

A Traffic Management System for Minimization of Intersection Traffic Congestion: Case Bengkong Junction, Batam

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ABSTRACT

Purpose: An increase in the number of vehicles that are not matched by the growth of road area is one of the causes of road Traffic congestion in Batam City. Traffic congestion occurs, especially in business and densely populated residential areas. The government has carried out various engineering and traffic management to keep the road service level under control. This study aims to analyze traffic management's efficiency in reducing Traffic congestion on roads in Batam City.

Design/methodology/approach: This study uses a case study at the Bengkong red light intersection, Batam City. The analysis was carried out using The Indonesian Highway Capacity Manual-1997.

Findings: Traffic management and engineering must be implemented gradually to get a suitable implementation model. Actual conditions in the field become essential in determining the right choice of traffic management and engineering.

Research limitations/implications: Traffic management and engineering analyzes were conducted locally at the case study site.

Practical implications: The analysis of traffic management reduces traffic congestion's impact.

Originality/value: Original paper

Paper type: A case study

Keywords: Intersection, Management System, Minimization, Traffic Congestion

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I. INTRODUCTION

Transportation is one of the means that can be a medium to connect people with certain goals. Transportation provides convenience for humans in carrying out daily activities, meeting life's needs, and interacting with humans (Balirante et al., 2020). Transportation makes people more productive because they can move from one place to another quickly, which has an impact on time efficiency. Transportation has become the lifeblood of human life in terms of politics, economy, society, culture, and defense and security (Rifai, Thalib, et al., 2022). Transportation, in general, serves as a means that can accelerate the achievement of objectives to support the economic growth of a region and as a unifying region within the Unitary State of the Republic of Indonesia (Manihuruk et al., 2022).

Transportation, which consists of land, sea, and air transportation, also carries out essential public service functions on a domestic and international scale. One part of transportation is island transportation. Motorized vehicles are a necessary means of land transportation. The number of motorized vehicles is increasing every year, this shows that people are increasingly in need of transportation facilities along with the increase in population (Andiyan & Rachmat, 2021).

Batam City is a city that is heading towards the form of a Metropolitan City to develop into an Industrial City. Especially Batam, one of the cities that became a Free Trade Area. The city of Batam, in its development, is getting more and more crowded, especially before the hours when people go to work or school. Based on data submitted by the Police Office of Riau Archipelago mentioned that every year from 2007 to November 2010, two-wheeled and four-wheeled vehicles increased by about 12 thousand units. This means that every month there are 600 new vehicles registered with Samsat or about 30 units per day. The total number of motorized vehicles circulating from 2007 to November 2010 and registered with Samsat reached around 236,000 units. Meanwhile, the population growth rate of Batam city from year to year always increases sharply. Batam in Figures data released by the Central Statistics Agency in 2010 shows that population growth from 2005 to 2009 increased significantly (Sama et al., 2022).

The number of queues at several intersection points in a plot in Batam City triggers traffic congestion on the highway. This is followed by the number of heavy vehicles that are not running in their lane and the number of public transportation that picks up and drops passengers out of place. the roadside is a prominent peak of traffic congestion. This is considering the service from the road infrastructure itself is still not balanced when viewed from the development of the number of vehicle passengers in the city of Batam (Salsabila & Nurwati, 2020). These symptoms must be observed so as not to worsen with preventive measures. It can be added that most people lack discipline, arbitrariness, and irregularity in parking their vehicles (Rifai, Putra, et al., 2022).

Roundabout control is generally used in urban and out-of-town areas. The traffic scheme at the roundabout is that traffic already at the roundabout takes precedence, so vehicles that will enter the roundabout must allow traffic already at the roundabout first. The roundabout function is to parse the Traffic congestion that occurs on a road segment (Hasibuan & Muttaqin, 2021). The greater the traffic volume at an intersection, the larger the traffic circle required to reduce traffic congestion. The capacity of the roundabout under field traffic conditions. The Bengkong Harapan intersection, located in Batu Aji, Batam City, Riau Islands, is a government project to improve transportation infrastructure. This is done due to the increasing volume of population and vehicles in Batam City. According to the Batam City Central Statistics Agency, the population volume in the city of Batam itself in 2019 was 1,076,009 people in the 2020 population census, the population in the city of Batam increased to 1,196,296 people (Alvin & Sani, 2019).

