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ANALYSIS OF TRAFFIC ACCIDENTS IN THE WEST SURABAYA REGION (CASE STUDY: KALIANAK ROAD TO ROMOKALISARI HIGHWAY)

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ABSTRACT

The high volume of heavy vehicle traffic on Kalianak Street, Greges, Tambak Langon, Tambak Osowilangun and Romokalisari causes the roads to become increasingly congested, which causes frequent traffic accidents. Accident data used for 2017, 2018, 2019, 2020, 2021 and 2022 to determine accident-prone areas using the z-score method, the number of accidents for each level of victim severity using the Accident Rate method and to determine the amount of loss caused by accidents using the Gross method Output (Human Capital). The results of the analysis show that the highest number of accidents was in 2017 - 2016 for the classification of deaths, serious injuries and minor injuries on Romokalisari Street with an accident rate of 0.246 people per 1 million vehicle kilometers per year, the classification of seriously injured victims was 0.092 people per 1 million vehicle kilometers per year in Kalianak and minor injury victims of 0.406 people per 1 million vehicle kilometers per year on Romokalisari Street. The accident-prone area (Blacksite) with the largest value is the Tambak Osowilangun Z-Score for 6 years of 1.45 and the last year of 1.14. Total costs for accident victims based on the Gross Output (Human Capital) method for each year; 2017 amounting to IDR 12,529,506.23, in 2015 IDR 11,439,656,822, in 2019 IDR. 13,324,550,588, 2020 Rp. 11,010,983,853, in 2021 Rp. 19,071,950,542 and in 2022 Rp. 26,214,460,693.

Keywords: *Traffic Accident; Amount of Casualty Costs Accident; Z-Score; Kalianak Road; Tambak Langon – Osowilangun; Romokalisari Highway.*

1. Introduction

When driving on the highway, safety is the main thing in East Java, especially in the Surabaya area. The very high rate of traffic accidents in several years has resulted in the death rate caused by traffic accidents in Surabaya being second only to Jombang (East Java Regional Police Chief, 2019). Accidents that occur are unforeseen or intentional events carried out by motorists on the road involving or not involving other drivers that can cause fatalities or material losses. [18].

Road sections where accidents can occur, especially in the western area of Surabaya City, are Kalianak, Greges, Tambak Langon, Tambak Osowilangon and Romokalisari, which are roads in the primary arterial category which have two-way roads. Apart from being a connecting road and main access route for heavy vehicles from Surabaya, Gresik, Lamongan. This road section should have good physical condition and adequate facilities. There are differences in geometric conditions on several of these road sections, between Kalianak and Greges roads, the road width is smaller and there is no median. Greges road leads to Tambak Langon, there is a three-way intersection which intersects with Margomulyo road to be able to pass to Tambak Langon. Tambak Osowilangon which has a road width of ≥ 6meters divided into 4 lanes in 2 directions with a road median. Meanwhile,Tambak Osowilangon leading to Romokalisari has a road width of ≥ 4meters which is divided into 2 lanes in 2 directions.

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This condition is of particular concern for prevention by the government and related agencies. Based on the problems or problems that have been described, deeper observations are needed regarding the analysis of traffic accidents in the West Surabaya area (Kalianak to Romokalisari High-way) in order to determine the magnitude of the number of traffic accidents, identify accident-prone areas and provide solutions to reduce the level of traffic accidents in future case study locations.

2. Material and Methods

Steps in the analysis of traffic accidents in the west Surabaya region (Kalianak road section to Romokalisari Highway) are as follows:

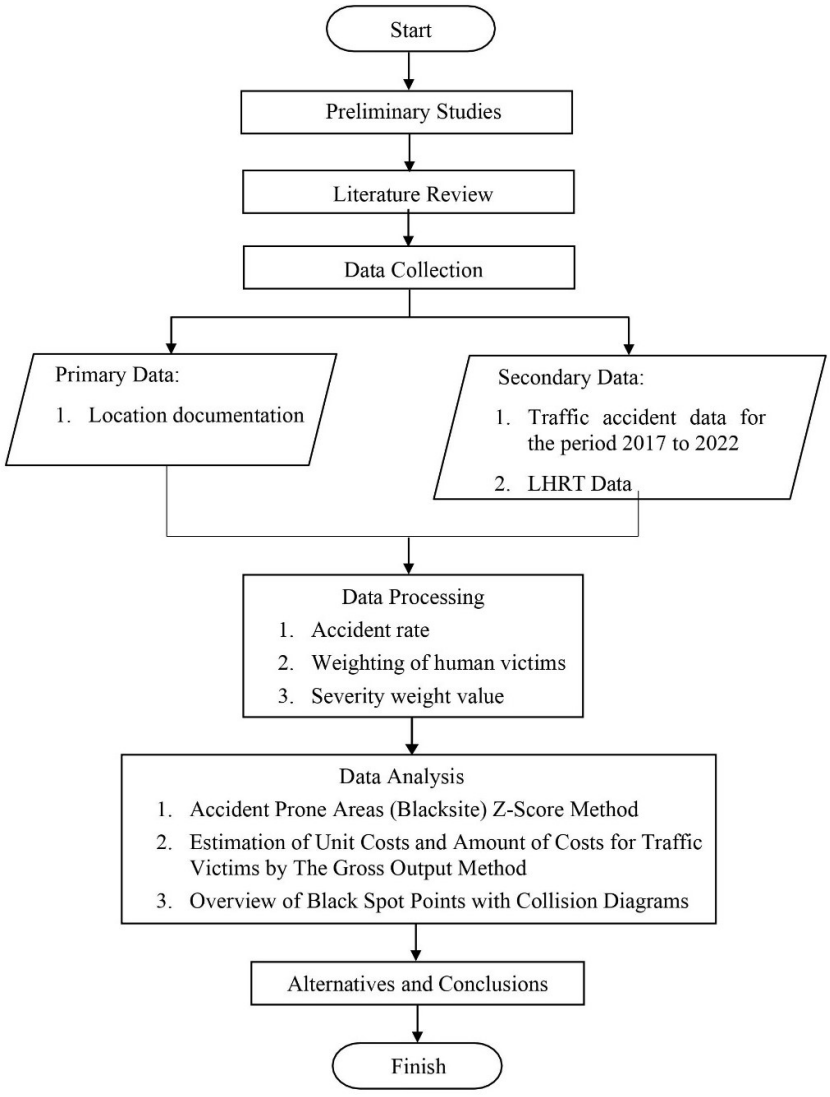

Figure 1. Step of Research

2.1. Research sites

The following is a map of the research location marked with a red line along Jl. Kalianak, Jl. Greges, Jl. Tambak Langon - Osowilangun, and Romokalisari Highway.

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Figure 2. Research Location

2.2. Data Collection Technique

There were 2 sources of data, namely primary data and secondary data. The primary data obtained directly and realistically by observing road conditions (Location documentation). These include; Markings on roads, signs on road facilities, and lighting in the form of street lights, as well as whether the physical condition of the road. Secondary data includes data on traffic accidents on the Jalan Kalianak, Greges, Tambak Langon, Osowilangon, and Romokalisari for six years (2017-2022) which can be requested from the Surabaya Police Traffic Unit and the Tanjung Perak Harbor Police Traffic Unit and Annual Average Daily Traffic Volume (LHRT) on the road sections studied, data requested to the Surabaya City Transportation Department.

2.3. Data Analysis Technique

A. Accident rate (AR) which calculates the value of the number of accidents on all types of road sections, as long as the total number of accidents, the length of the road section, and Annual Average Daily Traffic Volume (LHRT) data are known. Classifying accidents based on their severity such as death (MD); Minor injuries (LR); and serious injuries (LB).

$$\frac{\sum \text{accident injuries (/year)} \times 10^6}{\text{The length of road (km)} \times \text{LHRT (/year)}} \quad (1)$$

$$\frac{\sum \text{accidents death (/year)} \times 10^8}{\text{The length of road (km)} \times \text{LHRT (/year)}} \quad (2)$$

B. Calculate the weighting of victims on each road section reviewed to generalize the severity of victims by equalizing the weights. Which multiplies the multiplier factor, the weight of the dead victim (MD) is 3, seriously injured (LB) is 2, and minor injured (LR) is 1.

C. Analysis of Black Site Accident Prone Areas. The Number of Human Casualties (JKM) with a multiplier value of 12, the Number of Accident Perpetrators (JPK) with a multiplier value of 3 and the Number of Accidents (JK) with a multiplier value of 1 are used to calculate the weighting value of accident data by multiplying the accident weight value and the criteria.

