Assessment of Current Speed Zoning Criteria

DAVID L. HARKEY, H. DOUGLAS ROBERTSON, AND SCOTT E. DAVIS

As early as 1947, studies concluded that the majority of drivers ignore speed limits and drive at speeds that they believe are safe and reasonable. Since then, some studies have supported this conclusion whereas others indicated that speed limits do affect travel speeds in varying degrees. In an FHWA-sponsored assessment of current speed zoning criteria, speed and accident data were collected at 50 locations, both urban and rural, in four states on roadways with posted speed limits ranging from 25 to 55 mph. These data were analyzed to determine travel speed characteristics, compliance with posted speed limits, and the point of minimum accident risk. Significant findings were as follows: Mean speeds exceeded posted speed limits by 1 to 8 mph; 85th-percentile speeds ranged from 6 to 14 mph over the posted speed limit, or 4 to 7 mph over the mean speed; the majority (70.2 percent) of free-flow drivers observed did not comply with posted speed limits; in general, 85 percent compliance was achieved at speeds 10 mph over the posted speed limit; accident rates for the 25-mph zones were consistently much higher than for any of the other zones; and the speed at which accident risk was minimized occurred at the 90th percentile of the travel speeds observed.

The practice of establishing speed limits, or speed zoning, began early in the history of motorized travel when officials realized that excessive speed could result in damage and injury to others. The first speed limit in the United States was enacted in Connecticut in 1901 and since that time the evolution of speed limits in this country has become both complex and controversial. As early as 1947, studies have concluded that the majority of drivers ignore speed limits and drive at speeds that are believed safe and reasonable (*1*). Since then, some studies have supported this conclusion whereas other research indicated speed limits do affect travel speeds in varying degrees (*2*).

Perhaps one reason for the lack of consensus on the effect of speed limits is the lack of uniformity in establishing speed limits. Speed zoning is generally defined as the establishment of safe and reasonable speed limits. Although safe speed is difficult to define, reasonable speed is nearly impossible for all drivers to agree on. Broad interpretations of these terms combined with the lack of sound engineering knowledge has led to use of a wide variety of regulations and procedures posting speed limits.

Lack of uniformity in speed zoning among jurisdictions creates problems for motorists, law enforcement officials, and judges. If posted speed limits are unreasonably low, the majority of drivers become technical violators of the law, which places law enforcement officials and judges in the position of arbitrarily selecting violators. This process also produces criticism of highway officials responsible for posting speed limits and can often lead to concerned citizens and legislators taking an active role in speed zoning decisions (*3*).

In an FHWA-sponsored assessment of current speed zoning criteria, speed and accident data were collected at 50 locations, both urban and rural, in four states on roadways with posted speed limits ranging from 25 to 55 mph (*4*). These data were analyzed to determine travel speed characteristics, compliance with posted speed limits, and the point of minimum accident risk.

SITE SELECTION

Although travel speed characteristics may vary from one state to another, an attempt was made to select states believed to be representative of travel speeds in a particular region of the country. This result was accomplished by dividing the nation into four geographic regions (southwest, northeast, midwest, and west) and selecting two states from each region (one primary and one alternate) on the basis of the following criteria:

- The national maximum speed limit (NMSL) data base had to contain 3 years of vehicle speed data for the control sampling locations;
- The accident data base had to be computerized and accessible by highway location; and
- The accident data reported by each state had to contain, at a minimum, estimated travel speed, posted speed limit, violations cited, time of day, day of week, severity, type of collision, and number of vehicles involved.

On the basis of these criteria, the four states selected were North Carolina, Delaware, Colorado, and Arizona.

Selection of roadway segments within each state for which speed and accident data were collected began with the stratification of sites by area type, roadway type, and speed limit. On the basis of national daily vehicle miles of travel (DVMT) obtained from the Highway Performance Monitoring System (HPMS) data, sites were selected in 11 cells (8 urban and 3 rural cells) as presented in Table 1. The 11 cells chosen were multilane and two-lane cells with the largest DVMT value. Included were five multilane sites and six two-lane sites in each state.

Sites were selected in each of the four states using a data tape containing HPMS roadway segments and their characteristics. Segments were first stratified into the 11 cells identified for data collection in Table 1. A list of segments within

D. L. Harkey and S. E. Davis, The Scientex Corp., 500 East Morehead Street, Suite 315, Charlotte, N.C. 28202. H. D. Robertson, University of North Carolina, Department of Civil Engineering, Charlotte, N.C. 28223.

TABLE 1 STRATIFICATION OF STUDY SITES BY AREA TYPE, ROADWAY TYPE, AND SPEED LIMIT (NATIONAL DVMT)

Roadway Type \ Speed Limit (mph)	Area Type					
	Rural		Small Urban		Large Urban	
	25/30/35	40/45/50	25/30/35	40/45/50	25/30/35	40/45/50
Freeway	374	1,320	403	2,323	5,663	62,781
Multilane	9,182	29,716	34,354	26,783	276,018	259,248
Two Lane	67,770	179,712	76,700	27,575	330,968	151,328

each cell was then compiled for each state showing the HPMS number, length of the segment, location (county), and average daily traffic.

In order to make data collection as efficient as possible, sites were selected in one or two concentrated areas within each state. A large urban city was selected as the center of each area, and the surrounding counties falling within a 100- to 200-mi radius were included to complete the cluster of counties in each state from which the sites were selected. The section length for some of the segments identified by HPMS was small (less than 0.3 mi in many cases). Data collection required the vehicles to be traveling at free-flow speeds. In order to achieve this goal, no segments with lengths of less than 0.4 mi were selected.

Using the list of available HPMS sections and a random numbers table, one primary site and two alternate sites were selected for each cell in each state. Alternate sites were used in cases in which the primary site had been physically changed or could not be used at the time of data collection.

In addition to the non-55-mph sites selected for data collection, six 55-mph sites were selected from the control sampling locations used in monitoring NMSL. Speed data are collected four times a year at each of these locations by the state transportation personnel. Of the six rural sites selected, four were on two-lane roads and two were on multilane highways.

