Relationship Between Curvature and Accident Experience on Loop and Outer Connection Ramps

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This paper examines the relationship between accident rate and curvature on loop and outer connection ramps of the Interstate Highway System. Ramp characteristics considered include maximum curvature, location of ramp, enter or exit direction with respect to the main-line unit, and average daily traffic. Accidents per million vehicles are used as the primary indication of accident experience. Results of the investigation indicate that accident rates increase with maximum curvature for all right entering or exiting loops and outer connections except rural loops. Accident rates are lower on right entering or exiting outer connections with no curvature (less than 1 deg) than on those with curvature for all but one urban ADT category. All urban right entering or exiting loops and outer connections, except urban loops, show a positive correlation between ADT and accident rate. The effect of traffic volume on rural ramp safety for various curvatures exhibited mixed relationships.

•THE PURPOSE OF THIS PAPER is to examine the influence of maximum curvature and average daily traffic (ADT) on the accident rate of loop ramps and outer connection ramps. This study grew directly out of the first general analysis (1) of the Interstate System Accident Research, Study II (ISAR-II), and is similar to a recent ramp study conducted in part by the author (2).

This analysis is restricted to a study of right entering or exiting (REE) and left entering or exiting (LEE) loop ramps and outer connection ramps in urban and rural areas as defined in the ISAR-II data base. (Terms used in this paper are defined in a glossary at the end of the paper.) These 2 types of ramps are integral parts of cloverleaf interchanges, and all ramps in this study are part of the Interstate Highway System. These 2 types of ramps were not compared in this study, though various figures are available if such a comparison is desired.

This study examines the geometric variable, maximum curvature, the traffic variable, ADT, and several characteristics of ramp accidents. Maximum curvature, as measured in this data base, is not a continuous variable but a discrete variable with 10 possible categories of curvature varying from 0 to 36 deg and above. Maximum curvature as well as ADT data were each stratified into 3 groups. Also, accident rate comparisons were made between no-curvature and curvature outer connections as well as between low- and high-curvature loop ramps. Accident characteristics, such as time of accident and manner of collision, were also examined.

FINDINGS

1. Except for ramps located in rural areas, all REE ramps show an increase in accident rate with increasing curvature.
2. All rural LEE or REE outer connections as well as REE loops show a mixed relationship between accident rate and increasing ADT, whereas all urban REE or LEE outer connections show increasing accident rate with increasing ADT.

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3. Outer connection ramps without curvature have accident rates lower than those on outer connection ramps with curvature in urban and rural areas for all ADT levels except 0 to 500 for urban outer connections.
4. Urban loop ramps with high curvature have accident rates higher than those on urban loop ramps with low curvature for most ADT categories. But, rural loop ramps with low curvature have accident rates higher than those on rural loop ramps with high curvature for most ADT categories.
5. Urban loops and outer connections, regardless of left turning or right turning, dramatically differ from rural loops and outer connections in ADT levels (higher in urban), curvature (higher in urban), accident rates (higher in urban), manner of collision of accidents (mostly rear-end in urban), vehicles per accidents (greater than 1.5 vehicles per accident in urban), accidents involving commercial traffic (lower in urban), and in the period of occurrence of accidents (mostly between 7 a.m. and 6 p.m. in urban).
6. For urban REE, loops and outer connections, the percentage of rear-end collisions and the percentage of daytime (between 7 a.m. and 6 p.m.) accidents increase with maximum curvature.
7. For rural REE outer connections, the percentage of noncollision accidents increases with maximum curvature.

ANALYSIS

Data Characteristics

The data were obtained from the Interstate System Accident Research, Study II, data base. The number of data points available are as follows:

Ramp	REE Urban	REE Rural	LEE Urban	LEE Rural
Outer connections	1,548	1,364	122	101
Loops	1,084	852	10	7

Because of the insufficient number, LEE loops were excluded from this analysis.

Because there were so few 2-lane ramps, 1-lane and 2-lane ramps were not separated, but a distinction was made for analysis purposes between urban and rural and between REE and LEE ramps. Thus, there are 6 individual study groups in this analysis:

1. Urban loops, right enter or exit
2. Rural loops, right enter or exit
3. Urban outer connections, right enter or exit
4. Rural outer connections, right enter or exit
5. Urban outer connections, left enter or exit
6. Rural outer connections, left enter or exit

The first four are referred to as the primary study groups, and the last two referred to as the secondary study groups. Table 1 gives the contribution of data points by state for these 6 groups. Urban areas are

Traffic Volume (Veh /Day)	Maximum Curvature <20	20-30	>30	All Curvature
0 - 1000				
1000 - 4000				
Over 4000				
All Volume				

The table has 40 cells each containing the following accident data:
1. Number of accidents a year/total traffic volume for year of vehicles.
2. Number of injuries a year/total traffic volume for year of vehicles.
3. Number of fatalities a year/total traffic volume for year of vehicles.
4. Property damage a year/total traffic volume for year of vehicles.
5. Number of accidents a year.
6. Accidents to injuries ratio.
7. Number of units.

