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Identification of black spots for safe commuting using weighted severity index and GIS

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Abstract: The growth in the number of vehicles is a direct result of rapid growth of population and increased economic and technological development. But unfortunately, the corresponding growth in the road network has not been commensurate with the huge growth in vehicular population. Without adequate and timely maintenance, roads deteriorate excessively leading to high vehicle operation costs and increase in number of accidents. The location where there is possibility of occurrence of accidents is known as blackspots. Identification of these blackspots on highway has always been challenge to highway engineers. Several methods have been tried to detect the locations with high rate of accidents in order to reduce the accidents. There are statistical methods, which are helpful in the identification of these blackspots, but fail to identify the reason behind it. The success of traffic safety and highway improvement programs hinges on the analysis of accurate and reliable traffic accident data .The study discuses the present state of traffic accident information on SH-85 from Tavarekere to Magadi Town in Karnataka State. It shall also discuss the identification of blackspots by using Weighted Severity Index method. GIS Software is used in analyzing and prioritizing the blackspots. An attempt is also made to mitigate the blackspots by some engineering measures to provide an improved traffic safety.

Keywords: *GIS, Accident Analysis, Weighted Severity Index, Blackspots*

Introduction:

The growth in the number of motor vehicles is direct result of the rapid growth of population and the increased economic and technological development. Road accidents are essentially caused by improper interactions between vehicles, vehicles and other road users and/or roadway features. The accidents depend on the pavement characteristics, traffic, lack of enforcement, geometric, design of the pavement, vehicle design and mechanical failure of vehicles, driver's characteristics, fatigue and the environment. The main cause for the occurrence of the Accidents are, drunken driving, careless and rash driving, over speeding, sudden braking, skidding, traffic rule violation, sudden twists and turns while driving etc. According to the statistics released by National Crime Records Bureau (NCRB)[1], as many as 1,39,091 persons lost their lives in 4,40,042 road accidents in India during 2012. Road Transportation occupies a very dominant position in the overall transportation system of India. The growth of road traffic in the post-independence era has been quite unprecedented both in terms of goods and passenger traffic. India has experienced a tremendous increase in the total number of registered motor vehicles. The total number of registered motor vehicles increased from about 0.3 million as on 31st March 1951 to 159.5 million as on 31st March 2012[2]. Of all the systems with which people have to deal every day, road traffic systems are the most complex one. Road accidents are considered as one of the top three public health problems in India. Despite the Government's best efforts in recent years, there are about one lakh deaths to 4 lakh injuries from about 3 lakh accident cases recorded. It is estimated that the economic losses due to road accidents in India are over Rs 100 billion (approximately US$2.5 billion) per year. Identification of black spots is one of the road safety counter measures that are vitally important to reduce the traffic accidents. However, this method requires data collection processes by visiting the scene of road traffic accident right after having received report from the police or complaint from road users. The Indian Government has introduced blackspots treatment program as one of the Government's safety programs to help in reducing road accidents in the country.

Study Area:

State Highway 85 connecting Bangalore with Jalsoor via Magadi, Huliyurdurga, Kowdle, Nagamangala, KR Pet, Saligrama, Ramanathapura, Somwarpet, Vanagur and Subramanya (Saligrama Bypass length - 2.50 Km) and the total stretch of the road is 335 km.
This study was carried out on State Highway 85, starting from Magadi Town to Tavarekere Village. The study stretch is 28 km. This stretch consists of many steep horizontal curves and intersections with very poor visibility with ribbon development. The stretch is busy with more number of vehicles and over the years traffic density has gone up. In the recent years, fatal accidents are on the rise due to poor condition of the road.

Objectives:

The black spot studies on Tavarekere to Magadi road stretch of SH 85 has been taken up with the following objectives:

- To identify the black spots on the SH 85 from Tavarekere to Magadi.

- To carry out the investigations for frequent accidents on the selected stretch.
- To prioritize the blackspots in a scientific manner using available tools on Geographical Information System platform and also to suggest remedial measures.

