Recent Trends in Civil Engineering and Built Environment Vol. 2 No. 1 (2021) 215-225

RTCEBE

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

Traffic Assessment and Simulation of Jalan Raja Ashman Shah (In Front of Raja Permaisuri Bainun Hospital), Ipoh

Nursyakirin Mazlan[1], **Mohd Hanifi Othman**[1,*]

[1]Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia, Parit Raja, Johor, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rtcebe.2021.02.01.024
Received 30 January 2021; Accepted 28 April 2021; Available online 30 June 2021

Abstract: In Malaysia, traffic congestion is a common problem that often occur during rush hours that leading to adverse social, economic, and environmental issues. Ipoh, the fourth largest city in Malaysia is also not spared from experiencing traffic congestion which might happen due to high traffic volume and illegal parking along the road itself especially at the Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun Hospital). Therefore, this study was conducted to determine the speed and traffic volume at the Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun Hospital) at Ipoh town, to develop traffic simulation of the case study location using VISSIM 2020 (SP10) Student Version softwarea nd to propose a mitigation action to reduce or control the congestion issues at the Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun Hospital), Ipoh. The simulation model has been carried out to analyse the LOS of the study location during the peak hour in the morning, noon and evening. Results showed, LOS at the study location was F that cause delay during peak hour. Through observation, the congestion occurred due to the irresponsible attitude of road users who parked vehicles illegally on the side of the road and also due to the bottleneck phenomenon. From the result of the LOS of study location, an improvement had been suggested, by implemented of law enforcement to prevent illegal parking alongside of the study location, additional lane along Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun Hospital) and lastly the combination of law enforcement and lane addition. Combination of law enforcement and lane addition are selected as the suitable improvement method since LOS enhancement is much better than the other two approaches and the increased on the level of service of the study location improved to LOS C.

Keywords: Traffic Congestion, VISSIM Software, Traffic Simulation, Ipoh, Level of Service (LOS).

**Corresponding author: hanifi@uthm.edu.my*

1. Introduction

Traffic congestion is a phenomenon that happens as road usage increases, characterized by slower speeds, longer travel times and increased queuing [1]. As studied by reference [2], congestion means just waste of valuable time and the wasted time could effectively use in productive work for the future. Root causes of this congestion include accident, extreme weather, and road building. An accident can cause a road blockage or slow down traffic flow as drivers fail to understand what is happening. Similarly, when they think for their safety, poor weather will force drivers to slow down and road construction can often lead to restricted roads, allowing drivers to congest the open lanes.

Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun Hospital) was choose as the study location because there is the main hospital in Ipoh which is the main focus for patients that need to be treated in the state of Perak and also the staff who will carry out their duties every day. The road of Jalan Raja Ashman Shah in front of Ipoh hospital was used as parking because of the density of the road users. In addition, it is cause due to the shortage of parking spaces provided that allows drivers to stay on the road or park illegally, further worsening the situation. It was reported that the problem of lack of parking space at the hospital is so critical that motorists have resorted to parking illegally along Jalan Raja Ashman Shah. This situation becomes more serious when the peak time arrives in the morning when people want to go to work, and in the evening when returning from work.

From the physical observation, congestion on Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun Hospital) will cause problems to other users especially ambulances when there is an emergency and cause delays in order to save the lives and condition of the patients affected. Some of the patients also not survived due to traffic jam in which the ambulances cannot get a way to reach hospital as soon as possible [3]. In addition, traffic queues and delays are often causing problems and effected of delaying medical emergency services. Therefore, the following objective had been developed in order to reduce the traffic congestion at the study location. The first objective is to determine the speed and traffic volume at the Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun Hospital) at Ipoh town, to develop traffic simulation of the case study location using VISSIM software and to propose a mitigation action to reduce or control the congestion issues at the Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun Hospital) at Ipoh town by simulation in the VISSIM software.

2. Literature Review

In this chapter literature review was done on the basis of past studies and to achieve a better understanding regarding of the study.

