Traffic Accident Analysis and Mitigation Measures at Kariyad (NH -544), Ernakulam, Kerala

Mridula G M, Ashamol Jose, Lidiya P M

Abstract

Accidents are not natural but they are caused’ is a common cliche in the area of traffic safety. Thus if accidents are caused by some, surely the ones responsible for could be identified and appropriate remedial measures should be developed and implemented to the extend feasible. Various traffic studies such as details of road inventory, signage inventory, traffic volume, pedestrian volume count, spot speed, speed and delay, accident study etc helps in suggesting the improvement measures.

Accident data collection helps to identify the cause and type of vehicles involved in the accident. This helps in suggesting measures based on design or other conditions. Accident data collection is followed by the surveys to be conducted in order to check the efficiency of the existing design. Thus various surveys are conducted such as traffic volume count, speed and delay study and spot speed study and also road inventory details. The existing design will be unable to handle the increasing rate of accidents; hence a new design in terms of change in radius is adopted. The design should meet the target for which it was proposed and for that an analysis shall be done after the design is brought into use.

Introduction

Accidents, tragically, are not often due to ignorance, but are due to carelessness, thoughtlessness and over confidence. The increase in the number of motor vehicles on the road has created a major social problem– the loss of lives through road accidents. The problem of accident is a very acute in highway transportation due to complex flow pattern of vehicular traffic, presence of mixed traffic along with pedestrians. Traffic accident leads to loss of life and property. Thus the traffic engineers have to undertake a big responsibility of providing safe traffic movements to the road users and ensure their safety. Road accidents cannot be totally prevented but by suitable traffic engineering and management the accident rate can be reduced to a certain extent. For this reason systematic study of traffic accidents are required to be carried out. Proper investigation of the cause of accident will help to propose preventive measures in terms of design and control.

Blackspot

In road safety management, an accident blackspot is a place where road traffic accidents have historically been concentrated. It may have occurred for a variety of reasons, such as a sharp drop or corner in a straight road, so oncoming traffic is concealed, a hidden junction on a fast road, poor or concealed warning signs at cross-roads. Black spot is a term used to refer to a section of road that is regarded as a high-risk location for car crashes.

Objectives

The NH -544 is a main highway passing through the main economic centers of Ernakulum district. The accident rate in this highway is so high that each year there is an increasing trend. National Highway Authority Of India has identified certain black spots in this highway and one of the prominent spot of accident is at Kariyad. Studies show that more than 120 people died at this place during the last 10 years. At the same time around 1043 major accidents have occurred here. Thus it requires the need to conduct an accident study. Accident study helps to suggest corrective measures at the location. Thus the projects aims at conducting an accident study at Kariyad and thereby suggest engineering solutions as a counter measure to reduce the accident rate.

Scope Of The Work

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The project deals with the traffic accident study and analysis of a blackspot. The rate of accidents are increasing since the number of vehicles are increasing. For the accident study and its analysis, first of all the accident data have to be collected. The accident data at a particular place or a blackspot will give the details of the type of vehicles incurred and the casualty details. For a comparison of the number of accidents with the amount of traffic through the area, traffic volume surveys and speed studies have to be conducted.

Traffic volume will give a round figure of the amount of different type of vehicles through the area. Speed studies including, spot speed study and speed and delay study are conducted so that the instantaneous speed of the vehicle at the spot and the average speed of the travel respectively are determined. With the surveyed values, the existing design shall be checked and the way by which it differs will help in determining the remedial measures to reduce the accidents. Mitigation measures are so selected that it is practicable and is economical.

**Literature Review**

*SrinivasRao et al* [1] (2005) conducted an accident study on NH -5 between Anakapalli to Visakhapatnam during the year 2003 and it runs through urban, semi urban and rural areas. The accident data for the last five years were collected from the concerned police station and analysed thereafter. Various traffic studies such as details of road inventory, signage inventory, traffic volume, pedestrian volume count, spot speed, speed and delay, accident study were also conducted for suggesting the improvement measures.

Traffic volume and accident studies on NH22 between Solan and Shimla was conducted by *Rajiv Ganguly* et al [3] (2014). The process involved making manual count of the vehicles passing by on weekdays and weekends. Vehicle fleet was characterized as cars, buses, trucks and motorcycles. The mean traffic flow throughout the week was computed by considering the average of the number of vehicles observed on weekdays and weekends. The study also involved in identifying the ‘black spots’ which refers to those stretches on Shimla – Solan highway of NH 22 reported with the most number of accidents.

