CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Locations are in general classified as accident prone stretches after an assessment of the level of risk and the likelihood of a crash occurring at each location. At certain sites, the level of risk will be higher than the general level of risk in surrounding areas. Crashes will tend to be concentrated at these relatively high – risk locations. Locations that have an abnormally high number of crashes are described as, high hazard, hazardous, hot pot or Accident prone stretches. Sites with potentially hazardous features are sometimes described as grey spots.

2.2 CASE STUDIES

Rajat Rastogi (2006), analysed the accidents occurred on different categories of roads in and around Kota city in macro level. The data was collected in two parts, one from police records and other from personal interviews conducted in various parts of Kota city. Accident models were developed for the city and the district; accident prone locations were identified based on various methods along with the causative factors. Location wise corrective measures have been suggested.

Kamdar et al. (1988), analysed the traffic accidents occurred on NH 8 passing through Sabarkantha district, to ascertain the causes of accidents and to take steps for reducing the frequency and severity of accidents, through the remedial measures. Sarkar & Malleswari (1995) have identified risky stretches and black spots on city streets. Shaheem & Syed Mohamed (2006) have
evaluated the cost effectiveness of improvement of accident prone locations on N.H -7 in Kerala.

Gunasekaran et al. (2003), have taken four STUs for the study, viz. one operating exclusively in urban areas, one in relatively plain region, one in hilly region and the other throughout the state. Primary data collection included the driver interview, highway knowledge test, driver reaction time test and visual test. Secondary data i.e. STU bus accident data for the period 1992 – 1997 and details of driver characteristics were collected from the STUs. Curve fitting was done to identify the relation between driver characteristics and accident occurrence.

Srinivasan (1991), studied the impact of present and future traffic on different traffic management options for Delhi area to select the most suitable and feasible road network and traffic management plan. In total, 12 different options were considered for comparative evaluation on the basis of social benefits. Saija et al. (2000), have discussed the road accidents occurred in urban and rural areas. Sikdar et al. (1999), have identified hazardous locations and did accident investigation on regional road network using GIS.

Sanjay Kumar Singh & Ashish Misra (1972), stated that bus services in particular have deteriorated, and their efficiency and quality of service have been declining thus inducing passengers to turn to personalised modes and IPTs. This results not only in restricting the traffic flow, but also putting the road users’ life at a great risk. Persons killed per 100 accidents are alarmingly high. The adult working age group (18 to 60 years) accounted for more than 80%. A multi-disciplinary team of experts suggested corrective measures in the most accident prone location (NH 38, in which 15% of accidents are taking place).
Krishnamurthy (2015), discussed about the various current and past methods of black spot identification, viz. Spot Map Method, Accident Frequency Method, Accident Density Method, Accident Rate Method, Frequency Rate Method, Quality Control Methods, Accident Severity Methods, Index Methods and Complementary methods.

According to Hauer (2001), some researchers rank locations by accident rate (accidents per vehicle kilometers or entering vehicles), some use accident frequency (accident per km-year or accidents per year) and some use a combination of the two.

According to Deacon (1975), one of the most commonly used severity method is Equivalent Property Damage Only factor, where the different types of injuries are weighed in terms of property damage only.

2.3 VARIOUS MODELS

Anitha & Anjaneyulu (2013), have considered various dependent and independent variables for their study and four types of regression models had been done, viz. Multiple Linear Regression Model, Poisson Regression Model, Negative Binomial Regression Model and Zero-Inflated Poisson Regression Model. The suitability of different types of models for describing road crash frequency and the roadway and traffic variables that influence the road crash frequency confining to two lane two way rural highways had been identified.

Abdel-Aty & Essam Radwan (2000), had developed the Negative Binomial modeling technique was used to model the frequency of accident occurrence and involvement. The model illustrated the significance of the Annual Average Daily Traffic (AADT), degree of horizontal curvature, lane, shoulder and median widths, urban/rural, and the section’s length, on the
frequency of accident occurrence. Several Negative Binomial models of the frequency of accident involvement were also developed to account for the demographic characteristics of the driver (age and gender). The results showed that heavy traffic volume, speeding, narrow lane width, larger number of lanes, urban roadway sections, narrow shoulder width and reduced median width increase the likelihood for accident involvement.

