CHAPTER 4

THE SIGNALIZED INTERSECTION PERFORMANCE AND TRAFFIC EMISSION STUDY AT PRESINT 8, PUTRAJAYA

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4.1 INTRODUCTION

A signalized intersection is a kind of intersection control in which traffic signals regulate the flow of traffic on the road. A condition on the road when there are many cars on the roadway owing to a greater demand than the capacity at the same time and location is referred to as traffic congestion. Traffic congestion is most common during the morning and evening rush hours, when road users are traveling to and from work, school, or other institutions, among other destinations. Intersections are crucial components of a highway transportation system since they are the sites where delays, accidents, and pollutants tend to congregate the most often. The timing of the traffic light determines the intersection's traffic flow. The signal timing optimization thereby has an impact on the intersection performance, defining the degree of saturation, the length of the vehicle queue, vehicle delay, and level of service (LOS) intersection performance.

Every signalized intersections has it own green phase depending on time. There are different green phases between the peak hours and off-peak hours. During the peak hours, green phase of the traffic light might be longer than off-peak, but it also contribute to delays and emissions. Performance of signalized intersections consider important since vehicle on the road are the major contribution to air pollution. Whilst the impact related to high traffic volume along the road can contribute to air pollution, it is crucial to design the traffic flow to reduce the high traffic volume and the release of emission.

Moreover, traffic delays and lines are critical performance factors that impact the assessment of intersection level of service (LOS), the appropriateness of lanes, and the calculation of fuel consumption and emissions. Since numerous transportation authorities proclaimed that an acceptable LOS is one of the main qualities to be achieved in signal control design, the traffic engineers' major purpose has been to attain the smallest feasible delay [1].

According to traffic management and control research and practice, the issue of air pollution caused by automobile traffic is becoming more important. Vehicle emissions are influenced by factors such as traffic volume, road and vehicle characteristics, weather conditions, and driving behavior. Intersections are key parts of road networks in terms of their influence on air quality [2]. The kind of control used, and the physical form of the intersection may considerably impact vehicle emissions. Most of the time, cars slow down and often halt at intersections, disrupting traffic flow in various ways.

In addition, according to [3], the three operational efficiency measures may be connected, implying that an intersection capable of handling very peak traffic demand seems to be more likely to have reduced delay and queue length. Emissions from vehicles are often higher at intersections because cars must slow or stop, producing more pollutants than if they were travelling at a steady pace. Other variables that may have an impact on polluted air include traffic demand, vehicle types, and intersection management approaches. On the other hand, according to [4] a signalized intersection emits 50% more emissions than an unsignalized roundabout.

Using SIDRA, which stands for Signalized & Unsignalized Intersection Design and Research Aid, this study provides an examination of the operational effectiveness of three different kinds of crossings which is priority-controlled intersections, unsignalized roundabouts, and signalized intersections. To analyze operational efficiency, the three most often utilized performance indicators, intersection capacity, average delay, and total emissions, are employed. SIDRA simulates a range of traffic conditions to analyze their implications, such as variable volume ratios (a ratio of major versus minor traffic volumes) and turning ratios (a ratio of left, though, and right turning traffic volume) [5].

Hence, the purpose of this study is to assess the influence of traffic flow at signalized intersections on traffic delays and greenhouse gas emissions. The degree of performance of signalized intersections is determined by the traffic volume and the intersection's geometry. Due to relatively large amount of traffic on Lebuh Wawasan road, this stretch has an adverse effect on signalized intersections. Using the SIDRA program, this research examines the performance of signalized intersections along the Lebuh Wawasan route. After the study, the degree of saturation, vehicle queue length, vehicle delay, and LOS intersection of calibrated and verified models utilizing SIDRA software are all calculated to determine the performance of signalized intersections.

4.2 RESEARCH METHODOLOGY

The parameters of signalized intersection at Presint 8 located in Jalan Lebuh Wawasan which also connected to Jalan P8 and Jalan P8H, must be obtained to use as a reference for designing the intersections as shown in Figure 4.1. After that, the process of analyzing and designing the existing intersection would be carried out by means of SIDRA software in accordance with Signalized Intersection: Informational Guide. Finally, when the analysis and design phases are completed successfully and without errors, the modeling phase of the intersections will be executed utilizing using SIDRA software. As a result, the data and information about the intersections will be available.

