IOP Conference Series: Materials Science and Engineering

PAPER • OPEN ACCESS

Traffic condition with road upgrading during construction and operation stages based on level-of-service (LOS)

To cite this article: A C Tay and H H Lee 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **344** 012018

Traffic condition with road upgrading during construction and operation stages based on level-of-service (LOS)

A C Tay[1] and **H H Lee**

Faculty of Engineering and Science, Curtin University Malaysia, CDT 250, 98009 Miri, Sarawak, Malaysia

[1]Email: tayaichen@curtin.edu.my

Abstract: In this study, traffic survey was done at signalized intersection of both ends of an upgrading road during morning and afternoon peak hours throughout construction period. The intersections of Tudan Road located at Miri City in Sarawak State, Malaysia were chosen as study sites. The aim of this research was to investigate the traffic condition for the signalized intersections of a R3 secondary road that being upgrading to standard U5 dual carriageway during peak hours for construction and operation stages. Data collected from these sites were analyzed according to Highway Capacity Manual (HCM) 2010. From the results, the level-of-services (LOS) of Kuala Baram By Pass Road intersection improved from Level F to Level E at operation stage for weekday during peak hours in the morning. LOS of Lutong-Kuala Baram Road intersection at construction stage were Level C during peak hours in the morning and Level D during peak hours in the afternoon for weekends. However, the LOS during both peak hours for weekends were projected to improve to Level B at the operation stage. It proved that the road construction has affected LOS, and this temporary issue can be solved after the upgraded road is in operation.

1. Introduction

Traffic assessment is a process that used to identify the traffic condition of the roads. Over the years, the population in Miri is rising. Increase in population could result in high density of traffic causing traffic congestion. Hence, the road construction activity is growing rapidly in order to accommodate the traffic volume. With a deep investigation of proposed road construction on the road network system, the traffic impacts such as congestion and road safety could be greatly enhanced.

Traffic control condition can be explained as the saturation flow of an approach. Saturation flow of an approach is expressed as the maximum number of vehicles which are able to pass through the intersection during the green indication, which is also known as the maximum flow [1].

Delay could be explained as the discrepancy between the additional time that a vehicle experiences while passing through an intersection with and without traffic signal control [2]. The major factors that may influence control delay are cycle length, effective green time, traffic volume (demand) and capacity. In fact, there are also some minor factors which may also affect control delay such as signal control, grade of approach and etc. [3]. The volume-to-capacity ratio is considered one of the major factors to identify the traffic condition at the intersection. The volume-to-capacity (v/c) ratio is known as the degree of saturation. It stands for an ability of an intersection to accommodate the traffic demand in terms of ratio [4]. Normally, the volume-to-capacity ratio which is smaller than

0.85 implying that the capacity is sufficient enough to overtake the traffic demand. For this, the drivers suffer delays and queues.

A traffic impact assessment was carried out at proposed Hypermarket in Skudai Town of Malaysia, it reported that LOS were D for weekday and C for weekend at the pre-construction stage, but the projected LOS was F for the year 2025 after the completion of Hypermarket [5]

A case study from Istanbul, Turkey shows that adaptive control does improve the performance at signalized intersection. It avoids the problem for growing at exit road and prevent sending excessive vehicles from the entry by implementing a proper signal timing [6]. Weaving effect may also influence the safety of other drivers. Therefore, it is important to encourage drivers not to change their travel lane too often [7]. In semi actuated operation, the detectors are placed on the minor approaches only. It indicates that the major approach of an intersection is having a green indication at all times until a vehicle is detected on any other minor approaches [8].

Vehicle queue acts as a very important factor to measure the traffic performance and it should be considered as a major evaluation criteria of signalized intersections. Lane groups that are having queues are probably facing serious delay [9]. A pre-timed control at an intersection is suitable for an intersection that is having a high concentrated volume such as city center [10]. Even though pre-timed control is able to provide an efficient operation during peak hour, it can still result an excessive delay to drivers.

