ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Road Accident Investigations – A Case Study of Sricity

Emani Mahesh Babu
M.Tech Scholar,
Nalanda Institute of Engineering and Technology,
Kantepudi (V), Guntur, A.P.

Vinoth.S, M.Tech
Assistant Professor,
Nalanda Institute of Engineering and Technology,
Kantepudi (V), Guntur, A.P.

ABSTRACT

The spectacular increase in the number of motor vehicles on the road has created a major social problem – the loss of lives through road accidents. The appalling human misery and the serious economic loss caused by road accidents demand the attention of the society and call for the solution of the problem. A multi-disciplinary approach is needed in understanding the problem and providing solutions.

This study presents analysis of accidents occurred in Sri City, located towards the left hand side on NH-5 (Chennai to Kolkatta) near Tada. The procedure used for the accident investigation is data collection through field surveys. The preliminary field studies carried out is volume count and spot speed. From the speed studies, it is observed that all the vehicles are plying in permissible limits. It could be observed that there is not much variation in speeds of straight sections and sharp curves during day time. Major vehicles involved in the accidents were trucks. Most of the accidents occurred during the day time.

INTRODUCTION

GENERAL

Road safety is a serious concern in the developing countries. In India, the growth in vehicle population without adequate road infrastructure has been responsible for increase in the number of accidents. Heterogeneous mix of traffic, poor road geometrics and ineffective traffic control are some of the important contributing factors to the high accident rates.

The primary requirement for establishing a safe highway network is to thoroughly analyze and study the contributing factors along with the causes and circumstances, which lead to accidents, so that innovative methods in terms of design and control be developed to counter deficiencies in the system. The accident data need to be analyzed to identify accident – prone locations on the selected highway. Detailed investigations of the accident-prone locations need to be carried out to identify the deficiencies and to suggest improvement measures. The improvement proposals thus developed must be evaluated and prioritized for implementation according to the effectiveness of the schemes. The schemes implemented based on the safety effectiveness of the proposals would definitely lead to reduction in accidents and increase the safety of the highways.

There are two complementary approaches to accident investigation work;

1. Accident reduction, in which measures are taken to reduce the number and severity of accidents, and
2. Accident prevention, Accident prevention is the application of remedial measures preventing accidents from taking place in the future.

PRESENT SCENARIO

Though vehicle population have increased in multiplicity, but the roads are not adequate to accommodate the increased population reasons are social, political and others. The figures of accidents in our country are as follows: (Source: Motor transport statistics of India, Transport Research wing, New Delhi.)

(a) Killed – 85,000 persons per annum
(b) Injured – 5,00,000 persons per annum

In India, an accident occurs at every 1.2 minute and a person is killed in every six minutes, this is to say that 235 persons die every day and 1243 persons get injured in road accidents. Nearly 60% of total accidents take place during nights though the night traffic is hardly 15% of 24 hours volume which means that the accidents in India during night 8 times greater than the day traffic. Road accident scenario in India for

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

the last four decades is summarized in Table 1.1 and Figure 1.1 and 1.2.

Table1.1 Road accident Statistics of India 1980-2013 (Source: Motor transport statistics of India, Transport Research wing, New Delhi.)

Sl.no	Year	Total no. of road accidents (in numbers)	Total no. of persons killed (in numbers)	Total no. of regd.motor vehicles (in thousands)	No. of accidents per ten thousand vehicles	No. of persons killed per ten thousand vehicles
1	1980	114100	14500	1401	814.42	103.50
2	1990	153200	24000	4521	338.86	53.09
3	2000	282600	54100	19152	147.56	28.25
4	2001	295131	56278	21374	138.08	26.33
5	2002	275541	60113	23507	117.22	25.57
6	2003	284646	60380	25505	111.6	23.67
7	2004	325864	64463	27660	117.81	23.31
8	2005	351999	70781	30295	116.19	23.36
9	2006	371204	74665	33786	109.87	22.1
10	2007	373671	76977	37332	100.09	20.62
11	2008	385018	79919	41368	93.07	19.32
12	2009	386456	81966	44875	86.12	18.27
13	2010	391449	78911	48875	80.12	16.15
14	2011	405637	80888	54991	73.76	14.71
15	2012	407497	84674	58924	69.16	14.37
16	2013	406726	85998	67007	60.7	12.83

