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THE ROAD PERFORMANCE ANALYSIS IN JALAN AHMAD YANI BATAM USING IHCM 1997

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ABSTRACT

One of the congestion points that will be analyzed is on Jalan Ahmad Yani, Batam. Congestion will occur during the hours of entering and returning from work. Congestion occurs due to high levels of vehicles that exceed the capacity of the road. Road widening also had a temporary negative impact as traffic congestion worsened. The purpose of this paper is to analyze road performance on Jalan Ahmad Yani (Kepri Mall – Batamindo industrial area). All data is processed to obtain the road service level using the IHCM 1997 guidelines. From direct surveys and data calculations obtained, total traffic flow during peak hour is 5490 pcu/hour, free flow speed (FV) of light vehicles (LV) is 54.72 km/hour and 57 km/hour for each lane. The total capacity is 10407.21 pcu/hour, the degree of saturation per lane is 0.52 and 0.54, and the level of service of Jalan Ahmad Yani value is C.

INTRODUCTION

Traffic is considered a global problem, as it causes an increase in air pollution, vehicle noise, and travel time of private and public vehicles. Construction of roads, buildings, and infrastructure can boost visibility as a nation becomes more industrialized, but it can also result in traffic jams. Numerous variables can contribute to traffic congestion, including a growing population, construction of high-rise structures, traffic restrictions, and ongoing road and bridge construction. For instance, China is currently undergoing a rapid urbanization process, and as a result, a few significant societal issues have arisen, such as growing traffic congestion (Zhang L. , 2019). More broadly, Congestion causes people to feel more exhausted, behave differently in social situations (for example, by being more anxious), have trouble communicating, and have trouble sleeping, which ultimately hinders society's ability to develop sustainably (Sánchez González, Bedoya-Maya, & Calatayud, 2021).

Certainly, Indonesians often heard of the term “Traffic Congestion”. Surabaya is the most congested city in Indonesia, located in East Java, with a population density of 8.612 people/km^2. This is surprising considering that people know Jakarta as the most congested city in Indonesia. Surabaya is also ranked 41 as the most congested city in the world. Traffic congestion hurts economic, social, and environmental development. When traffic on the road is delayed due to the presence of other vehicles, this is referred to as Congestion (Koźlak & Wach, 2018). Besides that,

Congestion can also be caused by decreasing public inclination to use public transport or a level of vehicle traffic that exceeds a given road's capacity.

This paper focuses on Batam, the largest city in Riau Islands, Indonesia. Widening the road is one of the government's efforts to make Batam like Singapore. The road widening in Batam has been seen since 2016. However, it is not very practical for road users in Batam because it is still in the construction stage. Indeed, Batam's traffic congestion is better than Jakarta's, which is not only during peak hours but almost every hour. The traffic congestion occurred at the time of entering and returning from work. Because of that, there are several places in Batam where the road capacity is not balanced with many vehicles. That is what makes traffic congestion unavoidable.

When travel demand exceeds the limited supply of transportation services, traffic congestion occurs (Suryani, Hendrawan, Adipraja, Wibisono, & Dewi, 2020). One of the congestion points that will be analyzed is on Jalan Ahmad Yani, Batam. Congestion will occur during the hours of entering and returning from work. Congestion also occurs due to the level of vehicles that exceed the capacity of the road. Second, because the road widening is in progress, there is also making traffic congestion even worse.

The purpose of this paper is to analyze road performance on Jalan Ahmad Yani *(Kepri Mall – Batamindo industrial area).* The speed performance index is one of the indicators used to evaluate traffic congestion on urban roadways (Samal, Kumar, Santhosh, & Santhakumar, 2020). The parameters to be analyzed are the width of the road, whether the road is damaged or not, and several factors in the field that can trigger Congestion. This paper will provide some explanations about good road performance and the results of the case study analysis.

LITERATURE REVIEW

Road Performance

Traffic congestion occurs when traffic volume approaches road capacity. Peak-hour traffic jams may be wildly inefficient because Congestion is higher during rush hour (Kreindler, 2020). Congestion on road networks becomes more common as the population and number of vehicles grow (Sathiaraj, Punkasem, Wang, & Seedah, 2018). One of the factors causing Congestion is the tendency of users of transportation services to use private vehicles compared to public transportation. In addition, poor road performance can also hinder the smooth flow of the road.

