Macroscopic Determination of Speed and Flow Using Moving Car Observer Method in Johor Bahru, Malaysia

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Abstract: - Traffic flow rate estimation is very important in the planning and design process for all aspects of the road network. Moving Car Observer (MCO) method of determining the journey speed can be illustrated by considering a stream of vehicles moving along a section of road of length L in such a way that the average number of vehicles q passing through the test section per unit time is constant. The stream can be regarded as consisting of flows q_1 moving with speed v_1, q_2 with speed v_2, etc. This study was conducted to determine the stream flow between UTM and Taman Universiti during peak hour. Since almost the civil servants in UTM live in and near Taman Universiti. The traffic was expected to be high during peak hour along that way. From the analysis of traffic flow in this study, there are much difference of value between MCO and manually count method.

Key-Words: - Moving car observer; Flow; Journey time; Space mean speed; Level of service

1 Introduction

Taman Universiti (TU) is a university town near Johor Bahru city in Malaysia. It is located between Skudai and Pulai. It was given town status in 2002. Universiti Teknologi Malaysia (UTM) is a 5 minutes drive away from Taman Universiti, hence the name of the town. The town is dominated by lecturers, office workers and students from UTM. There are ten main areas in Taman Universiti, with each area are labeled with a name Pertanian, Penyiaran, Perubatan, Perdagangan, Kebangsaan, Kejayaan, Kebudayaan, Kemajuan, Kemuliaan, and Pendidkan. Taman Universiti is a small place consists of shops, banks, restaurants, shopping complex and residential [1].

One of the important components of traffic is the determination of speed-flow relationships. When the traffic is low, the vehicles can move freely without hindrance from the other vehicles. As the flow increases, the vehicles cannot sustain their free speeds due to intersection from other vehicles in the traffic stream. This leads to a decrease in speed and increase in interval time for the vehicles thereby adding to the road user cost. Hence, there is a need to re-establish relationship between travel time and flow.

2 Aim and Objectives

The purpose of the study is to evaluate the traffic stream along the way of UTM - Taman Universiti and Taman Universiti – UTM. The main objective of the study is to establish a relationship between flow and speed at peak hour of flow. Therefore, the objectives are:

- to determine the time it takes to travel from UTM to Taman Universiti and vice verse.
- to determine the number of vehicles travelling Taman Universiti – UTM in the opposite lane while the test vehicle is travelling UTM - Taman Universiti and vice versa.
- to determine the number of vehicles that overtake the test vehicle while it is travelling UTM - Taman Universiti and Taman Universiti – UTM.
- to determine the number of vehicles that the test vehicles passes while it is travelling UTM - Taman Universiti and Taman Universiti – UTM.
- to determine the number of vehicle that is travelling from UTM to Taman Universiti. And
- to determine the vehicle speed that is travelling from UTM to Taman Universiti.

3 Methodology

In this study, the observer makes a round trip on a test section. Where it is assumed that the road runs Taman Universiti – UTM.

The following data were collected as the test vehicle makes the round trip:

- The time it takes to travel to UTM from X-X to Y-Y (T_{UTM}), in minutes.
- The time it takes to travel to Taman Universiti from Y-Y to X-X (T_{TU}), in minutes.

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- The number of vehicles travelling to Taman Universiti in the opposite lane while the test vehicle is travelling to UTM (N_{UTM}).
- The number of vehicles that overtake the test vehicle while it is travelling to Taman Universiti from Y-Y to X-X, that is travelling in the Taman Universiti direction (O_{TU}), and
- The number of vehicles that the test vehicle passes while it is travelling to Taman Universiti from Y-Y to X-X, that is, travelling in the Taman Universiti direction (P_{TU}).

3.1 Case Study Description

The study area is in Universiti Teknologi Malaysia (UTM) and Taman Universiti in Skudai, Johor Bahru. Major lane uses in the area include residences, school and shops. The study area is shown in Fig. 1. One site was selected located on UTM for the collection of traffic speed and count data. For MCO method, the test car was traveled from UTM to Taman Universiti. It travelled along Jalan Universiti and Jalan Pendidikan, through several intersections.

Some features of UTM road are:

- a roundabout of around 4m diameter in front of UTM `s main gate.
- a road hump in front of UTM `s main gate, and
- a security control in front of UTM `s main gate.