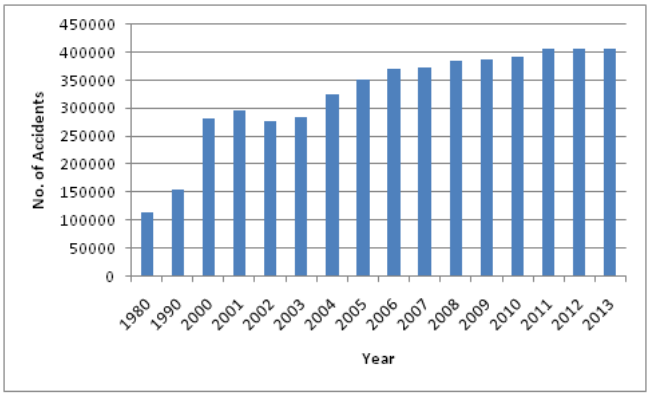

Figure 1.1: Total Number of Accidents by year wise

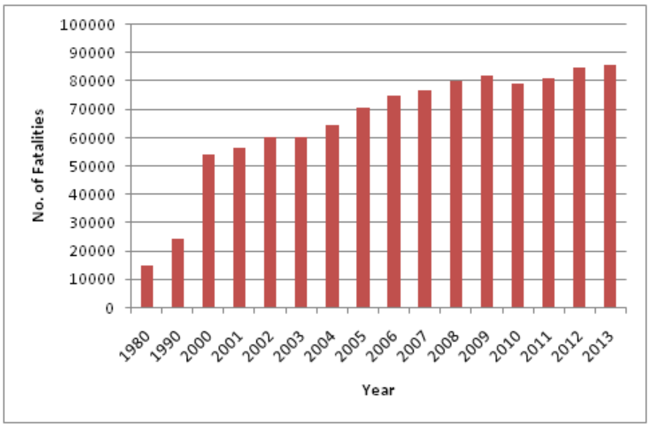

Figure 1.2: Total Number of Fatalities by year wise

Source: Motor transport statistics of India, Transport Research wing, New Delhi.

ACCIDENT CAUSATIVE FACTORS

"Road accidents do not just happen but are caused" is a common cliché in the area of traffic safety. The accidents are caused by some agents, surely they could be identified and appropriate remedial measures could be developed and implemented for their prevention to the extent feasible for the reduction of the ill effects and trauma of the accidents. Analysis of the data on accidents in the country exemplify that drivers of the motor vehicle are the single major factor responsible for the accidents as they fail to perceive the situation ahead because of poor reflexes, fatigue, inexperience or being under the influence of toxicants which contribute directly or indirectly to the road accidents. These are

1. The road
2. The vehicle
3. The road user
4. Environmental factors

If road factors are analyzed, it may be seen that it has several factors, first is the planning of the road in relation to the land use pattern and the town and country planners have an important role to play in land use pattern. Second is the geometric design of the road and provision of skid free pavement surfacing for safe movement of vehicles which fall under the purview of highway engineers. Third is the provision of suitable traffic guidance and control like signs, signals, pavement markings and delineators. Fourth is the land scaping of the road environment and provision of resting facilities for vehicles drivers so that they are

ISSN No: 2348-4845
International Journal & Magazine of Engineering,
Technology, Management and Research
A Peer Reviewed Open Access International Journal

alert while driving and this aspect is to be looked after by land scaping engineers and architects.

The unsafe situation along the corridors can be largely attributed to factors such as mixed traffic, a lack of safe driving culture, very low level of safety awareness amongst the road users, poor design and road condition and lack of safety measures and their enforcement. It is a known fact that traffic accidents usually take place as a result of the complex interaction of environmental and operational factors in time and space. Or putting it in simpler terms, accidents are due to the interaction of human, vehicle and road environmental factors. Generally, human factors contribute to about 75% of the accidents on roads. But the vehicle and road factors leading to the drivers fault cannot be overlooked.

