

## **ANALYSIS OF TRAFFIC FLOW PERFORMANCE AND CAPACITY ON CAPTAIN ISMAIL STREET, TEGAL CITY**

**Bambang Istiyanto<sup>1</sup>, Alfah Baharuddin<sup>2</sup>, Anisa Tegar Murdianingtyas<sup>1</sup>, Putu Linda Wahyuni<sup>1</sup>, Suci Sekar Mukti<sup>1</sup>**

<sup>1</sup>Rekayasa Sistem Transportasi Jalan, Politeknik Keselamatan Transportasi Jalan, Jl Perintis Kemerdekaan No. 17 Tegal, Central Java 52125, Indonesia

<sup>2</sup>Teknik Rekayasa Otomotif, Politeknik Keselamatan Transportasi Jalan, Jl Perintis Kemerdekaan No. 17 Tegal, Central Java 52125, Indonesia

\*[bambangistiyanto@pktj.ac.id](mailto:bambangistiyanto@pktj.ac.id)

### **ABSTRACT**

Tegal City is among of the cities where the population density is rather high. This causes high vehicle volumes and congestion at several points on the road. Street Captain Ismail is a road with a high level of activity and traffic jams at spesific times. The objective of this is with the purpose to recognize the elements that contribute to traffic flow on Captain Ismail road, so that ways can be suggested to overcome traffic jams that arise. This study uses numerical data from traffic volume, road capacity, road width and speed as data processing material. This study employs a literature study methodology, wich entails a thorough examination of the relevant literature namely by conducting an analysis based on MKJI 1977. The results of the research show that vehicle volume will continue to increase during holidays because this road section becomes an alternative route to the center Tegal City. The side resistance class in this area is low with a side resistance value of 224.1. The planned hourly volume data is 48.11 and the average speed on this road section is 38.9 - 40 km/hour. Based on data obtained, the Street Captain Ismail section has a service level of A with a degree of saturation of 0.24.

Keywords: road capacity; road width; traffic congestion; vehicle volume

### **INTRODUCTION**

Transportation is an important mode that is very necessary to fulfill all processes of moving the needs of goods and services, as well as people in today's life (Karim, 2023). The level of population density in an area will influence transportation performance in managing vehicle traffic on the road and serving community needs (Aminah, 2018). In urban environments, most of the population increases due to births and urbanization (Noverina, 2017). Transportation is a labor product that allows individuals to carry out their tasks more easily, which can help a region's growth and economic development. Transportation's purpose in economic development is to increase human demands by changing the geographic location of people and things; in addition, transportation serves as a way of linking to assist development activities (Soelistyo Pribadi et al., 2023). Transportation development is achieved by the creation of various infrastructures (Prih Raharjo et al., 2022). A transportation system consists of factors and interactions that create demand for travel within a certain region and provide transportation services to meet that need. Almost every aspect of a social and economic system in a region interacts to some extent (Cascetta, 2009).

Highways are a means of land transportation that forms a transportation network to connect one area to another, so that the wheels of the economy and development can run well (Istiyanto & Jannah, 2020). Economic activities generate journeys that connect one land function to another land function (Mahadita Chandra Rahayu et al., 2022). With transportation, of course there will be various things types of problems (Istiyanto & Tito Paksi, 2020), As traffic congestion worsens, researchers have created traffic flow models to better comprehend complex traffic phenomena (Lin et al., 2013). Accurate and trustworthy highway network information is critical for managing linear objects and utilities, as well as allocating funds for development and maintenance (Kotov & Pospelov, 2017)

Tegal City is included in the province of Central Java which has a high population density. A city is categorized as a dense city because there is an increase in population which is not followed by an increase in area (Mahendra, 2016). The increase in population can be caused by high birth and death rates, as well as due to population migration (Cahya, 2021). The more densely populated an area is, the more vehicles will be used (Mustikarani, 2016). This incident can cause traffic jams on several roads in the city of Tegal. Congestion in Tegal City is caused by an imbalance in the increase in vehicle volume and road capacity every year. Apart from that, people are not clearly aware of using public transportation because it is not suitable, such as the "tuyul bus". Generally, traffic jams occur during busy times, occurring in the time period 06.00 to 09.00 WIB and also 15.00 to 18.00 WIB (Maer, 2019). Captain Ismail street is a road with a high level of activity. The high volume of vehicles on the road causes problems with the smooth flow of traffic. Many activities are hampered during peak hours. On this road, there are vendor stands on the pedestrian walkway, forcing many pedestrians to use the road. Apart from that, vehicles public transportation such as public transportation or "ghost buses" often pass through this road and there is a process of boarding and descending passengers along the road, this can result in a decrease in speed for passing vehicles and reduce the capacity of the road.

