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# Parameters affecting fluctuation in traffic stream on urban roads

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**Abstract.** Moving Observer Method (MOM) is one of traffic data collection techniques that being used to collect the traffic flow at the urban roads. However, this technique is sensitive to the normal fluctuation of the traffic flow. Road length, intersection density, and driveway density are three main parameters contributed to the fluctuation of traffic flow in urban roads. This paper attempts to determine how much range of these parameters are affecting the fluctuation of the traffic flow. By using MOM technique, twenty urban roads in Johor Bahru city are selected randomly to analyse how these parameters contribute to this fluctuation of the traffic flow. Regression analysis is performed to identify the range of the effect of these parameters on the accessibility and fluctuation rate of traffic flow in urban roads. It is found that driveway density is significantly affecting the fluctuation of traffic flow followed by road length.

## 1. Introduction

Traffic data collection represents a cornerstone of transportation engineering. This is due to the success of planning, maintenance, and control of any transportation system depends on these traffic data [1,2]. Accordingly, if the traffic data is not correct, traffic engineering that being based on it will be flawed [2]. Various field techniques could be used to collect the traffic data such as, inductive tube, camera, radar, manual counting, videos camera, pneumatic tubes, Moving observer method (MOM), and others.

MOM is favourable and desirable technique for collecting traffic data in urban roads [3]. This is due to that MOM needs less time and cost to collect traffic data on urban roads [4,5]. However, the MOM technique is sensitive to the normal fluctuation of the traffic stream in urban roads [6]. The fluctuation of traffic flow in urban roads can be contributed by road length, intersection density, and driveway density. Therefore, this paper attempts to determine the effect of these three parameters on the fluctuation of the traffic stream.

## 2. Literature Review

### 2.1. Fluctuation of traffic flow demand

The fluctuation of traffic flow demand could be defined simply as the variation of traffic flow rate over certain period time [7]. Usually the fluctuation of traffic flow demand occurs in long- terms patterns such as day by week, week by month, and month by year [2]. However, the Highway Capacity Manual 2010, measured the fluctuation of traffic flow within the peak hour using the term Peak Hour Factor PHF [7]. The variation of traffic flow in short-time period is one of the key issues in the field of capacity

