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The Analysis the Role of Motorcycles on Saturation Flow Rates at Signalized Intersections in Gorgan

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Abstract

One of the traffic parameters associated with the traffic conditions for each country is saturation flow rate at signalized intersections. One of the vehicles that is impaired the capacity of Signalized Intersections are motorcycles, that affect the saturation flow rate. Checking this field shows that the motorcycles due to their small size compared to other vehicles can cross the intersections in particular forms. In this study, motorcycles at an intersection are divided into two groups, in the traffic flow and out of it that both of them affected the saturation flow rate. Inside flow motorcycles are defined as those that are located next to or behind other vehicles and when the light becomes green, pass through the intersection with other vehicles. Motorcycles outside the flow are called to those that located in front of the stop line and they are the first vehicles that exit the intersection after the light become green. The methodology of this work is to use a video camera mounted on a tripod on the sidewalk that focuses camera lens on pedestrian lane. Recording started when the light turn to green and stopped when it became red. The purpose of this paper is to collect traffic data of the intersection by screen capture, calculation of observed saturation flow rate based on the motorcycles in the flow, estimate the saturation flow rate by Malaysian HCM based on the motorcycles out of the flow and at the end, comparison of observed and estimated saturation flow rate. The results of this study indicate that in the estimation of saturation flow rate, only the motorcycles in the flow should be considered.

Keywords: Estimated Saturation Flow Rate, Motorcycles into the Flow, Motorcycles out of Flow, Observed Saturation Flow Rate, Signalized Intersections

1. Introduction

In general, to improve the performance of a system, it is necessary to identify and study the parameters and factors influencing it and existing problems in it. This study especially in relation to systems that human behavior plays a role on it is important. Intersection is a system that its performance directly related to the behavior of the users. One of the vehicles hampered the capacity of the Signalized intersections is motorcycle. This vehicle with low-volume and low fuel consumption is popular among people and causes doing work faster.

On the other hand, motorcyclists at intersections placed between different vehicles and the riders have to pass with more caution to prevent an accident and this, hampered the traffic flow and reduce the saturation flow rate at signalized Intersection. Due to the high maneuverability of the motorcycle, riders can cross the intersection more easily than other vehicles.

Their typical movements as follows:

1. First group of motorcyclists moves between the distance of the vehicles and gets to the stop line of the crosswalk. This group of motorcyclists is considered as out the flow of traffic motorcycles.
2. Second group is people that are placed behind or next to other vehicles and with getting the lights green, moved to leave the intersection. This group is considered as motorcycles within the traffic flow.

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Both of them influenced the saturated flow and thus the capacity of the intersection. This paper studies the effects of motorcycles on saturation flow rate at signalized Intersection.

2. Literature Review

In relation to the role of the motorcycles on saturation flow rates less research has been done.

Yanming Guo et al. researched the behavior of cyclists at signalized Intersections, thus, they presented a model for accidents between vehicles and bicycle and the effects of the bicycles on saturation flow rates[1]. For determining the F_{LB}(bicycle adjustment factor for left-turn) and F_{RB} (bicycle adjustment factor for right-turn), they presented new formulas and they concluded that when the traffic flow of the bicycle is high, the proposed model is very close to the field observation data and these results shows better corresponding than the HCM results.

Kara M. Kockelman and Raheel A. Shabih investigate the effects of light-duty trucks on saturation flow rate at signalized intersection[2]. They use van's Headway to determine their PCU (Passenger Car Unit). The results showed that vans require a greater distance than passenger vehicles and to determining the capacity of the intersections should be separately considered.

Chen Xiaoming et al. studied the effects of the bicycles on the capacity of the Intersections and determine the crossing time of the bicycles turning left from the opposite direction through the vehicles and presented a model for them[3]. They reached to these results that the Capacity of the vehicles passing and turning left at the predicted model is less than capacity in the prediction model of HCM. Also, vehicles turning right when the bicycle volume is low, the capacity of the model is close to the HCM model but when the bicycle volume is high the capacity of the model is higher than HCM.