2.1 Traffic Congestion

Increases in travel time, especially during peak hours, which have reached levels well above those deemed appropriate in some cities, are the most obvious consequence of congestion. The slow speed of circulation, however, is a source of exasperation and induces offensive actions in drivers [1]. According to[4], the geometric road design is more like the construction aspect of the curves, intersection designs and roadside landscape included entrance. Another factor of the traffic congestion is narrow road [5]. As example from the study that had been discovered in India, the bad condition of the pavement, non-uniform roadway characteristics in terms of carriageway and shoulder width, road invasion, abutting land usage and subsequent pedestrian activities, poor lane discipline, inappropriate position and arrangement of bus stops, vehicle with broad ranging technologies and operating conditions characteristics, traffic heterogeneity, uncontrolled on-street parking, suggest that the existence indicate that the nature and cause of congestion in India [6]. Reference [7] in his study revealed that cause of traffic congestion is poor discipline among the road user. The attitude of some drivers who are irresponsible and selfish as well as drivers who are not sufficiently trained to follow the rules of the road is an example of the attitude of drivers that allow congestion happened.

In addition, studied by reference [8] indicated that the irresponsible attitude of the driver that parked their car on street are one of the factor of traffic congestion. On parallel parking, drivers have to stop

on the middle of the road and enter the parking on reverse, this disrupts the movement of the vehicles on the road as they have to wait for the parking vehicle to enter the parking first before they can pass, this on-street parking also have been observed as causing many difficulties in many drivers [8].

The effect of congestion affecting poor traffic performance has a negative impact on economic growth, environmental health and safety by higher fuel use, higher goods and service prices, increased air emissions and worsening safety conditions [9]. People who are stuck in traffic congestion will affected the happiness because according to reference [10], people will have a good quality of life if the individuals can do anything that they are satisfied with, and live in a good environment, then they would have a good quality of life.

2.2 Traffic Modelling

A number of traffic simulation models have been developed over the past three decades, and many studies and applications have been performed using these traffic simulation models for imaginary and actual traffic operations [11]. In today's traffic research and in many traffic applications, such as traffic flow prediction, incident detection and traffic control, traffic models play an important role [12]. The aim of traffic modelling is to accurately recreate traffic as seen and measured on the street. The appearance of a traffic structure without replication was presumed by traffic modelling [13].

2.3 Type of Traffic Modelling

Driver behaviour, vehicle location, distance headways, time headways, and individual vehicle speed and acceleration are the parameters that need to be taken into consideration when modelling is implemented. Macroscopic, mesoscopic, and microscopic are the main types of traffic models. The models have been classified according to their implementation areas [13]. As indicated by reference [14], the difference between macroscopic and microscopic model is macroscopic models consider the aggregate behaviour of traffic flow while microscopic models consider the interaction of individual vehicles.In the macroscopic model, the traffic stream is represented in an aggregate measured in terms of the speed, flow and density characteristics [13]. In other hand, macroscopic do not consider car-following behaviour in detail, but instead model traffic as an aggregate fluid flow [11].

According to reference [14] in their study stated that this type of models is typically employed due to their low complexity. Confirmation data at macroscopic level need an effort because usually they consist of minute-by-minute flow records, average speeds and headings, all of which can be collected from loop statistics or traffic flow video recordings [11]. The aggregate parameters, such as average vehicle speed, density and length, are correlated at the macroscopic level with the simulation effects and field data to ensure that the overall activity is still accurately modelled. For such comparisons, statistical techniques can be used, such as regression analysis, variance analysis or time series analysis [11].

Microscopic models are often based on assumptions regarding human behaviour such as physical and psychological responses [15]. Data parameters such as flow, density, speed, travel and delay time, long queues, stops, pollution, fuel consumption and shock waves were obtained by microscopic modelling [13]. According to reference [13], the features of the microscopic modelling methods is based on the individual drivers' car-following and lane-changing simulations. Car following model as shown in Figure 1 was an idea that was understood by a driver and approached a lead vehicle at a lower speed without being able to change the lane. This behaviour can be characterized for specific groups such as intoxicated drivers, old and young drivers, and considering ethnicity and experience [14].