A signal phase is one part of the cycle length distributed to different traffic movement that guide their direction way at the same time in one or more intervals. A simple intersection should have a two phase cycle. However, there are also some intersections which consist of more than three phase cycle. Intersections with more than three phase cycle may cause more delay as the green time for other phases may decrease and the intersections will be consisting of longer cycle length and additional time intervals. The excessive phases may decrease the progression level and increase the percentage of queue vehicles and fuel consumption. A two phase cycle is then result in higher lane capacity and provide a better intersection performance [11]. However, from the point of view in discussing the road safety, more signal phase cycle will be favorable to the intersection as it leads to less traffic accidents in the intersection.

In this study, the signalized intersections of Jalan Tudan were chosen as study sites as Jalan Tudan was under and upgrading construction. In order to accomplish the goal of this project, the objectives are stated below:

- To understand the traffic condition of the both signalized intersections which allocated along Jalan Tudan
- To determine the delay and level-of-service (LOS) of the intersections during peak hours for road construction stage and projected completion stage.
- To study the improvements that can used to enhance the signalized intersections.
- This study focuses the control delay result from the signalized intersections. It also provides the survey data to show the traffic condition in terms of level-of-service (LOS) which are having 6 different of levels, from level A to level F. Additionally, this study will also assess the traffic significance relating to the civil engineering work construction to determine whether the intersections be able to handle the traffic demands in acceptable level-of-service.

2. Methodology

The signalized intersections along Tudan Road, Miri City in Sarawak, Malaysia were chosen as study site as it was a road upgrading project. Therefore, the intersections were investigated to compare the traffic condition for road construction stage and completion stage. This location provided a good access for survey members to collect data. The study area was located between the longitude of E 114° 0’ to E 114° 3’ and latitude of N 4° 28’ to N 4° 29’.

To carry out the traffic survey, a tally sheet was prepared. The traffic volume data in one-hour duration with 15 minutes interval was recorded. In this study, three survey members were recruited for the traffic survey manual counting. It is to improve the accuracy of the data obtained if the manual traffic count was carried out by more people. Each survey member owned a stopwatch and stayed at the spot where vehicle flow and signal time could be clearly observed. The time for data collection was implemented during morning peak (7am to 8am) and evening peak (5pm to 6pm).

Performance of the signalized intersections were analyzed by the rules and formulas provided from Highway Capacity Manual 2010 [12]. To analyze the traffic condition of signalized intersections, the parameters were determined in the sequence, which are movement groups, lane groups, adjusted saturation flow rate, proportion arriving during green, signal phase duration, capacity and volume-to-capacity ratio, delay and level-of-service (LOS). The road geometric condition of Jalan Lutong-Kuala Baram intersection and Kuala Baram By Pass intersection are shown in figure 1 and figure 2, respectively. The approaches for both intersections were identified as shown in figure 3 and figure 4, respectively. The descriptions for all the directions of the approaches are listed in table 1.

The level-of-service (LOS) was determined by the control delay and volume-to-capacity (v/c) as listed table 2. LOS A is described as the best performance in road condition while LOS F is the worst. LOS A describes the condition with less than 10 seconds control delay and v/c ratio that is less than 1.0.

Table 1. Descriptions for approaches direction.

Jalan Lutong–Kuala Baram Intersection	
Directions	Descriptions
NB(RT)	Northbound (Right Turn)
NB(TH)	Northbound (Through)
SB(TH)	Southbound (Through)
WB(RT)	Westbound (Right Turn)
Kuala Baram By Pass Intersection	
Directions	Descriptions
SB(TH)	Southbound (Through)
SB(RT)	Southbound (Right Turn)
NB(TH)	Northbound (Through)
EB(RT)	Eastbound (Right Turn)

Table 2. Level-of-service threshold.

Control Delay (s/veh)	LOS by V/C Ratio	
	V/C ≤ 1.0	V/C ≥ 1.0
≤ 10	A	F
□ 10 - 20	B	F
□ 20 - 35	C	F
□ 35 - 55	D	F
□ 55 - 80	E	F

