ENGINEERING BULLETIN

HIGHWAY
EXTENSION
AND
RESEARCH
PROJECT
FOR
INDIANA
COUNTIES

An Analysis of Traffic Accidents on County Roads

PURDUE UNIVERSITY—ENGINEERING EXPERIMENT STATION
in cooperation with
THE COUNTY COMMISSIONERS OF INDIANA

COUNTY HIGHWAY SERIES—No. 5

DECEMBER 1962

HIGHWAY EXTENSION AND RESEARCH PROJECT FOR INDIANA COUNTIES

The Highway Extension and Research Project for Indiana Counties (HERPIC) was organized at Purdue in 1959 to implement legislation by the Indiana General Assembly authorizing programs of extension and research for county highway departments throughout the state. The legislation by the General Assembly also designated Purdue University through its Engineering Experiment Station and School of Civil Engineering to develop and coordinate these programs.

The HERPIC program of extension and research provides for the preparation of manuals and bulletins setting forth recommended procedures and for regional workshop conferences with county road officials throughout the state to review typical road problems for their area. All of these activities are designed to assist and guide county highway officials in their problems of management, planning, design, and operation of county highway departments.

The HERPIC project operates as a cooperative effort between the county commissioners of Indiana and Purdue University. The program of extension and research is guided and approved by a 12-man advisory board, consisting of six county commissioners from over the state and six members from the staff of Purdue's School of Civil Engineering. The current membership of the HERPIC Advisory Board is listed below.

COUNTY HIGHWAY SERIES

an analysis of traffic accidents on county roads

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An Analysis of Traffic Accidents on County Roads

INTRODUCTION

In 1960, there were over 73 million motor vehicles in the United States. Approximately 12 million (17 per cent) of these were trucks and buses while the remaining 61 million (83 per cent) were passenger cars. Trucks traveled approximately 130 billion miles for that year and transported 38 per cent of the total tonnage of goods (1600 million tons), and passenger cars traveled approximately 590 billion miles (1, 2)*. This is a phenomenal growth in an industry and method of travel that did not exist 60 years ago.

With this great and increasing number of vehicles on the roads and streets today, the probability that they will hit each other or some other object or person becomes greater and greater. Sixty years ago, the accident problem was small. Today, there are slightly less than 40,000 deaths per year attributable to motor vehicles. In addition, there are many major and minor injuries plus an estimated cost to the United States economy of $6.4 billion (1960) for deaths, medical charges, time lost from work, property damage, and other related items (3).

In Indiana in recent years there have been approximately 100,000 accidents per year with greater than $50 damage. This figure has been about the same for the period 1952 to 1959 (4). During the same period, accidents on state highways have been decreasing while accidents on county roads have been increasing. Fig. 1 presents a graph of these trends for rural traffic accidents in Indiana for the period 1952-1959, and Table 1 shows the data from which these regression lines were determined.

The purpose of this research was to investigate the causes of and determine possible remedies for the rising number of county road accidents in Indiana. County road accidents were defined for the

* Numbers in parentheses refer to references listed in the bibliography.

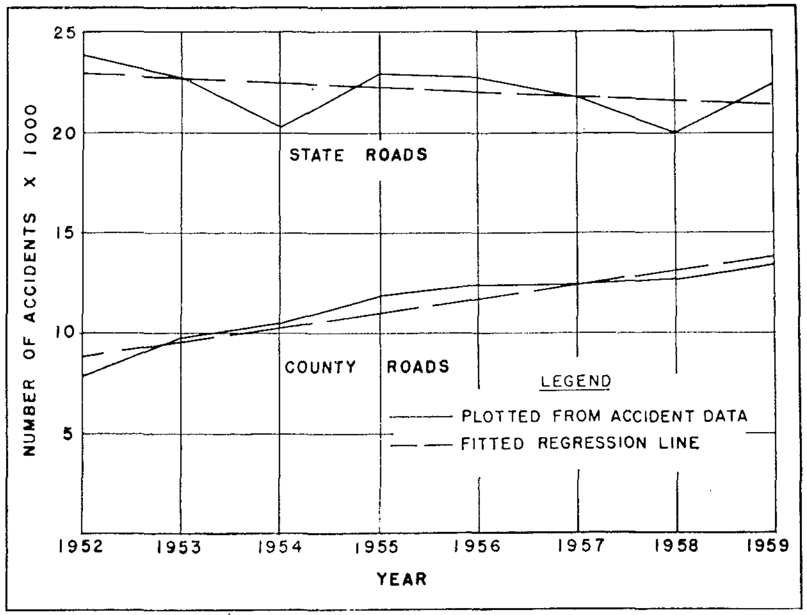

Fig. 1. State and county road accidents in Indiana, 1952-1959.

