The Effects of On-Street Parking toward Street Performance
(Case Study: Kaliurang Street, Yogyakarta, Indonesia)

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Abstract. Street is a transportation infrastructure that people use in daily activities. The quality of street performance greatly affects community activities. Street performance is influenced by various activities around the street. The purpose of this study is to determine the effect of on street parking toward street performance in terms of street capacity and level of service. The study was conducted in three stages, i.e. preliminary survey (determining the time and location of the study), data collection (geometric data of streets, traffic volume, parking volume, pedestrian volume, number of slow vehicles, and access of vehicles from the side of the street), data analysis (calculate streets capacity and level of service. The result of research shows that there is influence of on street parking activity toward street performance in Kaliurang street. The effective width of the street is 10 meters down by 3.6 meters and the street capacity decreases from 3097.5 smp/hour to 2151.5 smp/hour. The decline was caused by various activities on the side of the street such as one on street parking. On a weekday, the morning of the Monday and Thursday, the level of service in Kaliurang Street is at level C, while on the holidays precisely Sunday morning is at level B. The level of street services increased significantly during the afternoon. In the afternoon, the level of street services is at level E on weekday or holiday.

Keywords: on-street parking, street performance, level of service

1. Introduction
The implications of growing and developing an area, whether urban or rural, will certainly increase the needs of the community. Increasing community needs will have an impact on the increasing need for supporting facilities available around it. These facilities will be very necessary as a means of accessibility infrastructure to carry out daily activities. The success of the growth and development of an area is greatly influenced by the good quality of transportation infrastructure [1]. One of the needs that is very important along with the increasing needs of the community is transportation. Vehicles as a transportation tools that humans need for daily activities. The increasing number of transportation will demand street readiness as infrastructure used by various means of transportation.

In essence, the street network has a role and position related to the life of the community. The street also plays a role in controlling the structure of regional development at the national level to the regional level. In Indonesia, the street has become a transportation infrastructure in carrying out the life of the nation and state [2]. Streets have a very large role for the community, therefore the quality of accessibility from a street must be considered. The good quality of the street will make the
community more efficient in its activities both in terms of time and cost. The capacity of a street segment must be able to meet the amount of transportation used by the community.

Indonesia already has many streets with a large capacity in each region, but often activities around the street block the smooth performance of a street. This matter becomes a problem of transportation in Indonesia, especially in developing cities such as the Special Region of Yogyakarta. For example, Kaliurang Street, one of the important street located in the centre of economic activity in Yogyakarta. Along this street there are many shops, restaurants, cafes and several star hotels. The variety of economic activities found along this street will be an attraction for people to come and visit to do various activities. The more people who visit a street, of course, will increase the volume of vehicles on the street.

This increase in volume can impact the lack of available parking space. Available parking space capacity is not able to accommodate all vehicles owned by visitors. This has a negative impact on the street segment because it is used as a parking space. Street capacity will definitely decrease with the parking activities on the street. The decline in street capacity will certainly lead to a decrease in the performance of the street segment. The purpose of this study was to determine the effect caused by street parking (on street parking) on the performance of the street which was viewed from the street capacity and the level of street service.

2. Research Method

2.1. Research Flow

The method used in this study is to use a quantitative approach. This research was carried out in three stages, namely the first stage was the initial survey stage (determining the time and location of the study); the second stage is to collect data; and the third stage is the data analysis stage [3]. Dani Kusmianingrum said that the right method used to determine the performance of the street should start from the initial survey stage, the main survey to collect research data [4]. From some of the opinions above, the flow used in this study is as follows.

![Research Flow Diagram]

Figure 1. Research flow.

2.2. Research Time and Location

The initial survey was conducted at the location to determine the right time to collect data and determine the location for observation. Hari Patmadjaja in his research revealed that the initial survey was conducted to determine the day, observation time interval, division of the parker segment when the traffic flow reached peak hours [5]. From the initial survey results, it was decided to collect data on Monday and Thursday to represent working days, while Sunday was used to collect data representing holidays. Then, the time of observation is done at peak hours. First, in the morning at work (07.00-
08.00 AM). And second, in the afternoon when finished working (15.00 - 16.00 PM). The observation point is determined to be 200 meters along the Kaliurang Street in the ring street area that has quite a number of streets into residential areas.

