ACCIDENT INFORMATION SYSTEM FOR A STRETCH OF NATIONAL HIGHWAY

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF TECHNOLOGY

in

CIVIL ENGINEERING

(With Specialization in Transportation Engineering)

By

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CANDIDATE'S DECLARATION

I hereby certify that the work presented in this work which is being presented in dissertation report entitled **"ACCIDENT INFORMATION SYSTEM FOR A STRETCH OF NATIONAL HIGHWAY ",** in partial fulfillment of the requirements for the award of the Degree of Master of Technology in **Civil Engineering** with specialization in **Transportation Engineering,** submitted to the Department of Civil Engineering, Indian Institute of Technology Roorkee, , is an authentic record of my own work carried out from July, 2011 to June, 2012 under the guidance of **Dr. M. Parida,** Transportation Engineering Group, Department of Civil Engineering, Indian Institute of Technology Roorkee and **Dr. S. S. Jain,** Transportation Engineering Group, Department of Civil Engineering, Indian Institute of Technology Roorkee, India.

The matter presented in this dissertation report has not been submitted by me for the award of any other degree or diploma.

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CERTIFICATE

This is to certify that the above statement made by the candidate is true to the best of our knowledge.

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ABSTRACT

In India rapid development and expansion of the road network and the increase in number of motor vehicles have led to a substantial rise in levels of both passenger and freight movement. Concomitantly safety related issues have emerged. The number of road accidents and fatalities has been growing in recent years .The increasing rate of accidents on roads add a question mark on safety of highways. So to manage them is of vital importance. For management first and foremost is we should be able to measure it. Every year nearly 1, 30,000 persons are report killed and more than 5, 00,000 are injured on Indian roads. An accident takes place every 1.5 minutes and in every 6.2 minutes a person in road accidents. The national highways constitute only 2% of the total road network but carry 40% of the traffic and accounts for 25%of road accidents, out of which 34% lead to fatalities and 28% to injuries.

Accident information system is defined as a process of developing an accident database, identifying accident prone locations and evolving corrective measures.

Accident black spot is a location, whether link or node, on a highway where accidents repeatedly occur or a large number of accidents occur over a period of time. In this thesis report a methodology for identification of accident spots on a highway by using GIS software has been presented.

The transportation community has begun to identify the necessity of development of comprehensive performance measure for traffic safety. From last decade significant research has been going on. Most of studies done in previous years include any one of the dimensions (e.g. fatality rate). Through an Accident Information System, multiple parameters can be handled easily.

Keywords: Accident information system, GIS software.

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CHAPTER 1
INTRODUCTION

1.1 General

Road safety is an important issue in most countries. It involves large numbers of people, vehicles, and road sections, and as such, is a complex issue to understand and manage. The alarming growth of causalities and damage to vehicles in road accidents since the recent past, coupled with gigantic vehicle growth all over world have created complex problems of ensuring traffic safety on roads. Thus the aspect of traffic safety on roads has been attracting a lot of attention in all countries of the world and the importance of preventing road accidents will rapidly grow in near future.

Various studies on road accidents indicate that prevention of road accidents mainly involves in conscious planning, design and operations of roads. One of the most important factors in this method is the systematic identification and treatment of hazardous locations or the accident black spots. In general, the various factors that cause accidents can be broadly categorized into road related, vehicle related and driver related.

1.2 Global Scenario of Accidents

Around 10, 00,000 persons are killed on the roads annually throughout the world and those injured are many fold. Developing countries are having huge fatality rate in comparison to the developed countries. Many countries are experiencing an annual vehicle growth rate of around 17%.Examples are India (17%), china (18%), Vietnam (18%) and Malaysia (15%) . the number of deaths and injuries has been reducing steadily in the developed countries where as the number of deaths in Asian countries is rising at alarming rates. During 1981-1993, the number of road accidents deaths has increased in Asia Pacific region by 95% where as total population has increased only by 24%.

1.3 Accident Scenario in India

In India, every year more than 1, 30,000 persons are injured on the Indian roads. An accident takes place every 2 minutes and a person killed every 6 minutes on Indian roads. This number keeps on increasing. This increase in accidents is coincident with the increase in vehicle population. More than ten million road accidents have taken place on Indian roads after motor vehicles came to India and almost 1.8 million people have lost their lives and many more have suffered injuries. The Indian share in world vehicle population is not even 1% but in case of road accidents it has more than 10% share, while the motorization level is second lowest of the world. Road accidents and casualties are increasing at an alarming rate day by day. Road accidents in India for years 1970-2011 are shown in Table 1.1.

