cross traffic.

When segregated by intersectional volumes, three-way intersections showed no significant variation in accident rates. The rates at four-way intersections increased substantially with increased intersectional volumes, being over three times as great as for three-way intersections with volumes from 3,000 to 3,500 vehicles per day.

With respect to access points, it was found that there was no significant difference in accident rates for road sections having no access points and those having access points serving noncommercial purposes. This would seem to indicate that access points which are relatively infrequently used do not make a major contribution to the accident potential of a road section. The rate for sections with access points serving commercial activities, however, was twice as great as those in the other two categories.

When road sections were segregated by traffic volume groups, a good degree of correlation was apparent between the number of access points per mile and the accident rate.

Road sections whose margins were populated with commercial activities had relatively high accident rates. The rate for these sections was between two and three times the rate found on sections having no commercial development and nearly four times as great as the rate for strictly rural sections with few intersections. It was also found that intersections influenced by these marginal developments had higher accident rates than other intersections.

The location of a substantial majority of the 4,069 advertising signs less than 60 ft. from the centerline of the roadway suggests the probable elimination of many small signs by the present practice of acquiring wide rights-of-way.

The frequency of advertising signs per mile on curves was nearly half again as great as that found on tangent sections.

Highway sections having low traffic volumes had a low frequency per mile of advertising signs.

Highway sections having a high frequency of advertising signs had high accident rates.

Intersections at which four or more signs were located had an average accident rate approximately three times that for intersections having no signs.

CONCLUSIONS

This study has proved that due to numerous immeasurable factors the occurrence of motor-vehicle accidents can not be predicted on the basis of roadway elements and roadside features. It is evident, however, that these various elements and features, alone or in combination, make varying degrees of contribution to accident occurrence.

In general, it may be concluded that the magnitude or frequency of these characteristics governs the extent to which accident potential is generated.