4.1 SPOT SPEED STUDIES

Spot speed studies are conducted to estimate the distribution of speeds of vehicles in a stream of traffic at a particular location on a highway. The speed of a vehicle is defined as the rate of movement of the vehicle; it is usually expressed in miles per hour (mi/h) or kilometers per hour (km/h). A spot speed study is carried out by recording the speeds of a sample of vehicles at a specified location. Speed characteristics identified by such a study will be valid only for the traffic and environmental conditions that exist at the time of the study. Speed characteristics determined from a spot speed study may be used to:

- Establish parameters for traffic operation and control, such as speed zones, speed limits (85th-percentile speed is commonly used as the speed limit on a road), and passing restrictions.
- Evaluate the effectiveness of traffic control devices, such as variable message signs at work zones.
- Monitor the effect of speed enforcement programs, such as the use of drone radar and the use of differential speed limits for passenger cars and trucks.
- Evaluate and or determine the adequacy of highway geometric characteristics, such as radii of horizontal curves and lengths of vertical curves.
- Evaluate the effect of speed on highway safety through the analysis of crash data for different speed characteristics.
- Determine speed trends.
- Determine whether complaints about speeding are valid.

4.1.1 Locations for Spot Speed Studies

The following locations generally are used for the different applications listed:

1. Locations that represent different traffic conditions on a highway or highways are used for *basic data collection*.
2. Mid-blocks of urban highways and straight, level sections of rural highways are sites for *speed trend analyses*.
3. Any location may be used for the solution of a *specific traffic engineering problem*.

When spot speed studies are being conducted, it is important that unbiased data be obtained. This requires that drivers be unaware that such a study is being conducted. Equipment used therefore, should be concealed from the driver, and observers conducting the study should be inconspicuous. Since the speeds recorded eventually will be subjected to statistical analysis, it is important that a statistically adequate number of vehicle speeds be recorded.

4.1.2 Time of Day and Duration of Spot Speed Studies

The time of day for conducting a speed study depends on the purpose of the study. In general, when the purpose of the study is to establish posted speed limits, to observe speed trends, or to collect basic data, it is recommended that the study be conducted when traffic is free-flowing, usually during off-peak hours. However, when a speed study is conducted in response to citizen complaints, it is useful if the time period selected for the study reflects the nature of the complaints.

The duration of the study should be such that the minimum number of vehicle speeds required for statistical analysis is recorded. Typically, the duration is at least 1 hour and the sample size is at least 30 vehicles.

4.1.3 Sample Size for Spot Speed Studies

The calculated mean (or average) speed is used to represent the true mean value of all vehicle speeds at that location. The accuracy of this assumption depends on the number of vehicles in the sample. The larger the sample size, the greater the probability that the estimated mean is not significantly different from the true mean. It is therefore necessary to select a sample size that will give an estimated mean within acceptable error limits. Statistical procedures are used to determine this minimum sample size. Before discussing these procedures, it is first necessary to define certain significant values that are needed to describe speed characteristics. They are:

1. **Average Speed** which is the arithmetic mean of all observed vehicle speeds (which is the sum of all spot speeds divided by the number of recorded speeds). It is given as

$$\bar{u} = \frac{\sum f_i u_i}{\sum f_i} \tag{4.1}$$

   where

   $\bar{u}$ = arithmetic mean
   f_i = number of observations in each speed group
   u_i = midvalue for the ith speed group
   N = number of observed values

   The formula also can be written as

$$\bar{u} = \frac{\sum u_i}{N}$$

   where

   u_i = speed of the ith vehicle
   N = number of observed values

2. **Median Speed** which is the speed at the middle value in a series of spot speeds that are arranged in ascending order. 50 percent of the speed values will be greater than the median; 50 percent will be less than the median.
3. **Modal Speed** which is the speed value that occurs most frequently in a sample of spot speeds.
4. The ***i*th-percentile Spot Speed** which is the spot speed value below which i percent of the vehicles travel; for example, 85th-percentile spot speed is the speed below which 85 percent of the vehicles travel and above which 15 percent of the vehicles travel.

5. **Pace** which is the range of speed—usually taken at 10-mi/h intervals—that has the greatest number of observations. For example, if a set of speed data includes speeds between 30 and 60 mi/h, the speed intervals will be 30 to 40 mi/h, 40 to 50 mi/h, and 50 to 60 mi/h, assuming a range of 10 mi/h. The pace is 40 to 50 mi/h if this range of speed has the highest number of observations.
6. **Standard Deviation of Speeds** which is a measure of the spread of the individual speeds. It is estimated as

$$S = \sqrt{\frac{\sum (u_j - \bar{u})^2}{N - 1}} \tag{4.2}$$

where

S = standard deviation
$\bar{u}$ = arithmetic mean
u_j = jth observation
N = number of observations

However, speed data are frequently presented in classes where each class consists of a range of speeds. The standard deviation is computed for such cases as

$$S = \sqrt{\frac{\sum f_i(u_i - \bar{u})^2}{N - 1}} \tag{4.3}$$

where

u_i = midvalue of speed class i
f_i = frequency of speed class i

Probability theory is used to determine the sample sizes for traffic engineering studies. Although a detailed discussion of these procedures is beyond the scope of this book, the simplest and most commonly used procedures are presented. Interested readers can find an in-depth treatment of the topic in publications listed in the References at the end of this chapter.