In accordance with the problems above, it is necessary to carry out research and analysis to find out how to identify traffic problems on Street Captain Ismail, how to analyze traffic flow performance using the MKJI 1977 method, and find out whether there is a relationship between traffic volume and traffic flow capacity in easing traffic jams. the road area. Through this research, it is hoped that we can present other options or ways to overcome the traffic challenges that arise along Captain Ismail street.

## **METHOD**

This research uses numerical data from traffic flow, road capacity, road width and speed as data processing material. This research utilizes a literature review technique, which means that the literature has been investigated in detail in this related study, namely by conducting an analysis based on MKJI 1977 (Nazir and Sikmumbang, 2009). Then, using a quantitative approach to analyze speed data, calculations were carried out using the 85th percentile speed method. Not only that, this research used qualitative methods to review the variable data that had been obtained (Raco, 2010; Gunawan, 2022). A study was carried out to determine the characteristics of traffic conditions and the elements that trigger traffic density on Street Captain Ismail as part of the aim of this research. So that a solution can be obtained to handle road traffic safety problems on Captain Ismail street, Tegal City.

## **RESULTS**

### **Data Obtaining Result**

The information needed for this review is original information (primary data) and information obtained through indirect methods (secondary data). Primary data can be information obtained directly during field surveys. Meanwhile, secondary data can be obtained from the results of surveys, censuses, mapping, etc.

### **Road Geometric Data**

Contains information relating to the physical and geometric characteristics of a highway. This data is important for use in planning, design, construction and maintenance of road infrastructure.

### **Geometric situation of the road**

- a. Road category: 2/2 UD
- b. Road segment distance: 1000 m

- c. Road width: 8 m
- d. Middle of the road: none
- e. Alignment type: flat
- f. Road markings: present (most of them are faded)
- g. Road shoulder: 1 m

### Vehicle flow

The types of vehicles that use Street Captain Ismail include:

- a. Small vehicles (LV): passenger cars, public transport, pick up.
- b. Large vehicles (HV): buses and 2 axle trucks
- c. Motorcycle (MC)
- d. Non-motorized vehicles (UM): trishaws and bicycles

### Side Obstacles

On Captain Ismail Street there is a school and office area. Apart from that, there are many food stalls on the side of the road. So, in this area, there is an additional obstacle, where the vehicle parking area uses part of the road as a place to wait for passengers or when stopping in front of a food stall. Not only that, on this section of road there is no area for pedestrians in the form of a sidewalk, causing pedestrians to walk on the edge of the road. Side obstacles on this road section include:

- a. Pedestrian
- b. Park and vehicle stops
- c. Vehicles enter and exit
- d. Slow vehicle

### Information About Vehicle Flow And Vehicle Composition

Vehicle flow information obtained from direct monitoring results was then carried out every 15 minutes for 3 hours on the Captain Ismail Street section. The data obtained through the calculation process is vehicle flow volume data based on vehicle type which includes small vehicles (LV), large vehicles (HV), and motorbikes (MC). Then, a study of the amount of traffic flow is carried out and the peak hour is looked for to determine the peak hour. The results of data on the number of traffic vehicles can be found in the table below.

Table 1.  
 Results of a total 2-way vehicle flow volume survey on Thursday, June 15 2023

Captain Ismail Street, Tegal City				
Times	Type of Vehicle			Total Vehicles Vehicle/Hour
	LV	HV	MC	
07.00-07.15	21	3	160	184
07.15-07.30	19	2	138	159
07.30-07.45	19	0	132	151
07.45-08.00	11	2	126	139
08.00-08.15	10	0	134	144
08.15-08.30	16	1	118	135
08.30-08.45	16	0	118	134
08.45-09.00	12	4	106	122
09.00-09.15	14	2	102	118
09.15-09.30	14	1	100	115
09.30-09.45	18	0	130	148
09.45-10.00	10	0	112	122

Table 2.  
 The number of vehicles at peak hours on Thursday, June 15 2023  
 Captain Ismail Street, Tegal City

Time	Type of Vehicle			Total Vehicle Vehicle/hour
	LV	HV	MC	
07.00 - 08.00	70	7	556	633
08.00 - 09.00	54	5	476	535
09.00 - 10.00	56	3	444	503
180	15	1476		1671
18	2	147		167

From the results of direct observations on Captain Ismail Street in the table above, the busy time of vehicle flow was between 07.00 – 08.00 AM , the number reached 633 vehicles/hour, which was dominated by motorbikes, namely 1476 vehicles/hour at the time of observation.

