TRAFFIC CHARACTERISTICS AND SPOT SPEED ANALYSIS IN URBAN ROADS

Характеристики движения и скорость на улицах города

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Abstract
The main objective of this paper is to describe the traffic characteristics and analysis of spot speed of vehicles using urban roads. Some urban roads in Fayoum City in Egypt are taken as case study.

This research work was based on the traffic count and spot speed data was collected by using of moving car method through peak period. This speed is used to estimate the speed distribution of the traffic stream under the prevailing conditions. The speed distributions obtained have many applications such as study of speed trends, estimate maximum, minimum and average speed limits, geometric design elements, and accident analysis. The analysis of data collected showed the following results:

1. The estimated values of traffic congestion index are 0.95, and 0.81 for Mostafa Kamel / Saeed Bashah direction and Saeed Bashah / Mostafa Kamel direction respectively.

2. The average speed values of different vehicle types using Horia street are 34 km/hr, 33 km/hr and 28 km/hr for Mostafa Kamel / Saeed Bashah direction for passenger cars, microbuses, and trucks. For the other direction the values are 31.5 km/hr, 33.5 km/hr, and 29 km/hr for the same vehicles respectively.

Accepted Sep. 27, 1998.
3. Spot speed distributions for different vehicle types are yielded to normal distribution and are fitted by using Chi-Square test.

4. Low spot speeds registered for the study street must draw the attention to improve the driving and geometric conditions on this street.

1. Introduction

The traffic flow characteristics and spot speed measures are very important to study in order to know the individual speeds of vehicles passing at a given point on a road or a street [1]. These individual speeds are used to estimate the speed distribution of the traffic stream under the prevailing conditions [2]. The speed distributions obtained have many applications. They are:

- Study of speed trends,
- Establish maximum and minimum speed limits,
- Accident analysis, and
- Geometric design.

Some previous studies of speed characteristics can be described as follows: Measurements of speed/flow relations on residential roads during the summer of 1973 have been studied for traffic on improved and unimproved sections of A66 Penrith Cockermouth road in U.K. [3,4].

In Egypt, the spot speed characteristics on Egyptian rural highways are studied and evaluated [2]. In addition, the measurements of average running speed of Crouha street and traffic flow characteristics in Haipolis area have been studied [5]. Also, the spot speed characteristics for vehicles using urban street in Safaga city in Republic of Yemen are studied [6].

The primary objective of this paper is to investigate the variation of vehicle speed around the speed limit, especially in urban streets. Also, the traffic flow behaviors which gives traffic safety should be described. Fayoum city in Egypt taken as case study.

2. The Surveys

2.1. General

In this research work, the classified count of traffic flow was carried out on Horia street in Fayoum City between Mostafa Kamel intersection and Saad Basha intersection (as shown in Fig.1) between 8:00 a.m. and 11:00 a.m., on Tuesday, April 7th, 1998. Also, the spot speed at the same section traffic count was measured through 8:00 a.m. till 10:00 a.m. for both directions of study street.

The selection of this location of survey was made on the following bases:
- to cater for different environmental operating conditions, and
- this site has a medium traffic volume in order to avoid excessive vehicle interactions.
2.2 Vehicle type

For the purpose of this research, vehicles are classified by type as follows:
- Passenger cars including private cars, vans, jeep and taxi's.
- Buses with seating capacity of 40 more,
- Microbuses with seating of 28 seats,
- Pick-up vehicles with loading capacity of 1.5 tons, and
- Trucks including light, medium, and heavy vehicles.

2.3 Sampling Requirements:

The minimum sample size required for a normally distribution population may be determined by considering the confidence intervals. The required sample size (N) is determined using the following formula (1):

\[ N = \frac{z^2 \sigma^2}{\epsilon^2} \]

Where:
- \( z \) = a statistic value depends upon the confidence level. For 95% confidence level, \( z = 1.96 \)
- \( \sigma \) = standard deviation of the sample (in this case \( \sigma = 8.00 \) km/hr.)
- \( \epsilon \) = permitted error in the estimate of the population mean (in this case \( \epsilon = 1.00 \) km/hr.)