IMPROVING ACCIDENT PRONE LOCATIONS

It is generally agreed that up to 25% of accidents can be averted by just improving the accident prone locations in any city. It is also estimated that accident prone locations account for 1 to 3 percent of the total road length and therefore it is implied that a moderate investment in improving accident prone location

This would reduce accident costs by 25%.

Payback period of investment in accident prone locations is only 4 to 5 years. Apart from reducing accident costs, the improvement of accident prone locations would reduce fuel consumption, the vehicle operating cost and travel time. It would also enhance the riding quality and passenger comforts. Thus if can be understood that the identification and the improvement of accident prone locations is a cost-effective and a benefit-generating proposition.

IDENTIFICATION OF BLACK SPOTS

The most frequently used methods to identify and prioritize candidate high crash locations include the Crash Frequency Method, Crash Rate Method, Frequency-Rate Method, Crash Severity Method, Safety Indices, Severity-Rate Method, Rate-Quality-Control Method, and Bayesian Approach.

Black spots on the roads are those places, where accidents often appear to cluster or concentrate. These stretches are termed as accident prone locations or “black spots”. Studies conducted in the developed countries show that identification and improvement of accident prone black spot locations reduces the occurrence of accident significantly. The purpose of this chapter is to review the various techniques that have been suggested for identification of accident prone locations and to select appropriate technique for carrying out accident investigation.

CRASH FREQUENCY METHOD

The Crash Frequency Method summarizes the number of crashes by location. The main advantage to this method is that it is simple to use and doesn’t require additional information beyond number and location of crashes. Locations are ranked by descending crash frequency and those with more than a predetermined number of crashes are classified as high-crash locations to be further scrutinized for statistical significance. It is useful initially to identify locations for further analysis and ranking. The main disadvantage is that exposure (traffic volume) is not accounted for. Without being able to account for variations in traffic volume, locations that have high crash frequency due to high traffic volumes rather than some deficiency may be misidentified as high crash locations.

CRASH DENSITY METHOD

The Crash Density Method is closely related to the crash frequency method, the crash density method summarizes the number of crashes per mile for highway sections. Sections are defined as a minimum length of roadway with consistent characteristics, with the minimum distance used frequently being one mile. Locations are ranked by descending crash density and those with more than a predetermined density of crashes are classified as high-crash locations to be further scrutinized for statistical significance.

CRASH RATE METHOD

The crash rate method does account for both exposure and the total number of crashes. For links, crash rate is a function of the number of crashes, traffic volume, and the length of the segment. At nodes, crash rate is a function of the number of crashes and daily entering vehicles. Crash rate is typically expressed as the number of crashes per million vehicle miles traveled for road segments and number of crashes per million daily entering vehicles for intersections.

FREQUENCY-RATE METHOD

This method is a combination of the Crash Frequency and Crash Rate Methods. Locations are first ranked by Crash Frequency and the worst locations re-ranked using Crash Rate. The rational of combining Crash Frequency and Crash Rate is to eliminate or minimize the bias of the two individual methods. The frequency-rate method is a combination of crash frequency/crash density methods and the crash rate method. Locations are classified as high-crash locations if they have more than the prescribed minimum crash frequency or crash density and higher than the minimum crash rate.

CRASH SEVERITY METHOD

The Crash Severity Method accounts for monetary losses of crashes by considering and then weighting crashes at a location based on the resulting degree of injury. Fatal and injury crashes are usually weighted more heavily than possible or minor injuries and property damage only (PDO) crashes. This allows severity of accidents to be considered. Safety agencies and the general public are often most concerned with severe crashes.

EMPIRICAL BAYES METHOD

Hauer and Persaud (1984) suggest an Empirical Bayes (EB) method for identification of high crash locations. The EB method attempts overcome the difficulties with some of the conventional techniques. The EB method controls the randomness of crash data by using an estimate of the long-term mean number of crashes at a location. This method is used for predicting crashes in the future and then ranking based on the predicted number of crashes.