The minimum sample size depends on the precision level desired. The precision level is defined as the degree of confidence that the sampling error of a produced estimate will fall within a desired fixed range. Thus, for a precision level of 90–10, there is a 90 percent probability (confidence level) that the error of an estimate will not be greater than 10 percent of its true value. The confidence level is commonly given in terms of the level of significance (α), where α = (100 − confidence level). The commonly used confidence level for speed counts is 95 percent.

The basic assumption made in determining the minimum sample size for speed studies is that the normal distribution describes the speed distribution over a given section of highway. The normal distribution is given as

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2/2\sigma^2} \text{ for } -\infty < x < \infty \tag{4.4}$$

where

μ = true mean of the population
σ = true standard deviation
σ^2 = true variance

The properties of the normal distribution are then used to determine the minimum sample size for an acceptable error d of the estimated speed. The following basic properties are used (see Figure 4.1):

1. The normal distribution is symmetrical about the mean.
2. The total area under the normal distribution curve is equal to 1 or 100%.
3. The area under the curve between $\mu + \sigma$ and $\mu - \sigma$ is 0.6827.
4. The area under the curve between $\mu + 1.96\sigma$ and $\mu - 1.96\sigma$ is 0.9500.
5. The area under the curve between $\mu + 2\sigma$ and $\mu - 2\sigma$ is 0.9545.
6. The area under the curve between $\mu + 3\sigma$ and $\mu - 3\sigma$ is 0.9971.
7. The area under the curve between $\mu + \infty$ and $\mu - \infty$ is 1.0000.

The last five properties are used to draw specific conclusions about speed data. For example, if it can be assumed that the true mean of the speeds in a section of highway is 50 mi/h and the true standard deviation is 4.5 mi/h, it can be concluded that 95 percent of all vehicle speeds will be between $(50 - 1.96 \times 4.5) = 41.2$ mi/h and $(50 + 1.96 \times 4.5) = 58.8$ mi/h. Similarly, if a vehicle is selected at random, there is a 95 percent chance that its speed is between 41.2 and 58.8 mi/h. The properties of the normal distribution have been used to develop an equation relating the sample size to the number of standard variations corresponding to a particular confidence level, the limits of tolerable error, and the standard deviation.

The formula is

$$N = \left(\frac{Z\sigma}{d}\right)^2 \tag{4.5}$$

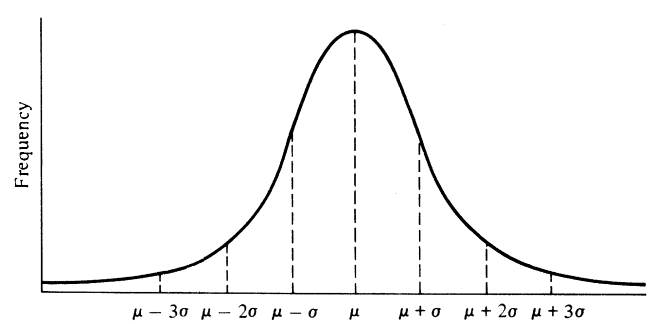


Figure 4.1 Shape of the Normal Distribution

Table 4.1 Constant Corresponding to Level of Confidence

Confidence Level (%)	*Constant Z*
68.3	1.00
86.6	1.50
90.0	1.64
95.0	1.96
95.5	2.00
98.8	2.50
99.0	2.58
99.7	3.00

where

N = minimum sample size
Z = number of standard deviations corresponding to the required confidence
= level 1.96 for 95 percent confidence level (Table 4.1)
σ = standard deviation (mi/h)
d = limit of acceptable error in the average speed estimate (mi/h)

The standard deviation can be estimated from previous data, or a small sample size can first be used.

Example 4.1 Determining Spot Speed Sample Size

As part of a class project, a group of students collected a total of 120 spot speed samples at a location and determined from this data that the standard variation of the speeds was ± 6 mi/h. If the project required that the confidence level be 95% and the limit of acceptable error was ± 1.5 mi/h, determine whether these students satisfied the project requirement.

