Influence of Road Width on Accident Rates by Traffic Volume

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A study was conducted to assess the effect of shoulder and road widening on accident rates. Twenty-five projects covering 152 mi of road were selected for analysis. Sampled roads had been widened to one of four widths: 32, 36, 40, or 44 ft. Accident rates were compared before and after the construction period. Reductions of 38 to 53 percent were observed in accident rates, although the amount of reduction varied with traffic volume and the roadway width after construction. Accident rate reduction for the sampled projects was statistically significant at the 95 percent confidence level for before and after comparisons on most of the roads. Further research of the effects of resurfacing, restoration, and rehabilitation projects on accident rates in New Mexico is recommended.

Two-lane rural highway safety has a high priority in transportation research because more fatal accidents occur on these roads than on other roads. New Mexico has 9,680 mi of two-lane rural highways, which comprise 83 percent of all its state highways. Twenty-eight percent of the total million vehicle-miles traveled (MVMT) are on two-lane rural roads.

The majority of resurfacing, restoration, and rehabilitation (3R) projects consist of widening, resurfacing, and overlaying existing roads. In addition, protective barriers may be built to shield vehicles from roadside objects, or these objects may be removed. Such measures as culverts and drain facilities to prevent water flow from washing out roads are other possible improvements undertaken in 3R projects. Also, horizontal and vertical curves may be realigned, although the realignment is usually minor (major realigning of roads is undertaken in 3R reconstruction projects).

Traffic volume has been identified by Cleveland et al. (*1*) to be the most important factor in the frequency of accidents for two-lane rural roads with annual average daily traffic (AADT) below 3,000. Another factor that influences accidents is clear recovery zones (*2,3*). Some researchers (*1,4*) have concluded that intersections have a stronger influence than other geometric characteristics on accident frequency.

The effects of a few dominant elements, such as average horizontal curvature (sum of external horizontal angles between tangents divided by segment length) and average vertical curvature (sum of vertical distances between crest and following sag divided by segment length), have been noted (*1,4–7*). Gradient has been found to have a weak effect when it is not accompanied by other geometric characteristics, such as intersections or horizontal curves (*4,6,8*).

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It is difficult to identify the contribution of geometric elements to accident frequency because the design elements of existing roads interact (*1*). The findings of the studies that were reviewed were, in some cases, conflicting.

In particular, the relationships among road width, accident rate, and accident severity have not been established. Some studies have claimed small or even negative effects on the accident rate when roads are widened (*1,4,6,8*). Most studies, however, indicate that widening roads reduces accident rates, although at least one study has claimed that the reduction in accidents occurs with shoulder widening up to 8 ft after which there is an increase in accident rates.

A study conducted by the California Department of Transportation (*9*) investigated the relationship between shoulder widening projects and accident rates. The conclusion was that the safest widths depend on the volume of traffic. Several specific pairings between AADT and road width were supported: (a) if AADT is less than 3,000, a road should be widened to at least 32 ft (b) if AADT is between 3,000 and 5,000, the road should be widened to 32 ft; and (c) if AADT is more than 5,000, the road should be widened to 40 ft. These recommended widths were based on the following findings:

AADT	*Pavement Width after Widening (ft)*	*Percent Reduction in Accidents*	*Significant?*
<3,000	28	16	No
3,000–5,000	32	35	Yes
>5,000	40	29	Yes

It was concluded that there was no point in widening a 24-ft road to 28 ft because the reduction in accidents would not be great enough.

In TRB *Special Report 214* (*7*), the recommended minimum widths on highways with running speeds over 50 mph and more than 10 percent trucks are as follows:

AADT	*Pavement Width (ft)*
<750	24
751–2,000	30
>2,000	36

The criteria for widening roads in New Mexico are functional classification, AADT, and design speed. Almost all of the AADT values for the sampled roads are below 3,000. In general, roads with lower AADT have smaller widths than those with higher AADT. The current study verifies the relationships among accident rates, AADT, and road widening that were found in the California study (*9*) and the TRB special report (*7*).