2.3. Data Collection.
Data collection is carried out in the second stage after the time and location of the study are determined. The data collection phase is carried out by knowing the geometric conditions of the street, the characteristics of traffic flow and parking activities in the street segment that has been determined as the observation point. Street geometric data is collected by measuring the dimensions of the street (street width and shoulder width). Characteristics of traffic flow data are collected by calculating the traffic volume that passes in the peak hour interval, then the vehicle speed is measured by calculating the travel time of the vehicle that crosses the 500 m observation point. Parking data by calculating the number of vehicles entering and leaving parking in an hourly period. Side barriers data (number of pedestrians on streets, vehicle stops, vehicles slow and vehicles in and out of the side of the street) are needed to calculate street capacity.

2.4. Data Analysis
The data analyzed were data on traffic flow volume, parking data, number of pedestrians, number of vehicles that were slow and the number of vehicles in and out of the side of the street.

2.5. Discussion
The discussion is carried out by comparing the condition of traffic flows on weekdays and holidays. From the results of this comparison will show how much influence on-street parking activities on the performance of street segments based on street capacity and level of service.

3. Result

3.1. Street Geometric Data
Kaliurang Street is a street that has an undivided two lane type with a lane width of 5 m. This street has two lanes with a street width of 10 m. This street has a sidewalk width of 30 cm and a pedestrian path width of 1 m. For more details can be seen in Figure 2 below. Based on the initial survey, data collection was carried out twice per day.

![Figure 2. Geometric data of Kaliurang Street.](image)

3.2. Traffic Volume Analysis
Data collection of traffic volume was carried out by 4 surveyors to calculate the number of vehicles passing south to north and from north to south. The number of vehicles crossing the street is calculated using mobile phone applications based on Android “Traffic Counter”. The objects of observation in this survey are all motorized vehicles with heavy vehicle (HV) classification, light vehicle (LV) and also motorcycle (MC) crossing the Kaliurang Street. Based on the survey that was conducted in the
morning and evening, starting on Monday, May 28, 2018, then Thursday, May 31, 2018 and Sunday, May 27 2018, the results of the number of vehicles crossing the Kaliurang Street from south to north and north to south with the details as in table 1 below.

### Table 1. The results of the traffic survey on Sunday 27 May 2018.

| Street segment                  | Peak hours | Time     | Transportation type | Total (vehicle/hour) | Volume (smp/hour) |
|---------------------------------|------------|----------|---------------------|----------------------|-------------------|
| From the north Kaliurang street | morning    | 07.00 – 08.00 | HV      | 5               | 941               | 415.5             |
|                                 | evening    | 15.00 – 16.00 | LV      | 31              | 3991              | 1922.4            |
| From the south Kaliurang street | morning    | 07.00 – 08.00 | HV      | 8               | 1088              | 492.9             |
|                                 | evening    | 15.00 – 16.00 | LV      | 29              | 3929              | 1883.4            |
| Overall total                   |            |           |                     | 73               | 9949              | 4714.2            |

### Table 2. The results of the traffic survey on Monday 28 May 2018.

| Street segment                  | Peak hours | Time     | Transportation type | Total (vehicle/hour) | Volume (smp/hour) |
|---------------------------------|------------|----------|---------------------|----------------------|-------------------|
| From the north Kaliurang street | morning    | 07.00 – 08.00 | HV      | 9               | 2075              | 1146              |
|                                 | evening    | 15.00 – 16.00 | LV      | 24              | 3792              | 1920.9            |
| From the south Kaliurang street | morning    | 07.00 – 08.00 | HV      | 10              | 3162              | 1689.8            |
|                                 | evening    | 15.00 – 16.00 | LV      | 20              | 3530              | 1775.1            |
| Overall total                   |            |           |                     | 63               | 12559             | 6531.8            |

### Table 3. The results of the traffic survey on Thursday 31 May 2018.

| Street segment                  | Peak hours | Time     | Transportation type | Total (vehicle/hour) | Volume (smp/hour) |
|---------------------------------|------------|----------|---------------------|----------------------|-------------------|
| From the north Kaliurang street | morning    | 07.00 – 08.00 | HV      | 11              | 2026              | 1119.5            |
|                                 | evening    | 15.00 – 16.00 | LV      | 27              | 3852              | 1949.65           |
| From the south Kaliurang street | morning    | 07.00 – 08.00 | HV      | 11              | 3034              | 1625.7            |
|                                 | evening    | 15.00 – 16.00 | LV      | 25              | 3727              | 1884.7            |
| Overall total                   |            |           |                     | 74               | 12639             | 6579.55           |

