THE PERFORMANCE ANALYSIS OF JALAN TENGKU SULUNG IN BOTANIA, BATAM INDONESIA

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ARTICLE INFO

Published: January 17th, 2023
Keywords: Level of service, performance road, secondary collector.

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ABSTRACT

Jalan Tengku Sulung in Botania is a secondary collector road with traffic density. The dense population causes the traffic density on Jalan Tengku Sulung in Botania, damage to road access, and parking activities on the road. For this reason, a study was conducted to analyze the level of road performance on Jalan Tengku Sulung in Botania. The method used in this study is a survey and data analysis method using IHCM 1997. The data used in this study is the primary data in the form of location conditions, road dimensions, number and speed of vehicles. Secondary Data is required in the form of map location, population data, and land use. Based on the analysis that has been done, the degree of saturation at the intersection is 1.43 with LOS F. In contrast, the results of road performance analysis obtained the highest volume of vehicles occurred at 06:45 - 07:00 with a total of 600.6 pcu/hour. Saturation degree value 0.92 with LOS E.

INTRODUCTION

Transportation starts from the development of the vehicle to the road. Although, at present, the traffic and transportation conditions in each region are different. Traffic conditions in the European region are more modern than in developed countries. European countries have used a transportation system called C-ITS (cooperative intelligent transport system). It aims to improve traffic safety and efficiency, energy efficiency, and comfort based on technology and can be combined with various ways to create stand-alone and collaborative vehicle systems (Lu, et al., 2018).

In contrast to developing countries regarding the traffic problems faced. Traffic congestion has become a common phenomenon, one example being Indonesia's capital Jakarta. The government has made many efforts to improve roads and increase investment in transport infrastructure, but soaring public demand for private vehicles has had little impact (Luo, G., B., & L., 2019.). The problem with land transportation is that as the population increases, residents of large cities feel uncomfortable using the available transportation, causing congestion. As a result, the demand for automatic transport will increase, and the number of inhabitants will increase (Ratnawati, 2021). In addition, the disorganization of the public as road users in traffic rules. This is one of the most significant factors in the occurrence of congestion.

The congestion in Indonesia is also felt in the city of Batam. It is not only congestion but also the number of access roads damaged due to poor drainage conditions. This caused flooding to inundate the streets in Batam city. Insufficient surface drainage creates different tensions...
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between the surface cover and the subsurface. Puddles cause the road surface to sink, causing potholes and discoloration (Shaikh, Agrawal, Dengle, Wadekar, & P, 2021).

Not only damage to roads due to the poor drainage system, which is a factor in congestion but also increases the value of the degree of traffic saturation. Controlling parking on the road is also the most important thing to control traffic so that the value of the degree of traffic saturation can be minimized. Roadside parking activities could be more effective. The width of the road used by the shoulder of the road reduces the ability of the road to accommodate the flow of passing vehicles. In order words, the reduction of road capacity (Akbar, Paresa, & Pamuttu, 2021). It is often found on Tengku deciduous street in Botania.

As outlined above, several issues that occur in the world, such as the high number of traffic accidents, traffic accidents, and damaged road access, affect the level of services. The performance of road sections, also known as road services, is usually referred to as speed, freedom of movement, traffic congestion, and safety comfort. The conditions author conducted a case study on Jalan Tengku Sulung Botania. The purpose of this paper is to analyze the performance of the Jalan Tengku Sulung Botania.

LITERATURE REVIEW
The Roads Class

Roads are essential in everyday life because they link from one place to another. However, the road also has many meanings for everyone, one of which is. A road is a land transportation infrastructure that covers all parts of the road, including buildings intended for transportation and facilities located at ground level, below the surface land or water, and above the water level, but excluding railroads, highway trucks, and funicular (Rifai & Aulia, 2019). Roads have various types based on their authority, and roads are divided into 5: national, provincial, city, district, and village.

In addition to the five roads classified just now, as for the low-volume roads. A low-income road serves the socio-economic needs of an area (Pinard, 2003). Such as connecting markets, schools, places of worship, and villages and cities. In most countries, these low-volume roads can be classified according to administrative or political criteria and not on traffic or other road characteristic (Pasindu, 2020). But from the point of view of low-volume road engineering, this needs to be classified according to its functionality, such as traffic (PUPR, 2018). For example, Jalan Tengku Sulung Botania in Batam city is a class III road with details such as secondary collector roads, has a speed of at least 20 km/hour, and has no deviation signaled.

Road conditions affect the rate of traffic accidents. This can be seen from the high number of accidents caused by lighting on the road. This statement is supported by the results of a case study conducted in Mexico over two years that concluded lighting conditions were the most significant variable in the rate of past accidents cross and severe injuries (Kassu, 2019).

