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Pedestrian Accidents on Rural Highways

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Pedestrian accident experience in two New Mexico counties is far in excess of statistically expected levels. These accidents, which occur principally on rural roads, result in a fatality more than 60 percent of the time. This research was undertaken to determine if engineering improvements could reduce the frequency of these accidents. Field studies were conducted at 95 rural pedestrian accident sites in these two counties. It was found that roadway geometrics at these locations were good and that sight distance exceeded standard requirements. Fixed objects, parked vehicles, and other features that might conceal a pedestrian along the roadside were noticeably absent. At the same time, pedestrian safety devices and amenities were employed infrequently at the accident sites. Most locations had adequate right-of-way width to accommodate separate sidewalks or paths for pedestrians. Although more than 80 percent of the accidents occurred at night, roadway lighting is a viable improvement at only a limited number of the rural locations. Two cluster areas of pedestrian accidents may warrant the most immediate attention. The inability of engineering features or deficiencies to explain a significant amount of the variation in the characteristics associated with these pedestrian accidents suggests that other, nonengineering factors may play a more important role in their occurrence.

One of the tasks of highway and traffic engineers is to provide for the safe movement of pedestrians. In several regards, the pedestrian is at a considerable disadvantage in the traffic system. However, engineers attempt to accommodate pedestrians through the provision of special facilities, such as sidewalks and crosswalks, and the use of other features, such as street lighting, which may be of value to both pedestrians and motorists. Because pedestrian activity occurs predominantly in urban areas, attention has traditionally focused on these areas.

PEDESTRIAN ACCIDENT STATISTICS

The problem of pedestrian-vehicle interaction is suggested by nationwide accident statistics. During the past decade, pedestrian fatalities in the United States have averaged 9400/year. Although pedestrians are involved in less than 1 percent of all accidents, they account for 18 percent of the highway fatalities. In 1980, New Mexico accounted for 1.29 percent of the nationwide pedestrian fatalities and 1.16 percent of the nationwide nonpedestrian highway fatalities. Table 1 compares nationwide characteristics of pedestrian accidents with those in New Mexico. As shown in the table, the fatal pedestrian rates based on population, registered vehicles, and vehicle miles of travel are all about twice the national rates. It is also noteworthy that nearly half of New Mexico's fatal pedestrian accidents occur in rural areas versus one-third nationwide.

Data from the 1980 Fatal Accident Record System (FARS) suggest that pedestrians account for a larger share of highway fatalities in the more urbanized states. Analysis of nationwide data shows a highly significant correlation between population density and the pedestrian proportion of highway fatalities. The 10 states with population densities greater than 200 persons/mile^2 report that 20 percent of their highway fatalities involve pedestrians, while in the 10 states with densities less than 20 persons/mile^2, the corresponding value is 12 percent. In New Mexico, where the density is 11 persons/mile^2, pedestrians constitute more than 19 percent of the highway fatalities.

Table 1. Pedestrian accident characteristics, 1980.

Item	United States	New Mexico
Pedestrian accidents	130 000[a]	630
Pedestrian fatalities	8180	106
Fatality index	0.06	0.17
Rural fatality (%)	34	49
Travel-based rates		
Accidents per 100 million vehicle miles	8.52	5.64
Fatalities per 100 million vehicle miles	0.54	0.95
Population-based rates		
Accidents per 100 000 persons	58.6	48.8
Fatalities per 100 000 persons	3.7	8.2
Mileage-based rates		
Fatalities per 1000 miles	2.1	1.5
Urban fatalities per 1000 miles	7.9	9.9
Rural fatalities per 1000 miles	0.9	0.8
Registration-based rate, fatalities per 100 000 vehicles	5.3	10.3

Note: Data in this table are compiled from the following sources: Federal Highway Administration; Fatal Accident Record System, National Highway Traffic Safety Administration, U.S. Department of Transportation; New Mexico accident record system; National Safety Council; and National Traffic Safety Bureau.
[a]Estimate. The accuracy of this number, and the rates based on it, are subject to debate.

