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The Road Performances Analysis on U-Turns in Jalan Raja Alikelana, Batam-Indonesia

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ABSTRACT

Traffic character is an inseparably interconnected system between volume, speed, and traffic density. In Indonesia, the use of U-turns is often the main impact of road conflicts. Batam is a city with fast economic growth in Indonesia. Therefore, many residents from outside Batam come to work. This affects road performance in Batam where more and more residents are concentrated on Jl. Raja Alikelana. During busy times, such as when people come home from work. Long traffic jams often occur which cause vehicles to be diverted to turn around at the next U-turn. The purpose of this paper is to determine the degree of saturation and the level of road service (LoS) with the IHCM 1997 guidelines. From the survey, the total peak flow data on the first line was 1489.7 pcu/hour and the second line was 1371.9 pcu/hour with degrees of saturation per lane 0.96 and 0.88 with the level of road service for each lane on Jl. Raja Alikelana namely E and D.

1. Introduction

Transportation is one of the critical factors that has an essential role in the mobility of a country. Transportation is divided into three categories based on the place of operation: water Transportation, Air Transportation, and especially land transportation. Of the various types of transportation. Land transportation is one of the most widely used types of transportation. in its use, land transportation requires important infrastructure to support its mobility. One of them is the Roads. As the main infrastructure in land transportation, Roads provide maximum service for traffic flow, such as safety and comfort for road users. On city roads with a median, it is required for the vehicle to make a U-turn on the median opening, which is made as a special requirement [1]. A U-turn is a place to turn back which is made to turn the direction of the vehicle to make it easier and shorten the time for wheeled drivers. But, it is not uncommon for U-turns to be a factor in congestion, accidents, and traffic violations. Therefore, maximizing the use of U-turns aims to improve safety, and control traffic density [2].

Traffic character is an inseparably interconnected system between volume, speed, and traffic density. In Indonesia, the use of U-turns is often the main impact of road conflicts. The increase in the number of vehicles is one of the factors causing the conflict. Long queues of vehicles due to activities in educational areas, places of worship, and residential areas. The magnitude of the movement of the passing traffic flow also affects the build-up of vehicles on the road, especially U-turns. The long travel time due to the build-up of vehicles affects increased fuel consumption, the amount of time lost, and the number of exhaust emissions emitted by vehicles [3].

Batam is a city with fast economic and industrial growth. This is in line with the population growth in this city. where many migrants from outside the area come to work in Batam. This is affecting road performance in Batam where the population is increasing, and the problem is exacerbated by the lack of transportation provided for workers by the companies that employ them. To this problem, workers indirectly have to use private vehicles to go to work. This economic growth also effects of the increment in the number of vehicles which causes problems in transportation. Many facilities such as road

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widening, public facilities, and vehicle mobility infrastructure need to be developed this condition has resulted in a lot of congestion of vehicles in several places, especially at conventional intersections and U-turns in the city of Batam [4].

Figure 1. Jalan Raja Alikelana (Botania 2)

One example of a U-turn in Batam City is on Jl. Raja Alikelana. During rush hour, such as when people come home from work and when students schedule evening classes. Long traffic jams often occur, which cause vehicles to be diverted to turn around at the next turn. It's because of the accumulation of universities and inadequate road width. Many large industrial two-wheeled vehicles, such as trucks and vehicles belonging to students and workers, cross the road. Traffic jams on this road can cause a series of problems for everyone, especially students and teachers who are heading to college. In addition, drivers will face delays, inconvenience, and financial loss due to traffic jams and air pollution [5].

This study aims to determine the movement of vehicles toward U-turns on Jl. Raja Alikelana and to find out traffic flow performance due to U-turns on roads. The analysis is carried out with road performance parameters such as speed, density, and road volume. This research is expected to solve problems in traffic problems that occur at Jalan Raja Ali Kelana.

2. Literature Review

2.1 Road Performance

Traffic congestion occurs when the volume of vehicles at a certain point has reached the road capacity limit. And it gets worse if it happens during rush hour. Traffic jams in urban areas often occur in strategic places. Consistent areas where congestion often occurs in urban areas usually occur in strategic and critical places. Examples of strategic and critical places are shopping areas, schools, places of worship, and workplaces [6]. The behavior of people who prefer private vehicles and do not use public transportation is also a factor in poor road performance.