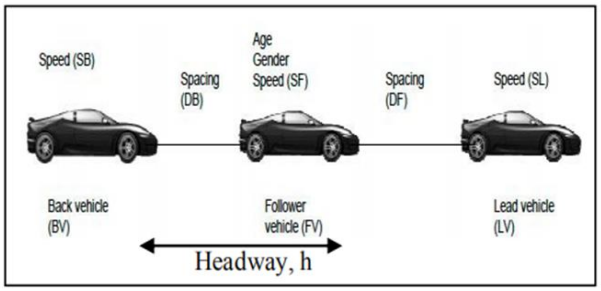

Figure 1: Car following model

At the microscopic level, the attributes of individual vehicles computed from the simulation model, such as location, time, headway, and speed, are contrasted with those obtained from field data. Generally, microscopic simulation is focused on the movement and relative time and space of individual vehicles. The closer the following vehicle is to the lead vehicle, the more sensitive the lead vehicle is to the response of the following vehicle. With speed, this sensitivity increases as well. This is because if the main car is moving at a faster speed, the speed is then decreased by the intervening vehicles. The occurrence of car platoons and traffic congestion resulted in this [13]. One of the important components of microscopic model in lane changing model. It is necessary to ensure that in these models the lane changing behaviour of drivers is recorded accurately [16].

Mesoscopic models are the combine the characteristics of microscopic and macroscopic models. These models describe the effect of nearby vehicles and then estimate the combined behaviour of temporal and spatial traffic [17].

2.4 Mitigation Action to Reduce Traffic Congestion

The first mitigation action that has been suggested by reference [18] is use of ramp metering. Ramp metering is a technique used to control the number of traffic approaching a freeway at a given time in order to maximise the activity of the freeway [19]. The effectiveness use of ramp meter has been proved by Cambridge Systematics, Inc., (2001b) on their survey. The data was collected in two situations with ramp meter and without the ramp meter at the selected area at the Twin Cities area. The result was an improvement in travel times of 22 percent and a reduction in travel speeds of 14 percent in the highway system, with a large net increase in car pollution. Indeed, the other obvious way to reduce the traffic congestion is to share a vehicle. Carpooling also appeals more to persons who drive at least 10 miles or whose journey takes 20-30 minutes [20]. Co-workers can share vehicles at work, friends who live nearby should also share the vehicle if traveling to the same destination.

The next mitigation action that can be considered to reduce traffic congestion is by using an optimization tools for the traffic light system. With rising computer technology specifications, single-board computers, software packages, platforms, and APIs (Application Program Interfaces), it has become increasingly simple for developers to install signal control systems and information systems [21]. According to reference [22], mitigation action that had been discussed in their study are by expanding road capacity. Like many of the other cities, building more roads and widening existing roads were the most commonly agreed solutions to tackle traffic congestion at the start of Hangzhou 's urbanization. However, one possible outcome is new road capability added the rapid population and vehicle growth in Hangzhou would soon counter this.

Sometimes traffic congestion becomes exaggerated due to some physical deficiencies in the road network. Such physical deficiency may be the closer of some strategically important roadway links or reduction of effective roadway width creating bottlenecks to traffic flow [23]. As studied had been done at Dhaka it is deemed important for the identification of all bottleneck points and lack of or closed network connections. Improving road network includes opening up closed roads, building missing links or widening links that create bottlenecks.

3. Methodology

The case study region that has been selected is at Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun Hospital) as shown in Figure 2-(a) and Figure 2-(b) below. According to reference [24] in their study said that Ipoh is famous as a tourist hotspot and has been greatly enhanced efforts to preserve the British colonial-era architecture.

Figure 2 (a)

Figure 2 (b)

Figure 2: Vehicle flow at the Jalan Raja Ashman Shah

Because of the location of Hospital Ipoh and the tourist attraction, Jalan Raja Ashman Shah was aimed on increasing of the vehicle volume over day and will be going more crowded and congestion problem will keep increasing. According to reference [25], there are two methods for collecting traffic volume data which is automatic and manual. Manual method of traffic volume count was used in this study in order to collect the traffic volume data because of the automatic equipment is not available, in addition the count period is less than a day. Speed of the vehicle at the study location also will be conduct using manual method via a camera as shown in Figure 3 below, scenario of spot speed manual data collection. The vehicle speed will take randomly at a selected study location, a sample size of at least 50 vehicles is obtained depend on the vehicle class.

