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# Analyzing the Performance of a Signalized 4-Leg Intersection Connecting Jalan Kluang Federal Route (FT050) – Jalan Sri Bengkal (Johor State Route J125)

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**Abstract**: Malaysia and other emerging countries suffer from traffic congestion. The population expands along with the number of vehicles. When traffic exceeds road capacity, congestion occurs, including at intersections. Delays, pollution, accidents, and increased of operational expenses were all caused by congestion. Due to the heavy traffic volume at the signalized intersection of Jalan Sengkuang (J125), this location was chosen for this study. Examining this signalized intersection may helped resolve the congestion. This research evaluated the performance of a signalized intersection at Jalan Kluang Federal Route (FT050)-Jalan Sengkuang (Johor state route J125) in terms of Level of Service (LOS), vehicle delay, and queue length. Data on vehicle volume was recorded using a CountCam2 for the morning, afternoon, and evening peak hours on a weekday and a weekend. Meanwhile, traffic signal timing and road geometric data were measured using laser distance and stop watch. The Signalized and Unsignalized Intersection Design and Research Aid (SIDRA) version 8.0 was used to analyze the data. The critical LOS was F, as determined by SIDRA. LOS F has occurred on the main road connecting West Kluang Road and East Kluang Road, and it has been found on all days and at all peak times.

**Keywords**: Signalized Intersection, LOS, Delay, Queue Length, SIDRA Software

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## 1. Introduction

A traffic signal is a signal device that is installed at a road intersection or other point to indicate safe driving conditions using a standardized color code. At intersections, traffic signals are used to regulate traffic flow [1]. Traffic signal controllers are identifiable by signal color, traffic phase, and traffic phase separation to ensure a safe flow of traffic. (i.e., the time interval between two traffic phases) [2]. Traffic lights are an important part of figuring out how well urban roads work and reducing the number of accidents. Large cities face difficulties in controlling intersection traffic signals. Traffic signal controllers monitor traffic flow and assist in reducing congestion at intersections.

It is important to solve the problem of traffic congestion at signalized intersections because it will improve traffic flow, safety, and conditions. This study examined the performance of a signalized intersection at Jalan Kluang Federal Route (FT050) - Jalan Sri Bengkal (Johor State Route J125). The daily traffic volume on these roads (FT050) was often increased, causing road conditions to worsen.

### 1.1 Problem and Objective

Johor had one of the worst traffic conditions in Malaysia. The growth in car numbers in Johor has generated major traffic issues. Recently, Batu Pahat has grown significantly with the addition of several colleges and universities being built over recent years [3]. Local residents, business people, and students used the district's roadways every day. Thus, the rise of automobiles contributed to traffic congestion in the Batu Pahat areas.

In this study, the signalized 4-leg intersection located at Jalan Sri Bengkal (Johor state route J125) was chosen because of its irregularity and high traffic flow during peak hours, as seen in Figure 1a below. The majority of issues arise during peak hours, when the high traffic flow mechanism was unable to handle the required capacity [4]. As part of this study, motor vehicles, including automobiles, buses, lorries, and other types of vehicles, were examined. Thus, by analyzing this signalized intersection, this research may helped solve the issue that had been identified.

Therefore, this research was conducted in order to accomplish the following objective which was to analyze the performance of a signalized intersection in terms of Level of Service (LOS), vehicle delay and queue length at Jalan Kluang Federal Route (FT050) - Jalan Sri Bengkal (Johor state route J125). Figure 1b depicts the route layout plan at the signalized intersection of Sri Bengkal. The main roads were West Kluang Road and East Kluang Road, while the minor roads were Parit Yaani/Sri Bengkal Road and Kencana 1A/A Road.

