Recent Trends in Civil Engineering and Built Environment Vol. 4 No. 3 (2023) 059-069


**RTCEBE**

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rtcebe
e-ISSN :2773-5184

# Performance Analysis of Signalised Staggered Intersection at Jalan Pasir Pelangi, Johor Bahru, Johor

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DOI: https://doi.org/10.30880/rtcebe.2023.04.03.007
Received 06 January 2022; Accepted 15 May 2023; Available online 31 December 2023

**Abstract**: As traffic volume increases, congestion at intersections increases as well. Congestion on roadways and signalised intersections has posed significant problems throughout the world. This study is done at the signalised staggered intersection at Jalan Pasir Pelangi in Johor Bahru namely the signalised intersection of Jalan Pasir Pelangi/Jalan Bakar Batu (Site 1) and Jalan Pasir Pelangi/Jalan Persisir Pantai (Site 2). The aim of this study is to improve signalised staggered intersection since the increasing traffic demand resulting in worsen of traffic congestion. The current performance is evaluated in terms of Level of Service (LOS), Degree of Saturation (DOS) and queue length by collecting data for one-weekday and one-weekend in the morning, noon and evening peak hour sessions in which one-hour data was collected in each session. Then the data were used as input in Signalised Intersection Design and Research Aid (SIDRA) Software Version 8.0. The analysis showed that signalised staggered intersection at Jalan Pasir Pelangi were the worst on weekday during noon peak hour and weekend during evening peak hour. During noon peak hour on weekday and evening peak hour on weekend, the overall intersection of Site 1 was LOS D. Meanwhile on the overall intersection of Site 2 was LOS F.

**Keywords**: Congestion, Signalised Staggered Intersection, SIDRA Software Version 8.0

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## 1. Introduction

According to the Malaysia Transportation Statistics in 2020, the number of registered vehicles in Johor state decreased 17.54% from 42,923 in 2019 to 35,394 in 2020. However, the cumulative number of transport vehicles increased 3.73% in 2020 that is 32,378,174 compared to 2019 that is 31,214,772 [1]. Consequently, transport problems such as congestion issues occur in urban areas is the norm hence, traffic congestion has remained a serious concern in cities globally [2]. A signalised intersection phasing is a popular traffic control measure used in urban areas [3]. However, urban traffic congestion is worst at road intersection that are unquestionably the most congested points on city streets [4].

A well-known signalised staggered intersection at Jalan Pasir Pelangi was chosen as the study location since traffic congestion often occurs during peak hours and it is one of the Sydney Coordinated Adaptive Traffic System (SCATS) area of traffic control system locations by Johor Bahru City Council (MBJB) for traffic surveillance. Due to an increasing population and numerous development projects, a rise in traffic is expected since it is a strategic location with several developments as shown in Figure 1.


**Figure 1: Aerial view of the study location**

During peak hours, traffic queues on the road are common. Because of the increasing traffic demand on Jalan Pasir Pelangi and that intersection, it is expected that the current traffic congestion will only get worse from time to time especially during peak hours. Hence, traffic management is an essential element in the roadway connection that can affect the development of an urbanisation area. As for that reason, this study is mainly focus to improve signalised staggered intersection at the study location. To achieve the aim of this the study, the performances of the intersection in terms of Level of Service (LOS), Degree of Saturation (DOS) and queue length were analysed by using Signalised Intersection Design and Research Aid (SIDRA) Software Version 8.0 so that a better design can be recommended.

## 2. Literature Review

Signalised intersection enable for shared use of road space by segregating and allocating time as according to the United States Federal Highway Administration (FHWA) [5]. Properly designed signalised intersections can improve the traffic safety and efficiency by reducing congestion and conflicts between vehicle movements. The staggered intersection is a unique intersection in a street layout that made up of two T-legged intersections. This type of intersection is separated by a distance that classified into left–right "(LR) type" and right–left "(RL) type" that has two traffic volumes that are main road and minor road that crosses it. As main road traffic increases, minor vehicle spacing

become inadequate. As a result, traffic signals can be erected at each or both offset T-intersections to control traffic volume [6].

The US Highway Capacity Manual (HCM) defines six LOS letters from Grade A to F as quality indicator of traffic service to a certain flow rate [7]. The average control delay per vehicle is the best available measure of LOS in evaluating the performance of traffic signal controllers [8]. DOS is the ability of intersection to accommodate the vehicular demand that shows the greater the DOS, the slower the traffic performance [7]. Meanwhile, queue length influences signal timing and geometric design decisions as traffic system improvements are made easier with queue length data as such signal timing optimisation could benefit from effective signal control solutions to reduce oversaturation based on queue lengths [9].

## 3. Methodology

The study was organised started from problem identification. The selected signalised staggered intersections is shown in Figure 2 below. The intersections have three legs each that were Jalan Pasir Pelangi/Jalan Bakar Batu (Site 1) and Jalan Pasir Pelangi/Jalan Persisir Pantai (Site 2). One of the most serious concerns was the rate of development at the area, which is predicted to increase traffic and congestion on the study location.

