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"Road Safety Audit"

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Abstract : *Road safety audit is formal procedure for assessing accident potential and safety performance in the provision of new road schemes, the improvement and rehabilitation of existing road & in maintenance of roads. The role of auditor is to provide independent advice in the form of written recommendations. The designer or client then considers the advice and formal decision is made by them on whether or not to adopt each of the recommended safety alterations. The primary role of audit team is to identify the potential problems of a highway project by conducting the site inspection & collecting data from various agencies.*

The objective of the study is the identification of accident prone areas on the road from FIR, to study the effect of roadway geometrics and traffic conditions on the road stretch and development of statistical relationship between accident rates and various factors causing accidents.

The scope of the study is to reduce accidents on road network, reducing severity of accidents and the need for costly remedial work is reduced.

The road selected for the study is Bannerghatta road (12 km). The accident analysis is done from four years data. The V.F.Babkov's analysis is done by collecting geometric features of the road. Pedestrian safety analysis also done. Accident prone locations are identified by the all analysis.

Key words: *First Investigation Report (FIR), Road Geometrics, Babkov's analysis*

I. Introduction

1.1 Background [3]

The Road Safety Audit (RSA) process started in 1980's in the UK, moved to Australia and New Zealand in 1990s, and was introduced in USA in mid -1990s.A wealth of experience of audit has been gained since 1990 in the UK. Road Safety Audit has been taken up in major way in Australia and New Zealand where Austroads Guidelines have been published and in Denmark where road safety audits are mandatory to all national roads. Now, World Bank has made it mandatory that all World Bank aided highway projects would be audited from the road safety point of view.

1.2 Road Safety In India [3]

In India, at present there is no formal requirement for road safety audits to be undertaken. However, India has also started realizing the importance of road safety audits. It is because of Ministry of Road Transport and Highways sponsored the project on "Development of Safety Audit Methodology for Existing Roadway Sections" to Central Road Research Institute in April 2002. The National Highway Authority of India entrusted CRRI to carry out RSA of engineering design for construction packages under TNHP(8 packages) and GNTRIP (7 packages) on NH-2 . The total length of these 15 packages was about 900km which was the longest road project for which RSA has been carried out in the world. Also, first RSA was carried out again by CRRI in 2000 on Indore Bypass. It is understood that the entire NHDP will be subjected to RSA as part of its implementation. However it is to be recognized that RSA are to be under taken all types of roads.

1.3 Decade of Action for Road Safety[7]

On 11 May 2011, the Decade of Action for Road Safety 2011-2020 was launched in more than 100 countries including India, with one goal: to prevent five million road traffic deaths globally by 2020. Moving from the Global Plan for the Decade to national action, many countries have taken measures towards improving road safety, either by developing national plans for the Decade (e.g. Australia, Mexico, the Philippines); introducing new laws (e.g. Chile, China, France, Honduras); or increasing enforcement of existing legislation (e.g. Brazil, Cambodia, the Russian Federation), among other concrete actions. The recent UN General Assembly resolution on global road safety sponsored by more than 80 countries gives further impetus to the Decade by calling on countries to implement road safety activities in each of the five pillars of the Global Plan.

1.5 Objectives of the study

Each accident calls for systematic study in a scientific manner and detailed investigation of the accident spot. This type of investigation will help to identify some of the causative factors responsible for accidents and

to give relative importance. The results of the study could be employed advantageously to take up preventive measures to reduce the accidents

The objectives of the present study are

- Identification of accident prone areas on the Bannerghatta road from First Investigation Report.
- To study the effect of roadway geometrics and traffic conditions on this road stretch.
- Development of statistical relationship between accident rates and various factors causing accidents

1.6 Scope of the study

- The accidents on road network can be reduced.
- The severity of accidents can be reduced.
- The need for costly remedial work is reduced.

II. Review Of Literature

2.1 General[1]

The problem of ensuring traffic safety on roads have been attracting greater and greater attention in all countries of the world during last decades in connection with the considerable number of causalities and damage to vehicles in road accidents.

People depend on roads in their daily life to get to school, to work, or to the health centre. Roads underpin the businesses, agriculture and trade which provide the jobs that lift nations out of poverty. It is concerned mainly with those major road networks that provide the linkages between towns and cities and with the busy commuter routes in urban corridors. These major roads are generally the roads where the majority of people are killed and in their greatest concentrations.