The broad techniques for the identification of black spot may be categorized as.

a) Statistical methods

b) Bio-medical engineering approach

c) Engineering methods

d) Subjective assessment techniques

OTHER METHODS

STATISTICAL METHODS

Accident statistics are intended to provide insight in to the general safety of highway safety and systematic contributing causes of accidents. Although use of statistics and statistical analysis can yield valuable information for the engineer, providing insight that help in the development of corrective measures. Accident statistics are most often used to quantify and describe three principle information elements.

a)Accident occurrences

b)Accident involvement

c)Accident severity

Statistics in each of these three categories can be stratified and analyzed in an finite number of ways, depending upon the factors of interest to the analyst. Accident statistic and their proper analysis reveal commonalities and trends concerning to the under lying causes of the accident. These provide the information from which the systematic improvements in policy, design, control and enforcement can be developed and implemented.

Some of the criteria in define accident black spots based on statically methods are

a)Annual accident total methods

b)Weighted severity index method

c)Quantum of accident method

d)Accident rate based on traffic flow

e)Multi factor approach

f)Accident prone index

g)Potential accident reduction procedure

In the annual accident total method the no of accident in the year are considered and the stretches having the more number of accident are taken as accident prone stretches.

Weighted severity index method assigns weight to different types of accident and their weighted severity total has been calculated. This value ranges from 0 to 90, the stretches that are having 90 or more were taken as accident prone stretches.

In the quantum of accident method consequent three data is considered for analysis. These are level, consistency and, tendency; from this accident prone index values are calculated.

While first three methods favour improvement of sites with larger number of accident, the accident rate on the other hand picks up those sites having high rate of accidents in relation to traffic flow neither of them can be justified on their own merits. Multi factor approach assigns weight to different accident reflecting severity, type of road user involved and accident cost information. This has been mainly recommended for identifying black spots with higher pedestrian accidents. Statistical methods though useful in their own right, do not address themselves to the type of Improvements, which can lead to reduction of accidents.

BIO-MEDICAL ENGINEERING APPROACH

During, a driver receives and processes much information coming to him. If the amount of information to be processed for taking decision increases, the perceptual load of the drivers increases. This over-load causes nervo-physical strain of drivers. The effect of the perceptual the driving task is discussed by Allen (1970).

For number of years, the chair of the road design of Moscow highway engineering institutive has been investigating of the features of perception by driver of road condition in order to design the road standards. According to above study the galvanic skin responses, changes in the encephalograms and cardiograms of drivers are the external manifestations of the nervous and the psychic processes taking place in the cortex of the drivers, when drivers are traveling over a road section.

Relative growth of galvanic skill response in traveling over curved section of road under different conditions are tabulated in Babkov(1975). Lesser the values of radius of the horizontal curve, higher the relative change in the value of galvanic skill response.
In spite of several advantages, the bio-medical techniques are difficult to be used by organizations lacking in the necessary expertise for carrying out field the field studies. The instrumentation required will usually be out of reach.

SUBJECTIVE ASSESSMENT TECHNIQUES

Subjective methods are those which are based on the result of the safety evaluation by a group of drivers, traffic engineers, experts in traffic safety and others. Multi dimensional perceptual study of road safety is the ultimate aim of the subjective assessment methods.
As already pointed out, research in road safety can be characterized either as micro or macro in nature. Traditional research which use physical condition of the road , traffic volume , road side characteristics etc.., is former type. On the other hand subjective assessment, which is driver's physiological value, system apart from the other dynamic factors belonging to the later.

The usefulness of these techniques in black spot identification is yet to be established. However, these techniques appear to have great potential, particularly in view of developments.

In video logging, the whole road can be brought to the laboratory and safety evaluation can be performed by a group of experts, whose individual differences can also be taken into account in the overall evaluation.