OBJECTIVES

There were two objectives for this study. First, road widening and accident rates were matched for rural two-lane highways. Second, the findings of two studies (*7,9*) that AADT, road widening, and accident rates are related were confirmed.

DATA COLLECTION

Data were collected on two-lane rural roads classified as either federal-aid primary (FAP) roads or federal-aid secondary (FAS) roads. FAP and FAS roads were chosen because the majority of 3R projects are constructed on these roads. All projects completed from early 1981 to late 1986 were collected. Projects were rejected if they met one or more of the following four conditions:

1. Projects costing less than $200,000 per mile,
2. Projects that included major intersections,
3. Projects in urban areas, and
4. Projects having more than two lanes.

Twenty-five projects were chosen, comprising 152 mi of roadway. Project length varied from 1.5 to 15 mi.

Data collected for each project included project identification (ID), route, beginning and ending milelog, and estimated AADT. The projects were located using a milepoint system used by the New Mexico State Highway and Transportation Department (NMSHTD) in their consolidated highway data base. These points were used to match the appropriate AADT values to the segments and to match accidents to the appropriate segments.

Geometric information was collected from the as-built plans, including information on road widths, project lengths, sideslopes, average vertical curvature, and average horizontal curvature. Construction dates for projects were obtained from the districts that oversaw construction.

AADT values were obtained from a log used to record road segments and AADT. Most of the AADT values came from portable counters and are short-term counts. The counts were factored to an annual statistic using a growth statistic from permanent counters. Before 1988, the short-term counts were taken only once every 4 to 5 years; in between, the counts were factored to AADT using growth factors. These growth factors often did not match the actual rate of growth. Therefore, straight-line estimation was used rather than the growth factors for the years between the counts. The AADT varied from 300 to 3,700 for all surveyed projects.

Table 1 presents the pavement widths, number of projects, total project miles, and AADT (rounded to the nearest hundred) for projects included in this study.

Accident records were obtained from computer files kept by NMSHTD for a period beginning in 1978 and ending in 1988. The accident files are from reports filed by the New Mexico state police. The following variables were obtained from the accident files: accident location, date of accident, severity of accident (fatal, injury, or property damage), number of people killed or injured, and accident classification (e.g., fixed-object, other-vehicle, overturn, and parked-vehicle). The accident location was given in terms of milepoint and was reported to be accurate within 1/10 mi.

The years of accidents that could be included were limited because 1988 was the latest date that accidents had been recorded and accident records before 1978 were not available on the computer. Also, the period of time before construction and the period after construction had to be matched for the available accident records. One project had a 1½-year period for which accident records could be used for the before-construction period and for the after-construction period. All other projects were matched with at least 2 years of accident records before and after construction.

Accident rates per million vehicle-miles (AMVM) for the before and after periods were calculated using the average AADT values from each period. The following formula was used to compute the rates:

$$\text{AMVM} = \frac{\text{Number of accidents} \times 1{,}000{,}000}{\text{AADT} \times \text{segment length} \times \text{number of years} \times 365} \quad (1)$$

MVMT was computed using the following formula:

$$\text{MVMT} = \frac{\text{AADT} \times \text{segment length} \times \text{number of years} \times 365}{1{,}000{,}000} \quad (2)$$

DATA ANALYSIS

T-tests were performed on the data using the SAS Institute statistics package. In a *t*-test, a rate is first found for individual projects and then the rates for individual projects are averaged together by widening group (e.g., one group would be all roads widened to 32 ft), instead of computing one before and one after rate for a whole group. The *t*-test was based on the rate averages presented in Table 2.

Two different *t*-tests at the 95 percent level were used with the data. One of the *t*-tests was a comparison of group means *t*-test. The other *t*-test, a paired comparisons *t*-test, was used with $\log_{10}$-transformed data.

The paired comparisons *t*-test was used to measure before and after accident rates more precisely because, in this procedure, accident rates are contrasted before and after construction for the same road segment. Data used in the paired comparisons *t*-test were normalized by a $\log_{10}$ transformation.