2.2 Road Safety Audit[3]

Road safety audit is a formal procedure for independent assessment of the accident potential and likely safety performance of a specific design for a road or traffic scheme, whether new construction or an alteration to an existing road[Eugene M. Wilson]. The procedures enable the skills of road safety engineering and accident analysis to be used for the prevention of accidents on new or modified roads. The use of skills to reduce the occurrence of accidents on existing roads by means of local safety schemes, in many cases in the form of low-cost measures.

2.2.1 Definition [8]

The internationally accepted definition of an RSA as used from The Canadian Road Safety Audit Guide[NCHRP] and is as follows: "An RSA is a formal and independent safety performance review of a road transportation project by an experienced team of safety specialists, addressing the safety of all road users."

2.3 RSA methodology [3]

For carrying out RSA in a systematic and impartial way, it is essential to follow a rigorous procedure [Prof.P.K.Sikdar and Dr.Nishi Mittal]. The four key elements which makes RSA most productive are:

I. Selections of projects for audit
II. Role of different organization in RSA
III. Team selection
IV. Audit organization

III. Selections of projects for audit

Road safety audits are applicable to all types of road projects, to all types of roads and to all existing roads, with the possible exception of routine maintenance where the line marking is not being altered. A project as small as a new school crossing or set of road humps, or as large as a major new freeway can benefit from a road safety audit.

- **Road Safety Audit Cam Be Conducted On Road Projects As Diverse As**

a) New freeway.
b) Major divided roads.
c) Pedestrian and bicycle routes.
d) Deviated local roads near major projects.
e) Local area traffic management schemes and their component parts.
f) Signal upgrading.

Several road authorities require all projects, or a percentage of projects on major roads to be audited. Others require all projects, or a percentage of projects, above a set of value to be audited. While the experience in this area is still growing, in deciding which roads or projects to be audited ahead of any other, the effective allocation of resources should be a deciding factor. It may not always be the case that large projects are

associated with the largest savings or benefits from an audit. Some relatively inexpensive projects, used by thousands of people every day, may involve hazards with a potential for severe injuries.

IV. Role of different organization in RSA

RSA is based on the principal of an independent review. The process reveals that three parties will be involved in this process –Client, Designer and auditor.

- **Role of designer:** Designer is responsible for planning/designing the project. Designer bears the responsibility for ensuring that a road safety audit is conducted and that the necessary measures are agreed on the basis of the auditor's recommendations and/or the client's decisions. The designer is also responsible for ensuring that the audit input information is unambiguously defined and that all circumstances are described in an easily understood manner.
- **Role of client:** Client is one who allots the project to the designer and owns the project. It is the task of the client to arbitrate in cases where the designer and auditor disagree. The role of the client thus to:
  - Select an appropriate audit team
  - Provide all the relevant and necessary documents
  - Hold a commencement meeting with auditor and designer
- **Role of auditor:** Auditor's responsibility is to carefully review the presented project material in its entirely, in the light best road safety expertise and from the viewpoints of all relevant road users. Auditor also indicates all circumstances that cause misgivings concerning road safety. Persons designated as road safety auditors shall have experience of road accident analysis. Auditors must be familiar with road planning, designing and construction work and must undertake to keep their expertise up to date. Auditors should work within the terms of reference. They should comment only on the safety implications of schemes and provide constructive recommendations as to how any potential difficulties can be resolved.

V. Team selection

For large or significant projects, it is likely to have at least two members in the audit team, but not more than four members. For small projects ,single team member will be sufficient. One of the team member should be nominated as RSA manager. The one essential ingredient in RSA team is road safety engineering experience. It is also better to include local experienced people.

VI. Audit organization

Practically two options are there for conducting a road safety audit:

- Audit by specialist auditors.
- Audit by those within the original design team or by any other road designers.

2.4 Stages In RSA

There are five stages at which a road safety audit can be conducted, regardless of the size and nature of a project. They are:

a) The feasibility stage.
b) The draft design stage.
c) The detailed design stage.
d) The pre-opening stage and
e) An audit of an existing road.

The earlier a road is audited within the design and development process the better. If an appropriate concept or treatment (i.e. one with inherent safety problems in the particular context) is chosen at the feasibility stage, it is very difficult and, often impossible to remove safety problems at later design stages or once the traffic is using it, early auditing can also lead to early elimination of problems and, consequently, minimization of wasted design time at later stages.