3.3. **Street Section Capacity Analysis**

To calculate the capacity of street sections, the data must be collected, among others, basic capacity, adjustment factors due to the width of the traffic lane, adjustment factors due to direction separators, and adjustment factors due to side barriers.
3.4. Basic Capacity.
Basic capacity can be known by analyzing the geometric conditions of the street to be carried out by the research. As is well known, the Kaliurang Street is a flat urban street with two types of undivided two-way lanes, the basic capacity according to the 1997 Indonesian Street Capacity Manual (MKJI) with a value of 2,900 smp/hour.

3.5. Adjustment Factors Due to Traffic Line Width (Fcw).
Based on geometric data, the width of the Kaliurang Street with the two-lane two-way type is 10 m. Parking conditions on this street are 180° straight parking in the direction of the street. In the event of one-layer on street parking on both edges of the lane, the traffic lane width is reduced by 3.8 m. So that the width of an effective traffic lane to be used is 6.2 m. Based on the MKJI traffic line width adjustment factor table in 1997, the Fcw value is 0.896.

3.6. Adaptive Separation Factor (FCsp).
Based on the results of the survey that has been carried out, then on the Kaliurang Street for separation of the direction of SP with a ratio of 50 - 50 percent so that the FCsp value is obtained based on the 1997 MKJI table 1.

3.7. Adjustment Factors Due to Side Obstacles (FCsf).
Based on the survey results, obtained the number of pedestrians, parking, vehicles in and out of the side of the street and slow vehicles. From table 4, 5 and 6 can be seen the number of weighted Sunday is 236.9, 189.5, 232.7 then the side barriers in the Kaliurang Street are categorized as low. Based on geometric data, the shoulder width of the Kaliurang Street is 0.3 m, so it can be seen from the MKJI 1997 table that the FCsf value is 0.92.

| Type of side barriers | Symbol | Weight factor | Frequency of events | Weighted frequency |
|-----------------------|--------|---------------|---------------------|--------------------|
| Pedestrian            | PED    | 0.5           | 50                  | 25                 |
| Parking, Vehicle Stop | PSV    | 1             | 166                 | 166                |
| Vehicles Enter and Exit Side of the Street | EEV    | 0.7           | 53                  | 37.1               |
| Slow Vehicle          | SMV    | 0.4           | 22                  | 8.8                |
| Total                 |        |               |                     | 236.9              |

Table 4. FCsF value of Kaliurang Street on Sunday 27 May 2018.

| Type of side barriers | Symbol | Weight factor | Frequency of events | Weighted frequency |
|-----------------------|--------|---------------|---------------------|--------------------|
| Pedestrian            | PED    | 0.5           | 37                  | 18.5               |
| Parking, Vehicle Stop | PSV    | 1             | 135                 | 135                |
| Vehicles Enter and Exit Side of the Street | EEV    | 0.7           | 44                  | 30.8               |
| Slow Vehicle          | SMV    | 0.4           | 13                  | 5.2                |
| Total                 |        |               |                     | 189.5              |

Table 5. FCsF value of Kaliurang Street on Monday 28 May 2018.
Table 6. FCsF value of Kaliurang Street on Thursday 31 May 2018.

| Type of side barriers                        | Symbol | Weight factor | Frequency of events | Weighted frequency |
|----------------------------------------------|--------|---------------|---------------------|--------------------|
| Pedestrian                                   | PED    | 0.5           | 51                  | 25.5               |
| Parking, Vehicle Stop                        | PSV    | 1             | 159                 | 159                |
| Vehicles Enter and Exit Side of the Street   | EEV    | 0.7           | 58                  | 40.6               |
| Slow Vehicle                                 | SMV    | 0.4           | 19                  | 7.6                |
| Total                                        |        |               |                     | 232.7              |

3.8. City Size Adjustment Factor (FCcs).

Based on data from the Central Statistics Agency (BPS) of Sleman Regency, the total population in Depok Subdistrict is 188,771 people. From these data, FCcs can be obtained based on 1997 MKJI table of 0.9. This factor is very necessary to see the level of density of a city. City density describes the number of productive activities carried out to exceed the capacity of the existing transportation network [6].

