ACCIDENT ANALYSIS ON SURABAYA - GEMPOL TOLL ROAD

Sigih Priyanto

ABSTRACT

There are significant differences between ordinary road and toll road as a free way such as speed, design standard, comfort, and pattern of non- paid traffic. Limited access with unsignalized intersections and high average speed in long road sections are among the characteristics that differentiate it from ordinary roads. By the term 'free', it does not mean that toll road is entirely free from the problems of traffic accidents, even, the tendency for accident is higher in quality.

This study identifies the main factors that cause an accident, vulnerable areas, and actions that have been carried out based on the characteristics of accidents. It aims to formulate alternatives of solutions in order to eliminate the contribution of the causes of accident.

The characteristic of accidents on Surabaya - Gempol Toll Road shows a high rate of occurrence, in which driver take the highest responsibility followed by vehicles road and road environment. The road factor itself as the cause of accidents is almost undetermined. Among the various kinds of vehicle, minibuses are the most vulnerable ones to accidents and this indicates a different trend from the past few years.

There is an interrelationship among factors of accident, they are interacting one to another in causing an accident. An accident often happens due to driver’s unpreparedness for the condition created by the toll road. Actions to eliminate accident should be adjusted to the existing characteristics. Single zone management (by the installment of sign post, wingstop, etc) and mass action management (safety campaign and assistance, etc.) are among the recommended actions to take.

INTRODUCTION

There are significant differences between ordinary road and toll road as a free way such as speed, design standard, comfort, and pattern of non-paid traffic. Limited access with unsignalized intersections and high average speed in long road sections are among the characteristics that differentiate it from ordinary roads. By the term 'free', it does not mean that toll road is entirely free from the problems of traffic accident, even, the tendency for accident is higher in quality.

Surabaya - Gempol Toll Road is one of the toll roads constructed in East Java. The highest percentage of the causes of accident in 1983 is driver factor (56%), followed by vehicle factor (29%) and the rest is environmental and road factors. Approximately 10 years later (in 1994) the percentage of the causes of accident, vehicle and driver factors increase to 34.42% and 62.83%, respectively, and the most factor is driver factor. Therefore, it is quite wrong to consider that the driver is to be blamed as the major cause of accident without looking at the contribution of other factors.

This study tries to analyze traffic accidents in relation to the main factors causing accidents, the vulnerable areas, and the sections that may best be taken to eliminate accident, including their relevance to the efforts to improve traffic safety. It aims to find alternatives of solutions to reduce the contribution of the dominating factors of the cause of accident to a minimum by taking preventive or protective actions to reduce the accident rate.

APPROACH

Accident Rate

Statistical analysis of accidents data is an approach toward an accident. The statistical analysis enables to monitor the tendency of accident and to identify the success of a change immediately. Through this analysis, a betterment is acknowledged to be the result of an action, not merely a fluctuation.

Accidents and death rates usually occupy one of the following fundamental categories. Those categories are:
1) Population-base rates. The rate is static and not dependent on the use of vehicle or the total number of the vehicle's travel being made.
2) Exposed-base rates. It is the calculation of the length of the travel as a substitute to individual exposure toward a potential accident situation.

The accidents and death rates for a certain year are calculated using the following formula:

\[ \text{Rsc} = \frac{A \times 100 \times t_2}{365 \times T \times V \times L} \]

\[ \text{Rsc} = \text{accident involvement rate} \]
\[ L = \text{length of road} \]
\[ T = \text{period of observation} \]
\[ A = \text{number of accident} \]
\[ V = \text{traffic volume} \]

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The accident rate shows the total accident in a certain period of time. The involvement rate describes the vehicles and the drivers involved in an accident. The death rate shows severe accidents. In the accident rate calculation, the figures are scaled to get significant values in the accident analysis.

Vulnerable Area

An area with high rate, high risk, and high potential of accident on a road section may be referred to as a vulnerable-to-accident area. This area can be identified on a particular road location (black spot) or a particular road section (black-site).

Several parameters are applicable to determine the locations of black spot and black-site. For black-spot area, several applicable parameters are:

1) Number of accident during a certain period exceeds a certain value.
2) The accident rates (per-vehicle) for a certain period exceeds a certain value.
3) Both the number and the rate of accident exceeds a certain value. The accident rates exceed the critical value derived from the available statistical analysis.