1.4 Need of the Study

It can be easily inferred from the above stated statistics that there is an alarming situation of accidents occurring on the roads. And there is an urgent need of an efficient and effective crash data analysis system for clear understanding of the characteristics and causes of traffic accidents. Considering the complexities in developing, updating and processing the crash data, there is an urgent need to adopt new concepts in information technology. With powerful functionality in spatial referencing, data management and visualization Geographic Information Systems (GIS) provides a natural platform for such a work.

1.5 Objectives of Study

The objectives of the study are as follows.

- To prepare a database of crashes based on the accident data available from the police stations on National Highways No. 58 (from Km 75 to Km 138) for the last 5 years (2007-2011).
- To plot Km- wise crash data on National Highways No. 58 (from Km 75 to Km 138) for the last 5 years (2007-2011).
- Analysis of the crash data in various forms through GIS.
- To identify the various accident black spots in GIS environment.
- To evolve remedial measures for the identified accident black spots /High crash locations/hazardous locations.

TABLE-1.1 Road Accidents in India, 1970-2011

Year	Road Accidents (In thousands)	Persons Killed (In thousands)	Persons Injured (In thousands)
1970	114.1	14.5	70.1
1971	120.2	15	70.7
1972	122.3	16.1	76.4
1973	121.6	17.6	79.3
1974	114.3	17.3	76.7
1975	116.8	16.9	77
1976	124.7	17.8	82.5
1977	135.4	20.1	95.6
1978	146.3	21.8	99.5
1979	144.4	22.6	102.9
1980	153.2	24.6	109.1
1981	161.2	28.4	114
1982	166.2	30.7	126
1983	177	32.8	134.1
1984	195	35.1	156.2
1985	207	39.2	163.4
1986	215.5	40	176.4
1987	234	44.4	189
1988	246.7	46.6	214.8
1989	270	50.7	229.7
1990	282.6	54.1	244.1
1991	293.4	56.4	255
1992	260.3	57.2	267.2
1993	280.1	60.7	287.8
1994	320.4	64	311.5
1995	348.9	70.6	323.2
1996	371.2	74.6	369.5
1997	373.7	77	378.4
1998	385	79.9	390.7
1999	386.4	82	375
2000	391.4	78.9	399.3
2001	405.6	80.9	405.2
2002	407.5	84.7	408.7
2003	406.7	86	435.1
2004	429.8	92.5	464.6
2005	434.6	98.2	475.6
2006	442.7	105.7	504.1
2007	453.8	114.5	518.7
2008	476.3	118.2	540.8
2009	489.5	124.5	562.2
2010	501.5	130.2	583.7
2011 (p)	518.9	135.4	598.4

1.6 Scope of the Study

In this study, the scope of work is to develop accident information system using GIS and identifies the various accident black spots on National Highways No.58 (from Km 75 to Km 138). The crash data analysis has been done based on the available accident data obtained from the police stations of sections of National Highways No.58 (from Km 75 to Km 138), the Accident Black Spots have been identified using critical crash rate factor method and mainly to developed Accident information System for the accident locations. All the above work has been done in GIS environment. And for some of the accident black spots, generalized remedial measures have been suggested.

1.7 Applications of Accident information system

- Evaluation of changes in overall traffic safety performance.
- Benchmarking road safety performance of countries.
- Better traffic accident investigation procedure (e.g. Accident site measurements, reconstruction).
- Adherence to the official Traffic Accident Investigation Report (TAIR) from creation of an integrated traffic accident database system.
- Geo-referencing of accident occurrences.
- Utilization of available cost-effective technologies (e.g. Geographic Information System, Global positioning System).
- Utilization of client/server network architecture for better information delivery, and
- Training and education of traffic accident investigators in the field of accident investigation and reconstruction.
- A better understanding of the factors associated with crashes which facilitate the identification of suitable countermeasures that could further reduce the occurrence of crashes.
- Applications include trend identification, problem prediction, target and priority setting and impact assessment of measure.

1.8 Composition of the Thesis

The present report has been divided into six chapters. The first Chapter introduces the problem and brings out the global and Indian scenario of accidents. And also the scope and objective of the present study have been discussed. Second chapter contains literature review in which techniques adopted for Accident Information System and identifying accident black spots have been discussed. Third Chapter deals with the methodology adopted for Accident Information System using GIS. Fourth Chapter illustrates the data collection. Fifth Chapter contains the data analysis and results and finally the sixth chapter presents the conclusions drawn from the present study and recommendations for the future work.

CHAPTER 2
LITERATURE REVIEW

2.1 General

GIS-based accident information systems can identify relationships between spatial phenomena that are almost impossible to determine with a non-spatial database. Since 1990, there have been many studies about GIS technologies and its applications on traffic safety and accident analysis as a spatial pattern. Many agencies and researchers have reported the use of GIS analysis of accidents. The types of analyses, applicable for accident analysis, include intersection analysis, segment analysis, cluster analysis, density analysis, pattern analysis, proximity analysis, spatial query analysis and spatial accident analysis modeling techniques.