The road serves as vehicle infrastructure and facilitates the accessibility of goods, services, and community activities (Amril & Junaidi, 2019). Roads are expected to provide the community with convenient, safe, and efficient transportation services. Good road performance can be seen when the traffic volume is running smoothly. Congestions usually occur when vehicles are moving very slowly or are stationary. As a result, the relationships between speed and flow, speed and density, and flow and density are critical in transportation engineering (Romanowska & Jamroz, 2021).

Road performance is a quantitative measurement representing the specific conditions encountered on a set of roads. To identify traffic congestion parameters, travel time reliability

measures such as level of service, roadway congestion index, and lane-mile duration index can be used (Samal, Kumar, Santhosh, & Santhakumar, 2020). In addition, the speed performance index is one of the indicators. Traffic delays are caused by recurring or non-recurring Congestion. While recurrent Congestion is caused by similar patterns (such as rush hour), non-recurrent Congestion is caused by unexpected events, such as incidents or severe weather (Karaer, Ulak, Ozguven, & Sando, 2020).

The problem of road performance inhibition must be considered. Congestion arises because of the inconsistency of vehicular traffic in all aspects of the road and the potential for traffic accidents that can cause harm to the health and financial condition of road users (Wangsa, Samba, Handajani, & Muldiyanto, 2021). In addition, the economic potential and concentration of the population in metropolitan areas create traffic congestion when there are too many transport needs in a spatially limited area (Koźlak & Wach, 2018). Therefore, a better understanding of the factors affecting traffic flow can ultimately be used to plan, design properly, and maintain a road design and thereby reduce the risk of Congestion.

Intersection

An intersection is a part of the road that becomes the center of conflict points from various traffic flow movements (Sraun, Rumayar, & Longdong, 2018). An intersection is a junction of three or more road junctions and can be abstracted as a simple node or various complex structures (Deng, et al., 2018). Traffic regulation at intersections is a critical component of the intelligent transportation system, which is defined as the integration of communication and information technologies in vehicles and road infrastructure to improve traffic flow and safety. The performance of an intersection is good by identifying the traffic flow and fault factors.

Intersections are the most critical factors in determining a road network's capacity and travel time, particularly in urban areas. The intersections are divided into four types: uncontrolled intersections, regulated intersections with priority (give way, stop), roundabouts (roundabout), and regulated intersections with traffic signaling devices/grade separated. There has been much discussion in road intersections about signalized crosswalks and their associated problems (Olayode, Tartibu, Okwu, & Uchechi, 2020). Effective traffic light control is key in reducing traffic congestion, reducing passenger wait times, increasing road network throughput, and reducing vehicle emissions and fuel consumption (Guo, Wang, Chan, & Askary, 2019).

In the traffic congestion distribution rules study, the traffic congestion index of the congestion length at adjacent intersections is frequently calculated using fluctuation, hysteresis, and transmission of congestion diffusion characteristics (Sun, Lin, Jiao, & Huapu, 2020). High rates of traffic accidents occur at complex and varied intersections, which are significant bottlenecks for traffic flow and safety. Intersection performance is a measure of acceptable traffic conditions at an intersection. Intersection performance can be measured by intersection delay and capacity (Ariesta, Waloejo, & Agustin, 2020).

The author can determine the performance of the intersection by using the degree of saturation. The degree of saturation, defined by IHCM guidelines, is the ratio of the flow rate (passenger vehicle unit/hour) to the capacity of the intersection (passenger vehicle unit/hour) and

is used as a key factor in evaluating and determining the level of road performance. The degree of saturation value indicates whether or not the road segment will have capacity issues (Jati & Wulansari, 2019).

$$DS = \frac{Q}{C}$$

Description:

DS = *degree of saturation*
Q = *Traffic flows (passenger vehicle unit/hour)*
C = *Intersection capacity (passenger vehicle unit/hour)*

Traffic Flows (Volume)

Congestion is a significant transport problem in large cities, including Indonesia, with a high vehicle volume on roads and highways. This issue arises because the number of cars on the road exceeds the available capacity, resulting in longer travel times. At a given point in time, traffic flows have the following spatial characteristics, such as the impact of traffic flow upstream and downstream of a road, as well as rules for speed limits and traffic flow restrictions at the same road level (Zhang, Lu, & Li, 2020). Traffic is the number of vehicles passing through a road segment in a unit of time (year, month, day, hour, minute).