The type of information allocated in this survey include:

- MCO survey data relating to journey time, traffic volume and speed.
- Traffic count data for traffic volume of different type of vehicles. And
- Spot speed data.

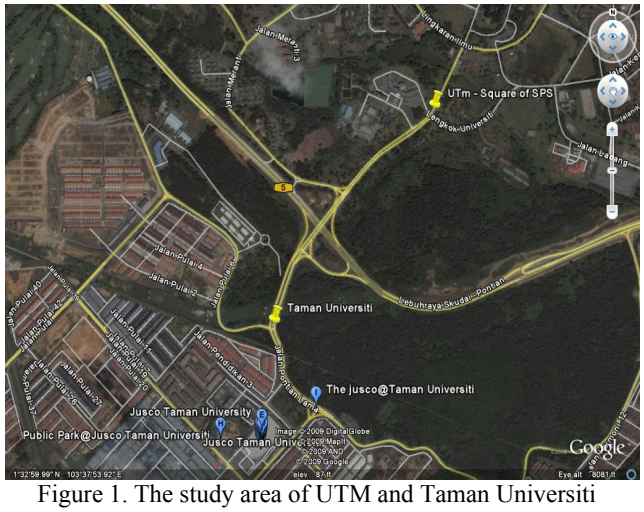

Figure 1. The study area of UTM and Taman Universiti

3.2 Data Collection

The data were collected on 23th March 2009 during good weather. The time and day were selected such that they are responsive to the working days peak hour. The data were collected when university is in session. Peak hour was taken generally from 4.30 p.m. to 5.30 p.m., where the civil servants going back from office at 5.00 pm.

One 20m stretches on the site was marked to measure the traffic speed in UTM – Taman Universiti directions, for peak hour of the same day. The traffic count was done manually. Meanwhile, the Moving Car Observer method was counted along 1.2 Km way of UTM - Taman Universiti and Taman Universiti – UTM.

The data collected were divided into three parts, which are: traffic speed, traffic count and traffic stream using MCO method.

Traffic speeds were measured by observing the time taken by a vehicle in crossing the stretch of 20m already marked, using a stop watch. Thus the space mean speed of vehicles moving on this pre-identified roads and the corresponding traffic volume at peak hours of a normal working day were estimated.

The car method of data using MCO was used. In this method, the journey time of the moving observation vehicle is noted, as is the flow of the stream is relative to the moving observer. This means that travelling against the flow, the relative flow is given by the number of vehicles that overtake the observer minus the number of vehicles that the observer overtakes [2].

The volume in the Taman Universiti direction is obtained using equation below:

$$Q_{TU} = (N_{UTM} + O_{TU} - P_{TU}) / (T_{UTM} + T_{TU}) \quad (1)$$

The average travel time, $\overline{T}_{TU}$, in the Taman Universiti direction is obtained using equation below:

$$\overline{T}_{TU} = T_{TU} - \frac{O_{TU} - P_{TU}}{V_{TU}} \quad (2)$$

The average speed, V_{TU}, in the Taman Universiti direction is obtained using equation:

$$V_{TU} = \frac{L}{\overline{T}_{TU}} \quad (3)$$

Where L is length of test section.

The computation of volume, travel time and mean speed for UTM direction is using the same equation as above, except the notation of TU is change to UTM.

Table 1 shows the traffic stream data from UTM to Taman Universiti and vice versa. The distance for both journey is 1.2 Km. Table 2 shows the data of traffic count from UTM to Taman Universiti.Table 3 shows data of traffic speed from UTM to Taman Universiti.

Table 1. Vehicle stream data

NO.		Start Time	Journey Time (min)	No. of Vehicle Met	No.of Vehicle Overtaking	No. of Vehicle Overtaken
1	UTM to TU	16.30	1.35	34	3	3
	TU to UTM	16.32	1.28	49	0	0
2	UTM to TU	16.38	1.31	59	1	1
	TU to UTM	16.40	1.29	54	1	2
3	UTM to TU	16.47	1.27	36	3	2
	TU to UTM	16.49	1.27	44	0	1
4	UTM to TU	16.55	1.23	34	2	0
	TU to UTM	16.57	1.43	54	1	1
5	UTM to TU	17.04	1.30	50	2	1
	TU to UTM	17.06	1.30	55	0	0
6	UTM to TU	17.13	1.28	45	3	1
	TU to UTM	17.15	1.35	57	0	0