Transportation is an effective means of supporting the success of development, especially in supporting community economic activities (Mufhidin et al., 2022). Smooth transportation conditions can improve population mobility services and other sources of economic growth. In addition, the smooth flow of traffic reflects the order and regularity of road users. However, on various occasions and in fact there is a tendency for the emergence of transportation problems that often accompany the development of a city (Andini & Akbar, 2020). However, the transportation problem that often occurs is traffic congestion. Traffic congestion can cause road users to feel stressed, the economy's pace is hampered, and much time is wasted. One of the steps that can be taken in overcoming the problem of Traffic congestion is to identify roads which include road capacity, traffic volume, and degree of saturation. Of course, specific methods are used to identify roads to make the results more accurate and precise (Qori'atanadya et al., 2020).

The purpose of this study was to determine whether the Bengkong Harapan Roundabout was effective against the traffic situation in the area. A traffic survey is carried out to determine the number of vehicles that pass through the road segment. The analysis carried out is the road capacity, traffic volume, and degree of saturation. From the research conducted, the value of the degree of saturation. Furthermore, it will be obtained to determine whether the segment has classified effectiveness. This research can be used as a reference to improve transportation performance.

II. LITERATURE REVIEW

A. Traffic Management

The roundabout is one type of intersection control that is generally used in urban and out-of-town areas. The traffic scheme at roundabouts is that traffic already at the roundabout takes precedence, so vehicles that will enter the roundabout must give the traffic already at the roundabout an opportunity first. The function of the roundabout is to break down Traffic congestion that occurs on a road segment. The greater the traffic volume at an intersection, the larger the traffic circle needed to reduce the traffic density (Fatimah, 2020).

Traffic impact analysis is a study whose results are stated in the form of reports and notes on field point observation activities on traffic management impacts on central development, it is relevant that any changes in land use will also cause changes in the transportation system (Safiullin et al., 2020). With incremental reliability, it can be possible to calculate how many trips the new traffic management and engineering generation will require to overcome their impact (Sidiq et al., 2022). Road traffic engineering and management

is a traffic planning technique applied directly in the field and is usually short-term. This will involve traffic conditions and supporting vehicles, both now and in the future (Vreeswijk et al., 2020).

The capacity of the roundabout in field traffic conditions is determined by the relationship between vehicle movement and surrounding conditions. For example, the traffic at the Bengkong Harapan intersection shows a decrease in Purba (2018). This is presumably due to the increasing volume of vehicles due to the increasing population in Batam City. Furthermore, in the population census in 2020, the population in Batam City increased to 1,196,296 inhabitants.

B. Intersection

Transportation is an essential means of supporting the success of development, especially in supporting community economic activities (Isradi et al., 2021). Smooth transportation conditions can improve population mobility services and other resources that can support economic growth. In addition, the smooth flow of traffic reflects the order and obedience of road users. However, on various occasions and in reality, a city's development is often followed by the emergence of transportation problems (Rokhman et al., 2022). The transportation problem that often occurs is traffic congestion. Traffic congestion occurs because the available road capacity is not proportional to the volume of passing vehicles. The accumulation of vehicles is often caused by people preferring to use private vehicles as a facility to travel compared to using public transportation and the lack of adequate infrastructure (Wadu et al., 2018).

Traffic conditions at unsignalized intersections in several cities in Indonesia are highly dependent on the conditions of each location. For example, if the intersection enters peak hours, it will cause traffic flow conflicts. Therefore the stagnation phase will start again due to delays and queues that make the intersection performance system weak due to conflict and do not receive attention from the local government (Wibisono et al., 2022).

There are other results from the traffic impact analysis, one of the requirements for developers to obtain permits from the government and local governments. A consulting firm with certified experts carries out traffic impact analysis. The authorized road traffic management agency must approve the results of the traffic impact analysis. Other regulations regarding the performance of traffic impact analysis are regulated by government regulations (Shepelev et al., 2020). In PP No. 32/2011 on Management and Engineering, Impact Analysis, and Traffic Demand Management, Traffic impact analysis is a series of research activities related to traffic impacts from the construction of activity centers, settlements, and infrastructure, the results of which are presented as traffic impact analysis. Inventory and analyze the impact of traffic to determine the impact of traffic on the planned development of activity centers, settlements, and infrastructure that affect road traffic safety, security, order, and circulation (Rismahayani, 2016).

