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Study the Effect of Traffic Congestion on Signalized Intersection in Bukit Chedang, Seremban Using SIDRA 6.0 Sotware

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Abstract

The signalized Intersection Design and Research Aid (SIDRA) software as an assistance for timing , capacity and performance analysis of isolated intersections. Delay at signalized intersections reflects the incompetence in the signal timing because of consecutive signalized intersections on the particular site. It is also represents a direct cost in terms of fuel consumption on road networks during inactivity and idleness. Furthermore, one of the significant ways to improve the performance of the network is by coordinating traffic signal in intersections. This study was done to highlight the ability of improving the level of service (LOS) of three leg intersections in Bukit Chedang, Seremban using SIDRA software version 6.0. In addition, the study aims to compare the results between an average delay, queue distance, travel speed, degree of saturation, performance index, fuel consumptions and total CO^2 before and after upgrade current situation of traffic flow at study area. The data required for the study were mainly collected through video filming technique. The calculation and simulation are constructed with the software SIDRA version 6.0 which is used to design and analyze the roundabout and intersection. The result obtained show that with addition a new lane and slip lane at all critical lane, the LOS can be improve to better grade from F to C. However, the value of delay, queue, PI , Fuel consumptions, total CO^2 and speed is better after optimization by SIDRA software. The average reduction of delay before and after optimization is from 224.3 sec to 25.0 Sec (88.9%), the speed on the road manage improve from 7.9 km/hr to 28.6 km/hr (72.4%) , Performance Index reduce up to 83.4% and fuel consumptions decrease from 269.6 l/hr to 96.3 l/hr (64.4%). It will be beneficial for the traffic planners in making judicious and decisions regarding control type at intersection.

Key-word: - Delay; fuel consumption; signalized intersections; Level Of Service (LOS); SIDRA software

1. Introduction

Malaysia and other developing counties are facing serious traffic congestion problem due to population growth and rapid motorization in their cities. Now days, Infrastructure development could not match the rapid motorization and as a result, serious congestion occurs almost at every intersection during peak hours mainly the inability of signal system to provide optimum flows, either due to optimum band width for progressive flows or the imbalance green time split. Traffic congestion is a condition on transport networks that occurs as use increases, and is characterized by increased vehicular queuing ,slower speeds and longer trip times. In Malaysia, delays and long queues are observed repeatedly during peak hours due to the poor strategies of road networks (Albrka, 2014). According to Shariff (2012), an explosive growth in the demand for transport vehicles and the total number of recorded motor vehicles in Malaysia has grown up to 15 million and hence, increasing the number of vehicles cause traffic congestion, resulting in slower travel speed. Highway traffic rules and regulations are required to develop better traffic capacity by controlling the high volume of traffic flow and at the same time expect the rise of future traffic flow volume.

In various cities, chronic traffic jam happens and traffic congestions lose billions money and hours, In order to reduce these losses, it is required to reduce the delay time and also to create an efficient method to resolve traffic congestion (Foad Shokri et al., 2009).

According Greenwood and Bennett (1996), Vehicle fuel consumption increases approximately 30% under heavily congestion and in the other hand the dynamic vehicular delay at intersections is a major current concern, because the standard static network equilibrium formulation fails to capture essential features of traffic congestion.

1.1 Problem Statement

Traffic congestion and long queues at the intersections and roundabout occurred during rush hours repeatedly observed at Bukit Chedang, Rasah Seremban. The entire quantity of recorded motor vehicles in Malaysia also has grown to fifteen million and hence, the increased number of vehicles causes' traffic congestion and slower travel speed. It is frequently observed in a rapidly growing Seremban that traffic congestion and long queues at intersections occur during peak hours. This problem is mainly due to the poor coordination between adjacent traffic signal controls resulting in inefficient progressive traffic flows, other problems are the inability of existing sensors to determine actual traffic demand and the conventional control methodology is unable to determine suitable green time split whenever the traffic demand exceed capacity.Therefore, a need to find out an applicable modern software have arised, to avoid the over crowding of traffic congestion at intersections as per SIDRA 6.0.

1.2 Scope and area of study

This study focuses on the estimation of queue lengths and delays that result from the adoption of a signal control strategy at intersections, as well as on a sequence of intersections. Traffic delay and queues are principle performance measures that enter into the determination of intersection Level of Service (LOS), in the evaluation of the adequacy of lanes and in the estimation of fuel consumption and emission. Therefore, the design of the intersection and to obtained minimum delay being the foremost goal to the traffic engineers. In this study we choose the most congested area in Bukit Chedang Rasah, Seremban Negeri Sembilan. This study was carried out at T- Intersection at Bukit Chedang as shown in figure below.

Figure 1.1: **S**tudy area at Bukit Chedang, Rasah Seremban N. Sembilan *Source:* Google Earth 2014

Figure 1.2 : Real site at T- Intersection

1.3 Objective

The Objectives of this study are:

a) To analyse a road networks at selected signalized T- intersection at Bukit Chedang, Rasah Seremban using SIDRA 6.0
b) Identify the set of variables those effect significantly the control delay traffic signal optimization
c) To recommend suitable solution to the problem detected.