Table 3.  
 Results of a total 2-way vehicle flow volume survey on Friday, June 16 2023  
 Captain Ismail Street, Tegal City

Times	Type of Vehicle			Total Vehicles Vehicle/Hour
	LV	HV	MC	
07.00-07.15	25	4	167	196
07.15-07.30	19	2	145	166
07.30-07.45	20	4	135	159
07.45-08.00	15	2	125	142
08.00-08.15	15	2	131	148
08.15-08.30	14	0	122	136
08.30-08.45	20	1	115	136
08.45-09.00	11	4	105	120
09.00-09.15	16	2	100	118
09.15-09.30	15	0	103	118
09.30-09.45	18	1	119	138
09.45-10.00	11	0	113	124

Table 4.  
 The number of vehicles at peak hours on Friday, June 16 2023  
 Captain Ismail Street, Tegal City

Time	Type of Vehicle			Total Vehicle Vehicle/hour
	LV	HV	MC	
07.00 - 08.00	79	12	572	663
08.00 - 09.00	60	7	473	540
09.00 - 10.00	60	3	435	498

It can be seen from the table above that the busy time of the vehicle flow occurs during 07.00 – 08.00 AM the number reaches 663 vehicle/hour.

### Capacity and Performance Study of Road Sections Applying the MKJI 1977 Method on the Captain Ismail Street Section

#### Total Current (Q)

The traffic flow figure (Q) refers to the total number of vehicles passing through a location in a certain time period. Described in passenger car units (PCU). All traffic flow values are converted into passenger car units and multiplied by the same number of passenger cars (emp) per vehicle. From the results of observations for 2 days, survey data was obtained which had

the highest number which took place on Friday, June 16 2023 at 07.00 – 08.00, the number reached 633 vehicles/hour. The Captain Ismail Street section, Tegal City has a two-lane road without division (2/2 UD), along with emp for undivided urban roads based on MKJI.

Table 5.  
 The Value of emp

Tipe Street : Undivided Tipe Street	Total traffic flow is two-way (Vehicle/hour)	HV	emp	
			MC	
			Width of traffic lanes $W_c$ (m)	
			≤ 6	>6
Two-lane undivided (2/2 UD)	0 ≥ 1800	1,3 1,2	0,5 0,35	0,40 0,25
Four-lane undivided (4/2 UD)	0 ≥ 3700	1,3 1,2		0,40 0,25

The total traffic flow in 2 directions is > 1800, so based on the table above, the EMP values for vehicles on urban roads are revealed, namely:

- a. Small vehicle (LV) = 1.0
- b. Large vehicle (HV) = 1.3
- c. Motorcycle (MC) = 0.4

After the emp value for each vehicle is found, then the value (Q) for that lane is calculated using the formula:

$$Q = [(emp_{LV} \times LV) + (emp_{HV} \times HV) + (emp_{MC} \times MC)]$$

Table 6.  
 The results of each Q calculation for comparison

Date and Time	Waktu	LV	HV	MC	Q PCU/hour
Thursday, 15 June 2023	07.00 - 08.00 AM	70	9,1	222,4	301,5
Friday, 16 June 2023	07.00 - 08.00 AM	79	15,6	228,8	323,4

From the results of observations, in general the traffic on Captain Ismail street is congested during rush hours because on the shoulder of the road there are activities along the road in the form of traders and buyers as well as people who want to worship and go home/going to work. So on weekends the traffic flow increases because many people are on holiday and want to try the culinary delights in the area.