For black-site area, the applicable parameters are:

1) Number of accident exceeds a certain value.
2) The accident rates (per-kilometer) exceeds a certain value.
3) The accident rate or the number of accident (per-vehicle) exceeds a certain value.

The accident rate can be calculated mathematically as in the following:

\[ TK = JK(T + L) \]  \hspace{1cm} (1)

In which \( TK \) = accident rate (per year, per km of the road length),
\( JK \) = number of accident during 7 year
\( T \) = duration of time of observation (year)
\( L \) = length of the observed road section (km)

The critical index of accident can be calculated using the following operation:

\[ RC = Ra + \frac{R_a}{m} \]  \hspace{1cm} (3)

In which \( RC \) = critical index of accident
\( Ra \) = average accident rate for the whole location

\( m \) = measurement of the number of accident permission of vehicle/km, or the Number of accident during the period of observation

\( K \) = Constant, depending on the level of confidence

Reducing Accident

Preventing an accident involves some betterment in the designing stage and in the design of new roads that leads its orientation to eliminating traffic accident and minimizing the casualties involved in it. Reducing accident, on the other hands, involves the economical management for the vulnerable-to-accident areas.

Several approaches of economical road management to reduce the accident rate are:

1) Single Sites: management on the location or section of the roads where accidents happen repeatedly.
2) Mass action: general management for the locations with general factors of causes.
3) Area action: integrated management on a certain area where the accident rates exceeds a certain standard, especially that relates to the spread accident, and is usually in urban areas.
4) Route action: management on roads of a particular type or class where the accident rates is above the average.

METHODOLOGY

In this study, reflective thinking manner is applied, i.e. by combining deductive and inductive thinking methods. It starts with an inductive method to describe the problem areas, followed by the deductive method to make the framework of reducing accident. The following flowchart describes the methodology to carry out this research.

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DATA COLLECTION

Data on the Average Volume of daily traffic

Traffic volume gives influence to accident. The higher the volume on the road sections the higher the frequency of accident tendency. Surabaya - Gempol Toll Road consists of eight road sections and has two lanes. Among those eight sections, the section of Kota Satelit - Gunungpari has the highest volume of daily traffic.

Table 1. Road Section and Average Daily Traffic in 1997

<table>
<thead>
<tr>
<th>No</th>
<th>Name of Section</th>
<th>Length (km)</th>
<th>Lane A (vehicle/day)</th>
<th>Lane B (vehicle/day)</th>
<th>Lane C (vehicle/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Broek-Dupak</td>
<td>4</td>
<td>10.328</td>
<td>14.064</td>
<td>24.352</td>
</tr>
<tr>
<td>2</td>
<td>Dupak-Banyu-Urip</td>
<td>2</td>
<td>25.286</td>
<td>26.415</td>
<td>51.701</td>
</tr>
<tr>
<td>3</td>
<td>Jatya Urip-Kon Satelit</td>
<td>2</td>
<td>22.598</td>
<td>26.784</td>
<td>40.292</td>
</tr>
<tr>
<td>4</td>
<td>Kon Satelit-Gunungpari</td>
<td>3</td>
<td>23.746</td>
<td>28.432</td>
<td>52.718</td>
</tr>
<tr>
<td>5</td>
<td>Gunungpari-Waru</td>
<td>5</td>
<td>23.664</td>
<td>26.642</td>
<td>50.366</td>
</tr>
<tr>
<td>6</td>
<td>Waru-Gempol</td>
<td>11</td>
<td>18.567</td>
<td>19.831</td>
<td>38.448</td>
</tr>
<tr>
<td>7</td>
<td>Gempol-Jua Margu</td>
<td>9</td>
<td>16.739</td>
<td>19.341</td>
<td>34.080</td>
</tr>
<tr>
<td>8</td>
<td>Jua Margu-Mojokerto</td>
<td>7</td>
<td>14.608</td>
<td>15.485</td>
<td>30.093</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>44</td>
<td>155.446</td>
<td>173.044</td>
<td>330.693</td>
</tr>
</tbody>
</table>

Data on Traffic Accident

The obtained data on accident serve as the secondary data. Data on accidents that is based on the historical data on traffic accident happened on Surabaya - Gempol Toll Road comes from PT. Jua Margu (Lzd) Branch of Surabaya - Gempol - Mojokerto. The emphasis is on those during the year of 1997 but it is still open for phenomena, which occur beyond this time period, to be described as long as they are relevant.