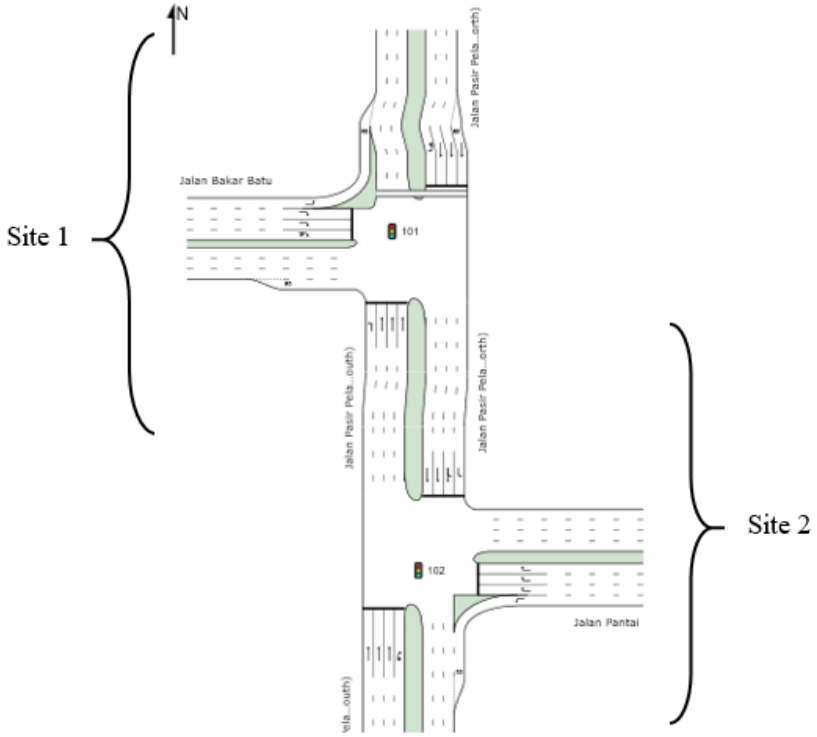


**Figure 2: Layout of the signalised staggered intersection**

Geometric, traffic and signal timing data were obtained from intersections by using video recording and suitable tools and equipment such as CountCAM2 to record video, smartphone to connect CountCAM2 application, analog counter to count data during observation, laser distance meter to determine the distance accurately, safety vest as a personal protective equipment to alert people and laptop to play back recorded video for data collection. Traffic volumes were collected in three sessions' peak hours at 7.00 a.m. to 8.00 a.m. in the morning, 12.30 p.m. to 1.30 p.m. in the noon and 6.00 p.m. to 7.00 p.m. in the evening peak hours on Tuesday, 2nd November 2021 and weekend Saturday, 30th October 2021. Data obtained were stored in Microsoft Excel then converted to Passenger Car Unit (PCU) to analyse the performance of the intersections by using SIDRA Software Version 8.0.

## 4. Results and Discussion

The performance of signalised intersections measures includes LOS, average delay, DOS and queue length that have a direct impact on the quality of travel on the road. Commuter data counts were taken at two sites of the three-leg T intersections that were Jalan Pasir Pelangi/Jalan Bakar Batu as Site 1 and Jalan Pasir Pelangi/Jalan Persisir Pantai as Site 2. Data that tabulated were then analysed by inserting road geometric data and traffic data according to the direction of vehicle in each lane into SIDRA Software Version 8.0 and the performances of each peak hours on weekend and weekdays were shown in Table 1 to Table 6.

Based on Table 1 and Figure 1, the overall intersection of Site 1 was LOS D during morning peak hour. However, still manageable in terms of traffic congestion. However, the worst LOS at Site 2 during morning peak hour on weekday was LOS F at Jalan Pantai approach. The highest of degree of saturation and queue length is due to high traffic volume than other approaches with percentage of heavy vehicles of 15.68% on overall intersection of Site 2.

**Table 1: Morning peak on weekday**

| Site | Approach | LOS | Delay (s) | DOS | Queue Length (m) |
|---|---|---|---|---|---|
| 1 | Jalan Pasir Pelangi (North) | C | 27.1 | 0.64 | 148 |
| | Jalan Bakar Batu | E | 55.2 | 0.27 | 51 |
| | Jalan Pasir Pelangi (South) | D | 39.1 | 0.39 | 117 |
| | Intersection | D | 36.2 | 0.64 | 148 |
| 2 | Jalan Pasir Pelangi (North) | C | 22.8 | 0.38 | 71 |
| | Jalan Pantai | F | 367.0 | 0.78 | 411 |
| | Jalan Pasir Pelangi (South) | C | 23.1 | 0.57 | 81 |
| | Intersection | F | 183.3 | 0.78 | 411 |