First, as traffic volumes and flows increase, so do the processing and memory required for traffic monitoring in network elements (Demianiuk, Gorinsky, Nikolenko, & Kogan, 2020). Some studies stated three main parameters of traffic flow volume, speed, and density (Bhat & Gupta, 2018). The speed of the movement is an essential indicator of traffic flow movement (Novikov, Glagolev, Novikov, & Shevtsova, 2019). Third, the model should be built with parameters such as the organization of roads, cars, and means of traffic to ensure compliance with real-world data. An accident occurs, and disturbance occurs around the community who stops seeing the incident or because the vehicle involved in the accident does not disappear from the traffic lane resulting in Congestion in the area.

Traffic volume has a moderate linear impact on travel delays (Kreindler, 2020). This volume of traffic is highly dependent on the season, day of the week, and time of day. It is also affected by traffic composition, road route division, road classification, land use type, road composition (tough roads, toll roads, etc.), and general road geometry. To calculate peak hour traffic volume. Peak hour is the volume at which the road receives the highest traffic during peak hours. Generally, determining the traffic volume is guided by busy times, such as when the road receives the maximum load.

Traffic volume is calculated based on the following formula:

$$v = \frac{\mathrm{N}}{\mathrm{t}}$$

Description:

v = *Traffic volume (vehicle/lane/hour)*
N = *The number of vehicles passing through the cross-sectional point in the time interval (vehicle)*
t = *Observation time interval (hour)*

Traffic volume is not evenly distributed over time but fluctuates. The relationship between the traffic volume and time (fluctuation) depends on the road's location and function. It also helps determine rush hours when the number of vehicles on the road peaks and travel demand is most significant (Hossain & Hassan, 2019).

METHOD

Traffic congestion is an ongoing issue for the long-term viability of transportation development (Afrin & Yodo, 2020). A systematic scientific research must begin with identifying the right problem (Rifai, Hadiwardoyo, Correia, & Pereira, Genetic Algorithm Applied for Optimization of Pavement Maintenance under Overload Traffic: Case Study Indonesia National Highway, 2016). The main problem is that traffic congestion can cause delays, inconvenience, economic loss, and air pollution. This paper will use quantitative methods to analyze road performance in Jalan Ahmad Yani, Batam. Which quantitative method consists of several stages, starting with data collection techniques to the stage of analyzing data based on IHCM guidelines.

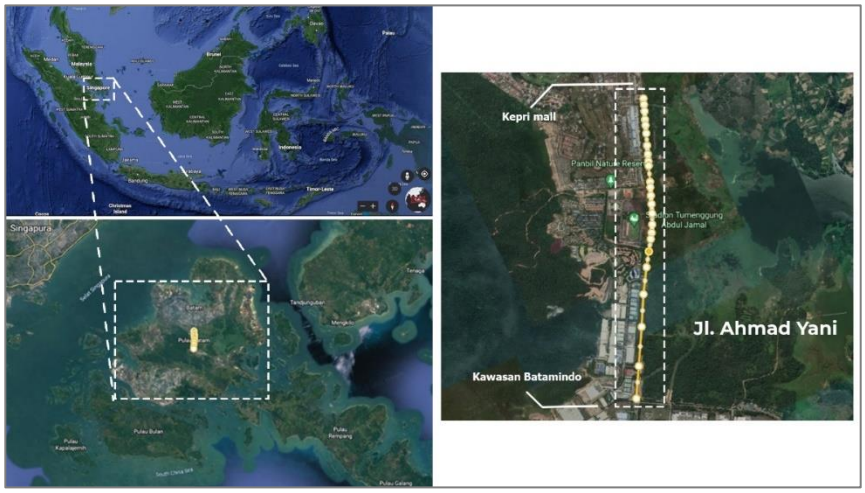

Figure 1 Jalan Ahmad Yani

Data is one of the main strengths in organizing research and scientific modeling (Rifai, Hadiwardoyo, Correia, Pereira, & Cortez, The data mining applied for predicting highway roughness due to overloaded trucks, 2015). The primary data survey was carried out on Jalan Ahmad Yani (*Kepri Mall – Batamindo industrial area*). The most crucial initial stage is determining the survey objectives (Rifai & Hafis, Analysis of Road Performance and Vehicle Parking Characteristics in the Halim Perdanakusuma International Airport Area, 2021). In carrying out the survey, there some information is needed, such as the arrival pattern of traffic flows (V), number of the vehicle, average vehicle speed, free flow speed (FV), degree of saturation (DS), road dimension, road condition and level of service (LOS)