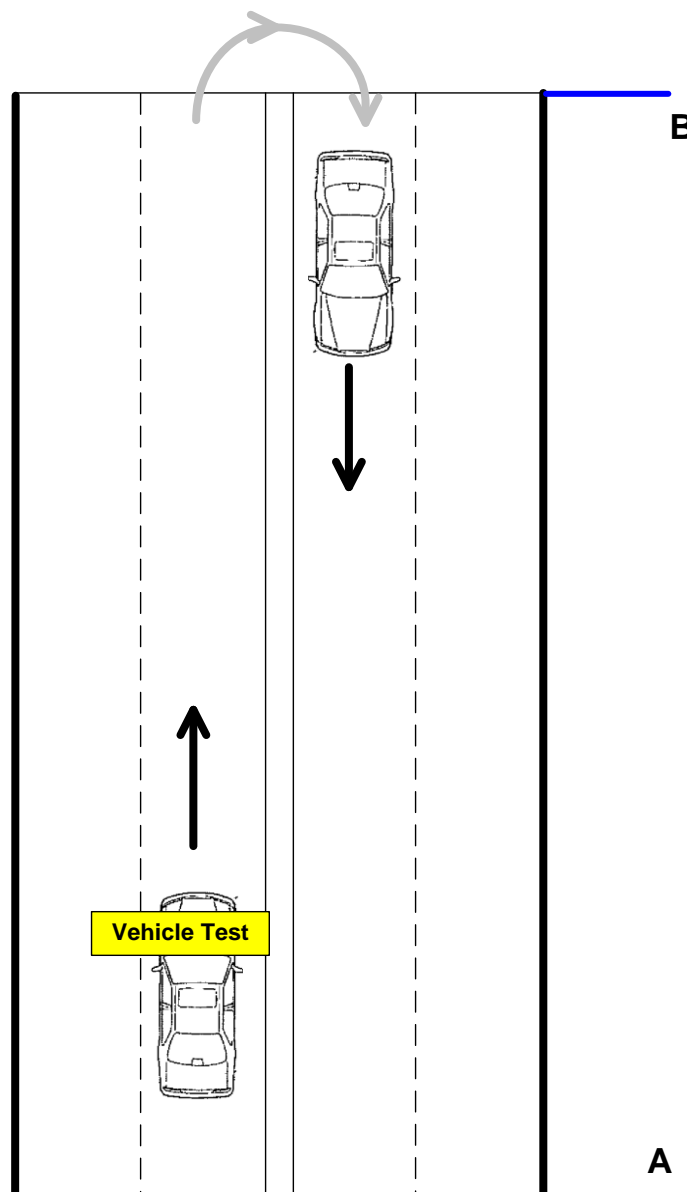


analysis, dynamic traffic control, and management [8,9]. This fluctuation of traffic flow in short-period time could be caused by traffic itself or by the infrastructure and the geometric layout of the facility [10]. Hence, most of the traffic flow fluctuation occurs in urban roads because it contains more access points over the entire road length [2,7].

Physically, two types of access points could be used for entering and discharging the vehicles along the entire urban road facility, driveways and intersections. Moreover, the road length of the urban road contributes for more accessibility of the traffic flow. This is because the road length could cover wide number of access points and residential area of people whose allow to enter the urban road facility within certain period time.

*2.2. Moving Observer Method (MOM)*

Moving Observer Method (MOM) developed by Wardrop in 1954 counts the traffic flow and travel time within a specific road segment with/against the traffic flow stream as shown in Figure 1 [11].



**Figure 1.** Illustration of moving observer method technique on road segment.

Referring to Figure 1, travel time and traffic flow within and opposite the moving observer are recorded. The obtained parameters are then used in the Equation 1, 2 and 3 to determine traffic flow, travel time and space-mean speed respectively.

$$q = \frac{(X+Y)}{(t_a + t_w)} \quad (1)$$

$$\bar{t} = t_w - \frac{Y}{q} \quad (2)$$

$$SMS = \frac{\bar{t}}{D} \quad (3)$$

Where

- q = the estimated flow on the road in the main direction,
- X = total number of vehicles met in the section when traveling against the stream,
- Y = total number of vehicles overtaken the observer minus the number of vehicles overtaken by the vehicle test when traveling with the stream,
- t<sub>w</sub> = the traveling time taken for the trip with the stream of the main direction,
- t<sub>a</sub> = the traveling time for the trip against the stream of the main direction,
- $\bar{t}$  = the mean traveling time of all vehicles in the stream,
- D = segment length,
- SMS = the space mean speed of the main direction

Average value of six (6) to twelve (12) trips of vehicle test were recommended [12–14]. Recently, modern GPS' technology and videos able to substitute the manual counting by Automatic Counting that being raised by the use and advantages of MOM technique [4].

### 3. Accuracy of MOM technique and trips number

Moving Observer Method (MOM) is one of the traffic data collection techniques to measure space mean speed and the traffic flow volume instantaneously on the same period time of the segment [11,15,3]. Using this valuable advantage, various studies were conducted to analyse relationship between traffic flow and the average travel speed on a road [16–19].

In MOM, the accuracy of the traffic volume for a certain period time relies on the normal fluctuation of the traffic stream on the road [6,16]. If the vehicle test make a number of trips on the road segment, the average value of traffic flow (q) on Equation 1 depends on the average value of total number of vehicles met in the section when traveling against the stream (X), total number of vehicles overtaken the observer minus the number of vehicles overtaken by the vehicle test when traveling with the stream (Y), traveling time taken for the trip with the stream of the main direction (t<sub>w</sub>), and traveling time for the trip against the stream of the main direction (t<sub>a</sub>) that being determined for every trip of the vehicle test. Hence, the accuracy of this average value (q) relies on the fluctuation of values “X, Y, t<sub>w</sub>, t<sub>a</sub>” were counting on one trip to next second one [6].

#### 3.1. Variance of traffic flow and trips number

The variance of the traffic flow is derived after end any sequence of trips. Accordingly, this variance value reflects the fluctuation of traffic flow conditions during the course time of trips. Equations 4, and 5 shows the equation to calculate mean traffic flow MTF and variance of traffic flow Var (TF<sub>m</sub>).

$$MTF_{tn} = \frac{\sum_{i=1}^{i=tn}(TF_i)}{(tn)} \tag{4}$$

$$Var(TF_{tn}) = \frac{\sum_{i=1}^{i=tn}(TF_i - MTF_{tn})^2}{(tn)} \tag{5}$$

Where

- tn : the trip number of the vehicle test,
- MTF<sub>tn</sub> : the mean traffic flow calculated for certain trip number tn,
- TF<sub>i</sub>, : the traffic flow volume for “ith” trip number,
- Var (TF<sub>tn</sub>) : the variance of the traffic flow for the trip numbers series.