These statistics suggest that the pedestrian accident experience in New Mexico differs somewhat from that of other rural states. To further examine this issue, the state's computerized accident records for 1978-1980 were evaluated. Of the 156 000 accidents during this period, 2090 (1.3 percent) involved a pedestrian, and in 96 percent of these, impact with a pedestrian was cited as the first harmful event. Of these accidents, 16 percent resulted in a fatality. An examination of accidents by county found that, with two exceptions, the reported percentage of pedestrian accidents was in good agreement with the proportionate share of all traffic accidents.

The two exceptions were McKinley and San Juan counties, which are located adjacent to each other

Table 2. Comparison of pedestrian accident characteristics.

Characteristic	San Juan/ McKinley (%)	Rest of New Mexico (%)
Nonintersection	80	70
Intersection	12	13
Intersection related	8	17
Fatal	26	14
Nonfatal injury	70	83
Daylight	37	56
Dark		
Lighted	25	20
Not lighted	38	19
Straight	93	95
Curve	7	5
Level	85	88
Grade, crest	15	12
Had been drinking	38	12
No drinking	29	66

Table 3. Selected characteristics of McKinley and San Juan counties.

Characteristic	McKinley	San Juan	New Mexico
Population	54 950[a]	80 833[b]	1 291 000
Area (mile^2)	5454[c]	5500[c]	121 412
Population density			
Total	10.1	14.7	10.6
Rural areas	6.3	5.9	3.6
Ethnic distribution (%)			
Anglo	23	52	52
Indian	61	35	7
Hispanic	14	12	38
Median age	19.2	20.7	23.9
Death rate per 1000 population	8.1	6.6	7.3
Median family income ($)	6780	8150	7850
Indian-owned land (%)	62	60	9

[a]4.3 percent of total population.
[b]6.3 percent of total population.
[c]4.5 percent of total area.

in the northwest corner of New Mexico. These predominantly rural counties account for 12.7 percent of all traffic accidents, while they report 21 percent of the pedestrian accidents. An even more disturbing statistic is that these counties report 33 percent of the fatal pedestrian accidents--a value almost three times as great as their share of all accidents. The pedestrian accident fatality index in these counties is 0.26, which is twice the value for the rest of New Mexico.

A comparison of selected pedestrian accident characteristics between these two counties and the remainder of New Mexico is summarized in Table 2. As the table shows, pedestrian accidents in these counties are more often characterized by nonintersection locations, the hours of darkness, and alcohol involvement. They occur slightly more frequently on curves and nonlevel roads.

Of the 393 pedestrian accidents in these two counties during a 30 month period, 144 (37 percent) occurred in rural areas. However, 82 (79 percent) of the 104 pedestrian fatalities were on rural roads. A major subset of the rural road system, which consists of those roads administered by the New Mexico State Highway Department, accounted for 122 pedestrian accidents and 74 fatalities.

Statistics clearly indicate that these two counties are responsible for a disproportionate share of the pedestrian accidents. The objective of this research was to determine, through an examination of rural pedestrian accident sites in these counties, if standard or specialized forms of remedial action could be implemented on the highways to reduce the potential for these types of accidents (1).

Selected characteristics of the two counties are summarized in Table 3. The counties account for 9 percent of the state's land area and nearly 11 percent of the population. The population density (persons per square mile) is 70 percent greater than the statewide average for rural areas. The counties both have a substantial Indian population, with McKinley and San Juan ranking first and third, respectively, in the percentage of Indians in the population. The median ages in these counties are the two lowest in the state. Because any of these distinguishing characteristics could influence the occurrence of pedestrian accidents, the results of this study may have limited applicability to other rural highways.

STUDY PROCEDURE

In view of the serious problem of pedestrian accidents in these counties, a plan was developed to examine the sites of 95 pedestrian accidents that occurred during a 30-month period on the 725 miles of rural, state-administered, non-Interstate roads in the counties. Of these accidents, 63 (66 percent) resulted in a fatality.