Figure 1. Sample output table generated by computer program for each model.

TABLE 1

DATA POINTS BY CONTRIBUTING STATE

State	REE Loops				REE Outer Connections				LEE Outer Connections			
	Urban		Rural		Urban		Rural		Urban		Rural	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Arizona	6	0.6	30	3.5	4	0.2	45	3.3	—	—	11	10.9
California	37	3.4	24	2.8	158	10.2	44	3.2	5	4.1	1	9.9
Connecticut	146	13.5	75	8.8	247	15.9	148	10.8	—	—	—	—
Florida	—	—	3	0.4	—	—	—	—	—	—	—	—
Illinois	487	44.9	230	27.0	550	35.5	304	22.3	85	69.7	15	14.9
Indiana	—	—	3	0.4	6	0.4	—	—	—	—	—	—
Kansas	110	10.1	—	—	179	11.5	—	—	11	9.0	—	—
Michigan	14	1.3	24	2.8	39	2.5	53	3.9	4	3.0	1	9.9
Minnesota	28	2.6	—	—	27	1.7	—	—	—	—	—	—
Mississippi	6	0.6	—	—	18	1.2	—	—	3	2.5	—	—
Montana	—	—	21	2.5	—	—	54	4.0	1	0.8	—	—
New York	35	3.2	10	1.2	40	2.6	25	1.8	—	—	—	—
North Carolina	125	11.5	172	20.2	133	8.6	285	20.9	5	4.1	21	20.8
North Dakota	5	0.6	4	0.5	4	0.3	10	0.7	—	—	9	8.9
Ohio	—	—	46	5.4	—	—	54	4.0	—	—	—	—
Oklahoma	2	0.2	5	0.6	2	0.2	15	1.1	—	—	2	2.0
Pennsylvania	10	0.9	8	0.9	13	0.8	14	1.0	—	—	—	—
Rhode Island	3	0.3	—	—	26	1.7	—	—	6	4.9	—	—
South Dakota	—	—	—	—	—	—	—	—	—	—	16	15.8
Vermont	—	—	28	3.3	—	—	70	5.1	—	—	13	12.9
Virginia	62	5.7	77	9.0	94	6.1	123	9.0	2	1.6	7	6.9
Wisconsin	8	0.7	92	10.8	8	0.5	115	8.4	—	—	5	5.0
Total	1,084	100	852	100	1,549	100	1,364	100	122	100	101	100

dominated by Illinois data while rural areas are dominated by both Illinois and North Carolina data.

Analytical Approach

The accident data for the 2 ramp types studied were tabulated by a computer program that was written by using a previously generated n-tuple tape for each ramp as input data. (In order to speed processing time, the n-tuple tape took only a limited number of variables from the original number in the ISAR-II data base.) A typical computer table of the accident data is shown in Figure 1. The tables are labeled at the top as to ramp type and location. The first 3 columns represent 3 maximum curvature categories. The fourth column sums the preceding 3 columns. Similarly, the first 3 rows provide a 3-way breakdown for ADT, and the fourth sums the preceding 3 rows. The lower right cell gives accident data for all the data points in that table. The various measures of safety and descriptive statistics tabulated for each cell of the tables are also shown in Figure 1. Computer programs were also used to tabulate accident characteristics and frequency distributions of data by ADT, curvature, and state.

Urban Versus Rural and REE Versus LEE

Data given in Tables 2, 3, and 4 show the marked differences among the 3 urban study groups and the 3 rural study groups. Table 2 gives ADT frequency distributions for each of the 6 study groups. Obviously, the ADT frequency distributions for the 3 rural study groups differ from the distributions for the 3 urban study groups. ADT distributions peak at lower volumes and drop off more rapidly in the rural than in the urban distributions.

Table 3 gives maximum curvature frequency distributions for each of the 6 study groups. Curvature distributions peak at a lower maximum curvature in the 3 rural than in the 3 urban distributions. Of course, this is expected because land in urban areas is usually more difficult to obtain for an Interstate Highway than in rural areas.