2. Literature Review

Computer simulation is very essential for the analysis of freeway and urban street systems. The Signalized Intersection Design and Research Aid (SIDRA) Software is an intersection-based platform established by the Australian Road Research Board (ARRB) in Australia as an assistance for capacity, timing and performance analysis of isolated intersections. According to H. Taale and H. Van Zuylen (2001), SIDRA is a very powerful analytical program for signalized intersections. Specialized engineering in simulation can study the formation and dissipation of congestion on roadways, compare alternative geometric configurations and assess the impacts of control strategies (J. Salzman at. all, 2002). Developments in traffic flow theory and computer technology have led to the widespread creation and use of traffic simulation models by traffic engineers and transportation designers involved in design of transportation facilities and the planning operations (W. Hook and M. Replogle. 1996). Prior to the development of traffic simulation, model studies for planning and improving roadway facilities was typically undertaken by computational methods that could estimate delay, level of service (LOS),capacity and other parameters for a given set of roadway conditions (L. Oduwaye. 2007).

The SIDRA intersection software is used as an aid in the design and evaluation of signalized intersections (fixed-time/pretimed and actuated), roundabouts, single point interchanges, signalized pedestrian crossings, roundabout metering, two-way stop sign control, give-way/yield sign-control and all-way stop sign control. The flexibility of SIDRA Intersection permits its application to many other situations, including merging analysis and uninterrupted traffic flow conditions (R. Akcelik and M. Besley. 2003). SIDRA Intersection is an advanced micro-analytical traffic evaluation tool that employs lane-by-lane and vehicle drive-cycle models coupled with an iterative approximation method to provide performance statistics (delay, queue length, stop rate) and estimates of capacity. The use of HCM version of SIDRA Intersection is based on the calibration of model parameters against the highway capacity manual. SIDRA intersection allows modelling of separate Movement Classes (heavy vehicles, light vehicles, buses, bicycles, large trucks and light rail / trams) with different vehicle characteristics. These movements can be allocated to different lanes, lane segments and signal phases, for example for modelling bus priority lanes at signals.

The level of service (LOS) provides a qualitative ranking of the traffic operational conditions experienced by users of facility. Highway Capacity Manual defines the LOS category for freeways and multilane highway as follows:

- **(A) Free Flow Traffic**. Individual users are practically unaffected by the presences of other vehicles on a road section. The choice of speeds and the maneuverability are free. The level of comfort is excellent as driver needs minimal attention.
- **(B) Steady traffic.** The present of other vehicles on the section begins to affect the behaviour of individual drivers. The choice of the speed is free, but the manoeuvrability has somewhat decreased. The comfort is excellent, as the driver simply needs to keep an eye on nearby vehicles.
- **(C) Steady Traffic but Limited** .The present of other vehicles affects the drivers. The level of comfort is decrease quickly and the choice of the speed is affected and maneuvering required vigilance. In contrast, the effected of incident at LOS A or LOS B are minimal, and cause only minor delay in the immediate vicinity of the event
- **(D) Steady traffic at high demand.** The speed and maneuvering are several reduce. Low level of comfort for the driver. A slight increase of the traffic risks causing some operational problem and saturating the network.
- **(E) Traffic at saturation.** Low but uniform speed. Maneuvering are is possible only under constrain for another vehicles. The user is frustrated.
- **(F) Congestion.** Describe a breakdown in vehicular flow. Vehicles actually operate at low speed in these conditions and are often required to come to a complete stop.

3. Methodology

In this study, there are three peak periods daily which normally start at 7:00 to 8:00 in the morning, at 13:00 to 14:00 in the afternoon and at 17:00 to 18:00 in the evening. The traffic data were collected at T- Intersection at Bukit Chedang Rasah Seremban on of 20 April 2017 (Thursday), 21 April 2017 (Friday) and 22 April 2017 (Saturday) using a video camera in order to record the whole movement of vehicles at intersections. Traffic flow data was extracted from videotapes of each intersection. All the videotapes were studied visually to extract the traffic volumes and turning movements for the analysis. Every vehicle coming from all the approaches was recorded on pre-prepared data collection sheets.

Hourly counts were used as input data for analysis using a SIDRA. These studies use computer simulation to estimate emissions before and after optimization and traffic flow data was analyzed using Design and Research Aid (SIDRA version 6.0).

