VALUATION OF SAFETY APPLICATION OF LAND TRANSPORTATION ON PORONG ARTERIAL ROAD – PURWOSARI ROADWAY STA 30+00 – STA 61+400

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**Abstract**

Highways can have an impact on the social and economic development of the surrounding community as well as progress in the industrial sector. Road safety is an important aspect that must be considered. The main problem that often occurs in these accidents apart from human factors can also be caused by road infrastructure. Along Porong Arterial Road – Roadway Purwosari STA 30+00 – 61+400 in certain locations along the road there are inadequate road completeness facilities such as PJU lights that do not turn on or PJU distances that are too far away, pavement damage and road markings less clear. Based on these field conditions, it is necessary to evaluate traffic safety based on the main attributes that must be repaired using the Importance Performance Analysis method, namely the street lights are on well, damaged roads have been replaced/repaiored and roads are free from damage such as waves, potholes, and puddles. According to the weighting with the EAN (Equivalent Accident Number) method based on data from the Police Resort of Sidoarjo Regency and Pasuruan Regency in 2016 - 2020 it was 486, located at STA 38+00 – 39+400 with a total of 590 cases. The blackspot point is located at the Apolo Roundabout with (R analysis) > (R Existing) = 30 m > 18.03 concluded that it does not meet the standards and the value of side freedom and (E analysis) < (E existing) = 5m < 7 m is concluded to have met the standard.

**Keywords:** EAN, Importance Performance Analysis Method, Transportation Safety, Blackspot Point.

**INTRODUCTION**

As the volume of traffic grows and the variety of types of vehicles increases, the risk of accidents increases. The losses caused are not only public health but also have an impact on the economy of the community and the country [3]. This is an important aspect of road user safety. According to the Director General of Highways (2012:2), in total, approximately 1.3 million people die every year and 25 million people suffer from permanent disability due to traffic accidents. This condition is getting worse along with the growing volume of traffic [4] [5].

The Directorate General of Highways based on the results of the latest research (2012:2) states that in Indonesia, the losses caused by traffic accidents reach 2.9% of the BRDP.

The construction of the Porong arterial road has a positive impact because previous road users passing through Porong Roadway which was damaged by the Lapindo hot mudflow could be another alternative. The road users from Surabaya to Malang who cross Jalan Arterial Baru Porong then to Jalan Malang – Gempol to Jalan Raya Purwosari and continue to Malang are very supportive of economic development and growth.

Therefore, by conducting an evaluation to minimize the possibility of accidents occurring in the same place. This can be done by clarifying bend lines, providing street lighting, creating pedestrian paths, paving the road shoulders and providing warning signs.

This research was carried out by identifying the potential hazards and the feasibility of geometric designs at blackspot points as well as road completeness in the form of installing signs and markings from the Porong new arterial highway to Purwosari highway. In addition, this measurement can provide an evaluation and measure of infrastructure misalignment that affects driving safety.

**RESEARCH METHODS**

In this study there are several stages which are shown in figure 1.
In this study, measurements were made to determine the satisfaction and expectations of road users for road infrastructure and road equipment. Besides that, it also determines and identifies accident-prone locations (blackspot points).

The data used are primary data and secondary data. Included in the primary data are the distribution of questionnaires referring to the Pd T-17-2005-B Road Safety [1]. Audit checklist using a Likert Scale, spot speed data at blackspot points, inspection of the completeness of road infrastructure in accident-prone areas. Meanwhile, secondary data is in the form of accident data for the 2016 – 2020 period from the Siodarjo Regency and Pasuruan District Police and LHR (average daily traffic) from the BBPJN (Great Center for National Road Implementation).