Data collection methods are crucial to getting the essential data for conducting the investigation. In this study, the data on the existing intersection was acquired utilizing qualitative approaches. Qualitative fieldwork includes getting access to and collecting data, recording information, resolving field concerns, and archiving data [6].

The times for data collection during the morning peak, and evening peak hours. Data was collected during weekday periods in the morning and evening. Field research was on Tuesday in morning and the period of time between the hours of 7:15 a.m. to 8:15 a.m., and evening in the time period between 16.45 p.m. to 17:45 p.m.

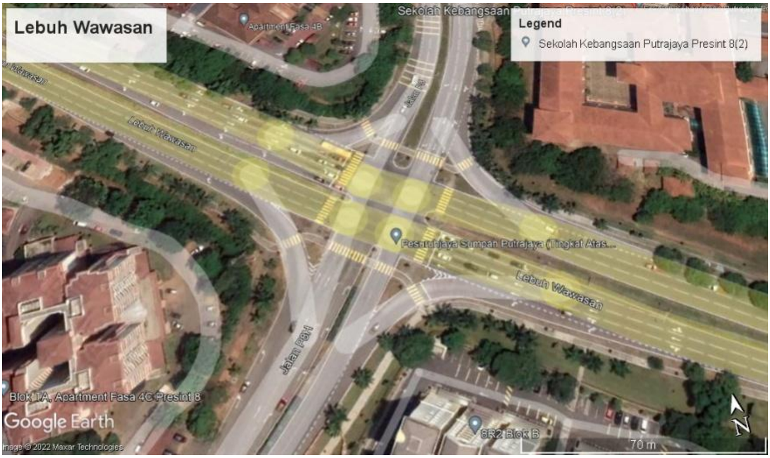

Figure 4.1: Location of the study area from Google Earth Pro

4.2.1 MODELLING SOFTWARE

According [5], SIDRA was created with four models of three distinct sorts, namely, priority-controlled unsignalized intersections with give-way and stop control, unsignalized roundabout, and signalized intersection. It is possible to replicate a four-leg intersection on a leveled terrain by using a pair of aligned legs perpendicular to the other pair, which is then repeated for the other pair.

4.2.1.1 INPUT OF SIDRA SOFTWARE

The intersection data, movement class input, lane configuration, lane input, vehicle volumes and vehicle movements data are presented in Figure 4.2 to Figure 4.6 below:

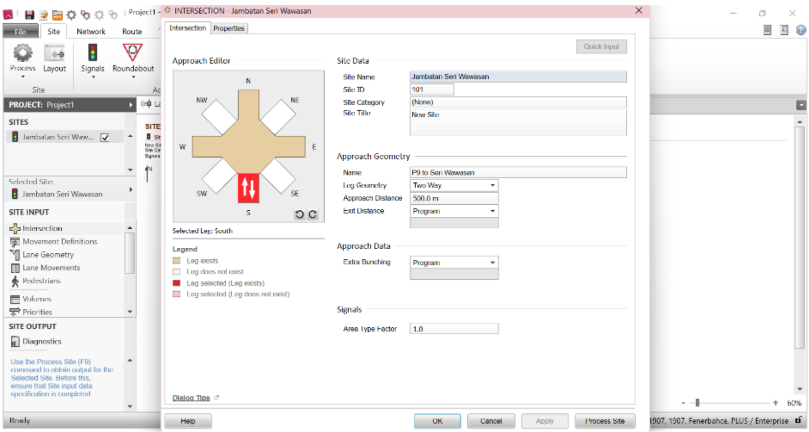

Figure 4.2: Intersection data input

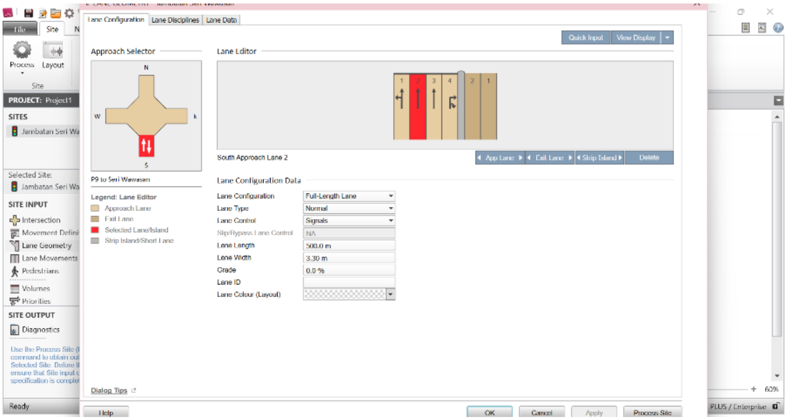

Figure 4.3: Lane configuration data input

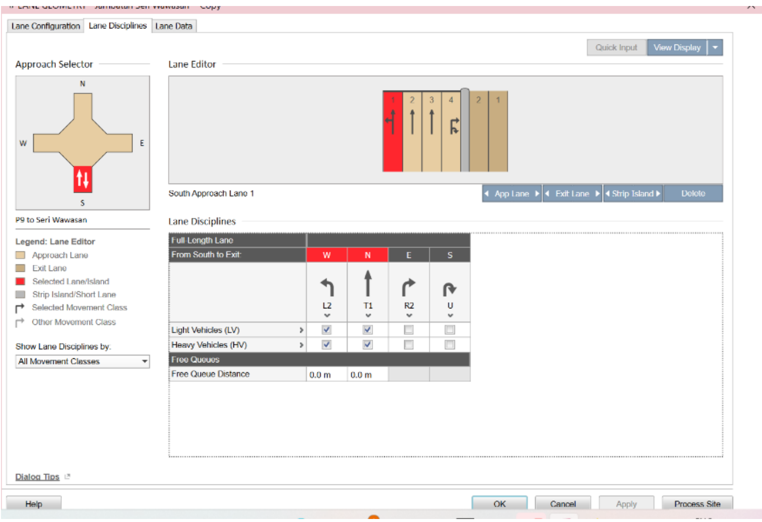

Figure 4.4: Lane disciplines data input

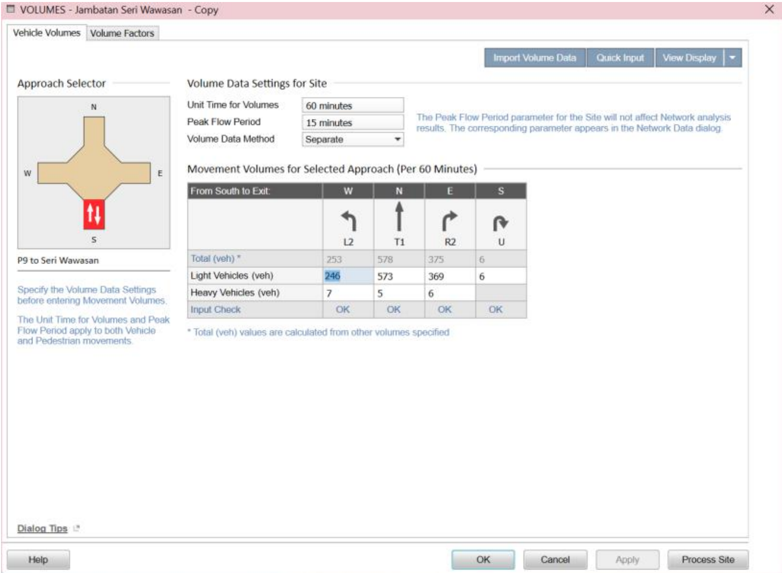

Figure 4.5: Vehicle volumes data input

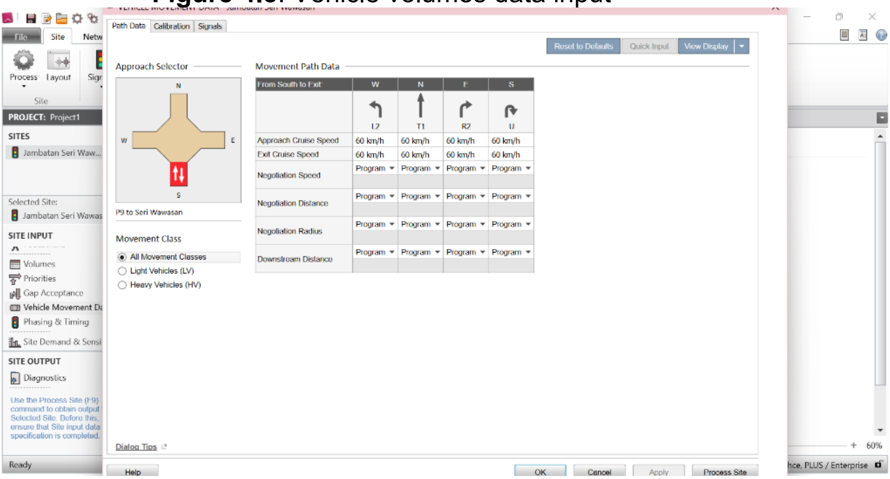

Figure 4.6: Vehicle movement data input

4.2.1.2 OUTPUT OF SIDRA SOFTWARE

Firstly, the analysis begins with determining the level of service, which reflects the overall performance of the intersection. Secondly, an intersection summary is generated to provide a comprehensive overview of traffic conditions. Thirdly, a movement summary is prepared to evaluate the performance of individual turning movements. Fourthly, a lane summary is developed to assess how each lane operates under existing traffic demand. Fifthly, the study identifies the level of service for each direction to highlight variations in traffic flow across approaches. Sixthly, the lane capacity for each direction is examined to determine whether the lanes can accommodate current and projected traffic volumes. Lastly, the travel speed for each direction is analyzed to understand how congestion affects vehicle movement throughout the intersection.

4.3 RESULTS AND DISCUSSION

Observation data was primary data that used to calculate the traffic movements and capacities at the study intersection. The observed data includes intersection geometric and traffic flow volumes, as well as cycle times for the traffic signals. The data will be evaluated using the SIDRA Intersection program.

4.3.1 VOLUME AND FLOW DISTRIBUTION

Tables 4.1 and 4.2 summarize the data for the traffic volume at the surveyed intersection, which are Jalan Lebuh Wawasan and Presint 8, Putrajaya. The survey was done for 1 hour from 7:15 a.m. to 8:15 a.m. in the morning and from 4:45 p.m. to 5:45 p.m.

Table 4.1: Raw volume data for morning peak hours

