Analysis of Traffic Jams: Cases of Congestion Caused U-Turns on Jalan Gajah Mada, Batam

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ARTICLE INFO	ABSTRACT
Keywords: U-turn, Traffic Jams, Road Performance	*U-Turn is used as a special access for drivers who want to change lanes while they are moving. However, the problem that often occurs is this. Intersections can be the main cause of congestion on the road. In the case of the U-Turn on Jalan Gajah Mada. Traffic jams are often caused by this, especially in the afternoon during working hours. According to the 1997 Indonesia Road Capacity Manual, this study attempts to evaluate the performance of intersections and determine whether they are the main cause of persistent traffic congestion. The techniques used to obtain data are observation and documentation. The results showed that the road capacity value was 1311 pcu/hour. Value of traffic volume direction Baloi – Tiban 1421 pcu/hour. 16.00 - 18.00 is like making a U-turn with an average travel time of 08'36".*

1. Introduction

Many cities around the world still experience severe traffic congestion, especially in countries with large populations and fast economic growth. Congestion can affect various aspects of life, including travel time and economic productivity [1]. Traffic congestion can be caused by many factors, including inadequate road infrastructure to accommodate the growing number of vehicles, road accidents, and lack of effective mass transportation. Traffic congestion has a significant negative impact on the transportation system and society as a whole. Congestion can cause longer travel times, use more fuel, and increase air pollution (Metz, 2018). According to sources from The Economic Times News, in 2022, the level of traffic congestion in the United States will increase by around 7% from the previous year. In addition, in 2021, several cities in the world will experience an increase in hourly congestion reaching its highest level, especially the city of Istanbul, Turkey, which has a congestion rate of 62% as measured by the TomTom Traffic Index.

Indonesia has the 4th largest population in the world, with a population of 276 million people. This causes Indonesia to experience quite serious congestion problems in several big cities. The high number of people who need transportation causes the number of vehicles on the road to increase, resulting in traffic congestion. Apart from that, traffic jams in Indonesia often occur due to other factors, such as the large number of traders selling on the side of the road, which causes vehicles to slow down or even stop on the side [25]. This causes the width of the road to become narrower and then causes a buildup of vehicles, further exacerbating traffic jams. To overcome the problem of congestion in Indonesia, the government and society need to work together to find practical solutions. Some of the efforts that can be made include improving public transportation, reducing the use of private vehicles by promoting the use of bicycles and public transportation, and developing better and adequate road infrastructure. In addition, the supervision of traders selling on the roadside must also be improved to not disturb vehicle traffic on the road [2].

Economic growth is one measure of the success of a region. Batam City is one of the industrial cities in Indonesia, with various industries that drive economic growth. This made the city of Batam an attraction for migrants looking for work, which in turn led to an increase in population and demand for vehicles. The increasing number of vehicles on the streets of Batam City, especially during rush hours such as morning and evening, causes quite severe traffic jams. To overcome the problem of congestion in Batam City, the government and society need to work together to find the right solution. One solution that can be done is to improve the quality and capacity of roads, improve public transportation, and reduce the use of private vehicles by promoting the use of bicycles and public transportation.

Jalan Gajah Mada is one of the arterial roads in Sekupang District, Batam city. Jalan Gajah Mada is often used to go to work and school. This causes Jalan Gajah Mada to become one of the congestion points in Batam. In addition, roads that are getting narrower due to road widening work can reduce road capacity, so that the speed of vehicles becomes slower and causes a buildup of vehicles. Jalan Gajah Mada is an uphill and downhill road, usually prone to congestion because large-laden vehicles or trucks passing through the road will experience a decrease in speed when going uphill. In addition, on uphill roads, small vehicles such as motorbikes or cars with small engines will also experience difficulties when going uphill and cause the vehicle's speed to slow down. Road conditions that are uphill or downhill can also add to the burden on the vehicle's brakes, causing the vehicle's brakes to wear out quickly and potentially causing an accident if not properly repaired [3].

This study aims to determine the effect of diverting traffic flow on road performance during peak hours in the morning or evening, which is very important in determining appropriate traffic control policies. By knowing the effect, effective and efficient policies can be taken in reducing traffic congestion. Diverting traffic flow can be a solution to unravel congestion on congested arterial roads during rush hour. However, the policy of diverting traffic flow must be carried out carefully and with careful consideration so as not to cause new problems such as increasing congestion on the chosen alternative route or disrupting the activities of residents around the diverted road. Therefore, this research is very important to obtain accurate information regarding the impact of traffic diversion on road performance and to provide appropriate policy recommendations in overcoming the problem of congestion in cities.