DATA COLLECTION

Speed Measurement

Speed data were collected at a total of 50 sites (44 non-55-mph sites and six 55-mph sites). At each location, 24 hr of vehicle speed data was collected using an International Road Dynamics 1040 Traffic Statistics Recorder (TSR) and inductive loops. These loops were either in rubber mats fabricated by the project team or were permanent loops used by the state at the NMSL locations. When the loop mats were used, the equipment was deployed at a location within each segment determined by three factors: section representation, adequate sight distance, and availability of permanent structures to which the equipment could be secured.

The first factor, representation, was the most important. A location had to be selected where vehicles traveled at free-flow speeds that were representative of speeds throughout the section. This criterion meant avoiding locations close to intersections or locations governed by advisory speed zones. Once a deployment location was found, the mats were placed in the center of each lane at a distance of 16 ft from leading edge to leading edge.

With the mats and lead wires securely in place, the accuracy of the unit was checked by comparing speeds obtained with a hand-held radar unit to speeds obtained by the TSR. The TSR recorded raw vehicle data in terms of speed, length, and time with respect to the lane of travel for each vehicle. Actual number of vehicles (raw counts), usable number of vehicles (actual counts), number of passing vehicles, and number of loop errors for each hour the unit was operating were recorded in the TSR statistics table.

Usable vehicles were defined as vehicles with a length and speed. If a vehicle did not cross both mats in a lane, an upstream only or downstream only reading would be recorded depending on which mat was missed. These vehicles were stored under the raw vehicle count but not under the usable vehicle count. When a loop error occurred, the upstream only or downstream only reading was also recorded and this information was used to determine the percentage of usable vehicles with respect to the raw vehicle counts and to determine whether the data for the 24-hr period were acceptable. If this percentage was less than 70 percent, another 24-hr period of data was collected before leaving the site.

At the conclusion of the 24-hr period, the equipment was removed from the roadway. The TSR statistics table was checked to determine if the 70 percent threshold had been achieved. If this percentage had not been obtained, measures were taken to determine the faulty loops or broken lead wires, and the equipment was removed, repaired, and replaced in the roadway for another 24-hr period. If the threshold had been obtained, the equipment was removed from the roadway. Raw vehicle data and TSR statistics table were then loaded into a laptop computer for analysis.

Raw vehicle data from each site were analyzed using a program developed by FHWA. From this program, descriptive speed statistics, percentiles, pace, compliance data, and other factors were obtained. Results from this program for each of the sites were combined and used in the overall analysis.

Site Characteristics

In addition to speed data collected at each of the selected roadway segments, several other geometric and traffic

characteristics collected were

- Development type (commercial, residential, etc.),
- Number of intersections (signalized and unsignalized),
- Number of intersecting roadways,
- Horizontal curvature (none, moderate, severe),
- Terrain (flat, rolling, mountainous),
- Median type and width,
- Posted speed limit,
- Advisory speeds and speed zones,
- Lane width, and
- Shoulder type and width.

Each item was collected for the entire length of each segment. For purposes of collecting these data and the accident data, each segment was extended in both directions beyond the original mileposts defining the HPMS section as long as the characteristics of the site remained constant.

Annual average daily traffic (AADT) volume for each roadway segment was obtained from the state. This information was used in combination with the accident data to develop accident rates.

Accident Data

Three years of accident data were collected from the states for each of the roadway segments where speed data were collected. Variables obtained were

- Route,
- Milepost,
- Date,
- Time of day,
- Day of week,
- Number of injuries,
- Number of fatalities,
- Speed involved (yes or no),
- Collision type,
- Vehicle type,
- Estimated travel speed,
- Weather conditions,
- Surface conditions,
- Driver condition,
- Accident severity, and
- Intersection accident (yes or no).

Of the variables listed, estimated travel speed was the only one not obtained in all states. Although the value was recorded on the accident report in the field by the investigating officer, data were not available from the computerized accident file in Arizona or Delaware.

RESULTS

Travel Speed Characteristics

General

Rural, small urban, and urban stratification used in identifying sites from the HPMS data base was eliminated on the basis of observations of the field data collection team. Some urban sites appeared to be more rural than urban and vice-versa on the basis of factors such as vehicle volumes, development type, intersection and driveway density, etc. Thus, giving results of the analysis in terms of rural versus urban would have been not only difficult, but misleading. Therefore, results are given in terms of posted speed limit and road type (number of lanes). Geometric and site attributes collected in the field by the project team were then used to better define area type influences on travel speed. Distribution of the 50 sites (by number of travel lanes and posted speed limit) used in the analysis are presented in Table 2.

Figure 1 shows the box plots of travel speed percentiles for each speed zone. Travel speed percentiles used for each plot are 5, 15, 50, 85, and 95. Plots express the normality of each speed zone data set because the 5th, 15th, 85th, and 95th percentiles are symmetrical about the 50th percentile. As shown by these plots, variations across speed zones are similar, indicating a homogeneous sample.

TABLE 2 DISTRIBUTION OF STUDY SITES BY NUMBER OF TRAVEL LANES AND POSTED SPEED LIMIT

	Speed Limit (mph)						
Road Type	25	30	35	40	45	50	55
Two-Lane	4	3	6	3	5	4	4
Multi-lane	1	1	5	2	6	4	2

