Analysis of Car Accident at the Location of Black-Spot and Rating for Accident-Prone Roads in Surabaya

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Abstract. Surabaya is a city that has a relatively high accident rate. As the capital of East Java Province, Surabaya has areas with diverse activities that attract movements. The large number of movements has the potential to cause traffic accidents on the roads in Surabaya. Since 2015 until 2017 there has been an increase in the number of accidents by 179 accidents. Cars became the type of vehicle with the second largest number of accidents after a motorcycle with a total of 6,666 accidents. One of the causes of accidents in Surabaya is the condition of roads that have holes and traffic violations. The main purpose of the research was to analyze car accidents at the location of black-spot and to compile accident-prone roads in Surabaya. The research used accident frequency method and accident level method. The results showed that Road segment that has the highest frequency value in the city of Surabaya is Ahmad Yani Street with a total percentage of 19.67 per cent.

Keywords: Car-accident, Black-spot, Surabaya

1. Introduction

According to the Law of the Republic of Indonesia No. 22 of 2009 on Road Traffic and Transportation, accidents are unexpected and unintentional incidents involving motor vehicles with other road users resulting in casualty and material loss. Traffic accidents can be classified into several categories: minor accidents resulting in damage to goods and vehicles, moderate accidents resulting in minor injuries and damage to property, and serious accidents resulting in death or serious injury. Traffic accidents can be caused by three factors including human factors, vehicle factors and road factors [1]. In the last three years, traffic accidents in Indonesia has been the third largest cause of death after coronary heart disease and tuberculosis based on WHO assessment [2]. Traffic accidents have different crash characteristics. Characteristics of accidents can be classified by type of accident, impact on the victim, time of incident, type of traffic accident involved. The number of vehicles involved is divided into three i.e. single accident is an accident that involves one vehicle, double accidents is an accident that involves two vehicles, and accidents that involves more than two vehicles [3].

The condition of the victim in a traffic accident is divided into three, namely the victim of minor injuries, serious injuries, and fatal / death [3]. Minor injury is a type of injury that does not require hospitalization in hospital. Severe injury is the condition of the victim who has a permanent defect and
requires treatment for more than 30 days. The fatal injury / death is the condition of the victim who is confirmed to be killed by accident. Traffic accidents are categorized by day and hour of accident. Traffic accidents can be divided into weekdays (Monday, Tuesday, Wednesday, Thursday, and Friday) and weekends (Saturday and Sunday). The timing of the event can be determined at a certain time interval. The characteristics of traffic accidents based on the age of the driver indicate that about 20 per cent of drivers involved in the accident are drivers who are under the age of 17 years. Of course, this can be a matter of thinking given that new driver can have a driver's license at the age of 17 years, while quite a lot of drivers involved in accidents were under 17 years [4].

Some researchers analyze that 91.9 per cent of pedestrian accidents occur in built areas, but only 35.6 per cent of accidents are caused by pedestrians. On the street, the situation is different, in 60.8 per cent of the cases, pedestrians are the suspected offenders [5]. The survey results showed that the percentage of users who used their phones while driving is very high and for this reason it is necessary to introduce tools that can reduce the number of accidents caused by this type of driving [6]. The evidence indicating a connection between a single car accident and suicide is not correct, but the topic is feasible for future investigations and may lead to a much better understanding of the causes of car accidents and proposals to reduce their incidence [8].

2. Methods
This research was conducted in 13 streets in Surabaya. The selection of the location in this research is based on the number of accidents that occurred in the roads in Surabaya City. This research used two methods to identify accident-prone locations, namely: frequency method and accident level method.

2.1 Frequency Method
This method was used to determine the amount of accidents occurred in a year for each kilometer, so that the result will present which segment has the highest or lowest part of the accident rate (blackspot). The equation for calculating accident rate by accident frequency method (Accident Frequency Method) is:

$$AF = \frac{A}{L \times T}$$  \hspace{1cm} (1)

AF = accident frequency (accident/km/year)
A = total of accident
L = segment length/road (km)
T = period (year)

2.2 Accident Level Method
This method combines the frequency of accidents with the presence of vehicles (ie, traffic volume) and is expressed as "accidents per million vehicles for crossing" or "accidents per million vehicle - miles of travel" for the section of the highway. The place is then ranked in order of crash rates. A highway system of 10,000 miles or less can use this method.

a. To point places:

$$Rsp = \frac{A \times 1,000,000}{365 \times TV}$$  \hspace{1cm} (2)

b. For part of the road:

$$Rsp = \frac{A \times 1,000,000}{365 \times TV \times L}$$  \hspace{1cm} (3)

Rsp = Accident level at one point (accident/million vehicles)
Rse = Accident level at a part of road (accident/million vehicle-mill)
A = Total accident
T = AADT in the research period (for intersection)
V = Sum of incoming volumes for all branches of intersection
L = Road length (mill)

3. Result and Discussion
This study used average daily traffic data or often abbreviated LHR to find out how many vehicles pass through the location of black-spot road segment in Surabaya.