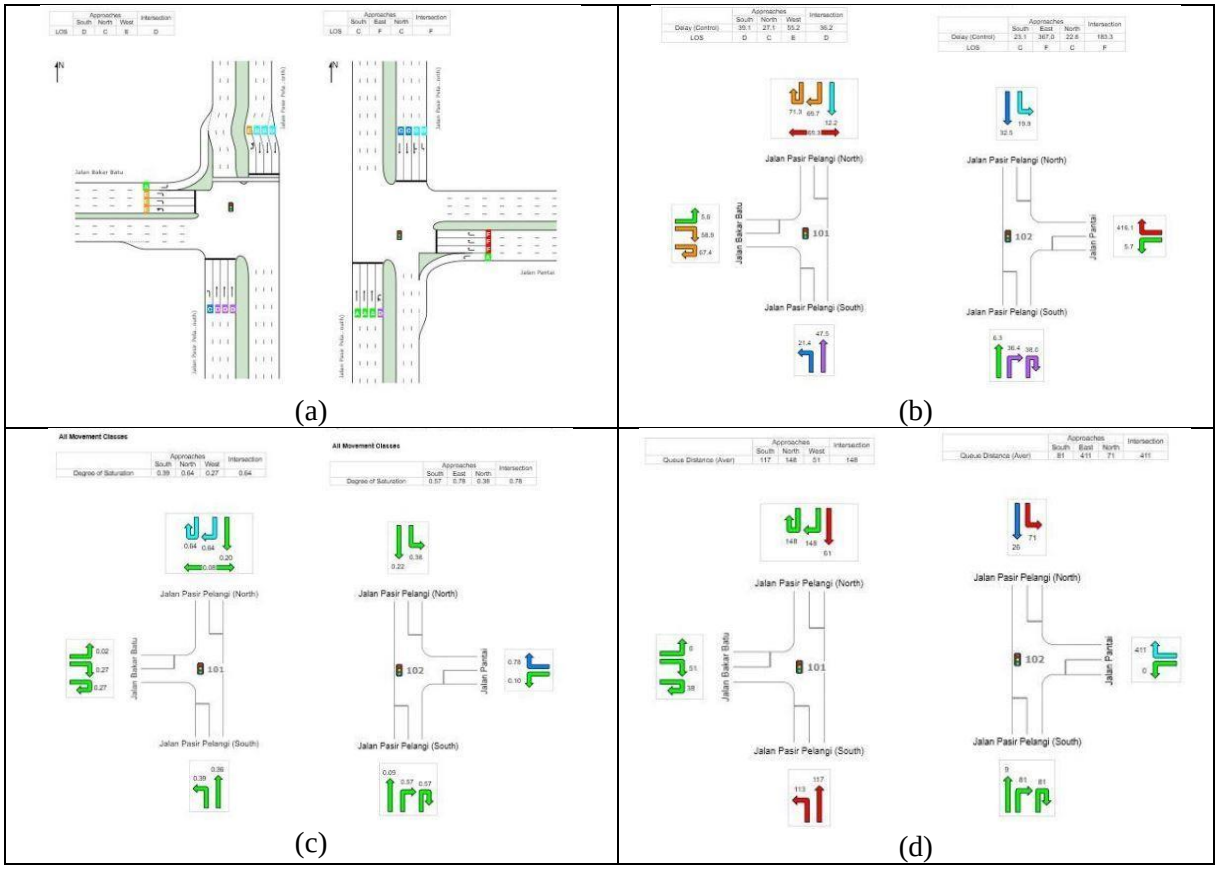


**Figure 1: Performances analysis of signalised staggered intersection on morning weekday; (a) LOS, (b) Delay, (c) DOS, (d) Queue length**

Referring to Table 2 and Figure 2, the overall signalised intersection of Site 1 in weekend during morning peak hour was LOS C in near free flow speed level of traffic volume condition with percentage of heavy vehicles of 13.86%. Whereas the overall signalised intersection of Site 2 was LOS C, where it was the same condition as Site 2 during morning peak hour on weekday with percentage of heavy vehicles of 23.16% on overall intersection of Site 2.

**Table 2: Morning peak on weekend**

| Site | Approach | LOS | Delay (s) | DOS | Queue Length (m) |
|---|---|---|---|---|---|
| 1 | Jalan Pasir Pelangi (North) | B | 18.7 | 0.64 | 59 |
| | Jalan Bakar Batu | D | 39.2 | 0.27 | 22 |
| | Jalan Pasir Pelangi (South) | C | 25.9 | 0.39 | 45 |
| | Intersection | C | 25.0 | 0.64 | 59 |
| 2 | Jalan Pasir Pelangi (North) | B | 16.4 | 0.38 | 38 |
| | Jalan Pantai | C | 33.1 | 0.78 | 59 |
| | Jalan Pasir Pelangi (South) | B | 19.7 | 0.57 | 41 |
| | Intersection | C | 24.3 | 0.78 | 59 |