2.2 Works done in Abroad

Tiglaco et al. (1978) presented traffic safety plays as key and integral role in a sustainable transportation development strategy. The main negative impact of modern road transportation systems today is injury and loss of life as a result of road accidents. The success of traffic safety and highway improvement programs hinges on the analysis of accurate and reliable traffic accident data. This study discuses the present state of traffic accident information in Metro manila. It shall also discuss the potentials of developing a traffic accidents information system using geographic information system (GIS). Initial attempts on the integration of geo-referenced traffic accidents data for spatial analysis shall be discussed. Lastly, this paper comes up with some recommendations on the institutionalization of such a system line Metro Manila.

Foldvary (1979) and **Jovanis and Delleur (1983)** have used simple models using mean and variance. These models are used to study variations in accident rates for different levels of exposure. These models are not able to incorporate the effect of risk factors on accident involvement.

Thill et al. (1980) at late 1980s saw the first widespread use of Geographic Information Systems (GIS) in transportation research and management. Due to the specific requirements of transportation applications and of the rather late adoption of this information technology in transportation, research has been directed toward enhancing existing GIS approaches to enable the full range of capabilities needed in transportation research and management. This paper places the concept of transportation GIS in the broader perspective of research in GIS and Geographic Information Science. The emphasis is placed on the requirements specific of the transportation domain of application of this emerging information technology as well as on core research challenges.

Simkowtiz et al. (1988) to explain why GIS technology is important to transportation professionals, describe how a number of transportation agencies are using GE9 and provide insight on how to participate in this technology. Transportation agencies are still in their infancy with respect to exploiting the power and possibilities offered by GIS technology. The paper examines the usefulness of spatially integrated data to transportation and clarities the distinction between GIS and other data base systems that use spatial data. The benefits of GIS are summarized, examples of GIS activities at the FHWA rend State highway agencies are described, and sources of digital geo coded data are discussed. The paper concludes with a more detailed discussion of hardware and software requirements, topology, overlay processing, and special issues involved in designing a GIS for transportation .This paper has attempted to explain GIS from the point of view of the needs of the transportation professional. There is no shortage of opportunities to apply GIS technology to transportation problem solving. As computer hardware continues to become less expensive and more powerful, and as the software continues to grow more sophisticated, cost-effective GIS-based solutions to traditional transportation problems will become more and more common with the transportation community.

Jovanis and **Chang (1989)** have used survival theory models. These models predict the probability of a vehicle being involved in an accident at time t given that the vehicle had survived until that time. Since the use of these models requires specifically collected data, this approach has not been widely adopted by other researchers in this field.

Baguely et al. (1991) presented the accident investigation and treatment framework developed for the Serem ban and Shah Alam Pilot Project. Accident data are based on the revised police accident form P0L27(Pin 1/91) specially designed to enable processing and analysis to be carried out using a customized microcomputer accident analysis package, MAAP. A hazardous location identification and prioritizing system based on accident maps, link-node-cell and grid coordinates was developed for urban areas while a kilometer post system was proposed for highways in rural areas. In -depth analyses on selected black spots are discussed and appropriate countermeasures proposed. An accident diagnosis system and black spots prioritizing system have been developed and tested for diagnosing accident, problems in the pilot project-areas .The new accident form, POL27 (Pin 1/91) has been redesigned and is now in use nationwide (since January 1992).The computer analysis system developed enables a thorough analysis not only on a macro scale but also on specific black spots. A hazardous location identification system based on accident maps, ink-node-cell system and coordinates has been recommended in the urban areas, with a kilometer post system for the rural highways. In-depth analyses of black spots can be produced by means of stick and collision diagrams.

Waters et al. (1992) it's presented a historical overview of the development of GIS-T together with a description of its main characteristics. Sources of data and software together with common applications of GIS-T in various levels of government have been described. A discussion of special topics within the broader field of GIS-T and a description of current and future research topics have concluded the account of this most exciting and useful field of GIS Endeavour. Although this chapter has shown that GIS-T has been part of the mainstream of GIS applications for a number of years it has yet to become part of the orthodoxy in transportation geography. Indeed, some of the most recent texts have completely ignored GIS-T (Hoyle and Knowles 1992; Simon 1996; Tolley and Turton 1995) while others, despite acknowledging the 'remarkable growth' and 'enormous promise' of GIS in transport geography, have made only token reference to this new technology (Taaffe et al 1996:400). One exception has been the second edition of Hanson (1995) which devoted a whole new chapter to GIS-T (Nyerges 1995). In the future it is unlikely that any new transportation geography text will be able to ignore the overwhelming impact of GIS-T on the sub-discipline.

