Analysis of the Safety of the Krebet-Bululawang Highway Section in Review from the Completeness of Road Infrastructure Aspects

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ABSTRACT

Road safety is a topic that is often raised, and is currently a world concern that not only affects transportation but also society. Therefore, it requires an analysis of road safety in terms of the completeness of road infrastructure to meet the standard value of the Indonesian Road Capacity Guideline. and the National General Plan for Road Traffic and Transportation Safety (RUNKLL). The purpose of the study was to determine the accident-prone points on the Krebet-Bululawang highway, Malang Regency. and provide handling efforts related to the results of the Krebet Highway Safety Analysis in Review from the Completeness of Road Infrastructure Aspects. In this study, what is calculated is the Z-score Technical Analysis of accident-prone areas (Black sites), the Cusum Technique of accident prone points (Black Spot). Based on the results of accident characteristic data processing, the location of accident-prone points (black spots) that have the largest custom value on Jalan Krebet is identified as accident-prone points in segments 1 and segment 3 as the cause of having the largest custom values, namely 7,200 and 5,250. Based on the accident data, the accident z-score values for each segment were obtained based on the total number of accident incidents during the period 2018 - 2022 with 2 road segments with the highest scores, namely segments 1 and 3 where the number of accident victims was 11 accident victims and the highest z-core value was 2.012 in segment 1 and segment 3 0.224 Identify characteristics that are deeper and more detailed, this is based on the results of analysis of accident z-score values that appear 2 priority road segments and aim in efforts to handle accident-prone segment location points that have been identified and determined previously. At this stage, the most important technical problems in road traffic safety will be described as Proposed Handling for accident-prone areas (black sites) and accident-prone points (back spots) that need to be installed warning signs for dangerous areas where accidents often occur. Usually the placement of these traffic signs is at least 50 meters before areas where accidents often occur according to the standard of RI transportation regulations No PM 13 2014 concerning traffic signs.

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1. INTRODUCTION

Road safety is a topic that is often raised, and is currently a world concern that not only affects transportation but also society [1]. Road safety issues are related to the way people use the road, the technical features of the various vehicles used, as well as the technical characteristics of the actual road construction after use. The probability of a casualty in case of a collision or accident is significantly reduced by roads that are designed and built keeping in mind the principles of road safety.

Jalan Raya Krebet - Bululawang is one of the access roads for large vehicles carrying large loads in Malang Regency which has quite a lot of population density with various land uses such as sugar factories, markets, offices, shops/shops, schools, Jalan Raya Krebet Bulalawang is a collector road segment and administrative area in Malang Regency which is located in the Bululawang District area, with vehicles passing from Malang City to Gondanglegi and Pegelaran and there is also a strategic road leading to Gondanglegi, namely the Krebet-Bulawang highway junction to Turen road. roads that have high traffic volumes and have the potential for traffic accidents and congestion According to an accident is an unplanned event that is seen as such by the person who experiences it and often causes damage and other losses that befall him. With all the changes that have occurred, a number of problems related to [2].

Management of road infrastructure is inevitable. One of them is the occurrence of vehicle traffic accidents caused by a lack of road infrastructure, ranging from minor accidents to serious accidents that result in material losses and substantial fatalities due to driver negligence. Vehicles, environmental variables, or human factors The cause of traffic accidents on the Krebet - Bululawang section often occurs every year due to growth. Based on accident data from the traffic accident unit of the Malang Police, Bululawang District is also a sub-district with an area level. In 2019, 63 accidents and in 2022, 47 accidents occurred and in 2021, 64 accidents. Bululawang District was recorded as the area with the highest accident rate and identified as accident-prone based on the Police Traffic Accident Unit (Malang posco media. id) [3].

The purpose of this research is to determine the level of road safety with the effort needed to improve road safety and to ensure that all road schemes can operate as safely as possible from all sides of road users. Traffic accidents are a negative aspect of increasing the mobility of transportation flows without infrastructure improvements that prioritize safety functions. Road infrastructure and facilities, visibility, turning radius, as well as turn-around conditions and facility layout, therefore researchers want to conduct research on accidents "Safety Analysis of Jalan Raya Krebet - Bululawang in Review from the Completeness Aspect of Road Infrastructure".

