Traffic Assessment for Completion of Road Upgrading from Secondary Road to Dual Carriageway

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Abstract. A traffic study was carried out at the signalized intersections to assess the road condition after a road upgrading from secondary road (3 m wide lane) to dual carriageway (3.5 m wide lane). The site selected was Tudan Road, which is located in Miri City in Sarawak State, Malaysia, and it is about 20-minute drive from the Border of Brunei Darussalam. Tudan Road connects Kuala Baram Bypass and Lutong-Kuala Baram Road with traffic light intersections. Traffic count data was collected at both intersections of Kuala Baram Bypass and Lutong-Kuala Baram Road by recording the traffic volume for every 15 minutes interval during an hour period of morning and afternoon peak hours. The collected data were then analysed according to Highway Capacity Manual (HCM) 2010 to determine Level of Service (LOS). By using the traffic volume collected, the LOS was estimated for Tudan Road as a secondary road prior to upgrading. The results indicated that the LOS during weekend afternoon has improved from Level F to B for Lutong-Kuala Baram Road intersection and Level F to D for Kuala Baram Bypass intersection after the upgrading of Tudan Road to dual carriageway. During weekday afternoon, the LOS for both intersections has also improved. The LOS for both intersections varied between morning and afternoon, and between weekday and weekend. The variation is caused by changes in lane capacity and volume-to-capacity ratio for different periods when the road users might actively commute for daily work or some leisure activities. Intersection delay time reduced 50% at Lutong-Kuala Baram Road and 74% at Kuala Baram Bypass after the road upgrading. From the LOS analysis, it proved that the upgrading of Tudan road has improved intersection performance at Lutong-Kuala Baram Road and Kuala Baram Bypass with different levels depending on morning or afternoon, and weekday or weekend.

1. Introduction

Urbanization with increase in human population causes increase of road users with high traffic volume. The high traffic volume at a small capacity road generates serious traffic congestion at peak hours. To solve the problems of traffic congestion, road upgrading is performed to improve road system for better Level of Service (LOS). LOS is commonly used for traffic assessment to evaluate traffic condition of roads [1, 2, 3]. In a traffic assessment in Skudai Town of Malaysia due to proposed Hypermarket, LOS were reported deteriorate from C or D to F [4].

Road upgrading is intended to improve lane width, speed limit, traffic capacity and safety to cater for the needs of development in a certain area [5, 6]. A sufficient road network provides good connectivity and shorter travel time [7, 8]. To improve the traffic flow, an effective setting of traffic sign is required to guide the road users in clear vision and driving safety [9]. A signal timing is planned with permitted
left turn to have a better LOS in intersections [10]. Besides the left turn lanes, countdown timers can be installed to enhance the road safety at signalized intersections [11].

This research was aimed to determine the traffic condition of signalized intersections at both ends of an upgraded road from secondary road to dual carriageway, and to compare the Level of Service (LOS) between the secondary road and the dual carriageway. Based on the results analysis, some improvements were recommended to further enhance the efficiency of signalized intersections.

2. Methodology

2.1. Site Selection
Tudan Road located at Miri City in Sarawak, Malaysia was chosen as a study site in this research. The area coverage for this study was between the longitude of E 114° 0’ to E 114° 3’ and latitude of N 4° 28’ to N 4° 29’ [12]. Tudan Road was a heavy traffic road due to a rapid housing and commercial development in nearby areas. Tudan Road was previously a secondary road with a single carriageway of 3 m wide lane. The construction work of upgrading Tudan Road to a dual carriageway of 3.5 m wide lane started in early 2016. The dual carriageway of Tudan Road was completed or in full operation in late 2017. Both ends of Tudan Road connects to signalized intersections, which has provided good sampling points for this study.

2.2. Traffic Survey
A tally sheet was used to record the traffic volume data in 15-minute interval for an hour duration during the morning peak hour (7 am until 8 am) and the afternoon peak hour (5 pm until 6 pm). The survey date were carried out in March and April 2018. Three survey members were allocated at each signalized intersection to manually count the traffic number. The vehicle flow and signal time were investigated by every survey member standing at a strategic location with a stopwatch. The strategic locations might vary according to the vehicle direction where the observation could be done clearly.

2.3. LOS Determination
From the traffic survey, the adjusted saturation flow rate, proportion arriving during green and signal phase duration were determined. These values were applied for calculating volume-to-capacity ratio and intersection delay. The LOS was then identified to determine the efficiency of signalized intersections based on the guidelines given in Highway Capacity Manual 2010 [13]. The data collected was for the upgraded Tudan Road with dual carriageway. The traffic condition of the secondary road of Tudan Road prior to upgrading was estimated using the road geometry of single carriageway in 3 m wide lane. The Approaches directions for Lutong-Kuala Baram Road and Kuala Baram Bypass intersections are shown in Figure 1 and Figure 2, respectively. Both intersections were in four lane groups and movement groups.