Saccomanno et al. (1992) developed A GIS-based accident risk model for the Ontario highway network. The model provides estimates of accident risk at four levels of spatial aggregation as specified by the user: network wide, route-specific, route-section-specific and site-specific. The basic structure of the model has been described, with emphasis on its data base management and spatial referencing systems. The model makes use of ARC/ INFO software for application in a PC environment. The results of this study, though preliminary, underscore the usefulness of a GIS platform in road accident risk modeling. A number of sources of error were noted and accounted for in merging databases from different sources for input into GIS. The efficacy of the GIS/ARM model in assessing risk reduction measures and policies was demonstrated by applying the model to a simple problem of black spot identification along a given stretch of highway.

Shankar et al. (1995) Traffic safety studies explore the effect of various factors on safety performance, either qualitatively or quantitatively, such as the influence of various geometric features of road design, weather conditions, lighting factors or geographical conditions on accident occurrences.

Sayed et al. (1996) developed a method to identify accident-prone locations (APLs) based on an assessment of factors that contribute to accidents. Current methods to identify APLs make no distinction between accidents that result from road and non road-related factors. Combining accidents that are treatable and non treatable by road improvements can be misleading and may lead to a misallocation of funds by road authorities. And presented a computerized procedure that uses safety experts' knowledge on classifying accidents into a finite set of categories. In practice, the categories can include anyone or a combination of the three basic highway system components: the driver, the vehicle, and the road environment. Realizing the complex interaction of these components within the accident environment, the procedure employs fuzzy pattern recognition techniques for the classification process. Accidents that do not belong to the road environment category are excluded from the identification of APLs. Current methods to identify accident-prone locations do not account for causes of accidents. This paper described an algorithm to identify accident-prone locations, based on an assessment of accident contributing factors (causes). The algorithm uses fuzzy pattern recognition techniques to assess the degree to which each accident belongs to the three highway system components: the driver, the vehicle, and the road environment. The output of the algorithm is the degree of membership of each accident in the three highway system components. The algorithm was applied to three sets of data. Each of them containing 300 accidents. The results indicated that the algorithm can effectively classify accidents into a finite set of categories. The algorithm output can be used to calculate Various accident measures that correspond with the three highway system components.

Jones et al. (1996) several studies have been conducted to establish spatial patterns in vehicle or pedestrian accidents for the identification of critical locations. **Thomas et al. (1996)** carried out a study for hot zones using spatial autocorrelation and kernel methods on road segments.

Affum and Taylor (1997) described the development of a Safety Evaluation Method for Local Area Traffic Management (SELATM), which is a GIS-based program for analyzing accident patterns over time and for the evaluation of the safety benefits of Land Area Traffic Management schemes.

Kirchsteiger et al. (2000) the paper discusses the use of modern information technologies, and in particular geographic information systems GIS .In the management and control of major accident risk. For this purpose, the regulatory framework of the recent ASeveso IIB Directive is briefly described. This asks for more transparent procedures and decision-making, and requires consultation of the public in land-use and off site emergency planning. Correspondingly, new demands are put to support tools being developed. The main features of tools dealing with hazard sources mapping, risk assessment, risk management, and emergency planning are discussed. it is argued that, if appropriately designed, their use can enhance the dialog between plant operators, authorities and the public to facilitate a consensus on risk issues. Finally, limitations in the use of these tools and prospects for future developments are discussed.

Hirasawa and Asano (2003) at Civil Engineering Research Institute developed a traffic accident analysis system for Hokkaido, Japan. This system manages accident data, road structure and road accessory facilities using GIS technology. It allows for the analysis of accident frequencies, accident rates and seasonal effects on accidents.

Rytkonen et al. (2004) developed an emerged as an innovative and important component of many projects in public health and epidemiology. One of the most useful functions of GIS in epidemiology continues to be its utility in basic mapping. GIS may also involve more sophisticated spatial analysis of disease occurrence and contributing environmental factors. Depending on the quantity and quality of data and the methodology used in analysis, a given map may be either useful or misleading. Although visual analyses (mapped evidence) strengthened by exploratory analyses are mostly sufficient for epidemiologists, the formal testing of certain hypotheses or the estimation of relationships between measures of disease incidence.

Gartner et al. (2004) presented an accident research forms the basis for planners to take measures in the general area of transportation plan and of course in its special area of road safety planning. The spatial representation of accident research results is often inevitable for planning decisions because important connections and interactions of planning activities are mostly clarified in the spatial visualization. GIS systems represent an integral part of processing spatial distributed data .Within this work it shall be shown how a highly specialized GIS system can be made accessible to a broader, for the first step primarily planning, public. As communication platform the internet will be used. Via that platform the accident data (accident accumulation spots) from the Austrian road safety board will be published in real time from the internal specialized GIS system to an online information system.