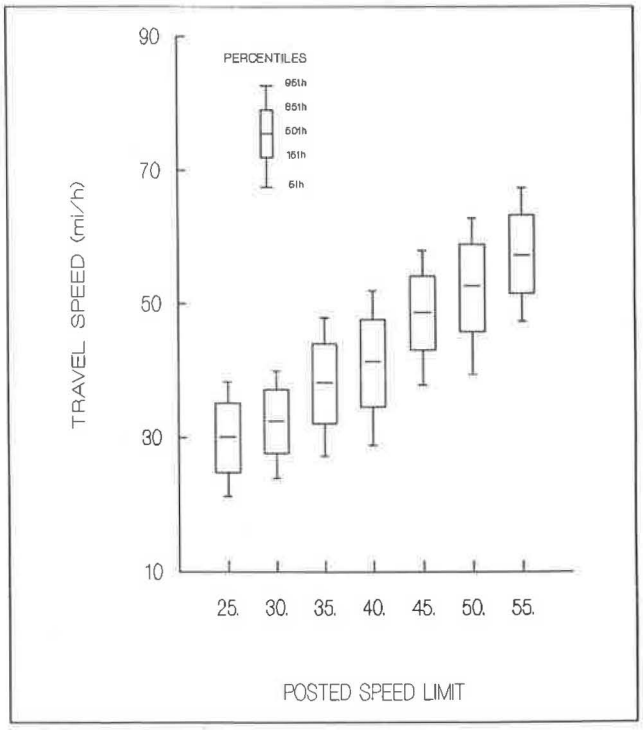

FIGURE 1 Box plots of speed percentiles for each speed zone.

Examining speed variance shows the standard deviation to range from 5.44 mph for 25-mph zones to 7.59 mph for 50-mph zones. In order to compare the variance between groups of sites within different speed zones, the coefficient of variation was calculated for each speed limit group and is presented in Table 3. This measure of relative variation indicates no consistent pattern with the exception of the 45-, 50-, and 55-mph zones having the smallest values indicating a lower degree of spread in the distribution.

Two-Lane Versus Multilane Roadways

Comparison between free-flow mean speeds for two-lane roads versus multilane roads showed no observable differences except for the 30-mph zone. However, in this case, the multilane cell contained only one site. As shown in Figure 2, the means exceeded the posted speed limit across all speed zones by 1 to 4 mph with the exception of the 25- and 30-mph speed zones in which a difference of 8 mph was observed. The 85th-percentile speeds, shown in Figure 3, ranged from 6 to 14 mph over the posted speed limit or 4 to 7 mph over the mean speed. Extremes for the mean and 85th-percentile speeds are presented in Table 4. In no case was the 85th-percentile speed less than the posted speed limit.

TABLE 3 COEFFICIENT OF VARIATION FOR EACH SPEED LIMIT GROUP

Speed Limit	Standard Deviation	Coefficient of Variation
25	5.44	17.6%
30	5.73	15.7%
35	6.58	17.1%
40	7.30	17.5%
45	6.88	14.2%
50	7.59	14.7%
55	6.70	11.8%

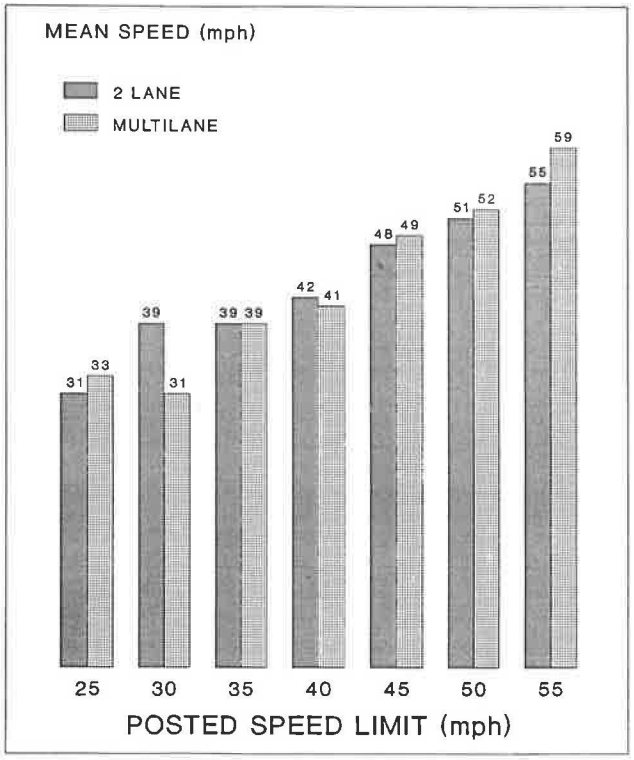

FIGURE 2 Comparison of mean speeds with posted speed limit by speed zone.

Cars Versus Trucks

Comparison between car and truck speed characteristics showed that cars travel 1 to 5 mph faster than trucks for all speed

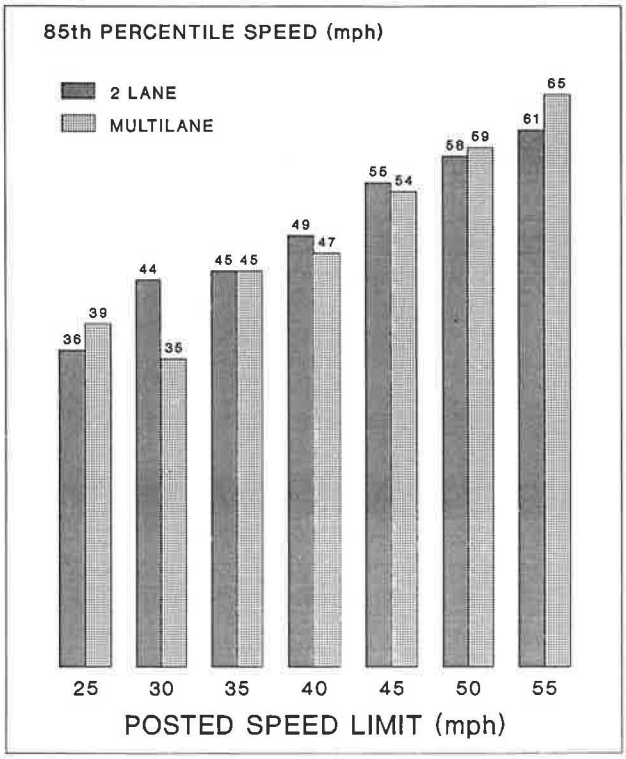

FIGURE 3 Eighty-fifth-percentile speeds.