TABLE 1 PROJECT DATA

Roadway Width After	Roadway Width Before	Number of projects	Total Project Miles	Annual Average Daily Traffic (AADT)
32	26–32	8	70.48	1000
36	26–28	5	18.60	1000
40	24–40	7	36.89	1500
44	24–32	5	26.56	2200
Total		25	152.53	

TABLE 2 RATE AVERAGES USED IN *t*-TEST

After Construction Width	Rate Before Construction	Rate After Construction	Percent Reduction
32 feet	2.70	.79	71%
36 feet	2.15	1.61	25%
40 feet	1.37	.89	35%
44 feet	1.24	.59	52%

The results for the *t*-test for group means and for the paired comparisons *t*-test with transformed data were the same.

No significant differences in accident and severity rates were found between the before and after construction periods for groups of projects widened to 36 and 40 ft. For road groups widened to 32 and 44 ft, the test results were significant.

Because the group results were inconsistent with some of the individual project accident rate reductions, the data were segregated into various AADT groupings. Table 3 gives some indication of the road widths necessary for safety benefits by AADT. The available projects are small in number for each cell, but they form a pattern in the degree of road widening, AADT, and accident rate changes.

Table 3 indicates that there is no safety benefit if a road is widened to 32 ft and AADT exceeds 1,000. Four projects that were widened from 28 to 32 ft and had AADT in the range of 1,001 to 2,000 had no significant reduction in accidents. The property-damage-only (PDO) accident rate actually increased on these projects, whereas overturn rates remained constant for the before and after periods.

Four projects with the range of 0 to 1,000 AADT did have a statistically significant reduction in accidents. Two of these projects were 26 ft wide, and the other two were 32 ft wide. Therefore, widening rural two-lane roads from 26 to 32 ft, with a combination of other improvements allowed in 3R practices, may reduce the number of accidents when AADT is under 1,000.

Accident severity and overturn rates decreased sharply for the three projects that were widened to 36 ft and had AADT between 1,000 and 2,000.

Five roads with AADT values less than 2,000 were widened to 40 ft. There was no significant reduction in accidents for these projects. Two projects in the group with more than 3,000 AADT exhibited significant accident reduction although the width of the road was not changed.

Four projects widened to 44 ft and having AADT > 2,000 exhibited reductions in accidents; however, a 40-ft width appears to be adequate for even the highest category of AADT. Further study will be required to more firmly establish the widths needed for the greatest safety.

REVISED DATA

On the basis of the findings presented in table 3, a road should be widened to 32 ft if AADT < 1,000, to 36 ft if it has AADT between 1,000 and 2,000, and to 40 or 44 ft if AADT > 2,000. Table 4 presents a summary of the reduction in percent.

ACCIDENT TREND OVER TIME

The time period included in this study is more than a decade. During this period accident rates on rural two-lane highways

TABLE 3 TOTAL ACCIDENTS BY AADT GROUPS

Width After	AADT	0 - 1000 Acc Rate	1001 - 2000 Acc Rate	2001 - 3000 Acc Rate	Over3000 Acc Rate
32	# Proj	(4)	(4)		
	Before	28 3.94	63 1.02		
	After	4 0.48	52 0.97		
	% Reduc	88*	5		
36	# Proj	(2)	(3)		
	Before	3 1.48	43 2.57		
	After	4 1.60	29 1.35		
	% Reduc	-8	47*		
40	# Proj	(3)	(2)		(2)
	Before	8 1.80	23 1.66		55 0.92
	After	4 0.49	20 0.91		31 0.60
	% Reduc	73	45		35*
44	# Proj	(1)		(3)	(1)
	Before	3 1.00		59 1.26	27 1.46
	After	3 0.98		25 0.47	9 0.58
	% Reduc	0		63*	60*

* Statistically Significant Reduction

TABLE 4 REVISED ACCIDENT RATE REDUCTION IN PERCENT

Roadway Width After	AADT	Total	Injury	PDO	Overturn
32	<1000	88	76	92	95
36	<2000	47	72	31	83
40	>2000	35	-7	52	10
44	>2000	63	47	71	63

changed because of new traffic laws and better vehicles. To account for these and other changes, the accident rates were adjusted for the accident trend on the routes as a whole.