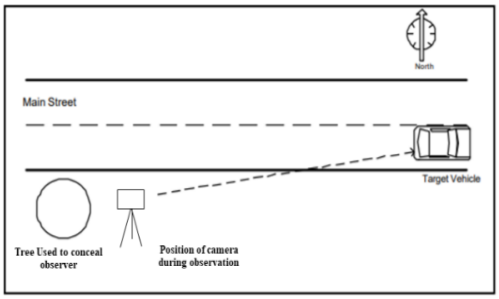

Figure 3 : Scenario of spot speed manual data collection

The volume of the vehicle at the Jalan Raja Ashman Shah are taken at the peak hour. The peak hour is determined from the observation of the first day which is on the three hours at the morning, noon and evening. Based on the observation, the peak hour was decided based on the higher data results among the three hours observation at the morning, noon and evening at Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun Hospital). The peak hour at the morning is decided between 7.00 am to 8.00 am, for the afternoon at the 1.00 pm to 2.00 pm and lastly at the evening the peak hour is between 5.00 pm to 6.00 pm. Once the data is collected and simulated from the VISSIM software, total intersection delays will be translated from the Highway Capacity Manual (HCM) to a letter grade LOS. Level of service (LOS) defined as a measurement of the operational conditions within a traffic stream, generally in terms of travel time, speed, freedom to maneuver, traffic interruptions, comfort and convenience [26]. Usually, six types of service are defined and a letter designation from A to F is assigned to each one, with LOS A reflecting the best operational conditions and LOS F being the worst. VISSIM 2020

(SP10) Student Version software is used in this study, and it is a time step and behaviour-based simulation model developed to model urban traffic and public transport operations and flows of pedestrians. The mitigation action was identified and listed for the further study and will be adapted to the case study location at Jalan Raja Ashman Shah (Infront of Raja Permaisuri Bainun) at Ipoh Town.

4. Results and Discussion

Based on the objective of the study which is to assess the physical parameter of traffic at Jalan Raja Ashman Shah at Ipoh town such as speed and traffic volume had been completed, as part of typical data analysis, the following steps can be taken into consideration. The speed of the vehicle was averaged among their classes and for vehicle class 1 is 60 km/hr, class 2 is 40 km/hr, class 3 is 40 km/hr and class 4 are 30 km/hr.

4.1 Traffic Volume Assessment

From the field observation consisting traffic volume studies that had been done for three days on the weekdays, the data of the vehicle volume at the peak hours on the morning, noon and evening of those days are analysed to achieve the first objective. The vehicle class are present based on the following classes, class 1 for motorcycle, class 2 for cars, class 3 for vans and small lorries and lastly class 4 for bus, big lorries and trucks. Figure 4-(a) below show the distribution of the number of vehicles passing through Jalan Raja Ashman Shah on the first day of observation.

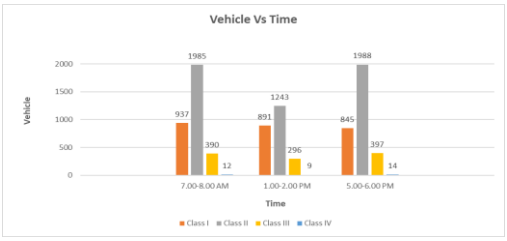

Figure 4 (a)

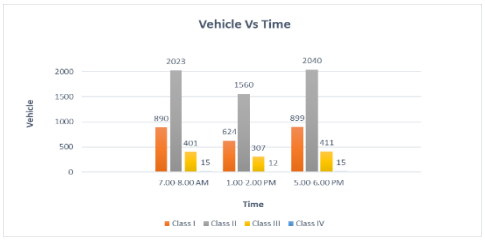

Figure 4 (b)

Figure 4 :Vehicle volume data

Total vehicle volume at the morning was 3324 which is 37 percent of the total vehicle volume of the day, while at the afternoon was 2439 or 27 percent and at the evening was 3244 or 36 percent. From this situation it showed that the total vehicle volume at the morning are the highest compared at the afternoon and evening. Class 2 vehicle which is car is leading by 58 percent of the total vehicle volume on the first day, followed by motorcycle 29 percent, 12 percent for vans and small lorries and lastly 1 percent for the bus, big lorries and truck.

