TRAFFIC ENGINEERING

Civil Engineering Department

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Methods of Conducting Spot Speed Studies (واجب تقرير)

Spot speed data are gathered using one of these three methods:

1. Manually (use stop watch methods).
2. Automatic:
   - road detectors.
   - Doppler principle meters.
   - principle of electronics.

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, therefore it necessary to use stastical methods in analyzing these data.

- Several characteristics are usually determined from analysis of data. some of them are calculated directly from data, others can be determined from a graphical representation of the data.

Example : (Determining speed characteristics from set of speed data)

The data collected are shown in Table(1) 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 modal speed.

Table (1) : Data of Speed Study

Car No.	Speed (mph)	car No.	Speed (mph)	Car No.	Speed (mph)	Car No.	Speed (mph)	car No.	Speed (mph)
1	35.1	12	44.6	23	46.1	34	53.7	45	47.8
2	44	13	45.2	24	54.2	35	40.8	46	47.1
3	45.8	14	41.1	25	52.3	36	54.5	47	34.8
4	44.3	15	55.1	26	57.3	37	51.6	48	52.4
5	36.3	16	50.2	27	46.8	38	51.7	49	49.1
6	54	17	54.3	28	57.8	39	50.3	50	37.1
7	42.1	18	45.4	29	36.8	40	59.8	51	65
8	50.1	19	55.2	30	55.8	41	40.3	52	49.5
9	51.8	20	45.7	31	43.3	42	55.1	53	52.2
10	50.8	21	54.1	32	55.3	43	45.1	54	48.4
11	38.3	22	54	33	39.0	44	48.3	55	42.8

Car No.	Speed (mph)	Car No.	Speed (mph)	Car No.	Speed (mph)	Car No.	Speed (mph)
56	49.5	66	49.5	76	63.4	86	53.4
57	48.6	67	56.0	77	60.1		
58	41.2	68	49.1	78	48.8		
59	48.0	69	49.2	79	52.1		
60	58.0	70	56.4	80	48.7		
61	49	71	48.5	81	61.8		
62	41.8	72	45.4	82	56.6		
63	48.3	73	48.6	83	48.2		
64	45.9	74	52.0	84	62.1		
65	44.7	75	49.8	85	53.3		

Solution:

1) The arithmatic mean speed $\bar{U} = \dfrac{\sum f_i u_i}{\sum f_i}$

$\sum f_i = 86$
$\sum f_i u_i = 4260$ } From table (2)

$\bar{U} = \dfrac{4260}{86} = 49.5$ mph

(1) Speed class	(2) class mid value (u_i)	(3) class frequency No. of obsv. in class (f_i)	(4) ($f_i u_i$)	(5) (%) of obsv. in class	(6) Cumulative (%) of all observ.	(7) $f(u_i-\bar{u})^2$
34-35.9	35.0	2	70	2.3	2.3	420.5
36-37.9	37.0	3	111	3.5	5.8	468.75
38-39.9	39.0	2	78	2.3	8.10	220.5
40-41.9	41.0	5	205	5.8	13.9	361.25
42-43.9	43.0	3	129	3.5	17.4	126.75
44-45.9	45.0	11	495	12.8	30.2	222.75
46-47.9	47.0	4	188	4.7	34.9	25.0
48-49.9	49.0	18	882	21.0	55.9	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	98.0
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	180.5
60-61.9	61.0	2	122	2.3	96.5	264.5
62-63.9	63.0	2	126	2.3	98.8	364.5
64-65.9	65.0	1	65	1.2	100	240.25
Total		86				3632.00

2) Standard deviation is computed

$$s^2 = \frac{\sum f(u_i-\bar{u})^2}{(\sum f - 1)} = \frac{3632}{85} \Rightarrow s = \pm 6.5 \text{ mph}$$

