SHORT PAPER
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# Evaluation of Traffic Characteristics: A Case Study

Arash Moradkhani Roshandeh*, Mahmood Mahmoodi Nesheli, and Othman Che Puan

Department of Geotechnics and Transportation Engineering, University Technology of Malaysia, 81310, UTM, Johor Bahru, Malaysia;
Email: mrarash2@siswa.utm.my
mnmahmood2@siswa.utm.my; othmancp@utm.my

***Abstract*- Speed is an important transportation consideration because it relates to safety, time, comfort, convenience, and economics. Spot speed studies are used to determine the speed distribution of a traffic stream at a specific location. The data gathered in spot speed studies are used to determine vehicle speed percentiles, which are useful in making many speed-related decisions. The intent of spot speed studies are to record speed characteristics under prevailing traffic conditions at a specific location along a roadway. Because traffic engineering involves the collection and analysis of large amounts of data for performing all types of traffic studies, it follows that Spot Speed Study is also an important element in traffic engineering. Managing traffic within our communities is a growing task for traffic engineers. As traffic volumes increase and public financial resources decrease, targeting improvement projects to anticipate growth patterns is critical. This paper represents traffic condition on the Malaysia Federal Route 5 - Skudai-Pontian Highway.**

***Index Terms*- Spot Speed, Mean Speed, Flow, 85th Speed**

## I. INTRODUCTION

Speed is an important measure of the quality of level and safety of road network. Speed by definition is the rate of movement of vehicle in distance per unit time.

A typical unit of speed is kilometers per hour (kph) or miles per hour (mph). basically there are two types of speed: the time-mean speed and the space- mean speed. Space mean speed is the length of a road section divided by the average travel time of several vehicles over this specific section. The time-mean speed (spot speed) is the average spot speed of several vehicles measured at a given spot.

### *A. Federal Road Standards*

The total length of federal roads in Malaysia is 49,935 km (31,028 miles). Federal routes are labeled with only numbers for example Federal Route 1 while state routes are labeled with the state code letter followed by assigned numbers, for example Route J32 is a Johor state road. However, federal route numbers can also be added with the FT-- prefix, which is normally used by JKR and Malaysian police. For example Federal Route 1 can also be written as Federal Route FT 1.

Both federal and state roads have blue road signs and the text colour is white.

### *B. Malaysia Federal Route 5*

Federal Route 5 is a main federal road on the west coast of Peninsula Malaysia. The road connecting Ipoh, Perak in the north until Skudai, Johor in the south. The road was constructed in 1905 and completed in 1909. At most section, the Federal Route 5 was built under the JKR R5 road standard, allowing maximum speed limit of up to 90 km/h.

### *C. Skudai-Pontian Highway*

Skudai-Pontian Highway route 5 is a highway that connects Skudai in the east with the town of Pontian Kechil in the west. It is also known as Jalan Pontian (at Johor Bahru district side) and Jalan Johor (at Pontian district side). It is one of the only two federal roads that are paved with concrete (from Universiti Teknologi Malaysia interchange to Taman Sri Pulai junction) besides Jalan Batak Rabit-Sitiawan (also part of Federal Route 5) while other federal roads are paved with typical tarmac.

### *D. Area of Study*

Area of study in Skudai-Pontian Highway route 5 is a highway that connects Skudai in the east with the town of Pontian Kechil in the west. It is also known as Jalan Pontian and Jalan Johor.

## II. LITERATURE REVIEW

### *A. Introduction*

A spot speed study is made by measuring the individual speeds of a sample of the vehicles passing a given point (spot) on a street or highway. These individual speeds are used to estimate the speed distribution of the entire traffic stream at that location

*Corresponding author: Arash Moradkhani Roshandeh; Email: mrarash2@siswa.utm.my; HP: +60176392661.

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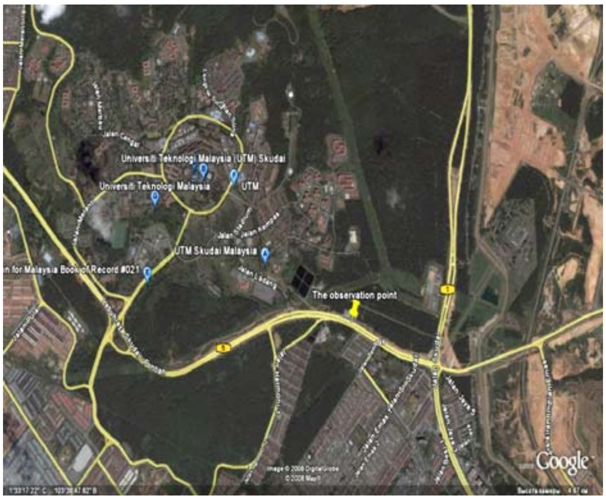


Figure 1. Map of Federal Route 5


Figure 2. Map of Observation Points

under the conditions prevailing at the time of the study.