On the second day, as shown in Figure 4-(b) the total vehicle passing through Jalan Raja Ashman Shah are 9197 vehicles. 36 percent on the morning, 27 percent at the afternoon and 37 percent at the evening. From this figure, conclusion can be made that car which is in class 2 are the most vehicle that are passing at the Jalan Raja Ashman Shah throughout the day by 61 percent of the total vehicle, followed by motorcycle 26 percent, 1119 vehicle on class 3 or 12 percent and lastly class 4 vehicle which is 1 percent. While Figure 4-(c) shows distribution of the vehicle volume on the third day of observation. On the third day, the total vehicle are 9015 vehicles. 37 percent on the morning, 27 percent at the afternoon and 36 percent at the evening. Vehicle in class 2 is the higher among the other three vehicle class by 61 percent, followed by 26 percent of class 1 vehicle, 12 percent of class 3 vehicle and lastly class 4 vehicle by 1 percent or 47 vehicles.

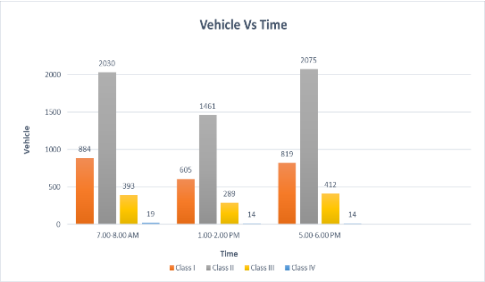

Figure 4 (c)

Based on the data that had been presented in Figure 4-(a), 4-(b) and 4-(c), from the situation, it can be concluded that the total of vehicle on the day two at the Jalan Raja Ashman Shah is the highest compared on the day one and day three by 33.9 percent, followed by day three 33.2 percent and lastly day one by 32.9 percent. From the graph illustrate above, the trend of the vehicle volume on the Jalan Raja Ashman Shah is higher in the morning between 7.00 am to 8.00 am, it is because everyone is going to work or school at the same time cause of road capacities are not enough to accept increasing of cars. Traffic congestion often occurs at peak hours in the evening as people encounter back from work. Congestion is occurred because people are driving so fast to reach their destination or home. When people drive at the high speed because of they are in hurry to come home, it is indirect effect to the movement of the vehicle on the road.

4.2 Simulation of Traffic Flow and Its LOS

Figure 5-(a) below show the case study location through google map and are simulate into the VISSIM software as illustrated in Figure 5-(b). The road scenario was simulated into the VISSIM software and the LOS of the Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun Hospital) at Ipoh Town on the morning, afternoon and evening were obtained.

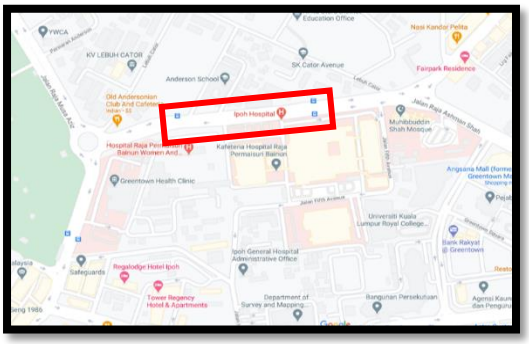

Figure 5 (a)

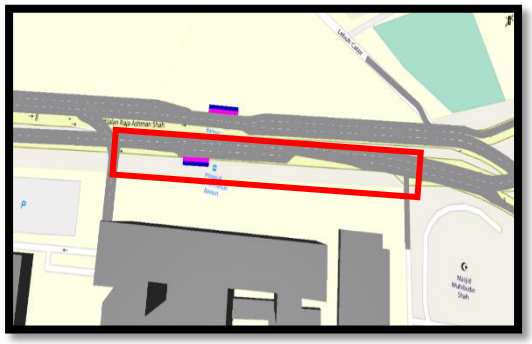

Figure 5 (b)

Figure 5: Location of case study

Figure 6-(a) shows the Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun) simulation in the peak hour at morning on 7.00 am to 8.00 am. The total vehicle volume at the morning on the first day observation was 3324, followed by 3329 and 3326 at the third day of observation. The LOS has been recorded in simulation is LOS F. LOS F is recorded due to the congested traffic conditions that occur in Jalan Raja Ashman where vehicles are rushing to catch up to their destination such as work and hospital.