TABLE 4 EXTREMES FOR MEAN AND 85th-PERCENTILE SPEEDS

Speeds > mean				
Site No.	Speed Limit	No. of Lanes	Mean (mph)	85th % (mph)
8270B	30	2	44.2	51.0
242	30	2	41.3	47.8
11829	35	4	44.8	51.9
Speeds < mean				
Site No.	Speed Limit	No. of Lanes	Mean (mph)	85th % (mph)
304	35	4	31.0	36.1
361	50	2	46.7	54.0
41	30	2	29.9	34.3

zones (see Table 5). For both cars and trucks, 85th-percentile speeds were 4 to 7 mph greater than the mean speed. The largest difference between car and truck speeds for an individual site was 9.8 mph, whereas the smallest observed difference was zero.

Day Versus Night

Free-flow mean and 85th-percentile speeds presented in Table 6 for daytime, nighttime, and dawn and dusk indicated a 0- to 3-mph difference. However, no consistent increase or decrease in speeds was observed on the basis of time of day across all speed classes. The largest observed difference for an individual site was a night speed of 12.5 mph below the dawn and dusk speed. Several sites had speed differences less than 0.5 mph.

Compliance with Posted Speed Limits

General

Throughout the analysis, compliance was treated in terms of the percentage of free-flow vehicles exceeding the posted speed limit, i.e., those vehicles not in compliance with the law. In general, data from the 50 sites revealed that the majority of drivers (70.2 percent) did not comply with posted speed limits. Noncompliance by site ranged from a low of 32 percent to a high of 97 percent with the exception of one site where noncompliance was only 1 percent. This finding remained generally consistent throughout the analysis, regardless of the factors or combination of factors examined.

Figure 4 shows percent noncompliance by posted speed limit. The number at the top of each bar is the percent exceeding the limit; the next number is the percent exceeding the speed limit by more than 5 mph; the next by more than 10 mph; and the bottom number by more than 15 mph. Overall, the percent of drivers exceeding posted speed limits by more than 5 mph was 40.8 percent; by more than 10 mph, 16.8 percent; and by more than 15 mph, 5.4 percent. If the 85th-

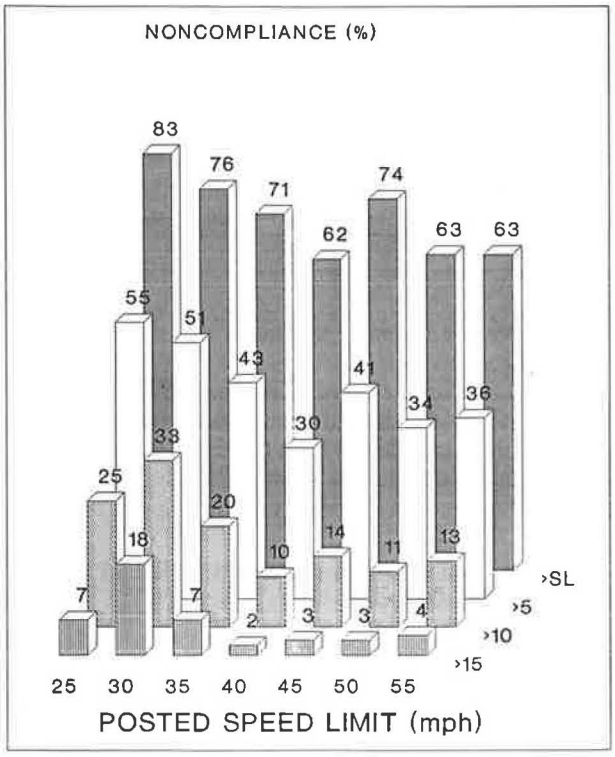

FIGURE 4 Percentage of noncompliance by posted speed limit.

TABLE 5 CAR AND TRUCK SPEED CHARACTERISTICS

Speed Limit (mph)	Mean Speeds (mph)		85th %tile Speeds (mph)	
	Car	Truck	Car	Truck
25	31.1	29.0	36.2	33.6
30	36.6	32.6	42.2	39.1
35	38.6	36.6	44.6	41.3
40	41.8	38.4	48.4	44.9
45	48.6	44.4	54.6	51.1
50	51.6	48.1	58.6	54.5
55	56.3	53.9	62.3	60.5

TABLE 6 FREE-FLOW MEAN AND 85th-PERCENTILE SPEEDS FOR DAYTIME, NIGHTTIME, AND DAWN OR DUSK CONDITIONS

Speed Limit (mph)	Mean Speeds (mph)			85th %tile Speeds (mph)		
	Day	Night	Dawn/Dusk	Day	Night	Dawn/Dusk
25	30.8	30.8	31.1	36.1	35.7	35.9
30	36.6	34.4	36.7	42.1	39.2	41.9
35	38.5	38.9	38.6	44.4	44.9	44.4
40	41.4	39.8	41.2	48.1	45.9	48.2
45	48.5	49.3	48.7	54.4	55.0	54.8
50	51.3	51.6	51.8	58.1	56.9	58.2
55	56.1	56.8	56.2	62.2	61.9	61.8

percentile speed criteria for establishing speed zones was carried over to compliance, the data indicated that, in general, 85 percent compliance was achieved at speeds 10 mph over the posted speed limit.

Noncompliance ranged from a low of 6.2 percent in 40-mph zones to a high of 83.4 percent in 25-mph zones. The only discernible pattern was with the percentages exceeding the limits by more than 10 and 15 mph. Percentage of noncompliance at each of these levels at speed limits of 40 mph and greater was about half that of the noncompliance for sites with speed limits under 40 mph, which may indicate some reluctance by drivers to speed excessively on higher speed roadways.