This primary data was obtained based on direct observations or surveys (Mufhidin, Karimah, Isradi, & Rifai, 2022). First, take geometric data by measuring road segments, such as road width and shoulder width. Secondly, count the number of vehicles using a software

application. Thirdly, all data is processed to obtain the level of service for the road using the IHCM 1997 guidelines. The research was conducted during peak hours on Friday (18 November 2022) morning. The research was conducted for 1 hour, from 07.30-08.30.

Figure 2 Jalan Ahmad Yani situation (direction 1 – direction 2)

RESULT AND DISCUSSION

Road Section Geometric Data

The research was carried out directly on Jalan Ahmad Yani, Batam, Riau Islands, with a road segment length of 3,153 meters (**Figure 1**). The width of each lane is also different. There are 17.62 meters wide (direction 1) and 8.49 meters wide (direction 2), with 2.5 meters wide median and a shoulder width of 1.5 meters. Based on the Central Bureau of Statistics (BPS) data, Batam has 1.196 million people. The following is an image of the data from the geometric conditions of the roads, including:

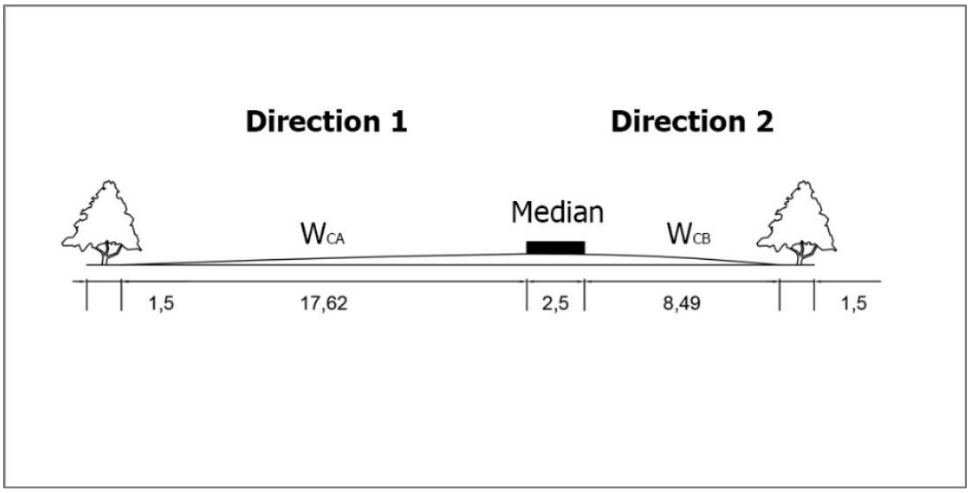

Figure 3. Condition of section Jalan Ahmad Yani

Traffic Flow

Traffic flow will not always be regular (varying); if you want an average volume, the measurement is over a long period. Because the author needs to find the traffic flow, it is necessary to calculate the number of vehicles. The survey was conducted by counting the number of vehicles at predetermined points at 1°06'03" N 104°02'17" E and 1°06'03 "N 104°02'18 "E. In this study, the survey was conducted during peak hours for 1 hour, namely 07.30-08.30 with an interval of 15 minutes (07.30-07.45; 07.45-08.00; 08.00-08.15; and 08.15-08.30).

Traffic flow data is obtained after the survey is completed. Based on the data, the composition of vehicles passing through the road is light vehicles (LV) by 25%, heavy vehicles (HV) by 4%, and motorized vehicles (MC) by 71%. The percentage of vehicles will be different if the two lanes are different. The percentage of vehicles passing in direction 1 is 70.0%, and vehicles passing in direction 2 is 30.0%. From this percentage, the author can conclude that the direction separation (SP) is 70%.