ENGINEERING METHODS

Composition etc.., which are responsible for the accidents. The methods that are suggested under this are innumerable but for the purpose of selection of appropriate techniques the following procedures are discussed. These are
a)Speed profile method
b)Safe coefficient method
c)Traffic conflict studies
d)Wheel path study of vehicle
e)Accident coefficient method

SPEED PROFILE METHOD

In the speed profile method, a test vehicle is driven on the road stretch for a couple of time under physically free conditions. The speed of the test vehicle on different runs along the road over different stretches is calculated by knowing elapsed time. These are plotted as a profile along the test section. The basic premise of this method is that the variance the speed will be large at accident –prone locations.

SAFE COEFFICIENT METHOD

Instead of using the speed profiles, Babcov recommends the use of the ratio between the vehicle speeds in neighboring road sections, which he called as safe coefficient. According to him greater the difference between speeds on adjacent sections and smaller the coefficient, greater will be the accident proneness of the section.

DETAILED DESIGN AN IMPLEMENTATION OF COUNTERMEASURES

DETAILED DESIGN PHASE:

The next stage after selecting an appropriate remedial measure is the detailed design. This is likely to be carried out by a different unit to that investigating the problems. The design drawings will need to be based on the proposals of outline plans of the accident investigators and this same team should also remain actively involved with the designers throughout the design process.

It is important that the objective of introducing a scheme (such as speed reduction, improving pedestrian safety and so forth) is clearly brought out before the beginning the detailed design process. It is totally important that the design, which is being implemented, is in accordance with the results of the accident investigation. It should be seen that it has not been modified or trimmed to the point where it will not have a meaningful effect on the accident problem. If it is being implemented in conjunction with other works at the site or nearby, it is important that these other works do not introduce any new safety problem. If there is any reason for concern, road safety engineering advice (e.g. in the form of a detailed design stage road safety audit) should be sought. An ‘outline’ scheme design should be drawn up which may include several different approaches and engineering measures for achieving the objection of the scheme. The next stage is to identify the individual elements of a scheme and to put them together to form a cohesive, detailed design. Engineers should consider all aspects further they should consider the needs of all road users, including disabled, pedestrians and motorists. The design process would include drafting clear, well-annotated, vertical and horizontal drawings. Outline plans should be on a scale of 1:5000 for a route. Otherwise they should be 1:2500 or 1:1250. Full detailed plans should be on a scale of at least 1:500, or 1:200 for a more complex scheme.

IMPLEMENTATION PHASE:

Consultation will largely take place after an outline scheme design has been proposed and before full design is finalized. The various stages of scheme design, consultation etc. should be documented, to reduce the amount of work necessary incase a similar scheme be installed in future. During the implementation phase, traffic safety will continue to be important. Work zones can be potential places for crashes, due to the changes in road layout and the temporary absence of permanent kerbing, delineation, markings or signs. Works zone traffic controls need to be planned before works commence and carried out in a manner which provides safety for the traveling public and works personnel. National and state guidelines on road work traffic management should be complied with. For larger, more complex projects, a road safety audit of the construction stage should be considered. This involves auditing the traffic management plans and undertaking site inspections during the construction. Once the works have been completed, the project can be the subject of a pre-opening road safety audit, to ensure it is implemented as planned and with no unexpected road safety hazards introduced.

MONITORING AND EVALUATION

Monitoring (Step 11) not only enables an assessment of the action(s) taken, they can also play an important part in determining future strategies and policies.

Monitoring is usually carried out using 'Before and After' studies in conjunction with selected control data. Control data may be from untreated sites in the locality with similar characteristics to that of the treated sites or from reliable regional or provincial data. Use of control site data helps in eliminating extraneous factors that might affect the after treatment accident levels e.g., government legislation that influences vehicle speeds etc. After data should be examined in some detail. This will highlight whether the target group of accidents has reduced and whether any other accident type has increased or been introduced.

There have been a number of studies (Kentucky Transportation Centre, “Development of Statistical models and procedures for identifying High-Crash locations & prioritizing Safety Improvements”, University of Kentucky, Research Report, KTC-03-15/SPR250-02-1F, June-2003) examining the best statistical methods for monitoring changes at treated sites. The Chi-square test with Yates’ correction. For small numbers is commonly used to determine whether Changes treated sites are statistically significant. The test compares treated site data with data from the control sites. A problem in evaluation studies include taking into account environmental changes such as closures to junctions close to the treated site, and random fluctuations. Random fluctuations make determining the effectiveness of treatment difficult and includes the regression to the mean effect. There is a reduction in accidents at a site(s) not due to any applied treatment but due to the random nature of road accidents. This is especially true of sites selected for the high number of accidents that might have occurred in a particular year.