2.5 Joint Influence of Road Conditions on Traffic Safety[2]

Road related factors are the most important factors which determine accident risk. Elements of road geometry require careful design and take longer time to implement. The most important element of the roadway which affects safety is cross-sectional elements, sight distance considerations, horizontal curve radius, grade and pavement surface characteristics.Every road consists of a combination of separate sections differing in these factors. The relative probability of a road accident on any section can be appraised by a summary accident rate calculated as the product of the separate relative accident rates characterizing the worsening of traffic conditions in comparison with a two-lane road having a roadway width of 7.5m, paved (or stabilized) shoulders and a non-skid pavement due to their influence of separate elements of the horizontal alignment, profile, cross-section and roadside strip

$\mathbf{K_{ac}=K_1\,K_2\,K_3\ldots K_{14}}$

Where

K_1 = Volume of traffic, vehicles/day
K_2 = Roadway width, m
K_3 = Shoulder width, m
K_4 = Radius of horizontal curve, m
K_5 = Radius of horizontal curve, m
K_6 = Sight distance, m
K_7 = Difference between width of roadway on bridge and on approach road, m
K_8 = Length of straights, KM
K_9 = Kind of road intersection
K_{10} = At-grade intersection with minor road at volume of traffic on main road, vehicle/day
K_{11} = Sight distance ensured at an intersection from the minor road, m
K_{12} = Number of traffic lanes
K_{13} = Distance from buildings to roadways, m
K_{14} = Characteristics of pavement /Co-efficient of friction.

VII. Present Investigation

3.1 General

The objective of the study is to establish a quantifiable relationship between accident rate and some factors influencing accidents. To develop such relationship, it is necessary to collect the accident data and details about the factors affecting the accident rate, such as roadway geometrics traffic conditions etc. The accident data for four years have been collected and used for the analysis. Surveys were conducted to collect the details like road geometrics, traffic volume, speed and delay etc. at selected locations.

3.2 Location

The Bannerghatta road (SH 87) was selected for analysis. The analysis is done for 12km stretch from Mico layout bus stop to Bannergatta village (Vijaya Bank bus stop). The present study is limited to analysis of accidents during the years 2008 to 2010.

3.3 Road Inventory Data

Selected road stretch was divided into number of sub stretches measuring approximately 1000 meters. At each sub-stretch details of following road geometrics were also collected.

3.4 Traffic Studies

a) 8 hours volume count was conducted at 2 locations of the stretch on a weekday covering both peak and off peak hours of a day.
b) Floating car method survey was conducted to find the speed at every kilometer of the stretch.

3.5 Collection of Accident Data

The accident particulars pertaining to the study stretch was collected from the respective police stations. The study stretch of 12 Kms (from Mico layout bus stop to Bannerghatta village) fell under the administration of Mico layout Police Station limit. Accident data related to past four years was collected for analysis purpose.The accident data form as prescribed by IRC has been prepared to collect the necessary information such as date, time, location, whether the accident was fatal, vehicle damage and injured.

VII. Analysis Of Data

4.1 Accident Analysis

The data regarding the road accidents in Bannerghatta road have been collected for a period of four years, i.e. 2008 to 2011 from the Traffic Police Station. The date, time, approximate place, types of vehicles involved etc., are entered in the First Information Report (F.I.R) and details are recorded in case diaries. In order to analyse accident data, it was found that the details were not recorded in standard format and police FIR lacked the important engineering aspects like Nature of Accidents (Head-On, Rear-End etc.,) Type of location (Mid Block, Intersections, Curves, Bridge etc.). Therefore, micro level analysis is not possible. The pedestrians are most affected by accidents in this road. The pedestrian safety is very low.Accidents which occurred during the study period, i.e. 2008 – 2011, are arranged Year-wise, Month-wise and Hour-wise . It is observed that more number of accidents have occurred in the year 2011.

To understand the causes of accidents, it is important to examine Kilometer-wise trends of the accidents, which will help to identify the accident prone stretches of the roads network. Kilometer-wise

distribution of accidents is shown in table 4.4. It was observed that most of the accidents are occurring between 1st to 4th kilometers. Graphical representation of kilometer-wise accidents are presented in figure 4.4.