The accident trends for the routes on which the projects took place were computed using a series of steps. Nineteen routes were identified for the 25 projects. The annual accident rates for the entire routes, with the exception of urban routes, were computed. Then, these annual accident rates were averaged within each widening group. The before and after periods for the projects were matched with the rates computed for the corresponding routes. As shown in Figure 1, not all years of actual data were available for the routes as a whole. When data were missing, the existing data were weighted more heavily. A percent reduction was determined for each individual project by comparing the average rates of before and after periods, using Figure 1. These reductions were averaged within each widening group, as follows:

Roadway Width After (ft)	*Percent Reduction*
32	35
36	2
40	32
44	25

The accident rates were reduced by 25 to 35 percent for all road groups except for roads widened to 36 ft. These roads had only a 2 percent reduction in their accident rates.

In the following table the corrected change in percent from before construction to after construction is shown for accident rates:

Roadway Width After (ft)	*AADT*	*Percent Reduction*
32	<1,000	53
36	<2,000	45
40	>2,000	3
44	>2,000	38

The corrected percentages are the result of subtracting the percent reduction in accident rates attributed to time trends

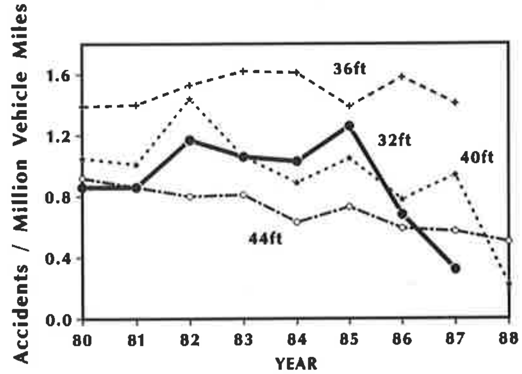

FIGURE 1 Trends of accident rates.

from the percent reduction in accident rates calculated from the project data. Most of the corrected percentages are still high. The only exception is the corrected accident rate percentage change of 3 percent for 40-ft roads with AADT values above 2,000. Because the two projects were 40 ft before construction, the small reduction in accidents is not surprising.

The corrected accident rate reductions may be due partly to factors other than road widening, such as improved pavement structure, improved riding quality, improved skid resistance of pavement surface, protection from roadside obstacles, improved signing, striping, and minor curve improvement.

ACCIDENT CLASSIFICATION

Accidents are categorized for roads widened to 32, 36, 40, and 44 ft in Tables 5 and 6. Most accidents fell within one of the four categories: overturn, other-vehicle, fixed-object, and animal. Table 7 indicates that the number of accidents was reduced by 45 percent for the overturn and other-vehicle class, 24 percent for the fixed-object class, and 33 percent for the animal class.

PARKED VEHICLES

The influence of road widening on the number of accidents classified as a parked-vehicle accident was also investigated, although this class is rare in the accident records. Table 5 indicates that only 2 percent of all surveyed accidents were related to parked vehicles. No further analyses were conducted.

TABLE 5 ACCIDENT CLASSIFICATION BY PERCENT

CLASS	FREQUENCY	PERCENT	CUMULATIVE FREQUENCY	CUMULATIVE PERCENT
ANIMAL	88	14.8	88	14.8
FIXED-OBJECT	93	15.6	181	30.4
OTHER-NON-COLLISION	33	5.5	214	35.9
OTHER-OBJECT	4	0.7	218	36.6
OTHER-VEHICLE	172	28.9	390	65.4
OVERTURN	191	32.0	581	97.5
PARKED-VEHICLE	12	2.0	593	99.5
PEDALCYCLIST	2	0.3	595	99.8
PEDESTRIAN	1	0.2	596	100.0