Aeron Thomas et al. (2004), in his study considered the impact of road crashes on the poor in Bangladesh and Bangalore, India. In Bangladesh, the survey was nationwide and all casualties were identified by the household surveys. In the Bangalore study, a slum and upper middle class neighbourhood were surveyed in Bangalore city, while the rural sample came from a Bangalore rural district. These locations are also at different levels of motorisation and economic prosperity. With 1.5 million motor vehicles registered, Bangalore city alone has more than three times the number of motor vehicles of Bangladesh. In light of the different survey approaches and the different stages of development, the case study summaries are presented separately below. The summary findings apply equally to the poor and non-poor, except where stated.

Chakraborty & Roy (2005), In this paper an assessment of the current level of road safety in Kolkata is made utilizing data obtained from secondary sources. The road safety level in Kolkata is assessed considering four parameters, namely, accident severity index, accident fatality rate, accident fatality risk and accident risk. The study is primarily confined to the accident characteristics of passenger vehicles in Kolkata. Models for the projection of future accidents in terms of total accidents and fatality and injury types of accidents have also been developed. These models can be used as tools to measure the effectiveness of future safety improvements implemented in the city.
Delen et al. (2006), have discussed in the area of accident severity research, investigated the relationship between the level of severity (dependent variable) and a set of explanatory variables, which usually include: driver attributes (e.g., age and gender), vehicle features (e.g., body type, vehicle age and number of vehicles involved in the accident), road characteristics (e.g., number of lanes, road surface conditions, intersection control and types of road), and accident characteristics (e.g., accident’s main cause). Occasionally, the influence of other variables on accident severity like speed limit, day of the week, time of the day, average traffic characteristics (AADT), weather and traffic conditions have also been scrutinized.

Joshua & Garber (1990), presented mathematical relationships obtained through multiple linear and Poisson Regression Analysis, relating the number of truck involved accidents per year at a section of highway with traffic and geometric variables. These models indicate that the slope change rate (absolute curve of slope changes in the vertical direction divided by the highway segment), the average daily traffic, the percent of trucks and the difference in speed between trucks and non-trucks influence the number of truck involved accidents at a given stretch of highway.

Rakesh & Suman (2012), had developed a model for the stretch of NH-77 from Hajipur to Muzaffarpur. It is estimated that heavy vehicles are involved in almost 48% of accidents followed by two-wheelers 16%, car 12% and buses 10%. Accident rate increases during the study year, whereas both injury and fatality rate show a declining trend over the study period. The developed model for accident prediction represents that the number of accidents per-km per year increases with Average Daily Traffic (ADT) and decreases with improvement in road condition.

Balachandran et al. (2005), have considered high speed Indian highway under mixed traffic flow condition for about 150 km stretch. The
various qualitative and quantitative variables have been considered for the study. The Generalized Linear Modelling (GLM) technique has been used to create an empirical road accident prediction modelling. The model is built on the assumption that occurrence of road accident follows a Poisson distribution over a long period.

Anjana & Anjaneyulu (2014), developed a simple and effective technique for safety evaluation of geometric design and traffic control measures, based on analysis of traffic crashes on urban single carriageway roads in Kerala. Crash prediction models were developed to establish the relationship between the explanatory variables and crash frequency. From the prediction models it is found that traffic volume, carriageway width, shoulder width, condition of sidewalk, Land use, presence of bus stop, minor intersecting roads, at grade pedestrian crossing and desirable warning signs significantly influence the occurrence of crashes on single carriageways. Crash Modification factor (CMF’s) which is a useful tool for evaluating the safety effect of alternate geometric design, traffic and control measures were developed.

Dominique Lord (2010), In his paper provides a detailed review of the key issues associated with crash-frequency data as well as the strengths and weaknesses of the various methodological approaches that researchers have used to address these problems. While the steady march of methodological innovation (including recent applications of random-parameter and finite mixture models) has substantially improved our understanding of the factors that affect crash frequencies, it is the prospect of combining evolving methodologies with far more detailed vehicle crash data that holds the greatest promise for the future.