*Sujin Mungnimit et al* [4] (2009) introduced the sequential pacing data analysis technique which simulates a manual method where road inspectors travel along a highway and inspect all accident records. Nearby accidents within 100- meter of distance will be grouped together as a black spot location, where any accident located farther than 100-meter away from the current location will be assigned another black spot location ID. The total number of accidents within each black spot location will be summarized and compared to the black spot criteria. The process continues from the first to the last kilometre of each highway route and covers all highways under supervision of the department of highways.

*Hoel* [7] (2005) describes an examination of the relationship between vehicular speed and side friction demand on horizontal curves. Models of speed and friction demand are described. The curve speed model explains the effect of approach speed, radius, and super elevation rate on curve speed. The side friction model explains the effect of approach speed and curve speed reduction on side friction demand. The terms in the model reflect a general desire by motorists for a lower side friction demand at higher speeds. Model terms also reflect a willingness by motorists to tolerate slightly higher side friction demand in an effort to minimize the amount of speed reduction required by relatively sharp curvature. This model is recommended as a rational basis for defining the maximum side friction factors for use in curve design.

**Methodology**

The methodology adopted to conduct the accident study and mitigation at Kariyad for a stretch of 1km. (321/500 to 322/500). The objective of the current study is to analyse the accident scenario at the spot by taking into account the several surveys and accident data. Based on the results of the survey conducted and accident data obtained it is desired to check the performance of the spot and also to give corrective measures in order to reduce the effect of current scenario.
Study Area - Kariyad

Kariyad is a place just 3.5 kilometres from Ankamaly, Ernakulam. It is considered as one of the major black spot on NH-544 (Valayar - Edapally). The junction and the sharp curve on the NH in Kariyad are considered as one of the most dangerous spots as more than 120 lives have been lost in vehicle accidents during the past 10 years. The accidents are reported to occur during day time but severity of accidents is during night. Since the number of accidents occurring at this place is more than 3 per year duration, it is considered as an accident blackspot.

Map Data – Kariyad

Kariyad consist of two curves simultaneously forming a reverse bend. As identified from the map data provided from National Highway Authority of India, the curves are identified as curve 22 and curve 23, a 1 kilometer stretch (321/500 to 322/500). The curves are marked in the direction of travel from Ankamaly to Aluva.

Data Collection and Analysis

The accident study basically involves the requirement of many data such as accident rate, volume count speed study etc. This is done to analyse the amount and frequency of accidents and classifying them on a certain basis. Analysing an accident data and conducting surveys will help to give out remedial measures that will reduce the number of accidents.

The main data requirements for the evaluation of the accident reduction measures on National Highway 544 was:

1. Accident Study
2. Traffic volume Count
3. Spot speed Study
4. Speed and Delay Study

Accident Study

To assess the accident scenario, it is very much necessary to collect the accident data. In this regard, accident data was collected from the year 2004 to 2014 from the concerned police station (Nedumbassery Police Station and Chengamanadu Police Station), who are responsible for recording and maintaining of accident data. The data obtained was accurate number of accidents happened at the spot and hence the accidents can be classified on the basis fatality, major accidents and minor accidents.

<table>
<thead>
<tr>
<th>Year</th>
<th>Fatality</th>
<th>Major accidents</th>
<th>Minor accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>12</td>
<td>126</td>
<td>77</td>
</tr>
<tr>
<td>2005</td>
<td>10</td>
<td>136</td>
<td>63</td>
</tr>
<tr>
<td>2006</td>
<td>11</td>
<td>74</td>
<td>48</td>
</tr>
<tr>
<td>2007</td>
<td>10</td>
<td>116</td>
<td>60</td>
</tr>
<tr>
<td>2008</td>
<td>13</td>
<td>105</td>
<td>30</td>
</tr>
<tr>
<td>2009</td>
<td>8</td>
<td>70</td>
<td>28</td>
</tr>
<tr>
<td>2010</td>
<td>9</td>
<td>84</td>
<td>30</td>
</tr>
<tr>
<td>2011</td>
<td>16</td>
<td>84</td>
<td>34</td>
</tr>
<tr>
<td>2012</td>
<td>14</td>
<td>85</td>
<td>24</td>
</tr>
<tr>
<td>2013</td>
<td>11</td>
<td>89</td>
<td>22</td>
</tr>
<tr>
<td>2014</td>
<td>6</td>
<td>74</td>
<td>23</td>
</tr>
</tbody>
</table>

Fatality rate
Major accidents

Traffic Volume Count

Traffic volume is the numbers of vehicle crossing a section of road per unit time at any selected period. The method adopted to determine the traffic volume is by using tally sheets which is a manual counting method. Vehicles passing through the study area are noted down on an interval basis. Usually the observations are done for a minimum of 12 hours during peak, off peak and mid day hours. The study is to be conducted during Tuesday, Wednesday or Thursday to get the correct traffic counts.