Research methods can be divided into some sub-chapter as followed:

1. Questionnaire filling

   The questionnaire that will be filled out by respondents is in the form of a checklist which refers to the Road Safety Audit checklist Pd T-17-2005-B using a Likert scale. The following is a Likert scale used in the level of satisfaction in this study consisting of:
   a. Strongly Agree with a weight of 5
   b. Agree given a weight of 4
   c. Simply Agree is given a weight of 3
   d. Disagree with a weight of 2
   e. Strongly Disagree with a weight of 1

   The Likert scale for the level of road users expectations is given five ratings with each weight as follows:
   a. Very Important given a weight of 5
   b. It is important to be given a weight of 4
   c. Important enough given a weight of 3
   d. Not Important given a weight of 2
   e. Very Unimportant given a weight of 1

2. Data adequacy test

   Furthermore, the data adequacy test determines the minimum number of samples from the population around the research site using the Slovin formula:
   \[ n = \frac{N}{1 + N \times e^2} \]

   Description:
   \( N \) = Number of elements/ sample members
   \( e \) = Error level (1% - 10%)

3. Raw data matrix compilation

   All data that has been collected based on the results of the study will be recapitulated into the raw data matrix. These data are original data from the answers of respondents who have responded to the statements in the questionnaire. This is done to make it easier to process data based on the level of performance and expectations of road users for road infrastructure and its completeness.

4. Test the validity and reliability using SPSS 22.0

   Next is the validity and reliability testing using SPSS 22.0 with the aim of knowing whether the attributes are valid and consistent.

5. Importance Performance Analysis Method

   The mapping uses the IPA (Importance Performance Analysis) method to show services that need to be improved or reduced to maintain service user satisfaction. The formula used in this method is as follows [7]:
   a. The first stage is calculating the level of conformity
   \[ T_{ki} = \frac{X_i}{Y_i} \times 100\% \]

   Description:
   \( T_{ki} \) = Respondent's level of suitability
   \( X_i \) = Average score of service provider performance appraisal
   \( Y_i \) = Average score of respondent's expectation assessment

   b. The average of all performance level attributes (Y and performance (X))
   \[ \bar{X} = \frac{\sum X_i}{k} \quad \bar{Y} = \frac{\sum Y_i}{k} \]

   Description:
   \( \bar{X} \) = Average score of performance/performance
   \( \bar{Y} \) = Average score of expectation/ importance
   \( k \) = The number of attributes that affect

6. Identification of accident prone

   Identify accident-prone areas for each kilometer tip using the EAN (Equivalent Accident Number) method.
Then determine the blackspot point from the accident data of the Sidoarjo District Police and Pasuruan District Police.

7. Compare the existing road geometry with the existing standard at the blackspot point [2][6].

a. Traffic volume
   Average daily traffic
   Average daily traffic (LHR) is the average traffic volume in one day.
   \[ \text{LHR} = \frac{\text{jumlah lalu lintar dalam 1 tahun}}{365} \]
   Planning hour volume
   The planning hour volume is the traffic volume in 1 hour used for planning.
   \[ \text{VJP} = \text{LHR} \times K \]
   
   Description:
   \[ \begin{align*}
   \text{VJP} & = \text{Volume of planning hours} \\
   \text{LHR} & = \text{Average daily traffic} \\
   K & = \text{Rush hour traffic volume factor (12%)}
   \end{align*} \]

b. Speed
   Average speed.
   The average speed is obtained from the division of a road segment by calculating the travel time passed by the road.
   \[ V = \frac{L}{T} \times 3.6 \]
   
   Description:
   \[ \begin{align*}
   V & = \text{Average speed m/s converted to km/hour} \\
   L & = \text{Segment length} \\
   T & = \text{Average travel time} \\
   \text{Plan speed.}
   \end{align*} \]
   According to Sukirman (1999:40) the design speed (Vr) is the speed chosen for planning purposes for each section of the highway such as bends/alignments, road slopes, visibility and others.

   Table 1 Design speed (Vr) based on function classification and road terrain.

<table>
<thead>
<tr>
<th>Fungsi</th>
<th>Kecepatan Rencana (Vr) km/ jam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Datar</td>
<td>Bukit</td>
</tr>
<tr>
<td>Arteri</td>
<td>70 - 120</td>
</tr>
<tr>
<td>Kolektor</td>
<td>60 - 90</td>
</tr>
<tr>
<td>Lokal</td>
<td>40 - 70</td>
</tr>
</tbody>
</table>

   Source: Rules for the geometric planning of inter-city roads no.038/TBM/1997

c. Visibility
   Braking distance (Jhr)
   The distance required to stop the vehicle from the time the driver applies the brakes until the vehicle stops.
   \[ d = 0.278 \cdot V \cdot \frac{V_r^2}{254 \cdot \text{fm}} \]
   