TABLE 1
SUMMARY OF RURAL HIGHWAY ACCIDENTS IN INDIANA

Year	County Roads No. of Accidents	Rural State Highways No. of Accidents	Total Rural Road Accidents	% County of Total Rural Accidents
1952	7857	23889	31746	24.2
1953	9794	22751	32545	30.1
1954	10436	20326	32177	32.5
1955	11851	23038	34889	34.0
1956	12322	22792	35114	35.2
1957	12339	21827	34166	36.2
1958	12634	20084	32718	38.7
1959	13330	22422	35752	37.3

purpose of this study as all traffic accidents occurring on roads which are administered by the County Commissioners in Indiana except accidents occurring at intersections of county roads with state highways. These latter accidents are normally charged to state highways.

The information used in this research was obtained from accident records. The best available source of this type of information, the accident reports which are filed at the Indiana State Police Headquarters in Indianapolis, was utilized.

State law requires that the driver of each vehicle involved in an accident file an accident report with the Indiana State Police for any accident which involves property damage of more than $50 or which involves an injury or death. The investigating officer, if there is one, also files an accident report. Therefore, most accidents of significance are recorded. Generally, the reports completed by police officers are quite complete while the reports filed by persons involved in an accident are often of questionable accuracy. The investigating officer has an opportunity to interrogate persons involved and to investigate the physical factors present; he does his best to prepare an accurate report.

The philosophy stated in the last paragraph is recognized by the Indiana State Police when coding the information for each accident so that it can be placed on punch cards which can then be summarized by machine methods. As a consequence, the punch cards contain the best information available about each accident. The accident report punch cards suited the purposes of this project very well and were the primary source of information for this study.

To determine which items of information would be most valuable, a thorough pilot study for one county was performed. For convenience, Tippecanoe County was used. In general, it was found that much of the recorded accident data did not supply information of value to this study. There were several items, however, which appeared significant and these were investigated in a general study for ten counties. These ten counties, except for Tippecanoe County, were chosen randomly by use of a table of random numbers, and are representative of all counties in the state. The ten counties selected are shown in Fig. 2 and were:

Adams	Madison
Brown	Steuben
Hendricks	Sullivan
Jefferson	Tippecanoe
Lawrence	Wayne

During 1958 and 1959 there were 2,650 accidents involving 3,953 vehicles in these ten counties, or approximately 10 per cent of the total number of accidents on county roads in the entire state. The accident factors which were determined from the pilot study to be worthy of possible profitable investigation were divided into roadway, traffic control, and miscellaneous factors.

Five roadway factors found that have an influence on the number of county road accidents were: (1) roadway defects, (2) surface char-

Fig. 2. Location of counties studied.

acteristics affecting skidding, (3) roadway curvature and speed, (4) vision obscurements, and (5) type of intersection. General recommendations, to minimize the number of accidents due to these five factors, are listed in the following sections of this bulletin.

Four traffic control factors were found which suggested that additional analysis was desirable:

a. Traffic controls utilized
b. Directional analysis
c. Driver violation
d. Speed

Three miscellaneous factors were found which indicated some possibility of providing interesting and valuable information related to accidents:

a. Weather conditions
b. Type of time (standard or daylight saving)
c. Accident severity and property damage

Each of these factors was investigated for the county road accidents which occurred in the ten-county sample and the results of the analysis, with recommendations, are reported in the following sections of this report.

ROADWAY FACTORS

Roadway Defects

For practical reasons, roadway surfaces were classified into two types—hard and granular. Included in the hard surface group were all surfaces which were not constructed of loose material, i.e., gravel, sand, or dirt. The important road defects are shown in Table 2. A total of 4.3 per cent of the hard surface road accidents occurred where loose surface material was present, perhaps gravel or dirt thrown unintentionally by vehicles from side roads and shoulders.

TABLE 2

PERCENTAGE OF ACCIDENTS CAUSED BY ROAD DEFECTS

Road Defects	Hard Surface	Granular Surface	All County Roads
Loose Surface Material, Gravel, etc.	4.3	25.2	11.3
Holes, Ruts, Bumps, etc.	2.0	7.9	4.0
Defective Shoulders	3.1	4.6	3.6
No Defects	90.6	62.3	81.1
	100.0	100.0	100.0
Percent of All County Road Accidents	66.6	33.4	

Holes, ruts, and bumps were found to be slightly more troublesome on granular surfaces in this sample. Defective shoulders caused about the same amount of trouble on both types of surfaces and occurred for 3.6 per cent of the total accidents.

No road defects, on the other hand, existed for 81.1 per cent of the total accidents. This is an indication that there are few defects on county roads that are blamed for traffic accidents by the persons involved in the accidents or that drivers compensate (by driving slower, with more care, etc.) for poor road conditions.

It is possible, however, that part of the 18.9 per cent which claimed a road defect could have been prevented by improved maintenance. Loose surface material on hard surfaces, holes, ruts, bumps, and defective shoulders do contribute to accidents on county roads. Their effect could be minimized by better elimination of these defects. Loose surface material, however, is inherent with granular surfaces, and little can be done about this claimed defect except the construction of a hard surface. This, however, may not be economically possible or desirable for much of the county road system. County road classification, based on traffic volumes and the development of a systems approach to county transportation, must be completed before it is decided which specific roads should be surfaced with other than granular surfaces. It is, therefore, recommended that all counties classify their county roads and plan for the early development of hard surfaces on the major county road systems. This action would undoubtedly result in fewer accidents.