Kim and Yamashita (2004), Levine et al. (1995) analyzed spatial patterns of pedestrian crashes in Honolulu, Hawaii using K-means clustering techniques. These spatial patterns show areas of high pedestrian crashes which have been explained in light of various demographic characteristics.

Liang et al. (2005) developed a traffic accident analysis system using GIS at the University of Putra in Malaysia. Using this system, the user can identify high accident locations, obtain the accident location's ranking, visualize the road accident and location information, input and retrieve the accident database, perform statistical analysis on the selected accident location and So on within a short period of time.

Durduran et al. (2007) presented the prediction of traffic accidents is one of most important issues in our life. In the prediction of traffic accidents, a GIS platform to extract the important features including day, temperature, humidity, weather conditions, and month of occurred traffic accidents has been used. In this study, a decision making system (DMS) based on correlation-based feature selection and classifier algorithms including support vector machine (SVM) and artificial neural network (ANN) has been proposed to predict the traffic accidents identifying risk factors connected to the environmental (climatologically) conditions, which are associated with motor vehicles accidents on the Konya–Afyonkarahisar highway with the aid of geographical information systems (GIS). Locations of the motor vehicle accidents are determined by the dynamic segmentation process in Arc GIS 9.0 from the traffic accident reports recorded by District Traffic Agency. In this DMS, firstly the number of dimension of traffic accidents dataset with five features (ay, temperature, humidity, weather conditions, and month of occurred traffic accidents) has been reduced from 5 to 1 feature by using correlation-based feature selection (CFS). In CFS method, the correlation coefficients between five features and outputs (the cases of without accident or with accident) has been calculated and chosen the feature that has highest correlation coefficient. Secondly, the traffic accident cases with one feature have been classified as without accident or with accident using SVM and ANN models. The proposed DMS has obtained the prediction accuracy of 61.79% with ANN classifier and achieved the prediction accuracy of 67.42% using SVM with RBF (radial basis function) kernel. These results have indicated that the proposed DMS could be used on prediction of real traffic accidents.

Saleh et al. (2010) we conclude this work with two general recommendations: (1) that more fundamental research and cross-talk across several academic disciplines must be supported and incentivized for tackling the multi-disciplinary issues of accident causation and system safety (e.g., through the creation ''academic hubs'' or ''centers of excellence'' dedicated to system safety); and (2) that more interactions and partnerships between academia, industry, and government (especially accident investigation agencies) on accident causation and system safety issues would be particularly useful for all involved in advancing the safety agenda, from both research and education perspectives, and for disseminating research results, safety recommendations, and lessons learned from accident investigations. We provided a brief overview of contemporary themes and thoughts on system safety and accident causation. We highlighted and critically assessed the key contributions to systems safety thinking from various disciplines and showed how they have evolved over the last few decades. Our main purpose in writing this work was to provide the reader who may be interested in but not familiar with the body of work on system safety and accident causation a short guide to this broad but fragmented literature and its main themes.

Polat & Durduran et al. (2011) presented the discrimination of traffic accidents as accident free and accident cases on Konya Afyonkarahisar highway in Turkey using the proposed hybrid method based on combining of a new data pre-processing method called subtractive clustering attribute weighting (SCAW) and classifier algorithms with the help of Geographical Information System (GIS) technology has been conducted. In order to improve the discrimination of classifier algorithms including artificial neural network (ANN),adaptive network based fuzzy inference system (ANFIS), support vector machine, and decision tree, using data pre-processing need in solution of these kinds of problems (traffic accident case study). So, we have proposed a novel data pre-processing method called subtractive clustering attribute weighting (SCAW) and combined with classifier algorithms. In this study, the experimental data has been obtained by means of using GIS. The obtained GIS attributes are day, temperature, humidity, weather conditions, and month of occurred accident. To evaluate the performance of the proposed hybrid method, the classification accuracy, sensitivity and specificity values have been used. The experimental obtained results are 53.93%, 52.25%, and 38.76% classification successes using alone ANN, ANFIS, and SVM with RBF kernel type, respectively. As for the proposed hybrid method, the classification accuracies of 67.98%, 70.22%, and 61.24% have been obtained using the combination of SCAW with ANN, the combination of SCAW with SVM (radial basis function (RBF) kernel type), and the combination of SCAW with ANFIS, respectively .The proposed SCAW method with the combination of classifier algorithms has been achieved the very promising results in the discrimination of traffic accidents.