Solution: Use Eq. 4.5 to determine the minimum sample size to satisfy the project requirements.

$$N = \left(\frac{Z\sigma}{d}\right)^2$$

where

$Z = 1.96$ (from Table 4.1)
$\sigma = \pm 6$
$d = 1.5$

$$N = \left(\frac{1.96 \times 6}{1.5}\right)^2$$
$$= 61.45$$

Therefore, the minimum number of spot speeds collected to satisfy the project requirement is 62. Since the students collected 120 samples, they satisfied the project requirements.

4.1.4 Methods for Conducting Spot Speed Studies

The methods used for conducting spot speed studies can generally be divided into two main categories: manual and automatic. Since the manual method is seldom used, automatic methods will be described.

Several automatic devices that can be used to obtain the instantaneous speeds of vehicles at a location on a highway are now available on the market. These automatic devices can be grouped into three main categories: (1) those that use road detectors, (2) those that are radar-based, and (3) those that use the principles of electronics.

Road Detectors

Road detectors can be classified into two general categories: pneumatic road tubes and induction loops. These devices can be used to collect data on speeds at the same time as volume data are being collected. When road detectors are used to measure speed, they should be laid such that the probability of a passing vehicle closing the connection of the meter during a speed measurement is reduced to a minimum. This is achieved by separating the road detectors by a distance of 3 to 15 ft.

The advantage of the detector meters is that human errors are considerably reduced. The disadvantages are that (1) these devices tend to be rather expensive and (2) when pneumatic tubes are used, they are rather conspicuous and may, therefore, affect driver behavior, resulting in a distortion of the speed distribution.

Pneumatic road tubes are laid across the lane in which data are to be collected. When a moving vehicle passes over the tube, an air impulse is transmitted through the tube to the counter. When used for speed measurements, two tubes are placed across the lane, usually about 6 ft apart. An impulse is recorded when the front wheels of a moving vehicle pass over the first tube; shortly afterward a second impulse is recorded when the front wheels pass over the second tube. The time elapsed between the two impulses and the distance between the tubes are used to compute the speed of the vehicle.

An **inductive loop** is a rectangular wire loop buried under the roadway surface. It usually serves as the detector of a resonant circuit. It operates on the principle that a disturbance in the electrical field is created when a motor vehicle passes across it. This causes a change in potential that is amplified, resulting in an impulse being sent to the counter.

Radar-Based Traffic Sensors

Radar-based traffic sensors work on the principle that when a signal is transmitted onto a moving vehicle, the change in frequency between the transmitted signal and the reflected signal is proportional to the speed of the moving vehicle. The difference between the frequency of the transmitted signal and that of the reflected signal is measured by the equipment and then converted to speed in mi/h. In setting up the equipment, care must be taken to reduce the angle between the direction of the moving vehicle and the line joining the center of the transmitter and the vehicle. The value of the speed recorded depends on that angle. If the angle is not zero, an error related to the cosine of that angle is introduced, resulting in a lower speed than that which would have been recorded if the angle had been zero. However, this error is not very large, because the cosines of small angles are not much less than one.

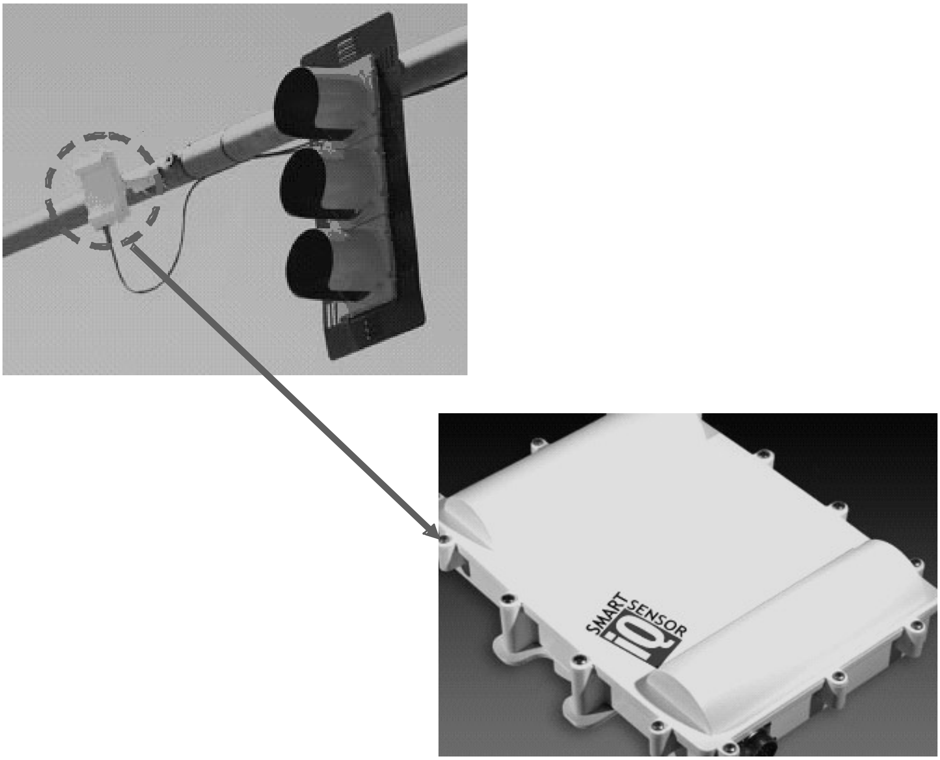
The advantage of this method is that because pneumatic tubes are not used, if the equipment can be located at an inconspicuous position, the influence on driver behavior is considerably reduced.