Monitoring and evaluation are tasks, which typically occur after countermeasure treatment is implemented. Monitoring is the systematic collection of data about the performance of road safety treatments after their implementation. Evaluation is the statistical analysis of that data to assess the extent to which the treatment or treatment program has met the accident reduction objectives. These tasks are important to ascertain the positive and negative effects of a treatment and thus improve the accuracy and confidence of predictions of that treatment's effectiveness in subsequent applications.

After analysis work, identified road accident problems and implemented solutions, a monitoring system must be established to measure the effectiveness of the road safety engineering work carried out. The treated site should be observed immediately after completion of the construction and regular visits made in the following days, weeks or months until the team is satisfied that the scheme is operating in the way expected. Whilst the fundamental aim of countermeasures is to reduce accidents (of a particular type) this often results directly from changes brought about in road users' behavior. It is strongly advised that any earlier behavioral measurements that were made during the investigation stage (e.g., traffic conflict counts, speed measurements, skid resistance) are now repeated as this will lend weight to any argument for making further changes at the site or, indeed, proving success. It can happen, for instance, that some feature of a scheme may produce an unforeseen reaction in drivers, which creates a potentially hazardous situation or lead to accidents of a different kind. Monitoring should highlight this problem at an early stage so that appropriate action can be taken quickly to remove this danger.

It is essential to carry out the monitoring effectively, not least to avoid the "bad publicity" which could occur if a road safety scheme was seen to be actually causing accidents by making the situation worse than it was before the work was implemented. Recording the results of the monitoring measures is also important to build up a database of types of treatment and the effects they produced. This will provide information for future safety engineering work.

EVALUATION

This final step of the procedure focuses on evaluating whether the treatment has been successful in achieving its objective of reducing the number of accidents. This, therefore, requires comparison of the number of accidents in the target group "before" the treatment with the number "after" treatment (with the assumption of a similar before pattern if nothing were done), and to study whether any other accident type has increased. Evaluation could also be carried out through comparison with similar untreated sites to act as a 'control' group when assessing the true accident due to reward work. Manual

The main problem when using accident data for evaluation (even assuming high recording accuracy) is to distinguish between a change due to the treatment and a change due to other sources. Another problem in evaluation studies is the regression to the mean effect where, due to the random component of accidents, despot sites are likely to have some fewer accidents in subsequent years even without treatment. This effect should ideally be taken into account when calculating accident savings. Also alternate routes to the treated sites should be mentioned in order to detect any accident migration. There have been a number of studies examining best statistical methods for evaluation the best statistical methods for monitoring changes at treated sites. Ch-Square test's corrections for small numbers are commonly used to determine whether changes at the treated site are statistically significant. The test compares safety performance at the location before and after a scheme has been implemented or compares treated site data with data from control sites.

CONCLUSIONS

The following conclusions can be drawn based on the present data

- The traffic volume at peak hour reaches the maximum capacity of the carriageway it leads to congestion further there is an increase in rear end collisions. Eg. Tada to Srikalahasthi
- From the spot speed analysis, it can be infer that most number of accidents occurred during day time.
- More number of accidents is occurred in Tada compared to Sricity.
- More number of deaths is recorded in Tada compared with Sricity.
- Heavy vehicles were major cause of accidents.
- It could be observed that there is not much variation in speeds of straight sections and sharp curves during daytime at tada.

SCOPE FOR THE FURTHER STUDIES

After suggesting the improvement measures it has to estimate the cost for the proposed improvements and develop the safety effectiveness score to measure the impact of the proposed schemes on accident reduction.

REFERENCES

1.Khanna S.K., Justo C.E.G. "Highway Engineering", (1994), Nem Chand & Bros, Roorkee, 7th Edition.

