Impact of Signalized Intersection on Vehicle Queue Length At Uthm Main Entrance

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Abstract

This paper present conducted study to determine the traffic capacity of signalized intersection, level of service signalized intersection and the congestion speed occur at study location. This study is focused at the area of UTHM main entrance and the signalized intersection located near to the main entrance. Congestion problems are closely related to the main entrance area because at this area there was a bottleneck phenomenon which can cause traffic congestion. Base on observation that has been conducted, traffic congestion occurs at peak hour which was vehicles through the area with the maximum amount. In this study, the peak hour for data collection was selected in the morning and evening peak. Video recording has been used to collect data at the study location. Level of Service for traffic lights obtained using the Highway Capacity Manual (HCM). Data observations have been made within a week to identify the day that has the highest traffic capacity. The analysis indicated that Tuesday recorded the highest traffic capacity with 374 vehicles per hour in the morning and 472 vehicles per hour in the afternoon. The level of service for the signalized intersection obtained from the analysis was at the level D during the morning peak and level E during afternoon peak. The movement of traffic congestion obtained at the exit lane was moving backward with a speed of -0.8km/hr and -0.2km/hr. At the entrance, movement of traffic congestion obtained was moving forward with a speed of 12.17 km / hr. From the analysis, we found that congestion occurs is critical to the exit from the entrance. Overall, it is found that congestion occurs at the exit lane is more critical than the entrance

Introduction

Traffic congestion is a condition on any traffic network as use increases and is characterized by slower speeds, longer trip times, and increased queuing. The most common example is for physical use of roads by vehicles. When traffic demand is great enough the interaction between vehicles slows the speed of the traffic stream, congestion is incurred. As demand approaches the capacity of a road or of the intersections along the road, extreme traffic congestion sets in. When vehicles are fully stopped for periods of time, this is colloquially known as a traffic jam.

In order to study this problem, the cause of this problem must be identified first. Various causes can be attributed to traffic congestion. They are divided into 3 major factors which are traffic influencing events, traffic demand and physical highway features [2]. These are the main factor that needs to be analyzed and study to understand about traffic congestion. From analysis the causes of occurring traffic congestion, the solution to overcome this problem will be find.

Monitoring congestion is just one of the several aspects of transportation system performance that leads to more effective investment decisions for transportation improvements. Safety, physical condition, environmental quality, economic development, quality of life, and customer satisfaction are among the aspects of performance that also require monitoring. Congestion is intertwined with all of these other categories since higher congestion levels have been associated with their degradation.

From the observations that have been made in the area, found that traffic congestion frequently occur. Usually, this thing happens during peak time in the morning and evening. This situation is a phenomenon that has become the norm for UTHM communities for enter and exit to the main campus during peak hours. It is happen due to a severe contraction in the main entrance road known as bottleneck. Actually the main entrance can accommodate the number of vehicles in and out but the situation is not practical and can cause congestion during peak hour. The situation was compounded further with the traffic lights in front of the main entrance which is by unsuitable traffic light cycle that also contribute to the traffic congestion. Even though UTHM has taken alternative to reduce traffic congestion by opening the other gate, this problem still occur. Therefore, the study of traffic congestion should be made for determine level of traffic congestion that occur at the UTHM main entrance during peak hour in order to take an action to reduce the traffic congestion.

By referring to the problem statement in this study which is congestion at UTHM main entrance area, locations of study already has been determined. The study area includes UTHM main entrance area and signalized intersection near to the UTHM main entrance. This study conducted at peak hour which at 7.00-9.00 am in morning peak and 4.00-6.00 pm in evening peak. This study will use shockwave theory as a method to evaluate the congestion that occurs at the UTHM main entrance.
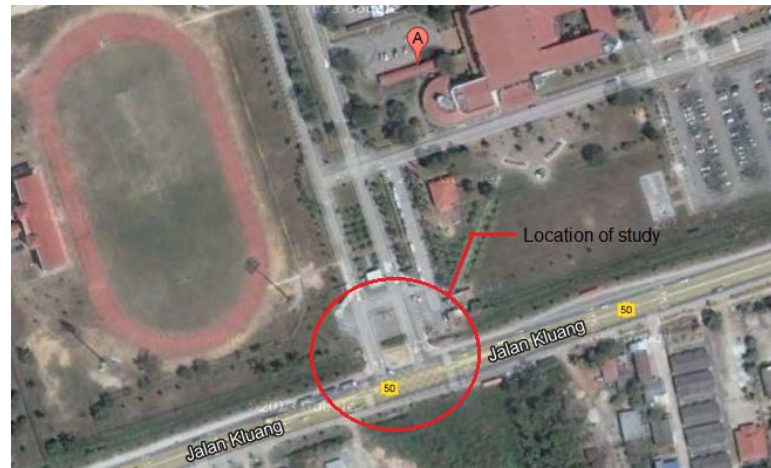

