The analysis of roadside obstacles to the performance of Syiah Kuala Street

R Musita¹, R Anggraini² and S Sugiar¹²

¹Civil Engineering Postgraduate Program, Department of Civil Engineering, Universitas Syiah Kuala, Banda Aceh, Indonesia
²Department of Civil Engineering, Universitas Syiah Kuala, Banda Aceh, Indonesia

Corresponding e-mail: renimusita@mhs.unsyiah.ac.id

Abstract. Urban roads are the segments that have permanent and continuous development, at least on one side of the road. The purpose of this study is to evaluate the performance of the road due to side constraints on Syiah Kuala Street, to find out how much the operational costs of the vehicle (BOK) based on the side obstacles on Syiah Kuala Street section, and to find out traffic management recommendations by considering subscriber scenarios. The research result indicates that the maximum volume of the vehicle at peak hour is 1987 pcu/hour (on Monday), and the corresponding roadside obstacle is 551.7, which is categorized in the high class. Based on this data analysis result, it is shown that the capacity on Monday is 1998 pcu/hour with the corresponding degree of saturation as much as 0.99. As a result, the level of service is E (unstable flow, obstructed, with intolerable delay). The average travel speed is around 25 km/hour; v/c ratio is 0.85 – 1.00.

1. Introduction

Drivers’ behavior and road users become the main factor of congestion since the lack of discipline of road users. The flow of traffic at the road could be influenced by several factors; one of them was the roadside obstacle.

The roadside obstacle often significantly affects the capacity and performance of the road, especially in an urban area. These roadside obstacles generally are related to pedestrians, people who cross the roads, street vendors, running vehicles, vehicles that stop carelessly, on-street parking vehicles, and other vehicles that go in and out the road-surrounding area through the roadside.

2. Methodology

2.1. Traffic volume

Traffic volume is the number of vehicles that pass a road’s point or cross-section at one time. For the use of design and evaluation, the traffic volume applied is the number of vehicles per hour [1]. The traffic volume defined as equation (1) below:

\[ q = n/T \]  \hspace{1cm} (1)

where:

\( q \) = traffic volume (vehicle/hour/lane);
n = the number of vehicle crossing a section of road at a line, in time interval of T, and
t = time interval observed.

2.2. **Capacity**
The capacity defined as the maximum flow of vehicles crossing a point in a road maintained hourly at a specific condition. For a two-lane and two-way road, the capacity determined by the two-way flow (two-way combination); However, for the multi-lane road, the flow is divided per way, and the capacity is determined by the number of the line [2]. The basic equation to determine the capacity is:

\[
C = C_0 \times FC_w \times FC_{sp} \times FC_{sf} \times FC_{cs}
\]

where:
- \(C\) = Capacity (pcu/hour),
- \(C_0\) = Basic capacity (pcu/hour),
- \(FC_w\) = Road width adjustment factor,
- \(FC_{sp}\) = Adjustment factor of separated way (only for undivided highway or single carriageway),
- \(FC_{sf}\) = Adjustment factor of roadside obstacle or side friction, and
- \(FC_{cs}\) = Adjustment factor of city size.

2.3. **Roadside obstacles**
The roadside obstacle is defined as the roadside activity that could evoke conflict and affect the movement of traffic flow and decrease road performance. The types of road obstacles are described as:
- a. A total number of pedestrians passing or crossing throughout the road;
- b. A total number of vehicles stopping and parking;
- c. A total number of motor vehicles going in and out of the roadside and on the roadside; and
- d. The flow of slow-paced vehicles, which is the total flow “vehicle/hour” of the bicycle, pedicab, ‘delman’, cart, tractor, and others.