Roads are the main infrastructure for land vehicles in the admission of goods, services, and community activities [7] [8]. Good roads can change and improve the economic conditions of an area. A good road is also expected to have good service performance, efficiency, comfort, and safety for the community. However, people's behavior towards roads should use existing facilities properly, such as using public transportation rather than private vehicles. Congestion that occurs in one place is generally dominated by private vehicles [9].

Road performance in general, is an inventory of data that is carried out quantitatively to determine the level of saturation of a road at a point on the observed land. Congestion in densely populated areas

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causes delays, which can decrease economic growth [10]. The high volume of vehicles can provide excessive travel time on transportation. Wrong road indications can also lead to congestion. The tendency for congestion indicates poor road performance [11].

Road performance is also affected by the road's speed, density, and volume. Side resistance is one of the problems in good road performance [12]. Side friction impacts traffic performance, such as slowing down of vehicles, vehicle actors, and other roadside activities. Side friction affects vehicle speed reducing road capacity and causing congestion. Current intensity can also change the effective road section, reducing vehicle speed.

2.2 U-turn

U-turn is a means of traffic on a one-way street that functions for vehicles going in the opposite direction. With the U-turn Road users can turn around with a shorter distance. With this shorter distance, many vehicles use this infrastructure [13]. This is where the start of the queue of vehicles. The population density and school facilities, shopping, and places of worship make this place a strategic location [14].

One of the factors causing congestion on the U-turn is the high traffic volume. U-turn is a type of vehicle movement where the vehicle must turn 180 degrees to change direction to the opposite direction. When the volume of vehicles passing through the U-turn exceeds the maximum capacity of the road infrastructure, this can cause congestion. Congestion occurs when a vehicle must wait to make a U-turn due to an oncoming vehicle or because the time allotted for this movement is insufficient [15]. Congestion at corners can also be affected by inadequate road geometry design, ineffective traffic management, or a driver's lack of knowledge to follow predetermined U-turn rules. Therefore, good planning is needed in designing U-turns and effective traffic management to reduce congestion at the U-turn point [16].

U-turns include infrastructure facilities that, in their use, can shorten travel distances. However, it requires rider skills to use this facility. Accidents often occur due to the driver's lack of skill in maneuvering the U-turn. In carrying out comfortable and safe roads, a traffic forecast is needed. In this way, accidents can be minimized. In addition, many factors influence accidents, such as the driver, the vehicle, and road environmental factors.

The congestion factor that occurs on U-turns is influenced by the median opening area where vehicles usually take up too much of the road body. Other parts of the road will be disrupted if a vehicle covers the part that should be passed. The median aperture also has a significant effect that makes vehicles collide with non-priority traffic. The effectiveness of a U-turn can be seen from the smooth flow of vehicles running in opposite directions. The median opening creates a conflict if it is affected by the saturation of a road.

2.3 Traffic Flow

The transportation problem in industrial or large cities with dense populations is congestion. This problem occurs because of the many private and industrial vehicles that use the road. Of these problems, the streets became full and the accumulation of vehicles at one point. So, the vehicle's travel time becomes much longer than it should be [6]. Traffic flow in each city has different congestion factors, such as population, road quality, weather problems, or other factors.

Urban road traffic flow refers to the number of vehicles passing through city streets at any time. This includes private vehicles, public transport, and motorcycles that move from one place to another within the city [17]. Population activities, travel patterns, economic developments, transportation policies, and available road infrastructure determine city traffic flows.

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Factors that affect the flow of city traffic can vary in each region. First, the number of residents and the focus of economic activity in a city can affect the degree of mobility and the need for transportation [18]. The denser the population, the higher the traffic flow obtained in a city. Second, the rate of economic growth and urbanization also contributes to the increase in traffic flow, because it increases population mobilization and business activities [19].

To deal with heavy traffic flow and congestion in cities, traffic management is needed to break down road congestion effectively. This involves managing road use and traffic handling, updating adequate infrastructure, using technology to monitor and regulate traffic flow, and using public transport [20]. By managing traffic flow well, cities can achieve smoother mobility, transport efficiency, and a better quality of life for the people.