2.3 Work done in India

Bayapureddy et al. (1981) the purpose of the paper is to show how to use various modules of Arc Info to perform operations such as fixed segment analysis, floating segment (sliding) analysis and spot analysis for identification of high accident locations. A prototype GIS system was developed for the purpose. the user can merge accident and roadway data, match the accident data and locations, analyze the data using fixed segment, sliding and spot analysis, calculate frequency and rate of accidents, select a variable for stratification to calculate mean and standard deviation of accident rates and frequencies and sort the sections based on selected criteria.

2.4 GIS Applications in Display and Analysis of Crash Data

2.4.1 Traffic Accident Records

Responding to an ever increasing demand for data and analytical capabilities, the County of Riverside, California, has developed the system Based Accident Records System (GIS BARS) over a two year period. The geographic information system-based Accident Records System (GIS BARS) Grant project's overall project objective was to develop and implement efficient, county-wide, GIS-based accident records system that will provide surveillance and identification of significant accident locations through the use of sophisticated display modeling, and analysis tools through the integration of diverse engineering information on the GIS.

The system helps to identify high accident rates for locations including intersections and roadway segments for deployment of Federal, State, county, and city resources to do the following within one year after the three-year project:

- To lower the county fatality frequency
- To lower the county injury frequency.
- To lower the county fatality rate per 100,000 population to that rate of the entire state, or lower.
- To lower the county injury rate per 100,000 population to that rate of the entire state, or lower.

The project was functionally categorized into three primary application groups- the data management module, user application module, and query modules. The data management module consists of two sub-menu groups:

- Collision Manager and
- Volume Manager.

Collision manager provides privileged user access to maintenance and development programs for collision info. All modifications, upgrades, new feature development and maintenance functions were conducted in this directory structure to insure system security and avoid the convergence of prototype and functional application releases. Volume manager focuses on data entry and editing functionality and also provides a secure directory structure for project and prototype development. Each of these two modules contains suites of customized tools for automated data conversion, interactive data input applications, a menu driven query and reporting applications, and links to programs contained in both user application and query modules.

The user application module currently contains 'Collision Info'. Collision Info is the foremost project application, providing accident query data, mapping and reporting to the end user. Collision Info provides both standard and customized reporting capabilities and is the first menu driven application to successfully handle an accident database of this size without lengthy delays. Collision Info uses the entire data set as the default set. In this manner county wide surveys and queries are available to the user without requiring programming assistance. Reselection sets are defined by location, date, type of collision etc. or by graphic selection.

Query Modules allow system users to select specific records in databases which are significant to traffic accident investigation. The Query Module provides links to include data such as number of lanes, pavement width, pavement management and Federal functional classifications from the pavement management database; Traffic control devices, through a link to the traffic control device inventory and reselected information on roadway volume. The pavement management and traffic control device inventory databases were not converted into spatial databases as they extend beyond the primary focus of the grant.

2.4.2 Development of Traffic Accident Information System Using Geographical Information System

Noriel Christopher C.Tiglaco from University of the Philippines developed a traffic information system using GIS in her research work in Philippines which reveals the need of an integrated traffic accident information system to be adopted by the government in order to delineate and relegate certain functions which are integral to the overall system.

In this proposed system, several remote sites shall be connected in a wide area network (WAN). A cost-effective network connection can be established using dial-up network protocols. Remote sites include the five traffic management districts in Metro Manila and PNCC for the North and South Expressway data. Fig. 2.1 shows that network configuration for the proposed traffic accident information system.

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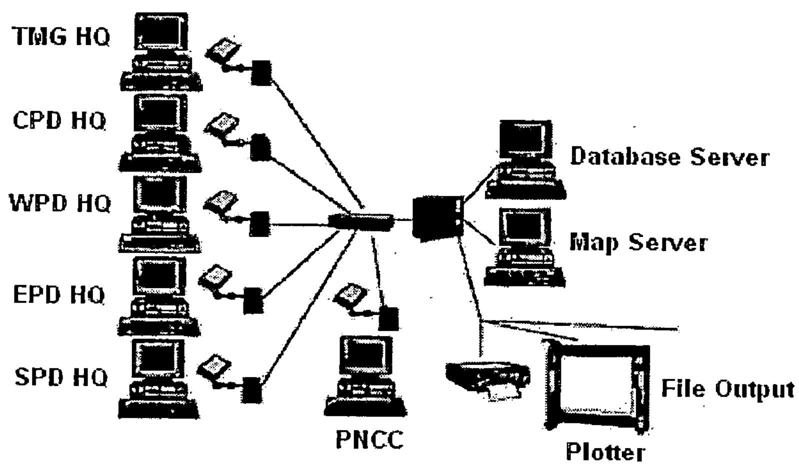

Fig. 2.1 Network Configuration

A central site shall maintain the database and map server. The central site shall also be equipped with plotting and external storage devices for achieving purposes. In such a system, information from the traffic accident investigation report forms is directly encoded via an interface program. The application shall be constructed under client/server Architecture as shown in Fig. 2.2. Reporting police stations shall only need to forward their reports to the district office for proper processing and input. Thus, accident reports can be updated on a daily or weekly basis to prevent backlog. The system shall also update the master database at the central site. The central site, on the other hand, shall prepare 'Accident Black Spots' and data processing and report preparation for the whole coverage area.