Surface Characteristics Affecting Skidding

Skidding information was obtained for hard and granular surfaces. Table 3 shows the results of this tabulation for 1958 and 1959 data.

The information in the table is for both wet and dry conditions as the pilot study indicated that a separate analysis of these conditions would not be of value. The tabulation indicates that skidding is an

TABLE 3
ACCIDENTS INVOLVING SKIDDING

Type of Surface	Total	Skidded	Skidded
	N	N	%
Hard Surfaces	1753	350	20.0
Granular Surfaces	880	221	25.1

important factor in accidents on both types of surfaces and that the frequency of accidents involving skidding on hard or granular surfaces is similar. The information indicates that converting a granular surface to a hard surface will not result in a great reduction in the number of accidents involving skidding.

Roadway Curvature and Speed

The first statistical analysis completed was to compare the speeds of hard surface road accidents with granular surface road accidents (see Table 4). This analysis indicated that people do have accidents

TABLE 4
ACCIDENTS, ROADWAY CURVATURE AND SPEED

Roadway Curvature	Straight	Straight	Curved	Curved	All
Surface type	Hard	Granular	Hard	Granular	Conditions
Number of accidents	1049	512	407	248	2216
85th percentile speed, mph	43	39	46	36	42
Average speed $(\overline{X})$, mph	25.8	25.2	30.4	24.1	26.3

$\overline{X}_{hard} = 27.1$ MPH

$\overline{X}_{granular} = 24.8$ MPH

at higher speeds on hard surface roads than on granular surface roads, a result which was not unexpected.

A second analysis was then made to determine whether there was a significant difference between the speeds on curves and the speeds on tangent sections of roads of a particular surface type. The difference in the two mean speeds (on curved and tangent sections) on hard surface roads was 4.6 mph, and it was therefore, concluded that accidents happened at significantly higher speeds on curves than on tangent hard surface sections. The mean speed difference for the two geometric conditions on granular surface roads was only 1.2 mph, a value which indicates no significant difference in the speeds just prior to accidents on curves and tangent sections of granular surfaces.

The reported accidents on curves of hard surface roads occurred at higher speeds than on tangent sections of these same roads. This indicates that in many cases motorists were traveling at speeds too high to safely traverse the curves on hard surface roads, possibly because they had too little warning of the curve or that they were traveling, as many drivers, on a "40 mph surface with a 20 mph geometry." There are three possible solutions to this problem: 1) the speeds might be reduced, 2) the geometric design of the road could be improved, or 3) the road should not be constructed with a hard surface. Speeds, as others have shown (6), are difficult if not impossible to reduce, especially for all but the most careful driver. The only alternatives which exist, therefore, are to improve the surface *and* the road geometry or to leave the road surface a granular one. It is, therefore, recommended that whenever a surface improvement is warranted, the geometric design of curves and other features *must* be changed so as to safely permit the higher speeds that will occur.

On granular surface roads, as there was no significant difference in accident speeds for curves and tangent sections, drivers apparently expect sharper curves and more defects and therefore make appropriate corrections in their driving speed.

Vision Obscurements

It has long been a belief of many people that county roads suffer from poor sight distance because of vision obscurements at intersections. This part of the study, therefore, was undertaken to determine the effects of vision obscurements on traffic accidents.

Some drivers may compensate for poor driving conditions, such as poor vision, but adjusting to such conditions is at least an irritant factor. Others do not adjust their driving to poor sight conditions, but move ahead blindly and rapidly. The seriousness of vision obscurement as an accident problem should be indicated by the percentage of drivers claiming a vision obscurement as one of the causes of their accidents.

Table 5 lists the vision obscurements by quantity and percentage of the total as determined in this study. Of the 2,650 accidents, there were only 256 accidents in which the driver or the investigating officer claimed a vision obscurement. Only 14 (0.5 per cent) of such accidents involved vision obscurements due to the highway or adjacent property. The remainder were vehicle related obscurements, such as fogged windshield, snow, etc.

It was concluded from these findings that vision obscurement at county road intersections due to roadside factors is not a major problem, and that any problem of vision obscurement is related to the vehicle.

Type of Intersection

It was found in the pilot study that three-way intersections were approximately twice as safe as four-way intersections. This study was then expanded to discover whether this was true for the ten counties

TABLE 5
ACCIDENT AND VISION OBSCUREMENTS

	Number of Accidents	Percent of Total
Vision Obscured	256	9.8
Trees, crops, etc.	9	.3
Sign boards	2	.1
Hillcrest	3	.1
Vehicle obscurements	242	9.3
Vision Not Obscured	2344	90.2
Total	2600	100.0

in the study. The number of the various types of intersections was obtained by counting them on official county road maps.