2.Environmental Systems Research Institute (ESRI) Inc. "ArcView GIS, version 3.1", 1996, New York Street, Redlands, California, USA.

3.Baguley Chris, McDonald Mike, et al, "Towards Safer Roads in Developing Countries, A Guide for Planners and Engineers", Transport Research Laboratory, 1994, pp 1-60

4.Kalga R.R, Silanda S.N, "Accident Rate Prediction on Arterial Roads of Durban, South Africa", Indian Highways Journal, July 2002.

5.Bobkov, V.F., "Road condition and traffic safety". Mir Publications, Moscow,1975.

6.I.V.R.L Narasimha Rao, Madhavi Latha Kaithapalli & Raghava Rao Gundala., "Safety Scenario on National Highways – A Case study of NH-5 passing through Visakhapatnam Metropolitan Region", Indian Journal of Transport Management, Vol 27, No.4, October – 2003.

7.K.K.Saija, C.D.Patel & V.J.Upadhyay., " Micro level study of accidents on NH – 8 passing through Valsad District", Indian Highways, Vol 30, No 8, August 2002.

8. Dinesh Mohan, "Traffic Injuries and Fatalities in India", Transportation Research & Injury Prevention Programme, Indian Institute of Technology Delhi, April-2004

9.Dr. S.B. Baviskar, "Analysis of road accidents on National Highways in Nashik District", Indian Highways, Vol. 26, No. 10, October-1998

10. Dr. S.M. Sarin, Faqir Chand & V.D. Rama Rao, "Minor improvements of highways for better road safety", Indian Highways, Vol. 33, No. 9, September-2005.

11. "Geometric Design Standards for the Urban Roads", IRC:86-1983

12. Transport Research Board, "Accident Black spot investigation", December-1994

13. Arapahoe Community College Academy "Accident Investigation manual", June-2002.

14.L.R. Kadiyali, "Traffic Engineering and Transport Planning", Khanna Publishers, Sixth Edition, 2004

15.DEPARTMENT OF TRANSPORT, 1986. Accident Investigation Manual. Department of transport, London.

16.DEPARTMENT OF TRANSPORT, 1987. Accident Investigation and Prevention. Traffic Advisory Unit Leaflet 4/87, DOT, London.

17.DOWNING, A J, 1985. Road Accidents in Pakistan and the need for improvements in driver training and

18.Traffic law enforcement. In: PTRC. Summer Annual Meeting, University of Sussex, July 15-18, Proc of Seminar H. PTRC, London.

19.THE INSTITUTE OF HIGHWAYS AND TRANSPORTATION, 1990. Guidelines for: The Safety Audit of Highways. The Institute of Highways and Transportation, London.

20.THE INSTITUTE OF HIGHWAYS AND TRANSPORTATION, 1990. Highway Safety Guidelines: Accident Reduction and Prevention - international Edition. The Institute of Highways and Transportation, London.

21.THE INSTITUTE OF HIGHWAYS AND TRANSPORTATION, 1991. Urban Safety Management Institute of Highways and Transportation, London.

22.JACOBS, G D, 1976. A study of accident rates on rural roads in developing countries. TR.RL Laborano-Report 732. Transport and Road Research Laboratory, Crowthorne.

23.R. Prasanna Kumar, V. Venkatramayya & T. Kashinath, "Macro Level study of road accidents on Dindigul - Palani section of National Highway-209", Indian Highways, Vol. 32, No. 11, November-2004

24.10. Sanjay Kumar Singh, Ashish Misra, "Road accident analysis: A case study of Patna City", Paper published in Urban Transport Journal 2(2): 60-75

25.Kentucky Transportation Centre, "Development of procedures for identifying High-Crash locations & prioritizing Safety Improvements", University of Kentucky, Research Report, KTC-03-15/SPR250-02-1F, June-2003

26.Dr. S.M. Sarin, Faqir Chand & V.D. Rama Rao, "Minor improvements of highways for better road safety", Indian Highways, Vol. 33, No. 9, September-2005