Li Lian et al. presented a model for dispersing the vehicles at the time of greening the light based on the analysis of characteristics of dispersing the vehicles at signalized Intersections, to determine the capacity of the bicycles and achieved the relationship between bicycle capacity, green lights, cycle and ratio of bike entrance to intersection[4]. Taylor et al. used camera to estimate the Headway of the different cars. This method is an inexpensive, rapid, accurate and the best method to assess traffic. Checking the Headway time on the highway, shows the potential of this technology in an environment with high speed[5].

Jin Xin CAO et al used video method to investigate the bicycle flow at signalized Intersection[6]. Their purpose was to estimate the flow capacity of the bicycles at signalized intersection. To describe the relationship between the length of the line bikes and parked bikes, IMU-LN model and to describe the relationship between the length of the line bikes and the average of the queue density, IMU-DL model was presented. They concluded that the IMU-LN model can be used to calculate the value of the queue length whereas the exact amount of density in the queue can be estimated by IMU-DL model.

Ibrahim et al. tries to determine the ideal saturation flow rate in Malaysia Intersections. He used filming method to determine the saturation flow rate[7].

$$S = 1020 + 265w \qquad R^2 = 0.876 \tag{1}$$

S = saturation flow rate (pcu/h)
W = the width of the line (m)
R = line regression

3. Research Methodology

Movement of the vehicles in intersection when the lights got green was recorded by a video camera. In this paper, two types of data were collected. A bunch of information pertains to the number of vehicles that categorized based on motorcycle, truck, bus and passenger cars. Second group of the data related to the behavior of motorcyclists at signalized Intersection. In this case, motorcycles divided into two categories.

1. Motorcycles have been stopped behind the stop line.
2. Motorcycles have been stopped beside and behind other vehicles in the traffic flow.

To calculate the observed saturation flow rate, the exiting pattern for vehicles, except outside flow Motorcycles, when lights get green observes for 10 seconds and recorded on specific Forms of the traffic flow. Observed saturation flow rate was determined based on the Table 1.

Table 1. Calculating the saturation flow rate at Falsafi intersection (south to north)

Number of the vehicles in each 10 seconds				cycle
fourth 10 seconds	third 10 seconds	Second 10 seconds	First 10 seconds	
9	11	5	11	1
8	12	5	6	2
1	7	7	6	3
3	6	6	9	4
2	7	5	11	5
12	3	4	5	6
4	6	6	8	7
4	8	9	7	8
11	9	5	6	9
8	7	11	8	10
11	11	8	7	11
4	9	4	8	12
7	8	5	6	13
11	5	7	8	14
5	8	5	6	15
6	4	7	7	16
5	3	3	4	17
7	5	7	12	18
5	11	3	7	19
6	4	9	4	20
129	144	121	146	Total vehicles
20	20	20	20	Number of samples
6.45	7.2	6.05	7.3	Average of the vehicle

Observed Saturation flow rate = (Total Flows in Saturated headway)/(Total samples in saturated headway)

$$S = \frac{146+121+144+129}{20\times 4\times 10} = 0.675\text{veh/s} = 2430\text{veh/h} \qquad (2)$$

Saturation flow rate estimated on the basis total Motorcycle volume by the Malaysian HCM (Highway Capacity Manual 2006) and compared with the observed saturation flow rate.

4. The Malaysian HCM Saturation Flow Rate

Saturation flow rate is the maximum flow of a variety of vehicles that can pass the intersection from an entering the signalized intersection, under the traffic and geometry conditions in an hour assuming that the effective green time for all the vehicles at all the time is established. According to equation (3), determining the saturation flow rate in Malaysia Regulations[8] is as follows:

$$S = S_0 \times f_w \times f_g \times f_a \times \frac{1}{f_c} \qquad (3)$$

Where

e_{car} = Factor of passenger
S = Saturation flow rate based on $\left(\frac{\text{Veh}}{\text{h}}\right)$
S = Perfect saturation flow rate that is estimated 1930
f_w = Line width adjustment factor
f_g = Slope adjustment factor
f_a = Place Adjustment factor

Since the PCU in each country and basically in every place is different, so the amount of PCU should be calculated in each intersection individually and used to calculate the saturation flow rate at each intersection.