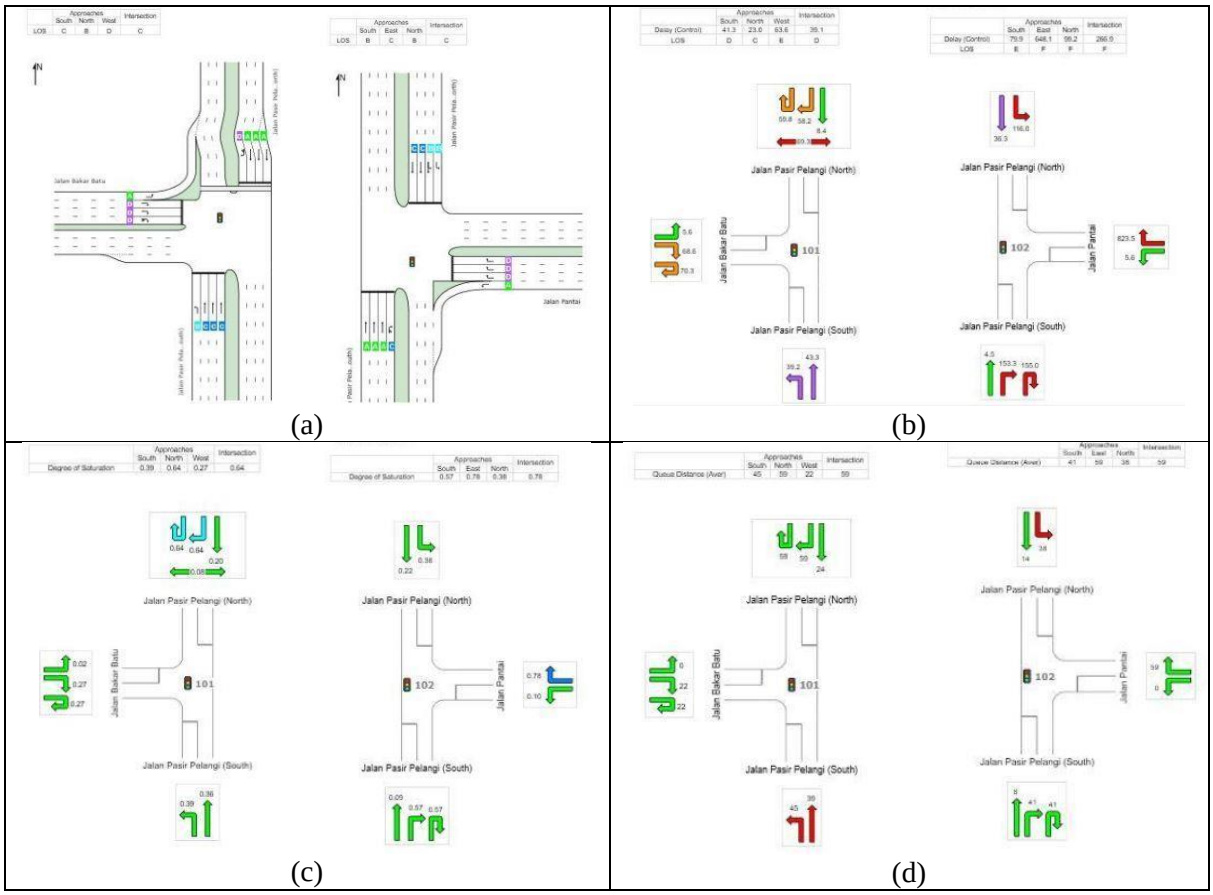


**Figure 2: Performances analysis of signalised staggered intersection on morning weekend; (a) LOS, (b) Delay, (c) DOS, (d) Queue length**

Referring to Table 3 and Figure 3, the overall intersection of Site 1 during noon peak hour on weekday where speed begin to decline slightly with increasing flow in LOS D with percentage of heavy vehicles of 44.92%. On the other hand, LOS of overall intersection of Site 2 were at worst at Jalan Pantai approach that was LOS F due to the presence of high number of heavy vehicles compared to other approaches with percentage of heavy vehicles of 30.14% on overall intersection of Site 2. As the result, delay happened thus queue will get longer.

**Table 3: Noon peak on weekday**

| Site | Approach | LOS | Delay (s) | DOS | Queue Length (m) |
|---|---|---|---|---|---|
| 1 | Jalan Pasir Pelangi (North) | C | 22.3 | 0.76 | 108 |
| | Jalan Bakar Batu | E | 55.3 | 0.57 | 64 |
| | Jalan Pasir Pelangi (South) | D | 36.7 | 0.66 | 124 |
| | Intersection | D | 36.2 | 0.76 | 124 |
| 2 | Jalan Pasir Pelangi (North) | C | 31.8 | 0.67 | 125 |
| | Jalan Pantai | F | 515.5 | 1.65 | 489 |
| | Jalan Pasir Pelangi (South) | F | 111.7 | 1.14 | 439 |
| | Intersection | F | 233.3 | 1.65 | 489 |