Two-Lane Versus Multilane Roadways

Data were next examined for two-lane versus multilane roadways for each posted speed limit. Table 7 presents the percentages of drivers exceeding the posted speed limit, and then exceeding the limit by more than 5, 10, and 15 mph. The comparison of noncompliance for two-lane roads versus multilane roads for 25- and 30-mph speed zones is not meaningful because there was only one multilane site in each case. In 35-, 45-, 50-, and 55-mph zones, noncompliance on multilane roads was higher, whereas in 40-mph zones, multilane noncompliance was lower in all categories.

Cars Versus Trucks

As presented in Table 8, noncompliance was higher for cars than for trucks at all levels. Car noncompliance ranged from a low of 63.2 percent in 40-mph zones to a high of 83.7 percent in 25-mph zones. Noncompliance for trucks, which made up an average of 1.38 percent of the free-flow traffic stream, ranged from a low of 40.6 percent in 40-mph zones to a high of 70.0 percent in 25-mph zones. When classified by road type, i.e., two-lane versus multilane, the results were essentially the same. Trucks had a lower noncompliance percentage at all levels in all speed zones. In general, cars exhibited a higher noncompliance percentage on two-lane roads than on multilane roads. With respect to trucks, the results were mixed for two-lane versus multilane roads in all speed zones.

Day Versus Night

Data were classified by time of day into three categories—day, night, and dawn or dusk. As shown in Figure 5, some differences in noncompliance percentages were evident. Significant differences occurred at sites posted as 30 and 40 mph. Percentage of drivers not complying with the speed limit at these locations during the night hours decreased by 9 to 11 percent over the daytime noncompliance rate. However, by examining the percentage of drivers excessively over the posted speed limit, i.e., those drivers traveling more than 10 mph above the limit, a different result is obtained. As shown in Figure 6, the number of drivers exceeding the posted limit by more than 10 mph at 40-mph locations during the night hours is 4 percent higher than the noncompliance rate for the daytime hours. A similar pattern emerged for the 25- and 45-mph sites. Thus, excessive speeding appears more prevalent at night.

Accident Risk

General

Accident data were gathered for each of the roadway segments where speed data were collected. Three years of data

TABLE 7 PERCENTAGE OF DRIVERS EXCEEDING POSTED SPEED LIMIT (OVERALL, AND FOR 5, 10, AND 15 mph OVER LIMIT)

Speed Limit	Road Type	>SL	>5	>10	>15
25	Two-lane	81.5	50.8	22.0	6.3
	Multilane	91.0	70.0	37.0	11.0
30	Two-lane	81.7	62.7	44.0	23.6
	Multilane	58.0	15.0	1.0	0
35	Two-lane	70.5	40.7	16.8	5.2
	Multilane	72.4	46.8	23.6	8.5
40	Two-lane	66.0	34.3	12.0	3.3
	Multilane	56.6	24.3	7.4	2.6
45	Two-lane	73.9	40.6	12.6	2.6
	Multilane	74.2	41.0	14.7	3.4
50	Two-lane	58.0	31.5	10.8	2.3
	Multilane	68.0	35.8	10.6	2.8
55	Two-lane	57.5	35.8	12.5	3.5
	Multilane	73.0	42.0	14.0	3.5

TABLE 8 PERCENTAGE OF DRIVERS EXCEEDING POSTED SPEED LIMIT (OVERALL, AND FOR 5, 10, AND 15 mph OVER LIMIT) BY TYPE OF VEHICLE

Speed Limit	Vehicle Type	>SL	>5	>10	>15
25	Car	83.7	54.9	25.2	7.5
	Truck	70.0	38.4	17.8	3.4
30	Car	75.9	51.2	33.7	18.2
	Truck	62.5	36.5	19.8	5.5
35	Car	71.5	43.8	19.9	6.6
	Truck	57.1	32.1	13.6	5.2
40	Car	63.2	31.0	10.4	2.6
	Truck	40.6	17.8	4.6	0.2
45	Car	74.9	41.7	14.8	3.1
	Truck	49.4	21.4	6.3	0.9
50	Car	63.4	34.1	10.8	2.5
	Truck	44.4	19.0	5.5	1.0
55	Car	63.3	37.1	13.4	4.5
	Truck	52.5	29.8	12.8	3.0

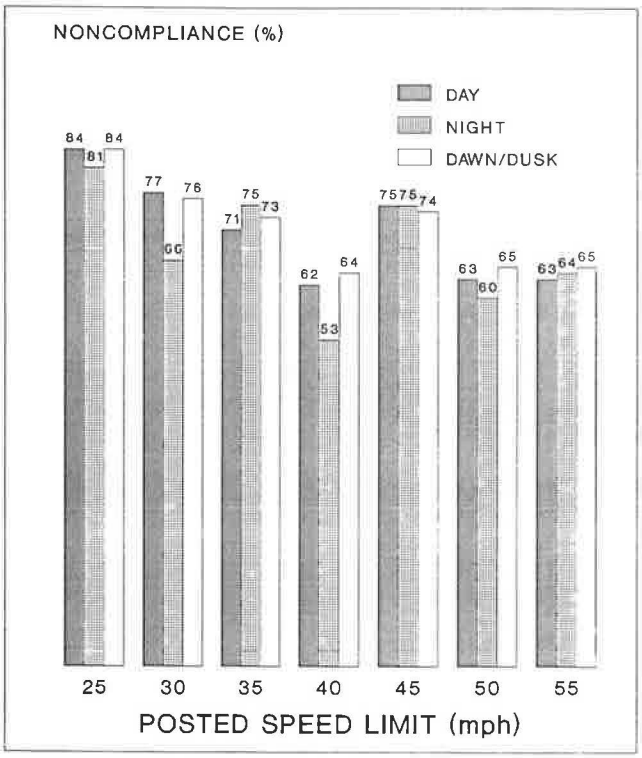

FIGURE 5 Percentage of noncompliance versus speed limit for day, night, and dawn or dusk conditions.