In the Traffic flow (table 1), the pcu factor is 0.475521, this result is obtained from the number of pcu/hour, which is 5493 divided by the number of vehicles/hours, which is 11552. Previously, to find pcu/hour and vehicles/hour, the author used the IHCM guidelines. where the vehicles/hour are obtained from the addition of the three-vehicle classifications (LV, HC, & MC) within 1 hour. For pcu/hour, it is obtained from the addition of the multiplication between the vehicle/hour and the price direction based on the vehicle classification (LV, HV, & MC).

Table 1. Jalan Ahmad Yani traffic flow data (vehicle/hour)

Direction	LV/hour		HV/hour		MC/hour		Total Traffic Flow (Q)		
	Veh.	PCU	Veh.	PCU	Veh.	PCU	Dir.%	V/hour	PCU/hour
1	1911	1911	246	295.2	6571	1642.75	70%	8728	3848.95
2	986	986	209	250.8	1629	407.25	30%	2824	1644.05
1+2	2897	2897	455	546	8200	2050	100%	11552	5493
				Direction separation (SP)			70%		
				Vehicle factors (pcu factors)					0.475502

Roadside Disturbance

Roadside disturbance greatly affects the level of service on a road section. This research uses the IHCM guidelines by calculating the frequency of events per 200 meters on Jalan Ahmad Yani. Therefore, there will be data regarding roadside disturbance from 2 directions of the road section.

Figure 4 Road segment survey location (direction 1, 200 meters)

This data is taken from direct survey results at points 1°06'01"N 104°02'16"E to 1°06'07"N 104°02'19"E (direction 1) and 1°06'08”N 104°02'19”E to 1°05'01"N 104°02'17"E (direction 2) by looking at the vehicles passing through this road segment. The value obtained for the total weighted frequency in direction 1 (**Table 2**) is 705.9 which indicates the roadside disturbance class is high and direction 2 (**Table 3**) is 401.8 which indicates the roadside disturbance class is moderate (the class value is obtained from the determination of the roadside disturbance class).

Table 2. Jalan Ahmad Yani roadside disturbance data (direction 1)

Type of roadside disturbance events	Symbol	Factor weights	Frequency of events	Weighted frequency
Pedestrian	PED	0.5	11	5.5
Parking stopped vehicles	PSV	1	31	31
Vehicles in + out	REV	0.7	898	628.6
Slow moving vehicles	SMV	0.4	102	40.8
Total				705.9

Side friction is the impact on traffic performance from road segment side activity. Side barriers that cause traffic disruption and affect road capacity and performance. The first is pedestrians who walk or cross along the road segment. Is the number of pedestrians walking along the sidewalk and shoulder of the road and crossing along the road segment. One of the elements that need attention in traffic engineering is pedestrians. Usually, in urban areas and central business districts, the movement of pedestrians creates high conflicts with motorized vehicles in traffic, causing quite high accident rates and vehicle delays. Irregular pedestrian paths are a point of conflict with vehicle traffic because pedestrians tend to look for the shortest path. Second is vehicle parking.

Furthermore, motorized vehicles that use the shoulder of the road to stop (vehicle parking) both in a relatively temporary/short or long time. On street parking is very difficult to do on roads with limited space, and parking in such places always creates cases of congestion and driver

confusion which further extends travel time and increases accidents. The third is vehicles entering and exiting the road. Is the number of motorized vehicles going in and out of/to the side/side of the road. Lastly is the slow vehicle. is the number of wheeled vehicles that use human or animal power, such as bicycles, rickshaws, horse-drawn carriages, and strollers, according to the Highways classification system.

Figure 5 Road segment survey location (direction 2, 200 meters)

The results of this study indicate that high roadside activity or side barriers have a significant effect on the level of traffic flow performance. The side resistance factors that greatly affect the speed of traffic flow are slow vehicle factors, road crossing factors, entry and exit vehicle factors, stopped vehicle factors. In addition, capacity values and degrees of saturation (DS) are obtained, the coefficient of determination (r) and changes in variables vehicles entering and exiting the study, stopped vehicles, pedestrians, and slow vehicles all affect the speed of traffic flow.