2. METHODS

2.1 Definition of Road Safety

Road safety is an effort to deal with accidents that occur on the highway which are not only caused by factors in the condition of the vehicle or the driver, but also caused by many other factors.[4]These other factors include natural conditions, road design (vertical or horizontal alignment), vehicle visibility, pavement conditions, completeness of road signs or instructions, cultural and educational influences of the people around the road, and applicable local level regulations or policies can indirectly trigger road accidents [5].

2.2 Traffic Safety General Plan (RUNKLL)

The National General Plan for Road Traffic and Transportation Safety is a government safety planning document for a period of 20 (twenty) years. It is a reference for ministries/agencies, district/city regional governments in synergizing the preparation of documents for planning, implementing and controlling traffic safety and road transportation. This document is the National General Plan for Road Safety (RUNK) which was prepared based on the mandate of Article 203 of

Law Number 22 of 2009, as a manifestation of the government's responsibility in ensuring road traffic safety. However, there are several similarities that can be generally outlined in five (5) pillars that reflect the concept of "safe system".

2.3 2016 Road Safety Audit.

A road safety audit can be defined as an inspection of a road or traffic project, existing or new road, by an independent team of experts, who reports on the safety performance and potential collisions of the project. Another definition of a road safety audit is a form of formal testing of an existing and future road section or traffic project, or any work that interacts with road users, which is carried out independently, by testers who are trusted in see the potential for accidents and safety performance of a road segment.

2.4 Definition of Traffic Accidents

According to the Law of the Republic of Indonesia No. 22 of 2009 concerning Road Traffic and Transportation, a traffic accident is an incident on the road that is unexpected and unintentional involving motorized vehicles with other vehicles or with other road users which can result in human casualties. and or loss of property [6].

2.5 Types of Traffic Accidents

Types of Traffic Accidents according to the Indonesian Ministry of Transportation (2006) can be divided into several types of collisions, namely:

1. Rear-Angle (Ra), a collision between vehicles moving in different directions, but not from the opposite direction;
2. Rear-End (Re), the vehicle crashes from behind another vehicle moving in the same direction;
3. Sideswape (Ss), a moving vehicle collides with another vehicle from the side when traveling in the same direction, or in the opposite direction;
4. Head-On (Ho), a collision between those traveling in opposite directions (no sideswape);
5. Backing, collision backwards.

2.6 Indonesian Road Capacity Guidelines (PKJI 2014)

The 2014 Indonesia Road Capacity Guidelines are guidelines for the planning, design and operation of adequate traffic facilities. The value of capacity and current speed relationship is used for the planning, design and operation of highways in Indonesia, in an effort to update the 2014 PKJI it is hoped that it can guide and become a technical reference for road administrators, traffic operators and road transport, teachers, practitioners both at the central and regional levels. regions in planning and evaluating the capacity of urban roads and intersection roads.

2.7 Road Traffic Flow

PKJI Indonesia Road Capacity Guidelines 2014, traffic flow is the number of motorized vehicles that pass a certain point per unit of time, expressed in vehicles per hour or pcu/hour.

a) Light vehicle (LV)
   Includes 2 axles 4-wheeled motorized vehicles with axles distance of 2.0 – 3.0 m (passenger cars, microbuses, pick-ups, small trucks, according to Bina.Marga classification).
b) Heavy vehicles (HV)
   Includes motor vehicles with an axle spacing of more than 3.5 m usually with more than four wheels (including buses, 2 axle trucks, 3 axle trucks and combination trucks).
c) Motorcycle/motor cycle (MC)
   Includes 2-wheeled motorized vehicles or 3 (including motorbikes and 3 wheels according to the Highways classification system).

d) Non-motorized vehicles (UM)
Includes wheeled vehicles that use human power, animals, and others (including rickshaws, horse-drawn carriages, strollers and others according to the Highways classification system)[6].

Tabel 1. Classification of Vehicles According to PKJI (2014)

City street	Interstate city	information
Vehicle Light (KR		Motorized vehicles with an axle distance of 3.5 to 5 m include small buses with 2 axle trucks with 6 wheels in the Highways classification system.
Medium Heavy Vehicle (MHV)	Medium Heavy Vehicle (MHV)	Motor vehicles with an axle distance of 3.5 to 5 m include small buses 2 axle trucks with 6 wheels in the classification system Highways.
	Big Truck (TB)	3 axle trucks and trailers with first to second axle spacing < 3.5m
	Big Bus (BB)	2 or 3 axle buses spaced between axle 5 to 6 m
Motorcycle (SM)		2 or 3 wheeled motorcycles, includes motorcycles and 3 wheeled vehicles in the Highways classification system.
Vehicle Not Motorized (KTM)		Wheeled vehicles powered by humans or animals, including rickshaws, horse-drawn carriages and strollers in the Highways classification.