D. Z-Score Method to identify the average incidence of accidents and Blacksite area.

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$$Z = \frac{Xi - X}{S} \quad (3)$$

$$X = \frac{\sum \text{ weighting value of accident (on point C)}}{n} \quad (4)$$

$$S = \sqrt{\frac{\sum (Xi - X)^2}{n}} \quad (5)$$

E. The Gross Output Method

The unit cost of traffic accident victims in a particular year (Tn) can be calculated using equation (6) and the unit cost of traffic accident victims is calculated in a specific year (n) using equation (7).

$$BSKOj\ (Tn) = BSKOj\ (T0) \times (1 + g)t \quad (6)$$

$$BBKO\ (Tn) = JKOj \times BSKOj\ (Tn) \quad (7)$$

F. Collision Diagrams carried out by dividing road sections every 100 meters, recapitulating traffic accidents based on the number of incidents, victims and type of accident at the location where's the accident occurred.

3. Result and Discussion

Based on the field survey carried out, the following data were obtained. Classifying accidents based on their severity such as accidental death (MD); Minor injuries (LR); and serious injuries (LB). Recapitulation accident data based on Unit Lakalantas Kota Surabaya.

Table 1. Characteristic Data

Segments	Category	Type of road		Measurement
				Length (Km)
Kalianak Street	Arteri Primer	Nasional	(4/2UD)	2
Greges Street	Arteri Primer	Nasional	(4/2UD)	1,7
Tambak Langon	Arteri Primer	Nasional	(4/2D)	1,5
Tambak Osowilangun	Arteri Primer	Nasional	(4/2D)	4,2
Romokalisari	Arteri Primer	Nasional	(4/2D)	1,1

Table 2. Accident Data in 2017

Segments	Accidents	Prepetrator	Victims	MD	LB	LR
Kalianak	23	40	27	8	4	15
Greges	9	13	12	4	2	6
Tambak Langon	11	18	14	5	1	8
Tambak Osowilangun	15	18	20	4	1	15
Romokalisari	9	11	11	2	1	8
Total	67	100	84	23	9	52

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Table 3. Accident Data in 2018

Segments	Accidents	Prepetrator	Victims	MD	LB	LR
Kalianak	19	33	25	6	4	15
Greges	6	9	8	2	1	5
Tambak Langon	5	7	9	4	2	3
Tambak Osowilangun	23	25	25	4	5	16
Romokalisari	8	10	12	3	2	7
Total	61	84	79	19	14	46

Table 4. Accident Data in 2019

Segments	Accidents	Prepetrator	Victims	MD	LB	LR
Kalianak	15	31	20	4	5	11
Greges	5	9	5	3	1	1
Tambak Langon	9	20	13	4	3	6
Tambak Osowilangun	30	34	39	9	4	26
Romokalisari	2	2	2	0	1	1
Total	61	96	79	20	14	45

Table 5. Accident Data in 2020

Segments	Accidents	Prepetrator	Victims	MD	LB	LR
Kalianak	12	13	21	3	3	15
Greges	5	5	5	2	1	2
Tambak Langon	5	4	5	2	1	2
Tambak Osowilangun	10	11	15	5	2	8
Romokalisari	10	10	16	3	0	13
Total	42	43	62	15	7	40

Table 6. Accident Data in 2021

Segments	Accidents	Prepetrator	Victims	MD	LB	LR
Kalianak	11	15	14	5	0	9
Greges	3	3	4	1	0	3
Tambak Langon	11	13	11	6	0	5
Tambak Osowilangun	20	25	27	10	1	16
Romokalisari	8	10	10	2	2	6
Continued of Table 6						
Segments	**Accidents**	**Prepetrator**	**Victims**	**MD**	**LB**	**LR**
Total	53	66	66	24	3	39

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Table 7. Accident Data in 2022

Segments	Accidents	Prepetrator	Victims	MD	LB	LR
Kalianak	9	11	10	6	0	4
Greges	9	10	9	7	0	2
Tambak	11	17	13	4	0	9
Langon						
Tambak	13	18	16	5	0	11
Osowilangun						
Romokalisari	13	15	19	8	0	11
Total	55	71	67	30	0	37

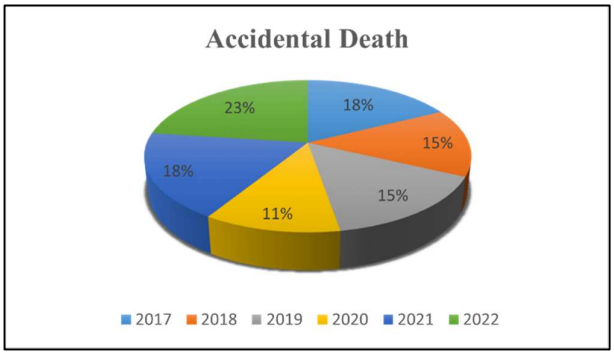

Figure 3. Comparison graph of the number of accidental deaths within 6 years.