A pie chart representation of the traffic volume details.

Minor accidents

Traffic Volume count

The chart showing peak hour and off peak hour traffic volume is as follows

A pie chart representation of the traffic volume details.

Spot Speed Study

Spot speed is referred to as the instantaneous speed of a vehicle at a point or a cross section. Traffic counts during a Monday morning or a Friday peak period may show exceptionally high volumes and are
not normally used in the analysis; therefore, counts are usually conducted on a normal volume days. Here the method adopted is stop watch method which is least expensive and easy to carry out. On the stopwatch spot speed datasheet the observer records the date, location, posted speed limit, start time and end time. As the front wheels of a vehicle cross a mark or pavement crack at the beginning of the predetermined study length, the observer starts the stopwatch. The watch is stopped when the vehicle’s front wheels pass a reference line in front of the observer. A slash is recorded on the data form corresponding to the elapsed time observed.

\[
\text{Speed} = \frac{\text{Distance}}{\text{Time}}
\]

For frequency distribution table of spot speed data is preparing by arranging the speed groups covering desired speed ranges (such as 10-20kmph, 20-30kmph etc.) and the number of vehicles in each speed range.

To determine speed percentiles, cumulative speed percentiles diagram is plotted as mean speed in X-axis and cumulative frequency in Y-axis, then 85\textsuperscript{th} and 98\textsuperscript{th} percentile speed is determined. 85\textsuperscript{th} percentile speed is the upper speed limit and 98\textsuperscript{th} percentile speed is generally taken as the design speed of the existing roadway facility.

The spot speed study conducted at Kariyad yielded the following results

### Spot Speed Study

<table>
<thead>
<tr>
<th>Speed (kmph)</th>
<th>Mean Speed (kmph)</th>
<th>Frequency</th>
<th>Percentage Frequency</th>
<th>Cumulative Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 10</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10 – 20</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 – 30</td>
<td>25</td>
<td>2</td>
<td>2.59</td>
<td>2.59</td>
</tr>
<tr>
<td>30 – 40</td>
<td>35</td>
<td>24</td>
<td>31.17</td>
<td>33.76</td>
</tr>
<tr>
<td>40 – 50</td>
<td>45</td>
<td>23</td>
<td>29.87</td>
<td>63.63</td>
</tr>
<tr>
<td>50 – 60</td>
<td>55</td>
<td>0</td>
<td>0</td>
<td>63.63</td>
</tr>
<tr>
<td>60 – 70</td>
<td>65</td>
<td>22</td>
<td>28.57</td>
<td>92.2</td>
</tr>
<tr>
<td>70 – 80</td>
<td>75</td>
<td>0</td>
<td>0</td>
<td>92.2</td>
</tr>
<tr>
<td>80 – 90</td>
<td>85</td>
<td>0</td>
<td>0</td>
<td>92.2</td>
</tr>
<tr>
<td>90 - 100</td>
<td>95</td>
<td>6</td>
<td>7.8</td>
<td>100</td>
</tr>
</tbody>
</table>

98\textsuperscript{th} PERCENTILE SPEED: This speed is used to determine the geometric design of road. It is obtained by drawing a graph between mean speed (kmph) and cumulative frequency (%).

### Classification of vehicles based on speed

<table>
<thead>
<tr>
<th>Speed Range(kmph)</th>
<th>Type of Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 10</td>
<td>NIL</td>
</tr>
<tr>
<td>10 – 20</td>
<td>NIL</td>
</tr>
<tr>
<td>20 – 30</td>
<td>Cycle, Tractor</td>
</tr>
<tr>
<td>30 – 40</td>
<td>Autorikshaw, Multi axle truck</td>
</tr>
<tr>
<td>40 – 50</td>
<td>2 wheeler, Taxi, LCV, Bus</td>
</tr>
<tr>
<td>50 – 60</td>
<td>NIL</td>
</tr>
<tr>
<td>60 – 70</td>
<td>Car, Van, Mini Bus</td>
</tr>
<tr>
<td>70 – 80</td>
<td>NIL</td>
</tr>
<tr>
<td>80 – 90</td>
<td>NIL</td>
</tr>
<tr>
<td>90 – 100</td>
<td>Car</td>
</tr>
</tbody>
</table>

### Speed Vs Cumulative Frequency

The 98th percentile speed obtained from graph is 92 kmph.