Source: PKJI Indonesian Road Capacity Guideline (2014)

2.6. Teknik analisis Z-score, Cusum dan Number Rate (NR)

To determine accident-prone areas (Black sites) and accident-prone points (Black spots) [8]. Z-score technique (Black site). Z-score is the Z number or standard number or standard number. Z numbers are searched from samples of size n, data X1, X2, X3, …, Xn with an average of X at standard deviation S, so that new data can be formed, namely Z1, Z2, Z3, …, Zn with an average of 0 standard deviations of 1. Find the average value:

$$\bar{X} = \frac{\sum X}{N} \quad (2)$$

Information:
X : is the number of accidents; $\bar{x}$: is the average number of accidents (total); N : is the amount of data at the location.

a. Find the standard deviation value
The value of the standard deviation (S) is the root of the sum of the squares of the average accident rate per year minus the average accident rate divided by the amount of data (Hasan 1.2008). In the following formula:

$$S = \frac{\sqrt{\sum(xi-\bar{x})^2}}{n} \quad (3)$$

Information :
S : is the standard deviation; Xi : is the average number of accidents per year; $\bar{x}$: is the average number of accidents (total); N : is the number of road segmentsMencari nilai Z-score.

The Z formula can be searched by the formula (Hasan 1.2008), shown in the following formula:

$$Zi \ \frac{xi-x}{s} \quad (4)$$

Information :
Zi : is the Z-score of the accident at the location; Xi : is the amount of data at location I; S : is the standard deviation; $\bar{x}$: is the average number of accidents (total); i : 1,2,3, …, n.
The classification in determining accident prone areas (black spots) is as shown in table 3 as follows.

Tabel 3. Determination of Classification of Accident Prone Points

No	Nilai Z-score	criteria
1	Positive values (0_+)	Accident prone
2	Negative Values (0_-)	Accident hotspot

(Source: (Austroad, 2009)

A positive Z-score is a Z-score below the average number of accidents, while a negative z-score is a z-score above the average number of accidents. Road sections that are identified as traffic accident-prone areas (black sites) are roads that have a positive z-score value and roads that are not identified as prone areas [8].

Determining the accident-prone class interval from the z-score value is by using the following formula: an accident is a road section that has a negative z-score value.

$$I \ \frac{Z_{Tertinggi} - Z_{Terendah}}{\sum I} \quad (5)$$

Information :
I : is the prone class interval; Highest Z : is the highest Z-score value; Lowest Z : is the lowest Z-score value; ∑I : is the number of intervals.

Then coupled with analysis techniques using cusum to determine accident-prone points. However, in analyzing it, you must first map all the accident locations with the help of a map (google maps and earth).

2.7 Cusum (Cumulative Summary)

Cusum technique (Cumulative Summary) is a procedure technique that can be used to identify black spots. The cusum graph is a standard statistical procedure as a quality control for detecting changes and mean values. The cusum value can be found by the formula [9] look for the mean (W) calculation to find the mean value of secondary data, namely with the following formula:

$$W = \frac{\sum X1}{L \ x \ T} \quad (6)$$

Information :
W = is the mean value; ∑X1 = is the number of accidents (total); L = is the number of intersections on the road; T = time/period (year).

Finding the accident Cusum value for the first year. The calculation for finding the accident Cusum value for the first year is to subtract the number of accidents each year from the mean value, namely by the formula.

$$So = (X1 - W) \quad (7)$$

X1= is the number of accidents per intersection year;
W =is the mean value.

Finding the next year's Cusum value to find the next Cusum value (S1) is to add up the first year's Cusum value with the results. reduction in the number of accidents and the mean value in the following year, namely by formula.

$$S1 = \ [So + (X1 - W)] \quad (8)$$

Information :
S1 : is the value of I after the accident in the following year; So : is the accident Cusum value for the first year ; X1 : is the number of accidents each year; W : is the mean value.