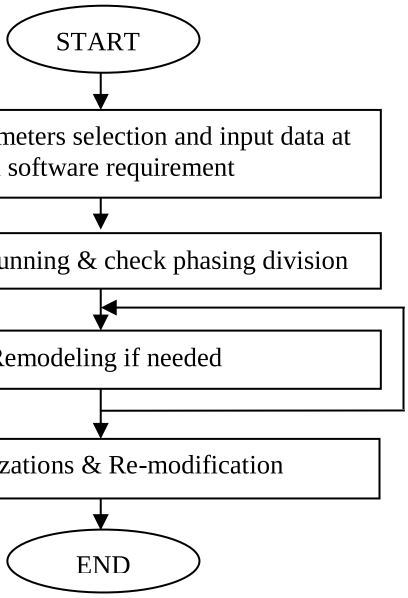


Figure 3.1 : Optimization plan for SIDRA 6.0

4. Results and discussion

4.1 Input Data (Intersection, Approaches and lanes)

In SIDRA Intersection we can enter input using graphics-base input dialogs. The intersection geometry and signal phasing style of SIDRA Intersection reflex the design process directly. The approaches and lanes input dialog allows to type in approach road names and specify various data which describes basic characteristic of a approach road (or intersection leg), and exist lane. Than , movement class and lane declines update before we key in the volume vehicles and process the data (refer figure below).

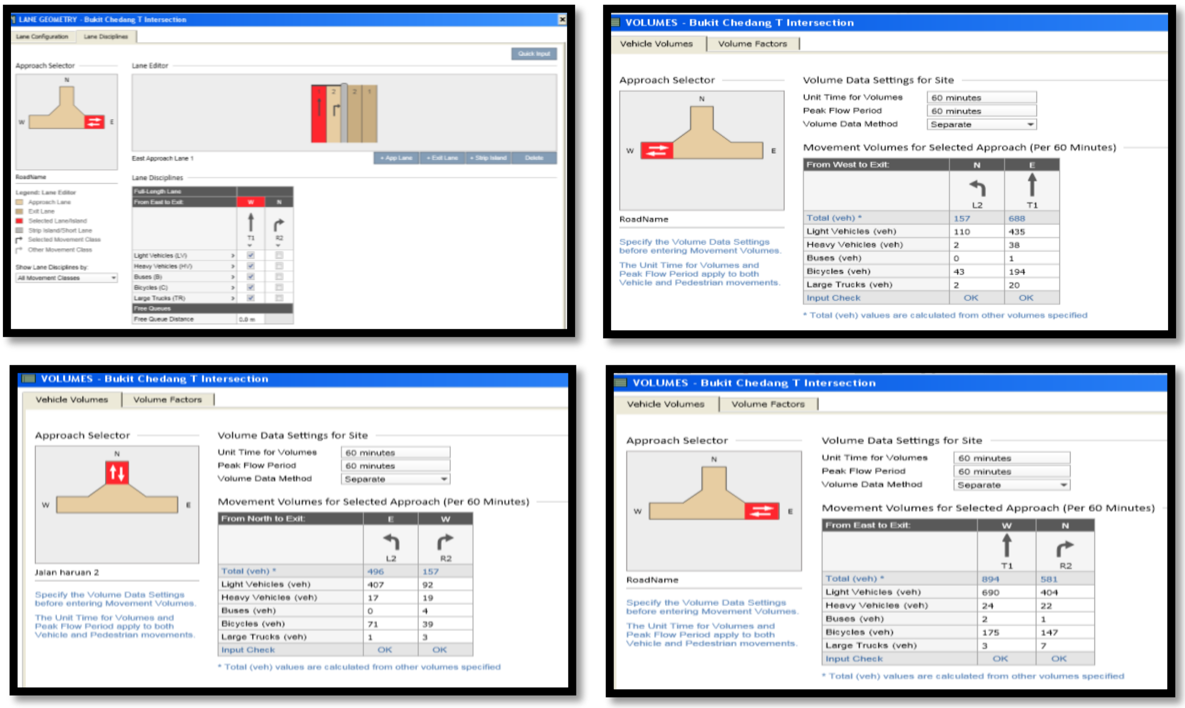
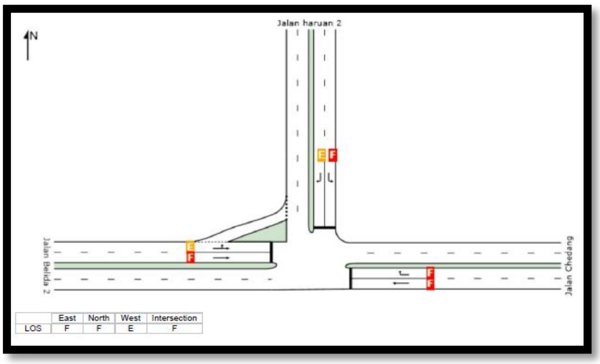


Figure 4.1: Lane Description and update vehicle volumes

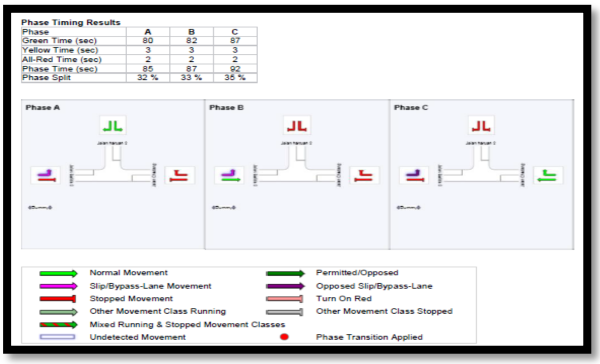
4.2 Existing condition (B*efore improvement*)