Parking on the body of the road is a problem because it can reduce the performance of a road. If this issue is not addressed, it can cause traffic disruptions. From research conducted in Jalan Gajah Mada, Rambipuji Jember produced that. The relationship between the use of parking
spaces and road performance strongly influences each other. With a correlation of 0.8-1.0 which means that parking on the road body reduces road performance and causes traffic disruption (Sulistyono, 2018).

The Interchange Facility

Interchanges are also included in the section of the road that the road system cannot separate. An intersection is where one road crosses another road or an intersection of two or more roads (Setiawan & Budayasa, 2017). The intersection of roads has several types, including signaled deviation and non-signaled deviation. The performance of an intersection is good by identifying the saturated flow of traffic and the fault factor.

The main types of intersections consist of intersections, bends, intersections with roundabouts, and two intersections. As for other essential types of intersections, they are two types. First, there are roads without traffic consisting of the same intersections, unequal intersections, and roundabouts. Secondly, the intersections with traffic are the basis for the intersections, which are uniformity of design, construction, and operation of the crossroads. That intersection should be recognized, visible, understandable, and convenient for passing and walking (Novikov, 2019).

Junction performance identification is the value of intersection performance or the performance of an intersection person used to measure precisely to optimize intersection performance. The values seen as intersection criteria are twofold: saturated traffic and phases. Saturated traffic is the maximum number of units used in a vehicle or hour. Vehicle saturation may be the basis for hourly intersections. The flow at the meeting was different because of some things that affected the saturated flow. Such as climbs and descents at each intersection, combined traffic, and curve radius, there is traffic turning right, and there is traffic coming from the opposite direction of traffic (Muhiuddin, Takallo, & Borzooei, 2020).

A phase is a part of the traffic light cycle that is provided for a specific combination of traffic movements. This phase will be grouped into several parts of the current sub-test. So that we can know the current is moving or the current can be stopped (Muhiuddin, Takallo, & Borzooei, 2020). This phase helps reduce traffic congestion and facilitate traffic flow at every intersection with a density. An example of an intersection with a phase is an intersection with a heavy traffic flow.

The Phenomenon of Congestion

Traffic congestion analysis is attracting more and more attention due to the status of heavy traffic (Vinagre-Diaz, Gonzalez, Wilby, & Richard, 2016). Congestion has a variety of definitions in interpreting it. Congestion is a phenomenon that occurs when the input volume exceeds the output capacity. The result of these congestions is to represent maximum or excessive use of the facility (Stopher, 2004). Several factors affect congestion. Namely traffic density during working hours, vehicle damage, traffic accidents, road work, and damaged road facilities.

In general, heavy traffic conditions can be measured by two categories: spatial congestion and temporal congestion. Spatial or residential congestion is a state of heavy traffic between
vehicles and the road at a given time. Temporal congestion is a density often detected by loop detectors. Temporal congestion is calculated by the percentage of time at the point on the road that the vehicles pass. This temporal congestion can only represent the degree of congestion at the point of space (Wan, Yuan, & Wang, 2017.)

Accidents frequently happen after the post-traffic situation (Paranjothi, Khan, Patan, M, & Atiquzzaman, 2020). Traffic jams can affect the condition of a driver's behavior to be aggressive such as driving a vehicle by speeding. Driver behavior can be analyzed at various levels, such as strategic and tactical behavior, situational awareness behavior, operational behavior, and non-driver behavior. This strategic behavior is like route selection to save time and distance—tactical behavior such as approaching the primary vehicle very closely (Li, et al., 2020).

In studying the influence of traffic jams on the behavior of motorists. Changes in driver lanes and finding that congestion will cause lane changes to be risky. This is analyzed based on the behavior of drivers who drive their vehicles and reported that drivers’ aggressive behavior accelerated after a (Huang, D, J, Zhang, & H., 2018). The aggressive behavior of the driver occurs during peak hours, and repetitive traffic jams occur. This makes drivers experience pressure and stress due to repeated jams causing aggressiveness and increasing speed in their cars.

To analyze traffic flow, traffic characteristics are needed as a measurement parameter. There are three main parameters used in the measurement. Where the relationship of parameters to one another is mathematically related (Setiawan & Budayasa, 2017). The first volume or current is the number of vehicles passing through a specific point on one road at a specific time. It is usually expressed in units of short-term passenger cars per hour (amp/hour). Secondly, traffic density is the number of vehicles that are usually placed in a particular unit of length expressed in units of vehicles per KM (vehicles/Km). Third, traffic speed is the distance that can be traveled in a particular unit of time and is usually expressed (Km/hour).