LOS F also occurs due to the attitudes of consumers who park their vehicles illegally on the side of the road along Jalan Raja Ashman Shah as shown in Figure 6-(b). It is due to the lack of parking around the hospital area which is often filled by visitors who need health services by the hospital.

Figure 6 (a)

Figure 6 (b)

Figure 6: Simulation during morning

Figure 7-(a) shows the simulation of Jalan Raja Ashman Shah during afternoon. The total vehicle volume at the afternoon on the first day observation was 2439, followed by 2503 and 2369 on the third day of observation. Comparison of vehicle volume on the peak hour between morning, noon and evening it can be concluded that the congestion on the noon time is less than peak hour in the morning and followed by the evening based on the vehicle volume. It is because not everyone goes out to enjoy their break, some of them are eat around the area and walk to the restaurant. However, the LOS is still in LOS F. It is due to the narrow road that unable to accommodate the vehicle that pass at Jalan Raja Ashman Shah.

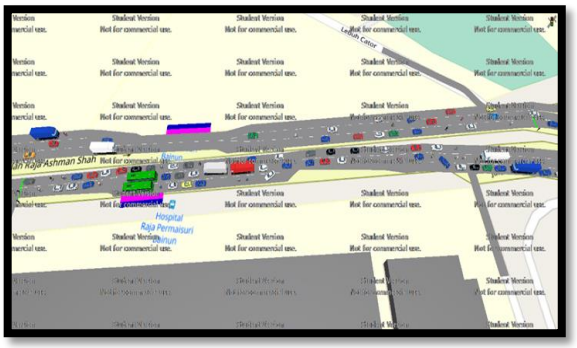

Figure 7 (a)

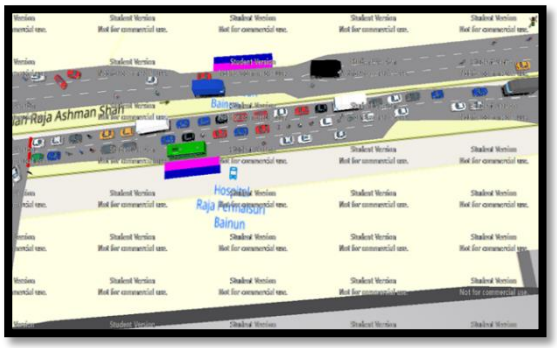

Figure 7 (b)

Figure 7: Simulation during afternoon and evening

Figure 7-(b) show the traffic simulation of Jalan Raja Ashman Shah on the evening peak hour between 5.00 pm to 6.00 pm and in the LOS F. The total vehicle volume at the evening on the first day observation was 3244, followed by 3365 and 3320 on the third day of observation. Between these hours, traffic seemed congested as people raced to get home after work. Congested in front of Hospital Raja Permaisuri Bainun is occur because of the vehicle that come from Jalan Dato Seri Ahmad Said and from Jalan Kamaruddin Isa that are pass through Jalan Raja Ashman Shah itself. To avoid traffic congestion at that time, users who do not have needs or users who only go out for their own benefit should think or plan their trip because at that time there are many vehicles.

4.4 Mitigation Action to Control or Reduce Traffic Congestion

The mitigation action in order to reduce or control the congestion issues at the Jalan Raja Ashman Shah (Infront of Raja Permaisuri Bainun Hospital) at Ipoh town are made and being modified using VISSIM software to improve the LOS at the study location. The choose method is combination of law enforcement and lane addition at the study location. Traffic conditions after being modified using the combination of law enforcement and lane addition, are shown in Figure 8-(a) and Figure 8-(b) show from the upper view along Jalan Raja Ashman Shah (In front of Raja Permaisuri Bainun Hospital). Meanwhile, the LOS was analysed after the simulation finished. LOS readings showed better improvement after combination of law enforcement and lane addition to LOS C.