□ 80	F	F

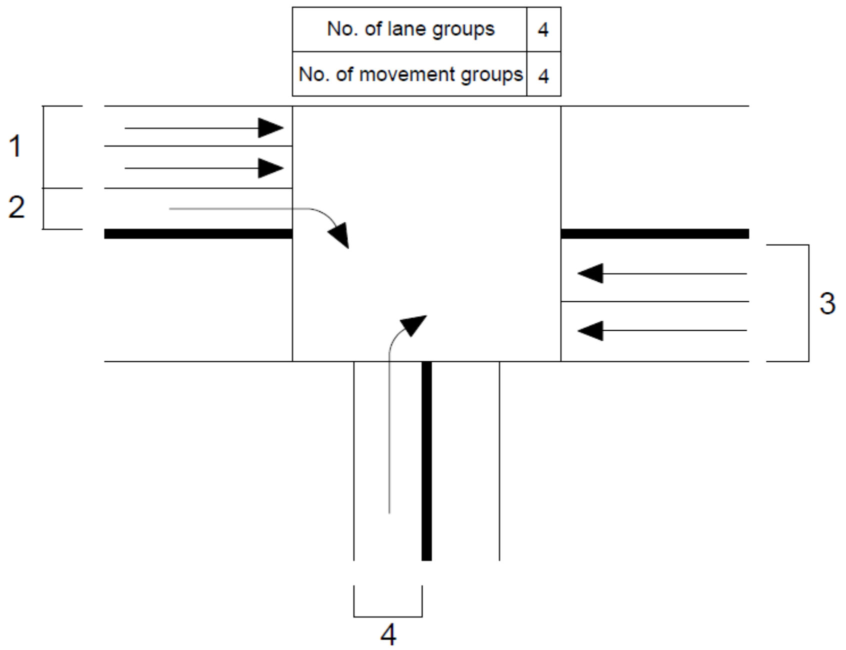

Figure 1. Road geometry of Jalan Lutong-Kuala Baram intersection.

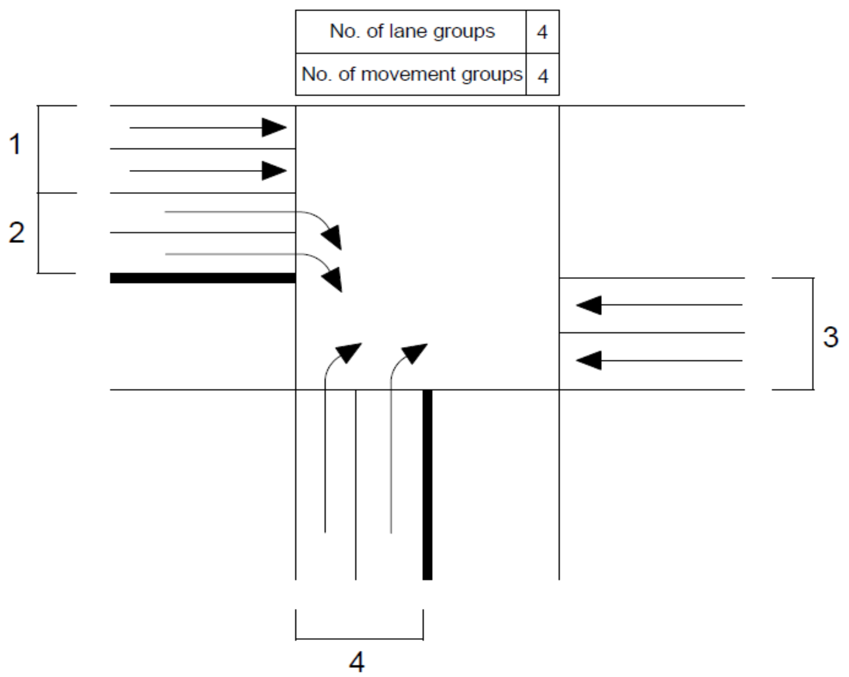

Figure 2. Road geometry of Kuala Baram by pass intersection.