METHOD

Data is one of the main strengths in compiling scientific research and modeling (Rifai A. I., 2015.). The scientific process must begin with identifying appropriate problems (Rifai A. I., 2016). The road performance analysis research with the case study of Jalan Tengku Sulung in Botania uses quantitative methods, which consist of several stages, starting with data collection techniques using traffic counter applications to analyzing data based on the IHCM 1997. This study will produce an output for calculating the degree of saturation, capacity value, and level of services with determination factors based on the type of road and intersection (IHCM, 1997). This research was conducted during the odd semester of 2022.
The data used to calculate the analysis of road performance and uncited intersections include primary and secondary data (Rifai A. L., 2020). Primary data includes location conditions, road dimensions, vehicle speed, and speed. Meanwhile, the secondary data needed are location maps, data population, and land use. For example, the location chosen by the research on the performance analysis is Jalan Tengku Sulung in Botania, Batam, Indonesia, as seen in Figure 1.

RESULT AND DISCUSSION

Performance analysis of uncited intersections was performed on intersections with two lines. Primary data on road conditions, road widths, and the number of vehicles were obtained by surveying the location of the Jalan Tengku Sulung in Botania. Secondary data from the population can be seen in the central statistic agency. The total population in Batam city reaches 1,196,396 (BATAM, 2020). Data is used to determine the size factor of the city. The following are the results of intersection and road measurements for geometry data:

Table 1. The data of the intersection

<table>
<thead>
<tr>
<th>Description</th>
<th>Major Street</th>
<th>Minor Street</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane Width</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Road Width</td>
<td>2x3.5</td>
<td>2x3.5</td>
</tr>
<tr>
<td>Width of the Shoulder of The Road</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Median Width</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pavement Width</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
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**Figure 2.** Traffic flow

**Intersection traffic data**

In the data, the number of vehicles is calculated with a predetermined emp value at the intersection with an emp lv value of 1.0. For HV value emp is 1.3 and for MC value emp value is set to 0.5, which is the product of the number of vech/hour with emp being pcu/hour. The results of the emp designation are in the graph traffic flow analysis road Figure 3.

**Figure 3.** Traffic of intersection

Determination of the value of the basic capacity seen from the intersection type 322 with a value of 2700 pcu/hour seen in table B-1:1 basic capacity by type intersection. The average approach width adjustment factor (Fw) is determined by looking at the graphic image B-3:1 unsigned intersection IHCM 1997. The median factor of the road is set at 1.00 because Jalan Tengku Sulung in Botania does not have a median. The city size Factor is determined based on secondary data in table 2. The side drag Factor is determined based on Data table 2 about the type of Environment, and for side drag, the ratio of non-motorized vehicles does not exist then set to 0. Then the FRsv value is obtained at 0.93.
In determining the adjustment factor, turn left, right and minor roads. First, set the value of the ratio of left, right, and the minor road turns. The determination of the left turn ratio value based on table B-7 ICHM is 1 Left Turn Ratio (Plt). The value of the Right Turn Ratio is determined based on table B-8: 1 Right Turn Ratio (Prt) by determining the intersection type first. Finally, determination of minor road ratio is determined based on table B-9: 1 minor road flow adjustment factor.

**Table 2.** data on degrees of saturation and delay at intersections

<table>
<thead>
<tr>
<th>Traffic Flow pcu/hour</th>
<th>Degree of Saturation</th>
<th>Interchange Traffic Delays</th>
<th>Traffic Delays on Main Road</th>
<th>Traffic Delays on Minor Road</th>
<th>Interchange Geometric Delay</th>
<th>Junction Delay</th>
<th>Queuing Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Q) 4107,7</td>
<td>(DS) 1,43</td>
<td>(DTI) 58,13</td>
<td>(DTMA) 180,94</td>
<td>(DTMI) 410,39</td>
<td>(DG) 4</td>
<td>(D) 62,13</td>
<td>(QP %) 86%-147%</td>
</tr>
</tbody>
</table>

The densest traffic flow is established at the time of the densest flow. Degree of saturation at the intersection of unsignalized at 1.43. For intersection traffic delay seen in table C-2: 1 intersection traffic delay VS degree of saturation. Main road traffic delays are determined based on table C-2: 2 main road traffic delays VS degree of saturation. Minor road traffic delays and junction delays are set based on the equation in IHCM 1997. Geometry delay set 4. The probability of queuing is determined based on table C-3: 1 queuing probability range (QP%) to the degree of saturation.

In analyzing road performance on Jalan Tengku Sulung in Botania, geometric data were obtained through the survey stage conducted by the author. Data collection on the number of vehicles is carried out by taking a sample of hours as the peak hour. The geometric conditions of the road sections required to perform the calculations are as follows.