C. Traffic Congestion

Congestion can be defined as a process that cannot work correctly, stutters, lingers, stalls, or is not smooth. Traffic congestion is a problem that occurs due to population growth and density, so the flow of vehicles moves very slowly. As a result, traffic congestion always occurs and makes Bandung City traffic very uncomfortable for motorists and the surrounding community. Another factor causing congestion is the number of public transportation or online motorcycle taxis that often stop carelessly, enter and exit the parking area, and the flow of vehicles crossing at intersections without traffic lights. This problem was slightly unravelled by the presence of someone who volunteered to manage the streets to keep traffic in order. However, in reality, it did not significantly affect the congestion problem at that location.

Traffic congestion can cause road users to feel stressed, the economy's pace is hampered, and much time is wasted. In dealing with Traffic congestion problems, one of the steps that can be taken is to identify roads, including road capacity, traffic volume, and degree of saturation. Of course, a specific method is used to identify a road so that the results are more accurate, precise, and efficient (Gorodokin et al., 2020). A public road is designated and used for public traffic with residents around the area building road barriers such as unloading cargo, unloading pairs, establishing speed bumps on roads, and having many time delays in roads that have an impact on the effectiveness of development. roads (Azizah et al., 2022).

III. METHOD

The research carried out in the Bengkong Harapan intersection, Batam City. The field observation survey was carried out on Sunday, July 31, 2022, from 16.00 to 17.00 WIB, which coincided with the busy road hours. The survey was carried out using a vehicle registration manual, after which the author tabulated the data from paper scribbles and changed it using Microsoft Excel. Later it would be converted to a visual graph for easy translation of the material in the results and discussion.

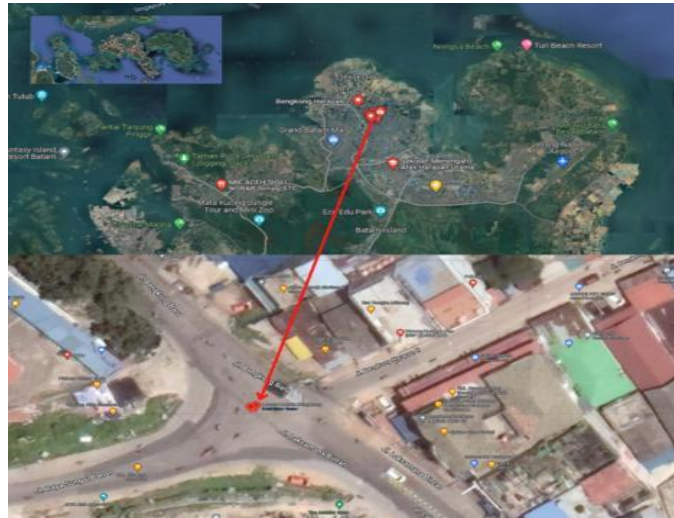


Figure 1. The research location

A. Road Capacity Analysis

Road capacity analysis itself is a series of procedures used in estimating the capacity of road segments to traffic flow under certain operational conditions, this analysis is applied to roads with development and development purposes and uses a case study of the Bengkong Harapan intersection. Road capacity is the ability of a road segment to accommodate the ideal traffic flow or volume in a certain time unit, which is expressed in the number of vehicles that pass a certain road segment in one hour (PCU/hour). This road capacity analysis is calculated using the formula in Indonesian Highway Capacity Manual-1997 (MKJI) as follows:

$$C = C_o \times FC_w \times FC_{sp} \times FC_{sf} \times FC_{cs}$$

- a. C_o : Basic capacity (PCU/hour). The surveyed road is a road divided into 2 lanes and 4 lanes, so the C_o value for one lane is 1650.
- b. FC_w : Road width adjustment factor. The effective traffic lane width is 7.5 m. One lane is 3.75 m, so FC_w is 1.04.
- c. FC_{sp} : Directional separator adjustment factor. The adjustment factor for the directional separator capacity here is taken from 50-50, so the FC_{sp} is 1.00.
- d. FC_{sf} : Adjustment factor for side barriers and curbs. Roads with a shoulder width of less than or equal to 1.0 or an effective shoulder width of 0.95 and a moderate side barrier class are categorized as moderate because the area under consideration is an industrial area with many shops on the side of the road. Then the FC_{sf} value is 0.95.
- e. FC_{cs} : City size adjustment factor. According to data from the Central Statistics Agency in 2020, the population of Batam is 1,196,296 people, so FC_{cs} is 1.00.
- f. Based on the MKJI 1997 to calculate road capacity with two-lane and four-lane roads, the analysis is carried out separately for each traffic direction, as if each direction is a separate direction.

B. Road Analysis

Traffic volume is the number of vehicles that pass a certain point or line on a road cross-section. The analysis of the road in this case study is the intersection of Bengkong expectations, and the results of this traffic volume analysis can then be used to calculate the degree of saturation. In the traffic volume analysis, the survey data obtained at the study site are classified as follows:

- a. Light Vehicles (LV) is the classification of 4-wheeled motorized vehicles (cross-sectional cars).
- b. Heavy Vehicle (HV) is the classification of motorized vehicles with more than four wheels (Bus, 2 Axle Truck, 3 Axle Truck, and suitable combination)
- c. Motorcycle / Motorcycle (MC), Classification of 2-wheeled motorized vehicles. Meanwhile, non-motorized vehicles (bicycles, tricycles, and strollers) and pedestrians are not included in the classification but are categorized as side barriers.

To equate various types of vehicles operating on a road segment into one type of vehicle, namely passenger cars, a correction factor or passenger car equivalent factor (EMP) is used. The MKJI 1997 has determined the correction factor values for various types of motorized vehicle groups.

Table1. Passenger cars on urban roads

Road Type	Traffic Flow	EMP	
		HV	MC
One Way Street and Street	Total Two Way		
Divided	(PCU)		
Two lanes one way (2/1) And	0	1.3	0.4
Four divided lanes (4/2 D)	1050		
Three lanes one way (3/1) And	0	1.3	0.4
Six divided lanes (6/2D)	1100	1.2	0.25

Source : (MKJI, 1997)

From the correction factor values obtained, the traffic volume for each classification (LV, HV, and MC) can then be calculated by multiplying the number of vehicles obtained during the survey by the correction factor. However, the total traffic flow volume is obtained by adding up all vehicle classifications (LV, HV, and MC) after considering the correction factor.

C. Saturation Degree Analysis

The degree of saturation (DS) is the ratio of road current to the capacity of a road, which is used as the main factor in determining the level of road performance. The value of the degree of saturation is influenced by several factors, including the width of the approach, the road's median, the city's size, and the turn ratio. The degree of saturation can be calculated by comparing the traffic volume (V) with the road capacity (C). The value of the degree of saturation is theoretically between 0 to 1. If the value is close to 1, the road conditions are close to saturation. Meanwhile, if the degree of saturation is far from the value of 1, then the road condition is not saturated.

D. Level of Service

Level Of Service (LoS) is a measure used to measure the quality of a road segment in serving the traffic flow that is passed is a description of the perceived condition of freedom of movement, terminology of speed, comfort in commuting, travel time, and safety to know that road volume and speed are an important aspect in determining the level of road service, as for the formula for calculating the level of road service according to Mintonogo et al. (2016)as follows:

$$LOS = \frac{v}{c}$$

The LoS formula for service quality is only used with the letters A to F which are listed in descending order of the level of service from the best to the worst.

IV. RESULTS AND DISCUSSION

The location of the study carried out in this research is at the intersection of four Bengkong Harapan (Simpang Empat Bengkong), and the analysis carried out in this study is to calculate the level of road capacity, analysis of intersection roads, analysis of the level of saturation and analysis of Level of Services on current flow. then cross the Bengkong Harapan intersection from the direction of Bengkong Maritime to Bengkong

Harapan and Bengkong Harapan to Bengkong Maritime to obtain the value of the analysis results whose reliability level is not in doubt.