Malaya Mohanty & Ankit Gupta (2014), have reviewed various models and concluded that male teenagers are the most affected victims of the
road crashes in urban roads. Also various statistical techniques were used to
model the road crashes quantifying the other factors like roadway, geometrical,
personal and environmental factors.

Bikramjit Das Gupta & Abhijit Kr Mandal (2013), concentrated on
causes of road accidents and highlighted and focused on the causes resulting in
road accidents in the North – eastern region of India by collecting data from
various sources using correlation coefficient model and suggested that most of
the accidents occurred are by “road condition”, “non-compliance & lack of
awareness with respect to traffic rules”, “drunken driving” and “over loaded
vehicles”.

Joshi & Gundaliya (2008), in their casestudy presented macro level
analysis of the road accidents by statistical approach, identified accident –
prone stretches and their prioritization, developed accidents model for Rajkot
city in Gujarat district and concluded that the police authorities are not using
the format given by Indian Road Congress and two wheelers contribute 80
percent of the traffic composition and they involved in accidents about 41
percent cases.

Mahesh Chand & Anu P Alex (2002), in their Comparative Analysis
of Accident risk of states in India has made an attempt to form two indices,
viz. Accident Severity Index and Accident Risk Index by combining a set of
accident indicators. Analysis has been made with the ratio of population growth
and number of accidents occurred. It was found that bigger states like Madya
Pradesh fall in the category of high growth of vehicles as well as accidents.
Goa and Tamil Nadu were among first five states in all the ratios. But
Nagaland had the least value in all the ratios except in area based ratio.

Martin (2002), described the relationship between crash incidence
rates and hourly traffic volume and discussed the influence of traffic on crash
severity, based on observations made on 2000 km of French interurban motorways over 2 years. Incidence rates involving property damage-only crashes and injury-crashes are highest when traffic is lightest (under 400 vehicles/h). These incidence rates are at their lowest when traffic flows at a rate of 1000-1500 vehicles/h. For heavier traffic flows, crash incidence rates increase steadily as traffic increases on 2- and 3-lane motorways and inflect on 2-lane motorways when traffic increases to a level of 3000 vehicles/h. For an equivalent light traffic level, the number of crashes is higher on three-lane than on 2-lane motorways and higher at weekends (when truck traffic is restricted) than on weekdays. In heavy traffic, the number of crashes is higher on weekdays. No significant difference was found between the number of daytime and night-time crashes, whatever the traffic. No difference was observed in crash severity by number of lanes or period in the week for a given level of traffic. However, severity is greater at night and when hourly traffic is light. Compared to the number of vehicles on the road, light traffic is a safety problem in terms of frequency and severity and suggested to introduce road safety campaigns targeting motorway users to influence their behavior in these driving conditions.

Nishi Mital & Gangopadhyay (2011), has discussed poor people in low income countries are believed to be particularly at risk on road crashes. Road traffic injuries cost the poorest countries between 1% and 5% of their Gross National Product. At least 100,000 people are killed in road crashes every year. It has been concluded that in India, just like other Asian and African countries the non-motorised transport road users consisting of pedestrians, cyclists and other slow moving vehicle riders are the most vulnerable group in road traffic accidents and these are generally economically poor people. Strategies are to be provided to reduce the impacts of road crashes on the poor like adopting need based transport planning, road safety audits,
traffic calming, access control, traffic segregation, education and training, post crash and emergency medical services for the poor.

Padma et al. (2012), discussed the trend of road crashes and quantified the loss. In order to do that, the road crash data was collected from National Highway Authority of India (NHAI) for the selected high speed corridors for the last two years. The road crashes were modeled to predict road crash occurrence, as well as severity, using Binary Logit Model and Multinomial Logit Model. For this, the influencing parameters, such as road characteristics, geometry, weather conditions, etc., were considered. Sivanesan, C, & Sundararajan, R (2011), Modelled the road accidents for undivided two-lane highway segments with mixed traffic.