Table 2. Parameters used in the estimation of saturation flow in Regulations of Malaysia

Amount	Parameter
=1	e_{car}
=0.22	e_{motor}
=2.08	e_{bus}
=1.19	e_{Lorry} PCU
1930	S_0
=1 other	f_a
=0.8454 CBD	
$=1+\frac{W-3.66}{3}.663$	f_w
$=1-\frac{\%G}{26}.34$ downhill	f_g
$=1-\frac{\%G}{14}.39$ uphill	
No gradients=1	

$$f_c = f_{car} + f_{hv} + f_m \quad (4)$$

$$f_{car} = e_{car} \frac{q_{car}}{(Q)} \quad (5)$$

$$f_{hv} = e_{Lorry} \frac{q_{Lorry}}{(Q)} + e_{bus} \frac{q_{bus}}{(Q)} \quad (6)$$

$$f_m = e_{motor} \frac{M_T}{(Q)} \quad (7)$$

$$Q = q_{car} + q_{hv} + M_T \quad (8)$$

Where:

f_c = Vehicles Composition adjustment factor
q_{car} = Traffic flow of car (veh/h)
q_{Lorry} = Traffic flow of lorry (veh/h)
q_{bus} = Traffic flow of bus (veh/h)
M_T = Traffic flow of total motorcycles (veh/h)
Q= Total flow (veh/h)

During the preliminary investigation it was found that motorcycle traffic during the peak of the afternoon and evening is more than during the peak of the morning. Therefore, The data collected in hours (12-13) and (18:30-19:30). Data collected during normal days and fine weather. Data collection was performed at three intersections and total of 12 approaches in Gorgan.

5. Result

After extracting traffic data and calculation of observed saturation flow rate based on the motorcycles inside the flow (M_{in}) and the estimated saturation flow rate based on the total motorcycles, the comparison was made. To observe the distribution of the Motorcycles and compare both inside and outside flow motors (M_{out}), Figure 1 was shown. This graph shows that the inside flow motors are more than outside flow motors.

The reason is the limited space behind the crosswalk. An average of 74.4% motorcycles is inside the traffic flow and 25.6% Motorcycles is outside of the flow traffic. Linear regression equations can be used to estimate the volume of the motorcycles per hour.

To determine the effects of a motorcycle on saturation flow rate per hour, the observed saturation flow rate

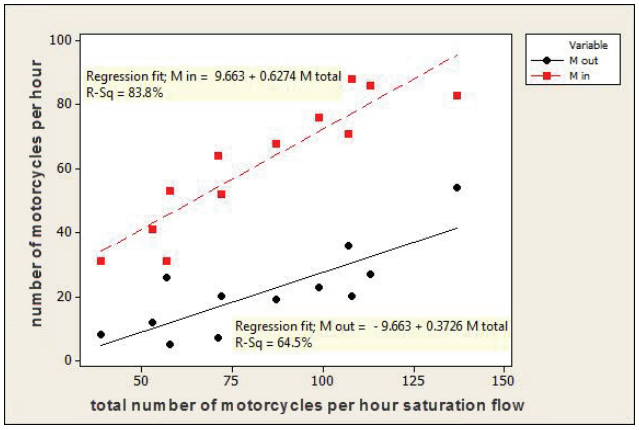

Figure 1. Comparison of both inside and outside flow motors.