The value of the degree of saturation is theoretically between 0 to 1. This means that if the value is close to 1, the road conditions are close to saturation. Meanwhile, if the degree of saturation is far from the value of 1, then the road condition is not saturated. The analysis carried out in this study is to calculate the volume of traffic flow in Bengkong. So from this analysis, the degree of saturation (DS) will be obtained.



Figure 2. The survey activity

A. Road Capacity

Road capacity is used to determine the ability of road segments to accommodate traffic flows or volumes. Road Capacity from Bengkong Harapan to Bengkong Harapan The road capacity from Bengkong to Bengkong with 2 lanes is as follows:

<i>Line I</i>	<i>Line II</i>	<i>Total Road Capacity</i>
$C = 1650 \times 1.04 \times 1.00 \times 0.95 \times 1.00$	$C = 1650 \times 1.04 \times 1.00 \times 0.95 \times 1.00$	$C = 1630.23 + 1630.23$
$C = 1630.23$	$C = 1630.23$	$C = 3260.46 \text{ smp/hour}$

Based on the above calculation, the total capacity of the road to Bengkong is 3260.46 PCU/hour. This value indicates that the road to Bengkong is effective based on the 1997 Indonesian Road Capacity Manual (MKJI). Road Capacity from Bengkong Harapan to Bengkong Harapan. The road capacity from Bengkong to Bengkong with two lanes is as follows:

<i>Line I</i>	<i>Line II</i>	<i>Total Road Capacity</i>
$C = 1650 \times 1.04 \times 1.00 \times 0.95 \times 1.00$	$C = 1650 \times 1.04 \times 1.00 \times 0.95 \times 1.00$	$C = 1630.23 + 1630.23$
$C = 1630.23$	$C = 1630.23$	$C = 3260.46 \text{ smp/hour}$

Based on the above calculation, the total capacity of the road to Bengkong is 3260.46 PCU/hour. This value indicates that the road to Bengkong is effective based on the MKJI 1997.

B. Traffic Volume

The volume of traffic flow is the number of vehicles that pass a road to be studied, where the data included is the volume of traffic which is calculated every hour. The volume of traffic flow is calculated based on the traffic flow of Bengkong Harapan area. The following is data on the number of vehicles passing through Bengkong Harapan to another area, which was obtained during the survey.

Table 2. Number of vehicle

<i>Time</i>	<i>Motorcycles (MC)</i>	<i>4 Wheel Vehicles (LV)</i>	<i>City Transport (LV)</i>	<i>Trucks/ Similar (HV)</i>
<i>17:00-17:15</i>	<i>580</i>	<i>241</i>	<i>19</i>	<i>23</i>
<i>17:15-17:30</i>	<i>617</i>	<i>273</i>	<i>30</i>	<i>26</i>
<i>17:30-17:45</i>	<i>591</i>	<i>255</i>	<i>23</i>	<i>19</i>
<i>17:45-18:00</i>	<i>566</i>	<i>233</i>	<i>18</i>	<i>16</i>
<i>Amount</i>	<i>2354</i>	<i>1002</i>	<i>90</i>	<i>84</i>

Based on Table 2. the above can be illustrated by the following graph.