3. RESULTS AND DISCUSSION

3.1 Methodology

3.1.1 Research Design

In this study using a type of quantitative research. This type of quantitative research is one of the ways used to answer the problem to be studied. According to Sugiyono (2018; 13) quantitative data is a research method that is based onpositivistic (concrete data), research data in the form of numbers that will be measured using statistics as a calculation test tool, related to the problem under study to produce a conclusion.

3.1.2 Research Locations

This research was conducted on the Krebet highway, Bululawang District, Malang Regency with a road length of 2 Km, the status of the road is primary collector. The research location is shown in Figure 1 as follows;

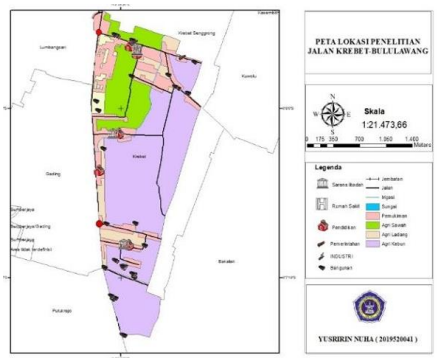


Figure 1. Research Locations

3.1.3 Geometry Data and Road Facilities

a) Road Type = 2 lanes, 2 directions, undivided (2/2 UD)
b) Road Status = District Road
c) Path Function = Primary Collector
d) Road Segment Length = 2000 Meters
e) Road Body Width = 7 Meters
f) Terrain Conditions = Straight, flat
g) Traffic Signs = Yes
h) Road Class = III
i) Type of Environment = Shopping Areas, Markets, School Stalls, PT Sugar, Offices

3.1.4 Data Processing Methods

The data collection carried out in this study was divided into two, namely secondary data and primary data. The analytical data were obtained from measurement results and direct field observations of road safety deficiencies, and were supported by historical accident anatomy data from the police station and information from the community around the study site.

a. Primary data

Primary data is data obtained from observations made to describe the condition of the road section and obtained directly from the research location to determine the movement of vehicles in traffic accidents. Things observed include:

a) Hysical condition or topography, road pavement around the road section

b) Situations and activities that exist around the roads which can be in the form of Schools, Restaurants, Markets, Factories, Shops, and Housing.
c) Average daily traffic data (LHR). This primary data collection was carried out by 8 surveyors and then counted the number of vehicles based on the type of vehicle class passing through the traffic flow at the research point, Jalan Raya Krebet Bululawang. Data collection was carried out from 06.00 am to 22.00 pm for 7 days. After the data is obtained, then the calculation of the volume of the number of vehicles and the percentage of average daily traffic is carried out. Calculation of traffic flows using the 2014 Indonesia Road CapacityGuideline method.

b. Data seconds

Data that refers to supporting data regarding Accident-Prone Areas as Research Locations.
a) Accident data, in this study required accident data to find out how many accidents occurred on the Krebet Bululawang highway, Malang city, East Java province, accident data were obtained from the Malang City Police Resort (Polres).
b) Data on the number of accident victims in 2018-2022;
c) Data on the number of vehicles involved in traffic accidents.

Tabel 4. Secondary Data Needs

No	Data	Institution
1	Accident data for 2018-2022	District Police Satlansta Poor
2	Data on the number of accident victims 2018 2022	District Police Satlansta Poor
3	Amount data which vehicle involved in an accident traffic	District Police Traffic Unit Poor

Source: 2023 accident data

3.1.5 Research Flow Chart

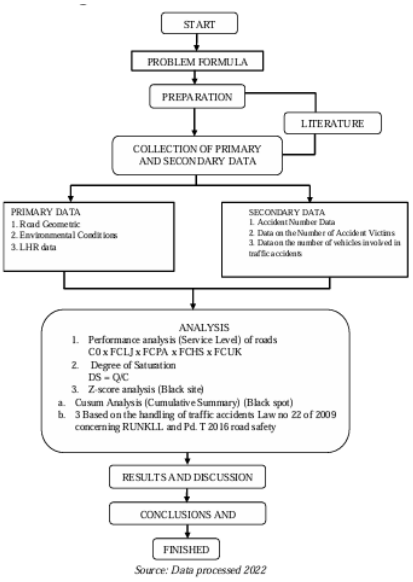


Figure 2. Research Flowchart

3.2 Results and Discussion

3.2.1 Calculation of Z-Score Analysis for Identification of Accident Prone Areas (Black Sites)

To determine accident-prone areas (black sites) the Z-score formula is used. By using this formula, it is known that the average growth rate of accidents and accident-prone areas on the Krebet road, Malang Regency. Z-score calculation for accident rate growth in segments 1 to 4 from 2018 to 2022