3.1 Accident Characteristics
Based on Annual Traffic data, it can be seen that Mayjend Sungkono Road has the highest LHRT value, that is 8631.14 pcu/hour compared to 13 other study area roads. The result of the calculation of Accident Frequency Method (AF) was obtained from the calculation of the number of accidents in a given period of time divided by the length of road which is multiplied by the number of periods used in the calculation, then it was obtained that Mayjend Sungkono Road has the highest AF value with a value of 4.586 and it can be considered as the black-spot most vulnerable to accidents in Surabaya (Table 1).

| No | Name                          | Road length (km) | Period (Year) | LHRT (pcu/hour) | Total Accident 2014-2017 | AF    |
|----|-------------------------------|------------------|---------------|-----------------|--------------------------|-------|
| 1  | Jalan Ahmad Yani              | 9.73             | 4             | 9675.23         | 83                       | 2,132 |
| 2  | Jalan Raya Mastrip            | 8.20             | 4             | 1845.83         | 66                       | 2,013 |
| 3  | Jalan Raya Darmo              | 5.11             | 4             | 5807.7          | 30                       | 1,467 |
| 4  | Jalan Raya Diponegoro         | 5.35             | 4             | 5713.65         | 31                       | 1,450 |
| 5  | Jalan Tambak Osowilangun      | 3.81             | 4             | 3621.88         | 43                       | 2,819 |
| 6  | Jalan Raya Jemursari          | 3.35             | 4             | 4084.2          | 24                       | 1,793 |
| 7  | Jalan Ngagel                  | 2.87             | 4             | 4921.7          | 16                       | 1,392 |
| 8  | Jalan Tanjungsari             | 1.10             | 4             | 14              | 3,184                    |       |
| 9  | Jalan Raya Sememi             | 1.40             | 4             | 4047.45         | 18                       | 3,222 |
| 10 | Jalan Kenjeran                | 3.11             | 4             | 4370.8          | 22                       | 1,768 |
| 11 | Jalan Kertajaya               | 2.63             | 4             | 6162.36         | 9                        | 0,857 |
| 12 | Jalan Dr. Ir H. Soekarno      | 4.50             | 4             | 6440.1          | 35                       | 1,946 |
| 13 | Jalan Citra Raya              | 3.06             | 4             |                 | 12                       | 0,979 |
| 14 | Jalan Mayjend Sungkono        | 1.04             | 4             | 8631.14         | 19                       | 4,586 |
The severity of car accident victims in Surabaya is dominated by casualties group with no injury condition, while the severity of serious injury is the group with the lowest percentage of victims. The severity of casualties in the group of minor injuries and serious injuries each year has an increased number of casualties, while the number of casualties in the group with no injuries and the group that died showed fluctuating number from 2014 to 2017 (Figure 1).

3.2 Rating of Road Accident Prone area in Surabaya

The accidents rate ranking can be determined by the Applied Equivalent (EAN) Scale approach, so that it can be known which location has the highest accident rate according to the severity level. Road segment that has the highest frequency value in the ranking table of accident-prone roads in Surabaya is at Ahmad Yani Road with a total percentage of 19.67 per cent (Table 2).

| Name          | Year | Total | 2014 | 2015 | 2016 | 2017 | Total |
|---------------|------|-------|------|------|------|------|-------|
| Ahmed Yani    | Total Data | 17 | 19 | 22 | 25 | | 19.67 |
|               | %    | 4.03 | 4.50 | 5.21 | 5.92 | | |
| Raya Mastrip  | Total Data | 12 | 21 | 19 | 14 | | 15.64 |
|               | %    | 2.84 | 4.98 | 4.50 | 3.32 | | |
| Raya Darmo    | Total Data | 12 | 10 | 5 | 3 | | |
4. Conclusion

The severity of car accident suspect in Surabaya City is dominated by group of suspect with minor injury condition, whereas the severity of serious injury is group with percentage of lowest suspect number. There has been an increase in the number of suspect based on the severity of minor injury group each year. The number of suspects in the group of minor injuries is in 2014 as many as 111 people, in 2015 as many as 112 people, in 2016 as many as 152 people, and in 2017 as many as 213 people. The results showed that Road segment that has the highest frequency value in the city of Surabaya is Ahmad Yani Road with a total percentage of 19.67 per cent. Specifically for the Black-spot area, things that can be conducted are installing careful warning signs at the accident-prone areas, improving and upgrading road facilities and pedestrian facilities, and making policies that can reduce the level of accidents at the site such as adding a lane to both roads, installing banners of appeal, and socializing good and proper traffic ways on the highway.

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