4.2.1 Level of service (LOS)

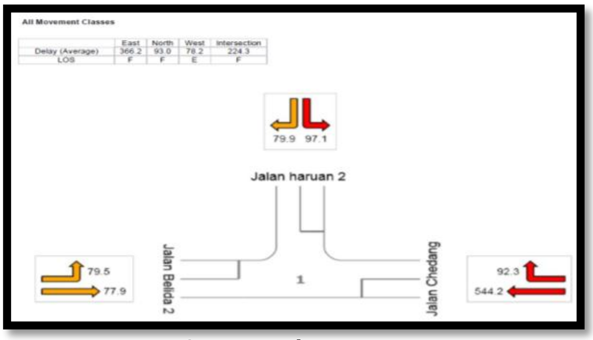
The value of delay, queue journey time and speed that obtained from practical measuring in the site shows the level of service (LOS) in the case study is **F** and driver have experienced long delay, long travel time and low speed. Figure below shows us the existing site of level of service in the studey area which is T-itersection at Bukit Chedang, Rasah Seremban. Current situation needs to undertake to improve in order to reduce the volume of traffic as well as trying to control traffic at intersections.



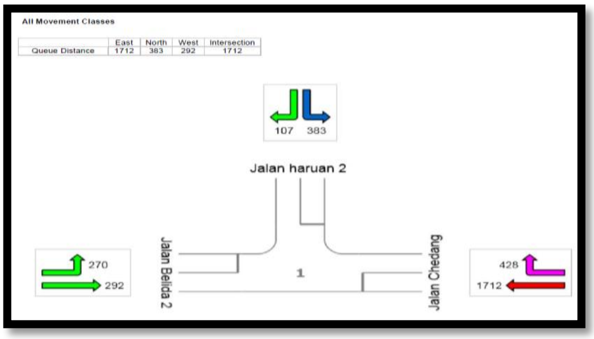
Level Of Service(LOS)



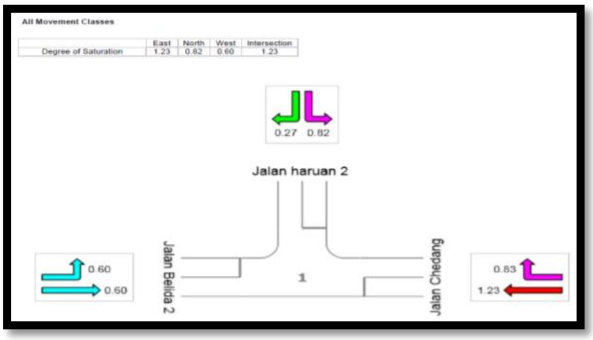
Phasing Summary



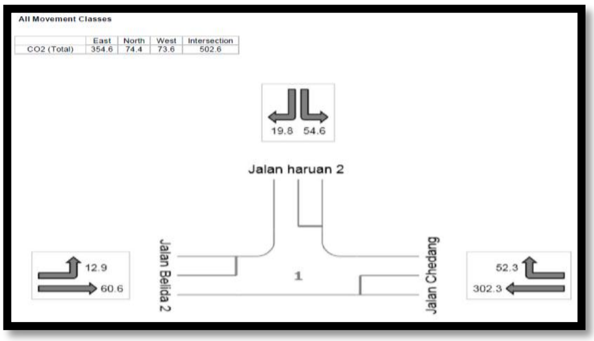
Average Delay



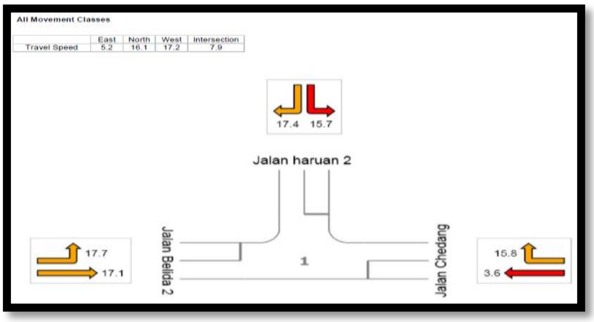
Queue Distance



Degree Of Saturation



CO_2 Total



Travel Speed

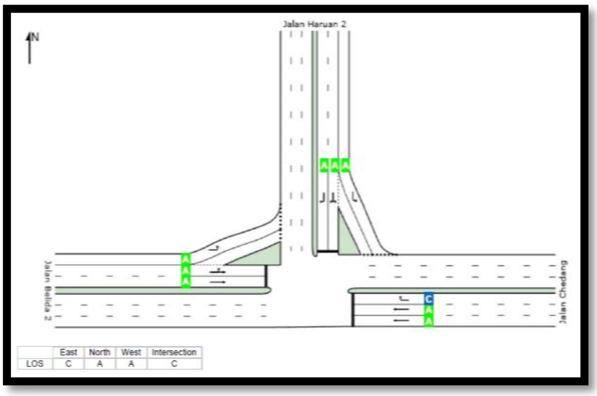
Figure 4.2: Existing condition (Before Improvement)