ANALYSIS

Accident's characteristics

Analysis and discussion commence by reviewing the distribution of accidents, while the focus of study is achieved by analyzing the causative factor from the distribution of the occurrence of accident.

1. Occurrence of accident

The stick-diagrams presented in the Fig. 2 and Fig. 3 show that the number of accident tends to increase every year, and the biggest increase took place in 1996 before it declined again in 1997. It is relieving since the increase of the number of accident is not accompanied by the increase of fatal and serious accident, even the opposite.

The causal factors are grouped into three factors namely: driver, vehicle and road environment. The biggest causal factor is the driver, followed by vehicle factor and road and environmental factor. During the period there is no accident caused by road factor only. However, the influence of road factor in inducing accidents is still apparent, for among the causal factors are interested.
Of driver factor, the lack of anticipation, is the dominant factor. Of vehicle factor, the dominant case is caused by tire burst. A worn-out surface and over pressure make the tire easily bursts out. And of the road environmental factor, although t/l road is a limited accessed road, crossers create obstruction that disturbs driver's concentration.

2) Time of accident

During the last 4 years, working days are the days when accidents often happen, and it is on Monday that the highest frequency of accident happens. Within a 4 hours interval, period between 12.00 - 18.00 has a distinctively high of accident. If this interval is divided into a one hour-interval, period between 11.00 - 12.00 is the time with the most accidents. In 1997 most of the cases were caused by lack of anticipation (driver factor).

3) Site of accident.

Based on the number of casualties, especially those who are dead or seriously injured, KM 34 + 000 - 35 + 000 is a relatively critical area because in 7 occurrences of accident 4 persons are killed, and 4 others are seriously injured. Based on the position of accident and the cause factor of accident, accident on the right lane (the driver lacks anticipation) frequently happens, and the one that happens on the left side lane is caused by tire burst (vehicle factor).

4) Vehicle in Accident

During the last 4 years, accident involving one car is remarkable. While the level of damage of the car (in 1997) shows that the most remarkable figure is for seriously damaged vehicle.
Reflecting to Fig.5, the type of vehicle involved in the accident in 1997, minibuses have the highest frequency of involvement, followed by small truck. This characteristic is different from what happened during the previous years. As seen from the severity of the casualty, the casualty in minibuses accident is also the most in number. The contributing factors to such big amount are the capacity of the car to transport passengers and the lack of equipment available to protect passenger's safety (such as safety belt).

Lack of anticipation as the remarkable causing factor from driver is shown by large truck; especially trucks with 2 axles as well as small truck. In case of minibuses, the important causing factors from driver are close-distance and lack of anticipation. For tire burst, such an accident often happens on minibuses.

5) Type of accident

Self-collision accident is the most common type in a single-car accident, whereas front-back collision is the most frequent type in multicar accident. Data in 1997 shows that self-collision accidents are mostly to happen in KM 6+000-7+000 and KM 16+000-17+000, and for front-back collision, it is on KM 13+000-14+000. Observing the cause factor of accident, tire burst is the recurring accident in the self-collision. For driver factor, lack of anticipation and dose are the most frequent cases in self-collision and front-back collision.

6) Weather in accident

Heavy rain seems to make driver more careful and slows down the speed when compared to other kinds of weather — shower and sunny. This is because the sight-distance in heavy rain becomes shorter. During the period 1994-1997, sunny days induce a condition where accidents happens more frequently. Analyzed from the cause factor of accident, lack of anticipation and tire burst are the most frequent cases during sunny days.

Vulnerable Area

In the following discussion vulnerable-to-accident area is divided into black-site (vulnerable-to-accident road section) and black spot (vulnerable-to-accident location). The study on the black-site is to analyze road sections which are already determined by the road authority (there are 8 road sections), and for the black spot, the analysis is taken for each kilometer.