As shown in Table 6, three-way intersections ("T" and "Y" inter-

TABLE 6
ACCIDENTS AT INTERSECTIONS

Type of Intersection	Percentage of Accidents	Percentage of Intersections	Safety Ratio Acc./Inter.
"T" Intersections	35.7	64.4	.057
"Y" Intersections	2.0	6.6	.031
Total — "T" and "Y"	37.7	71.0	.055
4-Way Intersections	62.3	29.0	.220
Total	100.0	100.0	——

sections) are approximately four times safer than 4-way intersections, assuming that similar volumes of traffic used the three and four-way intersections which were analyzed. Even though this may not be exactly true, it is true that volume differences can not account for the total difference in accidents.

One of the reasons for less accidents at three-way intersections is the well-known fact that there are only three conflict points at three-way intersections, and 16 conflict points at four-way intersections (7). This is graphically shown in Fig. 3. A second reason could be that drivers are better informed of the intersection at three-way than at

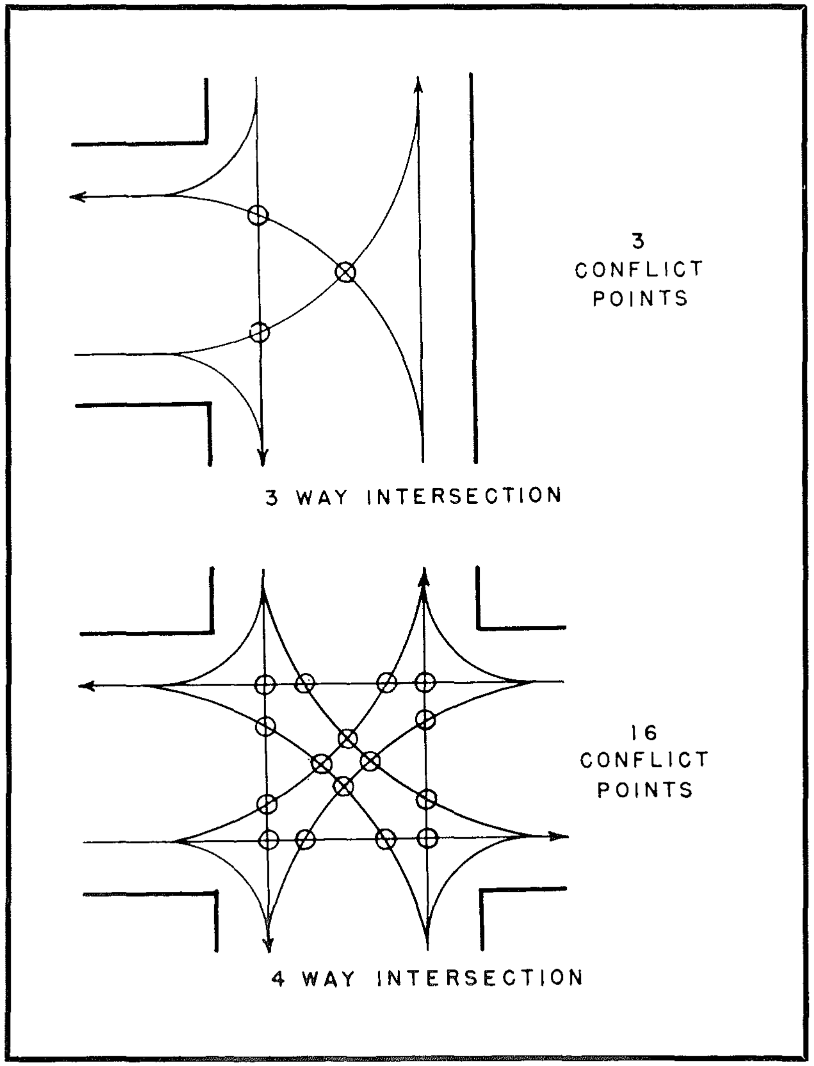

Fig. 3. Comparison of conflict points at three-legged and four-legged intersections.

four-way intersections. In most cases the driver approaching a three-way intersection on the non-through leg is warned of the intersection by directional arrows or other signing or by advertising signs. This information permits these drivers to take the necessary care when passing through the intersection. Drivers approaching four-way county road intersections, on the other hand, are seldom provided information relative to the location of the intersection; few such intersections are signed or utilize adequate traffic controls.

These results indicate that better traffic control at four-way intersections might improve the relatively poor accident experience at these intersections. Better control of traffic on one of the opposing crossroads by stop or yield signs, if the traffic volume is sufficient to warrant such signs, is recommended. All traffic control signs and signing practice, of course, should be in accord with the provisions of the current *Indiana Manual on Uniform Traffic Control Devices for Streets and Highways* and state and local laws (8).

The fact that three-way intersections are safer than four-way intersections should also be given serious consideration when road layouts in new county subdivisions are approved and in redesigning local, low-volume county roads.