Table 3. Jalan Ahmad Yani roadside disturbance data (direction 2)

Type of roadside disturbance events	Symbol	Factor weights	Frequency of events	Weighted frequency
Pedestrian	PED	0.5	23	11.5
Parking stopped vehicles	PSV	1	76	76
Vehicles in + out	EEV	0.7	389	272.3
Slow moving vehicles	SMV	0.4	105	42
Total				401.8

Free Flow Speed

Based on IHCM guidelines, the free flow speed is obtained from 2 directions of the road segment. The free flow speed is the average speed of traffic flow when traffic volume (V) is sufficiently low (or not affected by other vehicles). In this research, the author uses the base free flow speed for light vehicle (LV) value because the free flow speed for passenger cars is usually

10-15% higher than other types of vehicles. That way, the free traffic flow speed (FV) for the light vehicle (LV) at 54.72 km/hour (direction 1) and 57 km/hour (direction 2) (**Table 4**).

Table 4 Light vehicle free flow speed (km/hour)

Direction	**Base free flow speed (Vevo)**	**The adjustment factor for lane width (VFW)**	**VFR + VFW**	**Adjustment factor**		**Free traffic flow speed (FV) (km/hour)**
				Roadside disturbance (FFVsf)	**City size (FFVcs)**	
1	57	0	57	0.96	1	54.72
2	57	0	57	1	1	57

Road Capacity

Road capacity (C) is the maximum amount of traffic that can be served by that road segment. Road capacity is obtained based on the results of a survey that has been carried out. To determine road capacity, you can use IHCM guidelines as follows:

$$C = C_0 \; x \; FC_w \; x \; FC_{SP} x \; FC_{SF} x FC_{CS}$$

Road capacity data is taken in 2 directions. The road capacity for direction 1 is 1473.45 pcu/hour and for direction 2 is 1519.98 pcu/hour. If the two data are added together, the road capacity (C) is 2993.43 pcu/hour on that road segment.

Table 5. Jalan Ahmad Yani capacity (pcu/hour)

Direction	Base capacity (C0)	Capacity size adjustment factors				Capacity (C) (pcu/hour)
		Lane width (FC)	Direction separation (FC)	Roadside disturbance FC	City size (FCcs)	
1	1650	1	0.94	0.95	1	1473.45
2	1650	1	0.94	0.98	1	1519.98

Degree of Saturation, Speed, and Travel Time

The degree of saturation (DS) is the ratio of traffic volume (V) (**Table 4**) with road capacity (C) (**Table 5)**. Based on the data that has been recapitulated on Jalan Ahmad Yani, the degree of saturation is 0.52 (direction 1) and 0.54 (direction 2). The average speed (V) value is obtained by looking at the graph of the relationship between the average traffic speed (V) and the degree of saturation (DS) in the IHCM guide. The values of the average speed (V) are 62 km/hour (direction 1) and 64 km/hour (direction 2). After all the data is complete, based on IHCM guidelines, to find travel time (TT) is the ratio between the length of the road segment (L) and the average traffic

speed (V). With a road segment length of 3 kilometers, the travel time (TT) is 180 seconds (direction 1) and 174 seconds (direction 2).

Level of Road Service

Based on IHCM guidelines with the US-HCM 1985 approach, the level of road service is indicated by the degree of saturation. Jalan Ahmad Yani has a degree of saturation value of 0.5. In the road service level, where the degree of saturation is 0.45 to 0.75, the roads have steady traffic flow, speed is not affected by traffic, and traffic is suitable for urban roads.

CONCLUSION

The conclusion that the author got after a direct survey and data that has been processed. Intersection four on Jalan Ahmad Yani obtained the total traffic flow on November 18, 2022, during peak hours at 5490 pcu/hour with a pcu factor of 0.47. The composition of vehicles passing through the road is: light vehicles (LV) by 25%, heavy vehicles (HV) by 4%, and motorized vehicles (MC) by 71%. The free flow speed (FV) of light vehicles (LV) obtained is 54.72 km/hour and 57 km/hour for each lane. The total capacity for Jalan Ahmad Yani is 10407.21 pcu/hour. From the data obtained, the degree of saturation per lane is 0.52 and 0.54, respectively. With an average speed of 62-64 km/hour and a travel time is 174-180 seconds. Jalan Ahmad Yani has a road service level value of C. At a road service level with a degree of saturation of 0.45 to 0.75, the road has a stable traffic flow, speed is not affected by traffic, and traffic is suitable for urban roads. It can be concluded that on Jalan Ahmad Yani there is no traffic congestion during peak hours.

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