4.3 Result *(After improvement)*

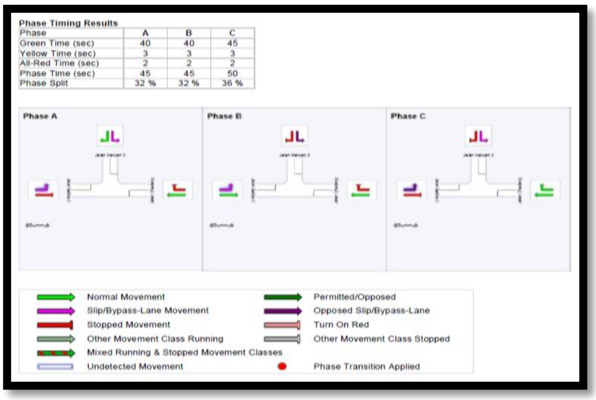
After we get the results from the study we observed that the level of service need to improvement as well. We can observed percentage dissimilarity before and after improvement. Therefore figure below shown level of service (LOS) after improvement we use a general point .

1) We have make some improvements in traffic light timing phase, but there have no significant changed.
2) Adjust a cycle time of intersection according to the volume of traffic flow at intersection , but there have no significant changed too,
3) So, we decided to make change in road alignment with the addition of slip lane to reduce the amount/volume of congestion and long queue and added new lanes to increase the capacity of intersection. This is the only solution that can be made to improve a level of services for the junction.

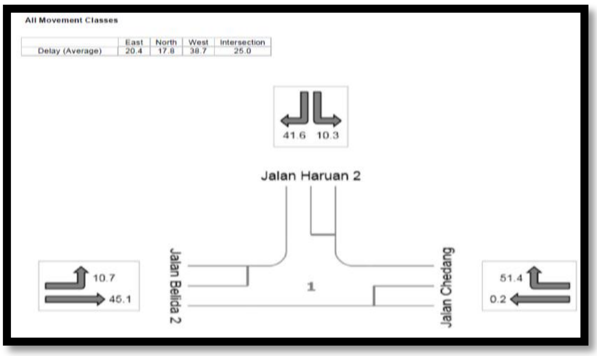
After improvement / Upgrading the result as below :



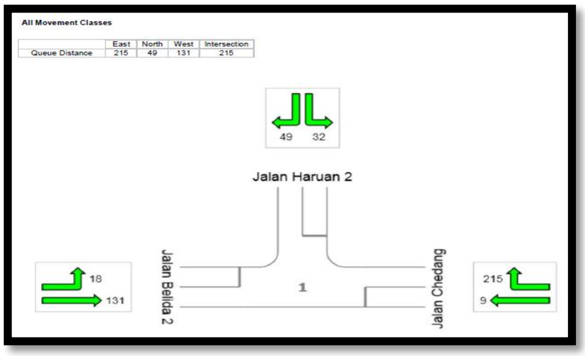
Level Of Service(LOS)



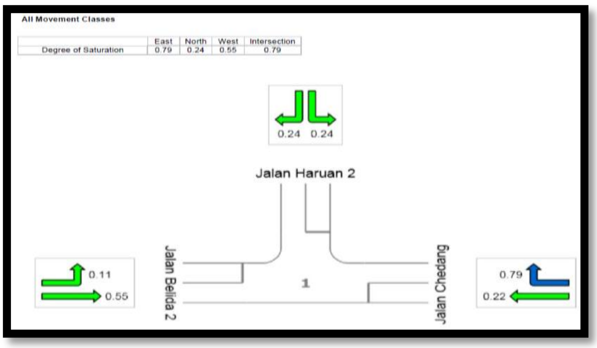
Phasing Summary



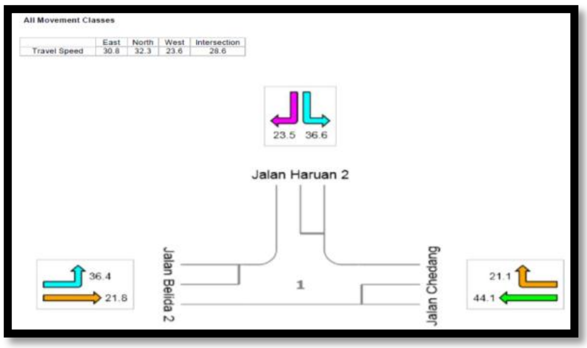
Average Delay



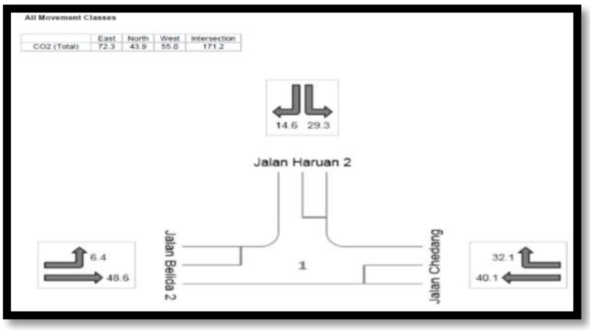
Queue Distance



Degree Of Saturation



Travel Speed



CO_2 Total

Figure 4.3: Result (After Improvement)