Table 2. Traffic count data

Volume		Time				Total
		16.30 – 16.45	16.45 – 17.00	17.00 – 17.15	17.15-17.30	
Car	Veh/hr	95	110	294	95	594
	Pcu/hr	95	110	294	95	594
Motor cycle	Veh/hr	37	44	137	37	255
	Pcu/hr	27.75	33	102.75	27.75	191.25
Lorry	Veh/hr	2	2	7	2	13
	Pcu/hr	4	4	14	4	26
Van	Veh/hr	13	7	10	13	43
	Pcu/hr	19.5	10.5	15	19.5	64.5
Total	Veh/15 min	147	163	448	147	
	Pcu/15 min	146.25	157.5	425.75	146.25	

Table 3. Speed data

Time (Sec)	Speed Km/h	Time (Sec)	Speed (Km/h)	Time (Sec)	Speed (Km/h)
2.10	34.29	2.02	35.64	2.98	24.16
1.84	39.13	2.42	29.75	2.45	29.39
1.98	36.36	2.53	28.46	2.10	34.29
2.67	26.97	2.56	28.13	2.37	30.38
2.27	31.72	1.95	36.92	2.29	31.44
2.14	33.64	1.98	36.36	2.63	27.38
2.02	35.64	2.55	28.24	2.14	33.64
2.15	33.49	2.31	31.17	2.49	28.92
2.60	27.69	2.22	32.43	2.04	35.29
3.12	23.08	2.66	27.07	2.02	35.64
2.66	27.07	2.59	27.80	1.91	37.70
2.33	30.90	2.34	30.77	1.95	36.92
2.24	32.14	2.18	33.03	1.91	37.70
3.40	21.18	2.61	27.59	1.90	37.89
2.47	29.15	2.29	31.44	2.16	33.33
2.15	33.49	2.69	26.77	2.18	33.03
2.59	27.80	2.67	26.97	2.29	31.44
2.17	33.18	1.74	41.38	2.14	33.64
2.31	31.17	2.28	31.58	2.33	30.90
2.69	26.77	2.16	33.33	1.91	37.70
2.31	31.17	2.23	32.29	2.20	32.73

4 Results and Analysis

From the data shown in Table 1 the result of stream flow for UTM – Taman Universiti and also for Taman Universiti – UTM are summarized in Table 4 and Table 5 in the Taman Universiti direction.

Table 4. Stream flow of UTM – Taman Universiti

Start Time	Relative Flow		T_{UTM}	T_{TU}	Q_{TU}	$\bar{T}_{TU}$	$\bar{V}_{TU}$
	With test car	Against test car					
16.30	0	34		1.35			
16.32			1.28		12.93	1.35	53.33
16.38	0	59		1.31			
16.40			1.29		22.69	1.31	54.96
16.47	-1	36		1.27			
16.49			1.27		13.78	1.34	53.63
16.55	-2	34		1.23			
16.57			1.44		11.99	1.40	51.54
17.04	-1	50		1.30			
17.06			1.30		18.85	1.35	53.21
17.13	-2	45		1.28			
17.15			1.35		16.35	1.40	51.34

Table 5. Stream flow of Taman Universiti – UTM

Start Time	Relative Flow		T_{TU}	T_{UTM}	Q_{UTM}	$\bar{T}_{UTM}$	$\bar{V}_{UTM}$
	With test car	Against test car					
16.30 16.32	1	49	1.35	1.28	19.01	1.23	58.66
16.38				1.29			
16.40	-1	54	1.31		20.38	1.34	53.77
16.47				1.27			
16.49	0	44	1.27		17.32	1.27	56.69
16.55				1.44			
16.57	0	54	1.23		20.22	1.44	50.00
17.04				1.30			
17.06	0	55	1.30		21.15	1.30	55.38
17.13				1.35			
17.15	0	57	1.28		21.67	1.35	53.33

Based on Table 4, the traffic speed along UTM – Taman Universiti way is between 50 and 55 Km/hr. meanwhile, in Table 5, the traffic speed along Taman Universiti – UTM way is between 50 and 60 Km/hr.