Figure 4.2 shows a RTMS radar-based traffic sensor manufactured by Electronic Integrated Systems (EIS). This sensor can be deployed either in the forward looking mode as shown in Figure 4.2a or in the side-fire mode as illustrated in Figure 4.2b. When deployed in the forward mode a speed trap or Doppler system is used, and in the side mode a Frequency Modulated Continuous Wave (FMCW) system is used.

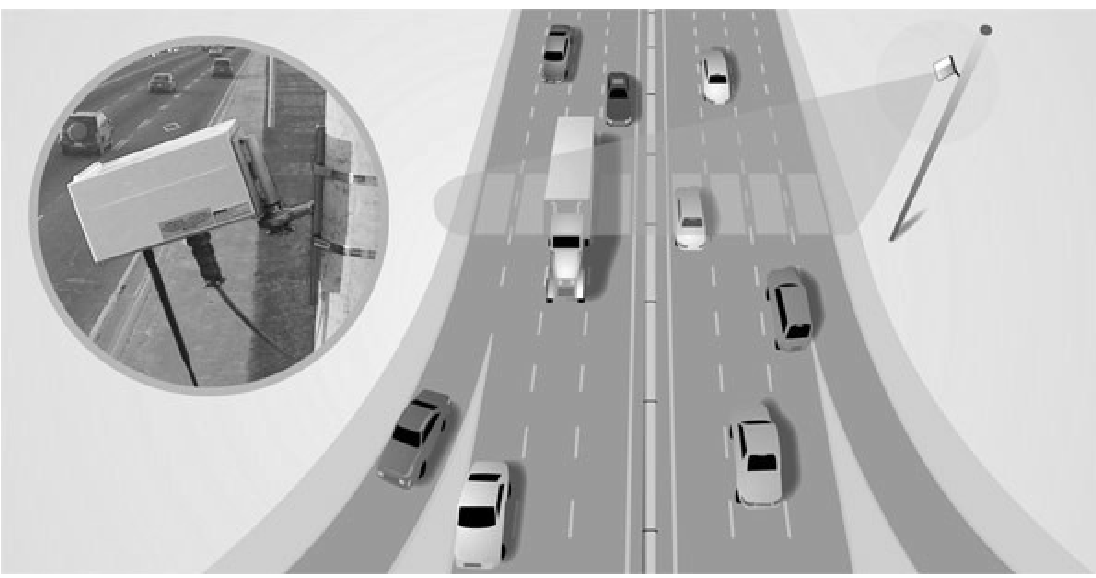
Electronic-Principle Detectors

In this method, the presence of vehicles is detected through electronic means, and information on these vehicles is obtained, from which traffic characteristics, such as speed, volume, queues, and headways are computed. The great advantage of this method over the use of road detectors is that it is not necessary to physically install loops or any other type of detector on the road. A technology using electronics is video image processing, sometimes referred to as a machine-vision system. This system consists of an electronic camera overlooking a large section of the roadway and a microprocessor. The electronic camera receives the images from the road; the microprocessor determines the vehicle's presence or passage. This information is then used to determine the traffic characteristics in real time. One such system is the **autoscope.**

Figure 4.3a schematically illustrates the configuration of the autoscope, which was developed in the United States. It has a significant advantage over loops in that it can detect traffic in many locations within the camera's field of view. The locations to be monitored are selected by the user through interactive graphics which normally takes only a few minutes. This flexibility is achieved by placing electronic detector lines along or across the roadway lanes on the monitor showing the traffic. The detector lines are therefore, not fixed on the roadway because they are not physically located on the roadway but are placed on the monitor. A detection signal, which is similar to that produced by loops, is generated whenever a vehicle crosses the detector lines, indicating the presence or passage of the vehicle. The autoscope is therefore, a wireless detector with a single camera that can replace many loops, thereby providing a wide-area detection system. The device therefore can be installed without disrupting traffic operations, as often occurs with loop installation, and the detection configuration can be changed either manually or by using a software routine that provides a function of the traffic conditions. The device is also capable of extracting traffic parameters, such as volume and queue lengths. Figure 4.3b shows a photograph of the autoscope deployed at a study site.