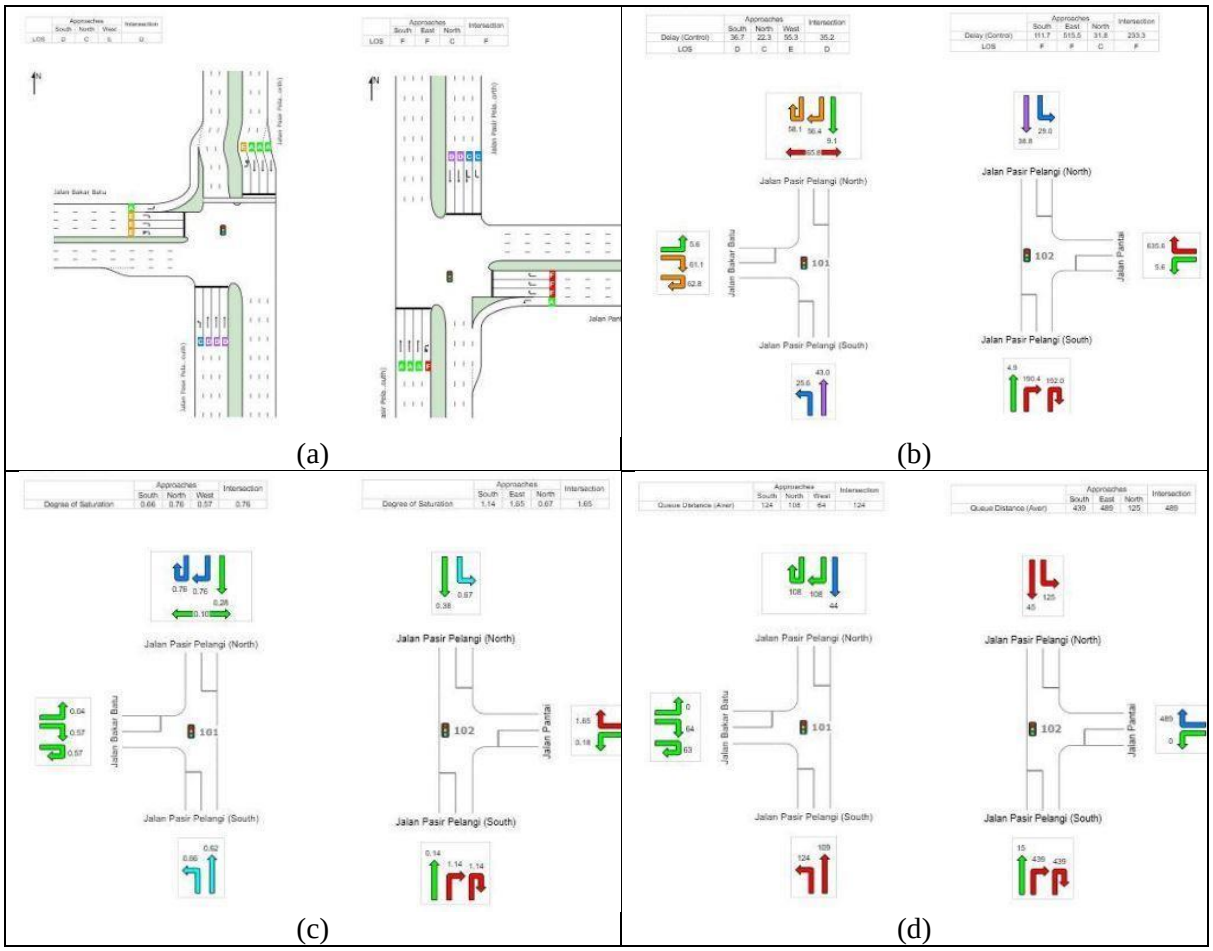


**Figure 3: Performances analysis of signalised staggered intersection on noon weekday; (a) LOS, (b) Delay, (c) DOS, (d) Queue length**

Based on Table 4 and Figure 4, Jalan Bakar Batu approach was the worst with LOS D among Jalan Pasir Pelangi (South) approach during noon peak hour on weekend at Site 1 due to signalised intersection that is located near to the access of commercial areas that is accessible through the Eastern Dispersal Link (EDL) Highway and Tebrau Highway as shown in Figure 1. The percentage of heavy vehicles on overall intersection of Site 1 was 25.97%. The overall intersection of Site 2 on weekend during noon peak hour were LOS F at Jalan Pantai approach, where it was the same condition as Site 2 during noon peak hour on weekday with percentage of heavy vehicles of 17.08% on overall intersection of Site 2.