Simon P Washington et al. (2010), study was to provide defensible guidance on how to appropriately model crash data. The paper was motivated by the vast array of modelling choices, the lack of formal guidance for selecting appropriate statistical tools, and the peculiar nature of crash data, which has lead to lack of consensus among transportation safety modelers. Four main conclusions were drawn from this research. Crash data characterized by a preponderance of zeros is not indicative of an underlying dual-state process. One or more of four conditions lead to excess zeros in crash data: (1) sites with a combination of low exposure, high heterogeneity and sites categorized as high risk; (2) analysis conducted with small time or spatial scales; (3) data with a relatively high percentage of missing or misreported crashes; and (4) crash models with omitted important variables.

Yu-Chiun Chiou & Chiang Fu (2013), integrated an accident frequency model with a severity model under the MGP architecture, and used the integrated model to analyze accident data—count data (crash frequency) and ratio data (severity)—such that the MGP model is more efficient in evaluating and presenting accident data. Notably, according to
estimation results, the factors contributing to accident frequency and severity differ markedly. Generally, traffic related factors have larger effects on crash severity and frequency than geometric factors. Additionally, four models were developed and compared. This study adopted the shared error term to construct common error terms and co-variance structure so as to improve model explanatory capability and reliability. The estimation results show that the EMGP model performs best, as this model specifies the error component in the crash frequency and severity model by allowing different errors in crash frequency and severity. Thus, the estimation results show that the proposed covariance structure can further enhance the model performance. Based on the proposed framework, future studies can introduce more flexible models in the context of frequency modelling, such as Poisson log-normal, random parameters and other mixed distribution count models.

Abishai Polus & Moshe Cohen (2012), compared the prediction power of a simplified non-canonical Poisson crash prediction model to other model types. The model, fitted to serious and fatal crash data from 86 two-lane, low-volume rural highway segments, showed a good fit, which was not significantly different from that of a negative binomial model. The application of the present model uses the linear form of the non-canonical Poisson model. Hence the simplification of the model versus other models results from the finding that the expected number of crashes per 1 km is directly proportional to the daily volume, unlike logarithmic functions in other models. In the non-canonical model, it is necessary to estimate only one parameter, whereas estimations of more parameters are needed in the negative binomial model. Research focused on the following issues: (1) further check of the fit of a non-canonical Poisson model to actual data sets of crashes from other highways and/or different driver populations; (2) analysis of the fit of other models, such as a mix of linear and quadratic models; (3) further evaluation of
the relationship between highway geometry and alignment consistency and the number of crashes.

Gianluca Dell’Acqua & Francesa Russo (2005), illustrated road safety statistical models to predict injury accidents. The Italian analyzed roadways in the Salerno Province which were composed of multilane roadways for 242 kilometers and Major and Minor two-lane rural roads for 3,101 kilometers. Two accident prediction models were calibrated: one is associated with two-lane rural roads and the other with multilane roadways. Explanatory variables were used including traffic flow, lanewidth, vertical slope, curvature change rate, roadway segments length. Several procedures exist in the scientific literature to predict the number of accidents per kilometer per year, and a lot of relationships between accidents and explanatory variables exist based on the multiple-variable non-linear regression analysis. The accident data, presented in this manuscript, were analyzed using this procedure based on least squares method. The predicted values obtained by calibration procedure were then compared to several models presented in the scientific literature to analyze the residuals by using the t-test.

Kumara & Chin (2003), paper examines zero-inflated Poisson regression with site-specific random effects (REZIP) with comparison to random effect Poisson model and standard zero-inflated poison model. A practical and flexible procedure, using Bayesian inference with Markov Chain Monte Carlo algorithm and cross-validation predictive density techniques, is applied for model calibration and suitability assessment. Using crash data in Singapore (1998–2005), the illustrative results demonstrate that the REZIP model may significantly improve the model-fitting and predictive performance of crash prediction models. This improvement can contribute to traffic safety management and engineering practices such as countermeasure design and safety evaluation of traffic treatments.
Rui Garrido et al. (2014), have shown the factors which have consistently connected to an increased severity were: (1) aging; (2) driving while intoxicated; (3) head-on collisions; (4) crashes with heavy-vehicles and motorcycles; (5) poor lighting conditions; (6) vertical and horizontal curvature; (7) rural versus urban areas; and (8) speeding. In this study, the ordered probit model was used to examine the influence of a number of factors on the injury severity faced by motor-vehicle occupants involved in road accidents. The model estimation results suggested that some types of road accidents, namely the rollover-type, run-off-road, collisions against fixed objects and head-on collisions, appear to be the major contributors for the most severe injury level. Also, those who travel in a light vehicle, at a two-way road and on dry road surface tend to suffer more severe injuries than those who travel in a heavy-vehicle, at a one-way road, and on a wet road surface. In contrast, the driver’s seat is clearly the safest seating position, and urban areas, although presenting the highest accident occurrence frequency, are linked to decreased severity level. Also, women tend to be more likely to suffer serious or fatal injuries than men. Further replications of the ordered probit model to larger and more comprehensive samples, including exposure variables, such as traffic flow and speed at the time of accident, could be challenging.