Thus, the necessary sample size is computed as:

\[ N = (1.96^2) \times 8^2 / 2^2 = 62 \]

Table (1) shows the sample size of the different vehicle types.

<table>
<thead>
<tr>
<th>Traffic</th>
<th>Passenger Cars</th>
<th>Microbuses</th>
<th>Buses</th>
<th>Pick-up</th>
<th>Trucks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mostafa</td>
<td>475</td>
<td>350</td>
<td>159</td>
<td>61</td>
<td>95</td>
</tr>
<tr>
<td>Sheh</td>
<td>390</td>
<td>335</td>
<td>48</td>
<td>38</td>
<td>88</td>
</tr>
<tr>
<td>Total</td>
<td>865</td>
<td>685</td>
<td>107</td>
<td>119</td>
<td>196</td>
</tr>
</tbody>
</table>

From Table (1), the sample size of buses and pick-up vehicles were rather low, and the number of buses and pick-up vehicles should be excluded from the analysis.

3. Statistics background

In traffic engineering practice, it is necessary to evaluate a set of field measurements in order to find a meaningful interpretation of their values. In this section, a number of statistics are illustrated as defined in Ref. [27]:
3.1. Arithmetic Mean:

The arithmetic mean is a measure of central tendency of the data. For grouped data (as in the case of speed data) the arithmetic mean is determined as follows:

\[
\bar{X} = \frac{\sum f_i x_i}{n}
\]

Where \(x_i\) and \(f_i\) are midpoint and frequency of the \(i^{th}\) group.

3.2. Standard Deviation:

The standard deviation is a measure of spread about the mean. For grouped data, it can be determined as follows:

\[
S = \sqrt{\frac{\sum f_i (x_i - \bar{X})^2}{n}} = \sqrt{\frac{(\sum f_ix_i)^2}{n} - \frac{(\sum f_ix_i)^2}{n^2}}
\]

3.3. The Standard Error of the Mean (SEM):

This statistic indicates the confidence with which the sample mean may be assumed to be the actual mean of all traffic. It can be determined as follows:

\[
SEM = \frac{S}{\sqrt{n-1}}
\]

3.4. Median:

It is the speed at which there are just as many vehicles going slower. Its value corresponds to the 50 percentile of the cumulative distribution curve.

3.5. The 85th Percentile Speed:

It is the speed below which 85% of drivers operate. It is sometimes referred to as the critical speed and used as a good guide in establishing speed limits.

4. Survey results:

4.1. Traffic count results:

4.1.1. Traffic volume and directional distributions

Traffic counts were collected for 3 hours starting at 8.00 a.m. till 11.00 a.m. in April 1998 for both directions of Hord street, Fayoum city at section lies between Mestafa Kamel and Saad Basha intersections. The traffic counts and the variation in traffic volumes were used to determine the peak hour traffic volume and directional distribution factors on the street under study.

Peak hour traffic volumes in vehicles and passenger car units (p.c.u) were obtained and given in Table(2).
### Table 2: Results of traffic counts

<table>
<thead>
<tr>
<th>Survey time</th>
<th>Traffic Volume</th>
<th>Mustafa Kamel / Saed Basha</th>
<th>Veh./hr</th>
<th>P.c.u./hr</th>
<th>Saed Basha / Mustafa Kamel</th>
<th>Veh./hr</th>
<th>P.c.u./hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.00 - 9.00</td>
<td>2215</td>
<td>2480</td>
<td></td>
<td></td>
<td>2500</td>
<td>2575</td>
<td></td>
</tr>
<tr>
<td>9.00 - 10.00</td>
<td>2755</td>
<td>3080</td>
<td></td>
<td></td>
<td>2450</td>
<td>2740</td>
<td></td>
</tr>
<tr>
<td>10.00 - 11.00</td>
<td>2620</td>
<td>2930</td>
<td></td>
<td></td>
<td>2250</td>
<td>2530</td>
<td></td>
</tr>
<tr>
<td>Peak hour traffic volume</td>
<td>2755</td>
<td>3080</td>
<td></td>
<td></td>
<td>2450</td>
<td>2740</td>
<td></td>
</tr>
</tbody>
</table>

| Directional distribution % | 0.49 | 0.31 |

From the table (2), directional distribution of Mustafa Kamel / Saed Basha direction 0.49 and for other direction was 0.31.