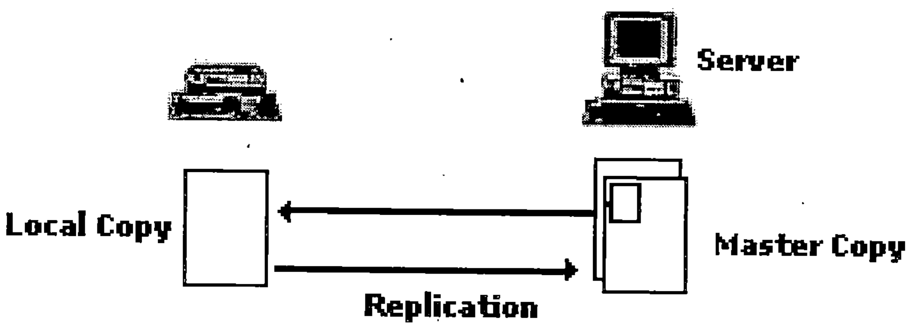

Fig. 2.2 Client/server Applications Architecture

2.4.3 Display and Analysis of Crash Data Using GIS

University Transportation Center for Alabama carried out a research project on Tuscaloosa area that describes the development and testing of a new geographic information system (GIS) application for the display and analysis of department of public safety (DPS) crash data stored in the critical analysis reporting environment (CARE) system. The primary objective of this study was to map crashes and correlate them with existing roadway features like bridges, crossroads, railroad grade crossings, etc. This application was developed to enable crash data to be presented graphically on maps, which is not currently possible in CARE alone. Digitizing the all the features like lanes, accidents.etc in the Tuscaloosa downtown area with the help of GIS software. It is shown in Fig.2.3.

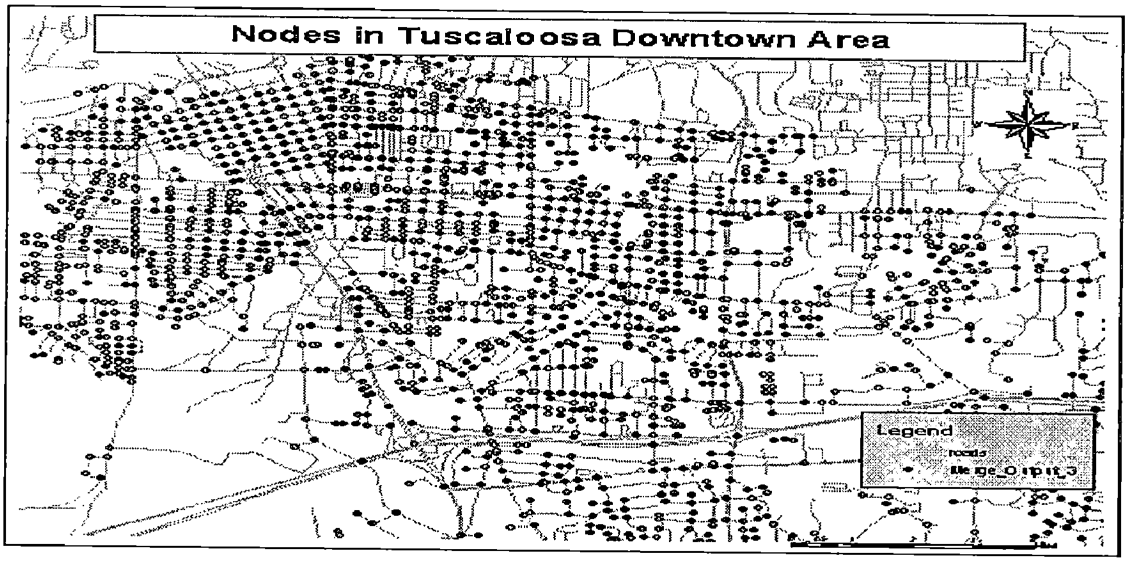

Fig. 2.3 Map Showing Nodes Digitized in the Tuscaloosa Downtown Area

The application utilizes the advantages of both CARE and GIS software. Reports can be created in CARE for detailed study, while representative maps can be generated in GIS. Crashes can be selected according to different parameters such as time of day, driving under the influence (DUI), pavement conditions, number of lanes, etc. This selection can occur in either CARE or GIS.