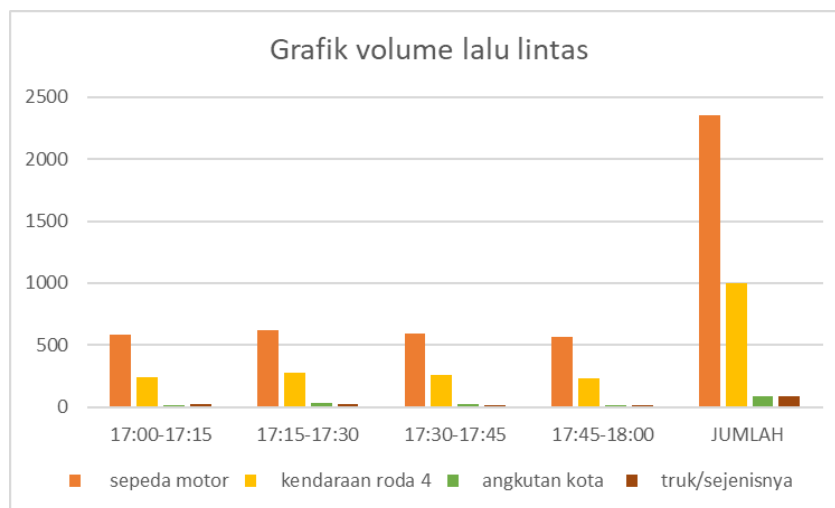


Figure 3. Survey data on the number of vehicles from Bengkong Harapan

It can be seen from the graph above that the traffic flow from Bengkong Harapan is dominated by motorized vehicles with a total of 2354 vehicles, followed by 4-wheeled vehicles with a total of 1002 vehicles, then city transportation with a total of 90 vehicles, and finally trucks. / and the like for a total of 84 vehicles. According to MKJI 1997, the vehicle correction factor is $LV = 1$, $HV = 1.3$ and $MC = 0.5$.

Traffic composition affects the flow velocity relationship if flow and capacity are expressed in vehicles/hour, i.e., depending on the ratio of motorbikes or heavy vehicles to traffic flow. However, if the flow and capacity are expressed in units of passenger cars (PCU), then the speed and capacity of light vehicles (PCU/hour) are not affected by traffic composition.

In the manual, the value of traffic flow (Q) reflects traffic composition, by expressing the flow in units of passenger cars (PCU). All traffic flow values, (per direction and total) are converted into passenger car units (PCU) using passenger car equivalence derived empirically for the following vehicle types:

- Light vehicles (LV), including passenger cars, minibusses, pick-ups, small trucks, and jeeps. In general, all 4-wheeled vehicles including small trucks.
- Motorcycle (MC) is a 2-wheeled vehicle.
- The effect of non-motorized vehicles is included as a separate event in the side drag adjustment factor. The passenger car equivalent (EMP) for each type of vehicle depends on the type of road and the total traffic flow expressed in vehicles/hour.

- d. Passenger car equivalent is a factor that shows differences in vehicle types compared to light vehicles in terms of its effect on the speed of light vehicles in traffic flow (for passenger cars and light vehicles with the same side, EMP = 1.0). A Passenger Car Unit (PCU) is a traffic flow unit where the flow of various types of vehicles is converted into light vehicle traffic (including passenger cars) using the equivalent of a passenger car (EMP). They can be calculated traffic volume based on the data obtained, as shown in Table 3.

Table 3. vehicle correction factor

<i>Correction Factor</i>	<i>Information</i>	<i>Calculation</i>	<i>Results</i>
<i>LV (x 1)</i>	<i>(Light Vehicles)</i>	$(1002 + 90) \times 1$	<i>1092</i>
<i>HV (x 1.3)</i>	<i>(heavy vehicles)</i>	84×1.3	<i>109.2</i>
<i>MC (x 0.5)</i>	<i>(Motorcycle)</i>	2354×0.5	<i>1177</i>
	<i>Total</i>		<i>2378.2</i>

$$Q_{total} = LV + HV + MC$$

$$= 1092 + 109.2 + 1177 = 2378.2 \text{ SMP/hour}$$

Based on Table 3. above, the traffic volume in Bengkong Harapan to Bengkong Harapan is 2378.2 pcu/hour. Traffic Volume from Bengkong Harapan to Bengkong Harapan The following is data on the number of vehicles passing through Bengkong Harapan to Bengkong Harapan, which was obtained during the survey.

Table 4. Number of vehicles to Bengkong Harapan

<i>Time</i>	<i>Motorcycles (MC)</i>	<i>4 Wheel Vehicles (LV)</i>	<i>City Transport (LV)</i>	<i>Trucks/ Similar (HV)</i>
<i>17:00-17:15</i>	<i>796</i>	<i>397</i>	<i>21</i>	<i>34</i>
<i>17:15-17:30</i>	<i>884</i>	<i>424</i>	<i>26</i>	<i>39</i>
<i>17:30-17:45</i>	<i>813</i>	<i>411</i>	<i>23</i>	<i>37</i>
<i>17:45-18:00</i>	<i>783</i>	<i>380</i>	<i>17</i>	<i>30</i>
<i>Amount</i>	<i>3276</i>	<i>1612</i>	<i>87</i>	<i>140</i>

It can be seen from the graph above that the traffic flow from Bengkong Harapan to Bengkong Harapan is dominated by motorized vehicles with a total of 3276 vehicles, followed by 4-wheeled vehicles with a total of 1612 vehicles, then city transportation. With a total of 140 vehicles, and the last one is trucks. /similar to a total of 87 vehicles. According to MKJI, the vehicle correction factor is LV = 1, HV = 1.3 and MC = 0.5.