A. Finding the Average Value of Data (¯X)

$$\bar{X} = \frac{\sum x}{n} \quad (9)$$

$$\bar{X} = \frac{38}{4} = 9.500$$

information : S : is the standard deviation; X : is the number of accidents; ¯x : is the average number of accidents (total); N : is the number of road segments at the location.
The average value of X is the total number of accidents from 2018 to 2022 divided by the number of roads where the number of accidents is 38 and the number of roads is 1. More detailed calculations can be seen in the table. Search for the Standard Deviation Value:

$$S\frac{\sqrt{(\sum xi-x)^2}}{N} \quad (10)$$

$$S\frac{\sqrt{5.000}}{4} = 1{,}118$$

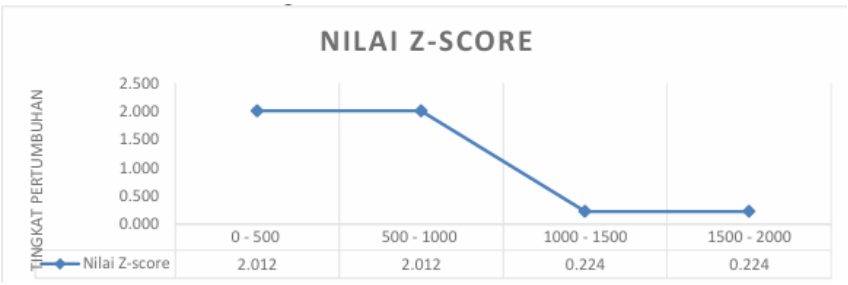
Information : S = Standard Deviation ; Xi = Average number of accidents per year ; X = Average accident rate; n = Number of road segments at the location .
The standard deviation value (S) is the root of the sum of the squares of the average accident rate from 2018 to 2022 minus the average accident rate divided by the amount of data, where the sum of the squared average accident rates from 2018 to 2022 is reduced the average accident rate is 5.00 divided by the amount of data of 4. More detailed calculations can be seen in Table.Mencari nilai Zi Per Segmen,

$$Z_i = \frac{x-\bar{x}}{s} \quad (11)$$

1) Segment 1 0 – 500 meters
   $Z_i = \frac{x-\bar{x}}{s} = \frac{2{,}250}{1.118} = 2{,}012$
2) Segment 500 – 1000 meters
   $Z_i = \frac{x-\bar{x}}{s} = \frac{2{,}250}{1.118} = 2{,}012$
3) Segment 1000-1500 meters
   $Z_i = \frac{x-\bar{x}}{s} = \frac{0{,}250}{1.118} = 0.224$
4) Segment 1500 – 2000 meters
   $Z_i = \frac{x-\bar{x}}{s} = \frac{0{,}250}{1.118} = 0{,}224$

Information :
Zi : is the Z-score of the accident at the location; Xi : is the amount of data at the location; S : is the standard deviation; ¯x : is the average number of accidents (total); I : 1,2,3, …n.

The Z-score value (Zi) is the average number of accidents per year minus the average number of accidents divided by the standard deviation, which in this calculation example is taken per segment of the Krebet highway with the average value of the number of accidents, the average value of accidents , and a standard deviation value of 1,118.



Figur 3. Graph of Black Site Analysis on Krebet Road Sections, Bululawang District
(Source: 2023 analysis results)

Based on the data above, the accident z score values for each segment are obtained based on the total number of accident incidents during the period 2018 - 2022 with 2 road segments with the highest scores, namely segments 1 and 3 where the number of accident victims is 11 accident victims and the highest z-core value 2.012 in segment 1 and segment 3 0.224 Identify characteristics that are deeper and more detailed, this is based on the results of data analysis of the z-score value of accidents that appear 4 priority road segments and are aimed at handling the location points of accident-prone segments that have been identified and previously set. At this stage, the most important technical problems in road traffic safety will be described as an effort to handle the accident-prone segment location points that have been identified previously on Jalan Krebet KM 01-02.