### Analysis of side obstacles during busy vehicle flow times

When looking for side obstacle classes, based on MKJI 1997 they can be classified into 4 types of events, namely as follows:

Table 7.  
 Type of side obstacles

Type of side obstacles	Weight
Pedestrian	0,5
Public transportation and other vehicles stop	1,0
Vehicles enter and exit the side of the road	0,7
Slow vehicle	0,4

During 2 days of observations, side obstacle data was obtained on the Captain Ismail Street section. Following are the results of the observations:

Table 8.  
 Results of weighted frequency calculations for total side obstacles in 2 directions on Street Captain Ismail on Thursday, June 15 2023

Type of side obstacles	Weight factor	Frequency of Occurrence	Wweighted Frequency
Pedestrian	0,5	52	26
Public transportation and other vehicles stop	1	65	65
Vehicles enter and exit the side of the road	0,7	154	107,8
Slow vehicle	0,4	45	18
Total			216,8

Table 9.  
 Results of weighted frequency calculations for total side obstacles in 2 directions on Street Captain Ismail on Friday, June 16 2023

Type of side obstacles	Weight factor	Frequency of Occurrence	Wweighted Frequency
Pedestrian	0,5	56	28
Public transportation and other vehicles stop	1	60	60
Vehicles enter and exit the side of the road	0,7	167	116,9
Slow vehicle	0,4	48	19,2
Total			224,1

Calculation of road capacity by considering road side obstacles based on activities in the road environment. Based on Figure 1 below, side obstacles in the road environment are calculated.

Side Frictions Class (SFC)	code	Number Of Incident Weights Per 200 M Per Hour (Two Sides)	Special Conditions
Verry Low	VL	< 100	residential areas, roads with side frictions
Low	L	100 – 299	residential areas, some public transportation
Middle	M	300 – 499	industrial area, some shops on the side of the road
High	H	500 – 899	commercial areas, high road side activity
Verry High	VH	> 900	commercial area with market activities next to the road side

Figure 1. Side Resistance Class Value

From the results of frequency calculation values which are weighted by side obstacles in a total of 2 directions on Street Captain Ismail, Tegal City, it can be seen that the highest frequency on Friday, June 16 2023 was 224.1. So the SFC side obstacle class for Street Captain Ismail, Tegal City is classified as low (L) with residential areas, some public transportation, etc. The large number of residents carrying out activities along the road in the form of street vendors, buyers, parked cars, and vehicles going in and out of small alleys causes an increase in the number of side obstacles in the area at weekends and an increase in traffic volume.

### 1. Capacity

The road capacity on Street Captain Ismail, Tegal City can be determined using the following formula:

$$C = Co \times FCw \times FCsp \times FCsf \times FCcs \text{ (smp/jam)}$$

Information :

- C = Capacity
- Co = Basic Capacity

FCw	= Traffic lane density adjustment factor
FCsp	= Direction separation adjustment factor
FCsf	= Side obstacles adjustment factor
FCcs	= City size adjustment factor

- The basic capacity of the Captain Ismail Street section for the two-lane undivided road type has a basic capacity of 2900 pcu/hour for a total of both directions based on the 1997 MKJI.
- The capacity adjustment factor is due to the width of the traffic lane (FCw), with an effective lane width ( $W_c$ ) = 8m, based on MKJI 1997, a capacity adjustment value of 1.14 is obtained due to the width of the traffic lane.
- The capacity adjustment factor due to direction separation (FCsp), based on MKJI 1997, the value of direction separation (50-50) has a value of 1.
- The capacity adjustment factor due to side obstacles (FCsf) for a two-lane undivided road, low side resistance class and an effective shoulder width of 1 m, obtained a capacity adjustment factor value due to side obstacles of 0.94.
- Capacity adjustment factor for city size (FCcs) based on BPS data in 2013. Tegal City has a population of 243,860 people, the value of the capacity adjustment factor for city size is 0.9.
- Once the values of all factors are known, the capacity value of the Captain Ismail Street section can be determined using the following equation:

$$\begin{aligned} C &= C_o \times FCw \times FCsp \times FCsf \times FCcs \text{ (smp/jam)} \\ &= 2900 \times 1,14 \times 1 \times 0,94 \times 0,9 \text{ (smp/jam)} \\ &= 2796,87 \text{ (smp/jam)} \end{aligned}$$

From the calculated values above, it is known that the capacity of the Captain Ismail Street section during busy vehicle flow times is 2796.87 pcu/hour.