Literature Review:

Chris Baguley[3], has attempted to give an overview of the current road accident statistics in developing countries, and highlighted the fact that these countries generate a highly disproportionate amount (85%) of the world's fatalities. However, methods applied in many of the developed countries have demonstrated that it is possible to slow or arrest this growth in accidents. The establishment of a reliable road accident database and analysis system is of importance. Indeed, it is likely that an unreliable or inaccessible database will only lead to inefficient management of road safety. The paper has discussed the more important elements of such a system and illustrated these with selected examples from systems in use and also describes a 10-step process for managing black spot improvements following the proven accident investigation and prevention process.

Deelesh Mandloi & **Rajiv Gupta**[4] describes a model developed to identify black spots on roads and using GIS. In order to model a road network, an information system capable of processing spatial data is required. A GIS can easily handle, store, analyze, manipulate and retrieve spatial data. Therefore a model for identifying accident-prone location on roads can be easily implemented using a GIS. For conducting the model analysis certain factors are considered. These factors are:

- Road width.
- Number of lanes.
- Approximate number of vehicles per day.
- Type of road.
- Drainage facilities.
- Surface condition of the pavement.
- Frequent vehicle type.
- Presence of shoulders, edge obstructions, median barriers and ribbon development.
- Radius of horizontal curve.

Prioritization of road for accident occurrence is carried out by considering different weights for different parameters and total weight is determined.

Data Collection:

The data available with the local police station was collected for analysis. Based on the accident data (FIRs), the relevant details were acquired for all the data points (for 4 years starting from 2009 to 2013) and were digitized.

The following issues were observed in the collected data:

- Availability and Accuracy of data: Some of the locations could not be pinpointed due to lack of details regarding its location in the FIRs.
- Under-Reporting of accidents: In case of minor accidents, due to the fear of authority and judicial action, people tend to settle the matter between themselves leaving the official authorities clueless about the accident.
- Possibility of biased account of details: As the data was collected from FIRs, there was a possibility that information, given by person filing the complaint can be incomplete.

Mapping:

For mapping, the satellite imagery was obtained from Google Earth and was geo-referenced and digitized. The following steps were followed:

- Mapping of roads: Roads were mapped with classification into three categories, namely, State Highway, paved roads and other roads.
- Mapping of villages and other features: Village Names, location and other features like bus stands, hospitals and police stations were digitized.
- The Latitude and Longitude of all accident locations was recorded using a hand-held GPS and transferred to the map.
- Data points were prepared and added to GIS database.

Analysis:

The main objective of this analysis is to determine the probable accident-prone zones in the considered road stretch of SH-85. For carrying out this analysis weighted index method is followed. In this study, the various factors, which tend to influence the occurrence of accidents on roads, are assigned weights on a scale of 1-10 in such a manner that the factor, which tends to increase the probability of the accidents are assigned lower weights. The total weights are calculated using a programmed Excel spreadsheet. For prioritization of the probable blackspots different factor are considered and suitable weighs are given to each of these factors. These include road related factors like road geometrics, visibility conditions etc. which lead to accidents. The following nine parameters are considered.

1. Number of lanes in each direction
2. Road formation width
3. Type of road
4. Surface condition of the pavement
5. Frequent vehicle type
6. Presence of medians
7. Ribbon development
8. IRI (International Roughness Index)
9. Visibility

The final weight which is assigned for each stretch of the road are obtained by adding all the individual weights and normalizing the value using the maximum weight (in this case 90) that is to be assigned.

Table 1. *Factors used in prioritization with their weights*

Sl. No.	Factors Affecting occurrence of accidents	Possible variation	Weights Assigned
1	Number of Lanes in each direction	1	2
		2	4
		3	6
		4	10
2	Width of Road	Single lane 3.75 m	2
		Intermediate carriageway, 5.5m	4
		Two lanes without raised kerbs, 7.0 m	6
		Two lanes with raised kerbs, 7.5m	8
		Multi-lane pavements, >12 m	10
3	Drainage Condition	Absent	2
		Poor	4
		Satisfactory	6
		Good	10
4	Surface Type	Earthen	2
		Surface Painted	4
		Bitumen	6
		WBM	8
		Concrete	10
5	Frequent Vehicle Type	Bus/ Truck	2
		Car	4
		All	5
		Two Wheeler	6
		Bicycle	8
		Carts	10
6	Presence of Medians	No	2
		Yes	10
7	Ribbon Development	Yes	4
		No	10
8	IRI (International Roughness Index)	>3.5	1
		3-3.5	2
		2.5-3	4
		2 - 2.5	6
		1.5-2	8
		1 - 1.5	10
9	Visibility	Very Poor	2
		Poor	4
		Average	6
		Good	10