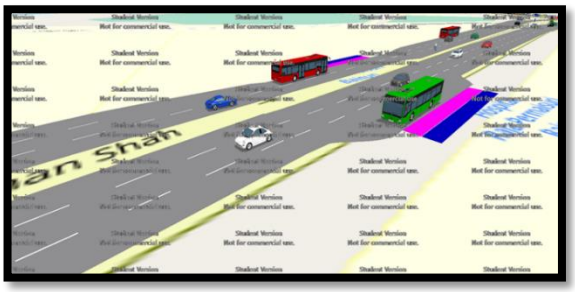

Figure 8 (a)

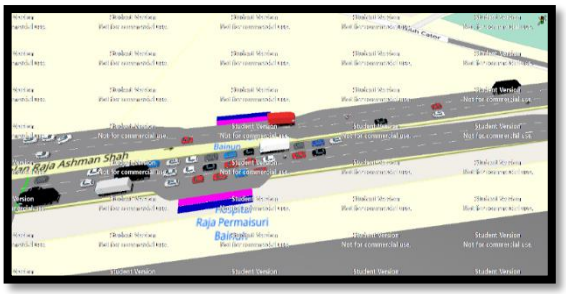

Figure 8 (b)

Figure 8: Traffic scenario conditions after being modified using the combination of law enforcement and lane addition

As indicated by reference [27] in their study at the Hangzhou, building more roads and widening existing roads, like many other cities, were the most commonly agreed methods at the start of urbanisation in Hangzhou to cope with traffic congestion. It seems possible and appropriate to provide more road space or upgrade the old road network in areas with rapid population or vehicle growth [27]. Meanwhile, the effect of illegal parking on traffic in the urban areas gives a big impact to the road users as shown in this study and this is in conformity with the studies carried out by reference [28] at the Thessaloniki City.

5. Conclusion

Combination of law enforcement and lane addition were selected in order to reduce and control the traffic congestion at the study location. This method is suggested because of the improvement of LOS is much better than the other two method. The Level of Services of this method are increased to LOS C compared to the before of the modification had been made which is LOS F.

Acknowledgement

The author extremely grateful to her supervisors, Dr Mohd Hanifi Bin Othman for his invaluable advice, continuous support, and patience during my degree study. His immense knowledge and plentiful experience have encouraged me in all the time of my final year project and daily life.The authors would also like to thank the Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] Bull, A. (2004). Traffic Congestion - The Problem and How to Deal with it? In United nations: Economic Commission for latin America and the Caribbean, Deutsche gesellschaft für Technische Zusammenarbelt (GTZ) GmbH. https://doi.org/10.1017/CBO9781107415324.004

[2] Kumar, A., & Singh, R. R. (2017). Traffic Congestion and Possible Solutions in Urban Transportation System. 630–634.

[3] Nasir, A., Chaudhry, A. G., Ahmed, A., & Shamim, F. (2015). Urban Traffic Jams, HealthEmergencies and Architectural Perspective. Pakistan Association of Anthropology, Islamabad, Pakistan Special Issue Sci.Int.(Lahore), 27(1), 611–613.

[4] Kiew, W. A. L. (2011). Perai Selatan , Pulau Pinang . Universiti Sains Malaysia.

[5] Rahane, S. K., & Saharkar, U. R. (2014). Traffic Congestion - Causes And Solutions: A Study Of Talegaon Dabhade City. Journal of Information, Knowledge and Research in Civil Engineering, 3(1), 160–163.

[6] Mohan Rao, A., & Ramachandra Rao, K. (2012). Measuring Urban Traffic Congestion – a Review. International Journal for Traffic and Transport Engineering, 2(4), 286–305. https://doi.org/10.7708/ijtte.2012.2(4).01[7]

[7] Kolawole, T. (2018). Managing traffic congestion in the Accra Central Market, Ghana. In Journal of Urban Management (Vol. 7, Issue 2). Elsevier B.V. https://doi.org/10.1016/j.jum.2018.04.002

[8] Segola, M., & Oladele, A. S. (2016). Traffic Congestion and Mobility Solutions for Francistown Road Transportation Network Systems. BIE Journal of Engineering and Applied Sciences, 6(2), 33–40.