The weight of the influence of roadside obstacles is designated in table 1.

| Type of roadside obstacle | Weighting factor |
|---------------------------|------------------|
| Pedestrian                | 0.5              |
| Stopping, parking vehicle | 1.0              |
| Slow-paced vehicle        | 0.4              |
| Street vendor             | 1.0              |

To simplify the roadside obstacles for the benefit of calculating road performance analysis, the Indonesian Road Capacity Manual (MKJI) [2] group them in five different classes from the lowest to the highest. These classes are defined in such a way as shown in the following table 2 below:

| Roadside Obstacle Class (SF<sub>C</sub>) | Code | Total number of weighting factor per 200 m (both sides) | Specific condition                      |
|-----------------------------------------|------|--------------------------------------------------------|----------------------------------------|
| Very Low                                | VL   | <100                                                   | Residential area; streets with a roadside |
By defining the class of roadside obstacles, the value of road width adjustment could also be obtained. The capacity adjustment factor of roadside obstacle (FCsf) with a defined road shoulder is shown in table 3 below:

| Road type | Side Obstacle/ Friction Class (SFC) | Adjustment factor of roadside obstacle and shoulder-width | Average effective shoulder-width Ws (m) |
|-----------|-----------------------------------|--------------------------------------------------------|--------------------------------------|
| Two undivided lane (2/2 UD) or one-way road | Very Low | 0.93 | 0.95 | 0.97 | 0.99 |
| | Low | 0.90 | 0.92 | 0.95 | 0.97 |
| | Moderate | 0.86 | 0.88 | 0.91 | 0.94 |
| | High | 0.78 | 0.81 | 0.84 | 0.88 |
| | Very High | 0.68 | 0.72 | 0.77 | 0.82 |

2.4. Degree of saturation
Degree of Saturation (DS) is defined as the ratio of traffic flow to the capacity which is used as the main factor in determining the performance level of intersection and road segment. The DS value indicates whether the road segment has any capacity segment or not. To measure a degree of saturation of an urban road, an equation is used from MKJI [2] published by the Directorate General of Highway as follows:

$$DS = \frac{Q}{C}$$  \hspace{1cm} (3)

where:
DS = Degree of saturation;
Q = Maximum flow (pcu/hour); and
C = Capacity (pcu/hour).

2.5. Level of service
LOS (level of service) is one of the methods used to measure road performance, which becomes the indicator of congestion. A road considered as having congestion if the calculation result of LOS value is close to 1. The correlation between the level of service, characteristic of traffic flow, and volume ratio to capacity (DS ratio = q/c) is shown in the following table 4.

| Level of Service | Explanation                        |
|------------------|------------------------------------|
| A                | Free flow, Drivers can maintain the desired speed without delay; |
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Average travel speed \( \geq 80 \text{ km/hour} \);  
v/c ratio 0.0 – 0.20.

B Free flow,  
The driver is free enough to choose the speed and lane that is desired;  
Average travel speed decreased to \( \geq 40 \text{ km/hour} \);  
v/c ratio 0.21 – 0.44.

C Free flow,  
The driver has limitations to choose speed, move lanes or overtake;  
Average travel speed decreased to \( \geq 30 \text{ km/hour} \);  
v/c ratio 0.45 – 0.74.

D Close to unstable flow,  
The driver has very limited freedom in running the vehicle;  
Average travel speed decreased to \( \geq 25 \text{ km/hour} \);  
v/c ratio 0.74 – 0.84.

E Unstable flow, obstructed, with intolerable delay;  
Average travel speed around 25 km/hour;  
v/c ratio 0.85 – 1.00.

F The flow is restrained, stuck;  
Average travel speed < 15 km/hour;  
V/C ratio requested exceeds the saturated intersection.

3. Results and discussion

3.1. Research location  
The research was conducted on Syiah Kuala Street in Kuta Alam sub-district. The road is a collector road that has two-lane and two way (2/2 UD) and around 250 meters of road length. The road is located in an education area.