   Description:
\[ e + f = \frac{Vr^2}{127R} \]

\[ R = \frac{Vr^2}{127(e+fm)} \]

**Description:**
- \( e \) = Superelevation (%)
- \( fm \) = Swipe style
- \( Vr \) = Design speed (km/h)
- \( R \) = radius of bend

**Degree of curvature**
According to Sukirman (1999:74) the degree of curvature is the magnitude of the curved angle that produces the arc length.

\[ D = \frac{14324}{R} \]

**Description:**
- \( D \) = Degree of curvature (°)
- \( R \) = radius of bend (m)

**Transition curve**
On a blunt horizontal bend with a large radius, the vehicle passes steadily on the road

\[ Ls = \frac{Vr^2}{3.6 T} \]

\[ Ls = 0.022 \times \frac{Vr^2}{RC} \times 2.727 \times \frac{Ve \times e}{C} \]

\[ Ls = \frac{(e_{max} - \epsilon_{n})Vr}{3.6 rc} \]

**Description:**
- \( Ls \) = Length of spiral arch (m)
- \( R \) = radius of bend (m)
- \( Vr \) = Design speed (km/h)
- \( e_{max} \) = Maximum superelevation
- \( \epsilon_{n} \) = normal superelevation
- \( C \) = Change in acceleration (m/s), the value is between 1-3 m/s
- \( rc \) = Level of achievement of road cross slope change (m/ m/ sec)

**Side freedom area**
The side freedom area is an obstacle-free space for the driver's view at the corner so that \( Jh \) (stopping sight distance) is met. This can be done by making it easier for the driver to see obstructions as far as \( E \) in meters.

If the stopping sight distance is smaller than the transition curve \( (Jh < Ls) \)

\[ E = R(1 - \cos \left(\frac{90^o \times Jh}{\pi \times R}\right)) \]

If the stopping sight distance is greater than the transition curve \( (Jh > Ls) \)

\[ E = R\left(1 - \cos \left(\frac{90^o \times Jh}{\pi \times R}\right) + \frac{1}{2} (Lh - Ls) \sin \left(\frac{90^o \times Jh}{\pi \times R}\right)\right) \]

**Description:**
- \( E \) = Barrier-free area (m)
- \( R \) = radius of bend (m)
- \( Jh \) = Stopping sight distance (m)
- \( Ls \) = Bend length (m)

8. Finally, analyze the completeness of road infrastructure in accident-prone areas
Most of the on-road information that drivers need is received visually. For this reason, the most general and important information is signs and line markings.

If the signs and line markings meet the six sign installation concepts, it will help the driver to use the road safely. The six concepts are summarized:
1) Clear (conspicuous) : The sign must be visible to the driver.
2) Easy to read (clear) : Signs must be clear and easy for drivers to read.
3) Understandable (comprehensible) : Signs should be easy to understand. Given that the driver only has 2 seconds to absorb the information seen.
4) Trusted : The message conveyed must be able to influence or be able to make the driver believe. This is to prevent drivers from ignoring the signs.
5) Consistent : Consistency reduces driver reaction time and improves driver understanding
6) Correct (correct) : Some signs look the same and have the same meaning. However, only one is absolutely correct.

**RESULTS AND DISCUSSIONS**

The research location is on the Porong arterial road – Purwosari Roadway STA 30+00 - 61+400 which connects Surabaya – Malang stretches for 31 km

A. Calculation of Number of Samples

After distributing and filling out the questionnaire, you must first know whether the data that has been taken is sufficient or not to represent one population.

The technique used in this research is the Porong Arterial Road – Purwosari Roadway STA 30+00 – 61+400 using simple random sampling. This is done without regard to gender and age. With a population based on population data from the Porong, Gempol, Pandaan, Sukorejo, Purwosari sub-districts in 2020 of 506,512 people. So,

\[ n = \frac{506,512}{1 + 506,512 \times 0.1^2} = 99.98 \approx 100 \text{ orang} \]

Based on the calculation can be obtained at least 100 respondents. The number of respondents who successfully filled out the questionnaire was 155 respondents. Respondents who filled out consisted of pedestrians, riders who rested and people around the road segment.
B. Validity and Reliability Test Using SPSS

For the $r_{table}$ value with a level of = 5% and degree of freedom (df) = N-2 = 155-2 = 153, then the $r_{table}$ value = 0.1577. The calculation of the value of $r_{count}$ can be known after processing the data with the help of the SPSS 22.0 application. The calculation results can be seen in table 2.

