Sample Size Determination for Spot-Speed Studies at Rural, Intermediate, and Urban Locations

J. C. OPPENLANDER, Department of Civil Engineering, University of Illinois

•IN THE estimation of traffic characteristics by a sampling technique, the design of experiment requires the determination of an adequate and economical sample size. The evaluation of speed characteristics is accomplished by a sampling survey and a statistical analysis. A statistical procedure for sample size determination was developed and previously presented (2). This information made it possible to design a spot-speed study with a sample size that is statistically acceptable.

The equation for mimimum sample size was derived, and graphical solutions for this expression were also presented (2). The determination of a sample size for a spot-speed survey is predicated on a knowledge of the standard deviation of vehicular speeds at the study location. The other variables in the sample size expression are selected in accordance with the desired precision of the spot-speed study.

This measure of speed variability can be obtained from the results of previous speed surveys. However, if this quantity is not available, then a reliable estimate of standard deviation permits the use of the equation for determining sample size. The purpose of this study was to supplement the findings of the previous investigation by analyzing the standard deviations of spot speeds for 2- and 4-lane highways in rural, intermediate, and urban areas. The determination of sample size requirements can be greatly facilitated by the availability of standard deviation estimates that accurately describe the variability of spot speeds for various highway types in different traffic areas.

PROCEDURE

Spot-speed data were collected in the summer of 1960 to develop reliable estimates of standard deviations of vehicular speeds. The following numbers of study locations were chosen to provide information for various highway types in different traffic areas of Illinois.

1. Rural area: (a) 2-lane highway, 60; and (b) 4-lane highway, 50.
2. Intermediate area: (a) 2-lane highway, 42; and (b) 4-lane highway, 42.
3. Urban area: (a) 2-lane highway, 47; and (b) 4-lane highway, 40.

The following definitions were adopted to permit the delineation of the three traffic areas:

1. A rural area was any area where the number of residential, commerical, and industrial buildings along the highway was less than 10 per mile and where the number of crossroads and driveways was less than 20 per mile;
2. An intermediate area was any area where the number of residential, commerical, and industrial buildings along the highway was greater than 10 per mile but less than 100 per mile and where the number of crossroads and driveways was greater than 20 per mile; and
3. An urban area was any area where the number of residential, commerical, and industrial buildings along the highway was greater than 100 per mile.

The minimum lengths of highway considered were 1, ½, and ¼ mile, respectively. The speed sites were located on level, tangent roadway sections where traffic conditions were not influenced by the presence of intersections.

Paper sponsored by Committee on Characteristics of Traffic Flow (formerly Committee on Speed Characteristics).

Vehicular speeds were measured during the daytime for low volume conditions. It was considered desirable to evaluate the standard deviations of spot speeds during periods of low traffic flow in order to approach the maximum standard deviations occurring at the various study locations (2). A radar speedmeter was located adjacent to the lane or lanes of traffic being studied and was pointed toward the oncoming vehicles. After the spot speeds of 100 vehicles were obtained, the same procedure was repeated for the other direction of travel with the speedmeter relocated on the opposite side of the highway. This procedure provided a composite sample of 200 observations at each study site. The speedmeter and the observers were concealed from the view of approaching drivers. The average annual daily traffic volume (ADT) for each spot-speed site was obtained from information published by the Illinois Division of Highways (3).

The standard deviation of spot speeds was calculated for each location. Means and standard deviations of these standard deviations were obtained on the IBM 650 computer for the various combinations of traffic areas and highway types. To correlate standard deviation of vehicular speeds with average annual daily traffic volume, a regression routine for this computer provided the regression coefficients and the coefficients of correlation (1).