Table 4 gives accident characteristics for each of the 6 study groups. Because the LEE outer connections in rural areas have only 14 accident samples, the accident

TABLE 2

AVERAGE DAILY TRAFFIC FREQUENCY DISTRIBUTION

Average Daily Traffic	REE Loops				REE Outer Connections				LEE Outer Connections			
	Urban		Rural		Urban		Rural		Urban		Rural	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
0 to 499	228	21.0	599	70.3	288	18.6	809	59.3	3	2.5	27	26.7
500 to 999	226	20.8	177	20.7	317	20.4	353	25.9	15	12.3	33	32.7
1,000 to 1,499	141	13.0	54	6.3	239	15.4	111	8.1	21	17.2	10	9.9
1,500 to 1,999	158	14.6	8	0.9	202	13.0	38	2.8	17	13.9	7	6.9
2,000 to 2,499	94	8.7	5	0.6	122	7.9	36	2.6	9	7.4	3	3.0
2,500 to 2,999	46	4.2	6	0.7	90	5.8	13	1.0	6	4.9	3	3.0
3,000 to 3,499	55	5.1	0	0	53	3.4	2	0.1	3	2.5	6	5.9
3,500 to 3,999	42	3.9	1	0.1	67	4.3	1	0.07	2	1.6	4	4.0
4,000 to 4,499	35	3.2	0	0	46	3.0	0	0	2	1.6	4	4.0
4,500 to 4,999	13	1.2	1	0.1	23	1.5	1	0.07	1	0.8	1	1.0
5,000 to 5,499	12	1.1	0	0	31	2.0	0	0	4	3.3	1	1.0
5,500 to 5,999	4	0.4	0	0	12	0.8	0	0	2	1.6	1	1.0
6,000 to 6,499	4	0.4	1	0.1	12	0.8	0	0	6	4.9	1	1.0
6,500 to 6,999	8	0.7	0	0	12	0.8	0	0	3	2.5	0	0
7,000 and over	18	1.7	0	0	34	2.2	0	0	28	22.9	0	0
Total	1,084	100	852	100	1,548	100	1,364	100	122	100	101	100

characteristics of this study group probably are not representative of all LEE outer connections. In general, accidents of the 3 urban study groups occur mostly between 7 a.m. and 6 p.m.; most are 2-vehicle accidents, usually rear-end collisions. Accidents of the 3 rural study groups are much more likely to occur in the evening or at night, and to be single-vehicle accidents in which vehicles leave the road with or without hitting a structure. The 3 urban study groups have fewer accidents involving commercial vehicles (less than 10 percent) than the 3 rural study groups (more than 13 percent). This figure though, may only indicate that a greater percentage of rural traffic is commercial traffic. Unfortunately, the percentage of rural traffic that is commercial was not on the n-tuple tape, though it was in the original data base.

Figures 2 through 5 show accident, injury, fatality, and property damage rates respectively for each of 6 study groups for urban and rural areas. The accident rates are higher for ramps in urban areas than ramps in rural areas. The dotted lines indicate the various rates when all truck and bus traffic has been removed. The influence

TABLE 3

MAXIMUM CURVATURE FREQUENCY DISTRIBUTION

Curvature	REE Loops				REE Outer Connections				LEE Outer Connections			
	Urban		Rural		Urban		Rural		Urban		Rural	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Tangent	—	—	—	—	111	7.2	58	4.3	15	12.3	17	16.8
0 deg 29 min and under	—	—	—	—	4	0.3	3	0.2	—	—	5	5.0
0 deg 30 min to 1 deg 29 min	—	—	—	—	11	0.7	4	0.3	11	9.0	2	2.0
1 deg 30 min to 2 deg 59 min	—	—	—	—	30	1.9	47	3.4	10	8.2	9	8.9
3 deg to 4 deg 59 min	3	0.3	2	0.2	48	3.1	65	4.8	21	17.2	36	35.6
5 deg to 8 deg 59 min	1	0.1	5	0.6	243	15.7	409	30.0	24	19.7	24	23.8
9 deg to 14 deg 59 min	42	3.9	35	4.1	351	22.6	373	27.3	14	11.5	4	4.0
15 deg to 23 deg 59 min	64	5.9	90	10.6	294	19.0	244	17.9	19	15.6	3	3.0
24 deg to 35 deg 59 min	271	25.0	287	45.4	191	12.3	113	8.3	6	4.9	—	—
36 deg and over	703	64.8	333	39.1	265	17.1	48	3.5	2	1.6	1	1.0
Total	1,084	100	852	100	1,548	100	1,364	100	122	100	101	100