	Light Vehicle	Heavy Vehicle	Motorcycle
Left-Turn	1233	9	413
Straight	2804	16	775
Right-Turn	1017	7	279

U-Turn	16	0	6

Table 4.2: Raw volume data for evening peak hours

	Light Vehicle	Heavy Vehicle	Motorcycle
Left-Turn	1266	21	434
Straight	2811	16	800
Right-Turn	1354	9	329
U-Turn	48	0	1

4.3.2 OUTPUT FROM SIDRA

Congestion in urban areas has been a problem for drivers during peak hours, as it affects land use, driver behavior, and the economy. One solution is to re-coordinate the cycle time of an intersection according to the volume of traffic flow in the morning and evening. Another solution is to increase the capacity of a road at intersections by adding lanes or turning lanes. As a result, sections that discuss existing traffic flow data without optimization are discussed below using SIDRA INTERSECTION 5 software.

Table 4.3: Summary of output from Sidra software

Peak Hour	Average Delay (sec)	Level of Service	Average Speed (km/h)	Cost (Hourly) ($/h)	CO_2 (kg/h)
Morning	95.5	F	22.9	7794.92	1521.5
Evening	148.1	F	16.9	11789.25	1958.9

Table 4.3 shows the summary of output from the Sidra software. The table consists of the average delay (sec), level of service, average speed (km/h), cost in hourly values and CO_2 emission. The results for every output are discussed below.

Firstly, the delay time at a signalized intersection is the difference between a vehicle's arrival and departure timings at the intersection compared to an ideal condition in which no interruptions occur, and all vehicles pass without delay. The output from the Sidra Intersection software demonstrates that during the evening peak hours, the delay at the intersection is greater than during the morning peak hours. This is due to the simultaneous movement of drivers to their preferred destinations (work zones) in the morning. However, the delay is more severe because people's motions toward their homes vary in the evening.