LOS was identified by examining control delay and volume-to-capacity (V/C) as shown in Table 1 [13]. Two categories of volume-to-capacity are V/C ≤ 1.0 and V/C ≥ 1.0. The LOS are ranked from A, B, C, D, E and F. By judging the control delay and volume-to-capacity of an intersection, LOS is A, if the road is in the best performance, and LOS is F, if the road is in the worst performance. LOS is A when the control delay of a road is less than 10 second with the condition of V/C is equal or less than 1.0.

| Control Delay (s/veh) | LOS by V/C Ratio | \( V/C \leq 1.0 \) | \( V/C \geq 1.0 \) |
|----------------------|------------------|------------------|------------------|
| ≤ 10                 | A                | F                |                  |
| > 10 - 20            | B                | F                |                  |
| > 20 - 35            | C                | F                |                  |
| > 35 - 55            | D                | F                |                  |
| > 55 - 80            | E                | F                |                  |
| > 80                 | F                | F                |                  |

Table I. Level-of-service Threshold [13]
3. Results and Discussion

The green ratios at Approaches of Lutong-Kuala Baram Road Intersection ranged between 0.29 and 0.65, which was generally higher than the Approaches of Kuala Baram Bypass Road Intersection. The smaller green ratio values caused higher delay time for the Approaches. During the weekday morning peak hours, traffic volume was recorded highest at SB(TH) Approaches of Lutong-Kuala Baram Road Intersection because many road users travelled to the Central Business District area in Miri city for work. During the evening peak hours, high number of road users returned home from work using NB(TH) Approaches of Lutong-Kuala Baram Road Intersection. The traffic volume of SB(RT) approaches of Kuala Baram Bypass Intersection was recorded highest at the evening because road users worked in Brunei use this Approaches to return to Miri City.
3.1. V/C Ratios
From the results obtained for V/C ratios, it showed that the dual carriageway was able to cater the traffic volume better than the secondary road. The WB(RT) Approaches for Lutong-Kuala Baram Road was improved from the V/C ratio of 0.87 to 0.40 in the weekday morning peak hours. The EB(RT) Approaches of Kuala Baram Bypass Road was improved from the V/C ratio of 1.49 to 0.68 in the weekend evening peak hours.

3.2. Intersection Delay
The intersection delay was caused by the individual delay due to every upstream approaches that connected to the Lutong-Kuala Baram Road Intersection or Kuala Baram Bypass Intersection. From this study, it indicated that the intersection delay for both intersections were reduced after road upgrading to the dual carriageway as shown in Table II. The intersection delay of Lutong-Kuala Baram Road was reduced from 99.9 at secondary road to 36.0 at dual carriageway for the weekday afternoon peak hours. By examining the Kuala Baram Bypass Road, the intersection delay was reduced from 90.3 at secondary road to 37.5 at dual carriageway for the weekend afternoon peak hours. Delay estimation is useful for designing traffic signal timings, and assessing the LOS at signalizing intersection approaches [14]. Average delay of every approaches delay is correlated with LOS [15].

Table II. Intersection Delay of Both Intersections for Secondary Road and Dual Carriageway during Peak Hours

| Intersection              | Road Type       | Weekday       | Weekend        |
|---------------------------|-----------------|---------------|---------------|
|                           |                 | Morning (7 – 8 am) | Afternoon (5 - 6 pm) | Morning (7 – 8 am) | Afternoon (5 – 6 pm) |
| Lutong–Kuala Baram Road   | Secondary Road  | 77.17         | 99.94         | 22.78         | 61.63             |
|                           | Dual Carriageway| 61.92         | 36.0          | 18.10         | 15.53             |
| Kuala Baram Bypass Road   | Secondary Road  | 245.81        | 172.59        | 22.20         | 90.33             |
|                           | Dual Carriageway| 20.38         | 62.68         | 17.32         | 37.52             |

3.3. LOS of Intersections
After upgrading Tudan Road to dual carriageway, the LOS for both intersections were improved in performance as shown in Table III, except the LOS remained the same as B in the weekend morning peak hours at Kuala Baram Bypass Intersection. During weekend morning, this intersection is heavy traffic due to the access between Miri and Brunei, which enabled the road users travel this intersection for their leisure activities. Low capacity and high volume-to-capacity ratio affected the LOS of the intersection, which was identified as F at secondary road. An efficient dual carriageway of Tudan Road as indicated by LOS improvement had contributed to better operational performance at Lutong-Kuala Baram Road and Kuala Baram Bypass Road Intersections. The dual carriageway functioned as a safety road with higher capacity, lower traffic delays and less traffic conflict [16].
Table III. LOS of Both Intersections for Secondary Road and Dual Carriageway during Peak Hours

| Intersection          | Road Type       | Weekday Morning (7 – 8 am) | Weekday Afternoon (5 – 6 pm) | Weekend Morning (7 – 8 am) | Weekend Afternoon (5 – 6 pm) |
|-----------------------|-----------------|----------------------------|-----------------------------|----------------------------|-------------------------------|
| Lutong–Kuala Baram Road | Secondary Road  | E                          | F                           | F                          | F                             |
|                       | Dual Carriageway| E                          | D                           | B                          | B                             |
| Kuala Baram Bypass Road | Secondary Road  | F                          | F                           | B                          | F                             |
|                       | Dual Carriageway| C                          | E                           | B                          | D                             |

4. Conclusion
Insufficient lane capacity at the secondary Road was the major problem causing the low performance of both Lutong–Kuala Baram Road and Kuala Baram Bypass Road intersections. Due to high volume of traffic, green indication time was not able to cater the traffic flow. It was a high control delay in the secondary road if compared with the dual carriageway. LOS was mostly F for both intersections prior to the road upgrading. This study proved that human activities at different peak hours either morning or afternoon had affected the LOS. The human activities were associated with their work and leisure in weekdays or weekends.

Both intersections of Lutong–Kuala Baram Road and Kuala Baram Bypass Road showed reduction in intersection delay more than 50% with the Tudan Road geometry improvement. However, the LOS A was not achieved with the road geometry improvement. To further improve the LOS of the intersections, some measures could be practiced such as weaving effect reduction, installation signal coordination and signal phase enhancement. For the weaving effect reduction, the driver shall keep to the same lane if possible to avoid moving from current position to other position too often that will result in drop of lane capacity. Installation of signal coordination provides countdown of green time enabling drivers to get prepared at the traffic light. Signal Phase Enhancement can be practiced to guide different traffic movement at appropriate cycle length.

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