*B. Uses of Spot Speed Data*

The result of spot speed studies are used for many different purposes by traffic engineers, including:

1. Establishing the effectiveness of new or existing speed limits or enforcement practices
2. Determining appropriate speed limits for application
3. Establishing speed trends at the local, state, and national level to assess the effectiveness of national policy on speed limits and enforcement
4. Specific design application determining appropriate sight distances, relationships, between speed and highway alignment, and speed performance with respect to steepness and length of grades
5. Specific control applications for the timing of “yellow” and “all red” intervals for traffic signals, proper placement of signs, and development of appropriate signal progressions
6. Investigation of high-accident locations at which speed is suspected to be a contributing cause to the accident experience

*C. Data Requirements*

For this project the most important traffic characteristics to be collected from the “Jalan Skudai-Pontian” include spot speed and flow.

The key point of measurement is the vehicle volume count. Data was collected manually on 28.11.2008 during non-peak hour with short interval of 15 minutes and for each type of vehicles like cars, two wheelers, buses, utilities, trucks, multi axle trucks. From the flow data, flow and headway can be derived.

This study are used to determine the level of service for streets, document congestion and quantify the need for street improvements and also for a variety of purposes and differ in the level of detail and data collected.

*D. Determine an Appropriate Selection Strategy*

Except for studies conducted under low-volume conditions, it is impossible to obtain a radar measurement for every vehicle. For peak flow analysis, speeds are measured during the peak period. For assessing general speed trends or for setting speed limits, off-peak measurements are more appropriate.

The selection of the target vehicle that represents the vehicle population under study is also important. A good question to ask is, “What type or types of vehicles are of concern—cars, trucks, buses, or others?” Typically cars, station wagons, pickup and panel trucks, and motorcycles are classified as passenger cars. Other trucks and buses are classified as trucks.

School buses and farm equipment may be recorded separately. When the target vehicle is defined, a selection strategy is developed to provide a random sample. A random sample will reduce the tendency to select the vehicles that stand out. For example, the observer could obtain a speed reading from every fourth vehicle or every tenth vehicle.

## III. METHODOLOGY

*A. Introduction*

The objective of this study is to get traffic characteristics from the Jalan Skudai-Pontian include spot speed and flow. This study are used to determine the level of service for streets, document congestion and quantify the need for street improvements and also for a variety of purposes and differ in the level of detail and data collected.

TABLE 1

VEHICLE TALLY SHEET

| Type of Vehicle | | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Car & Taxi | | | 380 | | | 309 | | | 340 | | | 304 | 1333 |
| 2 | Smal Van & Utility | | | 38 | | | 37 | | | 31 | | | 35 | 141 |
| 3 | Moderate Size Lorry & Large Van | | | 42 | | | 52 | | | 50 | | | 47 | 191 |
| 4 | Truck | | | 22 | | | 17 | | | 19 | | | 20 | 78 |
| 5 | Bus | | | 5 | | | 2 | | | 6 | | | 4 | 17 |
| 6 | Motorcycle | | | 73 | | | 84 | | | 83 | | | 80 | 320 |
| Total (Veh/h) | | | | 560 | | | 501 | | | 529 | | | 490 | 2080 |

For a spot speed study at a selected location, a sample size of at least 50 and preferably 100 vehicles is usually obtained (Ewing 1999). Traffic counts during a Monday morning or a Friday peak period may show exceptionally high volumes and are not normally used in the analysis; therefore, counts are usually conducted on a Tuesday, Wednesday, and Thursday.

Spot speed data are gathered using one of three methods: (1) stopwatch method, (2) radar meter method, or (3) pneumatic road tube method. The stopwatch method is the least expensive and least accurate of the methods.

*B. Instrument*

*Counter*

A Counter meter is a commonly used to take the number. In this method, the observer stay at the point of interest and count the vehicles with the help of hand tallies using counter meter (Fig. 3).