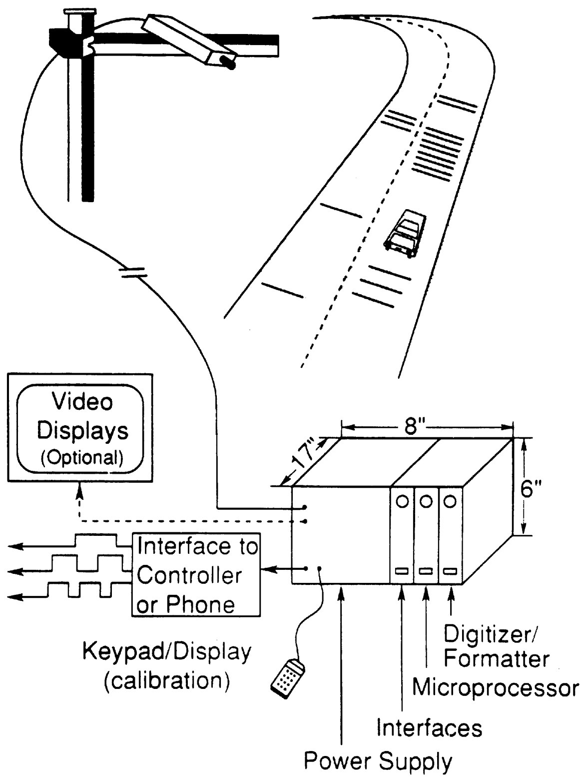
(a) RTMS Deployed in the Forward Looking Mode



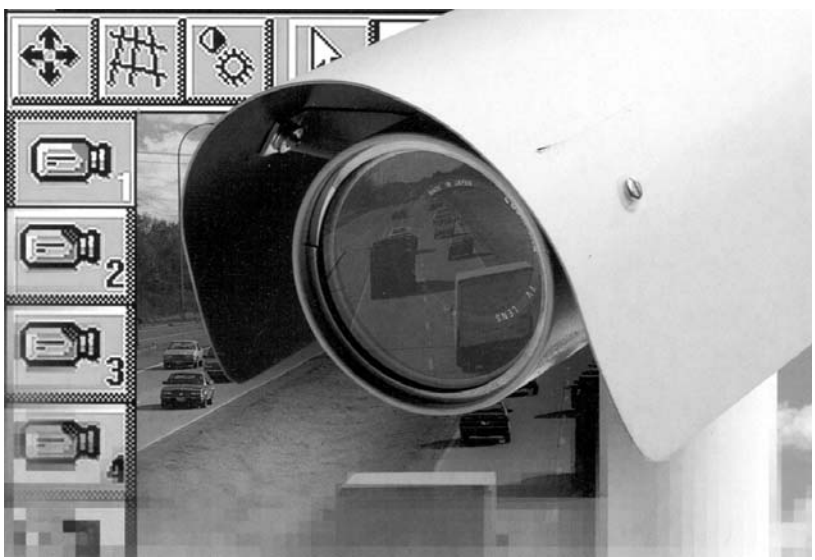
(b) RTMS Deployed in the Side-fire Mode

Figure 4.2 The RTMS Radar-Based Traffic Sensor

SOURCE: From http://www.roadtraffic-technology.com/contractors/detection/eis/



(a) Schematic Illustration of the Autoscope



(b) The Autoscope Deployed

Figure 4.3 The Autoscope

4.1.5 Presentation and Analysis of Spot Speed Data

The data collected in spot speed studies are usually taken only from a sample of vehicles using the section of the highway on which the study is conducted, but these data are used to determine the speed characteristics of the whole population of vehicles traveling on the study site. It is therefore necessary to use statistical methods in analyzing these data. Several characteristics are usually determined from the analysis of the data. Some of them can be calculated directly from the data; others can be determined from a graphical representation. Thus, the data must be presented in a form suitable for specific analysis to be carried out.

The presentation format most commonly used is the frequency distribution table. The first step in the preparation of a frequency distribution table is the selection of the number of classes—that is, the number of velocity ranges—into which the data are to be fitted. The number of classes chosen is usually between 8 and 20, depending on the data collected. One technique that can be used to determine the number of classes is to first determine the range for a class size of 8 and then for a class size of 20. Finding the difference between the maximum and minimum speeds in the data and dividing this number first by 8 and then by 20 gives the maximum and minimum ranges in each class. A convenient range for each class is then selected and the number of classes determined. Usually the midvalue of each class range is taken as the speed value for that class. The data also can be presented in the form of a frequency histogram, or as a cumulative frequency distribution curve. The frequency histogram is a chart showing the midvalue for each class as the abscissa and the observed frequency for the corresponding class as the ordinate. The frequency distribution curve shows a plot of the frequency cumulative percentage against the upper limit of each corresponding speed class.