[9] Sutandi, A. C. (2009). ITS Impact On Traffic Congestion And Environmental Quality In Large Cities In Developing Countries. Proceedings of the Eastern Asia Society for Transportation Studies, 7.\

[10] Kittipichai, W., Arsa, R., Jirapongsuwan, A., & Singhakant, C. (2015). Quality of life among Thai workers in textile dyeing factories. Global Journal of Health Science, 7(3), 274–282. https://doi.org/10.5539/gjhs.v7n3p274

[11] Wang, Y. (1996). Synopsis of Traffic Simulation Models. July 1996.

[12] Bellemans, T., De Schutter, B., De Moor, B., De, B., Bellemans, T., De Schutter, B., & De Moor, B. (2002). Models for traffic control. Journal A, 43, 3–4

[13] Nor Azlan, N. N., & Md Rohani, M. (2018). Overview of Application of Traffic Simulation Model. MATEC Web of Conferences, 150, 1–6. https://doi.org/10.1051/matecconf/201815003006

[14] Imran, W., Khan, Z. H., Aaron Gulliver, T., Khattak, K. S., & Nasir, H. (2020). A macroscopic traffic model for heterogeneous flow. Chinese Journal of Physics, 63, 419–435. https://doi.org/10.1016/j.cjph.2019.12.005

[15] Nagel, K., Wagner, P., & Woesler, R. (2003). Still flowing: Approaches to traffic flow and traffic jam modeling. Operations Research, 51(5), 681-710+837. https://doi.org/10.1287/opre.51.5.681.16755

[16] Moridpour, S., Sarvi, M., & Rose, G. (2010). Lane changing models: A critical review. Transportation Letters, 2(3), 157–173. https://doi.org/10.3328/TL.2010.02.03.157-173

[17] Jamshidnejad, A., Papamichail, I., Papageorgiou, M., & De Schutter, B. (2017). A mesoscopic integrated urban traffic flow-emission model. Transportation Research Part C: Emerging Technologies, 75, 45–83. https://doi.org/10.1016/j.trc.2016.11.024

[18] Fesler, D. H. (2013). Evaluating Traffic Congestion Mitigation Strategies.

[19] Federal Highway Administration. (2004). Mitigating Traffic Congestion - The Role of Demand-Side Strategies.

[20] Federal Highway Administration. (2014). Ramp Metering : A Proven Effective Strategy. Federal Highway Administration, September, 40–43

[21] Mishra, S., Bhattacharya, D., & Gupta, A. (2018). Congestion adaptive traffic light control and notification architecture using google maps APIs. Data, 3(4). https://doi.org/10.3390/data3040067

[22] Nilsson, J., & Markus, E. (2011). Managing Traffic Congestion - Case study of Hangzhou. May.

[23] Habib, K. N. (2014). Evaluation of Planning Options to Alleviate Traffic Congestion and Resulting Air Pollution in Dhaka City Evaluation of Planning Options to Alleviate Traffic Congestion and Resulting Air Pollution in Dhaka City by Master of Science In Civil Engineering (T. January 2007, 0–157.

[24] Abdul Rahman, N., Ghani, I., Teh, M. Z., & Ibrahim, K. A. (2020). Rethinking Urban Public Space: Physical and Functional Analysis through Visual Surveys. IOP Conference Series: Earth and Environmental Science, 409(1). https://doi.org/10.1088/1755-1315/409/1/012002

[25] Kusimo, K., & Okafor, F. (2016). Comparative Analysis of Mechanical and Manual Modes of Traffic Survey for Traffic Load Determination. Nigerian Journal of Technology, 35(2), 226. https://doi.org/10.4314/njt.v35i2.1

[26] Highway Capacity Manual (2000). Transportation Research Board, National Research Council, Washington, DC

[27] Nilsson, J., & Markus, E. (2011). Managing Traffic Congestion - Case study of Hangzhou. May.

[28] Tsakalidis, A., & Tsoleridis, P. (2015). The impacts of illegal parking on the urban areas' traffic and environmental conditions: The case of the city of Thessaloniki. Spatium, 1(33), 41–46. https://doi.org/10.2298/SPAT1533041T