Traffic composition affects the flow velocity relationship if flow and capacity are expressed in vehicles/hour, ie depending on the ratio of motorbikes or heavy vehicles to traffic flow. If the flow and capacity are expressed in units of passenger cars (PCU), then the speed and capacity of light vehicles (PCU/hour) are not affected by traffic composition. In the manual, the value of traffic flow (Q) reflects the traffic composition by expressing the flow in units of passenger cars (PCU). All traffic flow values (per direction and total) are converted into passenger car units (PCU) using passenger car equivalence derived empirically for the following vehicle types:

- a. Light vehicles (LV), including passenger cars, minibusses, pickups, small trucks, and jeeps. In general, all 4-wheeled vehicles including small trucks.
- b. A motorcycle (MC), is a 2-wheeled vehicle.
- c. The effect of non-motorized vehicles is included as a separate event in the side drag adjustment factor. The passenger car equivalent (emp) for each type of vehicle depends on the type of road and the total traffic flow expressed in vehicles/hour.
- d. Passenger car equivalent is a factor that shows differences in vehicle types compared to light vehicles in terms of its effect on the speed of light vehicles in traffic flow (for passenger cars and light vehicles with the same side, emp = 1.0). A passenger Car Unit (PCU) is a traffic flow unit where the flow of various types of vehicles is converted into light vehicle traffic (including passenger cars) using the equivalent of a passenger car (emp). The traffic volume can be calculated based on the data obtained, as shown in Table 5.

Table 5. Vehicle Correction Factor

<i>Correction Factor</i>	<i>Information</i>	<i>Calculation</i>	<i>Results</i>
<i>LV (x 1)</i>	<i>(Light Vehicles)</i>	$(1612 + 87) \times 1$	<i>1699</i>
<i>HV (x 1.3)</i>	<i>(heavy vehicles)</i>	140×1.3	<i>182.1</i>
<i>MC (x 0.5)</i>	<i>(Motorcycle)</i>	3276×0.5	<i>1,638</i>
	<i>Total</i>		<i>1882.7</i>

$$Q_{total} = LV + HV + MC$$

$$= 1699 + 182.1 + 1638 = 1882.7 \text{ SMP/hour}$$

Based on Table 5 above, the traffic volume in Bengkong Harapan to Bengkong Harapan is 1882.7 PCU/hour.

C. Degree of Saturation

The degree of saturation analysis is used to determine the level of saturation of a road segment. Theoretically, the degree of saturation ranges from 0 to 1, which means that if the value is close to 1, the road conditions are close to saturation. The degree of saturation of the road from Bengkong Maritime to Bengkong Harapan. The analysis found that the road capacity from Bengkong Harapan to Bengkong Harapan is 3260.46 PCU/hour and has a traffic volume of 2378.2 PCU/hour. Then the degree of saturation can be calculated as follows:

Table 6. Degree saturation with V/C Bengkong Maritim

<i>DS</i>	<i>V/C</i>
	$2378.2/3260.46$
<i>Total</i>	<i>0.72</i>

From the calculation analysis above, the degree of saturation is 0.72. This value is below the maximum threshold set by the 1997 Indonesian Road Capacity Manual (MKJI), which is 0.75. This is the threshold value set by the 1997 MKJI based on the classification system in the 1997 MKJI, which means that the road from Bengkong Harapan to Bengkong Maritim is considered adequate.