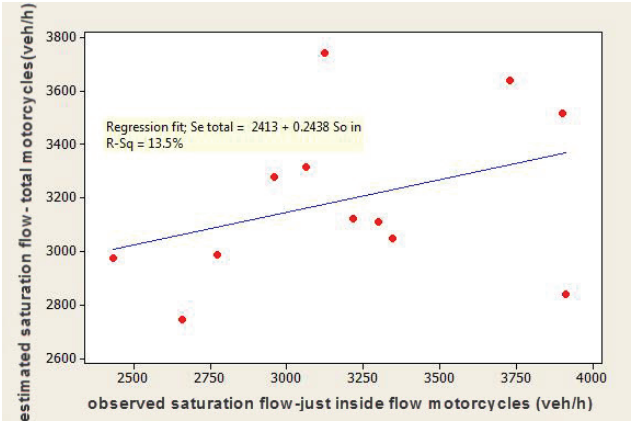

Figure 2. The comparison of the observed and estimated saturation flow rate.

based on inside flow motors (So_{in}) and the estimated saturation flow rate based on total Motorcycles (Se_{total}), were compared. The results are shown in Figure 2.

According to the Figure 2, it was observed that in 50% of the data, the observed saturation flow rate is greater than the estimated saturation flow rate. The percentage of the difference between the observed and estimated saturation flow rates at three intersections and twelve approaches is summarized in Figure 3. The highest percentage of the difference that was calculated is 22.39% while the lowest is -27.4%. So in order to determine the effect of the volume of the motorcycles on saturation flow, Figure 4 is presented. According to this Figure, it was observed that when total motorcycles and inside flow Motorcycles is about 10%, the observed and the estimated saturation flow rates are equal.

Figure 5 is shown the influence of inside flow motorcycles, the estimated saturation flow rate based on

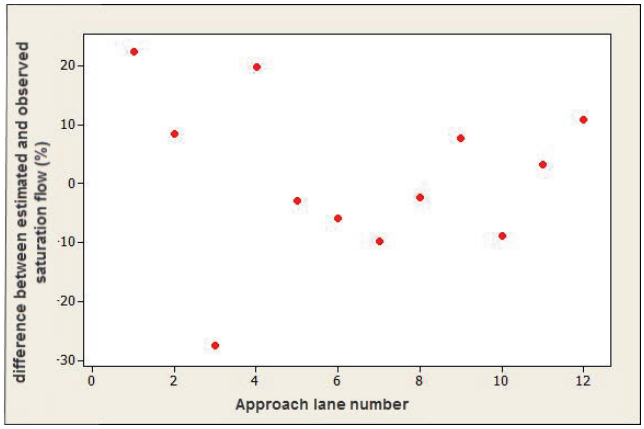

Figure 3. Percent of difference between $\mathbf{So}_{in}$ and $\mathbf{Se}_{total}$.

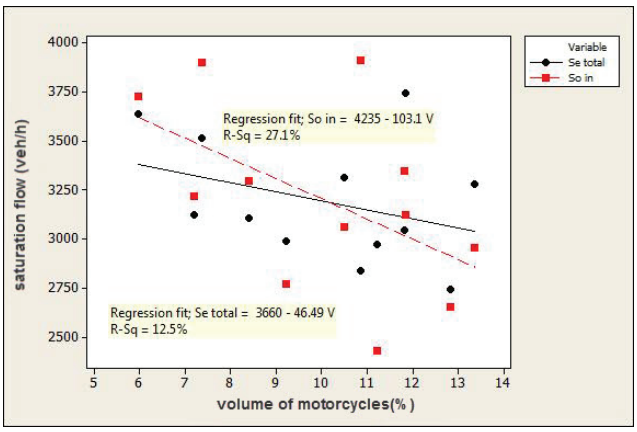

Figure 4. The effect of volume of the motorcycles on saturation flow.

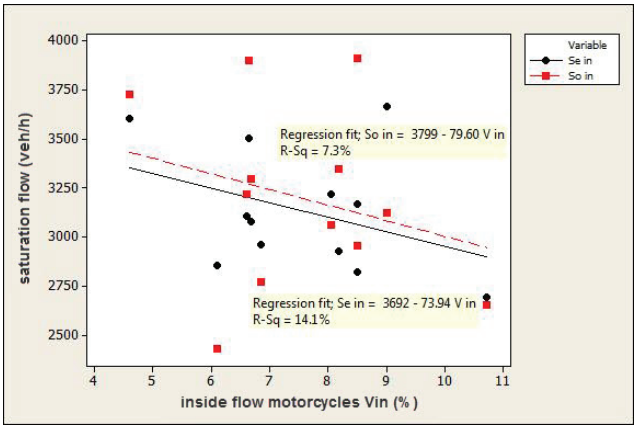

Figure 5. The effects of the inside flow motorcycles on the saturation flow rate.