4.4 Intersection summary (B*efore and After*)

Intersection Performance - Hourly Values

Performance Measure	Vehicles	Persons
Demand Flows (Total)	2973 veh/h	3664 pers/h
Percent Heavy Vehicles (Demand)	5.6 %	
Degree of Saturation	1.234	
Practical Spare Capacity	-27.1 %	
Effective Intersection Capacity	2409 veh/h	
Control Delay (Total)	185.26 veh-h/h	227.30 pers-h/h
Control Delay (Average)	224.3 sec	223.3 sec
Control Delay (Worst Lane)	544.2 sec	
Control Delay (Worst Movement)	544.2 sec	544.2 sec
Geometric Delay (Average)	3.3 sec	
Stop-Line Delay (Average)	221.0 sec	
Idling Time (Average)	211.3 sec	
Intersection Level of Service (LOS)	LOS F	
95% Back of Queue - Vehicles (Worst Lane)	267.8 veh	
95% Back of Queue - Distance (Worst Lane)	1712.0 m	
Queue Storage Ratio (Worst Lane)	2.10	
Total Effective Stops	3629 veh/h	4455 pers/h
Effective Stop Rate	1.22 per veh	1.22 per pers
Proportion Queued	0.96	0.96
Performance Index	1689.0	1689.0
Travel Distance (Total)	1733.5 veh-km/h	2136.1 pers-km/h
Travel Distance (Average)	583 m	583 m
Travel Time (Total)	219.2 veh-h/h	269.1 pers-h/h
Travel Time (Average)	265.4 sec	264.4 sec
Travel Speed	7.9 km/h	7.9 km/h
Cost (Total)	6661.13 $/h	6661.13 $/h
Fuel Consumption (Total)	269.6 L/h	
Carbon Dioxide (Total)	502.6 kg/h	
Hydrocarbons (Total)	0.430 kg/h	
Carbon Monoxide (Total)	2.170 kg/h	
NOx (Total)	0.911 kg/h	

Level of Service (LOS) Method: Delay (HCM 2000).
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values

Performance Measure	Vehicles	Persons
Demand Flows (Total)	1,427,040 veh/y	1,758,816 pers/y
Delay	88,924 veh-h/y	109,106 pers-h/y
Effective Stops	1,741,736 veh/y	2,138,234 pers/y
Travel Distance	832,088 veh-km/y	1,025,341 pers-km/y
Travel Time	105,198 veh-h/y	129,154 pers-h/y
Cost	3,197,342 $/y	3,197,342 $/y
Fuel Consumption	129,408 L/y	
Carbon Dioxide	241,236 kg/y	
Hydrocarbons	206 kg/y	
Carbon Monoxide	1,042 kg/y	
NOx	437 kg/y	

Before Optimization

Intersection Performance - Hourly Values

Performance Measure	Vehicles	Persons
Demand Flows (Total)	2973 veh/h	3654 pers/h
Percent Heavy Vehicles (Demand)	5.6 %	
Degree of Saturation	0.788	
Practical Spare Capacity	14.1 %	
Effective Intersection Capacity	3771 veh/h	
Control Delay (Total)	20.67 veh-h/h	25.71 pers-h/h
Control Delay (Average)	25.0 sec	25.3 sec
Control Delay (Worst Lane)	51.4 sec	
Control Delay (Worst Movement)	51.4 sec	51.4 sec
Geometric Delay (Average)	2.4 sec	
Stop-Line Delay (Average)	22.7 sec	
Idling Time (Average)	19.7 sec	
Intersection Level of Service (LOS)	LOS C	
95% Back of Queue - Vehicles (Worst Lane)	35.8 veh	
95% Back of Queue - Distance (Worst Lane)	214.8 m	
Queue Storage Ratio (Worst Lane)	0.26	
Total Effective Stops	1620 veh/h	1994 pers/h
Effective Stop Rate	0.54 per veh	0.55 per pers
Proportion Queued	0.55	0.55
Performance Index	279.7	279.7
Travel Distance (Total)	1673.9 veh-km/h	2057.6 pers-km/h
Travel Distance (Average)	563 m	563 m
Travel Time (Total)	58.5 veh-h/h	72.2 pers-h/h
Travel Time (Average)	70.9 sec	71.1 sec
Travel Speed	28.6 km/h	28.5 km/h
Cost (Total)	1806.05 $/h	1806.05 $/h
Fuel Consumption (Total)	96.3 L/h	
Carbon Dioxide (Total)	171.2 kg/h	
Hydrocarbons (Total)	0.108 kg/h	
Carbon Monoxide (Total)	0.734 kg/h	
NOx (Total)	0.478 kg/h	