TABLE 4

PERCENTAGE DISTRIBUTION OF ACCIDENT CHARACTERISTICS

Accident Characteristics	REE Loops		REE Outer Connections		LEE Outer Connections	
	Urban	Rural	Urban	Rural	Urban	Rural
Time of accident						
Night (12 to 7 a.m.)	15.8	34.1	12.6	23.6	12.6	28.6
Evening (6 to 12 p.m.)	16.0	23.0	17.3	20.0	24.3	28.6
Day (9 a.m. to 4 p.m.)	33.5	25.6	30.9	29.7	36.9	21.4
Rush (7 to 9 a.m. and 4 to 6 p.m.)	34.6	17.0	39.2	26.9	26.2	21.4
Manner of collision						
Rear-end	46.4	6.5	61.8	14.5	70.9	50.0
Head-on	0.3	2.4	0.1	0.7	1.0	0
Angle	1.3	1.2	2.7	2.1	1.0	14.0
Collision with pedestrian	0	0	0.2	0.7	0	0
Other collision	34.4	47.5	27.4	37.9	23.3	14.0
Noncollision	15.4	39.0	7.6	44.1	3.9	21.4
Not known	0	0	0	0	0	0
Vehicles per accident						
1 vehicle	49.3	87.8	35.1	82.7	27.2	35.7
2 vehicles	28.9	10.9	61.8	15.2	61.2	64.3
3 vehicles	1.3	2.4	3.2	2.1	10.7	0
4 vehicles	0.4	0	0	0	1.0	0
Ratio of vehicles to accidents	1.53	1.13	1.68	1.19	1.85	1.91
Type of vehicle involved						
Passenger cars	89.7	76.3	44.0	81.5	89.0	87.0
Pedestrian	0	0	0	0	0	0
Unknown or other	1.1	0	1.1	2.9	3.7	0
Trucks and buses	9.2	23.7	4.7	15.6	7.3	13.0
Total number of accidents	537	82	822	145	103	14

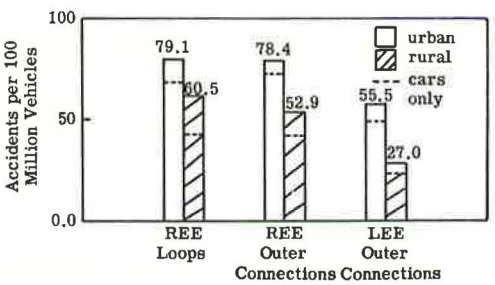

Figure 2. Accident rates.

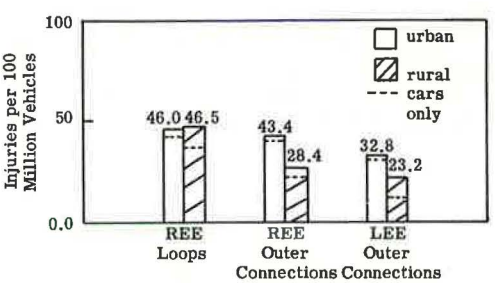

Figure 3. Injury rates.

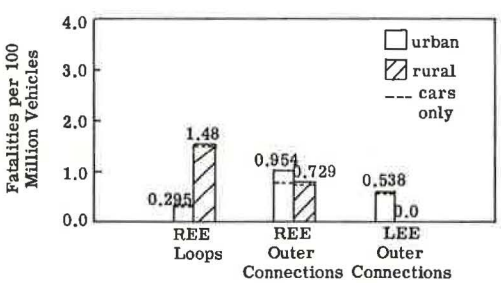

Figure 4. Fatality rates.

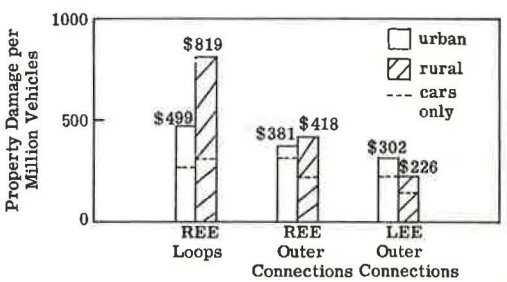

Figure 5. Property damage rates.

of trucks and buses on the fatality rates is very small, but on property damage rates, very large, especially on rural loops.

The importance of separating urban and rural data is that dividing lines for ADT and maximum curvature for the analyses to follow can be selected without bias. For example, if urban and rural data were not separated, the lower ADT level of 0 to 1,000 vehicles used in the analysis would contain mostly rural data points and the level of 1,001 to 4,000 would be mostly urban data points. Thus, a bias of rural data would exist in the lower ADT level of the example. Therefore, an urban-rural bias has been avoided by the realization of the difference in geometric variables, traffic variables, and accident characteristics between urban and rural ramps.

The data given in Tables 1 through 4 demonstrate and support the division of the ramp types into urban and rural. The data were also divided into left entering or exiting ramps and right entering or exiting ramps for the reason that there are so few left entering or exiting ramps that the ordinary driver has more difficulty negotiating them because he is less familiar with their traffic movement.

Separating the left and right entering or exiting ramps also allows each group to be more homogeneous and thus reduces possible bias. The only drawback from this separation is that it creates LEE categories for which there are few data points.

Maximum Curvature

Maximum curvature as defined in the data base is simply the greatest curvature that would be experienced by a driver as he drives his vehicle along the ramp. AASHO (3) defines maximum curvature as a "limiting value for a given design speed determined from the maximum rate of super-elevation and the maximum side friction factor." Thus, the 2 definitions of maximum curvature do not necessarily coincide.

