CHAPTER 1

ANALYSIS OF DELAY AND LEVEL OF SERVICE OF SIGNALIZED INTERSECTION AT KM 19 AND KM20

1.1 INTRODUCTION

The rate of new vehicles registration in Malaysia is growing continuously throughout these few years and this has resulted in massive increased in traffic volume. Thus, the traffic congestion problem is occurring every day in Malaysia. Traffic congestion is a situation with the characteristic of slow speeds, long trip times and long queue in any operating road condition with a great amount of traffic volume [1]. Along the Federal Route 50 (FT 50) Jalan Kluang, traffic congestion happens frequently at the peak hour periods especially at the signalized intersection. In this study, signalized intersection at KM 19 and KM 20 (Fig 1.1) were selected as the study area as traffic congestion always happen especially during morning and evening peak hours. The most popular measure of traffic congestion is the use of LOS as it is comprehensible by most of non-technical audiences [2]. LOS is accounted as a performance measurement to represent the quality of service with six level of service which is based on the perspective of the traveler and the operating road condition [3]. However, delay is the main parameter to determine LOS at the particular signalized intersection.

The objective of this paper is to evaluate delay and LOS at signalized intersection at KM 19 and KM 20 along the FT 50. This paper also proposed an effective cycle length of the traffic signal for both signalized intersections. In order to conduct this study, a weekday of traffic volume was recorded simultaneously using video recording technique during morning peak (7.00am to 9.00am) and afternoon peak (4.30pm to 6.30pm) with sunny weather situation. SIDRA Intersection 5.0 was used as aid of simulation to evaluate delay and LOS. JKR Arahan Teknik (Jalan) 13/87 was used to determine the LOS and computed effective cycle length of the signal timing.

Figure 1.1: Study location at KM 19 and KM 20 viewed from map.

1.2 LITERATURE REVIEW

1.2.1 DELAY

Delay is one of the essential measures of performance used to determine the LOS at signalized intersection [6]. Estimation delay can be done in several methods which currently widely used to determine the vehicular delay by using a simple and accurate technique with 4 measures of performance are namely: stopped delay, time-in-queue delay, approach delay and percentage of vehicle stopping and interrelationship [7]. There are many simulation software to evaluate the signalized intersection such as VISSIM, SIDRA and CORSIM [8]. In this study, SIDRA is selected to use to analyses delay and LOS as SIDRA's operation is easier than VISSIM and specially applied to simulate intersection including general intersection and roundabout [8].

1.2.2 LEVEL OF SERVICE

LOS is the performance for automobile, pedestrian and bicycle travel mode [3]. However, in this study, only LOS for automobile is considered. The LOS criteria for automobile which according HCM 2010 is presented in Table 1.1 whereas the LOS criteria for automobile which according JKR Teknik Arahan (Jalan) 13/87 is presented in Table 1.2.

Table 1.1: Level of service criteria for signalized intersection

Control Delay (sec/veh)	LOS by Volume-to-Capacity Ratio	
	≤1.0	>1.0
≤10	A	F
>10-20	B	F
>20-35	C	F
>35-55	D	F
>55-80	E	F
>80	F	F

Source: (HCM, 2010)

Table 1.2: Level of service criteria for signalized intersection

Level of Service	Delay per Vehicle
A	<5.0 seconds
B	5.1 to 15.0 seconds
C	15.1 to 25.0 seconds
D	25.1 to 40.0 seconds
E	40.1 to 60.0 seconds
F	>60.0 seconds

Source: (JKR, 1987)

1.2.3 TRAFFIC SIGNAL TIMING

Traffic signal timing is to minimize the delay and accidents conflicts at signalized intersection by assigning the right-of-way to various traffic movements [10]. However, installation of traffic signals need to consider the warrants for traffic signal stated in Arahan Teknik (Jalan) 13/87 which are included: Vehicular Operations, Pedestrians Safety and Accident Expereince. Cycle length is the time required to complete one sequence of the signal indication and illustrate in Figure 1.2. Normally, the cycle length is kept as short as possible and typically within 40 and 60 seconds. This is because the longer the cycle time will create an excessive delay. Hence in JKR Arahan Teknik (Jalan) 13/87, cycle time should be between 45 seconds to 120 seconds for practical purpose as there is an insignificant increase in capacity and rapid increase in total delay [10].

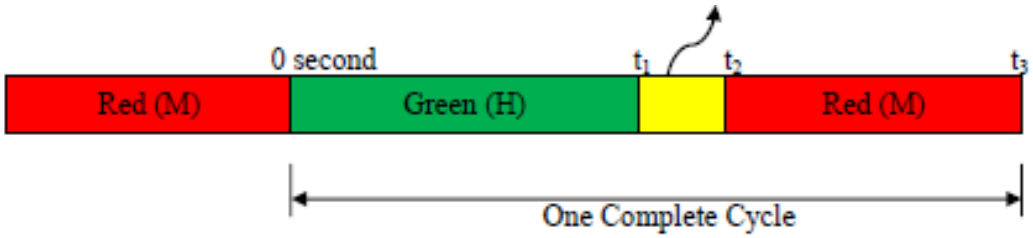

Figure 1.2: Definition of complete cycle time.