Distance (km)	vehicle Damage	Injured	Fatal	Total	Percentage
0-1	15	25	4	44	20.28%
1-2	10	13	1	24	11.06%
2-3	14	21	2	37	17.05%
3-4	18	6	4	28	12.90%
4-5	5	8	1	14	6.45%
5-6	5	7	1	13	5.99%
6-7	7	6	4	17	7.83%
7-8	3	8	0	11	5.07%
8-9	1	6	1	8	3.69%
9-10	4	3	2	9	4.15%
10-11	3	4	0	7	3.23%
11-12	1	3	1	5	2.30%
	Grand Total			217	

Table 4.4: Kilometer Wise Distribution of Accidents During 2008-2011

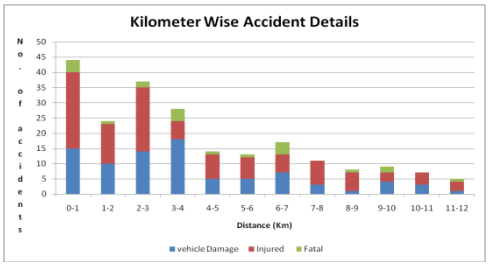

Fig 4.4: Kilometer Wise Distribution of Accidents During 2008 to 2011

The pedestrian safety is very low on this road. Gopallan mall opposite pedestrian crossing is major prone zone. Here we have underpass and flyover so vehicle moves very fast in this area. The trees on median creates sight problem to drivers .Near Micolayout bus stop people stand in the road to get bus. The rate of pedestrians affected by accident is shown in fig no 4.5.

Table 4.5: Pedestrians Affected by Accidents During 2008 to 2011

Total accidents	
Pedestrian	88
Other	129

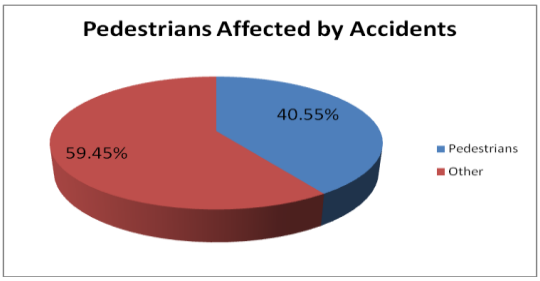

Fig 4.5**:** Pedestrians Affected by Accidents During 2008 to 2011

Reason for low speed of vehicles

- Width of the road.
- Running through populated areas.
- Delay at signals.

4.3 Relation between Causative factors and Accident Rate

4.3.1 Relation between Roadway width and Relative Accident Rate

A wide divided road provides enough space for overtaking operation whereas a narrow road hinders that operation. A careless man oeuvre on such stretches leads to accidents. To know the effect of roadway width on relative accident rate, a plot between them was obtained and the corresponding trend was shown in figure 4.6.

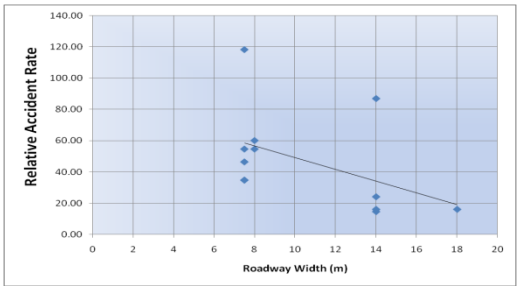

Fig 4.6: Relationships between Roadway Width and Relative Accident Rate

4.3.2 Relation between Shoulder Width and Relative Accident Rate

Shoulders are needed for parking stopped vehicles in India. They are used for crossing and overtaking the vehicles. To study the effect of width of shoulder on relative accident rate a plot of shoulder width and relative accident rate is obtained and is presented in figure 4.7.

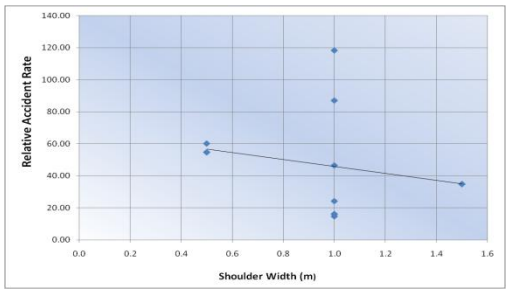

Fig 4.7: Relationships between Shoulder Width and Relative Accident Rate

4.3.3 Relation between Sight Distance and Relative Accident Rate

Sight distance can be for (i) safe stopping and (ii) overtaking. An insufficient sight distance is most frequently the cause of accidents in passing through intersections . To know the effect of sight distance restrictions on relative accident rate, a plot between them was obtained is shown in figure 4.8.