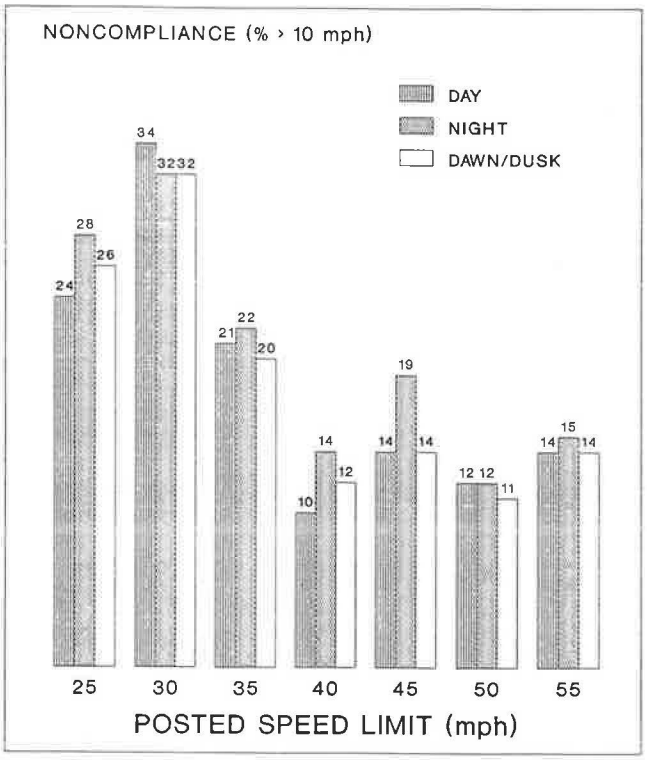

FIGURE 6 Percentage exceeding posted speed by more than 10 mph for day, night, and dawn or dusk conditions.

were used to develop relationships between speed, accident involvement, and accident severity. However, the small number of sites limited the analysis. Of the 44 non-55-mph sites, 25 sites had less than 30 accidents during the 3-year period and 10 sites had 10 or fewer accidents. On the other end of the spectrum, 5 sites had a total of 867 accidents (42 percent of the total 2,054 accidents in the data base) during the 3-year period. The lower and upper extremes of the data base were 0 and 291 accidents, respectively.

Accident Rate Analysis

For each speed limit class, calculated accident rates included overall, injury, fatal, speeding, day, and night rates. Results presented in Table 9 indicate that the rates for the 25-mph zone were consistently higher than for any of the other zones. This finding is primarily because of the one 25-mph, multilane site that had an accident frequency of 291 in a section that was only 0.70 mi long. Examining the remaining numbers in Table 9, the lowest rates are in the 45- and 50-mph zones. The highest rates, excluding the 25-mph zone, are in the 30- and 55-mph zones. Injury rates for each speed zone ranged from 28 to 50 percent of the overall rate, whereas the fatality rate was nonexistent with the exception of the 30- and 55-mph zones. The speeding accident rate was inconsistent among cells and ranged from 7 to 39 percent of the overall accident rate. Final rates, day versus night, indicated that the night rate was consistently lower than the daytime rate. This finding is in contrast to the national trend.

The next step in the accident analysis was to determine the statistical significance for the accident rates. Because the results from Table 9 indicate higher rates for the 25- and 30-mph speed zones, a weighted regression analysis used to test for statistical significance was computed using dummy variables for three speed zone categories—25 mph, 30 mph, and all others. The analysis was used to compare the rates for 25- and 30-mph speed zones to the rates for all other speed zones combined. The results, presented in Table 10, indicate that all rates were significantly different at a confidence level of 95 percent with the exception of the fatal accident rate in the 25-mph zone and the night accident rate and speeding accident rate in the 30-mph zone.

The next step in the analysis was determining variables that may be associated with differing accident rates. Among the variables examined was driveways per mile. Using weighted regressions, accident rates were compared for those sites having fewer than 20 driveways per mile with those sites having 20 or more driveways. The results, presented in Table 11, indicate that there was a significant difference at the 95 percent confidence level for all rates except the fatal and speeding accident rates. There was no significant difference for sites with commercial development versus sites without commercial development.

Accident Involvement Versus Speed

Prior research has indicated a relationship between accident involvement and deviation from the mean speed of the traffic stream (*5,6*). Figure 7 shows these findings for rural highways and freeways, with the lowest involvement rate occurring at 7 and 12 mph over the mean speed, respectively. As a driver deviates from these low points, the accident risk increases.

Results of this study produced similar curves for involvement rate using non-55-mph data from North Carolina and

TABLE 9 ACCIDENT RATES—OVERALL, FATAL, INJURY, SPEEDING, DAY, AND NIGHT

Speed Limit	Overall	Fatal	Injury	Speeding	Day	Night
25	13.53	-	4.45	5.24	6.71	2.68
30	10.81	0.19	2.90	0.72	6.47	1.01
35	2.89	0.02	1.07	0.63	1.97	0.32
40	1.96	-	0.82	0.36	0.92	0.42
45	1.52	0.02	0.66	0.49	1.07	0.30
50	1.74	0.02	0.89	0.17	0.76	0.25

TABLE 10 STATISTICAL SIGNIFICANCE FOR ACCIDENT RATES

Type of Accident Rate	Speed Zone		
	25 mph	30 mph	All Other
Overall	13.53*	10.81*	1.83
Injury	4.45*	2.90*	0.82
Fatal	-	0.19*	0.02
Daytime	6.71*	6.47*	1.19
Nighttime	2.68*	1.01	0.27
Speeding	5.24*	0.72	0.46

* Indicates significant difference from the All Other group at the 95 percent confidence level.

TABLE 11 ACCIDENT RATES USING WEIGHTED REGRESSIONS

Type of Accident Rate	Number of Driveways per Mile	
	<20	20 or more
Overall	1.46	3.11*
Injury	0.64	1.46*
Fatal	0.00	0.03
Daytime	0.91	2.47*
Nighttime	0.27	0.64*
Speeding	0.46	0.91

* Indicates significant difference from the <20 group at the 95 percent confidence level.