3.2. Data collection  
At this research, data collection specifically conducted on Syiah Kuala Street by adopting the Indonesian Highway Capacity Manual, called MKJI. The supporting data needed in this research were grouped into two types: the secondary data and the primary data. The primary data is data acquired directly from relevant instances.

The survey was conducted for 4 days (Monday, Tuesday, Thursday, and Sunday), at peak hours in the morning, afternoon, and evening, from 07.00 – 09.00 WIB, 12.00 – 14.00 WIB, and 16.30 – 18.30 WIB.

3.3. Data processing

3.3.1. Traffic volume. Traffic volume was obtained by recording every type of vehicle passing the observation point during the time interval of 15 minutes. Then, the traffic volume was processed to be the hourly interval traffic volume. Then, the data was equated into the passenger car unit (PCU) by multiplying the total number of each type of vehicle with the equivalent number of each type of vehicle (passenger car equivalent—PCE).

3.3.2. Roadside obstacle. The type of event and weighting factor is classified as follows:  
a. Total number of pedestrian passing or crossing the road segment (weight=0.5);  
b. Total number of stopping or parking vehicle (weight=1);  
c. Total number of the motor vehicle that was going in and out (weight=0.7);  
d. Traffic flow of slow-paced vehicle (weight=0.4); and  
e. Street vendor (weight=1).
3.4. Data analysis
The analysis conducted includes calculating several parameters affecting the road, such as traffic volume, capacity, roadside obstacle, and degree of saturation. The method implemented is MKJI [2] for the urban road. Result of calculation using this method further calibrated to gain a result that approaches the condition according to the real condition.

3.5. Geometric data of the road
Syiah Kuala Street is a collector road having a length of ± 250 m, two-lane and two way, the pavement width of 7 meters, each lane width of 3.5 meters, and the road shoulder of 1.5 meters each side.

3.5.1. Traffic volume. Retrieval of traffic volume data is carried out at intervals of 15 minutes, for 4 (four) days of observation, 6 hours each day—morning at 07.00 - 09.00 WIB, afternoon at 12.00-14.00 WIB, and evening at 16.00-18.00 WIB. Based on the survey result, table 5 lists the traffic composition obtained during four observation days.

| Day / Date          | Observation time | Type of vehicle | Total Two-way |
|---------------------|------------------|-----------------|---------------|
| Monday/ June 25, 2018 | 07:00 – 08:00    | 1318            | 657.75 11.7 1987 |
| Tuesday / June 26, 2018 | 07:00 – 08:00    | 1221            | 554.75 7.8 1783 |
| Thursday / June 28, 2018 | 07:00 – 08:00   | 1208            | 560 16.9 1785 |
| Sunday / July 01, 2018  | 12:00 – 13:00    | 1177            | 413.5 9.1 1599 |

3.5.2. Roadside obstacle. The calculation of side barriers on Syiah Kuala Street was performed at peak hours based on the MKJI procedure. Each of the factors causing the roadside obstacle is multiplied by the side drag coefficient. The peak hour roadside obstacle occurring at three observation days on Syiah Kuala Street is presented in table 6 below.

| Day     | Time          | Event’s frequency/hour | Weighting frequency | Total      | Class |
|---------|---------------|------------------------|---------------------|------------|-------|
| Monday  | 12.00 – 13.00 | 83 63 586 45 19        | PK_KP_KM_KL_PKPL   | 41.5 63 410.2 18 19 551.7 | H     |
| Tuesday | 12.00 – 13.00 | 62 85 522 71 18        | PK_KP_KM_KL_PKPL   | 31 85 365.4 28.4 18 527.8 | H     |
| Thursday| 12.00 – 13.00 | 64 111 518 47 14        | PK_KP_KM_KL_PKPL   | 32 111 362.6 18.8 14 538.4 | H     |
| Sunday  | 16.00 – 17.00 | 34 43 238 24 0           | PK_KP_KM_KL_PKPL   | 17 43 166.6 9.6 0 236.9  | M     |

where:
- PK : Pedestrians
- KP : Parking vehicles
- KM : Vehicle exit/ enter side road
- PKL : Street vendors
- KL : Slow vehicles
- H : High
- M : Medium

