Analysis of Accident Risk Points (Black Spots) on the Bubutan – Perak Barat Road Section Surabaya

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ABSTRACT

According to the traffic accident data from the Traffic Accident Unit of the Tanjung Perak Port Police and the Traffic Accident Unit of the Dukuh Pakis Police in Surabaya City in 2020-2022, traffic accidents that occurred on the Bubutan Road - West Perak Road section experienced an increase in the number of traffic accidents. The total details in 2021 were 13 incidents, in 2022 there was an increase to 17 incidents, besides that, the material losses incurred in 2022 had the highest figure, which amounted to IDR 46,000,000. So it is necessary to analyze the accident-prone points on the road section. The method used are AEK (Accident Equivalent Number), IPA (Importance Performance Analysis) method, and calculation of free flow speed, traffic volume analysis, and side obstacle analysis. Based on the analysis of accident-prone areas using the AEK method, it is known that the upper control limit value is 36.07 where Jalan Perak Barat has an AEK value above the BKA value in 2021 of 37, then in 2022 of 40. Jalan Perak Barat has an average traffic volume of 434.47 smp / hour, with a moderate level of side obstacles, but has a free flow speed that exceeds the planned speed. One of the factors causing traffic accidents on Jalan Perak Barat is the driver of a vehicle traveling at high speed, so rumble strip planning and road facility rejuvenation are recommended.

Keywords: *Accident-Risk Areas; Accident Rate; AEK Method; Black Spot; IPA Method.*

INTRODUCTION

Traffic accidents are a common problem in cities with heavy traffic. The city of Surabaya has a heavy traffic flow that often causes traffic accidents. An area located on the north side of Surabaya City, namely the Bubutan Road - West Perak Road section has an increasing number of accidents and a high amount of material losses.

According to data on traffic accidents in 2021-2022, the Traffic Accident Unit of the Dukuh Pakis Police Station and the Traffic Accident Unit of the Tanjung Perak Port Police, it is known that there was an increase in the number of traffic accidents that occurred on the Bubutan Road - West Perak Road section from 13 incidents in 2021, then in 2022 it increased to 20 incidents with details of the number of death victims as many as 2 people and minor injuries as many as 15 people. The highest material loss is also known in 2022, which amounted to IDR 46,000,000.

According to traffic accident data from the Tanjung Perak Port Police Traffic Accident Unit and the Dukuh Pakis Police Traffic Accident Unit in 2020-2022, a total of 48 traffic accidents were recorded. With total material losses for the 3 years reaching Rp 61,100,000. The number

of victims and the number of material losses from these traffic accidents certainly make people, especially road users, feel uncomfortable and unsafe passing through the Bubutan - Perak Barat road section.

Traffic accidents often occur on roads with high volumes of vehicles. Events that cost lives and materials can occur due to human factors and road facilities. With these problems, it is necessary to analyze the accident-prone areas on the Bubutan - Perak Berat Road section using the Accident Equivalent Number (AEK) method and then determined by the Upper Control Limit (BKA) method to determine the vulnerable points of traffic accidents, the Importance Performance Analysis method to determine the level of vulnerability and the factors that influence the causes of accidents based on the results of the questionnaire.

MATERIALS AND METHODS

This research uses primary and secondary data. Primary data was obtained by direct observation at the research location. Meanwhile, secondary data was obtained from the Tanjung Perak Port Police Traffic Accident Unit and the Police Traffic Accident Unit. Primary data is data obtained from direct observation or survey of objects in the field, which includes the following data:
1. Traffic volume data and average vehicle speed
2. Questionnaire of factors causing traffic accidents

Secondary data obtained from related agencies as follows:
1. Data on traffic accident victims
2. Characteristics of vehicles involved in the accident
3. Material loss in an accident
4. Age of the perpetrator of the accident victim
5. Type of traffic accident collision