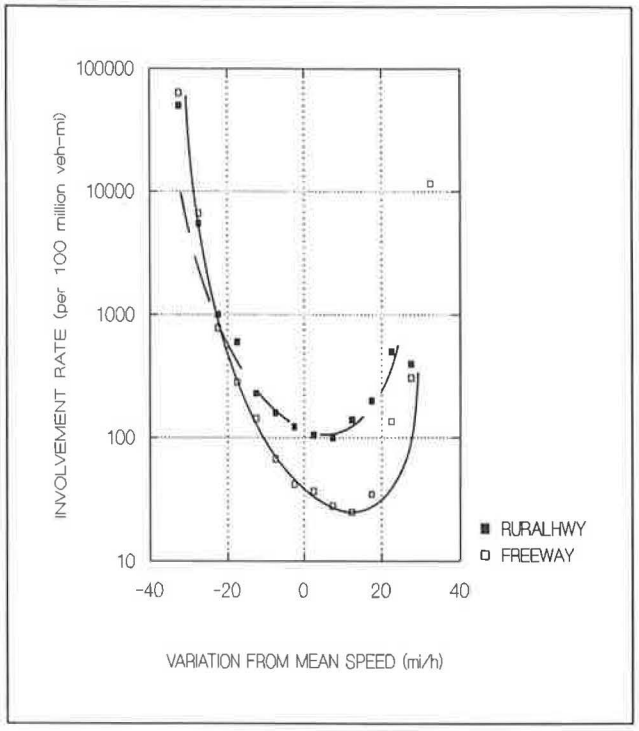

FIGURE 7 Accident involvement and deviation from mean speed of traffic stream for rural highways and freeways (*5,6*).

Colorado. Variation from the mean speed was plotted against involvement rate, which was defined as weekday, nonalcohol, and nonintersection involvements per 100,000 veh-mi (see Table 12 and Figure 8). The lowest involvement rate for this curve occurred at 7 mph above a mean speed of 44.2 mph at 24 involvements per 100,000 veh-mi. A closeup of this low point is shown in Figure 9. A proportion of the cumulative speed distribution curve for North Carolina and Colorado data, with respect to the variation from the mean speed, is also shown in Figure 9. On the basis of these data, the speed at which the accident risk was minimized occurred at the 90th percentile of the travel speeds observed, as shown in Figure 9 by the dashed line that projects upward from the low point of the accident involvement rate curve to the intersection of the cumulative speed distribution curve and then horizontally to the right-hand scale.

ASSESSMENT OF CRITERIA

Criteria used to establish speed limits are important as to whether speed limits are deemed reasonable by the public and whether accident risk is truly minimized. Of the 44 non-55-mph sites used in this study, 21 had speed limits set on the basis of engineering studies, often with 85th-percentile speed as the governing factor. Of the remaining sites, 10 were statutory limits, 2 were based solely on engineering judgment, and the criteria by which 11 were set were unknown. In Table 13, the percentage of vehicles exceeding the speed limit is shown for each speed limit class by the criteria used to establish the limit. In no case is compliance good, but it is extremely poor for the lower-speed zones in which statutory limits are imposed or in which engineering judgment by itself was used in setting the speed limit.

Examining the distribution of percent noncompliance, a natural breakpoint was found at 60 percent. A total of 12 sites exhibited a noncompliance rate of 60 percent or less as presented in Table 14. Also listed are the accident rates for each of those segments. The average accident rate for the 44 non-55-mph sites was 4.27 accidents per million veh-mi (MVM). Of the 12 sites with low compliance, 7 exhibited an accident rate lower than the average; of those 7, 3 had speeds established on the basis of an engineering study, 3 had statutory limits, and 1 was unknown.

The speed statistics reveal that only 7 of the 44 sites had mean speeds lower than the posted speed limits, and no site had an 85th-percentile speed less than the posted limit.

SUMMARY OF FINDINGS

Analysis of travel speed, compliance, and accident risk produced the following significant findings:

- Mean speeds exceeded the posted speed limit by 1 to 8 mph;
- 85th-percentile speeds ranged from 6 to 14 mph over the posted speed limit or 4 to 7 mph over the mean speed;
- Cars travel 1 to 5 mph faster than trucks for all speed zones;
- No consistent increase or decrease in speeds based on time of day was observed across all speed classes;
- The majority (70.2 percent) of free-flow drivers observed did not comply with posted speed limits;

TABLE 12 VARIATION FROM MEAN SPEED AND INVOLVEMENT RATE

Deviation from Mean Speed (mi/h)	Involvements	Vehicle Miles	Involvement Rate*
-25.0 to -29.9	38	1486.83	2556
-20.0 to -24.9	33	1678.41	1966
-15.0 to -19.9	54	4518.67	1195
-10.0 to -14.9	71	15818.39	449
- 5.0 to - 9.9	154	53957.38	285
0.0 to - 4.9	94	136799.50	69
+ 0.1 to + 4.9	63	141032.60	45
+ 5.0 to + 9.9	14	57385.67	24
+10.0 to +14.9	4	7861.62	51
+15.0 to +19.9	2	412.48	485
+20.0 to +24.9	4	64.19	6232
+25.06 to +29.9	1	14.14	7072

* Involvement rate = number of involvements per 100,000 vehicle-miles.