Pachaivannan Partheeban et al. (2010), studied on road safety including the estimation of the number of probable accidents in the future. The average income growth rate, discount rate per annum, notional value of pain, grief and suffering, average consumption per month were assumed for the model formulation. The reason was due to the road safety measures which were followed very regressively. The fatal accident rates were decreasing gradually for the projected period. A computer program has been prepared in DYNAMO language for forecasting the accidents and their costs. In this model
the 2000 year data is used as basedata for formulation of model. The forecasting of accidents is done by a simulation (dynamo language) and this model can be used to estimate the probable number of accidents in the future. Cost of accident is an important parameter in the economic appraisal of transportation projects. Even though there are several methods of calculating the accident costs, the choice of a particular method primarily depends on the objectives of the intended project and largely on national objectives.

Shankar et al (1995), paper explores the frequency of occurrence of highway accidents on the basis of a multivariate analysis of roadway geometrics (e.g. horizontal and vertical alignments), weather, and other seasonal effects. Based on accident data collected in the field, a negative binomial model of overall accident frequencies is estimated along with models of the frequency of specific accident types. Interactions between weather and geometric variables are proposed as part of the model specifications. The results of the analysis uncover important determinants of accident frequency. By studying the relationship between weather and geometric elements, this paper offers insight into potential measures to counter the adverse effects of weather on highway sections with challenging geometrics.

Ziad Sawalha & Tarek Sayed (2003), discussed and illustrated the ways to deal with two statistical issues related to modelling accidents using Poisson and negative binomial regression. A total of 58 arterials in the cities of Vancouver and Richmond were investigated for the purpose of developing APMs relating the safety of urban arterial sections to their traffic and geometric characteristics. Geometric data were directly collected from the field. The development of the APMs for the urban arterial sections of Vancouver and Richmond was carried out using the GLIM4 statistical software package. The study therefore presents flowcharts detailing the application of the procedures in connection with negative binomial regression models. The procedures were
then applied in the development of accident prediction models for the urban arterials of the cities of Vancouver and Richmond in the province of British Columbia, Canada.

Yiyi Wang Kara & Kockelman (2012), proposed, calibrated, and applied a Poisson log-normal multivariate CAR model, which captures zone-specific heterogeneity, correlation across response types, and spatial dependence ascribed to the latent error term. The use of Thiessen polygons to aggregate area-level crash count data was recommended, rather than using the natural tract boundaries, to ensure that high-crash locations can be uniquely assigned to a polygon zone. Also this work’s results reinforced the importance of advocating walking in order to reduce crash rates, as reflected by the drastic decrease in crash rates as walk miles travelled increase. Providing walking facilities (such as sidewalks and other pedestrian paths) and greater local street intensity for all road users may also reduce crash rates, per walk-mile travelled, as suggested by the conspicuous elasticity estimates for sidewalk and local-street provision in the pedestrian crash model’s results.

Jianming Ma, Kara, et al. (2008), introduced an MVPLN approach to simultaneously model injury counts by severity. The MVPLN model estimated incorporates the safety effects of several roadway design and traffic features of interest to traffic and transportation engineers. However, several features of interest that are not available have been omitted from the model, including, for example, driveway density and sight distance. In addition, the model generally treats the effects of individual geometric design features as independent of one another and ignores potential interactions among them. Such interactions may exist (such as combinations of horizontal and vertical curvature on the same segment), and these should be examined in the future endeavors of this type.