TABLE 6 SEVERITY BY TIME GROUP

FREQUENCY / PERCENT / ROW PCT / COL PCT	AFTER	BEFORE	CONSTRUCTION	TOTAL
FAT	10 1.68 45.45 5.52	8 1.34 36.36 2.56	4 0.67 18.18 3.88	22 3.69
INJ	65 10.91 30.95 35.91	112 18.79 53.33 35.90	33 5.54 15.71 32.04	210 35.23
PDO	106 17.79 29.12 58.56	192 32.21 52.75 61.54	66 11.07 18.13 64.08	364 61.07
TOTAL	181 30.37	312 52.35	103 17.28	596 100.00

CONCLUSIONS

The 3R improvements on surveyed rural two-lane FAP and FAS roads in New Mexico significantly reduced the accident rates for some of the AADT groups when the roads were widened to 32, 36, 40, and 44 ft.

The accident rate was reduced by 53 percent for roads widened to 32 ft when AADT was less than 1,000. The accident rate was reduced by 45 percent for roads widened to 36 ft when AADT was between 1,000 and 2,000. Determining the performance of roads 36 ft wide with AADT > 2,000 will require further investigation. The accident rate was reduced by 38 percent for roads widened to 44 ft with AADT > 2,000.

The results of the study support the practice of road widening to reduce accidents for two-lane rural roads. Also, the findings are consistent with the relationships found in the California study (*9*) and in the minimum standards set in TRB *Special Report 214* (*7*). In other words, the higher the AADT, the wider the road should be.

DISCUSSION OF RESULTS

The study results support the general findings of the California study (*9*) and TRB Special Report 214. (*7*). However, 3R practice in New Mexico requires a wider minimum finished roadway. This study indicates that the greater minimum width is justified by reduced accident rates.

Initially, there were some problems identifying which projects were 3R projects. Projects in the NMSHTD system are coded according to work-type descriptors. These descriptors, however, are not always accurate. Eventually, the basis for choosing the projects were the dollar amount per mile because this factor was independent of the coding.

Two other problems that could not be overcome in this research limited the analyses and strength of the conclusions. One was the small number of projects available for analysis, and the other was that the work on the projects was not

TABLE 7 CLASSIFICATION BY TIME GROUP

FREQUENCY / ROW PCT	AFTER	BEFORE	CONSTRUCTION	TOTAL
ANIMAL	30 34.09	45 51.14	13 14.77	88
FIXED-OBJECT	32 34.41	42 45.16	19 20.43	93
OTHER-NON-COLLISION	8 24.24	18 54.55	7 21.21	33
OTHER-OBJECT	0 0.00	3 75.00	1 25.00	4
OTHER-VEHICLE	47 27.33	85 49.42	40 23.26	172
OVERTURN	60 31.41	110 57.59	21 10.99	191
PARKED-VEHICLE	3 25.00	7 58.33	2 16.67	12
PEDALCYCLIST	0 0.00	2 100.00	0 0.00	2
PEDESTRIAN	1 100.00	0 0.00	0 0.00	1
TOTAL	181	312	103	596

uniform. The 25 projects included in the research had various structural changes: 52 percent had changes in their sideslopes, 16 percent had significant changes in vertical curvature, and 8 percent had changes in both the sideslopes and vertical curvature. Eight, or 32 percent, of the projects had no significant changes in either their sideslopes or their vertical curvature. This variety in the projects means that, for any detailed analysis of the projects' geometric characteristics, the individual groupings would have to be very small.

Inferences drawn from accident rates computed for two-lane rural road segments should be tentatively drawn because these roads tend to have more variable accident rates than those for rural roads as a whole. This is partly true because a low AADT in the equation for accident rate means that each accident has a greater effect on the calculated rate. Also, the absolute number of accidents will be smaller on low-volume roads, so each accident will have a greater effect.

The combined effects of the small sample size, variety in projects, and variable accident rates on two-lane rural roads mean that the researcher must look at data over a greater time period for these roads than for other road classifications.

The current study will be continued using additional data from 3R projects and the corresponding accident data. A more precise identification of the effects of the road improvements on accidents can then be drawn.

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