Example 4.2 Determining Speed Characteristics from a Set of Speed Data

Table 4.2 shows the data collected on a rural highway in Virginia during a speed study. Develop the frequency histogram and the frequency distribution of the data and determine:

1. The arithmetic mean speed
2. The standard deviation
3. The median speed
4. The pace
5. The mode or modal speed
6. The 85th-percentile speed

Solution: The speeds range from 34.8 to 65.0 mi/h, giving a speed range of 30.2. For eight classes, the range per class is 3.75 mi/h; for 20 classes, the range per class is 1.51 mi/h. It is convenient to choose a range of 2 mi/h per class which will give 16 classes. A frequency distribution table can then be prepared, as shown in

Table 4.2 Speed Data Obtained on a Rural Highway

Car No.	*Speed (mi/h)*	*Car No.*	*Speed (mi/h)*	*Car No.*	*Speed (mi/h)*	*Car No.*	*Speed (mi/h)*
1	35.1	23	46.1	45	47.8	67	56.0
2	44.0	24	54.2	46	47.1	68	49.1
3	45.8	25	52.3	47	34.8	69	49.2
4	44.3	26	57.3	48	52.4	70	56.4
5	36.3	27	46.8	49	49.1	71	48.5
6	54.0	28	57.8	50	37.1	72	45.4
7	42.1	29	36.8	51	65.0	73	48.6
8	50.1	30	55.8	52	49.5	74	52.0
9	51.8	31	43.3	53	52.2	75	49.8
10	50.8	32	55.3	54	48.4	76	63.4
11	38.3	33	39.0	55	42.8	77	60.1
12	44.6	34	53.7	56	49.5	78	48.8
13	45.2	35	40.8	57	48.6	79	52.1
14	41.1	36	54.5	58	41.2	80	48.7
15	55.1	37	51.6	59	48.0	81	61.8
16	50.2	38	51.7	60	58.0	82	56.6
17	54.3	39	50.3	61	49.0	83	48.2
18	45.4	40	59.8	62	41.8	84	62.1
19	55.2	41	40.3	63	48.3	85	53.3
20	45.7	42	55.1	64	45.9	86	53.4
21	54.1	43	45.0	65	44.7		
22	54.0	44	48.3	66	49.5		

Table 4.3, in which the speed classes are listed in column 1 and the midvalues are in column 2. The number of observations for each class is listed in column 3; the cumulative percentages of all observations are listed in column 6.

Figure 4.4 shows the frequency histogram for the data shown in Table 4.3. The values in columns 2 and 3 of Table 4.3 are used to draw the frequency histogram, where the abscissa represents the speeds and the ordinate the observed frequency in each class.

Figure 4.5 shows the frequency distribution curve for the data given. In this case, a curve showing percentage of observations against speed is drawn by plotting values from column 5 of Table 4.3 against the corresponding values in column 2. The total area under this curve is one or 100 percent.

Figure 4.6 shows the cumulative frequency distribution curve for the data given. In this case, the cumulative percentages in column 6 of Table 4.3 are plotted against the upper limit of each corresponding speed class. This curve, therefore, gives the percentage of vehicles that are traveling at or below a given speed.

The characteristics of the data can now be given in terms of the formula defined at the beginning of this section.