The steps of secondary and primary data analysis can be seen in Figure 1.
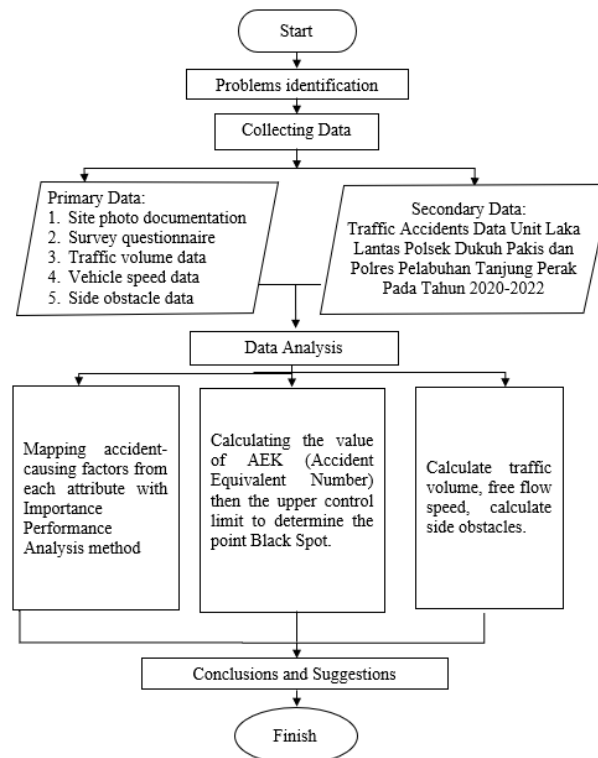

Figure 1. Research flow chart

Materials

1. Definition of Road

   According to Law No. 38 of 2004 concerning roads, roads are land transportation infrastructure that includes all buildings intended for traffic, which are above ground (Mulyadi et al., 2018). A highway is a road for public traffic with a minimum of 2 (two) lanes in each direction.

2. Factors Causing Accidents

   Factors that cause traffic accidents include:
   a. Road user factors
   b. Vehicle factors
   c. Road factors
   d. Environmental factors

3. Traffic Accident Probability Value

   The probability value of a traffic accident is used to determine how likely it is that a random accident will occur. Probability is divided into two types, namely single opportunities and conditional opportunities (Parsa, 2013). The general formula for probability is:

$$P(A) = \frac{(number\ of\ events\ A)}{(total\ of\ data)} \tag{1}$$

4. Accident Prone Areas (Blackspots)

   Blackspots or accident-prone areas are road sections with unusual accident rates (Yandi et al., 2020). The ranking of accident locations can be done with the approach of accident risk rate and quality control statistics, or weighting based on accident equivalent value (AEK). With the calculations that have been carried out, the location of traffic accidents can be identified as accident-prone areas if the calculated value of the accident equivalent rate is greater than the upper control limit value as a parameter determining a traffic accident prone point.

5. Calculation of Accident Equivalent Number (AEK)

   Determination of the location prone to traffic accidents is carried out based on the number of accidents on each road section that has an AEK value weight exceeding a certain limit value. Accident Equivalent Number is a number for ranking or weighting accident classes (Bolla et al., 2013). The accident rate can be determined by the following formula:
   $$AEK = 12\ MD + 3\ LB + 3\ LR + K \tag{2}$$

6. Upper Control Limit (BKA) Calculation

   The upper control limit value is influenced by the average value of the accident equivalent number in an area with a period of one year. The upper control limit value is formulated as follows:
   $$BKA = C + 3\sqrt{C} \tag{3}$$

7. Importance Performance Analysis

   Importance Performance Analysis is a method used to categorize various elements of the collected data and identify actions that need to be taken. Before mapping into a Cartesian diagram, the first step is to determine the average value of each attribute, namely the average value of the $\bar{X}$ and $\bar{Y}$ attributes. The formula used to determine the average value of each attribute is as follows:
   $$\bar{X} = \frac{\sum \bar{X}_1}{k} \tag{4}$$

$$\bar{Y} = \frac{\sum \bar{Y_1}}{k} \tag{5}$$

After knowing the average value, the grouping is carried out into the Cartesian diagram of the Importance Performance Analysis method shown in Figure 2 below.
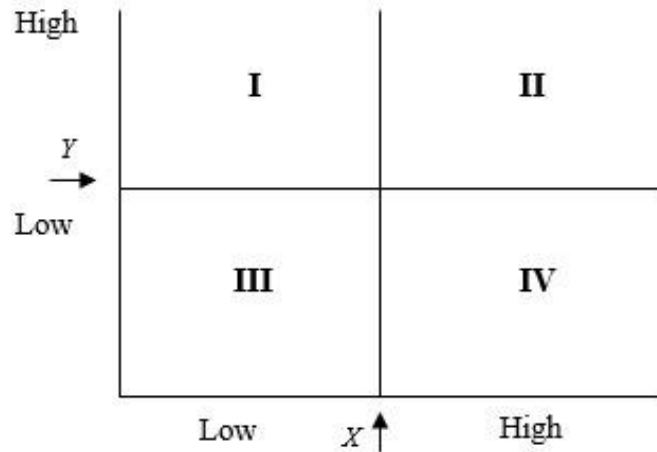

Figure 2. Cartesian diagram of Importance Perfomance Analysis (IPA) method

8. Validity Test

The validity test is a test whose purpose is to determine whether a measuring instrument is valid or invalid. The measuring instrument referred to here is a questionnaire. A questionnaire is said to be valid if the questions on the questionnaire can reveal what the questionnaire measures (Janna & Herianto, 2021). The formula used for the validity test is:

$$r = \frac{n\left(\sum XY\right) - \left(\sum X\right)\left(\sum Y\right)}{\sqrt{\left[n\sum X^2 - \left(\sum X\right)^2\right]\left[n\sum Y^2 - \left(\sum Y\right)^2\right]}} \tag{6}$$

9. Reliability Test

A reliability test is an index that shows the extent to which a measuring instrument can be trusted or relied upon. So that the measuring instrument can be consistent if repeated measurements are made many times. The formula used for the reliability test is:

$$r_{11} = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum \sigma_t^2}{\sigma_t^2}\right) \tag{7}$$

10. Aspects of Road Safety

Road safety is an effort to reduce the number of traffic accidents in traffic by considering the factors that cause accidents, including vehicle factors, human factors, road factors, and environmental factors. Road safety analysis is carried out to identify the possibility of traffic accident events for road users and other influencing factors (K. Amelia et al., 2011). Road safety aspects include road safety management, roads that meet road safety aspects, vehicles that meet safety aspects, and road users who meet safety aspects.

RESULTS AND DISCUSSION

1. Condition of Bubutan-Perak West Road Section

The research location reviewed is the road from the front of BG Junction Mall on Bubutan Road and ends at the Ministry of Transportation Office of the Directorate

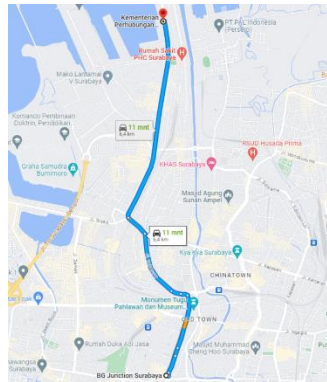General of Sea Transportation Class 1 Navigation District Surabaya along 6.5 km as shown in Figure 3 below.

Figure 3 : Lokasi penelitian

2. Questionnaire Analysis Results

    The number of respondents required is 100. The characteristics of the respondents are shown in the following figure.
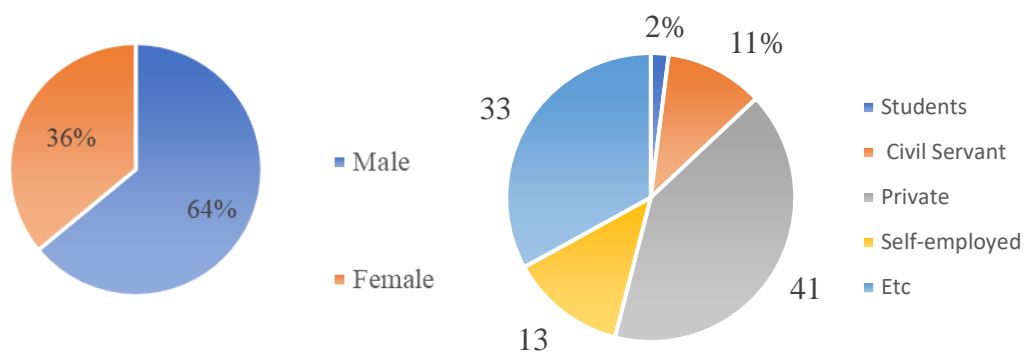
Figure 4. Respondents based on gender and jobs

3. Importance Performance Analysis (IPA)

    The Importance and Performance Analysis (IPA) method can be used to determine the order of service priority levels, as measured by the level of conformity. Calculation details can be seen in Table 2 below. In the Cartesian diagram presented in Figure 5, it can be seen the grouping of the attributes of each factor that resulted in the occurrence of traffic accidents in each segment on the Bubutan - Perak Barat Road section (STA 0+00 - STA 6+500) in each quadrant.

Table 2. Calculation of the average assessment of perception and reality and quadrants

| No	QUESTION	Suitability Level (%)	Quadrant
A. Road Factor			
1	Faded road marking colors	83.23%	IV
2	The bumpy asphalt road	75.94%	IV
3	The potholed road	94.70%	III
4	The existence of activities	80.07%	III
B. Environmental Factors			
5	The existence of activities	93.96%	III
6	Street lighting that is off or damaged	90.38%	II
7	Slippery and waterlogged roads	85.44%	I
8	The existence of road intersection activities	99.68%	II
C. Rider Factors			
9	A motorist who does not turn on his turn signal	93.31%	II
10	Motorists traveling at high speed	85.48%	II
11	Driving a vehicle while tired or drowsy	76.32%	IV
12	Drivers who precede from the right by violating road markings	92.39%	II
D. Vehicle Factor			
13	Vehicle lighting and brake lights are out or damaged	80.17%	I
14	Brakes that are not functioning properly	73.28%	I
15	Excessive vehicle load causes the vehicle to be unstable	97.78%	III
16	Worn tires cause skidding	79.18%	I
	Total		I
	Suitability Level (%)	86.33%	
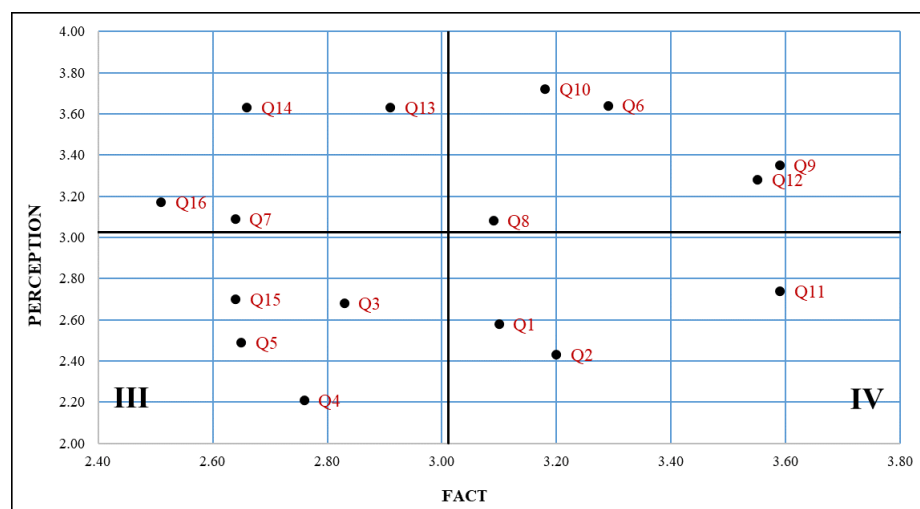
Figure 5. Cartesian diagram of the results of respondents' assessment of the factors causing traffic accidents on the Bubutan - Perak Barat Road section (STA 0+00 - STA 6+500)

4. Blackspot Analysis Using The IPA Method

An area can be declared as an accident-prone area if the AEK value exceeds the upper control limit value (AEK > BKA). The results of the Black Spot point analysis calculation can be seen in Table 3.

Table 3. AEK and BKA values

Segment	Year	Vehicle Type	Number of Events	AEK	BKA
1	2020	Died	0	7.00	36.07
		Serious Injury	0		
		Minor Injuries	2		
	2021	Died	1	19.00	36.07
		Serious Injury	0		
		Minor Injuries	2		
	2022	Died	0	10.00	36.07
		Serious Injury	0		
		Minor Injuries	3		
2	2020	Died	0	28.00	36.07
		Serious Injury	1		
		Minor Injuries	8		
	2021	Died	0	13.00	36.07
		Serious Injury	0		
		Minor Injuries	4		
	2022	Died	0	22.00	36.07
		Serious Injury	0		
		Minor Injuries	7		
3	2020	Died	1	31.00	36.07
		Serious Injury	0		
		Minor Injuries	6		
	2021	Died	2	37.00	36.07
		Serious Injury	0		
		Minor Injuries	4		
	2022	Died	2	40.00	36.07
		Serious Injury	0		
		Minor Injuries	5		

5. Traffic Volume Data Analysis

Survey data on the volume of vehicle traffic density on Jalan Bubutan - Perak Barat (STA 0+00 - STA 6+500) was taken during the morning peak hour (08.00-10.00 WIB), afternoon (12.00-14.00 WIB) and evening (16.00-18.00 WIB) for four consecutive days, namely September 11th to 14th, 2023 which are presented in the following table.

Table 4. Traffic Volume Data Analysis

Date, Day	Average Traffic Vol. on Segment To-		
	I	II	III
Monday, September 11th, 2023	347,90	399,64	324,74
Tuesday, September 12th, 2023	353,70	404,87	314,18
Wednesday, September 13th, 2023	329,30	404,87	339,02
Thursday, September 14th, 2023	330,43	397,27	329,02

6. Analysis of Basic Free Flow Speed of Vehicles

Based on PKJI (2014), the free flow speed can be calculated by dividing the length of the road section by 50 meters per segment. Free flow speed survey data was taken during the morning rush hour (08.00-10.00 WIB), afternoon (12.00-14.00 WIB), and evening (16.00-18.00 WIB) during the morning rush hour.

Table 5. Average vehicle speed

Date, Day	Average Vehicle Speed on Segment To-		
	I	II	III
Monday, September 11th, 2023	41,22	40,62	41,44
Tuesday, September 12th, 2023	41,41	40,81	41,66
Wednesday, September 13th, 2023	41,34	40,77	41,59
Thursday, September 14th, 2023	41,39	40,68	42,01

7. Side Barrier Analysis

Side barrier data was taken for 4 days during peak hours. The following is an analysis of each side obstacle segment:

Table 6. Side Barrier Analysis

Date, Day	Average Side Barriers on Segment To-		
	I	II	III
Monday, September 11th, 2023	534,80	486,73	344,60
Tuesday, September 12th, 2023	521,40	477,63	289,73
Wednesday, September 13th, 2023	513,10	473,30	335,63
Thursday, September 14th, 2023	505,83	463,50	329,13

8. Free Flow Speed Analysis

Analysis about free flow speed can be seen on the following tables.

Table 7. Free Flow Speed Analysis

Segment I				
Vehicle Types	Free Flow Speed (km/hour)			
	Monday	Tuesday	Wednesday	Thursday
MC	45,42	45,65	45,67	45,82
LV	42,42	42,65	42,50	42,64
HV	35,45	35,46	35,48	35,53

Segment II				
Vehicle Types	Free Flow Speed (km/hour)			
	Monday	Tuesday	Wednesday	Thursday
MC	45,29	45,44	42,43	42,60
LV	42,46	43,58	43,54	43,29
HV	36,84	36,88	37,05	39,96
Segment III				
Vehicle Types	Free Flow Speed (km/hour)			
	Monday	Tuesday	Wednesday	Thursday
MC	40,68	41,03	41,70	42,57
LV	39,51	39,85	39,70	39,92
HV	36,55	36,68	36,94	36,97

Discussion

In the calculation of traffic volume, free flow speed, and side obstacles that have been carried out, a conclusion is obtained that when the traffic volume and side obstacles have high values, the free flow speed of a road section is low. Conversely, if the traffic volume and side barriers have low values, the free flow speed of a road section is high.

In the calculation of the equivalent number that has been done, the segment identified as an accident-prone point is segment three of Jalan Perak Barat. On Jalan Perak Barat, the average traffic volume is 434.47 smp/h, the value of side obstacles obtained from the survey results and weight calculations obtained an average value of 313.30 which is included in the range of medium side obstacles (300-499), with an average free flow speed on Jalan Perak Barat of 41.71 km / hour.

CONCLUSION

Based on the results of research that has been carried out on the Bubutan Based on the results of research that has been carried out on the Bubutan - Perak Barat Road section (STA 0+00 - STA 6+500), it can be concluded as follows:

1. The dominant factors that cause accidents on the Bubutan - Perak Barat Road section are street lighting that is dead or damaged so that it affects vision at night, the existence of road intersection activities resulting in traffic accidents, drivers not turning on the penny lights when winding, drivers who are traveling at high speed, and drivers who precede from the right by violating road markings.
2. Segments that are at risk to traffic accidents or Black Spots were identified on Jalan Perak Barat in 2021 with an AEK value of 37.00 and in 2022 of 40.00. Where the accident equivalent number value exceeds the upper control limit value.
3. The average traffic volume contained in segment three which is identified as an accident-prone point with an average of four consecutive days is 434.47 smp / hour, and the value of side obstacles obtained with an average of 313.30 which is included in the range of moderate side obstacles (300-499), the average free flow speed on Jalan Perak Barat is 41.71 km/hour.
4. Alternative solutions that can be done to reduce the occurrence of accidents on the Bubutan - Perak Barat Road section are repairing damaged street lighting so that it can function at night, adding speedbumps to reduce the speed of motorized vehicles, and adding vehicle speed limit traffic signs.

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