**Figure 1a: Real Site Conditions at Signalized 4 – Leg Intersections**

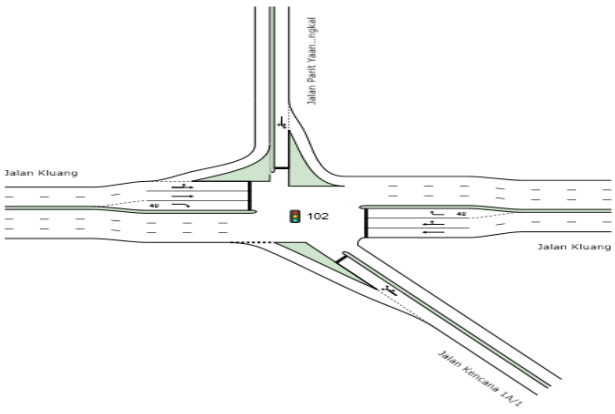


**Figure 1b: Layout Plan of Signalized Intersection in SIDRA Version 8.0**

### 1.2 Scope of Study

The study was conducted at the signalized 4-leg intersection of Jalan Kluang Federal Route (FT050) - Jalan Sri Bengkal (Johor State Route J125) during peak hours in order to ascertain the type and number of vehicles passing through the intersection during peak hours, as well as the time required for the vehicle to pass through the traffic signal. With the help of the SIDRA version 8.0 software, the data was evaluated in terms of LOS, vehicle delay and queue length. The purpose of this research was to estimate queue lengths and vehicle delays as a result of signal control system implementation at intersections. Traffic delays and queues were used to test the effectiveness of the ideas that were looked at in terms of the LOS of a signalized intersection and to figure out how many lanes were needed [5].

## 2. Performance of Signalized Intersection

Intersection is when two or more roads come together or are linked to one another. Traffic signals, traffic controls, and lane design are all factors that may be used to classify intersections. The intersection is intended for cars to go in a variety of directions, and it also serves as a platform for road users to shift their way in order to reach their desired destination more quickly [6].

Vehicle delay is a critical road traffic measure when assessing the operation of traffic signal controllers. Delay at intersections is frequently difficult to quantify due to the non- deterministic nature of the arrival and departure processes that may be induced by the presence of traffic lights, signs, and traffic crossings [7].

LOS is utilized to dissect the highway by sorting traffic flow and doling out quality levels of movement in view of execution measures like speed and density [8]. A road's or facility's capacity might be constant. LOS seeks to link trading service quality to a certain rate. It is a phrase used to describe a set of operating conditions for a certain facility type. The LOS can be categorized into six level which were LOS A to LOS F [8].

Queue length is the distance from the stop line to the tail of the latest vehicle stopped in a single lane during a red light within one signal cycle [9]. Practically, it can be replaced by the number of vehicles stopped in a queue for convenience. Queue length is a crucial measurement of effectiveness (MOE), as queues that exceed available storage space have a negative impact on the intersection's overall function, such as spillback and storage blocking [10].

SIDRA stands for "Signalized and Unsignalized Intersection Design and Research Aid" and was first published in 1984 [11]. This study makes use of AaSIDRA (Akcelik & Associates, Traffic Signalized and Unreported Intersection Design and Research Aid). Engineers and practitioners use this program to assess and design signalized and non-signalized intersections.

## 3. Methodology

The methodology described in this part was utilized to evaluate the performance of the signalized intersection on Jalan Sri Bengkal (J125) in Batu Pahat using the SIDRA version 8.0 software. The primary data collection method was followed precisely in order to get LOS, vehicle delay, and queue length at signalized intersections on Jalan Sri Bengkal (J125), Batu Pahat.

### 3.1 Road Geometric Data

The number of lanes, lane width, median type, shoulder width, median width, gradient, and turning radius were all considered in this study. A laser distance sensor was used to measure the lane and shoulder widths. The distance was determined using the laser distance sensor and to prevent inaccurate laser distance sensor readings, measurements were taken while the route was clear of moving vehicles.

### 3.2 Volume Data from CountCam2

The data collection method involved the use of a CountCam2 to correctly capture the volume of traffic at each intersection and the direction of each traffic flow. To conduct this study, important data such as traffic volume at signalized intersections during the morning, afternoon, and evening hours was gathered with the assistance of mechanical aids such as a video recorder, tripod, walking measure, timer, and safety vest. Six hours of data collection occurred, with one hour allocated to each peak time period, most notably the morning, afternoon, and evening. Data gathering took place over two days (Thursday, April 14, 2022 and Saturday, April 16, 2022). Between 7 and 8 a.m. in the mornings, 12 to 1 p.m. in the afternoons, and 5 to 6 p.m. in the evenings. The volume of traffic was divided into 15-minute intervals. Then, the data was entered into the vehicle classification form. Every vehicle was counted manually. This form is made according to the class of vehicles passing through at the intersection. Five different vehicle classes were involved and recorded in form which were Class 1 (Light Vehicle), Class 2 (Medium Weight Vehicle), Class 3 (Lorry), Class 4 (Bus) and Class 5 (Motorcycle). [12]

The average vehicle volume within an hour of peak time was estimated and entered into the SIDRA software version 8.0 to calculate LOS, vehicle delay, queue length, and traffic signal timing at the signalized intersection of Jalan Sri Bengkal (J125), Batu Pahat. To tabulate all of the data, Microsoft Excel was used. Nonetheless, if manual data gathering methods were utilized on-site, congestion induced by traffic flow from numerous directions would result in inaccuracies and errors in the observations [7]. Compared to observations made in the research area, the use of CountCam2 specifically for this study helped to eliminate mistakes and inaccuracies that might have been made.