1). Blacksite.

Using the existing approach the calculation of
Table 2. Accident Rate on Surabaya - Gempol Toll Road

<table>
<thead>
<tr>
<th>No</th>
<th>Section Name</th>
<th>Length of road (km)</th>
<th>Volume of average daily traffic</th>
<th>Casualty</th>
<th>Accident per km</th>
<th>Accident per 10 vehicles</th>
<th>Severity index (X)</th>
<th>Severity intensity</th>
<th>Severely injured per 100 million vehicle km</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perak - Depok</td>
<td>33.25</td>
<td>29,565</td>
<td>0</td>
<td>0.37</td>
<td>0.57</td>
<td>3</td>
<td>4</td>
<td>1,246</td>
</tr>
<tr>
<td>2</td>
<td>Depok - Banjar Urip</td>
<td>0.50</td>
<td>6,940</td>
<td>0</td>
<td>0.50</td>
<td>0.74</td>
<td>3</td>
<td>4</td>
<td>1,146</td>
</tr>
<tr>
<td>3</td>
<td>Banjar Urip - Kosambi</td>
<td>1.30</td>
<td>42,912</td>
<td>0</td>
<td>0.57</td>
<td>0.74</td>
<td>3</td>
<td>4</td>
<td>1,146</td>
</tr>
<tr>
<td>4</td>
<td>Kosambi - Cemara</td>
<td>7.20</td>
<td>51,078</td>
<td>1</td>
<td>0.57</td>
<td>0.74</td>
<td>3</td>
<td>4</td>
<td>1,146</td>
</tr>
<tr>
<td>5</td>
<td>Cemara - Widari</td>
<td>3.20</td>
<td>40,201</td>
<td>0</td>
<td>0.57</td>
<td>0.74</td>
<td>3</td>
<td>4</td>
<td>1,146</td>
</tr>
<tr>
<td>6</td>
<td>Widari - Surabaya</td>
<td>0.30</td>
<td>51,148</td>
<td>0</td>
<td>0.57</td>
<td>0.74</td>
<td>3</td>
<td>4</td>
<td>1,146</td>
</tr>
</tbody>
</table>

2. Blackspot.

By reviewing and combining several approaches to the calculation of accident rate, the analysis aims to obtain absolute critical spots vulnerable to accident. The area is considered to be a black spot when the accident involvement rate exceeds 40. Based on the analysis that has been carried out the black spot on Surabaya - Gempol toll road is presented in Table 3.

Table 3. Locations of Blackspot of Surabaya - Gempol 1997

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>ACCIDENT INVOLVEMENT RATE, Rec</th>
</tr>
</thead>
<tbody>
<tr>
<td>KM 7+000 - 4+000</td>
<td>53.05</td>
</tr>
<tr>
<td>KM 24+000 - 27+000</td>
<td>44.22</td>
</tr>
<tr>
<td>KM 30+000 - 34+000</td>
<td>91.20</td>
</tr>
</tbody>
</table>

3. Number of violations

Toll Roads, as free way are not a public facility for their users without control and monitoring. There are chances for violations to happen, especially those relating to speed limit, lane occupancy, load, traffic signal, etc.

As seen in Table 4, during the year 1997, violations to right lane, minimum speed and load control are among the most frequent cases, and it is goods transporting vehicle that makes the most violations of all. For trucks, the cases of violation reach 2,954 times, and for pick up 1,345 times. The type of violation that most (of the) vehicles commit is speed limit, i.e. minimum speed. This violation is a serious obstruction to other users, and it induces other types of violation such as left slip, or even the use of road shoulder to overtake another car because of the driver's impatience and lack of discipline. The last two violations are many, particularly on urban roads. This results in many accidents.