Secondly, the travel speeds in the evening peak hours were slower than those in the morning peak hours, as evidenced by percentage increases in delay and decreases in travel time. Analysis of the speed shows that the Lebuh Wawasan intersection has 22.9 km/h and 16.9 km/h for morning and evening peaks, respectively. These variations result from the Sidra Intersection application evaluating each intersection independently. In the morning, travel speeds related to delays were also higher at Lebuh Wawasan intersection.

Moreover, the results show that operational expenses increased in the intersection of four legs during evening peak hours compared to morning peak hours. The percentage increase was up to 20.37%. The analysis of CO_2 emissions further indicates a better level of service during the morning peak hour, attributable to shorter traffic congestion durations at the intersection compared to the evening. The amount of CO_2 produced by fuel combustion is determined by the amount of carbon in the fuel, which is determined by the amount of carbon in each fuel.

Acceleration speed at intersections substantially influences overall fuel usage when driving. Acceleration causes the engine to use more fuel to create power, resulting in higher fuel economy rates. Table 4.3 shows that the fuel consumption of vehicles for an hour is higher during evening peak hours compared to morning peak hours. Total fuel usage for the evening peak hour was 1282.6 L/h, while the morning peak hour reached 996.6 L/h, as indicated in the table below. As a result, it is apparent that the rate of fuel consumption increases by 12.55% in the evening.

Lastly, all existing conditions for the selected intersection based on the above criteria failed after analysis, with LOS rank F being the worst. All lanes within each section of the intersection are expected to pass with a minimum LOS of Class D. If these conditions are not met, the intersection should be converted into a roundabout, which is more economical with a sufficient level of service.

4.3.3 SUGGESTION FOR OPTIMIZATION

Total journey duration, average delay and degree of saturation, travel speed, operating cost, quality of service, and other performance parameters were discussed to considering the optimization.

- Adding lanes to each existing approach to the intersection did not pass the analysis with the provided goal LOS.
- Add slip lanes to the intersection for cars making a right turn.
- Converting the intersection that failed to meet the requirements to a four-lane approach.

4.4 CONCLUSION

This research aimed to assess traffic flow at a signalized crossroads in Presint 8, Putrajaya. The chosen crossroads were the Lebuh Wawasan intersection, a four-legged intersection in one of Putrajaya's busiest areas. Volume of traffic was measured during the morning and evening rush hours. The intersections demonstrate poor performance in the existing data scenario by having the greatest average intersection delay and the lowest rank of LOS.

All existing conditions for the specified intersection based on the criteria failed, with LOS rating F being the worst. All lanes inside each intersection segment are anticipated to have a minimum LOS of Class D. If these standards are not satisfied, the intersection will be transformed into a roundabout, which is more cost-effective while providing an adequate level of service.

Finally, an ideal solution for the suggested design was established, with higher flow capacity and quality, significantly reduced average delay and queue length, and lower total fuel consumption and carbon emissions. The conclusion should summarize the main findings of the study, and restate the key points inferred from trends observed and discussed regarding the data. Some suggestions should be included to encourage the continuation of the current research.

BIBLIOGRAPHY

[1] Eom, M., & Kim, B. I. (2020). The traffic signal control problem for intersections: a review. In European Transport Research Review (Vol. 12, Issue 1). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1186/s12544-020-00440-8

[2] Meneguzzer, C., Gastaldi, M., Rossi, R., Gecchele, G., & Prati, M. V. (2017). Comparison of exhaust emissions at intersections under traffic signal versus roundabout control using an instrumented vehicle. Transportation Research Procedia, 25, 1597–1609. https://doi.org/10.1016/j.trpro.2017.05.204

[3] Virginia P. Sisiopiku and Heung-Un Oh. (2001). Evaluation of Roundabout Performance Using SIDRA. Journal of Transportation Engineering, 127(2), 143–150.

[4] Mustafa, M. , & V. S. (1993). Analysis Of Pollutant Emissions and Concentrations At Urban Intersections.

[5] Ranjitkar, P., Shahin, A., & Shirwali, F. (2014). Send Orders for Reprints to reprints@benthamscience.net Evaluating Operational Performance of Intersections Using SIDRA. In The Open Transportation Journal (Vol. 8).

[6] Matthew B. Miles, & A. Michael Huberman. (1994). milesandhuberman1994.