3.2.2 Calculation of Cusum Analysis for Identification of Traffic Accident Prone Points (Black Spots)

Black spot is a point on a road that is prone to accidents. To determine the black spot using the Cusum method. Cusum is a standard statistical procedure for detecting small changes from the mean value. From the results of the calculation of the cusum then a graph is made, by making the graph it is easier to detect the points of the road that often occur and are prone to accidents. Calculation of the Cusum value to determine accident-prone road points from segments 1 to 4 data from 2018 to 2022.

a. Finding the Mean Value (W)

$$W = \frac{\sum X1}{L\ x\ T}$$

$$W = \frac{38}{8\ x\ 5} = 0{,}95$$

Information :
W = is the mean value; ∑X1 = is the number of accidents (total); L = is the number of intersections on the road; T = time/period (year).

The mean value (W) is the number of accidents divided by the number of segments multiplied by the time/period, where this calculation is taken from the Jalan Raya Krebet section, the number of accidents that occurred on the Jalan Raya Krebet section. Calculations in more detail can be seen in Table.

b. Finding the first year Accident cumulative value ($S1$)

Calculation to find the first year's cumulative accident value by reducing the number of accidents per year with the mean.

$$S1 = (X1 - W)$$

S1 = 4 - 0,95 = 3,050

Information:
S1 = First year Cusum
Xi = Number of Accidents per year

The first year accident cusum value (So) is the number of accidents each year minus the mean, where the number of accidents in the first year at the first station that occurred on the Krebet highway section were 4 accidents and a mean value of 0.95. More detailed calculations can be seen in Appendix B. Table B.

1. Looking for Second Year Accident Cusum Value $S1$

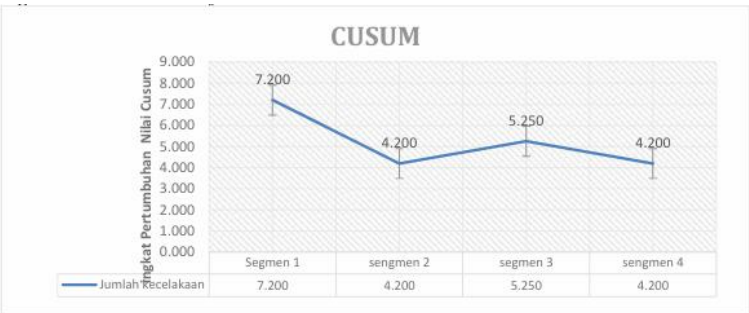
$$S_2 = S_1 + (X_1 - W)$$

$$S_2 = 3{,}050 + (3 - 0{,}95) = 5{,}100$$

Information: S2 = Cusum 2nd year ; S1 = Cusum first year

The next year's accident cusum value (*S*2) is the first year's accident cusum value mean value, where the first-2 year accident cusum value, then the first year's number of accidents at the first station that occurred on the Krebet highway section were 3 accidents and mean value of 0.95 Cusum calculations are carried out from 2018 to 2022 for each segment. Detailed calculations can be seen in table 6. The calculation results are presented in graphical form, which states the relationship between the custom value and the year the traffic accident occurred.

Based on the results of existing data processing, it can be concluded that the location of accident-prone points (black spots) that have the largest custom value on the Krebet road segment identified as accident-prone points is in segment 1 and segment 3 as the reason for having the largest custom value, namely 7,200 and 5,250.



(Source: 2023 analysis results)

Figur 4. Black Spot Graph on Jalan Raya Krebet

Figure 4 depicts a graph of the relationship between the number of accidents per year and the custom value on the Krebet highway. From the graph it can be 4.200 seen that the stations (hereinafter abbreviated as Sta) identified as accident-prone points are sta 0-500. Sta 500-1000, 1000-1500 and 1500-2000 are located in front of the Sugar Factory with the highest custom value of 7,200.

3.2.3 Recommendations for safe roads on the Krebet-Bululawang section

Based on the results of data analysis by carrying out safety inspections on the Krebet – Bululawang Km 0.1 to 0.2 road sections, which are accident-prone areas, several priority solutions are needed, so that later it can be proposed to overcome or reduce the number of accidents. traffic accidents at the study site. Based on the existing conditions on the road section Krebet - Bululawang Km 0.1s/d km 0,2 has not met the criteria for roadworthiness standards because there are still many deficiencies in infrastructure and facilities roads, and there are several road equipment facilities that do not meet road worthy standards. The following are recommendations or problem-solving efforts that the author can propose to meet road worthiness standards on the Krebet - Bululawang road section Km 0.1 to km 0.2 in Malang Regency. Efforts that can be given include the following.

a. Repairs to faded road markings;
b. It is necessary to install speed limit signs 50-100 meters before entering accident-prone areas;
c. It is necessary to install caution signs with a distance of 50 meters after the speed limit sign; there needs to be warning signs and prohibition signs
d. It is necessary to procure or install street lighting with a zig zag system on both sides of the road;
e. It is necessary to install pedestrian crossing signs.