*Radar Meter*

A radar meter is a commonly used device for directly measuring speeds in spot speed studies (Fig. 4 ).

This device may be hand-held, mounted in a vehicle, or mounted on a tripod. The effective measuring distance for radar meters ranges from 200 feet up to 2 miles (Parma 2001). A radar meter requires line-of-sight to accurately measure speed and is easily operated by one person. If traffic is heavy or the sampling strategy is complex, two radar units may be needed.

*C. Data Analysis and Calculations*

The results and analysis of the study are very important to ensure that the key objectives can be achieved. Expected result necessary to draw up at early stage before the project done, to be compared with the actual result.

After the study is completed and the data have been tabulated the following steps may be considered as part of the typical data analysis. Specifically, the idea would be to identify key parameters associated with roadway speeds, which may include any or all of the following:

1. Mean Speed: The average speed; calculated as the sum of all speeds divided by the number of speed observations.
2. 85th Percentile Speed: The speed at or below which 85 percent of a sample of free flowing vehicles is traveling; this is typically used as a baseline for establishing the speed (based on a spot speed study.
3. 95th Percentile Speed: The speed at or below which 95 percent of a sample of free flowing vehicles is traveling (based on a spot speed study).
4. Median (50th Percentile Speed): The speed that equally divides the distribution of spot speeds; 50 percent of observed speeds are higher than the median; 50 percent of observed speeds are lower than the median.
5. Mode: The number that occurs most frequently in a series of numbers.
6. Speed Variance: The difference in travel speeds for vehicles on the road. Mathematically, variance is the average of the squares of the difference to the mean for each observed speed.
7. Pace: A 10 mile-per-hour increment in speeds that encompasses the highest portion of observed speeds; often is the mean speed plus/minus five miles per hour.

In analyzing spot speed data a number of significant values are obtained. Some of these values are computed directly from the data while others are determined from a graphic representation.

Figure 3. Counter

Figure 4. Radar Meter

TABLE 2
LOCATION /DIRECTION: BEFORE SHELL CASE STATION, DATE: NOVEMBER 28, 2008, TIME: 9:25 AM, WEATHER: SUNNY

| Speed (km/h) | Number of Vehicles | | | | | | | | | | Flow (vph) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 0 | 0 | | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 3 |
| 40 | 2 | 0 | 3 | 4 | 2 | 5 | 3 | 7 | 5 | 7 | 38 |
| 50 | 7 | 9 | 8 | 5 | 14 | 18 | 5 | 3 | 13 | 12 | 94 |
| 60 | 16 | 21 | 19 | 13 | 13 | 15 | 9 | 14 | 9 | 11 | 140 |
| 70 | 17 | 5 | 16 | 11 | 8 | 10 | 12 | 10 | 14 | 10 | 113 |
| 80 | 3 | 8 | 3 | 4 | 0 | 2 | 1 | 0 | 11 | 1 | 33 |
| 90 | 2 | 1 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 7 |
| 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | 429 |

## 1V. COMPUTATIONS

### A. *Speed Percentiles and How to Use Them*

Speed percentiles are tools used to determine effective and adequate speed limits. The two speed percentiles most important to understand are the 50th and the 85th percentiles. The $50^{th}$ percentile is the median speed of the observed data set. This percentile represents the speed at which half of the observed vehicles are below and half of the observed vehicles are above. The 50th percentile of speed represents the average speed of the traffic stream. The 85th percentile is the speed at which 85% of the observed vehicles are traveling at or below. This percentile is used in evaluating/recommending posted speed limits based on the assumption that 85% of the drivers are traveling at a speed they perceive to be safe (Homburger et al. 1996). In other words, the $85^{th}$ percentile of speed is normally assumed to be the highest safe speed for a roadway section. Weather conditions may affect speed percentiles. For example, observed speeds may be slower in rainy or snowy conditions.

A frequency distribution table is a convenient way to determine speed percentiles. An example is given in "Table 2," The frequency of vehicles is the number of vehicles recorded at each speed.

$$\sum fi(vi - v)^\wedge 2 = 57937 \qquad (1)$$

$$\boxed{\sum fi - 1 = 428 - 1 = 427} \qquad (2)$$

The cumulative frequency is the total of each of the numbers (frequencies) added together row by row from lower to higher speed. The fourth column is a running percentage of the cumulative frequency.