### 4.1.2. Traffic Composition Results:

Traffic counts were carried out in order to evaluate the amount and composition of traffic on the street under study.

Table (3) shows the number of different vehicle types and their percentages during peak hour for Horsa street.

<table>
<thead>
<tr>
<th>Street</th>
<th>Traffic direction</th>
<th>Traffic Composition Peak hour 9-10 a.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mustafa Kamel</td>
<td>Passenger Cars</td>
<td>Micro-buses</td>
</tr>
<tr>
<td>Saed Basha</td>
<td>No. %</td>
<td>No. %</td>
</tr>
<tr>
<td>1570 57</td>
<td>362 24</td>
<td>110 14</td>
</tr>
<tr>
<td>Saed Basha</td>
<td>1471 80</td>
<td>362 23</td>
</tr>
</tbody>
</table>

From table (3), the results of traffic compositions during peak hour time between 9.00 a.m. and 10.00 a.m. showed the following characteristics:

1. Mustafa Kamel / Saed Basha direction: the passenger cars of this direction represent 57% of total vehicles, while the micro-buses represent 24% of total vehicles; buses represent only 4% of total vehicles; pick-up vehicles represent 2%; truck vehicles represent 12%; and only 1% of total vehicles represent others.

2. Saed Basha / Mustafa Kamel direction: the traffic compositions for this direction during peak hour between 9.00 a.m. and 10.00 a.m. showed about 60%, 23%, 3%, 4%, 12% and 2% of total vehicles represent passenger cars, micro-buses, buses, pick-up, trucks and others respectively.

### 4.1.3. Traffic Congestion Index and Level of Service

Traffic congestion index is the ratio between traffic volume and capacity for every direction of street. Traffic volume of study road is calculated after converting counted vehicles into passenger car units by using equivalent factors of 1.0, 1.5, 2.0, 3.0 and 0.3 for passenger cars and buses, micro-buses, buses, heavy trucks, and others. Also, the capacity of study road was calculated for every direction considering the width for every direction is 12.5 m. Percentage of truck was estimated for every direction, shoulder width 1.75 m for
every direction. The traffic congestion index is estimated for every direction of study road [8].

Table (4) shows the level of service and \( (v/c) \) ratio in each direction on Helia street, Fayoum city.

<table>
<thead>
<tr>
<th>Street direction</th>
<th>Area type</th>
<th>Practical Capacity ratio</th>
<th>Level of service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mostafa Kamel / Saad Basha</td>
<td>C.B.D</td>
<td>880</td>
<td>0.91</td>
</tr>
<tr>
<td>Saad Basha / Mostafa Kamel</td>
<td>C.B.D</td>
<td>880</td>
<td>0.81</td>
</tr>
</tbody>
</table>

From Table (4), the estimated values of \( (v/c) \) ratios are 0.91, and 0.81 for Mostafa Kamel - Saad Basha direction and Saad Basha - Mostafa Kamel direction respectively. Also, the level of service of study street is computed as level E.

4.2. Properties of speed distribution

All speed data were stored on the computer according to its type. Vehicle speeds were grouped into speed intervals of a constant width of 5.0 km/hr. A series of statistical parameters such as mean, median, standard deviation, and standard errors were estimated [7].

Previous research work [2] have shown that when the data for passenger cars on level roads were assembled, the speed distribution were found to be normal. Although the normal distribution is sometimes appropriate, previous experience indicated that lognormal distribution might be of more application.

To test the validity of the normal distribution, the Chi-squared test was performed at a 5% significance level. This test is used to decide whether the true distribution (of which the collected data constitute a sample) could be identical with the normal distribution. The procedure of fitting using the Chi-squared test is detailed in Ref.[1].

Table (5) shows the spot speed data distribution for Mostafa Kamel - Saad Basha, and Saad Basha - Mostafa Kamel directions for different vehicle types.