TRAFFIC CONTROL FACTORS

Type of Accident

Table 7 summarizes the accident data by important traffic controls. The tabulation clearly shows that traffic controls were not appreciably

TABLE 7
ACCIDENTS AND TRAFFIC CONTROL

Type of Traffic Control Use	Accidents	Occurring
	N	%
Traffic Signal	19	.7
Stop Sign	158	5.9
Warning Sign	158	5.9
Center Line	55	2.1
No Traffic Control	2233	85.4
	2623	100.0

utilized at locations where county road accidents occurred in 1958 and 1959. The 85.4 per cent of "no control" for all county road accidents is an extremely high percentage. As a comparison, no traffic control existed at only 41.9 per cent of all traffic accidents in Indiana, including those on county roads, and at only 25.7 per cent of the total intersection accidents in Indiana in 1958. These data may indicate that traffic control is not utilized on county roads as much as is desirable.

Table 8 compares the county road accident data for the ten counties for 1958-1959 with similar data for all reported accidents on

TABLE 8
ACCIDENTS BY TYPE

Two Vehicle Accidents			One Vehicle Accidents		
Type of Accident	Counties %	Ind. %	Type of Accident	Counties %	Ind. %
Angle Collision	22.9	23.3	Left Road (Straight Road)	48.9	42.6
Rear End Collision	4.6	19.8	Left Road (at curve)	30.0	18.8
Sideswipe	34.1	18.7	Other Collision types	10.1	12.5
Hit Parked Car	6.1	13.3	Struck Pedestrian	1.3	12.4
Turning	7.4	9.8	Left Road at Intersection	7.6	7.9
Driveway	14.4	6.8	Non Collision	2.1	5.8
Others	10.5	8.3			
TOTAL	100.0	100.0	TOTAL	100.0	100.0

all highways for the entire state. The information of this table indicated a similarity of accident type on county roads and on all roads and streets in Indiana except for rear-end collisions, sideswipe accidents, collisions with a parked car, and driveway accidents for two vehicles, and left road at a curve and pedestrian accidents for single vehicles. For three of these accident types—rear-end collision, collision with a parked car, and pedestrian accidents—the higher rate is on other than county roads. This is not unexpected because of the low volumes of traffic, the small number of parked cars, and the few pedestrians on county roads.

Three accident types, however, occurred at a higher rate on county roads than on all highways and streets in Indiana. These constituted 48.5 per cent of all two-vehicle accidents and 30.0 per cent of all one-vehicle accidents on county roads—percentages which if reduced to those for all accidents would be a reduction for two-vehicle accidents of 21.9 per cent and for one-vehicle accidents of 11.2 per cent.

Sideswipe collisions, with the involved vehicles meeting head on or going the same direction, was the most frequent type of two-vehicle accident on county roads. This type of accident constituted 34.1 per cent of all county road two-vehicle accidents, but only 18.7 per cent of all Indiana two-vehicle accidents. There are many possible conditions

that could cause this, but narrow pavement and shoulders and the almost complete absence of centerlines on even hard surfaced roads are the most probable causes.

Accidents occurring at driveways were also much greater (percentages) for county roads. There are two possible causes for driveway accidents: driver inattentiveness and poor visibility conditions. However, it was found, as previously mentioned, that there is virtually no visibility cause for accidents except for vehicle obscurements. This is an indication that the careless driver exiting or entering a driveway is often a cause for these accidents, since the other vehicle on the road has the right-of-way and/or good visibility.

The third type of accident which occurs more often on county roads than data for the state indicate that it should is where one vehicle leaves the road on a curve. As previously discussed, a large number of single vehicle accidents occur on hard surface county roads at curves because of speed at these locations. Experience indicates that centerlines, edge lines, curve, and other warning signing on roads at curves are helpful in reducing accidents at these locations, since they give the driver a forewarning of the curve and guidance around the curve.

Driver Violations

Several driver violations occurred in sufficient volume to warrant an analysis. Table 9 shows these data tabulated in a two-way frequency with Traffic Control Present. Again, there is a preponderance

TABLE 9
ACCIDENTS AND TRAFFIC VIOLATIONS

Traffic Violation	Traffic Control Present	No Traffic Control Present	Total
Did not give right-of-way	75	242	317
Followed too closely	39	125	164
Other improper driving	74	246	320
Driving to left of center	63	614	677
Improper passing	17	111	128
Exceeded legal or safe speed	44	179	223
Made improper turn	22	84	106
Disregarded traffic signal	10	—	10
Disregarded stop sign	36	—	36
TOTAL	380	1601	1981

of "No Control Present" for most classes of violation. For each of these, there is no proof that controls would reduce the number of accidents. However, it is recognized that traffic controls do reduce accidents when used appropriately (7).

It is probable, moreover, that the presence of centerlines on the hard surface roads where some of the driving left of center violations occurred would have reduced the violations and the accidents. It is also highly probable that yield or stop signs at the locations where a right-of-way violation occurred would have reduced the violations and the accidents if the volume on the major road warranted such signing. It is also possible that better speed control on county roads would have reduced the accidents on these roads.

One type of violation—disregarded traffic signal or sign—shows that considerable violation of the little traffic control signing which occurs on county roads already occurs. This, however, is not a condemnation of good traffic control practices but maybe a result of the non-standard, poorly planned, inadequately maintained, and inadequate signs and signals which do exist.