The initial procedures for data collection were predicted on the findings of previous studies of urban pedestrian accidents. However, there are obvious differences between the pedestrian problems in urban and rural areas. As a general rule, urban areas are characterized by lower speeds, greater traffic density, more children interacting with traffic, and more roadside distractions. Urban areas also make much more extensive use of special pedestrian facilities such as sidewalks, crosswalks, WALK/WAIT signals, and refuge islands. The principal emphasis for urban pedestrian facilities is at intersections, although two-thirds of the pedestrian accidents occur at nonintersection locations.

The factors that appear to be of primary importance in a site examination of rural pedestrian accidents include visibility, presence of special pedestrian facilities, and potential for countermeasure application. These factors are reflected by such items as alignment, illumination, presence of roadside objects, and application of traffic-control devices. A field form for obtaining these and related items was developed and tested in spring 1981. The actual data collection was accomplished by a two-person field crew who used simple engineering measurement devices.

DATA ANALYSIS

The mean, minimum, and maximum values of numeric characteristics evaluated for all pedestrian accidents are summarized in Table 4. The mean values of curvature are slightly, but not significantly, to the right. However, 85 percent of the pedestrian accidents occurred at sites where the degree of roadway curvature was less than 1°. The average gradient at the pedestrian sites is negative and is on the borderline of being statistically significantly less than zero. With respect to the general nature of the vertical alignment in the vicinity (0.25 mile) of the accident site, 40 percent were described as downgrade while 30 percent each were described as level or upgrade. As expected, superelevation averages were positive, where the sign convention employed the positive designation for normal crown sections on tangents and proper banking on curves.

The roadways averaged 35 ft in width, with a 9-ft shoulder on the side of the roadway on which the pedestrian was struck. The mean roadway width is somewhat misleading because the study sites were virtually all on two- or four-lane roads, with the former being slightly more common than the latter.

Table 4. Selected characteristics at accident sites.

Characteristic	Mean	Minimum	Maximum
Curvature[a]			
In advance of accident site			
150 ft	-0.04	-15.11	4.81
50 ft	-0.26	-30.26	2.75
Avg	-0.15	-22.68	3.69
Absolute[b]	0.55	0	22.68
Gradient			
In advance of accident site			
150 ft	-0.35	-5.80	4.80
50 ft	-0.19	-6.10	5.00
Avg	-0.27	-5.95	4.90
Superelevation			
In advance of accident site			
150 ft	1.70	-1.90	6.40
50 ft	1.67	-1.90	6.10
Avg	1.68	-1.25	6.25
Roadway width (ft)	35.5	14.3	74.5
Shoulder width (ft)	8.9	0	20.8
Right-of-way (ft)	200	40	720
No. of lanes	2.88	2	4
Avg daily traffic	6608	570	20 000
Speed limit (mph)	53	25	55
Pedestrian age	31.9	2	82
Driver age[c]	33.1	17	85

[a]Curves to the left were assigned positive algebraic signs.
[b]Absolute value of curvature.
[c]Not all driver ages were reported because of hit-and-run accidents.

The right-of-way width, which was estimated on the basis of fence locations or the position of other boundary locators, averaged 200 ft, which suggests that, in the typical case, there is sufficient roadside width to accommodate a pedestrian path or sidewalk.

The volume of vehicular traffic at the sites averaged 6600/day, although certain sites had daily volumes as high as 20 000. The median speed limit was 55 mph, which reflects the fact that the studies were conducted at pedestrian-accident sites on rural highways. As might be expected, pedestrians were slightly younger than the drivers of vehicles that struck them, but the difference is not statistically significant.

Because previous studies of pedestrian safety had indicated that objects along the roadside may tend to hide pedestrians from the driver's view, the field study included a count of spot objects and the measurement of continuous objects in a 200-ft-long rectangle immediately upstream of the crash site and that extended 20 ft from the edge of the roadway. A substantial number of the sites had no fixed objects. Although spot objects averaged about 1.7 objects/site for those sites with objects, the value averaged over all the study sites was only 0.6. With the exception of embankments (slopes steeper than 4:1), which were present at 24 percent of the study sites, continuous fixed objects were found infrequently. Sight distance, measured during daylight hours and by using a 3.5-ft height of a driver's eye and a 4-ft height of an object, was less than 1000 ft at only 15 percent of the study sites. All of the sites provided a sight distance in excess of the values recommended by the American Association of State Highway Officials (AASHO) (2). The preliminary conclusion from the data in Table 4 is that, as a general rule, neither roadway alignment nor roadside features are causing a serious sight-distance restriction that could contribute to pedestrian accidents.