The results of the analysis show that there are several problems that cause accidents on Jalan Krebet. So It Needs Immediate Handling To Reduce The Number Of Accidents And Increase Traffic Safety In The Years To Come. The Efforts That Need To Be Done Are. Referring to the theory according to RI Law 22 of 2009 Article 1, Traffic Signs/Signs Are One Of The Road Equipment, In The Form Of thresholds, letters, numbers, sentences, and or a combination of the two as warnings, prohibitions, orders or instructions for road users [10].

The picture below is the existing condition in segment 1, to complement the deficiencies in segment 1. The author provides a proposal for an overview of the installation of existing road equipment facilities on the road section Jalan Krebet – Bululawang Km 0.1 to Km 0.2:

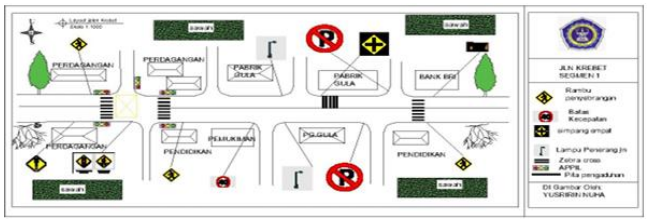


Figure 5. Recommendations for Jalan Krebet Segment 1 (0-600 M) ***(Source: 2023 analysis results)***

1. Recommended Segment 1 (0 – 500 M)

There Are Several Additional Road Equipment Facilities In Segment 1 Referring To Theory According to RI Law 22 of 2009 Article 1, Traffic Signs/Signs Are One Of The Road Equipment, In The Form Of Symbols, Letters, Numbers, Sentences, And Or A Combination Of Both As Warnings, Prohibitions, Commands Or Instructions For Road Users.

1) Painting of the Yellow Box Junction markings which are not found in signalized intersection areas so that road users can prevent the accumulation of vehicles in the area.
2) Installation of speed limit signs on the side of the road which aims to inform drivers regarding the maximum speed limit when driving on Jalan Krebet Km 0.1 to km 0.2.
3) Installation of crossing warning signs so as to reduce traffic accidents.
4) Provision of street lighting with an interval of 30 M which aims to enable drivers to drive well at night.
5) Installation of noise tape which functions to reduce speed when entering the access area of PT Sugar.
6) as well as painting the zebra crossing because the speed on the main road is very high so it needs to be installed on segment 1.
7) Maintenance of roadside plants so as not to block the light from street lighting.
8) Installation of warning signs in accident-prone areas so that drivers are more careful.

2. Recommended Segment 2 (500 – 1000 M)

There are several additional road equipment facilities in segment 2, namely the installation of speed limit signs on the side of the road which aims to inform drivers about the maximum speed limit when driving on Jalan Krebet Km 0.1 to km 0.2.

1) Installation of crossing warning signs so as to reduce traffic accidents.
2) Installation of warning signs in no parking so that drivers cannot park illegally.
3) Provision of street lighting with an interval of 30 M which aims to enable drivers to drive well at night.
4) Adding a shoulder to the left of the road segment
5) as well as painting the zebra crossing because the speed on the main road is very high so it needs to be installed on segment 2.
6) Maintenance of roadside plants so as not to block the light from street lighting.

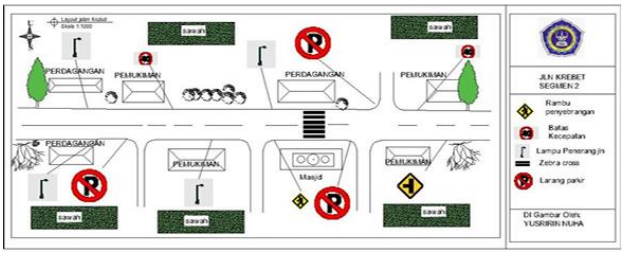


Figure 6. Recommendations for Jalan Krebet Segment 2 (600-1200 M) (*Source: 2023 analysis results*)

3. Recommended Segment 3 (1000-1500 M)

There are several additional road equipment facilities in segment 3, namely the installation of speed limit signs on the side of the road which aims to inform drivers about the maximum speed limit when driving on Jalan Krebet Km 0.1 to km 0.2.