RESULTS

The results of the regression and correlation analyses are given in Table 1. Except for 4-lane highways located in intermediate and urban areas, the correlation coefficients were not significantly different from zero at the 5 percent level. However, these significant variations in standard deviation of spot speeds were explained to a limited degree by the variations in ADT volume. These linear equations, consequently, offer no advantage in estimating standard deviations for sample size determination. In the first investigation a significant linear relationship was established between standard deviation and ADT for 2-lane rural highways. The standard deviations of vehicular speeds were independent of traffic volumes for 4- and 6-lane rural highways (2).

Because standard deviation was generally independent of ADT for the locations studied, the statistics in Table 2 provide reasonable and proper estimates of standard deviation for computing sample size requirements in the experimental design of spot-speed studies. As indicated by the low standard errors of estimate, the average values produce sample sizes that are statistically adequate. Average standard deviations plus one or two standard errors of estimate are tabulated for use in studies requiring precise speed statistics. Average standard deviations minus one or two standard errors

TABLE 1

RESULTS OF REGRESSION AND CORRELATION ANALYSES
STANDARD DEVIATION OF SPEED VERSUS AVERAGE
ANNUAL DAILY TRAFFIC VOLUME

Traffic Area	Highway Type	Intercept (a)	Slope (b)	Correlation Coefficient (r)	r^2
Rural	Two-lane	6.14	-0.0193	-0.136	0.0185
Rural	Four-lane	4.36	-0.0021	-0.032	0.0010
Intermediate	Two-lane	5.34	-0.0012	-0.012	0.0001
Intermediate	Four-lane	3.07	0.0170	0.366*	0.1340
Urban	Two-lane	6.63	-0.0202	-0.247	0.0610
Urban	Four-lane	1.04	0.0299	0.464*	0.2153

*Significant at the 5 percent level.

TABLE 2

STANDARD DEVIATIONS OF SPOT SPEEDS FOR SAMPLE SIZE DETERMINATION

Traffic Area	Highway Type	Average Standard Deviation (mph)	Standard Error of Estimate (mph)	Average Standard Deviation ± One Standard Error of Estimate (mph)	Average Standard Deviation ± Two Standard Errors of Estimate (mph)
Rural	Two-lane	5.31	0.41	5.72 - 4.90	6.13 - 4.49
Rural	Four-lane	4.16	0.38	4.54 - 3.78	4.92 - 3.40
Intermediate	Two-lane	5.28	0.46	5.74 - 4.82	6.20 - 4.36
Intermediate	Four-lane	5.25	0.45	5.70 - 4.80	6.15 - 4.35
Urban	Two-lane	4.81	0.46	5.27 - 4.35	5.73 - 3.89
Urban	Four-lane	4.88	0.49	5.37 - 4.39	5.86 - 3.90

of estimate are listed for the design of speed studies that are limited in scope by economic considerations. In general, the average standard deviations provide sample sizes that are both statistically sufficient and economical.

The results of this study were developed to augment the findings of the first report on sample size determination. The statistics shown in this paper permit the reliable estimation of a standard deviation of vehicular speeds if this value is not known from a previous spot-speed survey. Finally, the minimum sample size requirement can be calculated from the theoretical expression presented in the first report (2).

The average standard deviations (Table 2) ranged from 4.16 to 5.31 mph for the 6 combinations of traffic areas and highway types. Because this variability in the measures of speed dispersion was limited, an average standard deviation of 5.0 mph is suggested as a rule-of-thumb value for spot speeds on any highway type in any traffic area.

ACKNOWLEDGMENTS

This report is part of the work program of the Vehicular Speed Regulation Project, IHR-53, sponsored by the U. S. Bureau of Public Roads, and the Illinois Division of Highways.

REFERENCES

1. Croxton, F. E., and Cowden, D. J., "Applied General Statistics." 2nd Ed., Prentice-Hall (1955).
2. Oppenlander, J. C., Bunte, W. F., and Kadakia, P. L., "Sample Size Requirements for Vehicular Speed Studies." HRB Bull. 281, 68-86 (1961).
3. "Traffic Characteristics on Illinois Highways." Illinois Division of Highways (1961).