Maximum curvature may have served as a proxy variable in this analysis for other important design variables such as minimum stopping sight distance or distance from approach nose to portion of the ramp where curvature exceeds 10 deg. These 2 particular variables were examined, in a similar manner to ADT, by using a computer program, but no correlation was found between their results and maximum curvature results. Also, other connections and loops with very high maximum curvature could not be isolated because of the nature of the data base that combines all ramps with curvatures above 36 deg. This is only a minor drawback of the data base, however, and does not affect these results.

Generally, each of the 6 study groups, except for REE rural loops, showed an increase in accident rate with an increase of maximum curvature (Fig. 6).

Outer connection ramps can be thought of as having curvature or no curvature. Table 5 gives a comparison of accident rates for various ADT levels for urban and rural outer connections with and without curvature. An outer connection was considered to have no curvature if its curvature was less than 1 deg. For each ADT level in urban and rural areas, except for 0 to 499 urban outer connections, the no-curvature ramps have smaller accident rates than those with curvature.

TABLE 5

ACCIDENT RATES ON OUTER CONNECTIONS BY CURVATURE AND ADT

ADT	Urban		Rural	
	Without Curvature (<1 deg)	With Curvature (>1 deg)	Without Curvature (<1 deg)	With Curvature (> 1 deg)
0 to 499	0.74	0.64	0	0.67
500 to 1,000	0.34	0.72	0.13	0.49
1,001 to 1,500	0.64	0.84	0	0.61
1,501 to 2,000	0.15	0.93	0[a]	0.20
2,001 and over	0.49	0.82	0[a]	0.72
All volumes	0.44	0.81	0.05	0.56

[a]Less than 10 study units.

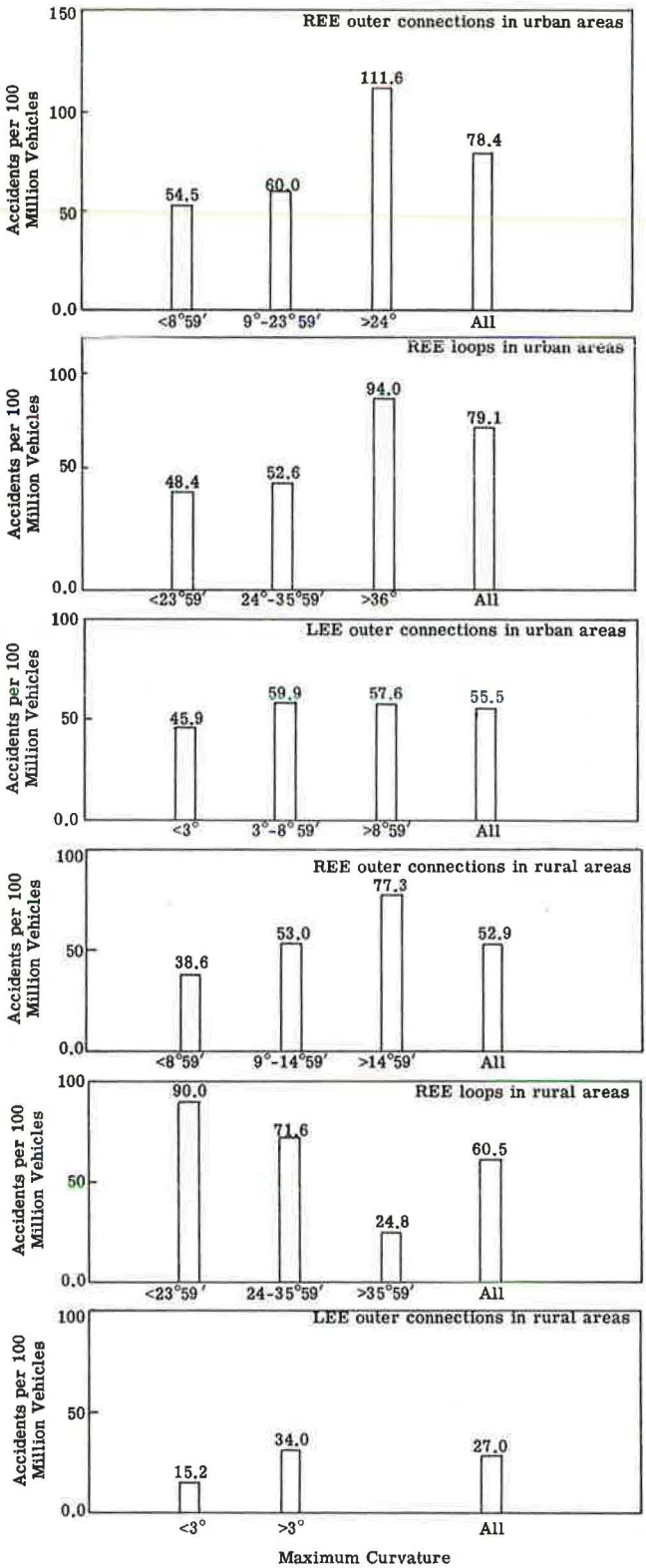

Figure 6. Accident rates for all traffic volumes by maximum curvature.