## 4. Results and Discussion

This chapter discussed the outcomes of data analysis conducted with SIDRA 8.0 software. In particular, fieldwork-collected data was imported into Microsoft Excel before being analyzed with SIDRA software. In addition, the obtained data was utilized to propose solutions and advance directives for the investigated routes.

### 4.1 Road Geometric Data

Geometric data is taken at each road, and this data was important for SIDRA software to obtain LOS, vehicle delay, and queue length for the signalized intersection. In addition, Table 1 shows the geometric design of the signalized intersection at Sri Bengkal that was observed during fieldwork.

**Table 1: Geometric Design of Signalized Intersection at Sri Bengkal.**

| Approach | Number of Lane | Road Width per lane (meter) |
|---|---|---|
| West Kluang Road | 3 | 3.30 |
| East Kluang Road | 3 | 3.30 |
| Parit Yaani/Sri Bengkal Road | 1 | 3.30 |
| Kencana 1A/A Road | 1 | 3.30 |

Table 1 also shows the number of lanes at the signalized intersection at Sri Bengkal. The main road had 6 lanes, consisting of 3 lanes from the direction of West Kluang Road and 3 lanes from the direction of East Kluang Road. While the minor road had 2 lanes, one direction from Parit Yaani/Sri Bengkal Road and one direction from the direction of Kencana 1A/A Road. Each road's width was 3.30 meters.

### 4.2 Traffic Volume Data

Table 2 below shows the data on the total volume of vehicles at the signalized intersection of Sri Bengkal, which was collected on weekdays (Thursday, April 14, 2022) and weekends (Saturday, April 16, 2022) in the evening peak. The evening peak was chosen since Thursday and Saturday had the highest total vehicle volume at that time. The total volume of vehicle was measured in both veh/hr and pcu/hr units.

**Table 2: Total Vehicle Volume in the Evening Peak**

| Day | Approach | Total Volume (Veh/hr) | Total Volume (pcu/hr) |
|---|---|---|---|
| Day 1 Thursday 14/4/2022 5:00 pm to 6:00 pm | West Kluang Road | 2729 | 2336.35 |
| | East Kluang Road | 1130 | 1085.37 |
| | Parit Yaani/Sri Bengkal Road | 1011 | 900.88 |
| | Kencana 1A/A Road | 416 | 354.86 |
| Day 2 Saturday 16/4/2022 5:00 pm to 6:00 pm | West Kluang Road | 2512 | 2200.50 |
| | East Kluang Road | 1115 | 1071.79 |
| | Parit Yaani/Sri Bengkal Road | 1040 | 935.03 |
| | Kencana 1A/A Road | 491 | 447.64 |

### 4.3 Summary of Results for the Most Critical LOS, Control delay and Queue Length.

Table 3 shows the details of the LOS, vehicle delay, and queue length at the signalized intersection of Sri Bengkal for weekday evenings peak (Thursday, April 14, 2022) and weekend evenings peak (Saturday, April 16, 2022). Evening peak has been selected for both workdays and holidays since it has the highest LOS, delay, and queue length values. On a weekday evening, West Kluang Road and East Kluang Road approaches produced LOS F and LOS E with vehicle delay values of 1339.2 seconds and 77.9 seconds, respectively, while Parit Yaani/Sri Bengkal Road and Kencana 1A/A Road approaches generated very saturated flow due to LOS F with vehicle delay values of 1438.0 seconds and 481.0 seconds, respectively. For the weekend evening, West Kluang Road and East Kluang Road approaches generated LOS F with vehicle delay values of 1140.2 seconds and 83.5 seconds, respectively, while Parit Yaani/Sri Bengkal Road and Kencana 1A/A Road approaches produced very saturated flow due to LOS F with vehicle delay values of 1657.1 seconds and 672.4 seconds, respectively. Besides, the weekday average vehicle queue length in the direction of West Kluang Road was 1987 meters, while the average vehicle queue length in the direction of East Kluang Road was 176 meters. The length of the vehicle queue in the direction of Parit Yaani/Sri Bengkal Road was 1,543 meters, while the length of the vehicle queue in the direction of Kencana 1A/A Road was 365 meters. On weekend, the average length of vehicles in the direction of West Kluang Road was 1696 meters and in the direction of East Kluang Road was 186 meters. The length of the vehicle queue in the direction of Parit Yaani/Sri Bengkal Road was 1638 meters, while the length of the vehicle queue in the direction of Kencana 1A/A Road was 505 meters. The length of the vehicle queue also contributes to traffic control delays. The SIDRA Intersection software indicated that the signalized intersection's LOS was F, which was extremely inadequate based on the obtained data. This indicated that intersections had considerable delays and congestion at the current state. This LOS was declared unsatisfactory by the majority of drivers. It occurs when the number of vehicles entering exceeds the capacity of each lane group, resulting in saturation.