3.6. Capacity
The value of the road capacity is influenced by several factors such as Co (basic capacity), FCW (adjustment factor of the width of the traffic lane), FCSP (adjustment factor for direction separation),...
FCSF (adjustment factor due to side barriers), and FCCS (adjustment factor for city size). The capacity value of the observed road is shown in table 7 below.

| Day     | Co (cpu/hour) | FC_W | FC_SP | FC_SF | FC_CS | C (cpu/hour) |
|---------|---------------|------|-------|-------|-------|--------------|
| Monday  | 2900          | 1    | 1     | 0.84  | 0.9   | 2192         |
| Tuesday | 2900          | 1    | 1     | 0.84  | 0.9   | 2192         |
| Thursday| 2900          | 1    | 1     | 0.84  | 0.9   | 2192         |
| Sunday  | 2900          | 1    | 1     | 0.91  | 0.9   | 2375         |

3.7. Degree of saturation

According to the calculation of capacity mentioned above, the degree of saturation obtained is listed in table 8 below.

| Day     | Maximum flow (cpu/hour) | Road capacity (cpu/hour) | Degree of saturation | LOS |
|---------|--------------------------|--------------------------|----------------------|-----|
| Monday  | 1987                     | 2192                     | 0.91                 | D   |
| Tuesday | 1783                     | 2192                     | 0.81                 | C   |
| Thursday| 1785                     | 2192                     | 0.81                 | C   |
| Sunday  | 1599                     | 2375                     | 0.68                 | A   |

Based on the calculation obtained, the traffic volume (cpu/hour) at the peak hour (07.00 – 08.00 WIB) on Monday, June 25, 2018, is 1987 cpu/hour. On Tuesday, June 26, 2018, the maximum flow recorded, at 07.00 – 08.00 WIB, is 1783 cpu/hour. On Thursday, June 28, 2018, the maximum flow, which was at 07.00 – 08.00 WIB, is 1785 cpu/hour. On Sunday, July 01, 2018, at 12.00 – 13.00 WIB, the maximum flow is 1599 cpu/hour.

The roadside obstacle on Monday was 551.7, which is categorized as a high obstacle; on Tuesday was 527.8, which is considered as a high obstacle; on Thursday was 538.4, which is considered as a high obstacle; on Sunday was 305.7, which is considered in the moderate class. The type of roadside obstacles that dominated this road are vehicles going in or out the roadside. This event causes decreasing vehicle speed, disrupting the traffic flow, and increasing vehicle operating cost (VOC).

According to the result of the data analysis, it is indicated that, on Monday, the capacity is 2192, the saturation degree is 0.91, the LOS is D; on Tuesday, the capacity is 2192, the degree of saturation value is 0.81, and LOS is C; on Thursday, the capacity is 2192, the degree of saturation value is 0.81, and LOS is C; on Sunday, the capacity is 2375, the degree of saturation value is 0.68, and the LOS is A.

4. Conclusion

It can be concluded that the excellent level of service on Syiah Kuala Street will be achieved if the side obstacles are moved to a particular place. Based on the result of research and data analysis conducted, several recommendations are suggested as follows:

1. The one-way street could be applied if the traffic flow is heavy. However, when the flow is normal, the one-way road could be returned into a two-way system (applied at the specific hours).
2. A rigid rule should be required for the street vendor who transacts at the roadside and does wild parking which often inhibits the speed of vehicles.
3. Mass transport should be encouraged, and school transportation should be organized. The bus will take the route scheduled based on the data of students’ residential area and stop at some particular points.
4. The government should apply the strict rules regarding a rearrangement of parking by parallel parking only on one side of the road, so the road or line that will be passed will be wider and the road performance improves.

References
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