**Table 3.** The data of road

<table>
<thead>
<tr>
<th>Street Section Name</th>
<th>Jalan Tengku Sulung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Type</td>
<td>2/2 UD</td>
</tr>
<tr>
<td>Width Lane</td>
<td>3.5</td>
</tr>
<tr>
<td>City Size</td>
<td>Big</td>
</tr>
<tr>
<td>Types Of Environments</td>
<td>Commercial</td>
</tr>
<tr>
<td>Median</td>
<td>-</td>
</tr>
<tr>
<td>Traffic Signs</td>
<td>Flat</td>
</tr>
<tr>
<td>Road Markings</td>
<td>Flat</td>
</tr>
</tbody>
</table>

In determining the geometric condition of the road based on the survey results measuring the road's width and the Jalan Tengku Sulung in Botania. Traffic volume data was taken on
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Wednesday 09/11/2022 at 06:15-07:15. Vehicle volume data retrieval using a traffic counter application was calculated per 15 minutes.

![Traffic of road](image)

**Figure 4. Traffic of road**

Based on the type of Jalan Tengku Sulung in Botania is 2/2 UD, and the total number of vehicles is 3,414 Vech/hour determining the emp HV 1.3. For emp MC value of 0.40 is obtained through the width of traffic lanes measured during the survey. An emp value of LV 1.0 is set. The results of the determination of emp data can be found on the chart traffic flow analysis road figure 4.

**Table 5. Speed data**

<table>
<thead>
<tr>
<th>Basic Free Flow Speed FV0</th>
<th>Adjustment Factor for Bandwidth FV0+FVw</th>
<th>Adjustment Factor for Roadside disturbance (FFvsf)</th>
<th>Free Flow Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>0</td>
<td>0.73</td>
<td>32.12</td>
</tr>
</tbody>
</table>

Table B-1: 1 basic free flow speed (FV0) for urban roads determines the free flow speed. The value of the adjustment factor for Lane width (FVw) is determined through table B-2:1 adjustment factor for the influence of traffic lane width on the speed of free flow of urban light vehicles. Finally, the side drag Factor is determined by table B-3: 1 adjustment factor for the effect of side drag and shoulder width. After all adjustment factors are determined, the resulting free flow velocity is 32.12.

The value of Co is determined based on the type of Jalan Tengku Sulung Botania two-lane undivided road determined by the basic capacity of 2900 pcu/ hour seen in table C-1: 1 basic capacity of urban roads. FCw is determined based on the lane width with a total two-way 7 m and the type of road two lanes undivided 1.00 seen in table C-2:1 capacity adjustment for the influence of traffic lanes for urban roads. FCsp authors set the separation of 50-50 with a value of 1.00, seen from table C-3: 1 capacity adjustment factor for directional separation. The determination of the FCsf value is established through the classes of side obstacles assigned based on the state of the road attached to the figure ( ). The results of VH and effective shoulder width ≤ 0.5 is 0.73, seen in
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table C-4: 1 capacity adjustment factor for the influence of side barriers and shoulder width on urban roads. Determination of FCcs based on the size of Batam city (population) set at 1.00 seen from table C-5: 1 capacity adjustment factor for the size of the city on urban roads. After determining the value of the factors required in the calculation of road capacity obtained, the value of road capacity of 2117.

**Table 6. Analysis of LoS**

<table>
<thead>
<tr>
<th>Time</th>
<th>Traffic Volume (pcu/hour)</th>
<th>Capacity (C)</th>
<th>Free Flow Speed</th>
<th>Degree of Saturation (DS)</th>
<th>Average Speed of The Vehicle (FVlv)</th>
<th>Level of Service (LoS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>06:45-07:00</td>
<td>600.6</td>
<td>2117</td>
<td>32,12</td>
<td>0.92</td>
<td>20</td>
<td>E</td>
</tr>
</tbody>
</table>

The level of service is the level of satisfaction with using road-related road facilities. The value of the level of service is set through the degree of saturation. The level of service is also determined based on the reference taken by US-HCM 1985.

**CONCLUSION**

From the results of a research survey on Jalan Tengku Sulung in Botania and the results of data processing obtained conclusions in the form. Jalan Tengku Sulung Botania is a type of road 322 road with an intersection of 3 arms. The results of the intersection performance analysis have a peak number of vehicles is 4107.7 pcu/ hour. With a degree of saturation of 1.43, intersection traffic delay of 58.13, main road traffic delay of 180.94, minor road traffic delay of 410.39, geometry delay of 4, intersection delay of 62.13, and a chance of queue of 86% -147%. The level of Service intersection analysis obtained F, which means the current is inhibited, low speed, and volume above capacity. For the analysis of the performance of Jalan Tengku Sulung in Botania, the total vehicle flow was 1963.5 pcu/hour with a peak flow of 600.6. The degree of saturation was the road analysis 0.92 with a free flow speed of 32.12 km/h and an average speed of 20 km/hour. The results of the road performance analysis obtained a level of service value E which means unstable current, low speed, and solid volume or close to capacity.

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