The fluctuation of traffic flow volume would be readable using the variance values calculated using equations 4 and 5. However, this variance is defined by the trips number allowed to achieve the limit of variations of traffic flow volume from one trip to the next one. Based on different studies, the ten percent of the error is reasonable and satisfactory accepted for purpose of traffic volume studies [6,11,20]. For instance, if the variance value at the end of 4th trips number is 10 percent, and at the end of the 5th trip number is 16 percent. This is meant that the scatter of the traffic flow volumes is no “representing” of this road segment within this period time of trips number. Vice versa, if the variance at the end of trip 4th is 11 percent and at the end of 5th trip is 12 percent, this is meant the fluctuation of the traffic flow is low and the mean traffic flow is “representing” within this time period.

Accordingly, if the adopted maximum value of the variance is ten percent (10%), it is useful to define the minimum trips number required for reasonable accuracy of traffic flow volume based on this variance limit (ten percent). For example, if the variance was calculated at the end of trip number 4 is 11, then no need to run more trips in the segment road by the vehicle test whereas if the variance was calculated at end of 4 trip number is seven (or any value less than ten) then the road segments needs to add more trips via vehicle test. Table 1 presents the changes in variance of traffic flow with series of trip number for five urban roads in Johor Bahru city.

**Table 1.** Variance schedule for trips series for different roads in Johor Bahru State.

Road Name	Variance of Traffic Flow				
	Trip Num. 4	Trip Num. 5	Trip Num. 6	Trip Num. 7	Trip Num. 8
Bakar Batu	13	12	16	15	11
Dato AbdulTaher	8	7	5	8	10
Dato Jaffar A	9	9	11	12	11
Dato Jaffar B	13	14	11	15	14
Kenang	3	8	10	13	11

As shown in Table 1, four to eight trips were conducted at five urban road segments in Johor Bahru. At Bakar Batu road segments, the variance of traffic flow at minimum 4 trips is 13 exceeds the maximum allowable variance value of 10 percent. Dato Abdul Taher road segment shows variance of traffic flow achieved the maximum allowable variance 10 %, when the number of trips conducted were eight trips, trips lesser than 8 showed a lower variance value. Kenang road segments achieved the maximum limit of variance 10 percent on the trip number of 6.

## 4. Method

### 4.1. Data collection

For this study, twenty urban roads were chosen randomly from the road network of Johor Bahru State with different geometric and traffic properties. The method that be used to measure the independent variables namely driveway density and intersection density is directly manual counting by human eyes along the whole urban road segment. Then the density of these two variables was calculated by dividing the quantity numbers of these parameters on the road length of the segment. The road length was measured using the odometer of the vehicle test.

For the dependent variable Trips Number  $t_n$ , it was calculated based on equations 1, 4 and 5 respectively. Firstly, the traffic flow “ $q$ ” for each trip number was calculated directly based on the equation 1. The terms of this equation 1 “ $X, Y, t_w, t_a$ ” could be measured manually using a team of persons ride inside the vehicle test or automatically using the new GPS-technology device that records all these data-terms in memory card. This memory card could be playing back the videos that records all these terms and easily extracted using the computer.

Then after calculating the “ $q$ ” value for each sequence of trips, the value of Variance of traffic flow “ $\text{Var}(\text{TF}_{t_n})$ ”, based on the equations 4 and 5, was calculated. Finally, the trips number of each road will be adopted when the value of the variance equal to or greater than ten percent. Table 2 contains all the data results of these variables after measuring from the field. The trips number for every road represents the trip number when the variance of the traffic flow exceeds the maximum limit (ten percent).

**Table 2.** Results of the trips number that achieve the variance limit (10 %) and the independent variables of 20 urban roads in Johor Bahru State.