The space mean speed along UTM – Taman Universiti way is shown below:

$$\bar{V}_{TU} = \frac{6}{\frac{1}{53.33}+\frac{1}{54.96}+\frac{1}{53.63}+\frac{1}{51.54}+\frac{1}{53.21}+\frac{1}{51.34}} = 52.97\,\frac{Km}{hr} \approx 53\,\frac{Km}{hr}$$

The space mean speed along Taman Universiti – UTM way is shown below:

$$\bar{V}_{UTM} = \frac{6}{\frac{1}{58.66}+\frac{1}{53.77}+\frac{1}{56.69}+\frac{1}{50.00}+\frac{1}{55.38}+\frac{1}{53.33}} = 54.50\,\frac{Km}{hr} \approx 55\,\frac{Km}{hr}$$

However, based on Table 3 of speed data, the traffic speed along UTM – Taman Universiti way is between 20 and 45 Km/hr. Table 7 shows the speed distribution data analysis. Fig. 3 shows the cumulative frequency curve for traffic speed.

Table 7. Speed distribution data analysis

	Speed Calass (Km/hr)					
	20 - 25	25 – 30	30 – 35	35 - 40	40 – 45	
Speed Average v_i (Km/hr)	22.5	27.5	32.5	37.5	42.5	
Frequency f_i	3	18	28	13	1	63
% Frequency	4.8	28.6	44.4	20.6	1.6	100
%Cumulative Frequency	4.8	33.3	77.8	98.4	100	
$f_i v_i$	67.5	495	910	487.5	42.5	2002.5
$f_i v_i^2$	1518.75	13612.5	29575.0	18281.3	1806.25	64793.75

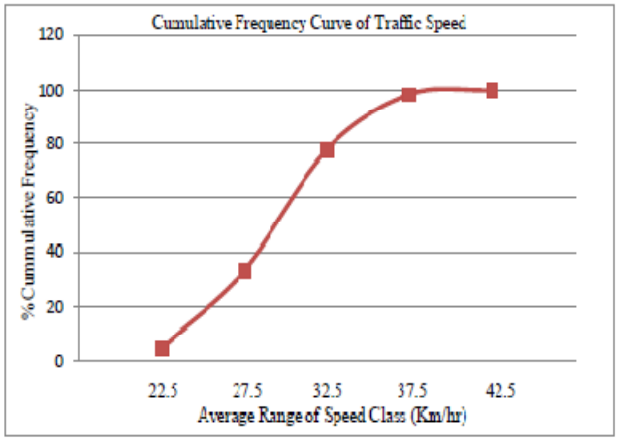

Figure 3. Cumulative frequency curve of traffic speed

From Fig. 3, the 50th percentile of speed is 29.5 Km/hr. While the arithmetic space mean speed from spot speed method is:

$$\bar{V}_{TU} = \frac{6}{\frac{1}{34.29}+\frac{1}{39.13}+\frac{1}{36.36}+\frac{1}{26.97}+\frac{1}{31.72}+\ldots+\frac{1}{32.73}} = 31\ Km/hr$$

The standard deviation and standard error of mean are:

Standard deviation

$$SD = \sqrt{\frac{\Sigma f_i v_i^2}{\Sigma f_i} - (\frac{\Sigma f_i v_i}{\Sigma f_i})^2} \quad (4)$$

$$= \sqrt{\frac{64793.5}{63} - (\frac{2002.5}{63})^2} = 4.26 \text{ Km/hr}$$

Standard error of mean $= \frac{SD}{\sqrt{n}}$ (5)

$$= \frac{4.26}{\sqrt{63}} = 0.54$$

- *Flow*

Based on Table 4, the mean flow along UTM – Taman Universiti way is shown below.

$$\bar{Q}_{TU} = \frac{12.93+22.69+13.78+11.99+18.85+16.35}{6} = 16.10\ veh/\text{min} = 966\ veh/hr$$

Based on Table 5, the mean flow along Taman Universiti - UTM way is shown below.

$$\bar{Q}_{UTM} = \frac{19.01+20.38+17.32+20.22+21.15+21.67}{6} = 19.96\ veh/\text{min} = 1198\ veh/hr$$

Based on Table 2, the highest traffic volume along UTM – Taman Universiti way is occurred during 5.00 – 5.15 p.m., which is 448 veh/15min or 426 pcu/15min.