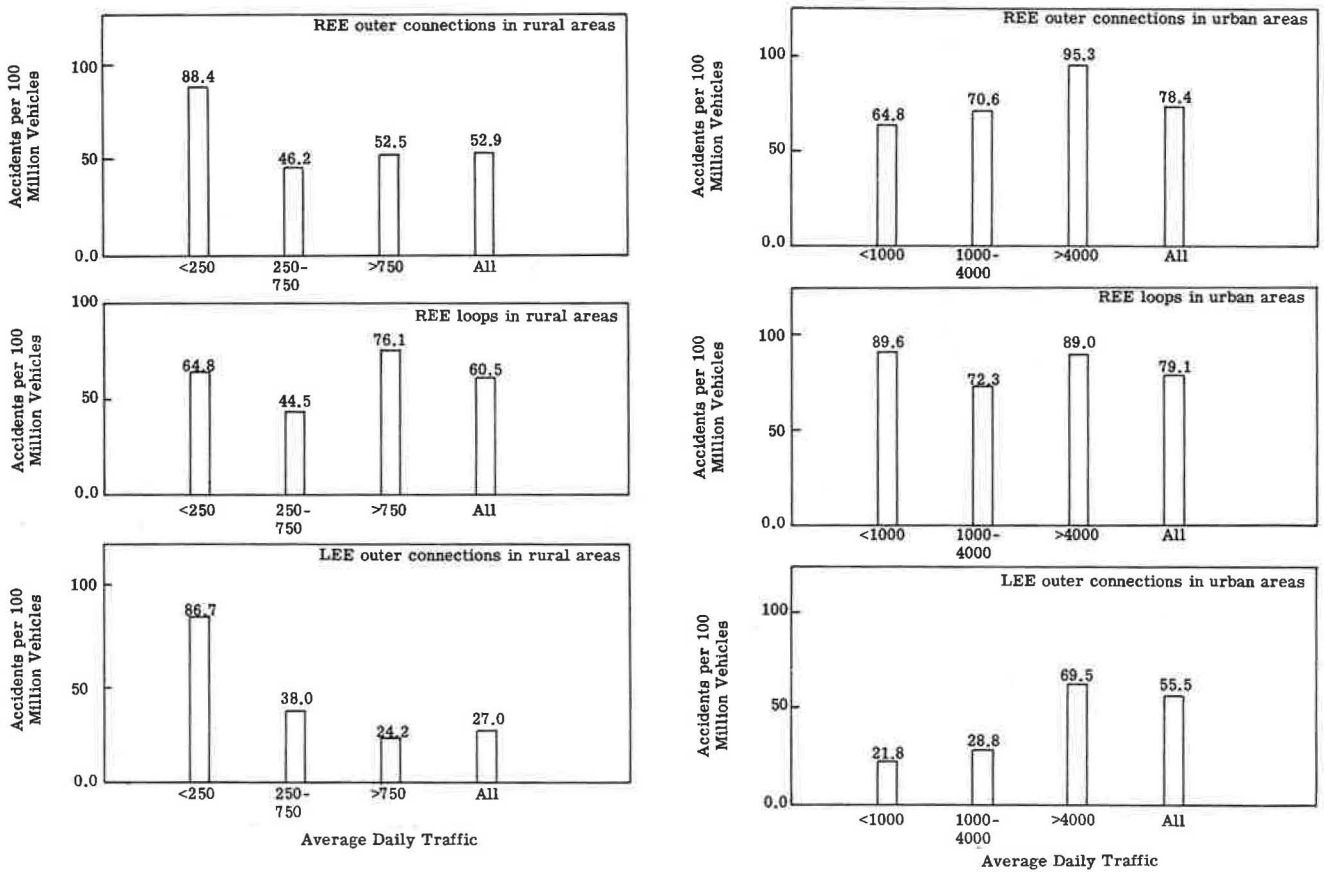

Figure 7. Accident rates for all degress of curvature by traffic volume.

TABLE 6

ACCIDENT RATES ON LOOPS BY CURVATURE AND ADT

ADT	Urban		Rural	
	Low Curvature (<12 deg)	High Curvature (>36 deg)	Low Curvature (<12 deg)	High Curvature (>36 deg)
0 to 499	0[a]	0.841	1.000	0.26
500 to 1,000	0[a]	0.960	0.810	0.37
1,001 to 1,500	1.320[a]	0.690	0[a]	0
1,501 to 2,000	0	0.720	0[a]	0
2,001 and over	0.141	1.000	—[a]	0
All volumes	0.200	0.940	0.631	0.25

[a]Less than 10 study units.