Figure 3.1: Satellite view of study location
(Google map, 2013)

Capacity of signalized intersections

The capacity analysis is carried out to ascertain the maximum traffic that can be accommodated by given traffic facility. It is also intended to estimate the maximum amount of traffic that can be accommodated by a facility without compromising the operational qualities. Capacity at signalized intersections is based on the concept of saturation flow and saturation flow rate [1]. The flow ratio for a given lane group is defined as the ratio of the actual or projected demand flow rate for the lane group (v_i) and the saturation flow rate (s_i). The flow ratio is given the symbol (v/s) for lane group i. The capacity of a given lane group may be stated as shown in equation 3.1.

$$C_i = S_i \frac{g_i}{C} \qquad (1)$$

Where:

C_i = capacity of lane group i (veh/h)
S_i = saturation flow rate for lane group i (veh/h)
g_i / C = effective green ratio for lane group i
C = cycle length (s)
g_i = effective green time for movement or lane group (s)

Determine level of service

The average control delay per vehicle is estimated for each lane group and aggregated for each approach and for the intersection as a whole. LOS is directly related to the control delay value. To determine the level of service for each lane, refer to the table 3.1

Table 3.1: LOS criteria for signalized intersections
(Highway capacity manual, 1988)

LOS	Control Delay per Vehicle (s/veh)
A	≤ 10
B	> 10-20
C	> 20-35
D	>35-55
E	>55-80
F	>80

Shockwave theory

A shockwave describes the boundary between two traffic states that are characterized by different densities, speeds and flow rates. Shockwave theory describes the dynamics of shockwaves, in other words how the boundary between two traffic states moves in time and space [3]. Shockwave basically occur from congestion and queuing along the road. Usually shockwave practice that traffic transition from flowing, speedy state to the congestion. However, it is also can present in opposite situation which is traffic transition from congestion to the sudden acceleration condition.

Shockwaves can be seen by the cascading of brake lights upstream along a road. They are often caused by a change in capacity on the roadways which is from 4 lane road drops to 3 lanes, an incident, a traffic signal on an arterial or a merge on freeway. In shockwave theory, the capacity maximum flow drops C_1 to C_2 also change the optimum density. Speeds of the vehicles passing the bottleneck will of course be reduced, but the drop in speed will cascade upstream as following vehicles also have to decelerate. In this equation, k_d and q_d represent downstream meanwhile k_u and q_u represent upstream flow conditions. In the flow concentration curve, the shockwave speed is represented by the slope of the line connecting the two flow conditions. The shockwave speed calculated by using formula above.

$$u_w = \frac{q_d - q_u}{k_d - k_u}$$

(2)

Where:

U_w = wave velocity (km/hr)

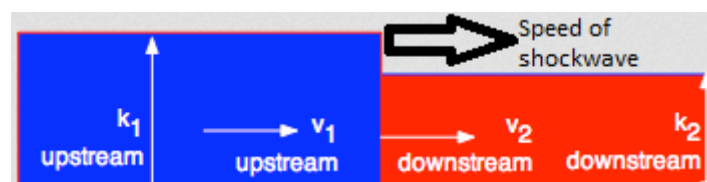k = density (veh/km)

q = flow (veh/hr)

Figure 3.2: Wave boundary

Methodology

In this study, video camera was used to record the flow of traffic movements through the intersection when approaching to UTHM main entrance. The collection data to determine the capacity of signalized intersections has been carried out within 5 days a week. The purpose of this method is to obtain and determine the highest capacity of traffic that approached to the UTHM main entrance. The day that has highest capacity in a week will refers for the further analysis.