Degree of road saturation from Bengkong Harapan to Bengkong Maritim, it was found that the capacity of the road from Bengkong Harapan to Bengkong Harapan is 3260.46 PCU/hour and has a traffic volume of 1882.7 PCU/hour. Then the degree of saturation can be calculated as follows:

Table 7. Degree saturation V/C Bengkong Harapan

<i>DS</i>	<i>V/C</i>
	1882.7 / 3260.46
<i>Total</i>	0.57

From the calculation analysis above, the degree of saturation is 0.57. This value is below the maximum threshold set MKJI 1997, which is 0.75. This is the threshold value set by the MKJI 1997 based on the classification system in the 1997 MKJI, which means that the road from Bengkong Harapan to Bengkong Harapan is considered adequate. This means that the road around the Bengkong intersection roundabout is adequate for at least the next five years. This is based on data from the Statistic Bureau, where Batam City's population growth is relatively stable yearly.

D. Level Of Service (LoS)

Level of Service (LoS) is a metric used to measure the quality of a road segment in serving traffic flow. That road volume and speed are essential aspects in determining service levels, as is the formula for calculating service levels

Table 8. Level of services

<i>Level of services</i>	<i>Ratio (V/C)</i>	<i>Characteristics</i>
<i>A</i>	<i>< 0.60</i>	<i>With free flow, low volume, and high speed, the driver can choose the desired speed</i>
<i>B</i>	<i>0.70 < V/C < 0.80</i>	<i>Stable flow, and speed can be controlled by traffic</i>

In determining the LoS, the author calculates the point of motion at the Bengkong Harapan intersection at the LoS level in severe operational traffic conditions with a perception of the terminology point of view between speed and road volume measured by 0.72 or B and in the volume of the road from Bengkong Harapan to Bengkong Maritime of 0.60 or A. The calculation of the level of service is estimated at the flow of stagnant Traffic congestion at the Bengkong Harapan intersection. Based on this qualitative data, it is stated that the estimated traffic level. The LoS operating conditions by measuring the traffic volume unit (V) with the vehicle unit (SMP) at the intersection of the four-segment intersection with the passenger vehicle equivalency factor (EMP).

E. Strategy Optimization and Traffic Management

The strategies and traffic management techniques that can be designed from the results of the observation of traffic problems at the Bengkong Harapan Intersection are to limit the number of motorized vehicles that take the right of the morning sidewalk for pedestrians according to their functions and uses, while the strategies to be designed and implemented are: clearing the lane pedestrians from the illegal parking of two-wheeled vehicles; provide stringent sanctions for perpetrators of traffic violations; provide parking facilities that are more likely to reduce the number of illegal parking actions on the shoulder of the road.

In the implementation method stage, the strategy implementation design and also the techniques to be applied are related to the rules that have been described previously by making policies to suppress illegal vehicle parkers, which will be carried out on time so that there will be no fuss from motorists in order to be able to comply with the policy. Moreover, traffic signs have been posted on the side of the road and at the Bengkong Harapan Intersection.

Socialization is essential if some new policies and decisions apply to the whole community. Without socialization, people will hesitate to take action, even if they are not aware of the new regulation. The way to publish new policies and regulations is by informing all parties involved, placing posters announcing the

regulation in the regions, uploading the new regulation to local newspapers, and stakeholder pamphlets. Furthermore, word of mouth, the people themselves can do it. However, people still lack discipline in obeying traffic rules if there are violations such as violating traffic signs installed or not using a helmet while driving a vehicle.

V. CONCLUSION

There are results and objectives, and conclusions from the MKJI 1997 method, and the authors also find a solution in the case study of the Bengkong Harapan intersection, as follows: Based on the results of calculations at the Bengkong Harapan intersection, the total road capacity to Bengkong Harapan is 3260.46 PCU/hour, if referring to the MKJI 1997 method, this value towards Bengkong Harapan is classified as effective. The traffic flow from Bengkong Harapan to Bengkong Maritime is dominated by 3276 two-wheeled vehicles, 1612 four-wheeled vehicles, 140 city transportation, and 87 trucks/similar. Based on this calculation, it is concluded that the traffic volume in Bengkong Harapan to Bengkong Maritime is 1882.7 junior high school/hour. From the results of the calculation of the degree of saturation analysis that is equal to 0, 57 this value is below the maximum threshold set by the MKJI 1997 of 0.75. In determining the Level of Services by calculating the point of motion at the Bengkong Harapan intersection, the LoS level value in heavy traffic operational conditions is measured at 0.72 or B, and the volume of the road from Bengkong Harapan to Bengkong Maritim is 0.60 or A.

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