Table 10 compares the percentage data of driver violations for accidents on county roads in the ten counties and in "all reported accidents" in the state. Three driver violations do not occur in similar percentages in the two cases. These violations are "did not give right-of-way," "followed too closely," and "driving to left of center."

TABLE 10
ACCIDENTS AND TRAFFIC VIOLATIONS

Traffic Violations	Percent	
	County Roads	All Indiana
Did not give right-of-way	16.0	23.3
Followed too closely	8.3	18.0
Other improper driving	16.1	12.5
Driving to left of center	34.1	10.8
Improper passing	6.5	9.7
Exceeded legal or safe speed	11.3	7.5
Made improper turn	5.4	6.6
Disregarded traffic signal	.5	4.6
Disregarded stop sign	1.8	3.5
Other	0.0	3.5
TOTAL	100.0	100.0

The first of these, "did not give right-of-way," occurs less frequently on county roads than for the state as a whole. As mentioned previously, traffic volumes on county roads are usually low while high volumes occur on most city streets and other rural roads (9). It is therefore logical that there are fewer violations of this type as there is less opportunity for them to occur.

The violation, "followed too closely," is also less on county roads because there are lower volumes of traffic on county roads than other roads and streets, and also less opportunity for this driver error to happen.

The third factor, "driving to left of center," is much higher for county roads than for "all reported accidents" in the state. These violation data further support the conclusion mentioned previously, that lack of centerlines definitely causes drivers to "crowd" the center of the road and/or that narrow roads and shoulders cause drivers to drive nearer the center of the road than when the roadway is wider.

Speed

Speed is often associated with accidents and is recognized as a contributing factor to accident severity. The accident reports included information relative to the speeds at which the drivers of vehicles involved in accidents were traveling just prior to involvement. Fig. 4 is a cumulative frequency curve of the reported speeds for all the county road accidents of 1958 and 1959 in the ten counties.

One half of the accidents occurred at reported speeds below 22.5 mph and 90 per cent of the accidents at speeds less than 45 mph. Approximately 10 per cent of the accidents occurred above a reported speed or 45 mph and only 1 per cent above 60 mph.

A 45 mph speed limit has been urged for all county roads except specific road sections otherwise speed zoned by county authorities. The speeds reported on the accidents analyzed in this study indicate that such a speed limit is realistic to drivers as 85 per cent of them reported a speed of 42 mph or less. The 85th percentile speed at which drivers travel on a road is often recognized as the proper speed limit for that location unless reasons which the driver cannot see warrant a lower speed limit.

MISCELLANEOUS FACTORS

Weather

Weather data were obtained from the U. S. Weather Bureau Monthly Reports for all weather stations in the Indiana area. With the aid of the State Climatologist, these data were interpolated station

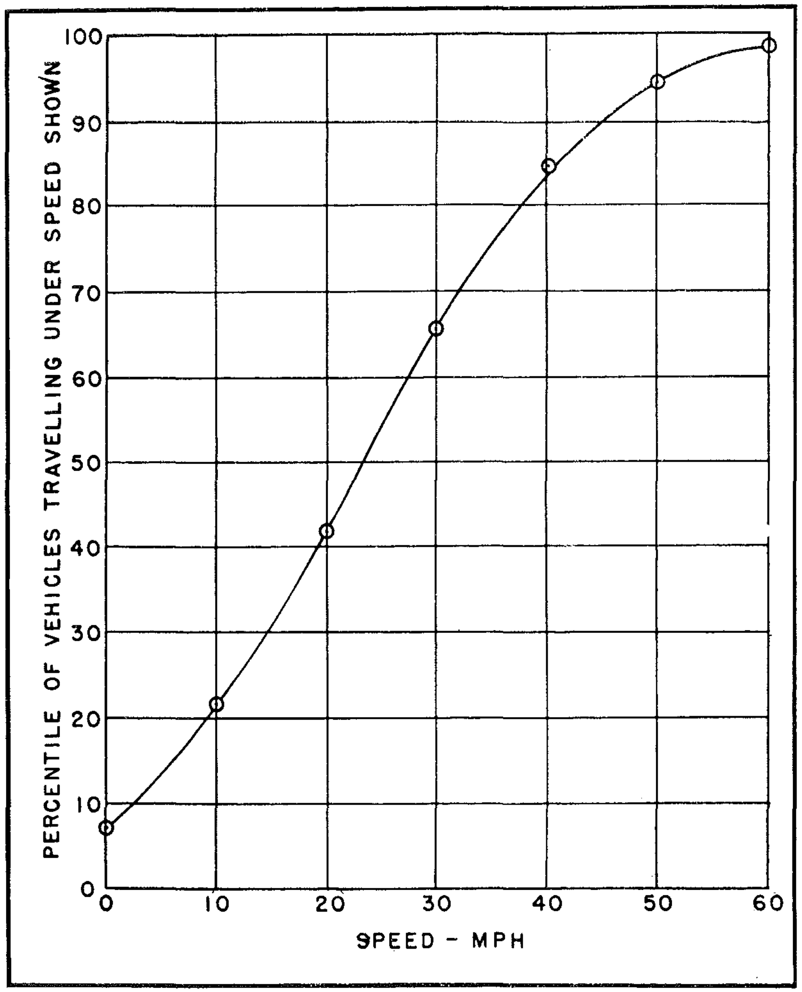

Fig. 4. Cumulative curve of stated pre-accident speeds by drivers involved in county road accidents.

by station to give the approximate number of hours of each type of weather for 1958 and 1959 for each of the ten counties studied. For each county, the percentage of the total number of accidents that happened in a given type of weather was divided by the percentage of the total number of hours of that type of weather. This factor is called Percent A/H Ratio and the results of this analysis are shown in Table 11.