Serial No.	Road Name	Trips Number @ max-limit 10 %	Road Length (Km)	Intersection Density (Num/Km)	Driveway Density (Num/Km).
1	Bakar Batu	4	1.80	1.67	2.79
2	Dato AbdulTaher	8	0.69	1.45	4.34
3	Dato Jaffar A	6	0.95	3.15	8.40
4	Dato Jaffa B	4	1.66	1.21	9.06
5	Kenang	6	0.76	1.31	10.48
6	Kebun Teh	6	0.94	2.13	5.32
7	Langkasuka	5	1.96	1.53	6.11
8	Serampang	5	1.93	1.56	6.22
9	Sri Pelangi	5	1.34	1.50	8.99
10	Kuning	5	1.65	1.82	6.66
11	Sungi Chat	4	2.00	1.50	7.51
12	Suria Utama	5	1.39	1.44	7.19
13	Tompak	8	0.43	1.00	4.65
14	Yehya Awal	7	0.95	2.10	2.10
15	Bakek	4	3.24	1.54	5.24
16	Pasir Masjid	7	0.99	1.01	3.03
17	Padi Emas	7	0.60	3.33	3.33
18	Padi Mahrusi	5	1.68	2.98	6.56
19	Tanjung	4	2.33	2.15	5.58
20	Tun Fatimah	4	2.67	1.87	5.24

#### 4.2. Data analysis

Using the popular statistical package software SPSS, multilinear regression analysis was implemented between the independent variables that being contribute for the fluctuation of the traffic flow and dependent variable as the trips number that the variance of this traffic flow exceeds the maximum limit “ten percent”.

### 5. Results and model development

Equation 6 shows model developed for trips number and three independent variables.

$$\begin{aligned}
 \text{Trips Number (Y)} \\
 &= 9.0 - 1.52 (\text{Road Length}) - 0.18(\text{Inters. Dens}) \\
 &- 0.18(\text{Driveway Density})
 \end{aligned}
 \tag{6}$$

The value of correlation coefficient R square and standard error of the model are 0.82 and 0.62 respectively (Table 3). As the ANOVA Table 4 shown, this model is significant at 95% level of confidence (p-value < 0.05). However, as the table of coefficients test of this model shown “Table 5”, the t-test value of the intersection density parameter of the model is 0.357 (should be lower than 0.05). This is meant that the contribution of this parameter over the model is not significant.

**Table 3.** Model summary.

Model	R	R Square	Adjusted R square	Std. Error of the Estimate
1	0.906	0.821	0.788	0.62486

**Table 4.** ANOVA table of the model equation.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	28.703	3	9.56	24.504	0.000
Residual	6.247	16	0.39		
Total	34.95	19			

**Table 5.** Coefficients results and tests of the model equation.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error			
Constant	9.155	0.595		15.382	0.000
Road Length	-1.523	0.195	-0.826-	-7.795	0.000
Driveway Density	-0.18	0.064	-0.310-	-2.922	0.010
Intersection Density	-0.18	0.189	-0.101-	-0.949	0.357

The other useful result of this model is the constant value of the model equation “nine”. This number “nine” was meant that if the urban road segment has no driveways or intersections, the initial trip numbers that being required to begin the variance of traffic flow volume exceeds the ten percent is nine. This is in turn needs time long enough before the fluctuation of traffic flow begins to rise ten percent of variance.

**6. Conclusion**

The investigation of this study was aimed to analyse the parameters contribute for the fluctuation of traffic flow in urban roads. Findings from the study revealed that road length, and driveway density significantly affecting the variance of traffic flow in urban roads using MOM technique. Based on the result of this study, it was found that the increase of driveway density by one driveway per one-hundreds of meter will decrease the trips number required to exceed the variance limit (10 %) by one trip. Whereas, the increase of road length of the urban roads by one and half kilometre will decrease the trips number required to exceed the variance limit (10 %) by one trip.

The other finding consequence of this study is the intersection density has no significant effect on the fluctuation of traffic flow comparing the driveway density. This could be interpreted as within the same period time, the frequency of vehicles in quantity arriving at the intersections were not high comparing to that quantity of vehicles entering or discharging from the driveways in the urban road segment.

Apart from these findings, this study approved that fluctuation of traffic flow is not affected only by the normal variation of the vehicles over the long or short-time periods. It was also affected by the geometric layout of the roads services the flow. Hence this is encouraging to take into account these parameters to assess the level of service of an urban road facility over a short period time of analysis.



Regarding the MOM technique, it is also approved by the results of this study that the fluctuation of traffic flow volume is not exceeded the level that being the application of MOM technique to measure the traffic flow demand is statically unaccepted in urban roads.

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