The 50th and 85th speed percentiles are determined from the cumulative percent column. For example data in "Table 2,", the 50th percentile falls between 27 and 30 mph and the $85^{th}$ percentile falls between 33 and 36 mph. The calculation of speed percentiles is easier if a sample size of 100 vehicles is collected. When the sample size equals 100 vehicles, the cumulative frequency and cumulative percent are the same.

The analysis of an example set of speed data is shown in "Table 3".

The data are first grouped into intervals of 5 km/h. The first two columns of the table show the grouping by lower limit, midpoint of mean (vi), and upper limit of each group. Column 3 shows the frequency (fi) or number observed in each group; column 5 shows the percentage of observation in class.

The cumulative percentages in column 6 are obtained by dividing each cumulative frequency by the total sample size and multiplying by 100. The mean square frequencies in Col. 7 ($fi(vi)^2$) are calculated by multiplying the mean frequencies FiUi (multiplying midpoints col.2 by corresponding frequencies col.4) the respective midpoints in Col. 2. These multiplications must be made accurately. The following values are then computed:

### B. *Mean or Average Speed*

The arithmetic average or mean speed is the most requently used speed statistic. It is a measure of the central tendency of the data and is computed from the formula:

$$\overline{V} = \frac{\sum f_i V_i}{\sum f_i} = 65{,}5 \qquad (3)$$

where: $\overline{V}$ = mean or average speed.

$\sum f_i V_i$ = sum of the mean frequencies

$\sum f_i$ = total number of vehicles observed (total of Col.3)

### C. *Distributions in Time and in Space*

Data collected at a point over a period of time, e.g.: by stopwatch or radar meter, produce speed distributions in time, whose means are time mean speeds. Data obtained over a stretch of road almost instantaneously as by two successive aerial photographs, result in speed distribution in space and space mean speeds.

TABLE 3
PERCENTAGE AND ANALYSE OF SPOT SPEED DATA

| speed class (km/hr) | class midvalue, $v_i$ | class frequency (number of observation in class), $f_i$ | $f_{ivi}$ | Percentage of observation in class | Cumulative percentage of all observation | $f(v_i - v)^2$ | |
|---|---|---|---|---|---|---|---|
| 30-34.9 | 32.5 | 1 | 32.5 | 0.2 | 0.2 | 1089 | |
| 35-39.9 | 37.5 | 2 | 75 | 0.5 | 0.7 | 1568 | |
| 40-44.9 | 42.5 | 11 | 467.5 | 2.6 | 3.2 | 5819 | |
| 45-49.9 | 47.5 | 27 | 1282.5 | 6.3 | 9.5 | 8748 | |
| 50-54.9 | 52.5 | 43 | 2257.5 | 10.0 | 19.6 | 7267 | |
| 55-59.9 | 57.5 | 51 | 2932.5 | 11.9 | 31.5 | 3264 | |
| 60-64.9 | 62.5 | 82 | 5125 | 19.2 | 50.7 | 738 | **50 th** |
| 65-69.9 | 67.5 | 58 | 3915 | 13.6 | 64.2 | 232 | |
| 70-74.9 | 72.5 | 57 | 4132.5 | 13.3 | 77.5 | 2793 | **85 th** |
| 75-79.9 | 77.5 | 56 | 4340 | 13.1 | 90.6 | 8064 | |
| 80-84.9 | 82.5 | 18 | 1485 | 4.2 | 94.8 | 5202 | |
| 85-89.9 | 87.5 | 16 | 1400 | 3.7 | 98.6 | 7744 | |
| 90-94.9 | 92.5 | 5 | 462.5 | 1.2 | 99.7 | 3645 | |
| 95-99.9 | 97.5 | 0 | 0 | 0.0 | 99.7 | 0 | |
| 100-104.9 | 102.5 | 0 | 0 | 0.0 | 99.7 | 0 | |
| 105-109.9 | 107.5 | 1 | 107.5 | 0.2 | 100.0 | 1764 | |
| total | | 428 | 28015 | | | 57937 | |

These distributions are not the same; time mean speed is higher than space mean speed. This can be understood if one visualizes a section of highway; a spot speed sample at one end taken over a finite period of time will tend to include some fast vehicles which had not yet entered the section at the start of the survey, but will exclude some of the slower vehicles which were within the highway section when the sample was started. An aerial photograph, however, would include all vehicles within the highway section at the moment of exposure.