Result

The data collection has been conducted to determine the capacity of signalized intersections within 5 days a week. The purpose of this method is to obtain and determines the highest capacity of traffic that approached to the UTHM main entrance for the further analysis. Figure 5.1 has shown a graph of capacity analysis in a week and found that Tuesday has a higher capacity. So for the further analysis such as level of service and shockwave theory will used Tuesday data.
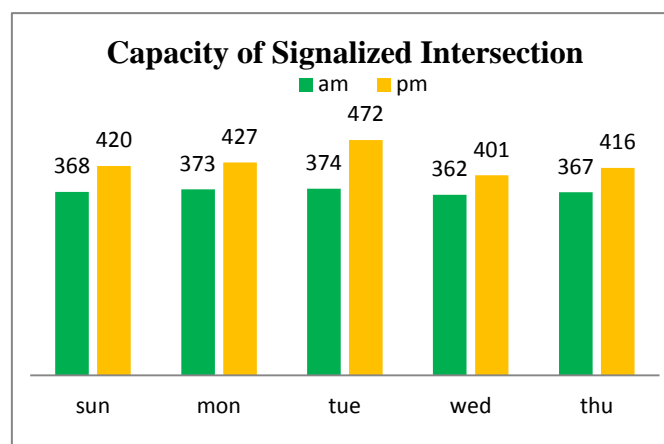

Figure 5.1: Capacity of signalized intersection at UTHM main entrance (veh/hr)

In order to obtain the LOS for the intersection, the amount of delay is required. The stopped delay can be measured to approximate the control delay and by using Highway Capacity Manual design, the level of service for the signalized intersection can be obtained. By obtaining the LOS, it can used to determine the current performance level of an existing signal and modification can be done by referring to the result. In this study, LOS is focus to the traffic that approach to the UTHM main entrance, so only two movements which is traffic flow in and out are measured.
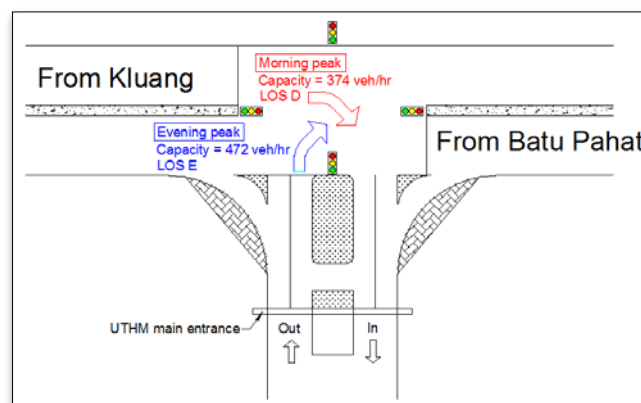

Figure 5.2: Capacity and LOS at UTHM main entrance

The locations for the analysis of shockwave has been identify which is at the entrance and exit lane. Both directions have bottleneck situation. At exit lane, shockwave analysis has been classified into 3 regions which are approaching zone, middle and free flow zone meanwhile at entrance lane shockwave analysis has been classified into 2 regions. Figure 5.3 show the region of shockwave at UTHM main entrance. The next step was calculated the shockwave speed from traffic volume and density data. Figure 5.4 and 5.5 show the shockwave speed at entrance and exit lane.
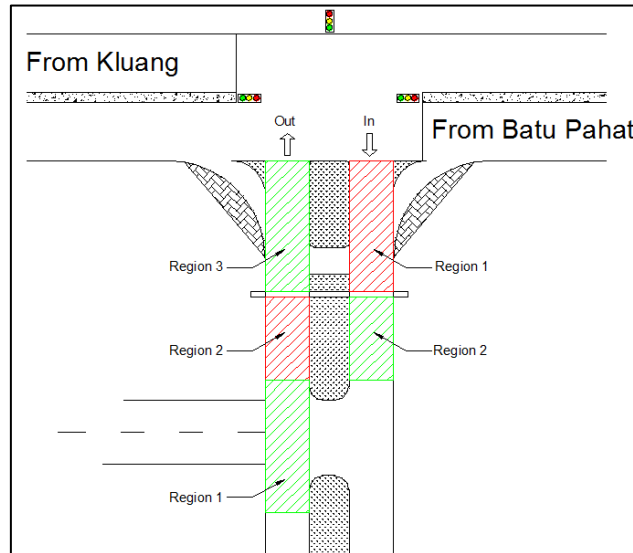