Table 2 Validity test

<table>
<thead>
<tr>
<th>No</th>
<th>Question Attributes</th>
<th>$r_{count}$</th>
<th>$r_{table}$</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Terdapat pemisah arus (median)</td>
<td>0.522</td>
<td>0.498</td>
<td>0.1577</td>
</tr>
<tr>
<td>2</td>
<td>Median jalan dilengkapi pembatas jalan beton (barrier)</td>
<td>0.404</td>
<td>0.442</td>
<td>0.1577</td>
</tr>
<tr>
<td>3</td>
<td>Terdapat pohon di jalan tersebut tidak mengganggu pandangan pengendara</td>
<td>0.482</td>
<td>0.261</td>
<td>0.1577</td>
</tr>
<tr>
<td>4</td>
<td>Pemberhentian bus yang tidak mengganggu pandangan pengendara</td>
<td>0.399</td>
<td>0.368</td>
<td>0.1577</td>
</tr>
<tr>
<td>5</td>
<td>Pandangan pengendara pada belokan dan sudut mencukup memadai</td>
<td>0.663</td>
<td>0.290</td>
<td>0.1577</td>
</tr>
<tr>
<td>6</td>
<td>Pandangan pengendara pada persimpangan dan penyeberangan jalan kaki cukup mencukupi</td>
<td>0.635</td>
<td>0.319</td>
<td>0.1577</td>
</tr>
<tr>
<td>7</td>
<td>Pandangan pengendara pada lintasan kereta api mencukupi</td>
<td>-0.092</td>
<td>0.076</td>
<td>0.1577</td>
</tr>
<tr>
<td>8</td>
<td>Pandangan untuk kecepatan lalu lintas pada sisi jalan mencukupi</td>
<td>0.642</td>
<td>0.255</td>
<td>0.1577</td>
</tr>
<tr>
<td>9</td>
<td>Kendali rambu dan marka baur dan terlihat jelas</td>
<td>0.819</td>
<td>0.276</td>
<td>0.1577</td>
</tr>
<tr>
<td>10</td>
<td>Terdapat praktis putus putus di sisi jalan tersebut</td>
<td>0.686</td>
<td>0.321</td>
<td>0.1577</td>
</tr>
<tr>
<td>11</td>
<td>Adanya lampu lalu lintas pejalan kaki</td>
<td>0.550</td>
<td>0.526</td>
<td>0.1577</td>
</tr>
<tr>
<td>12</td>
<td>Terdapat marka geberan di tempat penyeberangan jalan kaki</td>
<td>0.770</td>
<td>0.242</td>
<td>0.1577</td>
</tr>
<tr>
<td>13</td>
<td>Marka gari persimpangan dan belokan mencukupi</td>
<td>0.737</td>
<td>0.333</td>
<td>0.1577</td>
</tr>
<tr>
<td>14</td>
<td>Adanya marka gari permanen antara lajur sepeda dengan lalu lintas</td>
<td>0.336</td>
<td>0.421</td>
<td>0.1577</td>
</tr>
<tr>
<td>15</td>
<td>Lampu lalu lintas (lampu merah) dapat terlihat jelas dan tidak terhalangi</td>
<td>0.043</td>
<td>0.071</td>
<td>0.1577</td>
</tr>
<tr>
<td>16</td>
<td>Lampu lalu lintas (lampu merah) masih beroperasi dengan baik</td>
<td>0.070</td>
<td>0.053</td>
<td>0.1577</td>
</tr>
<tr>
<td>17</td>
<td>Lintasan jalan pada lokasi ini mencukupi</td>
<td>0.764</td>
<td>0.288</td>
<td>0.1577</td>
</tr>
<tr>
<td>18</td>
<td>Lampu jalan dapat menyala dengan baik</td>
<td>0.834</td>
<td>0.158</td>
<td>0.1577</td>
</tr>
<tr>
<td>19</td>
<td>Tersedia palang pintu pengaman dan pengetap yang menutup lalu lintas kereta api</td>
<td>-0.365</td>
<td>0.077</td>
<td>0.1577</td>
</tr>
<tr>
<td>20</td>
<td>Jalan yang rusak telah diganti/ diperbaiki</td>
<td>0.747</td>
<td>0.347</td>
<td>0.1577</td>
</tr>
<tr>
<td>21</td>
<td>Jalan bebas dari kerosakan seperti gelombang, lubang, dan genangan air</td>
<td>0.812</td>
<td>0.246</td>
<td>0.1577</td>
</tr>
</tbody>
</table>