Level of Service (LOS) Method: Degree of Saturation (SIDRA METHOD).
Intersection LOS value for Vehicles is based on worst degree of saturation for any vehicle movement.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values

Performance Measure	Vehicles	Persons
Demand Flows (Total)	1,427,040 veh/y	1,754,016 pers/y
Delay	9,923 veh-h/y	12,339 pers-h/y
Effective Stops	777,367 veh/y	956,891 pers/y
Travel Distance	803,469 veh-km/y	987,659 pers-km/y
Travel Time	28,091 veh-h/y	34,661 pers-h/y
Cost	866,905 $/y	866,905 $/y
Fuel Consumption	46,217 L/y	
Carbon Dioxide	82,170 kg/y	
Hydrocarbons	52 kg/y	
Carbon Monoxide	352 kg/y	
NOx	230 kg/y	

After Optimization

Figure 4.4: Intersection summary (before and after)

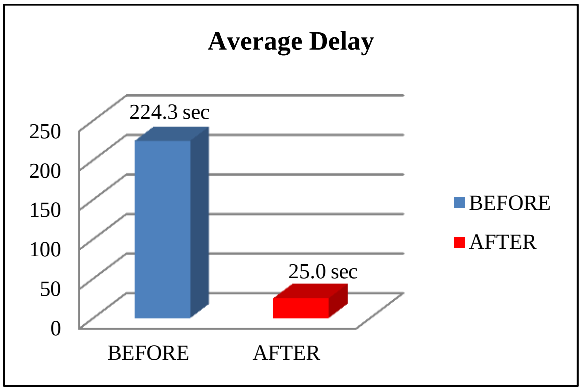
Table 4.1 : Summary of comparison result before and after improvement

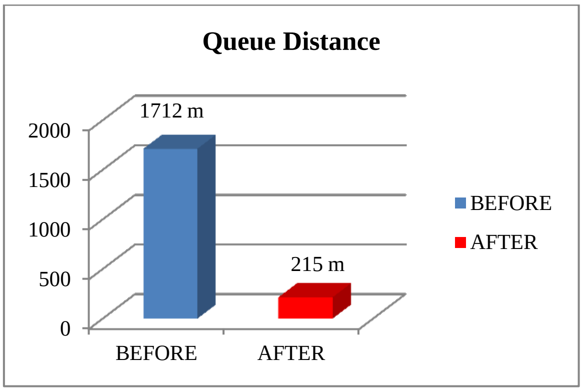
BIL	DESCRIPTION	BEFORE	AFTER	% REDUCTION
1.0	Level Of Service (LOS)	F	C	Improved
2.0	Average Delay	224.3 Sec	25.0 Sec	88.9 %
3.0	Queue Distance	1712 m	215 m	87.4 %
4.0	Degree Saturation	1.23	0.79	35.8 %
5.0	Travel Speed	7.9 Km/hr	28.6 Km/ hr	72.4 % (+)
6.0	CO2 total	502.6 L/hr	171.2 L/hr	66.0 %
7.0	Fuel cosumption total	269.6 L/hr	96.3 L/hr	64.4 %
8.0	Performance Index	1689	279.7	83.4 %

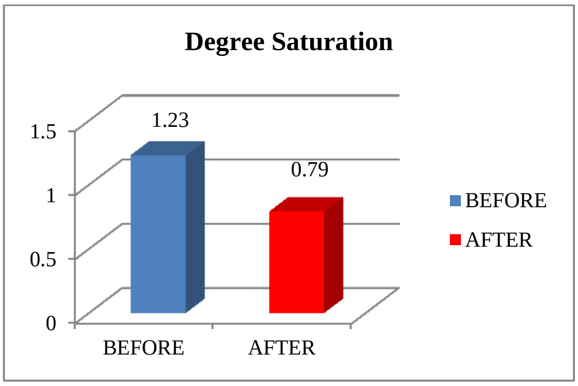
The result of reduction percentage (%) from the study before and after optimization revealed that the total travel time , total delay , total stop , level of service and CO2 total. After applying the SIDRA 6.0 software, an improvement was seen and the average delay had reduced down from **224.3 sec** to **25 sec**. The percentage of reduction was about **88.9% .** It also change the level of service (LOS) T- intersection at Bukit Chedang, Rasah Seremban from **F to C**.