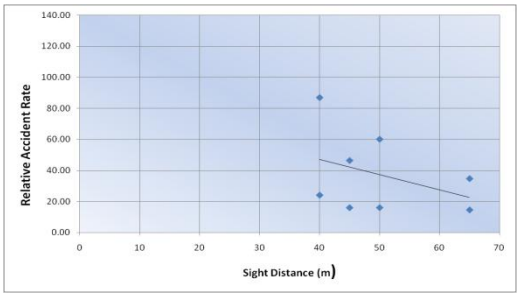

Fig 4.8: Relationships between Sight Distance and Relative Accident Rate

4.4 Road Safety Audit

The Bannerghatta road considered for this study area. Using the accident data along with the data related to road geometrics and traffic characteristics, analysis was done to find the summary accident rate for every kilometer of the stretch using the Babkov's partial severity factors.

The actual measurements of the geometric, traffic and other physical features long the Bannerghatta (BG) road stretch and the summary accident rate values obtained from the analysis are given in table 4.7.

K_1=Volume of Traffic, Veh/day	1.7											
K_2=Roadway Width, m	0.8					1						
K_3=Shoulder Width, m	1.7	1.7	1.7	1.7	1.7	2.2	2.2	1.7	1.4	1.4	2.2	1.7
K_4=Grade, %	1											
K_5=Radius of Horizontal Curve, m		1.6										1.4
K_6=Sight Distance, m		2.25										2.0
K_7=Width of Bridges, m	1.0											
K_8=Length of Straights, Km	1.0											
K_9=Kind of Intersection	1.5											
K_{10}=At-grade intersection with minor road	1.0											
K_{11}=Sight distance at intersection, m	1.0	1.65	1.1	1.1	1.65		1.1	1.1	1.0			
K_{12}=Number of traffic lanes	0.65					1.0						
K_{13}=Distance from buildings to roadway,m	5.0					7.5						
K_{14}=Characteristic of Pavement	1.3											
Summary Accident Rate	14.65	87.03	16.12	16.12	24.18	54.70	60.17	46.49	34.81	34.81	54.70	118.35
Actual Number of Accidents as per FIR	44	24	37	28	14	13	17	11	10	9	7	5
Kms	0.00-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-7.00	7.00-8.00	8.00-9.00	9.00-10.00	10.00-11.00	11.00-12.0

Table 4.7 Accident Rate Analysis by Babkov's Method

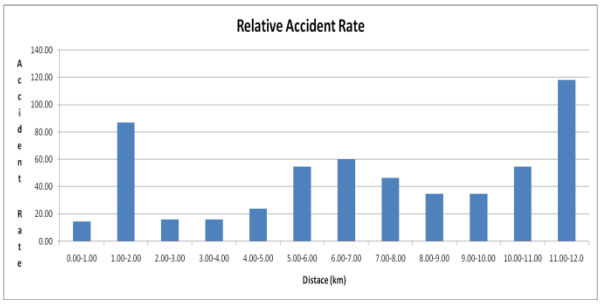

Fig 4.9: Accident Rate Analysis by Babkov's Method

VIII. Conclusions

5.1 General

The study stretch a Bannerghatta road that is from Mico layout bus stop to Bannergatta village km 0.0 to km 1.0 is accident prone due to multiplicity of causative factors. The analysis of accident data collected from the FIRs from 2008 to 2011 and field surveys conducted has yielded the following conclusions.

5.2 Accident Statistics

i. More number of accidents have occurred during 2011.
ii. No definite trend is observed with month wise distribution, the accidents have occurred all through the year.
iii. Majority of accidents have occurred during 8am to 12pm and 4pm to 6pm of the day and it is difficult to explain the particular trend.
iv. Analysing kilometer wise accident occurrence has shown that KMS 0 to 1 and 2 to 3have shown higher accidents.

5.4 Speed profile data

i. Along the study stretch from Mico layout towards Bannerghatta the accident prone locations are KM 0 to 5 has low Average Journey Speed of 22 kmph. Whereas from Bannerghatta towards Mico layout the accident prone locations are KM 7 to 12 has low Average Journey Speed of 18 kmph.

5.5 Pedestrian safety

The study stretch has very low pedestrian safety. The accident reasons for low low pedestrian safety are;

- Sight distance problem.
- Driving vehicles on footpath.
- People standing on the road near bus stand.
- Improper footpaths .
- Trees on the median.

5.6 Road Safety Audit

The analysis has indicated that the most severe accident prone locations are KM 0 to 1, KM 2 to 3 and KM 1 to 2. These stretches needs geometric improvement, pavement resurfacing etc., and needs 'Before' and 'After' studies to be conducted for economic and financial evaluation.

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