The relationship between the two mean speeds is expressed by:

$$\overline{V_t} = \overline{V_S} + \frac{S_s^2}{\overline{V_s}} = 65{,}5 + \frac{(11{,}63)^2}{65{,}5} = 67{,}56 \text{ km/h} \qquad (4)$$

where $V_t$ and $V_s$ are the time mean speed and space mean speed respectively, and $s_s$ is the standard deviation of the distribution in space.

*D.Standard Deviation*

All vehicles do not travel at the same speed, so there is a spread or dispersion of speeds about the mean. The standard deviation, *s,* is a statistical measure of this spread.

Assuming a normal distribution , the mean I plus and minus one standard deviation contains approximately 68% of the vehicles, plus and minus two standard deviations contains 95%, and plus and minus three standard deviations contains 99.8%. The standard deviation of the sample is computed by first calculating the variance of the sample and then taking the square root as follows:

$$S = \sqrt{\frac{\sum fi(vi - v)^\wedge 2}{\sum \; fi - 1}} = 11{,}63 km/h \qquad (5)$$

where: $S$ = standard deviation of the distribution

$\sum fi(vi - v)$ = sum of the mean square frequencies

$\sum fi(vi - v)^\wedge 2$ = square of the sum of the mean frequencies (total of Col. 7 squared)

*D.Standard Error of the Mean*

The means of different samples taken from the same population are distributed normally about the true mean of the population with standard deviation of $S/\sqrt{\sum \; f}$ where *a* is the standard deviation of the entire population. In large samples (n$\geq$>25) the standard deviation of the sample, s, is a good estimate of the standard deviation of the population. Therefore:

$$S_{\bar{V}}^2 = \frac{S^2}{\sum f} \tag{6}$$

$$S_{\bar{V}} = \sqrt{\frac{S^2}{\sum f}} = \frac{11,63}{428} = 2,717 \tag{7}$$

Where $S_{\bar{V}}^2$ = variance of the mean

$S_{\bar{V}}$ = standard error of the mean

$S^2$ =sample variance (from equation)

## V. GRAPHICAL ANALYSIS

The cumulative percentage calculated in "Table 3" is plotted against the upper limit of each speed group. A smooth S-shaped curve drawn approximately through the points (not connecting the points directly) is called the cumulative speed curve. Since the sample is used to estimate the total distribution, it is important that it be a smooth curve rather than a joining of points.

The data in "Table 3" are plotted and the corresponding cumulative speed curve is drawn in Fig 4. Significant values obtained from the curve shown on the figure are:

The vertical axis of the curve is the percentage of vehicles traveling at or below the indicated speed. Any specific percentile speed is the speed that corresponds to the desired percentile. The uses of some of the percentiles are as follows:

(1) *The Median (50th Percentile) Speed* is an alternative measure to the mean or average speed to describe the central tendency of the speed distribution. It is the speed which is exceeded or equaled by exactly half the vehicles in the traffic stream and is not attained by the other half. In a symmetrical (perfectly normal) distribution, the median value equals the mean value. The median is obtained from the curve by reading the speed that corresponds to the 50% value.

(2) *The 85th Percentile Speed,* sometimes referred to as the critical speed, is used as a a guide in establishing reasonable speed limits.

(3) *The 15th Percentile* may serve as the guide for establishing minimum speed limits. The vehicles traveling below this value tend to obstruct the flow of traffic, thereby increasing the accident hazard.

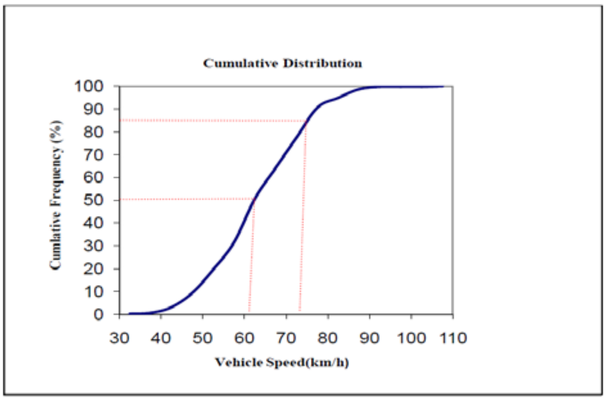


Figure 4. Cumulative Distribution

TABLE 4
PCU

| *PCU Values* | *Pcu/hr* | *Percentage of PCU* |
|---|---|---|
| 1 | 1333 | 49.42 |
| | | |
| 2 | 282 | 10.45 |
| | | |
| 2.5 | 477.5 | 17.70 |
| | | |
| 3 | 234 | 8.67 |
| | | |
| 3 | 51 | 1.89 |
| | | |
| 1 | 320 | 11.86 |
| | | |
| | 2697.5 | 100.00 |

## VI. CONCLUSION AND RECOMMENDATION

Unlike many other disciplines of the engineering, the situations that are interesting to a traffic engineer cannot be reproduced in a laboratory. Even if road and vehicles could be set up in large laboratories, it is impossible to simulate the behavior of drivers in the laboratory.