Hence,

$$Total\ Weight = \frac{(\sum Individual\ Weights)}{90} \times 100 \quad \ldots(1)$$

Table 2. *Prioritization Table*

Final Normalized weights	Accident Prone Level
75-100	Low
40-75	Medium
0-40	High

The road section with highest value will be less prone to accident than the road section with lower value. The classification of the road section is done according to the values given in Table 2.

Procedure for prioritization of blackspots

In order to model using the above mentioned factors and achieve the desired result, a step-by-step procedure as given below is adopted.

1. The satellite imagery obtained from Google Earth is imported into QGIS[5] for geo-referencing using 5 known point coordinates.
2. The geo-referenced map is used for further digitization of the road and other features near the road, which include the village locations, names, bus stops hospitals and police stations.
3. The accident locations with all related information are also digitized.
4. The existing horizontal radius of the curves is obtained from the digitized map.
5. The entire road stretch is divided into small segments and each of these segments have different values for different features.
6. The entire stretch is segmented using dynamic segmentation tool in Arc GIS[6], [7].
7. All the required features for evaluation are entered into a table in Excel so that the respective weights for each parameter are determined and sum total weight is determined.
8. Based on the final weight these locations are further classified into low accident probability zone, minimum accident probability zone, and high accident probability zone.
9. The zones that are classified under high accident-prone are given highest priority for suggesting suitable counter measures.

Survey was conducted at each location, which are highest accident-prone and suitable counter measures like providing speed breakers, signboards, installation of traffic signal system etc. were suggested.

Results and Counter Measures

After the analysis, most of the hazardous locations were obtained in the map. The actual accident spots matched with the predicted accident locations. Two accidents spot are as shown in Figure 1 and 2.

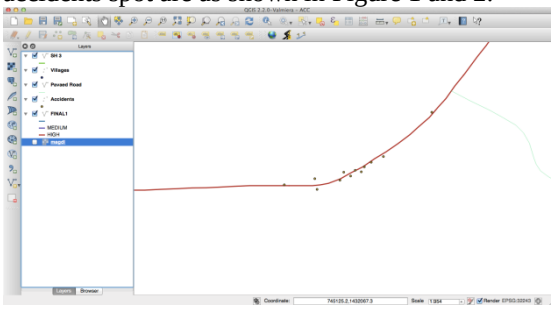

Figure. 1 *Blackspot at Hosapete Cross*

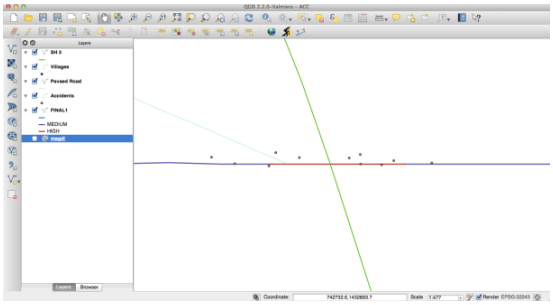

Figure. 2*. Blackspot at Jyothi Palya cross*

The presence of vertical curve and high speed at **Jyothi Palya Cross** makes it the most hazardous curve. **Safety issues** are, the combination of horizontal curve with a vertical curve coupled with high speeds leads to run-off road crash risks as well as head on collision. The radius of the curves does not satisfy the minimum radius specified by IRC [8], [9] . **Risk assessments** are, there is a probable likelihood of a crash and consequences of a crash are serious. There is a **very high** crash risk at this curve.