From the data above, it can be obtained the values to determine the capacity of the Kaliurang Street by using the equation of street capacity according to MKJI 1997 as follows [7]:

\[
C = C_0 \times F_{cw} \times F_{cs} \times F_{csf} \times F_{cs}
\]

\[
C = 2900 \times 0.896 \times 1 \times 0.92 \times 0.9
\]

\[
C = 2151.5 \text{ smp/jam}
\]

Table 7. Kaliurang Street capacity.

| Analysis factor | Reduced effective path width | Not reduced effective path width |
|-----------------|------------------------------|----------------------------------|
|                 | Sunday | Monday | Thursday | Sunday | Monday | Thursday |
| Co (smp/hour)   | 2900   | 2900   | 2900     | 2900   | 2900   | 2900     |
| FCw             | 0.896  | 0.896  | 0.896    | 1.29   | 1.29   | 1.29     |
| FCsp            | 1      | 1      | 1        | 1      | 1      | 1        |
| FCsf            | 0.92   | 0.92   | 0.92     | 0.92   | 0.92   | 0.92     |
| FCcs            | 0.9    | 0.9    | 0.9      | 0.9    | 0.9    | 0.9      |
| C (smp/hour)    | 2151.5 | 2151.5 | 2151.5   | 3097.5 | 3097.5 | 3097.5   |

From Table 7 it can be seen that the street capacity between working days and holidays has the same ratio. This means that the activity of traffic flow on the Kaliurang Street tends to be almost the same. On holidays there is a slight increase in on street parking activities on Kaliurang Street, because along this area there are cafes and restaurants that are used by the community as a place to greet one another. Then, the table above shows the significant difference in street capacity between street conditions that have on street parking activities and those that are not on street parking. This is in line with the opinion of Purbanto that the existence of on street parking affects the performance of street segments [8].

3.9. Performance Analysis of the Street Section

Street segment performance analysis can be calculated using V/C ratio analysis. V/C Ratio analysis is done by comparing the value of the traffic volume that has been multiplied by the passenger car equivalence number (EMP) with the value of the street capacity that has been calculated based on side
obstacles such as on street parking. The high value of V / C Ratio obtained is influenced along with the increase in traffic volume and reduced capacity on a street segment due to other activities on the side of the street. For more details, it can be seen as described in the table 8.

Based on the results of the study, the activity on the Kaliurang Street increased higher in the afternoon than in the morning. As seen, on Monday afternoon the V/C ratio reached 0.86 while in the morning it was only 0.66. Then on Thursday afternoon, the V/C ratio was 0.89 while in the morning it was only 0.64. Then the last Sunday which is a working holiday, the V/C ratio increases significantly on this Kaliurang Street. This is inversely proportional to the morning which tends to get a very small V/C ratio of 0.21. The case on this Sunday morning showed that the less traffic volume will increase the street capacity due to the lack of on-street parking vehicles which are obstacles to the performance of the street.

| Day     | Time   | Volume | Capacity | Ratio |
|---------|--------|--------|----------|-------|
| Monday  | 07.00 - 08.00 | 1417.9 |          | 0.66  |
|         | 15.00 - 16.00 | 1848   |          | 0.86  |
| Thursday| 07.00 - 08.00 | 1372.6 | 2151.5   | 0.64  |
|         | 15.00 - 16.00 | 1917.2 |          | 0.89  |
| Sunday  | 07.00 - 08.00 | 454.2  |          | 0.21  |
|         | 15.00 - 16.00 | 1902.9 |          | 0.88  |

4. Discussion

The discussion is carried out by comparing the characteristics of traffic on weekdays and holidays. Data collection for working days is on Monday and Thursday, while data collection for holidays is done on Sundays. The results of this discussion will show the level of service performance of the Kaliurang mesh segment as described in the following table.

| Day/Date   | Time     | V/C | LOS | Traffic condition (MKJI 1997)                                      |
|------------|----------|-----|-----|-------------------------------------------------------------------|
| Sunday 27 Mei 2018 | 07.00 – 08.00 | 0.21 | B   | The current is stable, but the operating speed starts to be limited by traffic conditions. Drivers have enough freedom to choose speed. |
|            | 15.00 – 16.00 | 0.88 | E   | Traffic volume approaches or is at an unstable current capacity, sometimes stopping |
| Monday 28 Mei 2018 | 07.00 – 08.00 | 0.66 | C   | The current is stable, but the speed and motion of the vehicle are controlled, the driver is limited in choosing speed |
|            | 15.00 – 16.00 | 0.86 | E   | Traffic volume approaches or is at an unstable current capacity, sometimes stopping |
| Thursday 31 Mei 2018 | 07.00 – 08.00 | 0.64 | C   | The current is stable, but the speed and motion of the vehicle are controlled, the driver is limited in choosing speed |
|            | 15.00 – 16.00 | 0.89 | E   | Traffic volume approaches or is at an unstable current capacity, sometimes stopping |