A standard statistical test was used to determine the significance of the different A/H ratios. It was found that on county roads inclement weather had no detrimental effects on the frequency of acci-

TABLE 11
ACCIDENTS AND WEATHER

Weather	Accidents, %	Hours of Weather, %	Percent A/H Ratio
Clear and Cloudy	82.6	75.5	1.12
Rain	11.4	9.3	1.11
Snow and Sleet	3.9	4.8	.73
Fog	2.1	10.4	.20
Total	100.0	100.0	1.00

dents. More specifically, fog and snow and sleet conditions resulted in fewer accidents, while rain had no significant effect on accident frequency. The results are contradictory to the beliefs held by many persons. However, one explanation could be that people drive fewer miles during an hour of fog or snow and sleet than they do in one hour of good weather. In the case of fog, it usually occurs in the early hours or morning when the traffic volumes are low; drivers may voluntarily reduce their driving when snow and sleet exist. Drivers may also compensate for the hazardous conditions and thereby travel with greater care during bad weather conditions.

The information obtained from this analysis indicates that county road safety programs to be of the greatest value should be directed toward reducing accidents during good weather conditions rather than during bad weather.

Time

Daylight saving time, or eastern standard time, has been a controversial subject in Indiana for several years. Reduction of accidents is one of the many factors which might occur because of a time change and which has been utilized by the proponents of daylight saving time.

Some of the counties which were used in this study operated on central standard time for at least a portion of the year while others operated on daylight saving time for the full year. It is also generally believed that any advantage for daylight saving time relative to accidents would occur in the winter months when dusk and darkness occur during the evening peak period of travel. These two conditions, therefore, indicated that an analysis of accidents by hour during the five month period, November through March, for the counties in each of the two time groups might show some improved accident condition for one of the two time types.

The accidents for these five months were tabulated with the two time zones and the 24 hours of the day as the two variables of classification. The results are illustrated in Fig. 5.

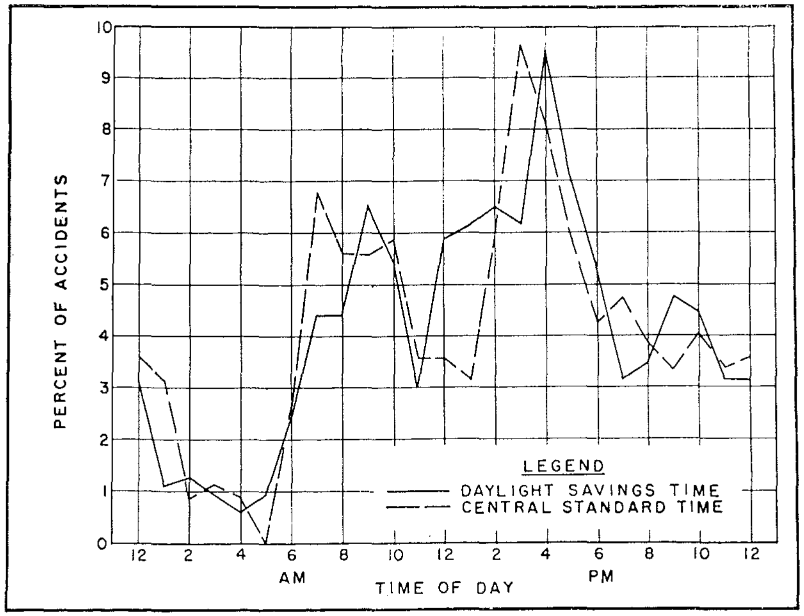

Fig. 5. Distribution of accidents by time of day and type of time.

The statistical analysis of the data indicated that, for the counties in this study, type of time had a significant effect on the distribution of accidents over the entire day. It also had an effect on distribution during the periods of the day when both light and traffic conditions were most variable, but no difference as to the total number of accidents was noted. The effect on accident distribution over the entire day may be due to different traffic volume patterns throughout the day because of the type of time and/or other factors. The significant effect on accident distribution during the variable light hours of the day may also be due to different traffic volume patterns during these hours. This study, moreover, indicated that no reduction of total accidents could be anticipated because of a change from Standard to Daylight Saving time.

Accident Severity

There are three classifications of accidents according to severity. They are fatal, non-fatal, and property damage. Property damage, of course, occurs in almost every accident but an accident is not classed as a property damage accident if a fatality or an injury occurs. Table 12

was prepared from the annual Indiana State Police Accident Summary Sheets and shows the number of fatal accidents per each 100 accidents for accidents on county roads and on rural state highways.