2. Literature Review

Roads are very important infrastructure for land transportation and people's mobility and play an important role in the economic growth of a region [18] [19]. Roads can be categorized based on their function, such as toll roads, arterial roads, collector roads, and environmental roads. In addition, roads are also categorized based on their ownership, such as national roads, provincial roads, district/city roads, and village roads. Each road category has a different role and function in supporting the mobility and economic growth of a region [4]. In Indonesia, roads are categorized into National, Provincial, District, City, and Village Roads (Public Works Department). Roads in Batam are included in the category of urban roads. Urban roads do refer to streets within cities or urban areas that have permanent and sustainable development along or almost all roads and are usually located close to city centers with a dense population, such as Batam which has a population of more than 100,000.

Traffic flow is the number of vehicles that pass a certain point or road at a certain period, such as per hour, per day, or per week. Traffic flow can be measured using a variety of methods, including manual counting and the use of vehicle detectors. Measuring traffic flow is important for understanding traffic conditions in an area, including the level of congestion, the time it takes to cross the road, and the safety of road users. Travel delay time or travel time delay is a common indicator of traffic jams. Travel delay time refers to the additional time required to complete the journey over the expected time if there is no traffic jam. The higher the density of vehicles and the worse the traffic, the greater the additional time

needed to complete the trip, so that the higher the travel delay. Therefore, the travel delay time is often used as an indicator of road performance and the level of congestion. Lack of road capacity can lead to vehicle congestion and traffic jams. Road capacity is defined as the maximum number of vehicles that can be passed on a certain section of the road at a certain time. If the number of vehicles exceeds the capacity of the road, then the density of vehicles will increase and cause congestion [5].

Traffic congestion is a widespread global phenomenon and is caused by several factors such as the rapid growth of motorized vehicles, high population density and lack of adequate infrastructure. Congestion occurs when the number of vehicles on the highway exceeds the maximum capacity that can be accommodated by the road. The most common definition of congestion is when the average speed of vehicles slows down or stops completely. This happens due to high traffic density, many vehicles stopping and moving slowly, as well as obstacles such as accidents, road construction, or weather factors. Batam is an industrial city, the city is an important center of industry and commerce in Indonesia, with a number of factories, ports, and a large shopping center. As an industrial center, Batam attracts many workers from various regions in Indonesia to work there. This causes the population of Batam to be quite high and continues to grow from time to time.

Congestion is usually measured using two main parameters, namely vehicle speed and vehicle volume. Vehicle volume is defined as the number of vehicles passing a certain point on the highway, a certain lane, or the direction of the road during a certain time interval. Meanwhile, vehicle speed is defined as the distance traveled by the vehicle at a certain time. Comparing the volume of vehicles with road capacity is one way to measure the level of congestion on the highway. When the volume of vehicles exceeds the capacity of the highway, congestion will occur. This method is called measuring the level of density or traffic density. Speed is the distance traveled in unit time. Road performance analysis of existing lane conditions is a study to evaluate the performance of roads that have been built by considering various aspects, such as capacity, density, speed, and road level service.

There are two types of traffic jams that are common, namely recurring jams and non-repeating jams. Recurring congestion is congestion that occurs regularly or periodically at the same time every day or week, such as during rush hour or during daily commutes. This congestion is generally caused by increased vehicle volume, limited road capacity, and poor road conditions. An example of recurring congestion is congestion that occurs on arterial roads leading to the city center during rush hour every working day (Agyapong, 2018). Congestion in the city can be caused by various reasons, such as excess demand, signals, incidents, weather-related work zones, or special events. Developing countries often face challenges in overcoming traffic congestion. Factors such as increasing population, rapid urbanization, and rapid economic growth can lead to increased demand for transport and the need for better roads. Meanwhile, investment in transport infrastructure is often limited or inadequate to meet growing needs. This causes an imbalance between demand and available road capacity, and eventually causes traffic congestion.