Dominique Lord (2010), provided a review of contemporary thinking in the crash frequency-analysis field and shown how methodological
approaches have evolved over the years to address this problem. To do this, it has been first discussed the fundamental data and methodological issues associated with the analysis of crash frequencies. Then did a critical assessment of the strengths and weaknesses of the various methodological approaches that have been used to analyze crash-frequency data, and concluded that crash data (from vehicle black boxes) holds considerable promise for the future development of the field. When these data become available to the full research community, an entirely new direction of research could potentially open up – one that would provide exciting new insights into fundamental cause and effect relationships as they relate to motor vehicle crash frequencies.

Srinivas Reddy Geedipally (2008), introduced a new statistical model for analyzing traffic crashes - a model that develops a relationship between traffic crashes and factors associated with their occurrence such as traffic flow, geometric design of road sections, horizontal curvature, vertical grade, lane width, and shoulder width among others. Traffic crashes cause significant economic and social costs. The economic cost of road crashes and injuries is estimated to be 1% of gross national product (GNP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries (World Health Organization, 2004). It was found that the risk of a misestimate posterior mean caused by LSM and SSS can be greatly minimized when an appropriate non-vague prior distribution is used for NB models. A similar analysis comparing the influence of informative and non-informative prior can be done for COM-Poisson models.

Zahid, H., Qureshi (2007), provided a review of key traditional accident modelling approaches and their limitations, and described new system-theoretic approaches to the modelling and analysis of accidents in safety-critical systems. This paper also discusses the application of formal methods to accident modelling and organizational theories on safety and
accident analysis and organized as follows: the traditional accident models; the issues and complexities of socio-technical systems were delineated; systematic accident modelling approach and models were described; a brief review of the application of formal methods to accident modelling; sociological and organizational theories and research on accident analysis; and finally, summarized the work on accident modelling and discussed future research trends.

Xuedong Yan et al. (2012), to understand the role of rural or urban settings in segment safety, the crash rate, crash frequencies, and the injury and fatality frequencies were taken into consideration to distinguish between rural and urban traffic safety. The GIS-based crash data during four and a half years in Pikes Peak Area, USA were applied for analysis. The GIS techniques for traffic data process have been proved effective to analyze and visualize crash data and have advantages in data display, clear presentation of spatial relationship, and convenient query of relevant data and discussed the suitability of various models in the prediction of crash frequencies, adopted zero-inflated negative binomial _ZINB_ regression models for crash frequency analysis and prediction, because zero-crash segments account for more than 40% of the total data in this study.

Lu Ma et al. (2014), considered two levels of severity, namely, fatal-injury accidents and property-damage-only accidents. The distributions of accident counts by each level of severity were presented. Moreover several explanatory variables such as intersection density of road segments, urban/rural location, and ownership were considered in the analysis. The basic descriptive statistics for explanatory variables and the exposure variable is an important first step towards comprehensive risk analysis of traffic accidents. In addition, there were several important avenues for further research. First, the regression models for the accident risks as a whole was found such that the relationship
between different types of accidents can be considered. Second, the nature of excessive zero count of accidents was taken into account in the model as an important supplement for the traditional quasi-likelihood models.

Parida et al. (2012), identified the most critical safety influencing variables of a section of four – lane NH – 58 through mathematical models that explain the relationship between crash counts and highway safety influencing variables. After conducting preliminary survey, data has been modulated for model development and validation. Analysis of models has been done by Poission - gamma or negative binomial regression technique. The most influencing safety parameters were road marking, traffic volume, condition of shoulder and average spot speed and concluded that crashes can be reduced on a section of four lane highway through effective monitoring of above influential parameters in order of significance.

MandarKhanal & Sarkar (2012), have discussed about safety on Indian Roads. About 12 lakhs people died in road accidents in the world and in which 90% are from developing countries. Pedestrians constituted the highest category of road users that were killed. To reduce accident OECD measures were taken in which speed management, reduced drunken driving, seatbelt use, enhanced vehicle safety, reduced young driver risks are recommended.