## 2. Degree of Saturation

From the results of capacity calculations, we can get the value of the degree of saturation using the method of vehicle flow volume (Q) divided by the road capacity value (C), here is the calculation process.

$$\begin{aligned} DS &= Q/C \\ &= 663/2796,87 \\ &= 0,24 \end{aligned}$$

From the results of calculating the degree of saturation above, it can be revealed that the DS on Captain Ismail, Tegal City is 0.24.

## 3. Speed

Spot speed studies evaluate the distribution of vehicle speeds in traffic on a street. The speed characteristics determined in a research are only applicable to the current traffic and environmental conditions, as well as segments with similar traffic and geometry features to the study area (Garber & Hoel, 2009). The data obtained was calculated using the 85 percentile method. Determining a speed limit that matches the speed data of vehicles crossing the road segment being analyzed is the goal of calculations using the 85 percentile speed method. So, in this way you can reach the appropriate speed limit on the Captain Ismail Street section with the available speed data. Speed at the 85th percentile is the speed at which 85% of drivers drive their vehicles on the road without being affected by slower moving vehicles on slow roads or adverse weather conditions. In simple terms, the speed at the 85th percentile reflects the speed generally used by the 85th percentile of drivers,

describing the speed often encountered in the field. According to Minister of Transportation Regulation no. 111 of 2015, it is explained that the speed limit on collector roads in the city is around 50 km/hour, while 30 km/hour is the maximum speed on residential roads. The following is the formula for determining percentile values.

$$P_i = T_b + \left( \frac{x_n - F_k}{F_i} \right) \cdot 100$$

The following is a recap of data from research on vehicle speeds on Street Captain Ismail, Tegal City on Thursday, June 15 2023 using the 85 percentile method, while speed data was obtained from 2 directions of vehicles on Captain Ismail street.

Table 10.  
 Percentile 85 method Thursday, June 15 2023

Reach Speed (Km/hour)	Middle Value (Km/hour)	Frequency (f)	Frequency percentage	Cumulative frequency percentage	fx
1	2	3	4=(3/Total)*100	5	6=2*3
1 sd 10	5	0	0	0	0
11 sd 20	15	5	3,0	3,0	75
21 sd 30	25	35	21,0	24,0	725
31 sd 40	35	109	65,3	89,2	3815
41 sd 50	45	15	9,0	98,2	945
51 sd 60	55	3	1,8	100,0	165
61 sd 70	65	0	0	0.0	0

The table above refers to calculations using the 85th percentile speed approach on Thursday, June 15 2023 for 2 directions on the Captain Ismail Street section, with a range of vehicle speeds during field observations, the number is calculated at a speed of 10 km/hour, while the average is taken from middle number of speed range. The frequencies obtained from calculating the mass of the vehicle at the time of observation have been grouped based on speed range. For frequency percentage, this is the result of dividing the total frequency then multiplying by 100, then the frequency percentage results are added together to find the 85th percentile of driver speed. To find the 85th percentile a calculation is carried out,

$$P_i = T_b + \left( \frac{x_n - F_k}{F_i} \right) \cdot 100$$

$$P_{85} = 20,5 + \left( \frac{85 - 3}{21} \right) \cdot 5$$

$$P_{85} = 20,5 + \left( \frac{82}{21} \right) \cdot 5$$

$$P_{85} = 20,5 + (21) \cdot 5$$

$$P_{85} = 20,5 + 19,5 = 40 \text{ km/ jam}$$

Table 11.  
 Percentile 85 method Friday, June 16 2023

Reach Speed (Km/hour)	Middle Value (Km/hour)	f	Frequency percentage	Cumulative frequency percentage	fx
1	2	3	$4=(3/Total)*100$	5	$6=2*3$
1 sd 10	5	0	0	0	0
11 sd 20	15	2	1.2	1.2	30
21 sd 30	25	31	18.2	19.4	775
31 sd 40	35	114	67.1	86.5	3990
41 sd 50	45	23	13.5	100	1035
51 sd 60	55	0	0,00		0
61 sd 70	65	0	0,00		0