Source: Calculation results

In this study, the reliability test used the SPSS 22.0 application. In the calculation of reliability if Cronbach's alpha is greater than $r_{table}$, then all attributes can be said to be reliable (cronbach's alpha > $r_{table}$ = reliable).

Table 3 Cronbach's alpha score of performance

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.87</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: Calculation results

Table 4 Cronbach's Alpha Expectation Score

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.469</td>
<td>21</td>
</tr>
</tbody>
</table>

Source: Calculation results

C. IPA Method Analysis (Importance Performance Analysis)

The analysis of the level of conformity between the performance score and the expected score can be seen in table below.

Table 5 Conformity level value

<table>
<thead>
<tr>
<th>Item</th>
<th>Performance Level (X̄)</th>
<th>Expectancy Level (Ȳ)</th>
<th>Conformity Level (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 1</td>
<td>823</td>
<td>616</td>
<td>101.14</td>
</tr>
<tr>
<td>Item 2</td>
<td>850</td>
<td>822</td>
<td>80.43</td>
</tr>
<tr>
<td>Item 3</td>
<td>609</td>
<td>890</td>
<td>101.30</td>
</tr>
<tr>
<td>Item 4</td>
<td>469</td>
<td>670</td>
<td>99.85</td>
</tr>
<tr>
<td>Item 5</td>
<td>446</td>
<td>688</td>
<td>96.71</td>
</tr>
<tr>
<td>Item 6</td>
<td>467</td>
<td>687</td>
<td>97.09</td>
</tr>
<tr>
<td>Item 7</td>
<td>871</td>
<td>673</td>
<td>99.70</td>
</tr>
<tr>
<td>Item 8</td>
<td>461</td>
<td>694</td>
<td>92.36</td>
</tr>
<tr>
<td>Item 9</td>
<td>461</td>
<td>692</td>
<td>98.41</td>
</tr>
<tr>
<td>Item 10</td>
<td>487</td>
<td>460</td>
<td>62.39</td>
</tr>
<tr>
<td>Item 11</td>
<td>488</td>
<td>469</td>
<td>92.70</td>
</tr>
<tr>
<td>Item 12</td>
<td>486</td>
<td>483</td>
<td>106.44</td>
</tr>
<tr>
<td>Item 13</td>
<td>274</td>
<td>191</td>
<td>73.85</td>
</tr>
<tr>
<td>Item 14</td>
<td>590</td>
<td>491</td>
<td>85.38</td>
</tr>
<tr>
<td>Item 15</td>
<td>548</td>
<td>670</td>
<td>81.07</td>
</tr>
<tr>
<td>Item 16</td>
<td>559</td>
<td>684</td>
<td>81.73</td>
</tr>
<tr>
<td>Item 17</td>
<td>325</td>
<td>492</td>
<td>75.87</td>
</tr>
</tbody>
</table>

Average | 89.44 |

Source: Calculation results

Based on table 4, it can be concluded that the lowest suitability value is found in item 11 with a value of 62.39% on the attribute of the availability of pedestrian traffic lights. While the highest suitability value is in item 3 with a value of 101.30% on the attribute of the presence of trees that do not interfere with the driver's view.

In determining the cut on the X axis and Y axis as a division of the area with the following formula: Furthermore, mapping using the SPSS 22.0 application.

$$X = \frac{62.41}{21} = 3.67$$

$$Y = \frac{48.83}{21} = 4.05$$
To find out the 17 attributes of the questions that have been grouped based on the priority scale, it is explained in the following information:

a. Quadrant 1 (Top Priority)

Attributes of the questions that are considered to have important value by road users / motorists but the performance of service providers on road infrastructure facilities is considered unsatisfactory. This is expected to be able to improve its performance. The attributes included in quadrant 1 are listed in the following table.