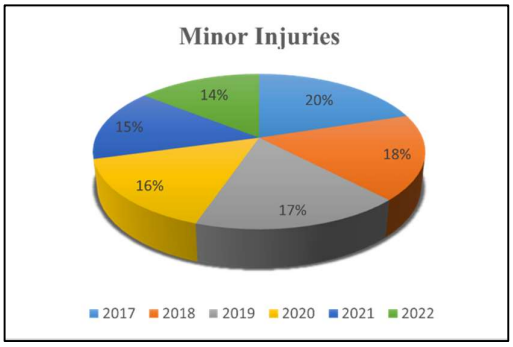

Figure 4. Comparison graph of the number of minor injuries within 6 years.

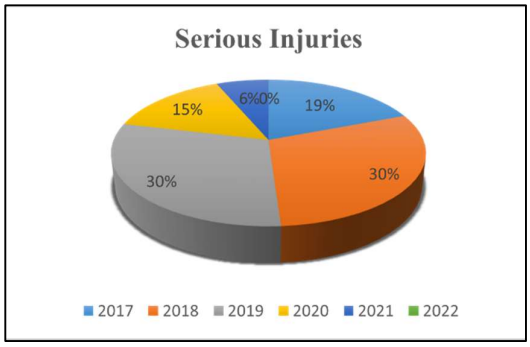

Figure 5. Comparison graph of the number of serious injuries within 6 years.

Based on table 8, it is known that by calculating the weighting of human casualties, the highest number of accidents occurred on Jalan Tambak Osowilangun with a total of 229 accidents.

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Table 8. Weighting of Human Victims

No.	Segment	Multiplying Factor	Year					
			2017	2018	2019	2020	2021	2022
1.	Kalianak Street	MD	8	6	4	3	5	6
		LB	4	4	5	3	0	0
		LR	15	15	11	15	9	4
		(MD x 3)	24	18	12	9	15	18
		(LB x 2)	8	8	10	6	0	0
		(LR x 1)	15	15	11	15	9	4
		AR	47	41	33	30	24	22
		Total	197					
2.	Greges Street	MD	4	2	3	2	1	7
		LB	2	1	1	1	0	0
		LR	6	5	1	2	3	2
		(MD x 3)	12	6	9	6	3	21
		(LB x 2)	4	2	2	2	0	0
		(LR x 1)	6	5	1	2	3	2
		AR	22	13	12	10	6	23
		Total	86					
3.	Tambak Langon	MD	5	4	4	2	6	4
		LB	1	2	3	1	0	0
		LR	8	3	6	2	5	9
		(MD x 3)	15	12	12	6	18	12
		(LB x 2)	2	4	6	2	0	0
		(LR x 1)	8	3	6	2	5	9
		AR	25	19	24	10	23	21
		Total	122					
4.	Tambak Osowilangun	MD	4	4	9	5	10	5
		LB	1	5	4	2	1	0
		LR	15	16	26	8	16	11
		(MD x 3)	12	12	27	15	30	15
		(LB x 2)	2	10	8	4	2	0
		(LR x 1)	15	16	26	8	16	11
		AR	29	38	61	27	48	26
		Total	299					
5.	Jalan Romokalisari	MD	2	3	0	3	2	8
		LB	1	2	1	0	2	0
		LR	8	7	1	13	6	11
		(MD x 3)	6	9	0	9	6	24
		(LB x 2)	2	4	2	0	4	0
		(LR x 1)	8	7	1	13	6	11
		AR	16	20	3	22	16	35
		Total	122					

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Table 9. Analysis of Black Site Accident Prone Areas