Table 4. Number of Traffic Regulation Enforcement (Tatig) by the Police Department on Surabaya - Gempol Toll Road 1997

<table>
<thead>
<tr>
<th>No</th>
<th>Type of violation</th>
<th>Number of violation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Right lane</td>
<td>1190</td>
</tr>
<tr>
<td>2</td>
<td>Minimum speed</td>
<td>1469</td>
</tr>
<tr>
<td>3</td>
<td>Left slip road shoulder</td>
<td>245</td>
</tr>
<tr>
<td>4</td>
<td>Load/weight control</td>
<td>1457</td>
</tr>
<tr>
<td>5</td>
<td>SP height and weighing</td>
<td>679</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>5,225</td>
</tr>
</tbody>
</table>

Still in the same year, the controls and measures taken by the traffic wardens for overloading and uncerdely loading number in 5191 violations. There are 3,486 vehicles out of them are told to leave the toll road, and the rest is given a reprimand. In addition to this, measures against broken rear light of the vehicles are often taken to prevent accident of front-back collision at night.

When closely observed, such conditions indicate that this driver, who should be responsible for their load / passengers are ignorant. This is because they are not informed about the regulation for traffic on toll road, or simply ignorant about it. It seems trivial but many case of accident teach us that carelessnes brings disaster to others.

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**Reducing Accident**

Human factor is the main factor in an accident because driver is the main component in the system, and he/she is always involved in traffic accidents. In fact, there is always driver factor in any accident but it should be related to the vehicle he/she is driving, the road being travelled on, and the environment where he/she is operating the vehicle. Driver plays an absolute role in the machine by riding, driving, accelerating, or decelerating, braking and stopping it. However, four factors of cause of accidents are integral and interrelated parts.

Table 4. Number of Traffic Regulation Enforcement (Tilang) by the Police Department on Surabaya – Gempol Toll Road 1997.

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of violation</th>
<th>Number of violations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Right lane</td>
<td>1190</td>
</tr>
<tr>
<td>2</td>
<td>Minimum speed</td>
<td>1440</td>
</tr>
<tr>
<td>3</td>
<td>Left slip/rear shoulder</td>
<td>459</td>
</tr>
<tr>
<td>4</td>
<td>LoadTransport control</td>
<td>1457</td>
</tr>
<tr>
<td>5</td>
<td>SF signpost and component</td>
<td>479</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>5,225</td>
</tr>
</tbody>
</table>

Driver's physical and psychological factors (inattention, lack of anticipation, doze) play their role in the occurrence of an accident and are facilitated by internal or external environmental factors while he/she is driving. The behavior also contributes some influences on the vehicle and emotionally it will give comfort or discomfort to other drivers. It also influences the surrounding (living environment), i.e. road users. A sudden maneuver that results in an accident of other cars often happens on toll road. Road can be assumed to cause an accident, too. However, the statistics hardly presents road component as a cause factor for an accident on toll road.

Reducing accident involves some economic management of the existing road. Based on the characteristics of the accidents found in Surabaya Gempol toll road, two models of action plan that are feasible in reducing accident could be applied, they are single sites, and mass action approaches. The action plans for accident handling are presented in Table 5 and Table 6.

### Table 5. Action Plan in Reducing Traffic Accident on Surabaya – Gempol Toll Road, Using Single Sites Approach

<table>
<thead>
<tr>
<th>No</th>
<th>LOCATIONS</th>
<th>PROBLEMS</th>
<th>MANAGEMENT PROGRAM</th>
<th>FORM OF ACTION</th>
</tr>
</thead>
</table>
| 1  | KM 34, KM 17-18, KM 26-27, KM 33-34, KM 34-35 | Toll Road Section with high accident rate | Black-spot and black-site location management  
  > Aim: to always remind the drivers of the accidents  
  > Target: toll road users | • Installation of suggestive sign  
  • Installation of board informing accidents in the blackspot and black site locations |
| 2  | KM 5-5, KM 8-9, KM 10-11, KM 12-13, KM 34-35 | Passing from left side and unlawful use of road shoulder | Management of location potential to road shoulder violation  
  > Aim: to reduce accident caused by a vehicle passing on road shoulder  
  > Target: Road users | • Installation of non-permanent suggestive sign  
  • Installation of exaggeration (nurse strip) on road shoulder in the location potential to left passing violation |
| 3  | KM 7-8, KM 14-15, KM 34-35 | Driver gets tired and dozing | Management of accident caused by driver's tiredness and doze  
  > Aim: to reduce accident caused by tiredness and doze  
  > Target: Road users | Providing larger and safer free spaces outside the existing resting place (esp. in urban toll road) |
| 4  | KM 4-5, KM 23-24, KM 33-33 | Driver get inattentive and dozing | Management of location potential to accident caused by inattentiveness and doze  
  > Aim: to reduce accident caused by inattentiveness and doze  
  > Target: road users | Installation of rabbit strip in the locations where trend by inattentiveness and doze often happen |