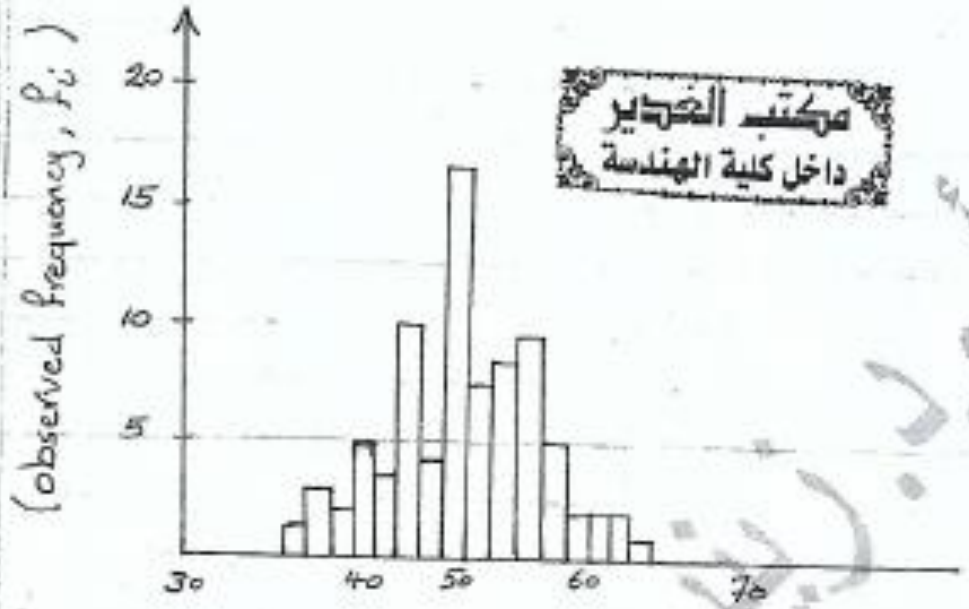

Figure (1): Histogram of observed vehicle speed.

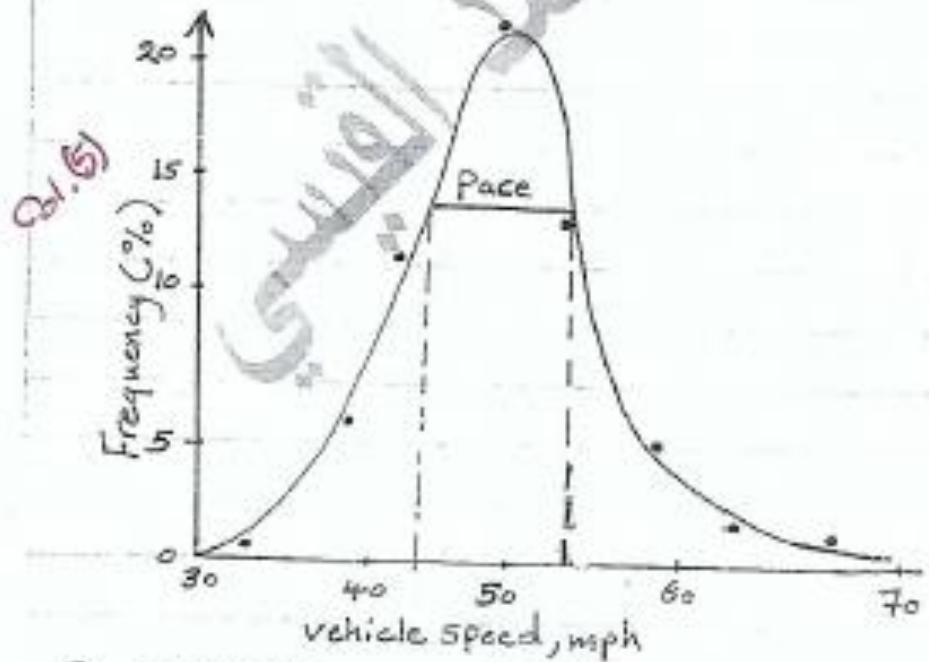

Figure (2): Frequency Distribution.

col. (6)