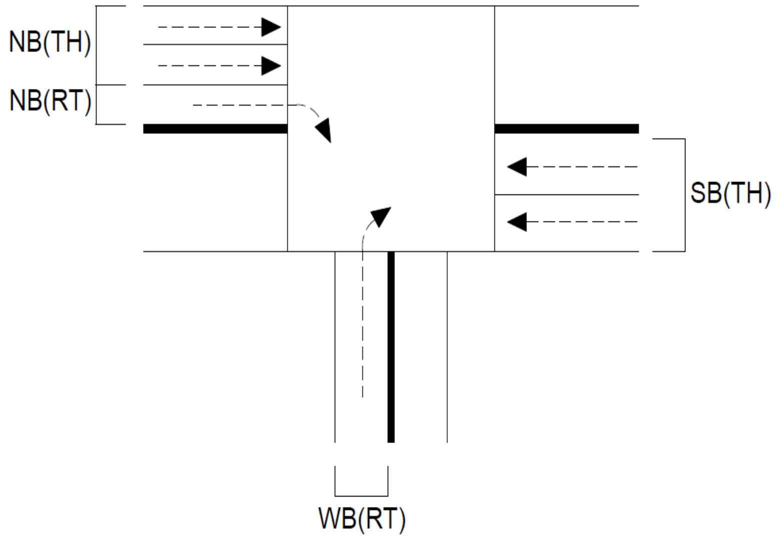

Figure 3. Approaches directions of Jalan Lutong-Kuala Baram intersection.

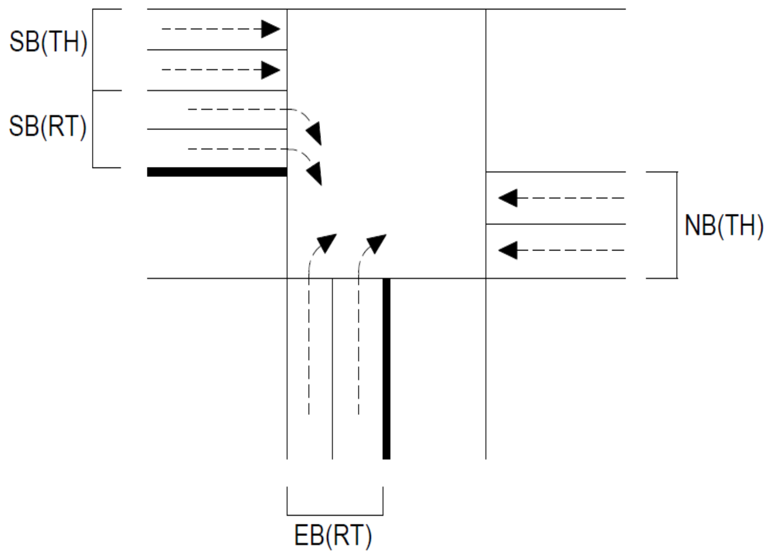

Figure 4. Approaches directions of Kuala Baram by pass intersection.

To project the traffic condition for completion stage, condition without heavy vehicles volume and road geometry enhancement were used for analysis. Amount of heavy vehicles obtained during road construction stage was excluded for projected completion stage. It is to investigate the effect of heavy vehicles to the intersection performance for completion stage.

3. Results and Discussions

Based on the data collected, NB(TH) approaches at Jalan Lutong-Kuala Baram and Kuala Baram

IOP Conf. Series: Materials Science and Engineering **344** (2018) 012018 doi:10.1088/1757-899X/344/1/012018

By Pass Intersections showed the highest average green ratio, which are 0.652 and 0.561, respectively. Among the green ratio at both intersections, the green ratio at Jalan Lutong-Kuala Baram Intersection is greater than the one at Kuala Baram By Pass Intersection.

In terms of passenger cars, buses and heavy vehicles, the traffic volume of passenger cars showed the highest distribution ratio at both intersections, followed by heavy vehicles and buses. The delay caused by heavy vehicles and buses to traffic condition at intersections may not be as significant as expected. It was due to the low distribution ratio of heavy vehicles.

For road construction stage, NB(RT) approaches at Jalan Lutong-Kuala Baram Intersection showed the highest volume-to-capacity ratio at weekday evening peak, 1.62. During weekday morning peak, SB(TH) at the same intersection showed the highest volume-to-capacity ratio, 1.50. For projected completion stage, the volume-to-capacity ratio for all approaches were reduced with road geometry improvement and without heavy vehicles.

The intersection delay is the average delay time of every up-stream approaches linked to the intersection. Intersection delay during road construction stage and projected completion stage is shown table 3. From the analysis, it showed that intersection delay was reduced in projected completion stage. The delay reduced at Jalan Lutong-Kuala Baram Intersection and Kuala Baram By Pass Intersection were around 49 percent and 19 percent, respectively.

The LOS for both intersections were proved to be enhanced for projected completion stage, except for weekday morning peak at Jalan Lutong-Kuala Baram Intersection (Table 4). It is due to high control delay at SB(TH) approaches at Jalan Lutong-Kuala Baram Intersection, which was affected by low capacity and high volume-to-capacity ratio.