In the field studies, an evaluation was made of those features that may influence the actions of pedestrians. These items have often been identified in studies of urban pedestrian accidents as either possible contributing factors or as potential forms of remedial action. The inherent differences between urban and rural areas caused these features to be found infrequently at these pedestrian accident sites. With the exception of refuge islands (that, as a practical matter, were installed at 23 percent of the sites to separate traffic and provide left-turn bays), few devices were present to promote pedestrian safety. Parked vehicles did not seem to pose a problem at any of the sites. None of the sites could properly be described as limited access roadways. In fact, 86 percent of the sites were within 1000 ft of an intersection, although only 15 percent were characterized as intersection related.

Because the accident sites studied in this research were principally on major state routes, it was expected that the majority would have traffic signs and markings in compliance with the Manual on Uniform Traffic Control Devices (3). Centerlines were found at 95 percent of the sites and edgelines at 79 percent. In view of the generally favorable roadway geometrics, it was unusual to find no-passing zones at 41 percent of the accident sites, although it is recognized that factors other than alignment may necessitate the use of such markings. Although a total of 60 official traffic signs were found among all of the study sites, the median number of signs at a site was zero. Pedestrian crossing signs were found at 14 percent of the accident sites.

The investigating officers' reports provided some interesting information with respect to these accidents. The reports indicate that 28 percent of the accidents were hit-and-run, which in turn reduced the amount of information on driver age and vehicle type. Among those accidents that involved a known vehicle type, in 47 percent of the accidents the impacting vehicle was a passenger car while in 40 percent of the accidents it was a pickup truck. Casual observation of the vehicle mix on these roads suggests that, despite their high percentage, pickup trucks may not be overrepresented in these accidents. The reports also indicate that the weather was clear in 88 percent of the accidents and that the pavement condition was dry 86 percent of the time. The hourly distribution of these accidents differs substantially from typical rural accidents, with 56 percent occurring between 6:00 p.m. and midnight, and an additional 26 percent between midnight and 6:00 a.m.

A review of the sketch drawn by the officer and his or her descriptive comments on the factors surrounding the accident gave some indication of the action taken by the pedestrian. The findings, summarized in the table below, must be viewed cautiously, considering that the majority of the pedestrians were fatally injured, and statements from drivers, who typically did not see the pedestrian until it was too late to take corrective action, must be considered suspect:

Action	Percent
Crossing roadway	47
Walking with traffic	19
Standing in roadway	8
Walking in roadway	6
Walk into vehicle path	5
Other	11
Unknown	4

The principal pedestrian action involved crossing the highway. Examination at the sites of these accidents showed that the principal attractions to cross the road were taverns (12 sites), houses (4), and to get to an intersecting street (4). In the remainder of the crossing cases, the reason for crossing could not be established. Although 18 ac-

cidents involved pedestrians walking with traffic, only 2 involved pedestrians walking against the direction of traffic.

The investigating officer is asked to report the sobriety of drivers and pedestrians involved in accidents. For the accidents evaluated in this study, 14 percent of the drivers and 40 percent of the pedestrians reportedly had been drinking. These values may be considerably in error, because the sobriety of 28 percent of the drivers (principally those involved in hit-and-run accidents) and 48 percent of the pedestrians was reported as unknown on the accident report. On the basis of supplementary information provided by the New Mexico Traffic Safety Bureau, it was determined that 61 percent of the pedestrians were intoxicated.

Following the measurements at the site and a review of the investigating officer's report, the researchers attempted to determine if one or more types of engineering countermeasures were applicable at the location. Several factors influenced the selection of suitable types of remedial action. For example, roadway illumination would not be recommended at an isolated point or at a location without available electric power. The table below summarizes the recommendations with respect to possible countermeasures. (Note, the percentage of sites totals to more than 100 percent because of multiple improvements at some sites. For improved signing, these primarily suggest the use of W11A-2, the pedestrian-crossing sign. Other actions primarily include improved pavement markings, although a few cases involved speed limit reductions.)