TABLE 12
ACCIDENT SEVERITY

	County Roads	Rural State Roads
Year	Fatal Acc./ 100 Acc.	Fatal Acc./ 100 Acc.
1952	1.92	2.63
1953	1.75	2.61
1954	1.64	2.44
1955	1.34	2.40
1956	1.41	2.49
1957	1.58	2.49
1958	1.39	2.39
1959	1.24	2.28
Total	1.50	2.47

The number of fatal accidents per 100 accidents on county roads was tested statistically to determine if there was any significant difference, at a significance level of .05, between it and the number found for state and rural roads. It was found that there have been significantly fewer fatal accidents per 100 accidents on county roads than on state rural roads during the past eight years.

It is generally recognized that the severity of an accident is relative to the speed of the vehicles involved. As the accident information included data on the speed of the vehicles involved, as reported by those involved in the accident or investigation, an analysis was made of the relationship between the reported speed and the severity of the accident. It was found that the average reported pre-accident speed for fatal accidents was 35.3 miles per hour, non-fatal injury accidents 27.9 miles per hour, and property damage only accidents 23.0 miles per hour. It was found that all three average speeds were significantly different.

The cost to the United States for vehicle accidents has been estimated at $6.4 billion for 1960. This study also included a determination of the cost of accidents on county roads in Indiana.

In the ten counties studied, there were 2,650 accidents with an estimated total reported property damage of $1,063,446. This is an average property damage per reported accident of $401.20 or approximately $400. If the $400 is multiplied by the total number of accidents per year on county roads in Indiana the total property damage per year is estimated. It has been estimated by the National Safety Council that each fatality is a cost to the national economy of $30,000 in wages lost and other items and that a corresponding figure for each non-fatal injury is $1,600 (10).

The total costs, using this method of calculation for Indiana and shown in Table 13, rose steadily from 1952 to 1957 but slightly decreased in 1958 and 1959. This, however, cannot, be taken as a trend

TABLE 13

COUNTY ROAD ACCIDENT COSTS

Year	No. of Accidents	Accident Costs
1952	7857	$13,500,000
1953	9794	14,900,000
1954	10436	16,500,000
1955	11851	17,600,000
1956	12322	18,600,000
1957	12339	19,900,000
1958	12634	18,800,000
1959	13330	18,300,000

because of the short time involved. The $18 million, of accident costs on county roads for 1959 is a tremendous economic burden for Indiana to carry and is 38 per cent of the total funds expended by county highway authorities on county roads in Indiana in 1959.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations relative to county road accidents in Indiana were made from the findings of this study:

1. Road defects are not a major cause of county road accidents. A slight improvement in county road accident statistics is possible, however, with improved maintenance of shoulders and the elimination of holes, ruts, and bumps.
2. Little improvement in the county road accident problem results from converting a granular surface road to a hard surface one. Accidents, in fact, will most likely increase if the road geometry is not improved at the same time as the conversion to a hard surface is performed. It is recommended whenever a surface improvement is warranted, based upon road classification and a systems approach to county highway transportation, that the geometric design of curves and other features must be changed so as to permit safely the higher speeds which will result.

3. There is no important highway-related, vision-obscurement problem which is not adequately compensated for by the drivers on Indiana county roads. There is a minor problem, however, of vision obscurement related to the vehicle, such as fogged windows, snow, etc.
4. Three-way intersections were found to be much safer than four-way intersections. It is recommended that this finding be used, whenever possible, in designing *local* streets in subdivisions and in redesigning *local* county roads.
5. Better traffic control at four-way intersections, where conditions warrant, is indicated. It is recommended that stop, yield, cross-road warning, or other traffic control devices be erected at all four-way intersections where the warrants as provided in the *Indiana Manual on Uniform Traffic Control Devices for Streets and Highways* are met. All such devices should be in accord with the requirements of this manual and other state and local laws.
6. A major cause of accidents on county roads in Indiana is the narrow roadway and/or shoulders and the absence of centerlines. It is recommended that county highway programs of roadway and shoulder widening for major county roads be developed and aggressively pursued and that centerlines be placed on all arterial hard surface roads.
7. Vehicles involved in accidents have an 85th percentile reported speed of approximately 42 miles per hour. It is recommended that a speed limit of 45 miles per hour for all county roads except sections specifically speed zoned for higher or lower speeds by county authorities be established.
8. The time distribution of accidents occurring in counties using Daylight Saving Time is significantly different from that in counties using Central Standard Time. No reduction or increase in total accidents which may be associated with the type of time was noted.
9. The average property damage resulting from each county road accident was $400 and the total cost of all county road accidents in the state was $18 million in 1959. This is a tremendous burden for the state.
10. The analysis of the data for this project emphasized the well-known fact that the driver is responsible for a major share of county-

road accidents. It is recommended that more attention be given in county safety programs to the driver and that he be continually informed and educated concerning accident causing conditions and the personal economic impact of having an accident.

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