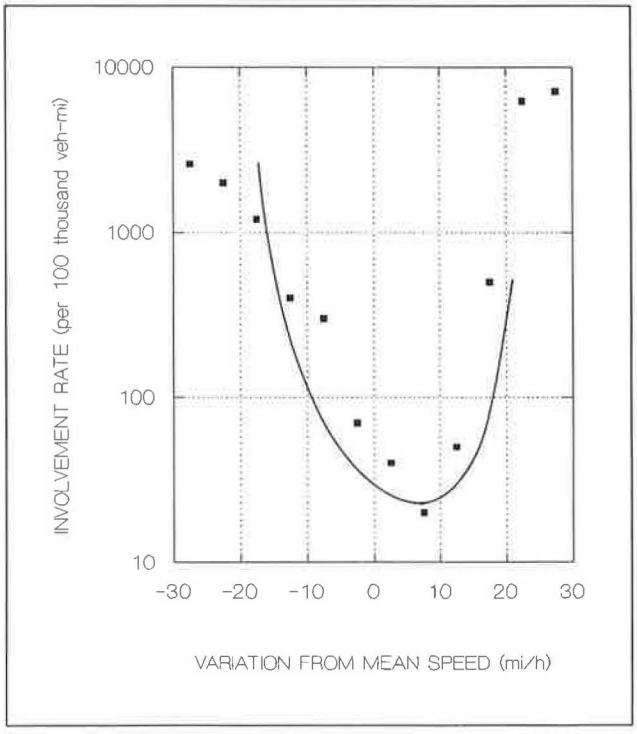

FIGURE 8 Accident involvement rate using non-55-mph data from North Carolina and Colorado (weekday, nonalcohol, and nonintersection involvements per 100,000 veh-mi).

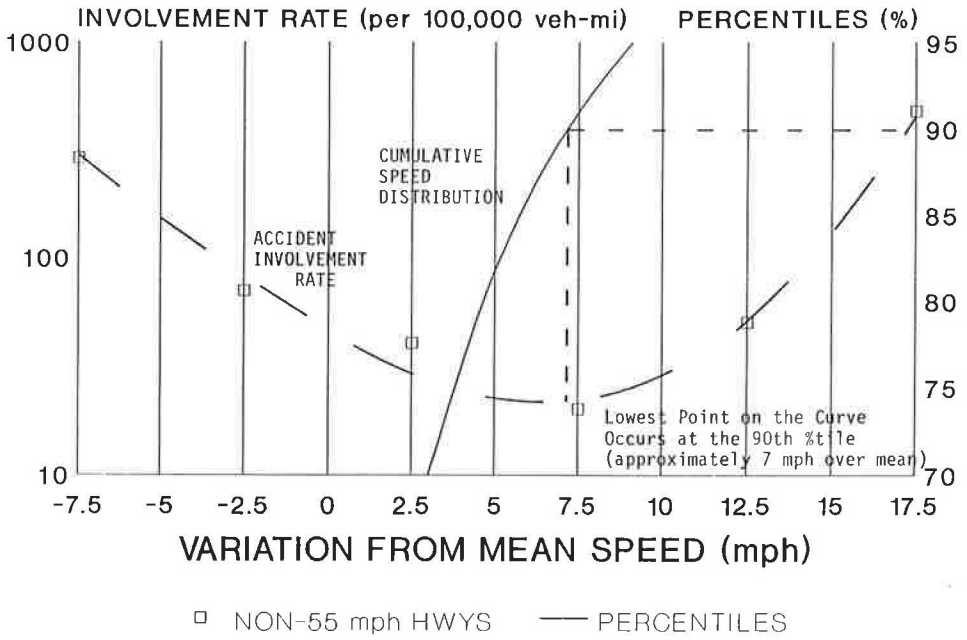

FIGURE 9 Low-point accident involvement rate and cumulative speed distribution curves for North Carolina and Colorado.

TABLE 13 PERCENT OF VEHICLES EXCEEDING SPEED LIMIT FOR EACH SPEED LIMIT CRITERION

Speed Limit	Criteria			
	Engineering Study	Engineering Judgement	Statutory	Unknown
25	74.0	---	95.0	87.0
30	77.5	96.0	---	52.0
35	63.9	---	90.2	52.5
40	60.1	76.0	54.9	---
45	76.7	---	73.0	64.1
50	74.0	---	53.5	67.4

TABLE 14 STUDY SITES WITH NONCOMPLIANCE RATES OF 60 PERCENT OR LESS

Site No.	Noncompliance (%)	Accident Rate (Acc/MVM)
340	51.0	0.79
2965	52.0	1.37
361	32.0	3.20
217	54.9	0.39
8170	58.2	1.71
214	41.6	5.77
133	58.0	1.47
304	41.0	0.42
436	58.0	8.76
041	52.0	19.14
047	58.0	8.31
120	57.0	8.60

- Overall, the percentage of drivers exceeding posted speed limits by more than 5 mph was 40.8 percent, by more than 10 mph, 16.8 percent, and by more than 15 mph, 5.4 percent;
- In general, 85 percent compliance was achieved at speeds 10 mph over the posted speed limit;
- Data indicated some reluctance by drivers to speed excessively on higher-speed roadways;
- Noncompliance was higher for cars than for trucks at all levels;
- Excessive speeding (more than 10 mph over the posted speed limit) is more prevalent at night;
- Accident rates for the 25-mph zones were consistently higher than for any of the other zones;
- In contrast to the national trend, the night accident rate was consistently lower than the daytime rate; and
- Speed at which accident risk was minimized occurred at the 90th percentile of the travel speeds observed.

REFERENCES

1. What Do Speed Limits Mean? *The American City*, Vol. 65, No. 11, Jan. 1950, p. 121.
2. K. B Joscelyn, R. K. Jones, and P. A. Elston. *Maximum Speed Limits—Volume I: A Study for the Selection of Maximum Speed Limits*. National Highway Safety Bureau, Washington, D.C., Oct. 1970.
3. M. R. Parker. *Guidelines for Establishing Speed Zones—Synthesis of Speed Zoning Practices*. FHWA, U.S. Department of Transportation, July 1985.
4. D. L. Harkey, S. E. Davis, H. D. Robertson, and J. R. Stewart. *Assessment of Current Speed Zoning Criteria—Final Report*. FHWA, U.S. Department of Transportation, June 1989.
5. D. Solomon. *Accidents on Main Rural Highways Related to Speed, Driver, and Vehicle*. FHWA, U.S. Department of Transportation, 1964 (reprinted 1974).
6. J. A. Cirillo. Interstate System Accident Research Study II, Interim Report II. *Public Roads*, Vol. 35, No. 3, Aug. 1968.

Publication of this paper sponsored by Committee on Traffic Law Enforcement.