No	Segments	Multiplying Factor	Year					
			2017	2018	2019	2020	2021	2022
1.	Kalianak Street	JKM	23	19	15	12	11	9
		JPK	40	33	31	13	15	11
		JK	27	25	20	21	14	10
		(JKM x 12)	276	228	180	144	132	108
		(JPK x 3)	120	99	93	39	45	33
		(JK x 1)	27	25	20	21	14	10
		AR	423	352	293	204	191	150
Total			1614					
2.	Greges Street	JKM	9	6	5	5	3	9
		JPK	13	9	9	5	3	10
		JK	12	8	5	5	4	9
		(JKM x 12)	108	72	60	60	36	108
		(JPK x 3)	39	27	27	15	9	30
		(JK x 1)	12	8	5	5	4	9
		AR	159	107	92	80	49	147
Total			634					
3.	Tambak Langon	JKM	11	5	9	5	11	11
		JPK	18	7	20	4	13	17
		JK	14	9	13	5	11	13
		(JKM x 12)	132	60	108	60	132	132
		(JPK x 3)	54	21	60	12	39	51
		(JK x 1)	14	9	13	5	11	13
		AR	200	90	181	77	182	196
Total			926					
4.	Tambak Osowilangun	JKM	15	23	30	10	20	13
		JPK	18	25	34	11	25	18
		JK	20	25	39	15	27	16
		(JKM x 12)	180	276	360	120	240	156
		(JPK x 3)	54	75	102	33	75	54
		(JK x 1)	20	25	39	15	27	16
		AR	254	376	501	168	342	226
Total			1867					
5.	Romokalisari	JKM	9	8	2	10	8	13
		JPK	11	10	2	10	10	15
		JK	11	12	2	16	10	19
		(JKM x 12)	108	96	24	120	96	156
		(JPK x 3)	33	30	6	30	30	45
		(JK x 1)	11	12	2	16	10	19
		AR	152	138	32	166	136	220
Total			844					

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Table 10. Calculation of Z-Score Values for 2017 – 2022

No.	Segments	xi	X	xi - X	(xi - X)²	S	Z
1.	Jalan kalianak	1614	1177	437	19096	476,6	0,92
2.	Jalan Greges	634	1177	-543	294849	476,6	-1,14
3.	Jalan Tambak Langon	926	1177	-251	63001	476,6	-0,53
4.	Jalan Tambak Osowilangun	1867	1177	690	476100	476,6	1,45
5.	Jalan Romokalisari	844	1177	-333	110889	476,6	-0,70
	Total (Σ)	5885			1135808		

Table 11. The Z-Score value based on the annual growth rate and the Z-Score value in the last year

No.	Nama Ruas Jalan	Z	Z 2022
1.	Jalan Kalianak	0,92	-1,11
2.	Jalan Greges	-1,14	-1,23
3.	Jalan Tambak Langon	-0,53	0,24
4.	Jalan Tambak Osowilangun	1,45	1,14
5.	Jalan Romokalisari	-0,70	0,96

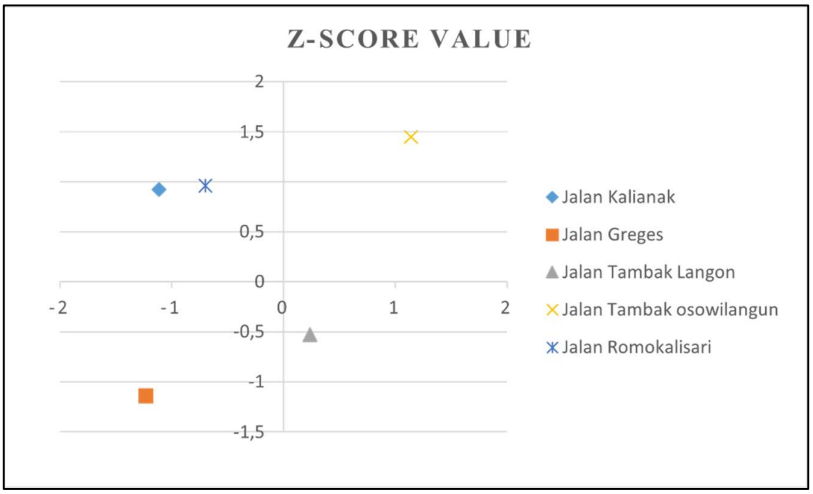

Figure 6. Graph of the relationship between z-score for the last year and for 6 year.

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Table 12. Amount of Costs for Traffic Accident Victims (2017 – 2022)