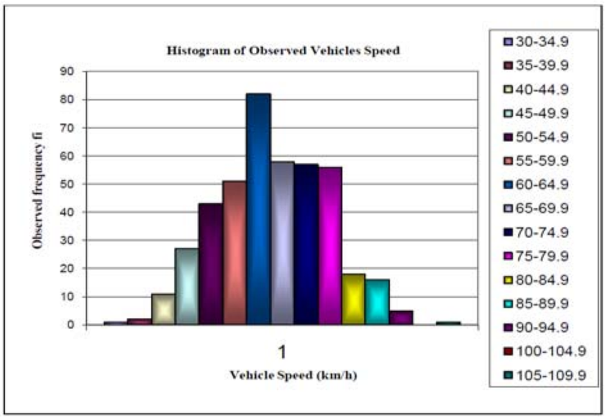


Figure 5. Histogram of Vehicles Speed



ACEEE

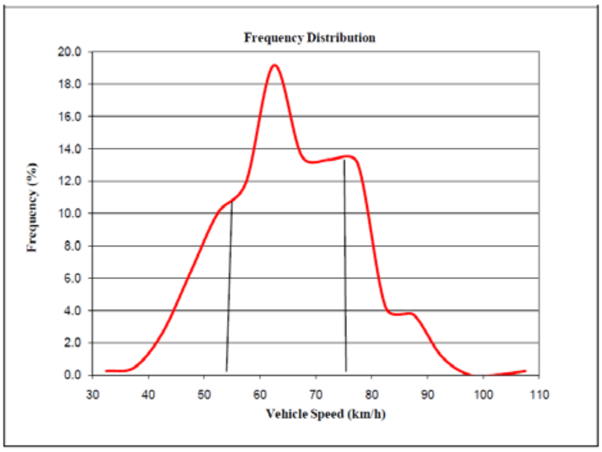

Figure 6. Frequency Distribution

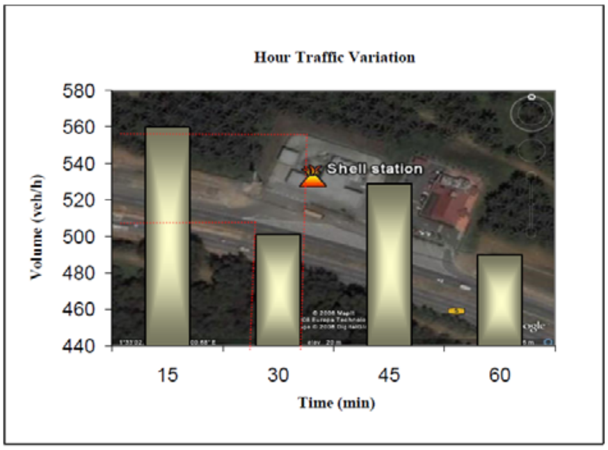

Figure 7. Hour Traffic Variation

Therefore, traffic stream characteristics need to be collected only from the field.

The data was collected on the Malaysia Federal Route 5 - Skudai-Pontian Highway and was analyzed with the following results:

1. The maximum speed on the road is equal to 90. The drivers almost do not exceed this speed. It was corroborated by our analysis where the vehicles were moved with the range of speed from 30 to 90 km/h.
2. The most part of vehicles moved with average speed 60 km/h – 140 vph (u-k relationship).
3. During 1hour the number of vehicle passed observation point is 2080 that also is equal to 2697.5 pcu.
4. The cars and taxis is the most appearing type of vehicles (1333vph).
5. Some of the results can have natural error that is result of purposefully decreasing of speed. Because observation group can be easily detected by drivers from the long distance.
6. This particular area doesn't contain any signboards about speed limit and some of the drivers over exceed the speed limit (100 km/h).

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