account of the better facilities offered by the improvements, the motor vehicle operator chooses to operate at a much higher speed than he did on the old surfaces, then his vehicle operating cost may be so much increased on account of his greater speed that no saving in vehicle cost results from the improvement In this case the vehicle operator has elected to transpose the saving in vehicle costs into saving of time, the value of which is intangible, but may be considerable

THE EFFECT OF PAVEMENT WIDTHS UPON ACCIDENTS

By Roger L Morrison

Professor of Highway Engineering and Highway Transport, University of Michigan

SYNOPSIS

Studies were made of traffic accidents occurring upon 20-ft , 18-ft and 15-ft pavements in Washtenow County, Michigan, during 1931

The conclusions reached, which may or may not be of more general application, are as follows

1 There are more accidents of all kinds on 15 and 18 foot pavements than on 20 foot pavements carrying similar traffic

2 The greatest percentage of increase is in "side-swipe" accidents No buses were involved in this type of accident

3 The increase in number of non-truck accidents is much greater than the increase in truck accidents

From these items it appears that wider pavements are needed more because of passenger automobile accidents than because of truck and bus accidents

It has been stated that the standard width of 20 feet for two-lane pavements is needed only because they are used by large trucks and buses, and that a width of 18 feet, or less, would be sufficient for passenger automobiles. This conclusion is based upon vehicle widths and clearances and a study of the actual positions occupied by vehicles upon pavement of various widths

Since the largest vehicles permitted by law, in most states, are eight feet wide, it is obvious that, if they are driven carefully, all classes of vehicles can pass each other upon an 18-foot pavement, and the only reason for a 20-foot pavement is added safety. Also it seems obvious that the only true measure of safety is to be found in accident records, but this has apparently not been considered in the various discussions which have been published. Perhaps the reason is that accident records of pavements of various widths are not readily available.

In 1932 a study was made of the motor vehicle accidents which occurred in Washtenaw County, Michigan during 1931 [1] While the effect of pavement widths was not particularly considered at the time,

[1] "An Investigation of Motor Vehicle Accidents in Washtenaw County, Michigan, for the year 1931" by W Sherman Smith, Graduate Student, University of Michigan. Assistant Professor of Civil Engineering, University of Toledo

the report includes data which throw considerable light upon that subject The main object of the present investigation was to find evidence bearing upon the desirability of building 20-foot pavements for passenger automobiles

There are four roads in the county carrying daily traffic of from 2600 to 3600 vehicles each, three of them being 20 feet wide and the other 18 feet Also there are two roads with a daily traffic of 1700 to 2100 vehicles One of these is 20 feet wide and the other averages about 15 feet wide

The 20-foot pavements in the first group are U S 23—M 17 between Ann Arbor and Ypsilanti, 5 miles long between city limits, U S 12 east of Ann Arbor, approximately 10 miles long to the county line, and U S 112 west of Ypsilanti, 19 miles long from there to the county line The

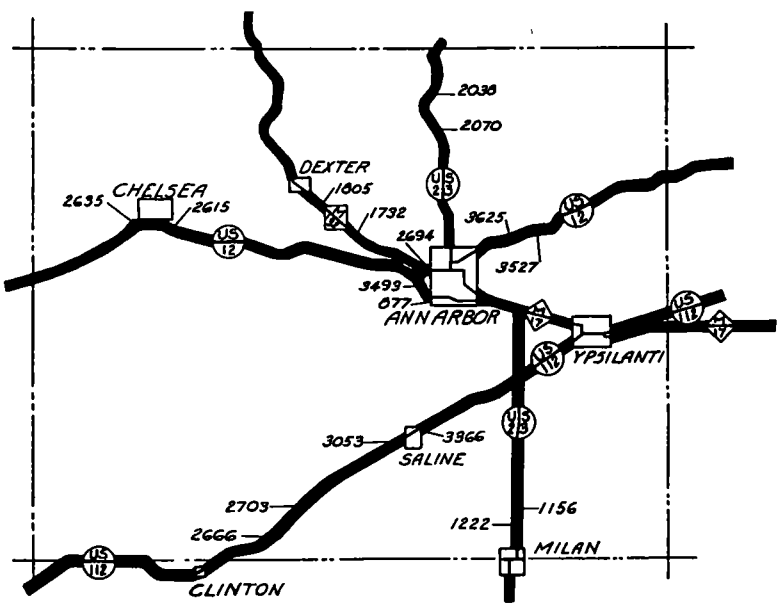

Figure 1

18-ft pavement is U S 12 west of Ann Arbor, about 19 miles long to the county line The relative locations of these roads are shown in Figure 1

FIRST COMPARISON

The first comparison will be between the 5-mile U S 23—M 17 and the first five miles of U S 12 west of Ann Arbor These two roads are similar as to vertical and horizontal alignment The 20-ft pavement, which has been widened to 30 feet since this investigation was made, is concrete and the 18-ft pavement is asphalt The traffic volume on the former is 3500 vehicles per day and on the latter it appears to be about the same at the Ann Arbor city limits, decreasing to 2600 vehicles 13 miles from the city.

There were 19 accidents reported on U S 23—M 17 between Ann Arbor and Ypsilanti In one of these a car was hit by a train, three were pedestrian accidents, one was at an intersection, and two were cases of vehicles (one a truck with trailer) skidding into the ditch, no other vehicle being involved in either case None of these seven accidents appeared to have been affected by the pavement width, thus leaving only 12 for further consideration The causes of these accidents, and similar ones on other pavements, are shown in Table II

There were 23 accidents reported on the 18-ft U S 12 pavement within five miles of the Ann Arbor city limits One was caused by a loose horse, four were due to left turns at intersections and one was caused by attempting a right turn too fast These apparently were not affected by pavement width, leaving 17 accidents for further consideration

SECOND COMPARISON

A second comparison may be made between the 20-ft U S 12 east of Ann Arbor, about 10 miles to the county line, and the first 10 miles of the 18-ft U S 12 west of Ann Arbor The former, known as the Plymouth Road, passes over a number of hills and is considered especially dangerous The daily traffic on this road averages 3600 vehicles at the Ann Arbor city limits and probably does not decrease any as it approaches Plymouth, on the way to Detroit

There were 22 accidents reported on this road One was a pedestrian accident, one was caused by loose horses, one involved a truck making a left turn, in one case a truck hit a car pulling onto the pavement, three automobiles and one truck ran off the road, in one a Ford truck was parked on the pavement without lights, one car was found in the ditch with a dead man and an injured man inside, the cause of the accident being unknown, and in one case no description was given Eliminating these eleven accidents leaves eleven in which pavement width was probably a factor

To compare an equal length of 18-ft pavement with the Plymouth Road the accidents on the second 5-mile section were investigated and it was found that the number reported was 16 Two trucks and two automobiles ran off the road, due in some cases to the driver being asleep One bus ran off the road and struck a guard rail, this being the only bus accident of any kind recorded on any of the roads In one case a speeding car hit the rear end of a truck going in the same direction, and in two cases, one involving a fatality, no description is given This leaves eight accidents probably affected by pavement width

THIRD COMPARISON

A third comparison can be made between the 20-ft U S 112 (Detroit-Chicago Road) between Ypsilanti and the county line, about 19 miles, and an equal length of the 18-ft U S 12 west of Ann Arbor The ter-

raine through which these two roads pass is similar and the traffic volume is about the same

Twenty-nine accidents were reported on U. S 112 from Ypsilanti west to the county line. There were two or three more the locations of which were uncertain but the indications were that they were on U. S. 112 east of Ypsilanti Two of the 29 accidents involved pedestrians, three were at intersections, two were due to left turns, one was a rear-end collision, six ran off the road, one hit a wagon with no lights, two skidded and rolled over on wet or icy pavement, and in one case the cause was not given. This leaves only eleven accidents in which pavement width appeared to be a factor

Ten accidents were reported on the last nine miles of U S 12 between Ann Arbor and the county line west Two of these involved pedestrians and in a third a tire blew out and the car went in the ditch The other seven cases were probably affected by pavement width

FOURTH COMPARISON

A fourth comparison may be made between a narrow road, M 132, from Ann Arbor to Dexter, seven miles long, and the first seven miles of U S 23 running north from Ann Arbor. The latter is a 20-ft concrete pavement and the former is gravel with a bituminous surface varying from 14 to 16 feet in width. These roads are not more than seven miles apart at any point in the sections under consideration and both lead to lake resorts, though U S 23 is also a trunk line to the northern part of the state. The average daily traffic on M 132 is 1800 vehicles near Dexter and 1700 about half way to Ann Arbor It probably is a little heavier near Ann Arbor but traffic counts at that point are not available. The average traffic on U. S. 23 is 2000 vehicles at the end of the 7-mile section and 2100 a couple of miles nearer Ann Arbor. It is probably much greater near Ann Arbor as the first two miles passes through a suburban residence district. U. S 23 was paved about seven years ago while M 132 has never had much improvement except for the surface treatment

ACCIDENTS ON U S. 23 NORTH

Five accidents were reported on the first seven miles of U S. 23 north of Ann Arbor. One was at an intersection and another appears to have been at an intersection also, though details are lacking In a third case the steering knuckle failed on a speeding car causing it to roll over on the pavement. This leaves two accidents, both involving passenger cars only, which might be affected by pavement width In one case a car was on the wrong side of the road and the other case was a "side-swipe" in passing the car ahead.

ACCIDENTS ON M 132—DEXTER ROAD

The accident situation on the Dexter Road was rather surprising. It has been termed "ideal for accidents" and nine accidents were re-

ported, but five of them were at intersections and two cars skidded and ran off the road Of the two remaining accidents, one was a collision, with no details given, and the other occurred when a car ran into the ditch to avoid a head-on collision in passing a car ahead

The comparison of accidents on these two roads is readily apparent from this brief description The traffic volume and nature, and the characteristics of the roads are different from the others under discussion, therefore they will be eliminated from further consideration

ACCIDENTS NOT AFFECTED BY PAVEMENT WIDTH

Table I shows the distribution between the 20-foot and the 18-foot pavements of the accidents which are believed not to have been materially affected by pavement width

TABLE I

ACCIDENTS NOT AFFECTED BY PAVEMENT WIDTH

Type of Accident	Pavement Width		Total
	20-ft	18-ft	
Ran off road—some drivers asleep	12	5	17
Pedestrian accidents	6	2	8
Left turns at intersections	3	4	7
Other intersection accidents	4	0	4
Rear end collisions	2	1	3
Skidded on wet or icy pavement	2	0	2
Hit loose horses	1	1	2
Made right turn too fast	0	1	1
Hit car coming onto pavement from shoulder	1	0	1
Hit a wagon with no lights	1	0	1
Hit by a train	1	0	1
Tire blew out	0	1	1
Cause unknown	3	2	5
Total	36	17	53

The 36 accidents occurred on 34 miles of 20-foot pavement, giving an average rate of 0 94 accidents per mile, while the 17 accidents occurred on 19 miles of 18-foot pavement giving an average rate of 0 90 accidents per mile This close check is further evidence that these accidents were not materially affected by pavement width If the three overlapping sections (the first 5 miles, the first 10 miles, and the whole 19 miles) of U. S 12, are considered as three separate roads then the figures become 36 accidents on 34 miles of 20-foot pavement and 37 accidents on 34 miles of 18-foot pavements.

ACCIDENTS AFFECTED BY PAVEMENT WIDTH

Table II gives the types and locations of the accidents in which the pavement width appeared to be a factor.

TABLE II

ACCIDENTS AFFECTED BY PAVEMENT WIDTH

Type of Accident	20-Ft Pavement				18-Ft Pavement			
	US 23-M 17	US 12 East	US 112	Total	1st 5 mi US 12 W	2nd 5 mi US 12 W	Last 9 mi US 12 W	Total
Side-swiped in passing	1	1	1	3	6	3	2	11
On wrong side of road, passing car ahead or otherwise	2	4	6	12	3	3	4	10
Collision—details lacking	3	2	2	7	2			2
Skidded into another car	1	2		3	2	1		3
Vehicle parked partly on pavement	2	1		3	1	1		2
Car ahead stopped or swerved forcing following car to turn out and hit third car	2			2	2		1	3
Ran off pavement to avoid collision	1	1	1	3				
Struck bridge			1	1	1			1
Totals	12	11	11	34	17	8	7	32
Accidents per mile of pavement				1 0				1 7
Increase 18-ft over 20-ft rate								70%

Table III is a summary of Table II with the three overlapping sections of U S 12 considered as three separate roads totaling 34 miles in length, the same as the 20-foot roads

TABLE III

ACCIDENTS AFFECTED BY PAVEMENT WIDTH ON BASIS OF 34 MILES OF 18-FOOT PAVEMENT

Type of Accident	20 Ft Pavement	18-Ft Pavement
Side-swiped in passing	3	26
On wrong side of road, usually in passing car ahead	12	19
Collisions, details lacking	7	6
Skidded into another car	3	8
Vehicle parked partly on pavement	3	5
Car ahead stopped or swerved	2	7
Ran off pavement to avoid collision	3	0
Struck bridge	1	3
Total	34	74
Accidents per mile of pavement	1 0	2 2
Increase 18-ft over 20-ft rate		120%

The method used in Table III, while fictitious in that the accidents in the first 5 miles of the 18-foot pavement are counted three times, and

those in the second 5 miles twice, is believed to constitute a more accurate comparison than that used in Table II This is because the traffic conditions on the 18- and 20-foot pavements are by no means comparable unless the three overlapping sections of U S 12 are considered as three roads

It is evident that there are many more accidents on the 18-foot road than on the 20-foot roads, with comparable traffic, and the next question is whether the accidents are caused mainly by trucks or by passenger automobiles As previously stated, there were no buses involved in any of these accidents although all the roads considered carry bus lines Table IV shows the truck accidents separately

TABLE IV

TRUCK AND AUTOMOBILE ACCIDENTS AFFECTED BY PAVEMENT WIDTH

Type of Accident	Pavement Width			
	20-Ft		18-Ft	
	Trucks	Autos	Trucks	Autos
Side-swiped in passing	0	3	3	23
On wrong side of road	4	8	6	13
Collision, details lacking	0	7	3	3
Skidded into another car	0	3	0	8
Vehicle parked partly on pavement	3	0	5	0
Car ahead stopped or swerved	1	1	1	6
Ran off pavement to avoid collision	0	3	0	0
Struck bridge	0	1	0	3
Total	8	26	18	56

This table shows that there was an increase of 10 truck accidents, or 125 per cent, on the 18-foot pavement as compared with the 20-foot The automobile accidents increased by 30, or 116 per cent—three times as large an increase, in number, as for trucks

All accidents in which a truck was involved in any way are entered in the table as truck accidents although a passenger car was also involved in every case, and usually the driver of the car was at fault In a number of cases the fact that a truck was hit was merely because it happened to be the first vehicle to come along when a passenger car was running wild

Unfortunately there is very little information and no exact statements as to the width of the trucks involved. It can only be inferred, in some cases, from the make or type of truck mentioned If every truck not specifically designated as a Ford or Chevrolet should be assumed to be 8 ft wide they would still account for only a small percentage of the increase in accidents on the narrow road as compared with the wider roads.

NATURE OF TRUCK ACCIDENTS

Following is a brief description of the truck accidents affected by pavement width

U. S. 23—M 17 (20 ft.). In two cases the truck was parked partly or entirely on the pavement while in the third case "a Packard sedan, going east, stopped suddenly in front of a Chrysler coupe also headed east The driver of the Chrysler turned to the left to avoid a collision and hit a Ford truck going west"

U S 12 East (20-ft) The two accidents were caused when automobiles attempted to pass trucks, one involving a head-on collision with another car and the other a drunken driver who ran into the ditch

U. S 112 (20 ft) One report states that a speeding car hit the truck as the car turned out to pass and the other states that a car on the wrong side of the road hit a truck

First 5 miles of U S. 12 West (18 ft) In one of these cases a truck crashed into the rear end of a sheriff's car parked on the pavement because of another accident In the second case a "truck and trailer, going west, hit Buick, going east Buick skidded crossways and was struck in center." The official report of the third truck accident says, "Driver of Ford was trying to pass a milk truck and went way over to the left side of the road and struck a culvert, then glanced off and hit a tree head-on Driver had smell of whiskey on his breath One pint bottle of whiskey was found in the car, contents half gone" One person was killed and three were injured in this accident One may speculate as to whether or not two more feet of pavement width would have prevented this wreck but the answer is very obscure In the fourth truck accident, "a Chevrolet coach, going east, skidded into a swaying trailer A Ford coupe, also going east, put on brakes and front end skidded into a truck ."

Second five miles of U S 12 West (18 ft) In one case "a Buick hit a truck on the truck's side of the road" and another involved three trucks (two parked) and two cars

Last nine miles of U S 12 West (18 ft) In one of the cases a truck was hit by an automobile which was on the wrong side of the road and in the other case a truck swerved to the left as an automobile was trying to pass it from the rear

BASIS OF COMPARISON

It is rather difficult to determine how the data obtained in this investigation should be arranged in order to make the comparisons necessary for drawing conclusions They have been arranged in various ways in the preceding tables but it seems logical first to separate the heavily traveled U S 12, U S 112 and U S 23—M 17 from the two seven-mile roads carrying lighter traffic. It is unfortunate that there was only one

18-ft pavement to compare with three 20-ft. pavements of different characteristics, but since each 20-ft pavement is similar in characteristics to one of the overlapping sections of the 18-ft road, it seems logical to consider each of these as a separate road. That gives a theoretical total of 34 miles of 18-ft. pavement to compare with the 34 miles of heavily-traveled 20-ft pavement

ECONOMIC ASPECTS

In order to determine the economic aspects of traffic lane widths it is necessary first to determine accident costs In 1924 the National Conference on Street and Highway Safety, in estimating the economic loss due to traffic accidents, put the cost of a fatality at $5000, a personal injury at $175, and average property damage at $50. There are about 35 personal injuries to each fatality. Vehicles involved in rural accidents are usually traveling at high speeds so that the average property damage in a rural accident is greater than in a city accident Investigations in two cities indicated an average property damage of $20, and it is possible that the rural damage averages $100, or more, but actual statistics on this do not seem to be available.

Also it is highly probable that the ratio of fatalities to personal injuries is higher in rural accidents. On the roads covered in this investigation the ratio was about 1 to 10 in the accidents reported, but on the other hand, all fatal accidents are reported while there are doubtless many minor personal injury accidents which are not reported The same is true of accidents involving property damage only

In order to work out the economic justification of wider traffic lanes, upon the basis of accident costs, it is necessary to study the records for a number of years so that actual relationships can be determined, otherwise one or two bad accidents may distort the picture For instance, in a recent accident on a county road three persons were killed outright and four were seriously injured As this is written two of the injured are not expected to live If they do recover, the estimated cost of the accident would be about $16,000, but if they do not recover it would be nearly $26,000 The difference would equal the cost of 100 non-injury accidents at $100 each, which is almost half as many accidents as were reported in the whole county in a year

This great distortion, due to chance location of very severe accidents, might be eliminated by estimating the cost of the "average" accident and then using this cost in every case

A set of statistics at hand shows the following relationships for rural accidents: Total accidents 190,710, killed 13,050, injured 214,100 This is a ratio of about 16.4 injured to one killed A ratio of 1 to 20 seems reasonably accurate, so it may be assumed that the cost of 20 average accidents is as follows:

1 fatality at $5,000	$5,000
20 injuries at $175	3,500
20 property damages at $100	2,000
Total	$10,500

Dividing this sum by 20 gives an average cost of about $500 per average reported accident

Upon the roads studied in this investigation there were 30 more accidents on the 18-foot than on the 20-foot pavements, considering only those accidents affected by pavement width At $500 each this is a total of $15,000 or about $450 per mile This should easily cover the annual cost of two extra feet of pavement width

Obviously when more or less arbitrary assumptions are made in evaluating various factors the accuracy of the results is open to question, but the important matter is the method of attack If that is logical then the accuracy of results will increase as more statistical data become available

CONCLUSIONS

The data presented in this report appear to indicate that:

1 There are more accidents on 15 and 18-foot pavements than on 20-foot pavements carrying similar traffic

2 The greatest percentage of increase is in "side-swipe" accidents

3. Buses are very seldom involved in accidents

4 The percentage of increase in truck accidents and non-truck accidents is approximately the same

5 The increase in the number of non-truck accidents is much greater than the increase in truck accidents

6 The additional cost of accidents on the 18-ft pavement appears to be greater than the annual cost of an additional two feet of pavement

From these items it is evident that wider pavements are needed much more because of passenger automobile accidents than because of truck and bus accidents

Of course this is merely a bit of evidence based upon only 115 accidents occurring on three 20-ft roads, one 18-ft road and one 14 to 16-ft road Further studies in other locations may contradict it, but it seems too consistent to be refuted merely by opinions or computations, unsupported by actual accident data It is hoped that a method of approach has been suggested which will be adopted, or improved, by other investigators