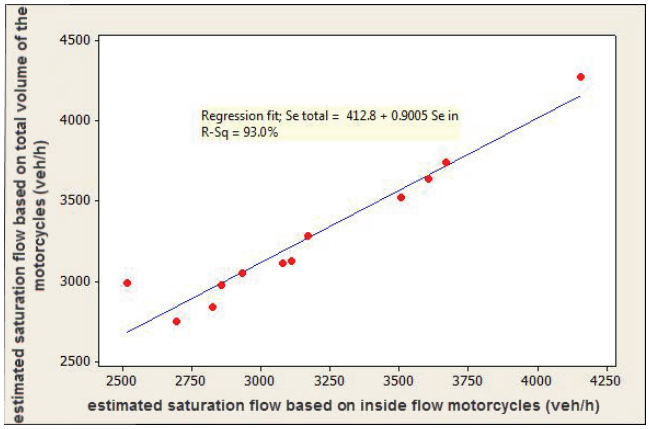

Figure 6. The effect of movement pattern of motorcycles on saturation flow rate.

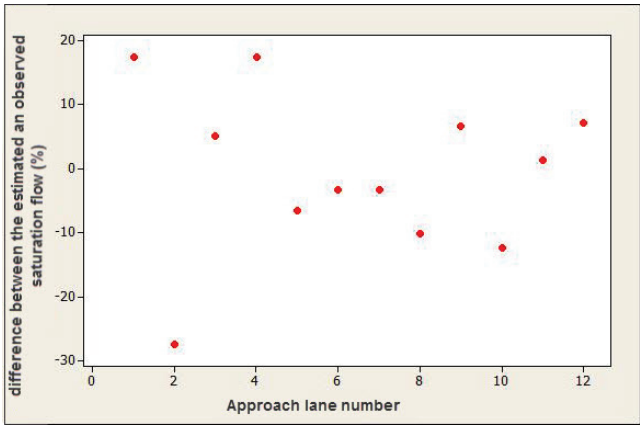

Figure 7. The percentage of the difference between the observed and estimated saturation flow rate based on the inside flow motorcycles.

only inside flow motorcycles and observed saturation flow rate. Again in 50% of the samples, the estimated saturation flow rate based on the inside flow motorcycles is greater than the observed saturation flow rate. Also, if the volume of the inside flow motorcycles (V_{in}) is approximately 19%, The estimated and the observed saturation flow rate are equal.

Figure 6 shows the effect of movement pattern of motorcycles on estimated saturation flow rate. According to this Figure, it was observed that the estimated saturation flow rate based on total motorcycles is greater than the estimated saturation flow rate based inside flow motorcycles. However, the distribution of the data points is lower and the data points are closer together, and it means that the difference between the obtained values is

not so much. In Figure 7, The maximum percentage of the difference between the estimated saturation flow rate based on inside flow motorcycles and observed saturation flow rate is about 17.57%, while the lowest percentage of the difference is -27.77%.

6. Conclusion

In this paper the behaviors of motorcyclists at signalized Intersections in Gorgan and its impact on the estimation of the saturation flow was studied. Observed saturation flow rate based on inside flow motorcycles and with observing the recorded films at the intersection and estimated saturation flow rate based on total motorcycles and Malaysian regulations were calculated. The results show that there is a huge difference between the saturation flow rates. For this reason the estimated saturation flow rate was calculated based on only inside flow motorcycles and compared with the observed saturation flow rate. This comparison showed that the difference between them is less. So it is better to estimate the saturation flow rate, just inside flow motorcycles considered instead total motorcycles to reach the results closer to reality.

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