It is impossible to examine separately those ramps with extremely high curvature because of the design of the data base. This deficiency is especially felt for urban loop ramps for which 60 percent of the data are in the highest curvature category. Thus a comparison was made between accident rates on loops with low curvature (maximum

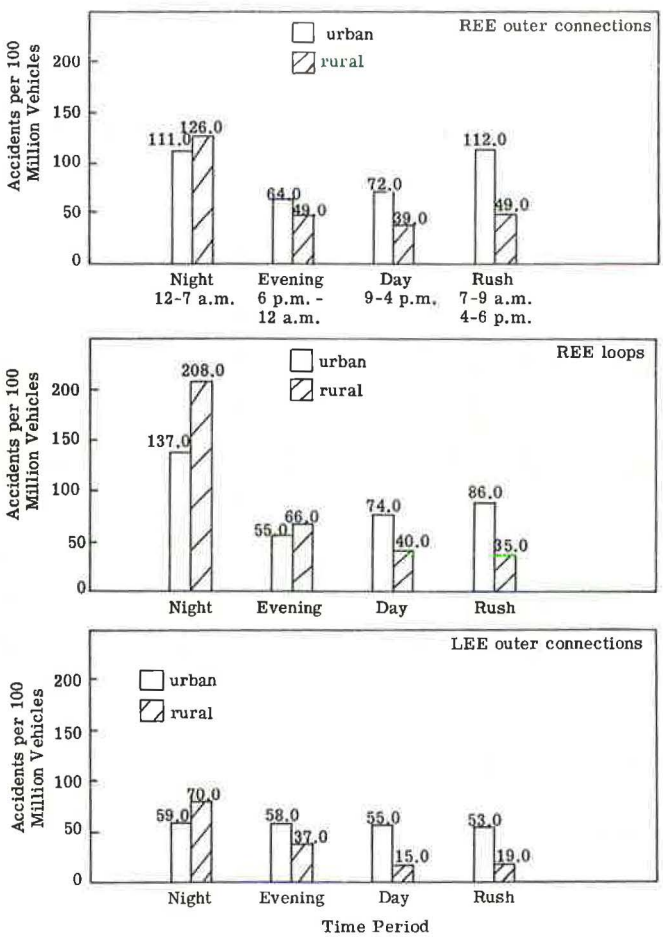

Figure 8. Accident rates by time period.

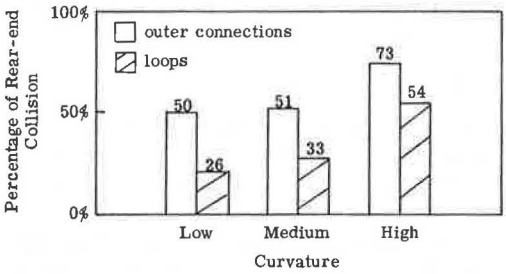

Figure 9. Percentage of rear-end collisions on REE outer connections and loops in urban areas by maximum curvature.

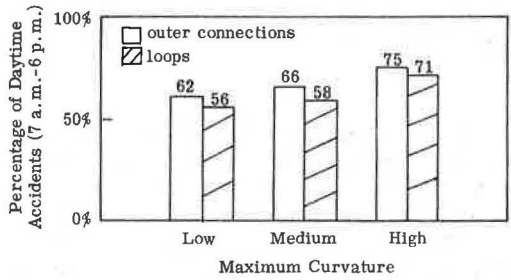

Figure 10. Percentage of daytime accidents on REE outer connections and loops in urban areas by maximum curvature.

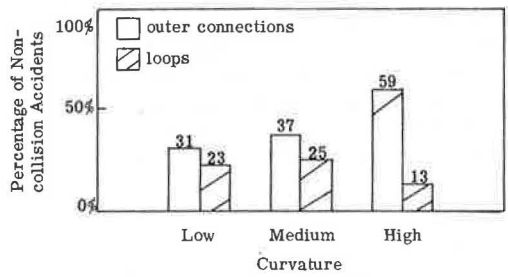

Figure 11. Percentage of noncollision accidents on REE outer connections and loops in rural areas by maximum curvature.

curvature of 12 deg or less) and loops with high curvature (maximum curvature of 36 deg or greater). Table 6 gives this comparison. In urban areas, high curvature loops have high accident rates for most ADT levels; in rural areas, low curvature loops have high accident rates for most ADT levels.

Average Daily Traffic

The 3 urban study groups are examined separately from the 3 rural study groups because of differences in ADT levels. The 3 urban study groups had ADT breakdowns of 0 to 999, 1,000 to 4,000, and 4,001 and over. The 3 rural study groups had ADT breakdowns of 0 to 249, 250 to 750, and 751 and over.