**Table 4: Noon peak on weekend**

| Site | Approach | LOS | Delay (s) | DOS | Queue Length (m) |
|---|---|---|---|---|---|
| 1 | Jalan Pasir Pelangi (North) | C | 24.6 | 0.87 | 151 |
| | Jalan Bakar Batu | E | 57.2 | 0.51 | 56 |
| | Jalan Pasir Pelangi (South) | D | 39.0 | 0.71 | 134 |
| | Intersection | D | 36.4 | 0.87 | 151 |
| 2 | Jalan Pasir Pelangi (North) | C | 29.6 | 0.60 | 95 |
| | Jalan Pantai | F | 241.9 | 1.29 | 284 |
| | Jalan Pasir Pelangi (South) | C | 22.8 | 0.86 | 131 |
| | Intersection | F | 105.8 | 1.29 | 284 |

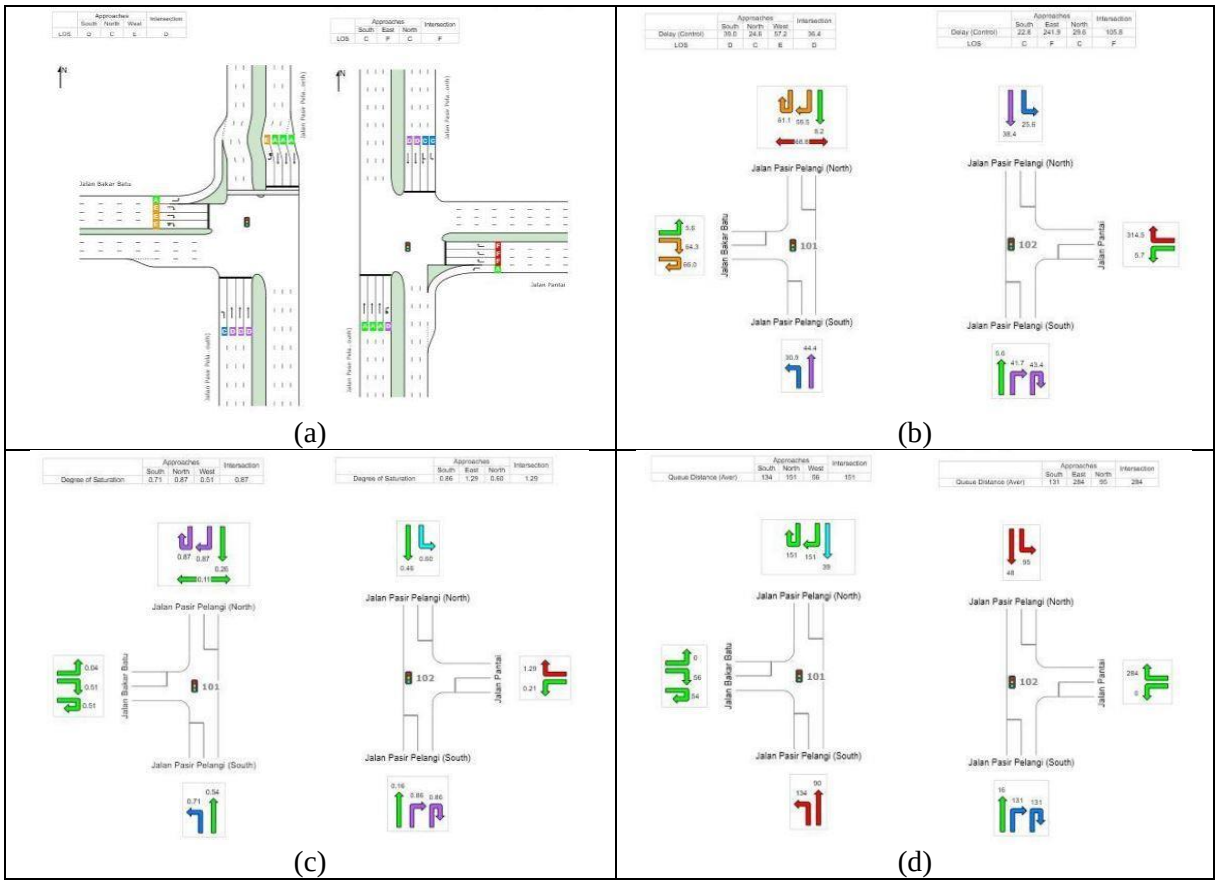


**Figure 4: Performances analysis of signalised staggered intersection on noon weekend; (a) LOS, (b) Delay, (c) DOS, (d) Queue length**

Based on Table 5 and Figure 5, the overall intersection of Site 1 during evening peak hour on weekday were in near free flow, thus moderate traffic congestion happened. However, Overall intersection of Site 2 were LOS F, where Jalan Pantai was the worst with LOS F followed by LOS E at Jalan Pasir Pelangi (North) and Jalan Pasir Pelangi (South) due to the increasing vehicles number used by people returning back from work.