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<table>
<thead>
<tr>
<th>No</th>
<th>PROBLEMS</th>
<th>MANAGEMENT PROGRAM</th>
<th>FORM OF ACTION</th>
</tr>
</thead>
</table>
| 1  | User’s lack of discipline    | Improvement of traffic discipline and dissemination of information about traffic on toll road.  
   |                               | ➢ Aim: to create safe and comfortable traffic atmosphere on toll road  
   |                               | ➢ Target: users of both ordinary and toll roads                                         | Traffic Safety Campaign  
   |                               | ➢ Publishing periodically articles on traffic discipline to create safe and comfortable traffic on ordinary and toll roads  
   |                               | ➢ Distributing brochures/leaflets about how to improve traffic safety and regulations directly to the toll road users |
| 2  | Obstruction from crossers by on toll road | Providing Assistance on dangers of crossing toll road  
   |                               | ➢ Aim: to reduce accident caused by crosser obstruction  
   |                               | ➢ Target: community along toll road                                                      | Direct assistance for community members |
| 3  | Accident caused by minimum speed and overloading | Installation of scale-bridge for goods-transporting vehicles  
   |                               | ➢ Aim: to reduce accident caused by low speed and to reduce early damage of the pavement  
   |                               | ➢ Target: goods transporting vehicles                                                    | Feasibility study on the installation of scale bridge as an effort to improve traffic safety and to reduce early damage of the pavement |
| 4  | High level of accident fatality (e.g. minibus) | Campaign for safety instrument and installation of safety instrument in cars  
   |                               | ➢ Aim: to reduce the fatality of casualty                                                  | ➢ Installation of banner advising on the importance of safety instrument in the cabinet  
   |                               | ➢ Target: Old-brand cars, especially passenger car (minibus)                             | ➢ Action of installing safety instrument in brand-old cars initiated by road management body in cooperation with safety instrument manufacturer |

**CONCLUSION**

Based on the accident analysis for Surabaya-Gempol toll road, some conclusions can be presented as follows:

a. The factors causing accidents interrelate and interact to one another in inducing an accident. The study of the accident analysis in multicausal approach is appropriate in order to get the pretexts; characteristics of accident.

b. Accident's characteristics on Surabaya-Gempol Toll Road indicate that the driver is the most frequent cause of accident (73.84%), followed by the vehicle factor (22.09%) and road and environmental factor (4.07%). The road is a direct factor to cause an accident is hardly identified, but as one of the cause factors it gives influence on the other factors in inducing an accident. The accident rate and the fatal and serious class of casualty are remarkably high in which self-collision accident (single accident) and front-back collision accident (multi accident) are remarkable.
The characteristics of lack of anticipation and burst tire as parts of cause factors (driver and vehicle factors) are remarkable. In addition, the accidents frequently happen on working days, especially on Mondays between 11:00-12:00. Blackspot location lies on the urban toll from Banyu Urip - Waru section. Blackspot location lies in KM 3+000-4.400, KM 17+000-18+400, KM 26+000-27+000, and KM 33+000-34+000. The characteristics of accident tend to be the same as the characteristics in general. However, it is important to note that in KM 11+000-12+000 lack of anticipation is the most remarkable cause factor, and that the class of casualty and the accident rate are also relatively high.

c. Actions to reduce accident must be adapted to the existing conditions. Two applicable approaches are single sites management and mass action management are developed based on the current conditions.

ACKNOWLEDGMENT

The author gratitudes his sincere thank to Sonya Sulistyono who collected data and helped the analysis in this study. The contribution from PT Jasa Marga Surabayas - Gempol Toll Road Branch in providing data is very much acknowledged. Thank also to be extended to Graduate Research Team on Sustainable Transport in Java, which put this study as part of the research framework.

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