Table 3. Intersection delay during road construction stage and projected completion stage.

Intersection Delay during Road Construction Stage and Projected Completion Stage (s)					
		Weekday		Weekend	
Intersection	Stage	Morning Peak (7am – 8am)	Evening Peak (5pm – 6pm)	Morning Peak (7am – 8am)	Evening Peak (5pm – 6pm)
Jalan Lutong–Kuala Baram	Road Construction	142.48	96.70	23.53	39.78
	Projected Completion	102.62	19.58	19.41	12.00
Kuala Baram By Pass Road	Road Construction	100.48	40.38	20.00	34.97
	Projected Completion	68.97	36.21	19.47	34.06

Table 4. LOS for both intersections during road construction and projected completion stage.

Level-of-service (LOS)					
		Weekday		Weekend	
Intersection	Stage	Morning Peak (7am – 8am)	Evening Peak (5pm – 6pm)	Morning Peak (7am – 8am)	Evening Peak (5pm – 6pm)
Jalan Lutong–Kuala Baram	Road Construction	F	F	C	D
	Projected Completion	F	B	B	B

Kuala Baram By Pass Road	Road Construction	F	D	B	C
	Projected Completion	E	D	B	C

4. Conclusion

Jalan Lutong-Kuala Baram Intersection indicated the low performance due to insufficient of lane capacity and green indication time during road construction stage. Therefore, high control delay occurred. During weekday, the LOS for road construction stage indicated to be level F. It proved that the traffic was the worst due to heavy traffic congestion. During weekend, the LOS determined were level C at morning peak and level D at evening peak, respectively. The LOS was improved to level B at projected completion stage. For projected completion stage, the delays at weekday morning and evening peak were analyzed to be reduced 102.62 and 19.58 seconds, while delays at weekend morning and evening peak were reduced to 19.41 and 12.00 seconds. From the analysis, it showed that Jalan Lutong-Kuala Baram Intersection was 49.22% improved from road construction stage to projected completion stage.

Kuala Baram By Pass Intersections showed the performance that is in average level. During weekday morning peak, the result showed that this intersection performed better at projected completion stage than road construction stage (from level F to level E). During weekday evening peak, it was found that the LOS was level D. During weekend morning and evening peak, both LOS were analyzed to be level B and level C, respectively for road construction and projected completion stages. Although the LOS was improved from level F to level E during weekday morning peak, it was not an ideal traffic condition for a signalized intersection because every driver was suffering a delay between 55 and 80 seconds at the intersection. The LOS was affected the road construction, However, this temporary issue can be solved after the upgraded road is in operation

References

[1] Gao L, Bhuiyan M A, Brian W R, Douglas K N and Richard S M 2016 *J. Traffic and Transportation Engineering* **3** 336
[2] Dion F, Rakha H and Kang Y A 2004 *Transportation Research Part B: Methodological* **38** 99
[3] Chen P, Liu H, Qi H S and Wang F J 2013 *J. Zhejiang University Science A* **14** 691
[4] Zhu Z H, Zheng J F, Gao Z Y and Du H M 2014 *Physica A: Statistical Mechanics and its Applications* **400** 200
[5] Minhans A, Zaki N H and Belwal R 2013 *Jurnal Teknologi* **65** 1
[6] Gündoğan F, Karagoz Z, Kocyigit N, Karadag A, Ceylan H and Murat Y S 2014 *J. Traffic and Logistic Engineering* **2** 198
[7] Kusuma A, Liu R, Choudhury C and Montgomery F 2014 *Transportation Research Procedia* **3** 51
[8] Lee C K, Yun I, Choi J H, Ko S J and Kim J Y 2013 *KSCE J. Civil Engineering* **17** 1749
[9] Wu N and Giuliani S 2016 *Transportation Research Procedia* **15** 63
[10] Park S Y, Kim D N, Lee S K and Jung J H 2016 *KSCE J. Civil Engineering* **20** 421
[11] Yang X F and Cheng Yao 2017 *Transportation Research Part C: Emerging Technologies* **74** 306
[12] Transportation Research Board 2010 *Highway Capacity Manual* vol 3 chapter 18 pp 1-107