PratapRaizada & Prakash Tikare (2012), analysed the risk mitigation measures to be adopted during road construction. The root cause of accidents could throw up the combination of factors which drove the situation out of human control; the user should have been aware of the risks in various scenarios and should have operated within limits where the consequences of human error would not be as disastrous. Hence, designer should make efforts to design each road according to its function and context, such that the design influences the user to comply with applicable traffic restrictions. For example, the design should make the driver expect the need to be more alert and to
maintain low speed in urban areas where pedestrian density and related facilities are higher.

Wilmot & Khanal (1999), paper draws on the results of studies conducted around the world on the effect of speed limits on speed and safety. It is observed that, generally, motorists do not adhere to speed limits but instead choose speeds they perceive as acceptably safe. Perceptions of safety are influenced by the environment in which travel takes place such as whether the road is a controlled access facility, the nature of adjoining land use, the geometry of the road and existing weather conditions. The relationship between speed and safety is influenced by factors such as the type of road, driver age and vehicle safety devices. Research shows that speed cannot be linked statistically to the incidence of accidents, although it is statistically significant in accident severity. If speed limits are increased only on controlled-access facilities, while retaining lower speed limits on other facilities, system-wide safety may not be adversely affected. The main benefits of increasing speed limits seem to be in improving their credibility with the public and regaining control of speed behaviour on highways.

Zegeer et al. (1988), based on data for two-lane of 5,000 miles of 7 states in the U.S., developed an accident model with subordinate variable of accident rates by accident types and independent variables of the whole width of shoulder, the width of lane, road vertical alignment and average daily traffic volume. The result showed that accident rate was decreasing with smooth vertical alignment, less average daily traffic, width of lane and use of whole shoulder.

Hadi & Jaradat (1998), developed an accident model by road-grade for Florida State using the independent variables such as road length, annual average daily traffic, the width of lane and shoulder, the types and width of median barrier, existence of curve, speed limit, grade and the number of
intersections. The results showed that widening of the width of median barrier on the four–lane roads enhanced safety and roads with two-way and left-turn median barrier were safer than non-separation roads.

Fitzpatrick (2000), applied the geometric structure variables such as the width of lane, existence of median barrier, curve radius, deflection angle, so on and examined the relations with accidents. Particularly, in road section of unlike width of lane has been shown an important variable through the model. Bonneson et.al (2001), developed accident prediction model according to each condition by distinguishing separation and non-separation of left–turn lane separating roads away from median separation facilities. As a result, they proposed that accidents were affected by annual average daily traffic, length of roads, density of land use and so on.

Dinu & Veeraragavan (2011), attempted to employ random parameter modeling for accident prediction on two-lane undivided rural highways in India. Three years of accident history, from nearly 200 km of highway segments was used to calibrate and validate the models. The results of the analysis suggest that the model coefficients for traffic volume, proportion of cars, motorized two-wheelers and trucks in traffic and driveway density and horizontal and vertical curvatures were randomly distributed across locations.

Michael J Maher & Ian Summersgill (1996), described the form of the TRL studies, the model-fitting procedures used and given examples of the models which have been developed and described various technical problems which needed to be addressed in order to ensure that the application of GLMs would produce robust and reliable results.
2.4 SUMMARY

Many researchers have carried out research work in the area of road accidents. Some of them have analyzed accident data in different ways. Some of them have developed accident models for forecasting accident trends. They have also proposed strategies for road safety. Considerable progress has been made in recent years in techniques for establishing the relationship between accidents, flows and geometry. Research workers in India unanimously agree that road crashes increase with increase in vehicle population, population density and road length. From studies conducted abroad researchers found no safety benefit in lane widening beyond 3.5 meters in urban road segments. Prohibition of on street parking is beneficial in reducing crashes on urban roads.

Crash prediction models are useful tools for identifying the crash prone locations and crash causative factors, but they are deficient for safety evaluation or selection of a best alternative out of many proposals for safety treatment of a facility. Crash Modification Factor is the latest concept in road safety evaluation and it is a constant or an equation that represents the change in crash frequency following a change in the design or operation of a facility. Researchers unanimously agree that research results should not be directly transferred across application sites that have different traffic, environmental, design, enforcement measures and different crash investigation practices.