The table above refers to calculations using the 85th percentile speed approach on Friday, June 16 2023 for 2 directions on the Captain Ismail Street section, with a range of vehicle speeds during field observations, the number is calculated at a speed of 10 km/hour, while the average taken from the middle number of the speed range. The frequencies obtained from calculating the mass of the vehicle at the time of observation have been grouped based on speed range. For frequency percentage, this is the result of dividing the total frequency then multiplying by 100, then the frequency percentage results are added together to find the 85th percentile of driver speed. To find the 85th percentile, calculations are carried out. Calculation results,

$$Pi = Tb + \left( \frac{i}{100 \times n - 1,2} \right) \frac{P}{F}$$

$$P_{85} = 30,5 + \left( \frac{85 - 1,2}{100} \right) \frac{18,2}{18,2} \times 4$$

$$P_{85} = 20,5 + \left( \frac{85 - 1,2}{100} \right) \times 4$$

$$P_{85} = 20,5 + 18,41 = 38,9 \text{ km/ jam}$$

Table 12.  
 Resume percentile 85 method data during observation

Date and Time	Lower Speed (km/hour)	Higher Speed (km/hour)	Total Speed data	Speed of Percentile 85 (km/hour)
Thursday, June 15 2023	18	56	167	40
Friday, June 16 2023	17	44	170	38,9



Figure 2. vehicle speed recapitulation graph for Thursday, June 15 2023



Figure 3. Vehicle speed recapitulation graph for Friday, June 16 2023

Based on the speed calculation value for the 85th percentile method above, the speed value that is usually used by 85 percent of drivers along the Captain Ismail Street section is found to be in the range of 38.9 - 40 km/hour. In this study, no difference was found between movement speed and road plan speed. By applying the 85th percentile speed method, it was found that the speed that occurred in the field did not exceed the design speed of the road. Vehicle speed is influenced by several factors, namely the presence of intersections, roadside vendors and vehicles parked on the side of the road.

#### 4. Traveling time

Travel time studies cover the substantial lengths of a facility or combination of facilities that comprise a route. Information on travel time between important places within the research region is gathered and utilized to identify portions that require improvement (Roess et al., 2011).

$$V = \frac{L}{TT}$$

Information :

- V = LV chamber average velocity (km/hour)
- L = Segment length (km)
- TT = Average LV travel time along the segment (hour)

From the calculation results obtained,

Table 13.  
 Results of calculating vehicle travel time in 2 days

Date and Time	known	Calculate
Thursday, June 15 2023	L = 1000 m = 1 km V = 40 km/h	$L$ TT = $V$ = 0,025 jam = 90 detik
Friday, June 16 2023	L = 1000 m = 1 km V = 38,9 km/h	$L$ TT = $V$ = 0,0257 jam = 92,52 detik

From the calculation results table above, it can be seen that the difference in travel time between Thursday and Friday is 2.52 seconds.

## 5. Level of Service

Based on the process of calculating the degree of saturation, it can be concluded that the degree of saturation that occurs on Street Captain Ismail, Tegal City is 0.24 and can be categorized as Street Captain Ismail as having a service level of A because the DS value is  $\leq 0.7$  based on MKJI 1997 with the service situation very optimal, where the vehicle can move smoothly.

## CONCLUSION

Based on the discussion regarding the performance and capacity analysis of the road, Captain Ismail can provide several conclusions, including: The volume of vehicle flow on this road segment will increase during holidays or weekends because this road section becomes an alternative route to the center of Tegal City. Side obstacles have increased and traffic volume has increased due to the large number of people parking on the shoulder of the road. The vehicles that use this road are mostly small vehicles (LV), large vehicles (HV), motorbikes (MC) and non-motorized vehicles (UM). The side resistance class in this area is low with a side resistance value of 224.1. Side obstacles in the area are street vendors, vehicles parked to buy food, going in and out of small alleys, as well as people who want to worship in places of worship around the area. After obtaining vehicle volume data, the planned hour volume data was obtained at 48.11. Based on the results of calculations using the 85th percentile speed approach, the average speed on this road section is 38.9 - 40 km/hour. This road section is a secondary collector road, according to Minister of Transportation Regulation No. 111 of 2015, it is explained that the speed limit on collector roads in the city is around 50 km/hour, while 30 km/hour is the maximum speed on residential roads. This means that the speed data obtained is in accordance with the planned speed according to the road design. Street Captain Ismail, Kota has a service level of A, with a degree of saturation of 0.24. The recommendation from the

results of this research is that it is necessary to provide special sidewalks for pedestrians so as not to hinder traffic flow activities. Apart from that, it is necessary to repaint the markings to make it easier for road users to see and identify important information from the markings.

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