1.3 MATERIALS AND METHODS

For implementing this study, some essential data like traffic volume at each intersection during morning and afternoon peak hour, geometry data, and traffic signal timing were collected by assisting some ancillary equipment such as video camera recorders, tripod, walking measure, stopwatch and safety vest. A day of traffic volumes of two signalized intersection were recorded simultaneously by using video recording technique at a proper vantage point for a clear view during a sunny weather. Traffic signal timing used a stopwatch to record with 3 times to obtain an average value.

After completing data collection, all the data are analyzed. Microsoft excel is applied to tabulated all the data. The traffic volume were grouped into 15-minutes as one interval. SIDRA Intersection 5.0 is used to determine the results of delay and LOS. Excel spreadsheet also applied to compute LOS and signal timing according JKR standard.

1.4 RESULT AND DISCUSSION

1.4.1 DELAY AND LOS

The data collection has been conducted and analyzed. SIDRA was applied to evaluate the delay and LOS at signalized intersection at KM 19 and KM 20. According to the results from SIDRA, the most critical LOS is LOS F. It is represented that both signalize intersection area under oversaturation situation and long queue with delay of 80sev/veh or greater. Thus, a poor traffic movement occurred along the road between signalized intersection KM 19 and KM 20. However, the most critical LOS computed according JKR standard also is LOS F. Table 1.3 and 1.4 shown the result of LOS from SIDRA and JKR at both signalized intersection. (Fig 1.3 shown the movement and approach ID for both signalized intersection). Based on the results, it shown some of the LOS is different as the adjustment considered in SIDRA is different from JKR. In SIDRA simulation which is according HCM

2010, it considered adjustment factor for lane width, heavy-vehicle, approach grade, existence of parking lane, bus blocking area, lane utilization, right turn and left turn lane group [9]. While in JKR standard, it considered adjustment factor for lane width, approach grade, right turn and left turn lane group only [10]. Moreover, the JKR standard did not provide any guideline when v/c ratio ≥ 1.0 whereas HCM 2010 has clarified the condition when v/c ratio ≥ 1.0 in table of LOS. Hence, it fails to provide a good estimation of delay by using JKR standard as v/c ratio ≥ 1.0 Therefore, a discrepancy results discovered in this case study by comparing two results of LOS. It can be concluded that the results from SIDRA is more reliable and accurate as more adjustment factors are considered when computed delay and LOS.

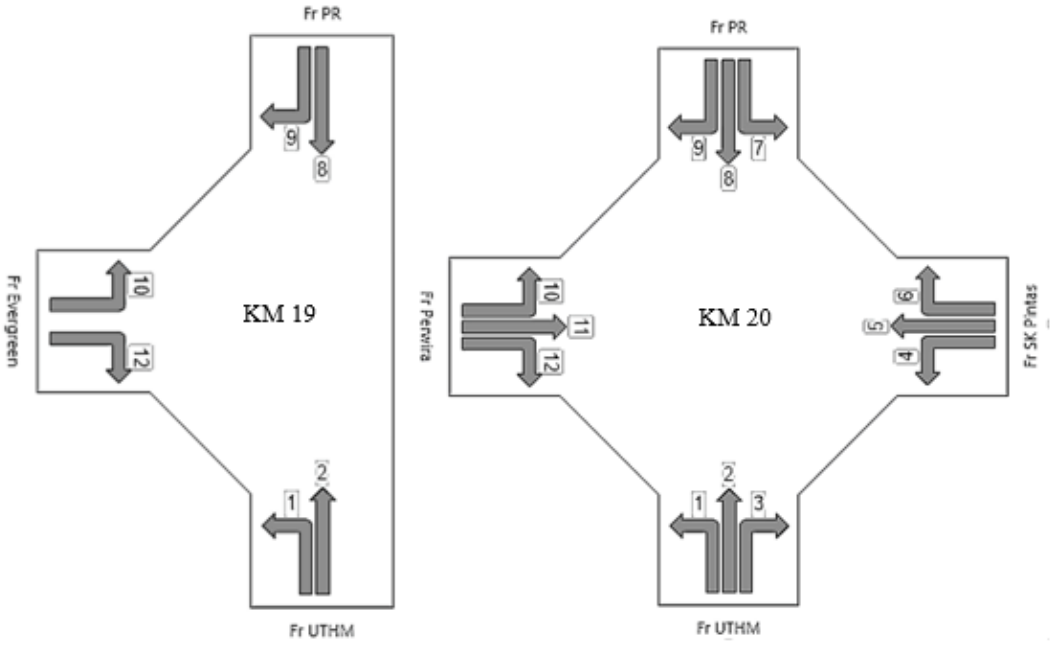

Figure 1.3: The movement and approach ID for signalized intersection at KM 19 and KM 20

Table 1.3: Level of service criteria for signalized intersection

Approach ID	Morning peak		Afternoon peak	
	SIDRA	JKR	SIDRA	JKR
1	C	B	F	B
2	C	D	F	D
8	F	E	A	D
9	F	F	D	D
10	F	E	F	D
12	F	D	F	F