No.	Victims			$(1+g)^t$	BSKO (Tn) (Rp)			BBKO (Tn) (Rp)
	MD	LB	LR		MD	LB	LR	
2017								
1.	8	4	15	4,31				Rp 4,272,108,229
2.	4	2	6	4,31				Rp 2,129,297,498
3.	5	1	8	4,31	Rp 513,011,444	Rp 25,112,629	Rp 4,504,411	Rp 2,626,205,134
4.	4	1	15	4,31				Rp 2,144,724,566
5.	2	1	8	4,31				Rp 1,087,170,803
Total								Rp 12,259,506,231
2018								
1.	6	4	15	4,78				Rp 3,603,154,729
2.	2	1	5	4,78				Rp 1,191,759,904
3.	4	2	3	4,78	Rp 569,442,703	Rp 27,875,018	Rp 4,999,896	Rp 2,348,520,535
4.	4	5	16	4,78				Rp 2,497,144,238
5.	3	2	7	4,78				Rp 1,799,077,416
Total								Rp 11,439,656,822
2019								
1.	4	5	11	5,31				Rp 2,744,080,682
2.	3	1	1	5,31				Rp 1,932,735,354
3.	4	3	6	5,31	Rp 632,081,400	Rp 30,941,270	Rp 5,549,885	Rp 2,654,448,718
4.	9	4	26	5,31				Rp 5,956,794,679
5.	0	1	1	5,31				Rp 36,491,155
Total								Rp 13,324,550,588
2020								
1.	3	3	15	5,90				Rp 2,300,271,070
2.	2	1	2	5,90				Rp 1,449,886,261
3.	2	1	2	5,90	Rp 701,610,354	Rp 34,344,810	Rp 6,160,372	Rp 1,449,886,261
4.	5	2	8	5,90				Rp 3,626,024,364
5.	3	0	13	5,90				Rp 2,184,915,896
Total								**Rp 11,010,983,853**

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Continued of Table 12.

No.	Victims			$(1+g)^t$	BSKO (Tn) (Rp)			BBKO (Tn) (Rp)
	MD	LB	LR		MD	LB	LR	
2021								
1.	5	0	9	6,54				Rp 3,955,479,579
2.	1	0	3	6,54				Rp 799,301,531
3.	6	0	5	6,54	Rp 778,787,493	Rp 38,122,739	Rp 6,838,013	Rp 4,706,915,020
4.	10	1	16	6,54				Rp 7,935,405,871
5.	2	2	6	6,54				Rp 1,674,848,541
Total								**Rp 19,071,950,541**
2022								
1.	6	0	4	7,26				Rp 5,217,085,478
2.	7	0	2	7,26				Rp 6,066,359,207
3.	4	0	9	7,26	Rp 864,454,117	Rp 42,316,241	Rp 7,590,194	Rp 3,526,128,215
4.	5	0	11	7,26				Rp 4,405,762,721
5.	8	0	11	7,26				Rp 6,999,125,072
Total								**Rp 26,214,460,693**

Table 13. Recapitulation Collision Diagram (2017 – 2022)

KM	Type of Accident	The severity of the accident
0+000 – 0+100	Back side	unsevere
	Front and side	unsevere
	Front and back	severe
0+100 – 0+200	To side	unsevere
	Front and side	severe
	Front and side	unsevere
	Single crash	severe
	To side	severe
	Back side	severe
	To side	unsevere
	Front and side	unsevere
	Front and side	unsevere
0+200 – 0+300	Front side	severe
	Back side	unsevere
	Front and side	unsevere
	To side	unsevere
	Front and back	unsevere
0+300 – 0+400	Front and side	severe
0+400 – 0+500	Front side	unsevere

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KM	Type of Accident	The severity of the accident
0+500 – 0+600	Front and side	severe
	To side	unsevere
	Front side	severe
	Single crash	unsevere
	Back and side	unsevere
	To side	severe
	Back side	unsevere

Source: Analysis, 2023

4. Conclusions

The results of calculating the Accident Rate for traffic accidents in 2017 - 2022 showed that the highest value in the classification of fatalities was 0.246 people per 1 million vehicle kilometers annually on the Romokalisari road section, for seriously injured victims it was 0.092 people per 1 million vehicle kilometers every year on Jalan Kalianak and the classification of minor injuries 0.210 people.

Accident-prone areas are that have a Z value of more than 0 or a Z value in quadrant I (which explains that the location has a high accident rate and the growth in the number of accidents is above average) along with areas that are accident-prone areas, namely Roads Osowilangun Pond with an accident rate of 1.45 and an accident growth of 1.11. The results of the Collision Diagram Analysis show that accident-prone points (Blackspots) are Jalan Kalianak and Jalan Romokalisari from 2017 to 2022. Amount of Costs for Traffic Accident Victims (2017 – 2022) listed in table 12.

Alternative solutions that can be implemented are carrying out very strict screening when creating a drive lisence and providing insight that can be understood so that it can be applied on the road, giving harsh sanctions to violators of road markings and installing CCTV surveillance on road sections monitored. Carry out road repairs, install road markings, medians, and regulate parking areas. Eliminating activities on road ROWs or prohibiting parking on the road shoulder.

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