1) Installation of crossing warning signs so as to reduce traffic accidents.
2) Installation of warning signs at no parking so that drivers cannot park illegally.
3) Provision of street lighting with an interval of 30 M which aims to enable drivers to drive well at night.
4) Installing street lighting and regular monitoring with scheduled road safety inspections at potential accident points
5) as well as the painting of the zebra cross which has experienced fading, because the speed on the main road is very high so it needs to be installed on segment 3.
6) Installation of speed limit signs so that they can warn and limit the speed of motorists passing through the Krebet road, so as to reduce the risk of accidents.

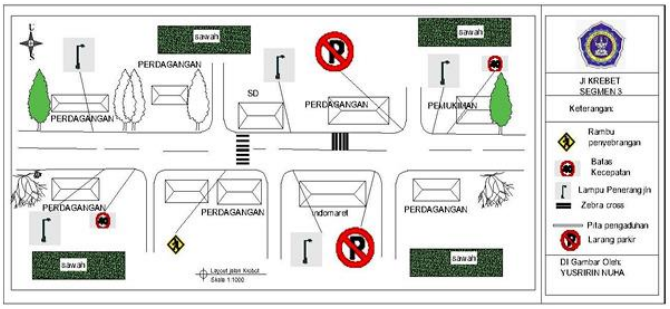


Figure 7. Recommended Jalan Krebet Segment 4 (1200-1800 M) (Source: 2023 analysis results)

4. Recommended Segment 4 (1500 -2000 M)

There are several additional road equipment facilities in segment 4, namely the installation of speed limit signs on the side of the road which aims to inform drivers about the maximum speed limit when driving on Jalan Krebet Km 0.1 to km 0.2.

1) Installation of crossing warning signs so as to reduce traffic accidents.
2) Installation of warning signs at no parking so that drivers cannot park illegally.
3) Provision of street lighting with an interval of 30 M which aims to enable drivers to drive well at night.
4) Installing a noise barrier which functions to reduce speed when entering the access area of PT Gula
5) as well as the painting of the zebra cross which has experienced fading, because the speed on the main road is very high so it needs to be installed on the 4th segment.
6) Maintenance of roadside plants so as not to block the light from street lighting.

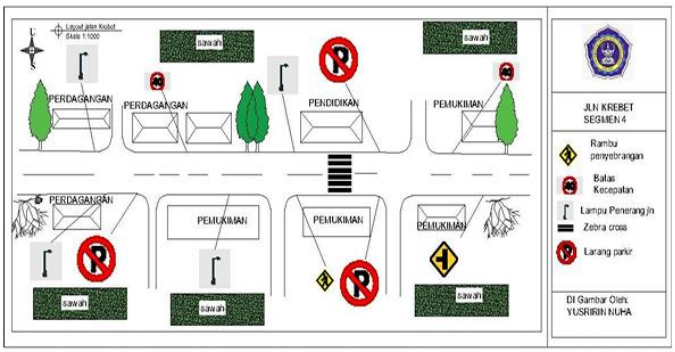


Figure 7. Recommended Jalan Krebet Segment 4 (1200-1800 M) (Source: 2023 analysis results)

4. CONCLUSION

Based on the results of existing data processing, it can be concluded that the location of Jalan Krebet is an accident-prone area (Black Site) and accident-prone spot (Black spot) which has the highest Z-Score value of 2.012 and the largest Cusum value of 7.200. Determination of accident-prone points (Black spots) and accident-prone areas (Black sites) on Jalan Krebet identified as accident-prone areas. Efforts to improve road safety on Jalan Krebet Inner City are by handling what can be done, repairing street lighting, installing signs -signs as they should, improve parking which is the most problematic for the agency Solutions that can be given include installing warning signs in accident-prone areas, regular supervision by the police to regulate traffic in accident-prone areas, installing warning signs in accident prone areas accidents, construction of sidewalks for pedestrians, cleaning.

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