Countermeasure	Percentage of Sites
Shoulder improvements	36
Improved lighting	29
Improved signing	19
Visibility enhancements	12
Other actions	11
Installation of refuge island	5
Installation of sidewalks	2
Pedestrian crosswalk	1

There is no guarantee that implementation of these recommendations will reduce the frequency or severity of the pedestrian accidents. The suggestions are based on site characteristics, the nature of the accident, and recommendations from technical literature (4).

The accident site data were examined with correlation analysis techniques. Although a number of variables were significantly correlated, their practical interpretations were intuitive and added little to the study's findings. Perhaps the most meaningful result of this analysis was the lack of significant correlation in two areas. It was found that the alignment parameters (curvature, gradient, and superelevation) were not correlated with one another or with any other variable in the analysis. In addition, roadway width--which is clearly a measure of the importance of the road as indicated by its positive correlations with average daily traffic (ADT), speed, and functional class--is not correlated with shoulder width. In practical terms, the conclusions from this analysis are that, at the sites of pedestrian accidents, higher-level rural roads do not have significantly better alignment features or shoulder width than the lower-class (functional) roads.

Previous analysis had found that only a few sites had what might be described as adverse geometrics. The degree of curvature was in excess of 2° at 5 of the sites, while 12 of the sites had gradients with an absolute value in excess of 3 percent. An examination of the combined alignment features showed that, for the most part, sites with sharper curvature tended to be close to level and sites on grades tended to be nearly tangent. Only one site had the combined features of high curvature and grade.

In a final attempt to determine underlying relations among the characteristics of the variables measured at the pedestrian accident sites, factor analysis was applied to 11 variables: ADT, light condition, pedestrian age, speed, road width, shoulder width, right-of-way width, number of lanes, curvature, gradient, and superelevation. This methodology sought to identify groups of variables (referred to as factors) that could explain substantial portions of the observed variations in the variables and had been used previously with some success in a study of suburban pedestrian accidents (5). Each factor consists of two or more variables that, when grouped together, provide a general characterization of the accident occurrence. The factors themselves do not have names, but rather must be interpreted by the analyst.

By using accepted statistical techniques, it was possible to reduce the 11 variables to 4 factors that accounted for a total of 61 percent of the variation. These factors are identified in the table below [note, all variables have positive loadings (i.e., correlations) with the factors except speed, which has a negative loading]:

Factor	Included Variables	Variation (%)	Interpretation
1	No. of lanes, road width, and ADT	20.4	Major road
2	Right-of-way and shoulder width	14.9	Room for safe pedestrian movement
3	Curvature, gradient, and speed	13.5	Adverse geometrics
4	Superelevation and pedestrian age	12.4	Uncertain

Factor 1 is made up of three variables, which as a group suggests a major roadway. This factor is not surprising, since the site-selection process emphasized these types of roadways. Factor 2 consists of two factors, which suggests the availability of room alongside the roadway for safe (longitudinal) pedestrian movement. Factor 3 consists of two alignment variables together with the speed limit, which has a negative correlation with the factor. The factor indicates poorer geometrics, principally at sites with lower speed limits. Factor 4, while statistically meaningful, does not seem to have a practical interpretation.

CONCLUSIONS

Rural pedestrian accidents have not been studied in detail because pedestrian activity in these areas is low, pedestrian accidents are (generally) few in number, and those that do occur are so spacially separated as to preclude effective remedial action. However, the limited geographic area examined in this research differs from the typical pattern of rural pedestrian accident frequency and, therefore, offered the potential of discerning what, if any, characteristics of a type susceptible to engineering forms of corrective action were common to these accidents.

Data from this study show that the pedestrian accident sites have several common characteristics.