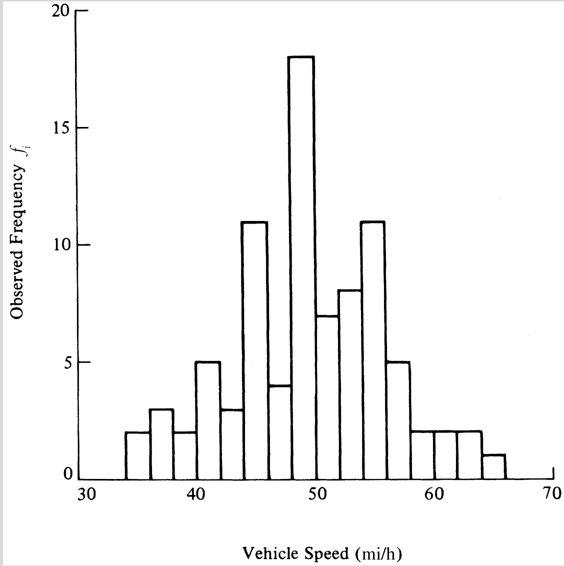


Figure 4.4 Histogram of Observed Vehicles' Speeds

Table 4.3 Frequency Distribution Table for Set of Speed Data

1 *Speed Class (mi/hr)*	2 *Class Midvalue, u_i*	3 *Class Frequency (Number of Observations in Class), f_i*	4 *$f_i u_i$*	5 *Percentage of Observations in Class*	6 *Cumulative Percentage of All Observations*	7 *$f(u_i - \bar{u})^2$*
34–35.9	35.0	2	70	2.3	2.30	420.5
36–37.9	37.0	3	111	3.5	5.80	468.75
38–39.9	39.0	2	78	2.3	8.10	220.50
40–41.9	41.0	5	205	5.8	13.90	361.25
42–43.9	43.0	3	129	3.5	17.40	126.75
44–45.9	45.0	11	495	12.8	30.20	222.75
46–47.9	47.0	4	188	4.7	34.90	25.00
48–49.9	49.0	18	882	21.0	55.90	9.0
50–51.9	51.0	7	357	8.1	64.0	15.75
52–53.9	53.0	8	424	9.3	73.3	98.00
54–55.9	55.0	11	605	12.8	86.1	332.75
56–57.9	57.0	5	285	5.8	91.9	281.25
58–59.9	59.0	2	118	2.3	94.2	180.50
60–61.9	61.0	2	122	2.3	96.5	264.50
62–63.9	63.0	2	126	2.3	98.8	364.50
64–65.9	65.0	1	65	1.2	100.0	240.25
Totals		86	4260			3632.00

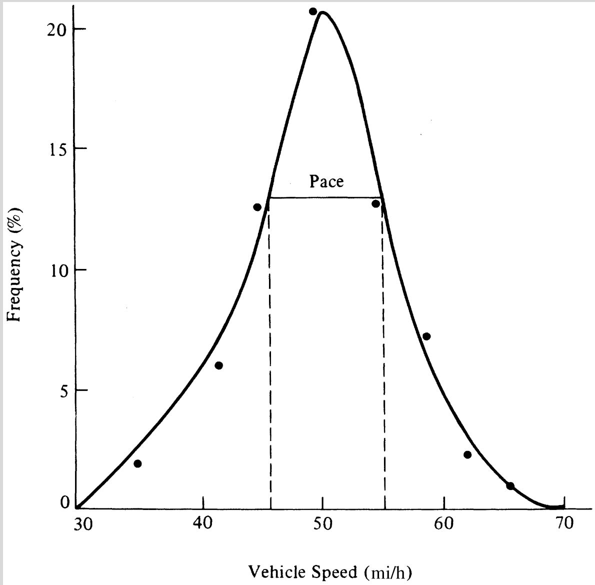


Figure 4.5 Frequency Distribution

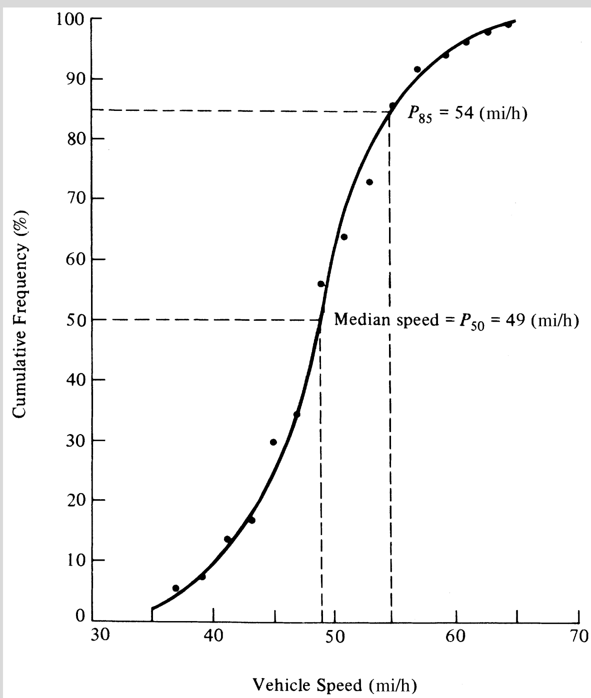


Figure 4.6 Cumulative Distribution

Solution:

- The arithmetic mean speed is computed from Eq. 4.1.

$$\bar{u} = \frac{\sum f_i u_i}{\sum f_i}$$

$$\sum f_i = 86$$

$$\sum f_i u_i = 4260$$

$$\bar{u} = \frac{4260}{86} = 49.5 \text{ mi/h}$$

- The standard deviation is computed from Eq. 4.2.

$$S = \sqrt{\frac{\sum f_i (u_i - \bar{u})^2}{N - 1}}$$

$$\sum f_i (u_i - \bar{u})^2 = 3632$$

$$(N - 1) = \sum f_i - 1 = 85$$

$$S^2 = \frac{3632}{85} = 42.73$$

$$S = \pm 6.5 \text{ mi/h}$$

- The median speed is obtained from the cumulative frequency distribution curve (Figure 4.6) as 49 mi/h, the 50th-percentile speed.
- The pace is obtained from the frequency distribution curve (Figure 4.5) as 45 to 55 mi/h.
- The mode or modal speed is obtained from the frequency histogram as 49 mi/h (Figure 4.4). It also may be obtained from the frequency distribution curve shown in Figure 4.5, where the speed corresponding to the highest point on the curve is taken as an estimate of the modal speed.
- 85th-percentile speed is obtained from the cumulative frequency distribution curve as 54 mi/h (Figure 4.6).