Table 1.4: Level of service criteria for signalized intersection

Approach ID	Morning peak		Afternoon peak	
	SIDRA	JKR	SIDRA	JKR
1	C	B	D	C
2	C	F	F	D
3	F	F	F	D
4	E	D	E	D
5	E	D	E	D
6	E	F	E	F
7	F	B	E	B
8	F	E	E	C
9	E	D	E	E
10	F	D	F	D
11	F	E	F	E
12	F	D	F	F

1.4.2 TRAFFIC SIGNAL TIMING

In order to propose a new signal timing, the ratio of flow to saturation flow (y) is required. However, the Y-value obtained is higher than 0.85 which is not preferred to proceed the optimum cycle time with the formula provided in JKR Arahan Teknik (Jalan) 13/87. But, for practical purpose, the optimum cycle time is recommended used 120 sec as the maximum value. This is because above a 120 sec will cause an insignificant increase in capacity and rapid increase in total delay [10]. Therefore, in this case study, 120 sec is proposed as optimum cycle time. Table 1.5 and 1.6 shown the new proposed signal timing. Figure 1.4 and 1.5 shown the timing schedule with new signal timing.

Table 1.5: Summary of signal timing at signalized intersection KM 19

	Phase 1		Phase 2		Phase 3	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
Green time (sec)	53	49	25	43	13	13
Amber time (sec)	3	3	3	3	2	3
All red time (sec)	2	2	2	2	2	2
Cycle time (sec)	105	120	105	120	105	120

Table 1.5: Summary of signal timing at signalized intersection KM 20

	Phase 1		Phase 2		Phase 3		Phase 4	
	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
Green time (sec)	48	60	11	16	14	11	12	13
Amber time (sec)	3	3	3	3	3	3	3	3
All red time (sec)	2	2	2	2	2	2	2	2
Cycle time (sec)	105	120	105	120	105	120	105	120

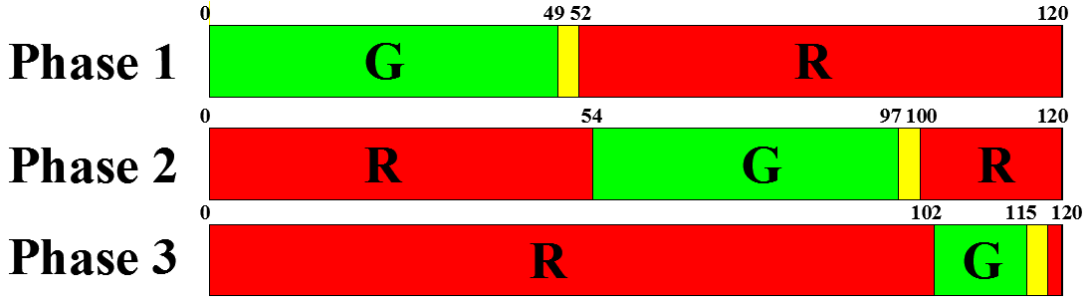

Figure 1.4: Timing schedule for 3 phase at signalized intersection KM 19

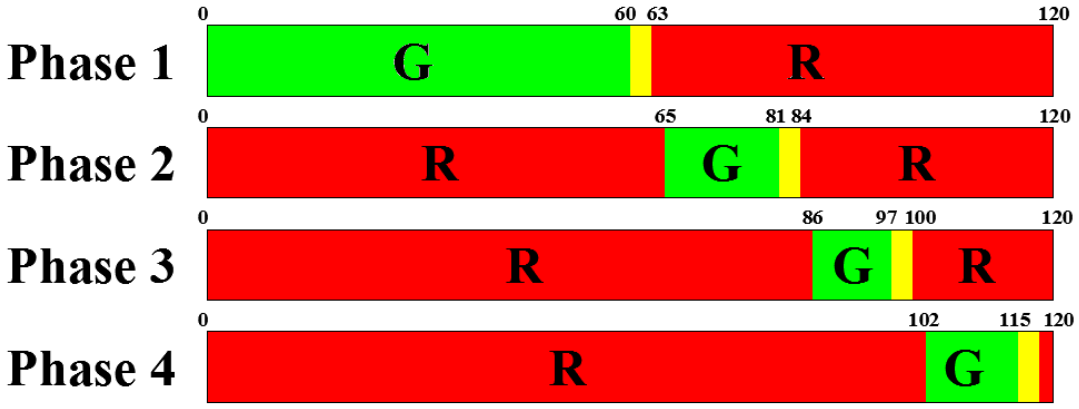

Figure 1.5: Timing schedule for 4 phase at signalized intersection KM 20

1.4 CONCLUSION

In a nutshell, both signalized intersection under oversaturated traffic flow condition. This is because the most critical LOS for both signalized intersection at KM 19 and KM 20 is grade F which means that both intersection accounts forced flow condition with oversaturation and long queue with delay of 80 sec/veh or greater. Besides, LOS F also represented that the intersection with poor traffic movement and high v/c ratio were resulting excessive delay and congestion problem. Moreover, a modification of traffic signal timing are proposed for both signalized intersection to reduce the delay and long queue problem.

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