On the positive side, the sites were generally characterized by good alignment. Daytime sight distance was more than adequate, with 85 percent of the sites having sight distances in excess of 1000 ft and all providing sight distances in excess of AASHO standards. The data also reflect the typically uncluttered nature of New Mexico's roadsides, with the absence of fixed objects, which precludes the opportunity for a pedestrian to dart-out from behind a tree or post into the path of a vehicle. Lane width, with an average of just greater than 12 ft, is certainly adequate for the types of roadways studied in this project. The presence of pedestrian warning signs at 13 of the accident sites shows a recognition by highway officials of the pedestrian activity at some of the study locations.

The principal negative finding from the field study involves the general lack of pedestrian facilities on these roadways. The absence of such facilities may be attributed in part to the failure of AASHO, the prime source of standards for rural highway design, to provide warrants for their use. Although the "Blue Book" (2) suggests that sidewalks along rural highways will reduce pedestrian accident experience, the general absence of sidewalks in rural areas of New Mexico virtually precludes the opportunity to evaluate either their use or effectiveness. AASHO supports the use of adequate shoulders in lieu of sidewalks.

A factor that is troublesome for the engineer is the 80 percent of the pedestrian accidents that occur at night. The good alignment, adequate sight distance, and clear roadside provided by the engineer all assume secondary importance when the actual sight distance is limited by the illumination from vehicle headlights. Although some of the sites, principally those near major intersections or commercial development, could profit from the installation or upgrading of roadway lighting, the application of this type of improvement was judged to be useful or practical at less than 30 percent of the accident sites.

One finding of the study that could be of value in planning and implementing corrective action is that the accidents are not uniformly distributed on the road system. The 95 sites studied actually involved only 82 locations; the difference is due to sites with multiple accidents during the study period. Two clusters of pedestrian accidents along 14 miles of rural road accounted for 39 percent of the accidents, and they obviously deserve the most immediate attention.

A final conclusion is worth mentioning. This study is one of the more thorough that has been conducted on this topic. The measurements made were comprehensive from an engineering point of view and suitably precise to meet the needs of the study. Statistical techniques, however, which experience has often shown are able to help in explaining the interaction of parameters associated with accident occurrence, yielded somewhat inconclusive results. The most logical explanation is that the human and vehicular factors not examined in this study may be of overriding importance in these accidents.

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The Obstacle Course: Pedestrians in Highway Work Zones

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There has been an increased awareness of the safety problems associated with highway work zones among traffic professionals and government agencies during the past several years. For the most part, attention has been focused on motorist safety, while pedestrian safety has been virtually ignored. Federal, state, and local manuals do not adequately address the issue of pedestrian accommodation and safety in highway work zones. There are currently no well-defined techniques, standards, or practices that pertain to pedestrian control and safety in work zones. Traffic-control plans for maintenance of traffic through work zones are prepared primarily for vehicular traffic and make rare reference to pedestrians. Inadequate pedestrian accommodation in work zones forces pedestrians to choose their own paths and fight through construction areas full of debris and other obstructions. Pedestrian accommodation and safety in work zones deserve careful attention. Guidelines for accommodating pedestrians should be developed at the federal level and preferably included in the Manual on Uniform Traffic Control Devices for proper implementation and uniform compliance. A concerted effort to improve pedestrian safety in work zones is highly desirable. Pedestrians should be afforded the same rights and privileges enjoyed by vehicles that pass through construction zones.

Traffic control in highway work zones has become a major safety concern for traffic professionals and government agencies during the past several years. Traffic-control efforts in highway work zones have primarily been directed toward vehicular traffic. The Manual on Uniform Traffic Control Devices (MUTCD) (1) and the associated supplements (2,3) provide a comprehensive coverage of guidelines, principles, and devices for vehicular traffic control in highway work zones. These guides, however, do not adequately address the issue of pedestrian safety and accommodations in highway work zones.

The requirements for preparation of traffic-control plans (TCPs) for all major highway construction projects are essentially related to vehicular traffic control in work zones. Maintenance of traffic is generally included as a separate pay item on all major highway projects. TCPs for highway projects rarely make reference to pedestrian accommodations and safety in work zones.

Given this lack of attention to pedestrian needs, one could expect to find, in general, a lack of pedestrian accommodations in terms of separators, protection, and guidance devices at highway work