**Table 3: Summary of Results for the Most Critical LOS, Control delay and Queue Length (Evening Peak)**

| Day | Approach | Level of Service (LOS) | Delay (second) | Queue Length (meter) |
|---|---|---|---|---|
| Day 1 Thursday 14/4/2022 5:00 pm to 6:00 pm | West Kluang Road | F | 1339.2 | 1987 |
| | East Kluang Road | E | 77.9 | 176 |
| | Parit Yaani/Sri Bengkal Road | F | 1438.0 | 1543 |
| | Kencana 1A/A Road | F | 481.0 | 365 |
| Day 2 Saturday 16/4/2022 5:00 pm to 6:00 pm | West Kluang Road | F | 1140.2 | 1696 |
| | East Kluang Road | F | 83.5 | 186 |
| | Parit Yaani/Sri Bengkal Road | F | 1657.1 | 1638 |
| | Kencana 1A/A Road | F | 672.4 | 505 |

### 4.4 Validation of Sidra Results

In order to validate the SIDRA results, the queue length displayed on the video with the queue length obtained using SIDRA software were compared. This comparison was taken on the evening of Thursday, April 14, 2022, as it had the longest queue length. Figure 2 illustrates the two approaches selected for the queue length from CountCam2. West Kluang Road and Parit Yaani/Sri Bengkal Road have been selected as the two approaches. Table 4 displays the average vehicle queue length at the signalized intersection of Sri Bengkal for two approaches selected on April 14, 2022, in the evening from SIDRA intersection. Figure 2 depicts the queue lengths for West Kluang Road and Parit Yaani/Sri Bengkal Road, which were far beyond 50 meters and 20 meters, respectively, whereas Table 4 represents the queue lengths for West Kluang Road and Parit Yaani/Sri Bengkal Road, which were 1987 meters and 1543 meters, respectively. At the SIDRA intersection, a longer queue length value was presented than the actual value measured on-site. This was due to the fact that the observed video footage did not provide a clear view of the actual queue length, and the length of the vehicle queue exceeded 50 meters. As can be seen in Figure 2, the SIDRA intersection results were acceptable as the queue length was significantly longer. Therefore, the analysis of the results using the SIDRA intersection is valid and can be used in this study.


**Figure 2: Two Approaches Selected for Queue Length in the Evening Peak from CountCam2 (April 14, 2022)**

**Table 4: Average Vehicle Queue Length (meters) at Signalized Intersection of Sri Bengkal for Two Approaches Selected from SIDRA Intersection (Evening Peak)**

| Day | Signalized Intersection Name | Queue Length (meter) |
|---|---|---|
| Thursday<br>Day 1<br>14/4/2022<br>5:00 pm to 6:00 pm | West Kluang Road | 1987 |
| | Parit Yaani/Sri Bengkal Road | 1543 |

## 5. Conclusion

As described in the previous chapter, the objective of the study was to analyze the LOS, and vehicle delay and queue length at the signalized intersection of Sri Bengkal during peak hours using a CountCam2. First, the process of transferring raw data into Microsoft Excel was completed, followed by the calculation of total vehicle volume in each direction of vehicle movement to obtain the actual total vehicle volume in each direction of vehicle movement and to determine the actual peak time of the vehicle through this signalized intersection. This intersection has four approaches with varying total vehicle volumes. Thursday, April 14, 2022 and Saturday, April 16, 2022 between 5:00 p.m. and 6:00 p.m. have been chosen as the days with the highest evening total vehicle volume. On Thursday and Saturday, the total vehicle volume in unit veh/hr was 5306 and 5180, while in pcu/hr unit was 4677.46 and 4654.96, respectively. Then, SIDRA 8.0 was used to evaluate the LOS, vehicle delay and queue length. Based on the collected data, the SIDRA software indicates that the signalized intersection's LOS was F, which was extremely poor. This indicates that there were significant delays and congestion at intersections. LOS F specified that the control delay for each vehicle exceeded 80 seconds, the progression was very weak, and the cycle length was short [13]. Numerous individual cycle failures and arrival flow rates exceed the capabilities of the signalized intersection at Sri Bengkal. This LOS was considered unacceptable by the majority of drivers. It happened when the number of vehicles coming in was higher than the capacity of each lane group, which led to oversaturation.

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