**Table 5: Evening peak on weekday**

| Site | Approach | LOS | Delay (s) | DOS | Queue Length (m) |
|---|---|---|---|---|---|
| 1 | Jalan Pasir Pelangi (North) | B | 19.3 | 0.69 | 89 |
| | Jalan Bakar Batu | D | 54.1 | 0.63 | 73 |
| | Jalan Pasir Pelangi (South) | C | 32.9 | 0.82 | 156 |
| | Intersection | C | 31.9 | 0.82 | 156 |
| 2 | Jalan Pasir Pelangi (North) | E | 70.8 | 1.00 | 417 |
| | Jalan Pantai | F | 548.6 | 1.74 | 501 |
| | Jalan Pasir Pelangi (South) | F | 88.4 | 1.11 | 390 |
| | Intersection | F | 226.6 | 1.74 | 501 |

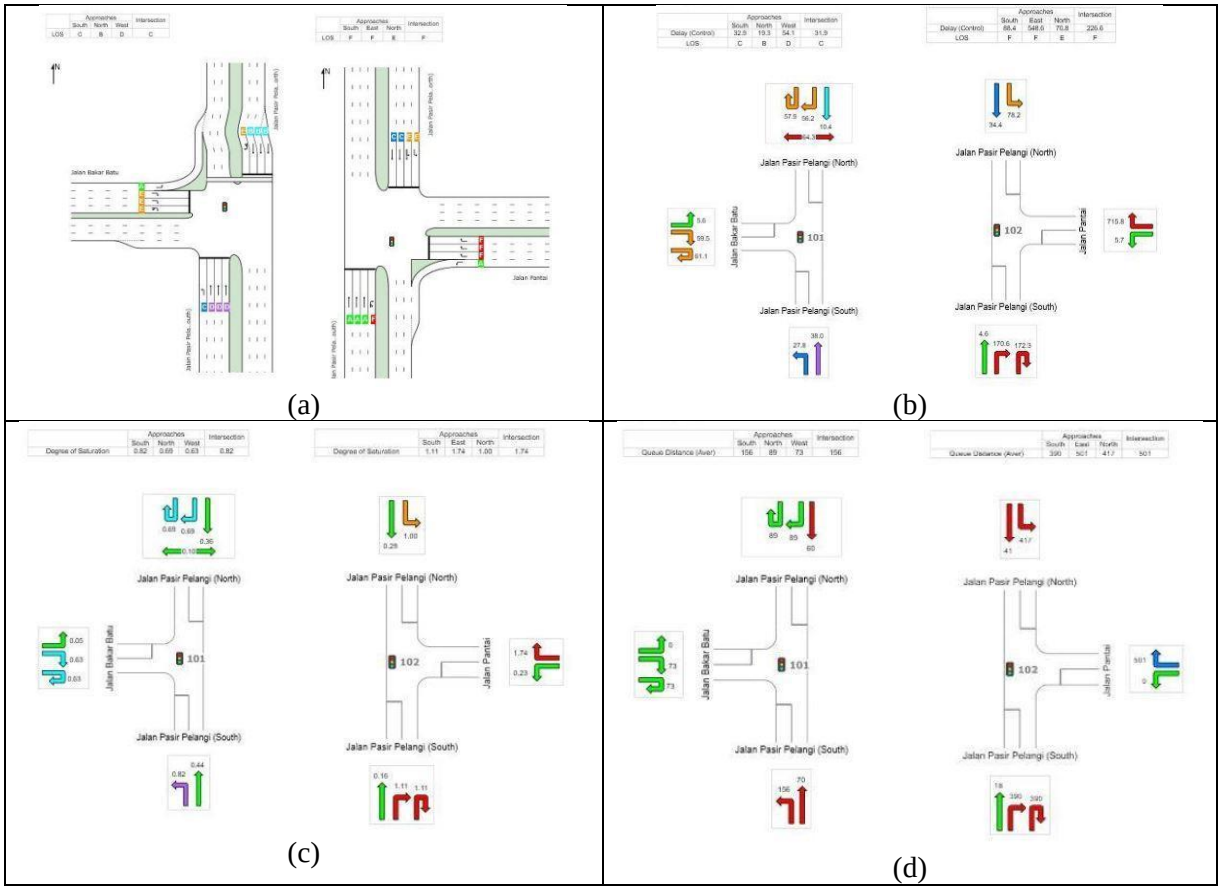


**Figure 5: Performances analysis of signalised staggered intersection on evening weekday; (a) LOS, (b) Delay, (c) DOS, (d) Queue length**

Referring to Table 6 and Figure 6, Jalan Bakar Batu approach is having a LOS E which is the worst on Site 1 due to signalised intersection that is located near to the access of commercial area. Followed by Jalan Pasir Pelangi (South) approach which was LOS D, however, still manageable in terms of traffic congestion. Meanwhile, Jalan Pasir Pelangi (North) was the finest which also can be seen from low delay, DOS and short queue length. Jalan Pasir Pelangi (North) approach and Jalan Pantai approach at Site 2 resulting the overall intersection during evening peak on weekend with LOS F due to the higher traffic volume at the both approaches compared to other approaches.