4.1.6 Other Forms of Presentation and Analysis of Speed Data

Certain applications of speed study data may require a more complicated presentation and analysis of the speed data. For example, if the speed data are to be used in research on traffic flow theories, it may be necessary for the speed data to be fitted into a suitable theoretical frequency distribution, such as the normal distribution or the Gamma distribution. This is done first by assuming that the data fit a given distribution and then by testing this assumption using one of the methods of hypothesis testing, such as chi-square analysis. If the test suggests that the assumption can be accepted, specific parameters of the distribution can be found using the speed data. The properties of this distribution are then used to describe the speed characteristics, and any form of mathematical computation can be carried out using the distribution.

Detailed discussion of hypothesis testing is beyond the scope of this book, but interested readers will find additional information in any book on statistical methods for engineers.

4.1.7 Comparison of Mean Speeds

It is also sometimes necessary to determine whether there is a significant difference between the mean speeds of two spot speed studies. This is done by comparing the absolute difference between the sample mean speeds against the product of the standard deviation of the difference in means and the factor Z for a given confidence level. If the absolute difference between the sample means is greater, it can then be concluded that there is a significant difference in sample means at that specific confidence level.

The standard deviation of the difference in means is given as

$$S_d = \sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}} \tag{4.6}$$

where

n_1 = sample size for study 1
n_2 = sample size for study 2
S_d = square root of the variance of the difference in means
S_1^2 = variance about the mean for study 1
S_2^2 = variance about the mean for study 2

If $\bar{u}_1$ = mean speed of study 1, $\bar{u}_2$ = mean speed of study 2, and $|\bar{u}_1 - \bar{u}_2| > ZS_d$ where $|\bar{u}_1 - \bar{u}_2|$ is the absolute value of the difference in means, it can be concluded that the mean speeds are significantly different at the confidence level corresponding to Z. This analysis assumes that $\bar{u}_1$ and $\bar{u}_2$ are estimated means from the same distribution. Since it is usual to use the 95 percent confidence level in traffic engineering studies, the conclusion will, therefore, be based on whether $|\bar{u}_1 - \bar{u}_2|$ is greater than $1.96S_d$.

Example 4.3 Significant Differences in Average Spot Speeds

Speed data were collected at a section of highway during and after utility maintenance work. The speed characteristics are given as, $\bar{u}_1$, S_1 and $\bar{u}_2$, S_2 as shown below. Determine whether there was any significant difference between the average speed at the 95% confidence level.

$\bar{u}_1 = 35.5$ mi/h	$\bar{u}_2 = 38.7$ mi/h
$S_1 = 7.5$ mi/h	$S_2 = 7.4$ mi/h
$n_1 = 250$	$n_2 = 280$

Solution:

- Use Eq. 4.6.

$$S_d = \sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}$$

$$= \sqrt{\frac{(7.5)^2}{250} + \frac{(7.4)^2}{280}} = 0.65$$

- Find the difference in means.

$$38.7 - 35.5 = 3.2 \text{ mi/h}$$
$$3.2 > (1.96)(0.65)$$
$$3.2 > 1.3\text{mi/h}$$

It can be concluded that the difference in mean speeds is significant at the 95% confidence level.

4.2 VOLUME STUDIES

Traffic volume studies are conducted to collect data on the number of vehicles and/or pedestrians that pass a point on a highway facility during a specified time period. This time period varies from as little as 15 minutes to as much as a year depending on the anticipated use of the data. The data collected also may be put into subclasses which may include directional movement, occupancy rates, vehicle classification, and pedestrian age. Traffic volume studies are usually conducted when certain volume characteristics are needed, some of which follow:

1. **Average Annual Daily Traffic** (AADT) is the average of 24-hour counts collected every day of the year. AADTs are used in several traffic and transportation analyses for:
   a. Estimation of highway user revenues
   b. Computation of crash rates in terms of number of crashes per 100 million vehicle miles
   c. Establishment of traffic volume trends
   d. Evaluation of the economic feasibility of highway projects
   e. Development of freeway and major arterial street systems
   f. Development of improvement and maintenance programs
2. **Average Daily Traffic** (ADT) is the average of 24-hour counts collected over a number of days greater than one but less than a year. ADTs may be used for:
   a. Planning of highway activities
   b. Measurement of current demand
   c. Evaluation of existing traffic flow