From the results of the research in table 9, there are differences in traffic conditions during the morning. On Monday and Thursday the traffic conditions were crowded, crowded and tight, but traffic flow was still smooth and stable. Although the driver is not free to determine the speed of the vehicle,
the vehicle is still running. But on Sundays, the condition of traffic flow is more loose and stable. In this situation, the speed of the vehicle can be determined by the driver quite freely.

There was a difference in the condition of traffic flow on Kaliurang Street on weekdays and holidays. Even though the differences did not seem too significant, there was a decrease in the performance of the street sections on weekdays and holidays. Traffic conditions that are classified as smooth in the morning are also due to the lack of commencement of trade activities and other economic activities along the Kaliurang street. This condition caused the absence of many side obstacles such as on street parking that were seen in the morning on the Kaliurang street.

However, other conditions appear to be very significant based on the results of the afternoon study. In the afternoon precisely on weekdays like Monday and Thursday, the condition of the traffic flow along the Kaliurang Street section looks very dense, tight and unstable. The visible situation of the afternoon is the time when the community has finished working and rushes to the journey home. This situation attracts a lot of vehicle access that crosses the Kaliurang Street because this street is one of the connecting streets between Yogyakarta City and Sleman Regency. For conditions during workdays such as Sundays, it is inversely proportional to the morning conditions as described previously.

On Sunday afternoon, the condition of the traffic flow along the Kaliurang Street looks quite crowded and tight. Although in general, people are on vacation and resting. But the condition of the Kaliurang Street does not show a decrease in activity as found during work. This can be caused because in the afternoon, economic activity and trading activities on the street are very much popular with the community. This condition makes traffic conditions along the Kaliurang Street segment have relatively the same level of service on weekdays and holidays.

5. Conclusion

Based on the results of the data analyst and discussion, it can be concluded from this study that there is an influence of on street parking activities on the performance of street segments, especially the Kaliurang Street. On street parking activities caused a reduction in the effective width of the street for traffic flow of 3.6 m, causing a decrease in street capacity. Kaliurang Street based on geometric conditions has a capacity of 3097.5 smp/hour. However, with the on-street parking activity, the street capacity has decreased to 2151.5 smp/hour.

Then, based on the performance of the street, the performance of the Kaliurang Street on weekdays and holidays looks different although not too significant. On Monday and Thursday working days, the level of service of the Kaliurang Street is at level C in the morning peak hours. This condition shows the condition of traffic flow on the street segment is stable, although the speed and movement of the vehicle is quite limited but the state of traffic flow remains smooth. There is a difference on holidays such as the Sunday morning, the state of the traffic flow is at level B. The state of the traffic flow at this level shows a steady flow, and the drivers are free enough to determine the speed of the vehicle.

Significant differences are seen in the afternoon, the performance of the street on Kaliurang Street is at level E on weekdays and holidays. This level shows that the traffic flow is close to an unstable category, the condition of the vehicle that is melted sometimes experiences a stop. The many economic activities and trade activities that have been carried out by the community in the afternoon affect the performance of the street along the Kaliurang Street both on work and on holidays.

6. Recommendation

Based on the results of the study, it is expected that the local government and the owners of economic activities to provide large parking spaces so as not to cause on-street parking activities along the Kaliurang Street. The government has to find a new parking alternative, along the street there is no empty land that can be used for parking. Neighborhood settlements can be used as an alternative. Residents can be involved to utilize vacant land in their neighborhood for parking space so that it can be an additional source of income for the surrounding residents.

In addition, the government must also continue to improve the performance of public transportation both in terms of service or the extent of access that can be reached. Public transportation is the right
solution to reduce the excess volume of vehicles that pass on public streets and increase the intensity of pedestrians. Therefore, the better the performance of public transportation and the more comfortable, safe and good the pedestrian infrastructure will optimize the performance of a street segment at a very good level of service and far from obstacles.

7. References

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