**Table 6: Evening peak on weekend**

| Site | Approach | LOS | Delay (s) | DOS | Queue Length (m) |
|---|---|---|---|---|---|
| 1 | Jalan Pasir Pelangi (North) | C | 23.0 | 0.88 | 144 |
| | Jalan Bakar Batu | E | 63.6 | 0.78 | 87 |
| | Jalan Pasir Pelangi (South) | D | 41.3 | 0.87 | 174 |
| | Intersection | D | 39.1 | 0.87 | 174 |
| 2 | Jalan Pasir Pelangi (North) | F | 99.2 | 1.06 | 516 |
| | Jalan Pantai | F | 648.1 | 1.86 | 569 |
| | Jalan Pasir Pelangi (South) | E | 79.9 | 1.09 | 360 |
| | Intersection | F | 266.9 | 1.86 | 569 |

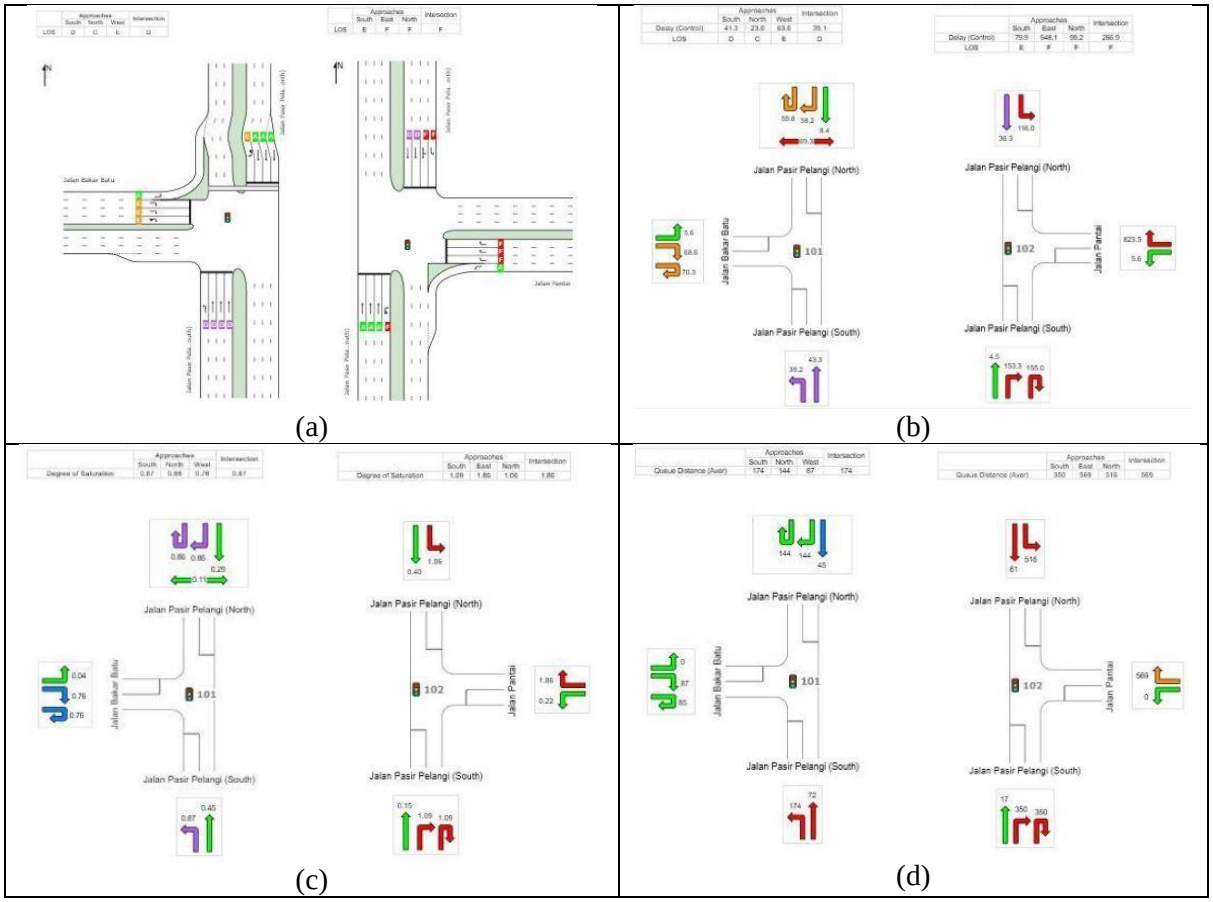


**Figure 5: Performances analysis of signalised staggered intersection on evening weekend; (a) LOS, (b) Delay, (c) DOS, (d) Queue length**

## 5. Conclusion

To put it concisely, the result of the site performances that have been obtained to accomplish the objectives can be drawn in this study:

1. After analysed Jalan Pasir Pelangi/Jalan Bakar Batu (Site 1) and Jalan Pasir Pelangi/Jalan Persisir Pantai (Site 2) as signalised staggered intersection, the worst performances were on weekday during noon peak hour and weekend during evening peak hour.
2. The most critical of LOS D is found at Jalan Bakar Batu at Site 1 and LOS F Jalan Pantai at Site 2.

## Acknowledgement

The authors would like to thank to Johor Bahru City Council for supplying information, Jbtech Enterprise for the guidance and Smart Driving Research Centre (SDRC) for providing tools and equipment to be used for this thesis.

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