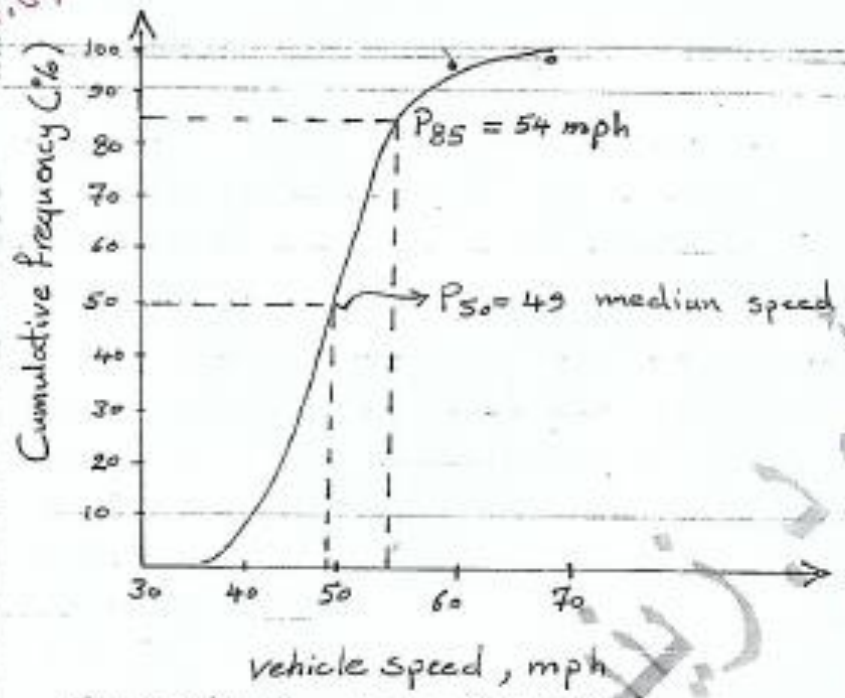

Figure (3): Cumulative Distribution.

3. The median speed is obtained from the cumulative frequency distribution curve (Figure 3) as 49 mph, the speed 50th percentile.

4. The pace is obtained from frequency distribution curve (Figure 2) as (45 to 55) mph.

5. The modal speed is obtained from the frequency histogram as 49 mph (Figure 1) or it can be obtained from the frequency distribution curve Figure (2).

6. The 85 percentile speed is obtained from Figure (3), cumulative frequency distribution as 54 mph.

Comparison of Mean Speed

It is also sometimes necessary to determine whether there is a significant difference between the mean speeds of two spot studies.

The standard deviation of the difference in means is given as:

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

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 $\overline{U}_1$ = mean speed of study 1, $\overline{U}_2$ = mean speed of study 2

$$\Rightarrow |\overline{U}_1 - \overline{U}_2| > Z\, S_d$$

$|\overline{U}_1 - \overline{U}_2|$ is absolute value of the difference in means

Z = number of standard deviations corresponding to the required confidence level = 1.96 for confidence level 95%

Table : Constant corresponding to level of Confidence

Confidence level (%)	Constant
68.3	1.00
86.6	1.5
90.0	1.64
95	1.96
95.5	2.00
98.8	2.5
99.0	2.58
99.7	3.00

Example: Speed data were collected at a section of highway during and after utility maintenance work. The speed characteristics are given as shown below, determine whether there was any significant difference between the average speed at 95 percent confidence level.

$\bar{U}_1 = 35.5$ mph $\quad \bar{U}_2 = 38.7$ mph

$S_1 = 7.5$ mph $\quad S_2 = 7.4$ mph

$n_1 = 250 \quad n_2 = 280$

Solution:

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

The difference in mean = 38.7 − 35.5 = 3.2 mph

$3.2 > (1.96)(0.65)$

$3.2 > 1.3$ mph

Example: Determine the minimum sample size required for a spot speed study on a rural two-lane highway if the confidence level for the study is 95 percent and the tolerance is ∓ 1 mph. Assume a standard deviation of ∓ 5.30 mph.

Solution:

$$N = \left(\frac{Z\sigma}{d}\right)^2$$, where: σ: standard deviation (mph)
d: limit of acceptable error in the speed estimate (mph)

$Z = 1.96$ (from table).

$\sigma = \mp 5.3$

$d = \mp 1$

$$\therefore N = \frac{(1.96 * 5.3)^2}{(1)^2} = 108$$ minimum sample size

Therefore, sample size should be at least 108.