### Speed and Delay Study

The speed and delay studies give the particulars of running speeds or the fluctuations in speeds, the locations and duration of delays or stoppages and the overall travel speed between two desired locations along a road. Floating car method is one of the method for finding speed and delay studies. Here floating car method is used for the speed and delay study. This method is used to determine the speed
along a road network. The distance of travel should be more than 500 metres or 0.5 kilometers. Travel time includes the total time of travel including the stop and delay. The process is as follows:

a) A test vehicle is driven over a 4km stretch approximately at the average speed of the stream, thus trying to float with the traffic stream.

b) One observer is seated in the test car with two stop watches or timers; one timer is used to record the time of arrival of the car at various control points like intersections, bridges or any other fixed points.

c) The time, location and cause of the delay during each test run are recorded by the second observer.

d) The number of vehicles overtaking the test vehicle are noted by one observer.

e) The number of overtaken by the test vehicles are also noted by other observer.

Floating Car Method

- Average speed of travel = 47.68 kmph

Geometric Design

Geometric design is an aspect of highway design dealing with the visible dimensions of a roadway. It is dictated within economic limitations, by the requirements of traffic and includes the design elements of horizontal and vertical alignment, sight distance, cross section components, lateral and vertical clearances, intersection treatment, control of access etc. The safe, efficient and economic operation of a highway is governed to a large extend by the curve with which the geometric design has been worked out.

The design of highway consist of the following steps.

1. Find out the value of superelevation as

\[ e = \frac{\left(0.75\times f\right)^2}{gR} \]

If the value of \( e \) is less than 0.07, adopt the superelevation as the obtained value. If the value of \( e \) is greater than 0.07, take the value of \( e \) as 0.07 and continue to step 2.

2. Find out the value of coefficient of friction

\[ f = \frac{v^2}{gR} - e \]

If the value of \( f \) is less than 0.15, take the obtained value of \( f \) and \( e \) as 0.07 for the design. If the value of \( f \) is greater than 0.15, take \( e \) as 0.07 and \( f \) as 0.15 and continue to step 3.

Find out the design speed, \( V \)

\[ e + f = \frac{v^2}{gR} \]

This is obtained by taking the value of \( e \) as 0.07 and \( f \) as 0.15.

Check On Existing Design

Curve 22

(L)

Radius of the curve, \( R = 171 \) m

Superelevation, \( e = 7\% \)

So adopting,

\[ e = \frac{\left(0.75\times f\right)^2}{gR} \]

\[ = \frac{\left(0.75 \times 0.15\right)^2}{9.81 \times 171} \]

\[ = 0.21 > 0.07 \]

Since \( e \) is greater than 0.07

\[ f = \frac{v^2}{gR} - e \]

\[ = \frac{25.55^2}{9.81 \times 171} - 0.07 \]

\[ = 0.314 > 0.15 \]

Since \( f \) is greater than 0.15

\[ e = 0.07 + 0.15 \]

\[ = 0.22 \]

\[ = 19.2 \text{ m/sec} \]

\[ = 69.15 \text{ kmph} \]

(R)

Radius of the curve, \( R = 179 \) m
Superelevation, $e = 7\%$

So adopting

$$e = \frac{(0.75)^2}{gR}$$

$$= \frac{(0.75 \times 25.55)^2}{9.81 \times 179}$$

$= 0.209 > 0.07$

The value of $e$ is greater than 0.07

$$f = \frac{v^2}{gR} - e$$

$$= \frac{25.55^2}{9.81 \times 179} - 0.07$$

$= 0.32 > 0.15$

The value of $f$ is greater than 0.15, therefore design speed is

$$v = \sqrt{\frac{0.07 + 0.15}{9.81 \times 214}}$$

$= 21.49 \text{ m/sec}$

$= 77.36 \text{ kmph}$

Curve 23

(L)