3. Method

Congestion often occurs in urban areas; this is normal because economic growth is not proportional to the availability of qualified roads [21]. In many areas, because the roads can no longer accommodate the volume of vehicles, many vehicles accumulate at one point. This problem is also supported by the increasing population growth in Batam [22]. Data on the population of Batam in 2020 comes from the Central Bureau of Statistics for the city of Batam, amounting to 1,196,396 people. by and traffic jams ensue. These traffic jams are getting worse from time to time. From these cases, we conducted research on Jl. Raja Alikelana to find out more about the congestion problem that occurred. We conducted research during peak hours on Thursday, 25 May 2023 from 05.00 PM until 06.00 PM.

Data is an important part of the scientific research [23]. Collecting data has a good level of accuracy. This study uses quantitative methods to collect and evaluate numerical data to develop statistics and identify patterns in research. Data collection involves primary data, such as the number of vehicles on the road and road geometry data [24]. In addition, the secondary data used are location maps and population data. The method used in this study is IHCM 1997, which assesses the level of road service. Thus, the research process is carried out systematically by identifying problems and applying relevant methods. Primary data is taken from vehicle volume data, vehicle speed, and geometry data [25] [26] [27] [28] [29]. Also, the secondary data taken is population data and map or GPS locations.

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Figure 2. Location of research

4. Result and Discussion

4.1 Traffic Conditions

This research was conducted on Jalan Raja Alikelana, a 4/2 D-type road. Each lane on this road has a width of 3.5 meters per lane and is divided by a median width of 1.5 meters. In this study, there are three types of vehicles used, namely Light Vehicle (LV), Heavy Vehicle (HV), and Motorcycle (MC). The EMP (Equivalent Motorization Parameter) factor used to calculate the level of traffic contribution is 1.00 for LV (light vehicles), 1.2 for HV (heavy vehicles), and 0.25 for MC (motorcycles). This traffic data was collected through a face-to-face survey for one day on Thursday, May 25, 2022, at the exact survey location. The results showed that the heaviest volume of traffic occurred in the time range between 05:00 pm to 06.00 pm with a total of 1489, 7 pcu/hour on line 1.

Table 1. Traffic Volume Data Lane 1

Time (pm)	Type of vehicle						Total per Horus	
	LV per hours		HV per hours		MC per hours			
	Vech	Pcu	Vech	Pcu	Vech	Pcu	Vech	Pcu
05.00-05.15	187	187	2	2.4	260	65	449	254.4
05.15-05.30	282	282	5	6	248	62	535	350
05.30-05.45	332	332	1	1.2	312	78	645	411.2
05.45-06.00	377	377	3	3.6	374	93.5	754	474.1
Total							2383	1489.7

And on the second line, we also calculated at the same hour and found that 05.45-06.00 was the peak time for vehicles with a traffic volume of 458.65 pcu/hour with a total of 717 vehicles. While the total traffic volume is 1371.9 pcu/hour at 05.00-06.00 pm with 2155 vehicles.

Table 2. Traffic Volume Data Lane 2

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Time (pm)	Type of Vehicle						Total per Horus	
	LV per hours		HV per hours		MC per hours			
	Vech	Pcu	Vech	Pcu	Vech	Pcu	Vech	Pcu
05.00-05.15	149	149	3	3.6	208	52	360	204.6
05.15-05.30	274	274	1	1.2	233	58.25	508	333.45
05.30-05.45	309	309	1	1.2	260	65	570	375.2
05.45-06.00	370	370	2	2.4	345	86.25	717	458.65
Total							2155	1371.9

4.2 Roadside Disturbances

Roadside disturbances have a significant impact on road services. This study uses IHCM 1997 guidelines to measure frequency disturbances every 200 meters on Jalan Raja Alikelana. Data was collected from the two-way street of this section through direct surveys, observing passing vehicles. The results show that the total weighted frequency in direction 1 is 241.3, indicating a low level of roadside disturbance, while in direction 2 is 101.8, indicating a low level of roadside disturbance.