Traffic accidents can be a cause of traffic jams in Indonesia and other countries [6]. Accidents can cause road closures, slow down vehicles, and cause congestion of vehicles, all of which can lead to traffic jams. Such as the construction of wider highways, the construction of freeways, or the development of a mass transportation system. In addition, irregular vehicle parking and in inappropriate places can also cause congestion in densely populated areas. Therefore, good transportation management and effective traffic management are needed to overcome the problem of congestion in the city. This is what causes infrastructure to be the cause of congestion.

Infrastructure development that is carried out inappropriately or without careful planning can indeed result in a reduction in the number or width of roads, which can lead to more severe traffic congestion

[21] [22]. Construction areas can cause delays or traffic jams. This is due to limited or changing road use (Goswamy, 2019). Road or bridge maintenance such as road widening or repairs can reduce road capacity and cause congestion. In addition, changes in environmental conditions such as rain or snow can also affect traffic flow and driver behavior, which can cause congestion. Road congestion due to the large number of people using cars in bad weather can make traffic slower and more congested. In addition, slippery and wet road conditions can increase the risk of accidents and more severe traffic jams.

Effective traffic management can help overcome congestion and improve transportation system performance [23]. Strategies such as diverted traffic and managed lanes can help reduce the impact of congestion on work zones. Traffic performance evaluation is very important before selecting a traffic diversion route. This evaluation may include an analysis of traffic volume, average speed, and travel time. By carrying out this evaluation, we can find out the performance of the road and identify the main problems that cause congestion. After that, we can find the best solution, such as diverting traffic or improving infrastructure [24].

3. Method

The process of systematic scientific research must begin with identifying the right problem. Identifying the right problem is an essential first step in scientific research because a clear and well-defined problem will help guide the entire research process [16] [17] [20]. Therefore, this research was conducted at U-turn Jalan Gajah Mada, Batam. This research was carried out directly, namely a location survey. The thing that needs to be considered during the survey is the volume of vehicles that occur on Jalan Gajah Mada during peak hours.

This study uses a quantitative approach as a research method. Data is a main factor that has a strong role in designing and developing scientific research and modeling. In this study, there are two types of data used, namely primary data and secondary data. Primary data includes information on site conditions, road dimensions, and the number and speed of vehicles. Meanwhile, secondary data needed includes location maps, population data, and land use. The location chosen for this research is Jalan Gajah Mada Baloi, Batam.

4. Result and Discussion

4.1 Road capacity analysis

Data were taken from Jalan Gajah Mada using field observation and survey methods. The author collects data by making direct observations in the field and conducting surveys. The following data on the Jalan Gajah Mada, turn around: 3.5 meters.

This study conducted a survey at the Jalan Gajah Mada location from 16:00 WIB - 18:00 WIB. Based on MKHI 1997, to calculate the volume of traffic flow, vehicles are classified into three categories, namely Light Vehicles (LV) with a factor of 1.0, Heavy Vehicles (HV) with a factor of 1.2, and Motorized Vehicles (MC) with a factor of 0, 25. After conducting the survey, the volume of vehicle data obtained was 3333.3 pcu/hour. Road capacity can be determined based on the survey results. Road capacity maps can use the 1997 MKHI guidelines by using the following formula.

$$C = C_O \, x \, FC_W \, x \, FC_{SP} \, x \, FC_{SF} \, x \, FC_{cs}$$

Where:

Co: is a variable in determining the basic capacity. To determine the basic carrying capacity, it is necessary to know the type of road from the survey location, as shown below in Table 1.

4.2 Traffic Volume

The purpose of this study is to estimate the volume of traffic that will cross the intended route. Traffic volume refers to the number of vehicles that pass a location or road section in a certain period of time, measured in units of vehicles per hour (pcu/hour). SMP stands for passenger car unit, which is the unit used in traffic planning. The data that has been obtained will be processed in accordance with the provisions contained in the 1997 MKJI. In determining the volume of traffic during the study location, vehicles passing through the road are classified into several groups.