The assumption in the examination of ADT is that, as it increases, the accident rate also increases because of vehicle interaction. Thus, one would not expect the 3 rural study groups to demonstrate increasing accident rate with increasing ADT because the ADT levels are so very low that vehicle interaction is low even at high (751 and over) rural ADT levels. Figure 7 shows the relationship between ADT and accident rates for each of the 6 study groups. Because of low ADT levels, the 3 rural study groups show no relationship between accident rate and increasing ADT. Increasing ADT increases accident rates in urban areas for REE and LEE outer connections but not for loops.

Time Period

Accident rates for various time periods on the ramps in urban and rural areas are shown in Figure 8.

Accident Characteristics by Maximum Curvature

The accident characteristics of the primary study groups were examined to locate those characteristics that increased consistently with maximum curvature. In urban areas for all the primary study groups, the percentage of rear-end collisions and the percentage of day (7 a.m. to 6 p.m.) accidents increase with maximum curvature (Figs. 9 and 10). Similarly, in rural areas for REE outer connections, the percentage of noncollision accidents increases with increasing maximum curvature (Fig. 11). On

rural loops the percentage of noncollision accidents also increases for low and medium maximum curvatures, but decreases for high curvature.

CONCLUSION

In this examination of outer connection and loop ramps, data were separated into 8 groups: REE and LEE outer connections and loops in urban and rural areas. After the number of data points in each group were examined, 2 groups (urban and rural LEE loops) were discarded.

The remaining 6 groups were examined for relationships between accident rate and maximum curvature and ADT. At first, each group was inspected individually for optimum data groupings for the analysis. Results indicated that (a) except for loops, in rural areas, all REE ramps showed an increase in accident rate with increasing maximum curvature, and (b) all ramps in urban areas, except urban loops, showed an increasing accident rate with increasing ADT.

Curvature versus no curvature was examined for outer connections and low curvature versus high curvature for loops. In both analyses, comparable urban-rural ADT levels were used. Outer connections without curvature have smaller accident rates than those with curvature in both urban and rural areas for all ADT levels except 0 to 499 on outer connections in urban areas. Unfortunately, the design of the data base prevented a true comparison of loops with low curvature with loops with high curvature. But, results showed that rural loops with low curvature had higher accident rates than rural loops with high curvature whereas the reverse was true for urban loops. The percentage of rear-end collisions and the percentage of day (9 a.m. to 4 p.m.) accidents also increased with maximum curvature on REE urban loops and outer connections.

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GLOSSARY

accident rate. Accidents per 100 million vehicles.

average daily traffic. Total traffic volume during a stated period divided by the number of days in that period. Unless otherwise stated, the period is a year. Abbreviation ADT.

commercial vehicle. A motor vehicle designed primarily for transportation of goods or more than 10 passengers or both in connection with business, industry, agriculture, public service, or the exploitation of natural resources.

criterion variable. Variable used as a measure of relative safety. In this study, accident rate is used as the criterion variable. Also called response variable.

data point. An n-dimensional point whose coordinates represent the criterion variable and the various independent variables. A new data point is produced for each year that a particular unit is studied.

injury rate. Injuries per million vehicles unless specifically noted.

left entering or exiting ramp. Ramp that exits or enters on the left side of the mainline roadway looking in the direction of the traffic flow. A left entering or exiting outer connection or loop almost always requires a left-turning movement. Abbreviation LEE.

loop ramp. A one-way turning roadway that curves about 270 deg to the right to accommodate a left-turning movement. It may include provision for a left turn at a terminal to accommodate another turning movement (AASHO). Also called loop.

maximum curvature. The greatest degree of curvature that is experienced by a driver negotiating a study unit, which in this paper, are loop and outer connection ramps.

noncollision accident. An accident in which a vehicle leaves the road but does not strike any object.

other collision accident. An accident in which a vehicle leaves the road and strikes an object without having hit another vehicle or object on the roadway.

outer connection ramp. A one-way turning roadway primarily for a right-turning movement. It may include provision for a left turn at a terminal to accommodate another turning movement (AASHO). In this study, diamond interchange ramps that satisfy this AASHO definition were not included in this category. Also called outer connection.

primary study groups. The following 4 study groups: urban right entering or exiting loops, urban right entering or exiting outer connections, rural right entering or exiting loops, and rural right entering or exiting outer connections.

right entering or exiting ramp. Ramp that exits or enters on the right side of the mainline roadway looking in the direction of the traffic flow. A right entering or exiting outer connection or loop nearly always requires a right-turing movement. Abbreviation REE.

rural. Any area not classified as a suburban area or an urban place, except an urban place with a population less than 5,000.

study groups. The 6 individual groups of data studied. The 2 ramp types, loop and outer connection, divided into urban or rural and right or left entering or exiting make 8 possible study groups, but, because left entering and exiting loops lacked sufficient data, the number was reduced to six.

urban. Urban places with populations equal to or greater than 5,000 and suburban areas surrounding urban places.