<table>
<thead>
<tr>
<th>Speed km/hr</th>
<th>Mostafa Kamel / Saad Basha</th>
<th>Saad Basha / Mostafa Kamel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Passenger Cars</td>
<td>Microbuses</td>
</tr>
<tr>
<td>15-20</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>20-25</td>
<td>33</td>
<td>51</td>
</tr>
<tr>
<td>25-30</td>
<td>65</td>
<td>50</td>
</tr>
<tr>
<td>30-35</td>
<td>90</td>
<td>82</td>
</tr>
<tr>
<td>35-40</td>
<td>122</td>
<td>98</td>
</tr>
<tr>
<td>40-45</td>
<td>95</td>
<td>53</td>
</tr>
<tr>
<td>45-50</td>
<td>45</td>
<td>22</td>
</tr>
<tr>
<td>50-55</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>55-60</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>60-65</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>475</td>
<td>350</td>
</tr>
</tbody>
</table>
Also, Figures 2, and 7, show the speed frequency distribution and cumulative curves for both directions of the study street as a typical example of passenger cars distributions. In all cases, normal distributions were fitted to data of passenger cars, microbuses, truck vehicles.

4.2.1. Variation in speed distributions

Table (5) shows the average speed of vehicles passing through Mostafa Kamel - Saed Basha direction is 36.44 km/hr and standard deviation is equal to 2.40 km/hr, while the average speed of vehicles passing through other direction of the street is computed as 35.80 km/hr and standard deviation of 7.80 km/hr.

A summary of the arithmetic mean of speeds and standard deviations of different vehicle types are given in Table (6).

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Pass. Cars</th>
<th>Microbuses</th>
<th>Trucks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mostafa Kamel / Saed Basha</td>
<td>36.44</td>
<td>7.52</td>
<td>35.11</td>
</tr>
<tr>
<td>Saed Basha / Mostafa Kamel</td>
<td>35.90</td>
<td>6.76</td>
<td>33.99</td>
</tr>
</tbody>
</table>

4.2.2. Spot Speed Statistics

Table (7) shows the fundamental statistical characteristics of spot speeds. Average and maximum speeds are calculated for every direction of the study street.

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Pass. Cars</th>
<th>Microbuses</th>
<th>Trucks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mostafa Kamel / Saed Basha</td>
<td>24</td>
<td>33</td>
<td>40</td>
</tr>
<tr>
<td>Saed Basha / Mostafa Kamel</td>
<td>33.5</td>
<td>31.5</td>
<td>30.5</td>
</tr>
</tbody>
</table>

5. Conclusions

This paper showed the importance of traffic count and spot speed distribution of all vehicles using urban streets. The survey results are based on traffic count and measurements of spot speed by using of moving car method through peak period.

The main results can be concluded as follows:

a) The directional distribution of Mostafa Kamel / Saed Basha direction is 0.49 and for other direction was 0.51.

b) Traffic compositions of Mostafa Kamel - Saed Basha direction were 57%, 24%, 4%, 2%, 12% and 1% of total vehicles for passenger cars, micro-buses, buses, pick-up, trucks, and others. For the other direction the traffic compositions were 60%, 22%, 3%, 1%, 11%, and 2% for the same vehicle types respectively.

c) The estimated values of (V/C) ratios (Traffic congestion index) are 0.91, and 0.81 for Mostafa Kamel / Saed Basha direction and Saed Basha / Mostafa Kamel direction respectively.
Fig. (2) Spot speed frequency and cumulative frequency distributions of passenger cars for Mostafa Kamel / Saed Basha, Horla street, Fayoum city.
Fig. (3) Spot speed frequency and cumulative frequency distributions of passenger cars for Saed Basha / Mostafa Kamel, Horia street, Fayoum city.
d) Average speed times of different vehicle types using Horia street, Faiyum city were 34 km/hr, 33 km/hr, and 28 km/hr for passenger cars, microbuses, and trucks for Mostafa Kamal - Saad Basha direction. The same results of other direction were 33,5 km/hr, 33,5 km/hr, and 29 km/hr for the similar different vehicle types respectively.

e) Spot speed distributions of passenger cars, micro-buses, and trucks were yielded to normal probability distribution.

f) The low spot speeds registered for this study street must draw the attention to improve the driving conditions on this street and geometric design elements must be improved in accordance with ideal operating conditions. Items such as lane and shoulder-widths, parking spaces and traffic control devices must be reviewed, updated and maintained.

6. References:


