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Analysis of High-Risk Traffic Accident Areas on Tegar Beriman Road, Bogor Regency

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Abstract
This study aims to identify accident-prone areas and evaluate the road segment performance on Tegar Beriman Road, Bogor Regency, to enhance traffic safety. The methods used include the Accident Equivalent Number (AEK), Upper Control Boundary (BKA) and Upper Control Limit (UCL) to determine blackspot segments, as well as an analysis of saturation degree (DS), free-flow speed, road capacity, and level of service (LOS) based on the Indonesian Road Capacity Guidelines (PKJI) 2023. The study results indicate that five road segments (11, 12, 15, 16, and 18) are categorized as blackspots, with AEK values ranging from 68 to 86, exceeding the BKA (64.58) and UCL (54.30–61.55) values. The primary causes of accidents are drivers' negligence (36%), loss of vehicle control (25%), and excessive speed (20%), with the most common type of accident being side collisions (42%) and the highest frequency occurring at night (46%). The road segment performance analysis shows that the highest saturation degree (0.67 eastbound, 0.65 westbound) occurs in the evening, with a level of service (LOS) categorized as C, indicating congested but stable traffic conditions. To improve safety, recommendations include speed limitations, enhanced lighting, improved road markings, and stricter supervision, particularly during high-risk accident hours. Periodic evaluations and further studies are necessary to ensure the effectiveness of safety policies and reduce the accident rate on this road segment.

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Keywords: Traffic accidents, accident-prone areas, blackspot, AEK, BKA, UCL, road segment performance, level of service, Indonesian Road Capacity Guidelines (PKJI), Tegar Beriman Road

1. Introduction

Tegar Beriman Road, the main focus of this study, functions as a collector road connecting the Bogor Regency government centre with various residential and commercial areas. As a result, the traffic volume on this road is relatively high. This road frequently uses various types of vehicles, including motorcycles, private cars, public transport, and heavy vehicles such as trucks (Albayati & Lateef, 2019; Obaidat & Ramadan, 2012) [1, 15]. High traffic volume, especially during peak hours, increases the risk of accidents, particularly if road infrastructure conditions are inadequate (Isradi *et al*, 2022) [8].

The geometric and physical conditions of Tegar Beriman Road are among the main factors contributing to the high accident rate. Some road sections feature sharp curves, intersections without clear traffic signs, and varying road widths. Additionally, damaged road surfaces, including cracks, potholes, and water puddles during rainfall, worsen the situation (Isradi, Prasetijo, *et al*, 2024; Isradi, Rifai, *et al*, 2024) [9, 12]. The lack of safety facilities such as traffic signs, road markings, and adequate lighting makes it difficult for drivers to anticipate hazards, especially at night or during bad weather (Sukirman, 1994) [17].

The presence of mixed traffic, where small vehicles like motorcycles share the road with heavy vehicles such as trucks and buses, further increases the risk of accidents. Speed and vehicle size differences create potential conflicts, especially when drivers are undisciplined or violate traffic rules (Hartatik *et al*, 2020) [7]. This situation is exacerbated by reckless driver behavior, particularly during heavy traffic or under poor road conditions (Isradi, Dwiatmoko, *et al*, 2024) [9].

Tegar Beriman Road was chosen as the primary focus of this study due to growing concerns over the high number of accidents occurring there (Athiappan *et al*, 2022; Kalantari *et al*, 2021) [2, 13]. Traffic accident statistics in Bogor Regency reveal an alarming trend, with increasing yearly accidents and fatalities. According to the latest data, Tegar Beriman Road has a higher accident rate than the average in other areas of the regency (Bogor Regency Transportation Agency, 2024). The findings of this study are expected to contribute to developing more effective strategies and measures to reduce traffic accidents in this area, ultimately improving safety and the quality of life for Bogor Regency residents. Moreover, an efficient transportation system can connect regions and significantly influence economic growth (Kinasih *et al*, 2022) [14].

2. Research Methodology

This study utilizes primary and secondary data from field surveys and accident records from the Bogor Police Traffic Unit. The analytical methods employed include:

- AEK, BKA, and UCL to determine accident-prone segments
- Road performance analysis based on traffic volume, saturation degree (DS), and level of service (LOS)
- Road condition surveys to assess factors contributing to accidents

A. Research location and time

This study was conducted on Tegar Beriman Road, Bogor Regency. Traffic surveys were carried out on weekdays and weekends during peak and off-peak hours. The survey was conducted on Tuesday, November 16, 2024, from 09:00 – 10:00 WIB and 16:00 – 17:00 WIB

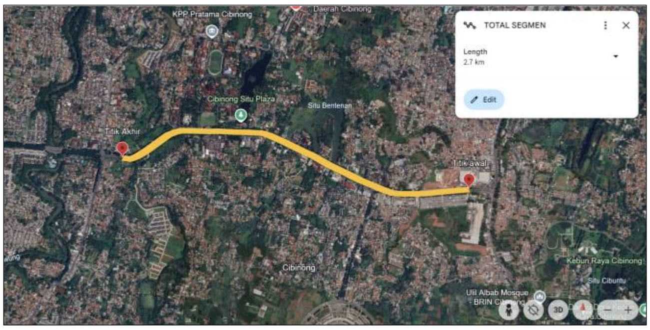

Fig 1: Research Location Map

B. Data Collection

The data used in this study consists of both primary and secondary data. Primary data was obtained through field surveys to identify the physical conditions of Tegar Beriman Road, including an inventory of safety facilities such as traffic signs, road markings, and road surface conditions. The survey was conducted using cameras, GPS, and manual recording forms. Secondary data was obtained from the Traffic Unit (Satlantas) of the Bogor Regency Police and the Bogor Regency Transportation Department, covering traffic accident data. This data includes the number of accidents, types of accidents, accident locations, and victims (fatalities, major injuries, and minor injuries) (Firdaus *et al*, 2021, 2022).

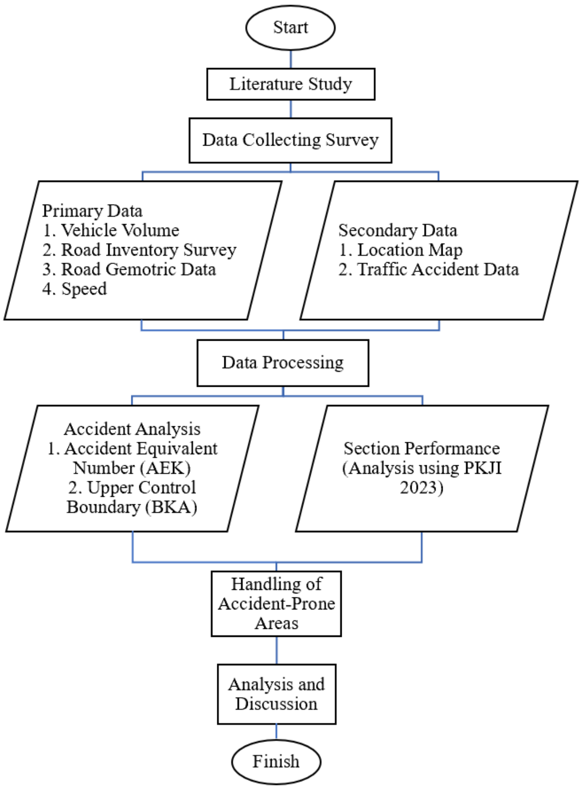

Fig 2: Research Flowchart

C. Data processing and analysis

In this study, data processing was done by analyzing secondary data obtained from accident reports from the Bogor Police Traffic Unit and primary data collected from field surveys. This was followed by analyzing accident-prone areas (Dermawan *et al*, 2020) [3].

1. Classification of Accident Data

Accident data was categorized based on the type of accident, time of occurrence, contributing factors, and severity of injuries. Irrelevant or duplicate data was identified and filtered to ensure the accuracy of the analysis results (Dwiatmoko *et al*, 2023; Prasetijo *et al*, 2020) [4, 16].

2. Calculation of the Accident Equivalent Number (AEK)

The Accident Equivalent Number (AEK) method was used to identify accident-prone locations, where each accident is assigned a weight based on its severity. The calculation formula is as follows

$$AEK=12MD+3LB+3LR+1K \quad (1)$$

Where:

MD	Number of Fatalities
LB	Number of Major Injury Victims
LR	Number of Minor Injury Victims
K	Number of Accidents

3. Upper Control Boundary (BKA) and Upper Control Limit (UCL) Analysis)

To determine whether a road segment is considered an accident-prone area, a statistical control method is used with the following formula (Isradi & Putri, 2021) [11]:

$$BKA=C+3\sqrt{C} \quad (2)$$

Where:
C = Average AEK value across all road segments

$$UCL = \lambda + \Psi \times \sqrt{\left(\frac{\lambda}{m} + \frac{0{,}829}{m} + \left(\frac{1}{2} xm\right)\right)} \quad (3)$$

Where:
UCL Upper Control Limit
λ Average accident rate
Ψ Probability Factor (2.576 for a 99% trust level)
M Accident equivalent value
If a segment's AEK value exceeds both BKA and UCL, it is categorized as a black spot.
4.Road Performance Analysis
To evaluate the performance of the road segment, the saturation degree (DS) formula is used:

$$DJ = \frac{q}{c} \quad (4)$$

Where:
D_J Dimensionless value, calculated using traffic flow and capacity expressed in Passenger Car Unit (PCU)/hour. D_J is used to determine traffic performance and as input for estimating travel speed.
Q Design-hour or peak-hour traffic volume in PCU/hour
C is JBH capacity, in PCU/hour

Road Level of Service (LOS) Categories based on DS:
LOS A: DS ≤ 0.35 ((Free Flow)
LOS B: 0.35 ≤ DS ≤ 0.45 (Stable Flow)
LOS C: 0.45 ≤ DS ≤ 0.75 (Congested but Stable)
LOS D: 0.75 ≤ DS ≤ 0.85 ((Nearly Unstable)
LOS E: 0.85 ≤ DS ≤ 1.00 (Saturated, Queue)
LOS F: DS > 1.00 (Traffic Jam)

5. Free-Flow Speed Analysis
The free-flow speed of vehicles is calculated using the formula:

$$V_B = (V_{BD} + V_{BL}) \times FV_{BHS} \times FV_{BUK} \quad (5)$$

Where:
V_B Measured speed from field observations in km/h.
V_{BD} Basic free-flow speed for MP, measured under ideal traffic, geometric, and environmental conditions, in km/h
V_{BL} Speed adjustment value due to lane width or road width (lane width for undivided roads or lane width for divided roads), in km/h
FV_{BHS} Free-flow speed adjustment factor due to roadside obstacles on roads with shoulders or curbs/sidewalks, considering the distance from the curb to the nearest obstruction

6. Mapping of Accident-Prone Areas
Accident-prone areas are mapped after calculating AEK, BKA, and UCL by considering road geometry data and environmental factors. This map serves as a basis for recommending accident mitigation measures

3. Analysis results and discussion
A. Analysis of accident-prone areas
Based on the analysis of accident-prone areas using the AEK, BKA, and UCL methods, the results obtained are as follows:

Table 1: AEK Value for Each Road Segment

Segment	Length (KM)	Accident Data				Value				
		MD	LB	LR	K	12MD	3LB	3LR	K	AEK
1	0.15	0	1	6	4	0	3	18	4	25
2	0.15	0	0	5	2	0	0	15	2	17
3	0.15	1	0	5	3	12	0	15	3	30
4	0.15	1	0	9	6	12	0	27	6	45
5	0.15	0	1	12	7	0	3	36	7	46
6	0.15	0	0	6	4	0	0	18	6	22
7	0.15	1	0	5	6	12	0	15	6	33
8	0.15	1	0	5	3	12	0	15	5	30
9	0.15	0	1	6	3	0	3	18	9	24
10	0.15	1	0	13	11	12	0	39	8	62
11	0.15	2	1	14	13	24	3	42	12	82
12	0.15	1	1	17	12	12	3	51	7	78
13	0.15	0	0	6	2	0	0	18	2	20
14	0.15	0	0	7	5	0	0	21	5	26
15	0.15	2	0	13	9	24	0	39	8	72
16	0.15	2	1	11	8	24	3	33	6	68
17	0.15	0	1	9	6	0	3	27	6	36
18	0.15	2	0	15	17	24	0	45	17	86

Table 1: Identification of Accident-Prone Locations based on BKA and UCL

Segmen	Length (KM)	Value						AEK>BKA	AEK>UCL
		AEK	C	BKA	λ	ψ	UCL		
1	0.15	25	44.556	64.58	44.556	2.576	54.30		
2	0.15	17					53.16		
3	0.15	30					55.02		
4	0.15	45					57.05		
5	0.15	46					57.17		
6	0.15	22					53.87		
7	0.15	33					55.45		
8	0.15	30					55.02		
9	0.15	24					54.16		
10	0.15	62					59.07		Blackspot
11	0.15	82					61.16	Blackspot	Blackspot
12	0.15	78					60.76	Blackspot	Blackspot

13	0.15	20					53.58		
14	0.15	26					54.45		
15	0.15	72					60.15	Blackspot	Blackspot
16	0.15	68					59.72	Blackspot	Blackspot
17	0.15	36					55.86		
18	0.15	86					61.55	Blackspot	Blackspot

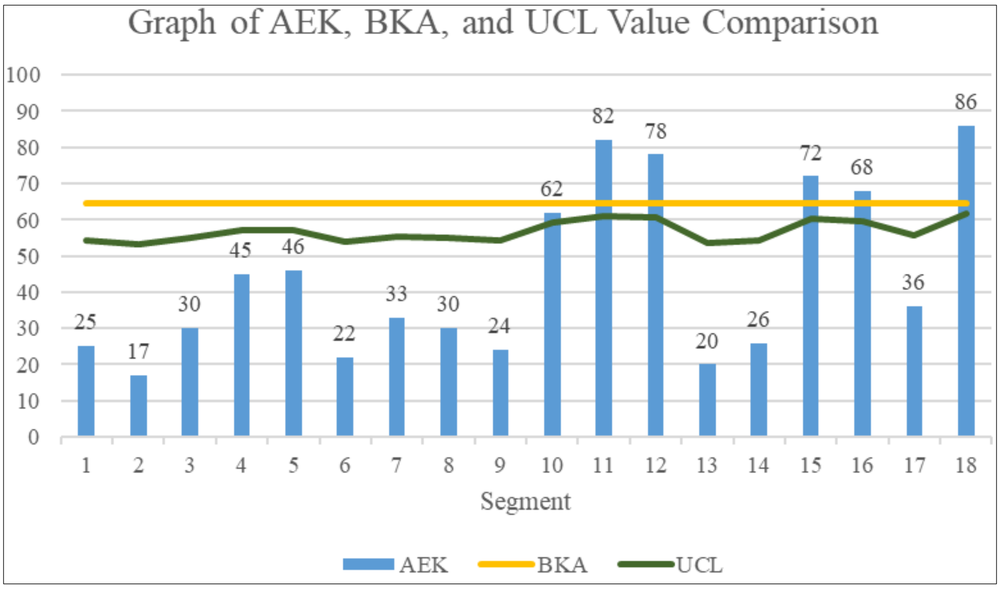

Fig 2: Graph of AEK, BKA, and UCL Value Comparison

B. Accident causal factors

Table 3: Percentage of Accident Causal Factor

Nomor	Cause of Accident	Number of Accidents	Percentage
1	Road Condition	13	11%
2	Weather Condition	11	9%
3	Drivers' Negligence	43	36%
4	Loss of Control	30	25%
5	Excessive Speeding	24	20%

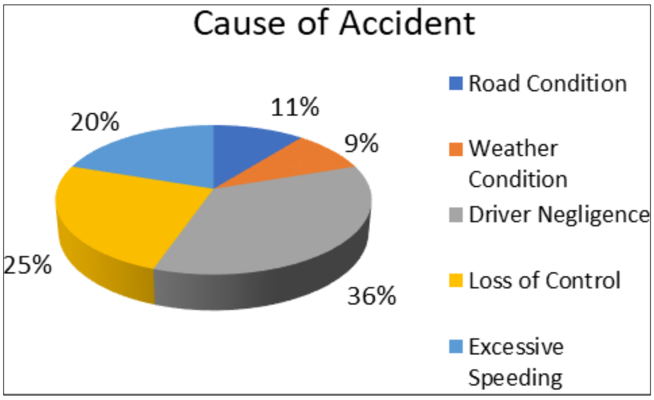

Fig 3: Chart of Accident Causal Factor

C. Types of Accidents

Table 4: Percentage of Accident Types

No	Types of Accidents	Number of Accidents	Percentage
1	Front Collision	12	10%
2	Side Collision	51	42%
3	Rollover	11	9%
4	Slipped	17	14%
5	Rear End Collision	30	25%

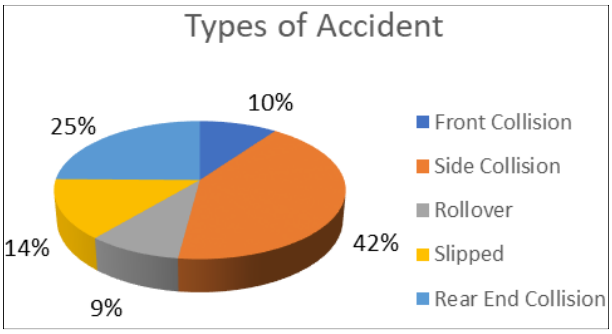

Fig 4: Chart of Accident Types

D. Time of Accident

Table 5: Percentage of Accident Times

No	Time of Event	Number of Accidents	Percentage
1	Morning	27	22%
2	Afternoon	23	19%
3	Late Afternoon	15	12%
4	Night	56	46%

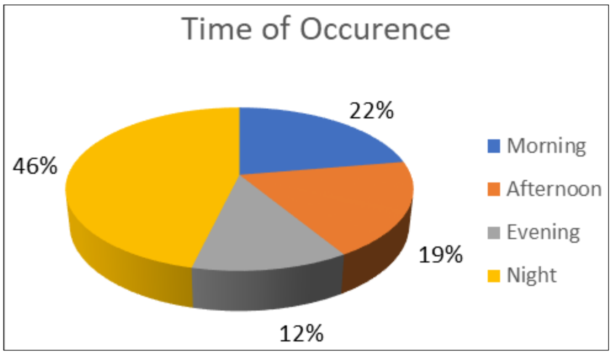

Fig 5: Chart of Time of Occurrence

E. Analysis of road performance

Table 6

Direction	Traffic Vehicle Volume (Q)	Basic Capacity	Actual Capacity	Free Flow Speed	Degree of Saturation	Speed	LOS	Actual Speed	Level of Service (LOS)
	PCU/hour	C0	C	FV	DS	Km/hour	Q/C	Km/hour	
Tuesday, 26 November 2024 Morning									
East	2957.4	5100	5453.36	61.32	0.54	45.4	0.54	45.40	C
West	3195	5100	5453.36	61.32	0.59	44.2	0.59	42.38	C
Tuesday, 26 November 2024 Late Afternoon									
East	3649.1	5100	5453.36	61.32	0.67	42.4	0.67	41.65	C
West	3538.1	5100	5453.36	61.32	0.65	42.7	0.65	38.95	C
Saturday, 30 November 2024 Afternoon									
East	2985	5100	5453.36	61.32	0.55	44. 3	0.55	44.72	C
West	2757.6	5100	5453.36	61.32	0.51	45.8	0.51	44.14	C
Saturday, 30 November 2024 Night									
East	1862.4	5100	5453.36	61.32	0.34	47.8	0.34	47.52	C
West	2177.4	5100	5453.36	61.32	0.40	47	0.40	49.60	C

Results show that the highest vehicle volume was on Tuesday evening in the eastward direction (3,649.1 PCU/hour), while the lowest was on Saturday night in the eastward direction (1,862.4 PCU/hour). The highest degree of saturation (DS) was recorded on Tuesday evening in the eastward direction (0.67), indicating denser traffic. In contrast, the lowest DS was on Saturday night in the eastward direction (0.34), signifying smoother traffic flow. Actual speed tended to be lower when vehicle volume was high, such as on Tuesday evening in the westward direction (38.95 km/h), and higher when traffic was lighter, such as on Saturday night in the westward direction (49.60 km/h).

Despite variations in traffic density, the Level of Service (LOS) remained in category C, indicating stable traffic conditions. This table clarifies the relationship between vehicle volume, capacity, speed, and density in determining road performance.

F. Analysis of the relationship between road performance and accident rates

1. Relationship Between Traffic Volume and Number of Accidents
   Traffic volume on Tegar Beriman Road varies throughout the day, with the highest volume in the evening (7,187.2 PCU/hour) and the lowest at night (4,039.8 PCU/hour). However, accidents were more frequent at night (56 incidents) compared to the evening (15 incidents). This indicates that accidents do not necessarily increase with traffic volume. When volume is high, vehicles move slower due to congestion. In contrast, vehicles tend to move faster during low-volume periods, increasing the risk of single-vehicle accidents due to loss of control.

2. Relationship between Vehicle Speed and Number of Accidents
   Vehicle speed is directly proportional to the number of accidents. The highest speed was recorded at night (47.8 km/h), while the lowest was in the evening (42.4 km/h). When vehicles travel faster at night, there were 56 accidents, significantly higher than 15 accidents in the evening. Higher speeds increase accident risk, especially on less congested roads. Speed limits and warning signs should be implemented in accident-prone areas to reduce risks.

3. Relationship between Degree of Saturation (DS) and Number of Accidents
   The highest degree of saturation (DS) occurred in the evening (0.67), while the lowest was at night (0.34). However, fewer accidents occurred when DS was high (15 incidents) than when DS was low (56 incidents). This occurs because dense traffic encourages drivers to be more cautious and drive slower. In contrast, lighter traffic allows vehicles to travel at higher speeds, increasing the risk of single-vehicle accidents.

G. Technical recommendations to improve safety

Based on the analysis of the relationship between road performance and accident rates, several technical recommendations can be implemented to enhance safety in Tegar Beriman Road:

1. Speed Control

a. Installing maximum speed limit signs (40 km/h) in accident-prone segments;
b. Installing speed bumps or traps at strategic points reduces vehicle speed at night.

2. Improving Road Lighting

a. Adding streetlights in accident-prone areas to improve visibility at night;
b. Maintenance and trimming of trees that obstruct streetlights, as dense foliage can cause dark areas and increase accident risk;
c. Ensuring existing streetlights function properly and regularly replacing dim or broken lights (Maintenance).

3. Road Infrastructure Improvements

a. Repainting faded road markings to improve driver visibility, especially at night or in rainy conditions;
b. Installing warning signs in accident-prone segments, such as caution signs at high-accident points;
c. Repairing potholes using better methods, as uneven patchwork can cause vehicles to lose control, particularly for motorcyclists;
d. Enhancing the quality of regular road maintenance, ensuring that repairs are temporary and meet safety and comfort standards for road users

4. Law Enforcement and Supervision

a. Installing CCTV or an electronic ticketing system at high-risk points to reduce speeding violations and dangerous driving behavior
   Deploying traffic officers during peak accident hours, especially at night, to monitor traffic and remind drivers to be more cautious.

4. References

1. Albayati AH, Lateef IM. Characteristics of traffic accidents in Baghdad. Civil Engineering Journal. 2019;5(4):940–9.
2. Athiappan K, Karthik C, Rajalaskshmi M, *et al* Identifying influencing factors of road accidents in emerging road accident blackspots. In: Advances in Civil Engineering [Internet]. 2022. Available from: https://doi.org/10.1155/2022/9474323
3. Dermawan WB, Isradi M, Pawaztris P. Analysis of accident-prone areas along Jenderal Ahmad Yani Road in Bekasi. Journal of Applied Science, Engineering, Technology, and Education. 2020;1(2):124–30. Available from: https://doi.org/10.35877/454ri.asci1239
4. Dwiatmoko H, Isradi M, Prasetijo J. Accident prevention and traffic safety for Sekolah Alam Robbani Bekasi (KidSafe). Journal of Safety Studies. 2023;2(1):56–63.
5. Firdaus HY, Isradi M, Prasetijo J, Rifqi M. Performance analysis and passenger satisfaction on Trans Jakarta bus services (Cibubur route – BKN). Journal of Science, Technology, and Engineering (JSTE). 2021;1(2):73–81.
6. Firdaus HY, Isradi M, Prasetijo J, Rifqi M, Halim H. Analysis of Transjakarta service performance on the Cibubur-BKN by Servqual method. European Journal of Science, Innovation and Technology. 2022;2(1):113–23.
7. Hartatik N, Prasetijo J, Isradi M. Characteristics of traffic accidents in Jalan Tol Surabaya-Porong, Jawa Timur. International Journal of Advanced Trends in Computer Science and Engineering. 2020;9(1 Special Issue 4). Available from: https://doi.org/10.30534/ijatcse/2020/4991.42020
8. Isradi M, Arifin Z, Setiawan MI, Nasihien RD, Prasetijo J. Traffic performance analysis of unsignalized intersection using the traffic conflict parameter technique. Sinergi. 2022;26(3):397. Available from: https://doi.org/10.22441/sinergi.2022.3.015
9. Isradi M, Dwiatmoko H, Prasetijo J, Rifai AI, Zainal ZF, Zhang G, *et al* Identification of hazardous road sites: a comparison of blackspot methodology of Narogong Road Bekasi and Johor Federal Roads. Sinergi (Indonesia). 2024;28(2):347–54. Available from: https://doi.org/10.22441/sinergi.2024.2.014
10. Isradi M, Prasetijo J, Irfan A, Andraiko H, Zhang G. The prediction of road condition value during maintenance based on Markov process. International Journal on Advanced Science, Engineering and Information Technology (IJASEIT). 2024;14(3):1083–90. Available from: https://doi.org/10.18517/ijaseit.14.3.19475
11. Isradi M, Putri GT. The impact of COVID-19 on areas prone to traffic accidents in Depok City (Margonda Raya Road case study). Journal of World Conference. 2021;3(2):241–51.
12. Isradi M, Rifai AI, Prasetijo J, Kinasih RK, Setiawan MI. Development of pavement deterioration models using

Markov chain process. Civil Engineering Journal (CEJ). 2024;10(09):2954–65. Available from: https://doi.org/10.28991/CEJ-2024-010-09-012

13. Kalantari M, Shahraki SZ, Yaghmaei B, Ghezelbash S, Ladaga G, Salvati L. Unraveling urban form and collision risk: the spatial distribution of traffic accidents in Zanjan, Iran. International Journal of Environmental Research and Public Health. 2021;18(9). Available from: https://doi.org/10.3390/ijerph18094498
14. Kinasih RK, Prasetijo J, Indriany S, Isradi M, Biantoro AW. Analyzing toll road as a solution to the existing highway problem. Res Militaris. 2022;12(route 1):6.
15. Obaidat MT, Ramadan TM. Traffic accidents at hazardous locations of urban roads. Jordan Journal of Civil Engineering. 2012;6(4):436–47.
16. Prasetijo J, Zhang G, Isradi M, Zainal ZF, Musa WZ, Setiawan MI. Accident prediction based on integrated design consistency with the lower number of vehicles/traffic volumes (due to health disaster/COVID-19). International Journal of Entrepreneurship and Business Development (IJEBD). 2020;3(3):287–95. Available from: https://doi.org/10.29138/ijebd.v3i3.1112
17. Sukirman. Dasar-dasar perencanaan geometrik jalan. Nova; 1994