Table 6 Improvements expected by service users/drivers

<table>
<thead>
<tr>
<th>Item</th>
<th>Question</th>
<th>Field conditions</th>
<th>improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Lampu jalan dapat menyala dengan baik</td>
<td>The need for service providers to provide sufficient lights</td>
<td>Provide a reflector on the road</td>
</tr>
<tr>
<td>20</td>
<td>Jalan yang rusak telah diganti/diperbaiki</td>
<td>Carry out road repairs on damaged and bumpy roads</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Jalan bebas dari kerusakan seperti gelombang, lubang dan genangan air</td>
<td>Carry out road repairs on damaged and bumpy roads</td>
<td></td>
</tr>
</tbody>
</table>

Source: Calculation results

b. Quadrant 2 (Maintain Achievement)

The attributes of the questions that are expected to support driver satisfaction and the service providers are already very good, so they must maintain this performance. The attributes included in these categories are:

1) Plants/trees on the road do not interfere with the driver's view (item 3)
2) Bus stops that do not interfere with the driver's view (item 4)
3) Driver's view on turns and incline is sufficient (item 5)
4) Driver's view of intersections and pedestrian crossings is adequate (item 6)
5) View for traffic speed on road route is sufficient (item 8)
6) Condition of signs, markings are good and clearly visible (item 9)
7) There are dashed markings on the route (item 10)
8) There is a zebra crossing marking at the pedestrian crossing (item 12)
9) Sufficient intersection and turning line markings (item 13)
10) Street lights at this location are sufficient (item 17)

In this quadrant, it shows attributes that are not considered important by road users so that they do not need to be prioritized excessively. Those included in quadrant 3 are:

1) The median road is equipped with a concrete barrier/barrier (item 2)
2) The presence of a pedestrian traffic light (item 11)
3) There is a dividing line marking between bicycle lanes and traffic (item 14)

D. Analyzing Accident Prone Areas

To find out the accident-prone areas along Porong arterial Road – Purwosari Roadway STA 30+00 – 61+400 using traffic accident data from the Sidoarjo City Police and Pasuruan Regency in 2016 – 2020 or for the last five years. Based on this data, the number of accidents, accident victims and the number of vehicles can be obtained which can then be calculated using the EAN (Equivalent Accident Number). An area can be declared as accident-prone if the EAN value exceeds the critical EAN value (EAN > EANc).

The EAN method is calculated by adding up the accident victims in each kilometer then multiplied by the accident weight value. The standard weighting used is death (MD) = 12, serious injury (LB) = 6, minor injury (LR) = 3.
The calculation of the EAN method along the Porong arterial road - Purwosari Roadway STA 30+00 – 61+400 in 2016 - 2020 can be seen in Table 6 below.

Table 7 The results of the analysis of accident victims using the EAN method

Table 8 VLHR and VJR values on the Gempol – Pandaan road section

F. Speed Analysis

Speed data (spot speed) is obtained from calculating the travel time required for the vehicle to pass a road segment so that the average travel time is obtained. This is then converted into the average speed.

Observations were made on three types of vehicles, namely: MC (motorcycle), HV (Heavy vehicle), LV (light vehicle).

From the speed survey of the Apolo STA 38+00 39+00 roundabout blackspot point, it can be concluded that the average speed of 27.56 km/hour is rounded up to 30 km/hour. Table 8 shows the results of the analysis of the comparison of the spot speed data with the planned speed according to the road function.

Table 9 Comparison of the average speed with the design speed

E. Traffic Volume in Accident Prone Areas

Traffic volume data was obtained from primary data obtained from the Central Java-Bali National Road Implementation Center (BBPJN). Primary data is attached with observations for 24 hours. In Table 7 below:

Based on Table 6, it can be seen that the road at Km 38+00 – 39+00 has the highest EAN value of 486 with the dominant accident case at 17.00 – 07.00 WIB.