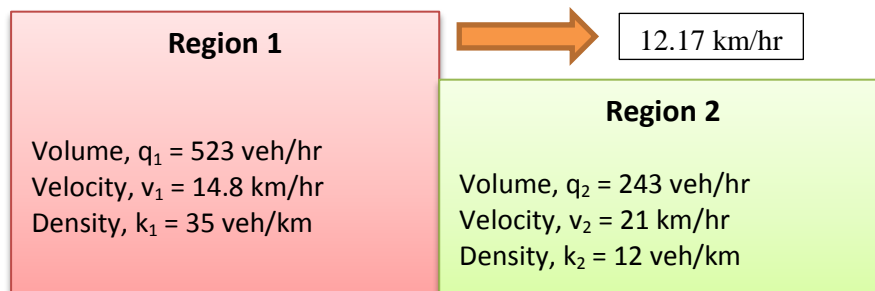Figure 5.3: Shockwave region at UTHM main entrance

Region 1

Volume, q_1 = 523 veh/hr
Velocity, v_1 = 14.8 km/hr
Density, k_1 = 35 veh/km

12.17 km/hr

Region 2

Volume, q_2 = 243 veh/hr
Velocity, v_2 = 21 km/hr
Density, k_2 = 12 veh/km

Figure 5.4: Shockwave speed at UTHM entrance lane

-0.2 km/hr

Region 3

Volume, q_2 = 316 veh/hr
Velocity, v_2 = 19.76 km/hr
Density, k_2 = 16 veh/km

Region 2

Volume, q_1 = 214 veh/hr
Velocity, v_1 = 0.47 km/hr
Density, k_1 = 455 veh/km

-0.8 km/hr

Region 1

Volume, q_2 = 564 veh/hr
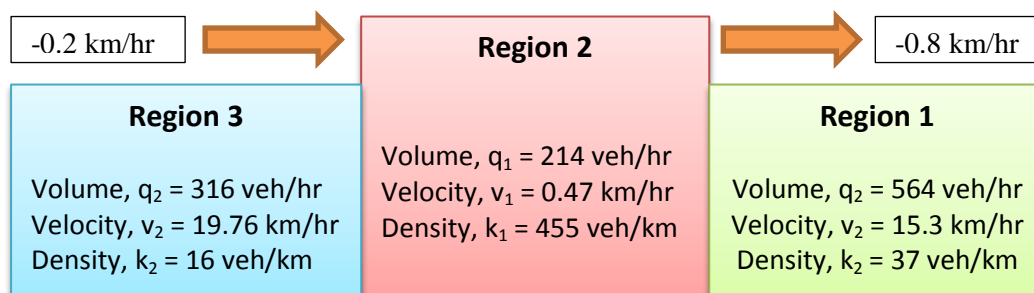Velocity, v_2 = 15.3 km/hr
Density, k_2 = 37 veh/km

Figure 5.5: Shockwave speed at UTHM main exit lane

Conclusion

The Overall, the effectiveness of signalized intersection at the minor road is considered not satisfied with level of service D and E. Minor road user trying to enter major road will suffer from excessive delay from congestion. Meanwhile result from analysis show that the effectiveness of UTHM main entrance also in poor condition in peak hour because of bottleneck phenomena.

References

[1] Highway Capacity Manual 2000 Chapter16 Signalized Intersections Transportation Research Board of the National Academies of Science US. 2000

[2] The Federal Highway Administration, FHWA (2013). Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation.

[3] H, Serge and K, Victor. Traffic flow theory and modeling. The Transport System and Transport Policy.