Therefore traffic volume is:

$Q_{TU} = 448 \times 4 = 1792$ veh/hr

$Q_{TU} = 426 \times 4 = 1703$ pcu/hr

The peak-hour factor (PHF) along UTM – Taman Universiti way is:

$$PHF_{TU} = \frac{594+13+43+255}{1792} = 0.51$$

$$PHF_{TU} = \frac{594+26+64.5+191.25}{1703} = 0.51$$

5 Discussion

The space mean speed of vehicles from Taman Universiti to UTM is a bit higher compared to vehicles speed from UTM to Taman Universiti. The traffic flow going to UTM is higher compared to flow going to Taman Universiti, this result is unexpected because during this hour, civil servants in UTM are going back from work. In addition, the traffic speed going to UTM is higher. Theoretically, during stable flow, low traffic flow will produce higher traffic speed and high traffic flow produce lower traffic speed. This is contrast to the test result.

The space mean speed from spot speed study and MCO method are further different. The space mean speed from spot speed method is 31 Km/hr. while from MCO method is 53 Km/hr. This is due to the site condition at spot speed location. The roundabout near the test site does not allow the vehicles to move fast because of maneuver movement. Besides, the existence of road hump with distance around 100m before and after the test site. Thus, drivers tend to decrease the vehicles speed. Another reason is the security control and checking at the main gate that slowing down the vehicles.

The speed obtained from this spot speed study is not applicable to represents the space mean speed for the entire test site area (including Taman Universiti). It is because the road from UTM to Taman Universiti, there is no road hump and security control along the way. Traffic speed and volume from MCO approach is better to represent the real situation in the survey site.

Based on small value of saturation deviation and standard error of mean, the speed obtained during spot speed data is acceptable and reliable. In fact, this space mean speed is applicable better within UTM area, the speed should be a bit higher to avoid the vehicles slowing down the flow that interrupt the traffic and reduce the density of the road.

As expected, the highest traffic volume is during 5.00 p.m. to 5.15 p.m. compared to other period during survey. The highest traffic volume is 448 veh/15min. During this time, civil servants and lecturers in UTM are going back from work.

From the analysis of traffic flow in this study, there are much difference of value between MCO and

manually count method. The comparison is made on the travel from UTM to Taman Universiti. The traffic volume using MCO method is higher that traffic count method. Table 8 shows the capacity of the road for level of service (LOS) evaluation.

Table 8. Capacity for level of service evaluation

LOS	A	B	C	D	E	F
Capacity	600	960	1440	1824	2200	> 2200

Using the result from MCO method, for traffic volume from UTM to Taman Universiti, the traffic volume is 966 veh/hr while from Taman Universiti to UTM is 1198 veh/hr. Both ways have the traffic volume less than 85% of category C road capacity, which is 1224 veh/hr. Thus, the road is categorized in LOS C. This remarks that this road has stable flow and acceptable delay. Speeds and maneuverability are more closely controlled by higher volumes. The quality of the traffic stream on both ways of this road is satisfactory.

However, using the result from traffic count method, traffic volume from UTM to Taman Universiti is 1792 veh/hr. This make the LOS of this road fall into category E. 85% of category E road capacity is 1870 veh/hr. This road has unstable flow and yet lowers operating speeds and perhaps stoppages of momentary duration. Volumes are at or near capacity congestion and have intolerable delay. This condition of traffic stream is unsatisfactory and improvement to be able to carry traffic without causing delay. Delay means increase travel time, which directly influence the travel cost.

The PHF accounts for the uniformity of traffic flow over the peak hour. Since the PHF along UTM – Taman Universiti way is 0.51, further from unity, it is considered as this road has non-uniform traffic flow during the hour. PHF of 0.51 also shows that the road has not reached congestion phase since it is further from unity. The traffic volume within this peak hour is still acceptable.

6 Conclusion

Since the traffic space mean speed from UTM to Taman Universiti is in the range of 50 Km/hr – 55Km/hr and from Taman Universiti to UTM is 50 – 60 Km/hr, the speed limit for the test car is 55 Km/hr. For speed limit within UTM, since there are university students and workers travel around, it is recommended to use 35 Km/hr. The road has stable flow which does not need any improvements for this time being.

It is recommended to conduct the same study on workdays, during morning peak hour. Besides, it is better to carry out spot speed approach and traffic count on both ways of the road. Another point is the test car must be done at several points in the test site to get the reliable and acceptable data.

Acknowledgment

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