At STA 38+00 – 39+00 blackspots were found which based on Police data were located at the Apollo Roundabout. This will be investigated to evaluate the causes of accidents on the geometric side of the road, especially the horizontal alignment and completeness of road infrastructure. There were no bumpy or damaged pavements along the road.

Analyze Braking Distance (Jhr) and Visibility Priority (JD)

a) Braking Distance (Jhr)

\[
d = 0.278 V_r t + \frac{V_r^2}{251 f_m}
\]

\[
= 0.278 \times 30 \times 2.5 + \frac{30^2}{251 \times 0.4} = 20.71 \text{ m}
\]

b) Visibility Priority (JD)

\[
d = d_1 + d_2 + d_3 + d_4
\]

\[
= 14.62 + 66.72 + 30 + 44.48 = 155.82 \text{ m}
\]

G. Analysis of the radius of bend and degree of curvature
The results of the analysis of the radius of bend and the degree of bend are shown in table 10 below.

Table 10 The results of data analysis of the minimum bend radius and degree of bend

<table>
<thead>
<tr>
<th>Located</th>
<th>Bend Radius (m)</th>
<th>Curvature Degree (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunderan Apolo</td>
<td>30</td>
<td>47.75</td>
</tr>
</tbody>
</table>

Source: Calculation results

H. Analysis of Side Freedom Area

The comparison of the analysis E value and the available E value is shown in the following table 11.

Table 11 Comparison of the area of lateral freedom (E) analysis with E available

<table>
<thead>
<tr>
<th>Located</th>
<th>V (Km/hour)</th>
<th>Rmin (m)</th>
<th>JPH</th>
<th>E Analysis (m)</th>
<th>E Available (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunderan Apolo</td>
<td>30</td>
<td>30</td>
<td>29.71</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>

Source: Calculation results

I. Condition of Accident-Prone Area Road Equipment Facilities

From the results of the observation survey conducted before sunset until the evening, the condition of the lighting of the PJU lights at STA 38+00 – 39+400 the Gempol – Pandaan Roadway section is mostly not lit. Coupled with the presence of lush trees at the blackspot point (turn around the Apollo Roundabout) so that the view of motorists is limited. Riders rely on motorcycle headlights and lights coming from stalls, houses or shops around the road.

PJU lights (public street lighting) are of course very important, especially for the safety of motorists as road guides. If it rains, there is the potential for an accident to occur due to the limited visibility of the driver. This is reinforced by the most dominant accident cases at 17.00 – 07.00 WIB. For this reason, it is necessary to increase the repair of PJU lights in order to minimize the risk of accidents, especially at night.

Other conditions such as road markings are very clearly visible and the installation of traffic signs can be read and the positioning of the signs is very precise so that it seems informative for road users. It's just that there are some sign plates that look bent.

Road markings and signs are equally important, for that it is necessary to have regular maintenance. So that the harmonization of infrastructure completeness can run well.

CONCLUSION

Measurements obtained from the use of the IPA method are that several attributes must be improved to improve safety in driving on the Porong arterial road – Purwosari Roadway STA 30+00 – 61+400, among others: street lights can be lit properly, damaged roads have been replaced / repaired, the road is free from damage such as waves, potholes and puddles.

The location of accident-prone areas/blackspot points along the new arterial road Porong – Purwosari STA 30+00 – 61+400 is 38+00 – 39+00 with an EAN value of 486. The blackspot point area is located at the Apollo Roundabout based on secondary data from resort police

From the measurement and geometric components of the road at the highest accident-prone point (blackspot point) on the Porong arterial road - Purwosari Roadway STA 30+00 – 61+400 it is known that: VLHR value = 22,281.5 pcu/day, spot speed = 30 km/hour meets standard Vr = 80 km/hour, JPH analysis = 29.71 m > 27 m (JPH Bina Marga) JD analysis = 155.82 m > 150 m meets standard, Rmin = 30 m > 18.03 (R existing) not up to standard, E analysis = 5 m < Existing E = 7 m meets the standard.

Factors causing accidents in terms of the completeness of road infrastructure in the highest accident-prone areas on Porong Arterial Road –Purwosari Roadway STA 30+00 – 61+400 are the number of lights that are not lit, especially at blackspot points which can increase the risk of accidents, especially evening

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REFERENCES