4.3 Road Capacity

To carry out capacity analysis research on Jalan Gajah Mada, formula calculations and analysis can be carried out regarding the 1997 MKJI guidelines by adjusting the existing conditions at the research location. The 1997 MKJI Guidelines provide a basic framework commonly used in traffic planning and road capacity analysis. However, it is important to adapt the formulas and methods in these guidelines according to the special characteristics of Jalan Gajah Mada, which will be examined in Table 3. As follows:

Table 1. Road Capacity Adjustment factor data

Adjustment Factor				
Co (pcu/hour)	FC_W	FC_{SP}	FC_{SF}	FC_{cs}
1500	0.92	1.00	0.95	1.00

After the data is collected, a review of the capacity calculation for the lines at the research location is as follows:

$C = CO \ x \ FCw \ x \ FCSP \ x \ FCSF \ x \ FCcs$

$C = 1500 \ x \ 0.92 \ x \ 1,00 \ x \ 0,95 \ x \ 1,00$

$C = 1311$ pcu/hour

4.4 Traffic Volume

Observation of traffic flow conditions is carried out during peak hour conditions around 16:00 to 18:00 in the afternoon for 2 hours. This observation was carried out on Jalan Gajah Mada with the object of observation in 1 lane, namely the Baloi – Tiban route. The main focus of this observation is the volume of vehicles passing through the route which has been classified into three groups of vehicle types, namely HV, LV, and MC. The findings of observations made by researchers, there are attached in Table 4, as follows:

Table 2. Traffic volume observation data

Day, Date, and time	Location: Jalan Gajah Mada, Batam		
Monday, 22 Mei 2023	MC	LV	HV
16:00 - 16:30	294	163	40
16:30 - 17:00	276	169	15
17:00 - 17:30	351	158	23

Day, Date, and time	Location: Jalan Gajah Mada, Batam		
17:30 - 18:00	416	152	8
Total	1337	642	85

Traffic volume for the Jalan Gajah Mada – Tiban Route (Afternoon)

MC = (1337 x 0.5) = 668.5 pcu/hour

LV = (642 x 1.0) = 642 pcu/hour

HV = (85 x 1.3) = 110.5 pcu/hour

Qtotal = 668.5 + 642 + 110.5 = 1,421 pcu/hour

4.5 Vehicle U-turn Data

Observations were made at the opening of the Jalan Gajah Mada median by observing the flow of vehicles making a U-turn from the direction of Baloi – Tiban. The vehicle data the researchers collected is attached in Table 3. As follows:

Table 3. Observation Data for Vehicles Making U-turns

Day, Date, and time	Location: Jalan Gajah Mada, Batam		
Monday, 22 Mei 2023	MC	LV	HV
16:00 - 17:00	420	189	22
17:00 - 18:00	528	211	8

The results are attached in Table. 5. It is shown that the number of vehicles that make a U-turn in the afternoon is 1378 vehicles/hour. The results of the observations were that the largest number of vehicles made a U-turn at 17:00 – 18:00, with a total of around 747 vehicles.

4.6 Vehicle Travel Time for U-turn

The results of the analysis that the researchers carried out as shown in Table 4, the typical travel time for vehicles making a U-turn are as follows:

Where:

Xi = Vehicle travel time (seconds)

n = number of vehicles

Table 4. Vehicle turn-around time data

Date and time Saturday, May 22, 2023	Research sites Jalan Gajah Mada
	Travel Time
16:00 – 16:30	6.42
16:30 – 17:00	5.09
17:00 – 17:30	7.64
17:30 – 18:00	14.29
Total Travel Time	33,44
Average	**8.36**

The results are attached in Table 4. Shows that the result of the average travel time of a vehicle making a U-turn from the Baloi - Tiban direction is 08'36" (in seconds).

5. Conclusion

Research on Jalan Gajah Mada concluded that the capacity of the road between Baloi to Tiban and Tg. Swaying toward Yellow Face has almost the same value, around 2884.1 vehicles per hour. Traffic on the road from Baloi - Tiban reached 1458.7 vehicles per hour, while the traffic volume from Tg. Jump to Yellow Face at 2475.4 vehicles per hour. Between 16.00 and 18.00, there were approximately 1033 vehicle U-turns, with an average vehicle U-turn time of around 8 minutes and 36 seconds. Field observation results show that the road from Muka Kuning to Tg. Uncang often experiences traffic jams because many vehicles make U-turns, compared to vehicles that go straight towards Tg. Kitbag. The road service level around Jalan Letjen Suprapto is 0.51 or service level C, due to an increase in the number of vehicles making U-turns and hindering the speed of vehicles that bridge the road, causing long traffic jams. These findings indicate that although the roads are still stable, vehicle speeds have begun to be under control. The results of this field study can be used as examples and references for future studies regarding the effectiveness of U-turns.

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