Recommended countermeasures:

- Re-mark a centerline and edge lines along the highway.
- Install "No Overtaking" signboard before the start of the curve [10].
- Clear the obstructions near the road.
- Re-mark the lane lines along the Highway
- Chevron alignment markers (CAM's) such as reflective signs are used to delineate non-standard curves.

They provide added delineation (over and above edge lines and guide posts) for those few curves that are considered to be in need of additional delineation. These include curves at the end of long straights; sharp reverse curves and compound curves where it is necessary to guide drivers/riders through the decreasing radius curve. Guideposts and edge lines make up a package of delineation to assist drivers/riders to remain on the Highway.

Hospet Cross has safety issues like, the road condition of SH 3 and SH 85 is poor. There is ribbon development. At many places, the shoulders are encroached. The presence of bus-stop near the intersection creates even more safety concerns. There is no proper lighting during nights, which increases the possibility of accident, and also the presence of a liquor outlet near to the intersection increases the rate of occurrence of accidents. **Risk assessments** are, there is a very high crash risk at this intersection and elsewhere though this village. There is a probable likelihood of a crash and consequences of a crash are serious.

Recommended countermeasures:

Step 1:

- Re-mark a centerline and edge lines along the highway.
- Clear the obstructions near the road.
- Re-mark the lane lines along the Highway.
- Install duplicate (on both sides) "Welcome to Hosapete" gateway signs with 40km/hr. speed restriction signs on a large rectangular (suggested 1.2m X 1.8m) yellow backing board[10].
- Discuss the preferred bus stop locations with village representatives and seal each bus stop area.
- Construct two suitable shelters for waiting bus passengers.
- Providing adequate street lights at the intersection.

Step2:

- Construction of channelization on SH 3 including a central splitting island and two left turn islands to provide physical separation of turning traffic through the intersection.

A yellow backing is proposed for greater conspicuity (than this green color) and 40km/h speed restriction signs are recommended as appropriate through these villages.

Conclusion:

The following conclusions were derived after the analysis:

- GIS offers a comprehensive platform to conduct spatial data analysis, graphic display, visual interface, data editing and query. These features provide a useful environment for comprehensive analysis of traffic safety problems.
- GIS has also been used as a tool to identify hazardous locations on highway depending on the historical road accident data, traffic condition, road geometrics, visibility and road condition.
- These in turn will help to improve the safety of road by advanced planning and maintenance of accident-prone areas.

- The Weighted Severity Index (WSI) method was used to rank the probable-accident locations.
- Based on the analysis, Jyothi Palya cross and Hosapete village junction were identified as most vulnerable accident locations in stretch of road from Tavarekere Village to Magadi Town, and suggested some remedial measures to improve the blackspots.
- The absence of trauma care facility in this stretch makes it more hazardous.

References:

[1] National Crime Records Bureau, "Accidental Deaths & Suicides in India 2012," New Delhi, 2012.

[2] Ministry of Road Transportation and Highway, "Road transport year book (2011-12)," New Delhi, 2011.

[3] B. Chris, "Road Safety Management of the Highway Network," Int. Symp. Traffic Safty Strengthning Accid. Prev., pp. 0–13, 2012.

[4] D. Mandloi and R. Gupta, "Evaluation of accident black spots on roads using Geographical Information Systems (GIS)," Map India, 2003.

[5] QGIS, "Quantum GIS (QGIS)." [Online]. Available: www.qgis.org. [Accessed: 11-May-2014].

[6] ESRI, "ArcGIS." [Online]. Available: https://www.arcgis.com/features/. [Accessed: 11-May-2014].

[7] ESRI, "Linear Referencing and Dynamic Segmentation in ArcGIS 8.1," 2001.

[8] Indian Road Congress, Guidelines for Design of Horizonatal Curves for Highways and Design Tables - 38. New Delhi: Indian Road Congress, 1988.

[9] S. K. Khanna and C. E. G. Justen, Highway Engineering. New Chand, 1971, p. 678.

[10] Indian Road Congress, Code for Practice for Road Signs, First Revi. New Delhi: Indian Road Congress, 2001