Table 3. Roadside Disturbance Activities Lane 1

Roadside Disturbance Activities	Symbol	Weights	Frequency	Weighted Frequency
Pedestrian	PED	0.5	24	12
Parked or stopped vehicles	PSV	1	11	11
Vehicles entering and exiting from or to the Side of the road	EEF	0.7	293	205.1
Slow moving vehicles	SMV	0.4	33	13.2
Total				241.3

Side friction is a consequence of activities on the side of the road that affect traffic performance. These factors include pedestrians walking on the beach, the number of vehicles parked on the shoulder of the road, the number of vehicles entering and leaving the road, and slow vehicles such as bicycles or rickshaws. The movement of pedestrians, especially in urban areas, often causes conflicts with motorized vehicles, increasing the risk of accidents and congestion. Vehicle parking on the shoulder of the road can also cause traffic jams and driver confusion. In addition, the number of incoming and outgoing vehicles and slow vehicles also play a role in traffic performance.

Table 4. Roadside Disturbance Activities Lane 2

Roadside Disturbance Activities	Symbol	Weights	Frequency	Weighted frequency
Pedestrian	PED	0.5	3	1.5
Parked or stopped vehicles	PSV	1	11	11
Vehicles entering and exiting from or to the side of the road	EEF	0.7	119	83.3
Slow moving vehicles	SMV	0.4	15	6
Total				101.8

This study shows that the level of roadside activity or side distraction significantly affects traffic performance. The factors that most affect traffic speed are slow vehicles, crossing roads, entering and exiting vehicles, and stopping vehicles. In addition, the variables of incoming and outgoing vehicles, stopped vehicles, pedestrians, and slow vehicles all affect traffic speed, as indicated by the value of capacity, degree of saturation, coefficient of determination, and changes in the variables in this study.

4.3 Free flow speed

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This study uses IHCM 1997 guidelines to obtain free flow velocity on the two-way section of the road studied. The free flow speed is the average traffic speed when the traffic volume is low or not affected by other vehicles. Based on this research, the free traffic speed (FV) for light vehicles is 58.94 km/hour.

FV = (FV0 + FVW) x FFVSF x FFVCS.

Table 5. Free flow speed

Free Flow Velocity Parameter	Mark	Unit
FV0	57	km/hour
FVW	0	km/hour
FV0+ FVW	57	km/hour
FFVSF	0.94	
FFVCS	1	
FV	58.94	km/hour

Road Capacity

Maximum road capacity affects the degree of saturation of a road. Road capacity (C) is a standard calculation of the degree of saturation. To determine the road capacity value, we can use IHCM 1997:

$$C=Co\ x\ FCw\ x\ FCSP\ x\ FCSF\ x\ FCCS$$

And in these calculations, the value of road capacity (C) will be found. In this study, it was found that the road capacity value was 1551 pcu/hour on both lanes.

Table 6. Road Capacity

Road parameters	Mark	Unit
Co	1650	pcu/hour
FCw	1	
FCSP	1	
FCSF	0,94	
FCCS	1	
C	1551	pcu/hour

4.4 Degree of Saturation

The degree of saturation is the ratio between the total current (Q) and the rated capacity (C). Since this involves computations on separate paths, we must perform separate computations for each path. The degree of saturation can be formulated as follows:

DS = Q ÷ C

Road performance refers to the evaluation of certain conditions of a road. This evaluation is generally based on capacity and saturation level (DS) through road performance studies. In addition, there is also a qualitative measure that describes the operational conditions of traffic flow and the driver's perception of driving quality, known as the level of road service.

Table 7. Degree of Saturation

The direction of the road	Q	C	DS	LoS
Lane 1	1489.7	1551	0.96	E
Lane 2	1372.9	1551	0.88	D

Road capacity refers to the number of vehicles that can be passed by a road section in a certain period. Road capacity can be affected by factors such as the number of lanes, road geometry, traffic control, and vehicle density. If the number of vehicles exceeds the capacity of the road, traffic jams or saturation may

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occur. From the calculation, it is found that the degree of saturation of line one is 0.96, thus the level of service (LoS) is E and the degree of saturation of line two is 0.88 with the level of service (LoS) is D.

5. Conclusion

From this, it can be concluded that the field survey results and calculations were made based on the survey data. First, Jalan Raja Alikelana has a heavy traffic volume in the afternoon, with 1489.7 pcu/hour on line 1 and 1371.9 pcu/hour and found a degree of saturation value of 0.96 in lane 1 and 0.88 in lane 2. By calculating the level of service (LoS) value according to the IHCM 1997 assessment, it is known that the road has an E value on lane 1 and D on lane 2. It can be interpreted that the current on unstable roads at a low speed is erratic, and the volume is close to the limit.

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