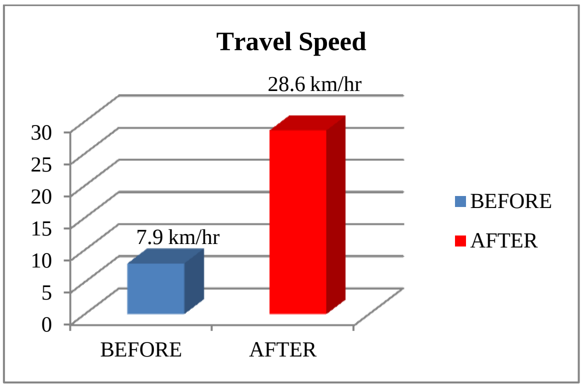
It is known that the speed on the roads is in direct correlation with traffic congestion, and also note from the Figure above that the rate of speed is very slow, but with using SIDRA software optimization, the speed on the roads managed to improve from **7.9 km/hr** to **28.6 km/hr** which is up to **72.4 %.** However the Performance index also reduce from **1689** to **279.7 (83.4%)** and the fuel consumption (total) was decrease from **269.6 L/hr to 96.3 L/hr (64.4%).**

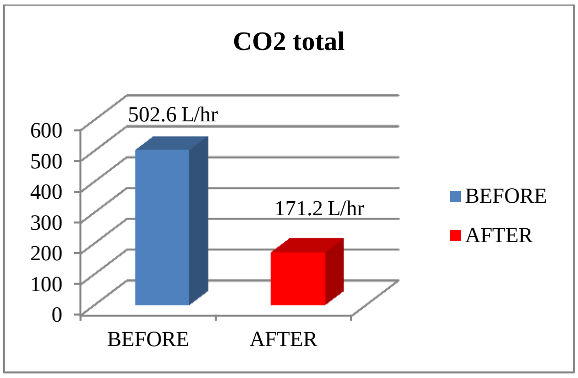
4.4.1 Comparison Graph before and after optimization

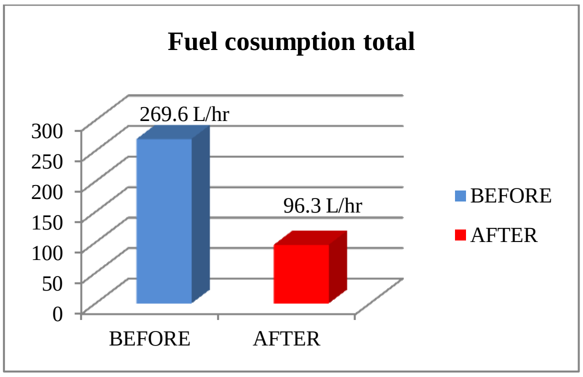












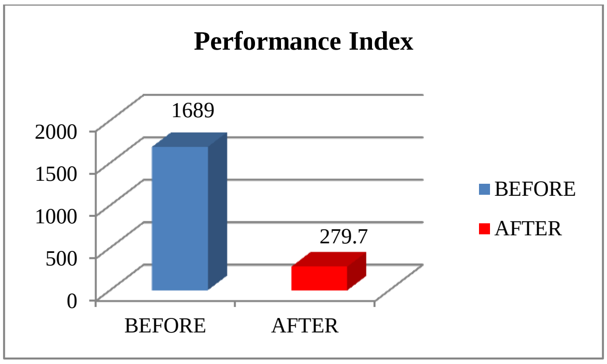


Figure 4.5: Comparison Graph before and after improvement

5.0 CONCLUSIONS AND DISCUSSION

Improvement of traffic signal coordination and timing is one of the most important strategies for increasing travel speed and reducing delays in urban areas. SIDRA 6.0 can help us to analyse and improve traffic conditions in a particular situation such as junction and roundabout. It can also help in the design of the most appropriate for a particular situation, especially in improving the Level of Services (LOS) of traffic flow. From the result and output from both of the calculation we can see a lot of changes especially on Level of Service (LOS). With addition a new lane and new slip lane at all critical lane, the total of LOS can be improve to better grade from **F to C** . By using recent version of SIDRA 6 package, it was revealed that the total delay averages, queue distance, degree saturated and CO^2 has decreased, and the system travel speed has increased, thus, a great range of reduction has been observed from the results before and after optimization of traffic flow at the intersections.

6.0 RECOMMENDATIONS FOR FUTURE

Based on the conclusions before and after optimization on derived from the study at T-Intersection Bukit Chedang , Rasah Seremban, several recommendations for future research can be drawn . There are :

a) The use of advanced control camera like CCTV camera to alleviate the congestion and the lack of any obstacles in the movement of traffic within the study area or,

b) Using a sensor as detected during congestion at road and rearrange a green time and phasing time automatic.

c) Proposed traffic control system (SCATS) which can minimise the possibility of traffic jam by controlling the formation of queues.

d) It could be useful to use software such as PARAMICS, VISSIM and HCS for the same case study and compare the results obtained from them with result of SIDRA 6.0.

e) The last recommendation is change from private transportation to public transportation to get rid of congestion and blocking traffic on the roads.

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