The radius of the curve, $R = 214\text{m}$

Superelevation, $e = 5.2\%$

$$e = \frac{(0.75)^2}{gR}$$

$$= \frac{(0.75 \times 25.55)^2}{9.81 \times 214}$$

$= 0.175 > 0.07$

The value of superelevation is greater than 0.07 therefore, the value of $f$ is obtained by,

$$f = \frac{v^2}{gR} - e$$

$$= \frac{25.55^2}{9.81 \times 214} - 0.07$$

$= 0.24 > 0.15$

The value of coefficient of friction, $f$ is greater than 0.15 therefore the design speed is calculated as

$$v = \sqrt{\frac{0.07 + 0.15}{9.81 \times 214}}$$

$= 21.08 \text{ m/sec}$

$= 75.9 \text{ kmph}$

Result

The analysis of existing curve shows that the design speed is less than the actual speed of vehicles through the curve. The design speed of curve 22 L and R are 69.15 kmph and 60.75 kmph respectively.
and the design speed of curve 23, L and R are 77.36 kmph and 75.9 kmph respectively. But the design speed of curve 22 is 65 kmph and that of curve 23 is 50 kmph. Therefore it is necessary to suggest a speed limit of 75 kmph, so that the drivers can manoeuvre safely through the curve without the risk of causing accident.

**Mitigation Measures**

Remedial measures are the measures taken in order to reduce the accidents. These measures are taken after the data collection and analysis at a particular area.

Three main measures can be adopted at Kariyad to reduce the rate of accidents and thereby save life.

1. Provide a speed limit of 75 kmph
2. Increase the radius of the curve so that it converges to redesign of the curve.
3. Provide appropriate shoulder width so that run off accidents are prevented.

The superelevation value is taken as 0.04 and the value of coefficient of friction is taken as 0.14.

**Design 1**

This design is adopted for curve no 23 only.

Here the superelevation and friction factor is taken as
e = 4% and f = 0.14

Therefore,

\[ e + f = \frac{Ve}{gR} \]

\[ 0.04 + 0.14 = \frac{20.63}{9.81 \times R} \]

R = 245.79 m

**Design 2**

This is applied to both curve 22 and curve 23. For curve 22 taking the value of e = 7% ad f=0.14

\[ e + f = \frac{Ve}{gR} \]

\[ 0.07 + 0.14 = \frac{20.63}{9.81 \times R} \]

R = 210.68 m

For curve 23 the same design is applied

\[ e + f = \frac{Ve}{gR} \]

\[ 0.04 + 0.14 = \frac{20.63}{9.81 \times R} \]

R = 245.79 m

**Design 3**

In this design a straight path is proposed. The design thus has only one curve and that is curve 22.

\[ e + f = \frac{Ve}{gR} \]

\[ 0.07 + 0.14 = \frac{20.63}{9.81 \times R} \]

R = 210.68 m

The best and most economic design will be the design 1 because it requires less alterations from the current design. The other two methods are a bit more expensive. Hence design 1 is given preference.

**Other Remedies:**

1. Improving pavement skid resistance
2. Paving the shoulders
3. Installation of roadside markings to guide drivers through the curve is beneficial for safety
4. Adequate horizontal clearance at the place of curve
5. Availability of Required sight distance should be periodically checked for removal of all obstructions.
6. Drivers should move slowly at the place of curve.
7. Repairs of road in urban area should be carried out during the non-peak hours. Repair to potholes, shoulder drop-offs caused during rainy season should be done soon after the said season so that minimum inconvenience is caused to traffic.
8. Existing shoulder should not be occupied by solid waste which causes environment pollution.
9. Slow sign shall be painted on the road.
10. Speed breaker should be provided
11. Proper lighting of the road

**Conclusion**

The project deals with the accident study and mitigation at Kariyad. The preventive measures brought through this report direct us to control or bring down the percentage of accidents by using new safety measures and design fatalities which
would definitely reduce the existing figures of pre-crash and crash conditions.

1. Most accidents are occurred by light commercial vehicles and passenger cars.
2. From volume count study it was observed that peak hour is 7 am - 9 am and off-peak hour is 12 pm - 2 pm.
3. From the spot speed study 98th percentile speed obtained for existing curve was 92 kmph, which is very much higher than the design speed of the curve. The design speed is 50 kmph and is 65 kmph. Therefore re-design of curve is necessary.
4. A new curve cannot be designed at a speed of 92 kmph. So, we designed the curve at a speed of 75 kmph, since the safe speed calculated with existing design points to this speed.

The main reason for the accidents at Kariyad was the over speed and the unexpected curve. The curve is a ‘S’ curve. We adopted three designs for the proposed location.

References


[8] Dr. L. R. Kadiyali, Traffic Engineering And Transport Planning, Khanna Publishers

PROPOSED DESIGN 3 AT KARIYAD

<table>
<thead>
<tr>
<th>CURVE 23</th>
<th>L</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>208.7 m</td>
<td>202.7 m</td>
</tr>
<tr>
<td>e</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>V</td>
<td>55mph</td>
<td>55mph</td>
</tr>
</tbody>
</table>

SCALE 1:200