Spatial analyses are performed on crash data that are mapped using the GIS application to identify "hot spots" at intersections, road segments and highway mileposts. The average daily traffic (ADT) data for different highway sections can also be represented graphically along with the crashes. The application also identifies the route with the least impedance, in the form of crashes, between origin and destination of a travel path using the network analysis feature of GIS This application identifies errors in the intersections node numbers used in crash data. This error results in mapping the same crash severity to multiple intersections. Errors like this are difficult to detect without displaying the data graphically. Crash severity at intersections is shown in Fig.2.4.

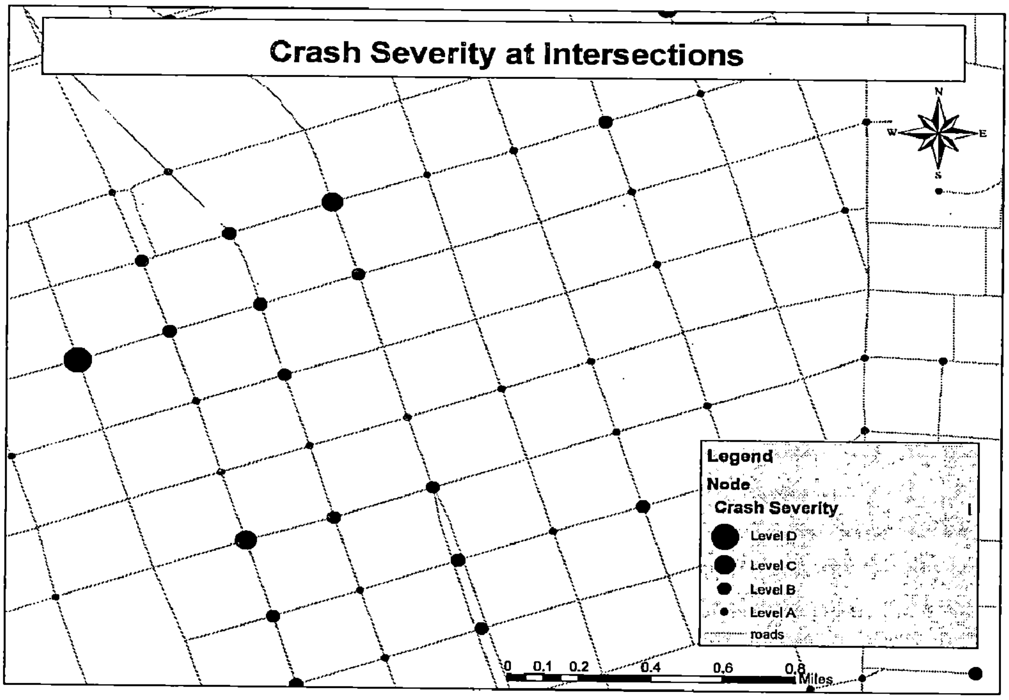

Fig. 2.4 Thematic Map for Crash Severity at Intersections

2.4.4 Prototype Traffic Safety GIS for Honolulu, Hawaii

Kim et al. conducted research at the University of Hawaii at Manoa, Honolulu, to develop a GIS spatial analysis system for vehicular crashes. The research produced a prototype GIS which would help in spatially analyzing crash data in combination with a crash outcome data evaluation system (CODES). CODES is a database containing detailed information about vehicular crashes that can be used to perform analyses on various traffic safety interventions such as motorcycle helmets, seatbelt effectiveness, etc.

A combination of software was used to create Hawaii's GIS application. A workstation environment was used to store and manage attribute data for crashes. A software engine called SAS carried out statistical analysis and database management. A desktop vector GIS using ATLAS GIS and MAPINFO were used for displaying and manipulating crash data spatially on maps. Cross-platform and cross-software transfers allowed users to take advantage of the strengths of various software packages and to evade some of their weaknesses.

The Hawaii project successfully mapped crashes that occurred at intersections and on road segments. However, crashes that occurred on freeways were not mapped because milepost locations were not available in digital form. This GIS application was used for studying collision patterns, formulating meaningful safety plans, identifying areas with high levels of crashes, identifying general patterns of crashes such as fatalities, alcohol related crashes, etc.

2.4.5 Accident Data Management for Mexican Federal Roads using GIS.

Mendoza et al. from the Mexican Transportation Institute developed a GIS based accident data management system for federal roads in Mexico. Information about accidents that occurred in 1997 were retrieved and stored in electronic files by the Federal Highway Police. The record for each crash was divided into two sub-bases, which represented accident data and participant data.

Each crash record is represented on a map as a reference theme having a geo coded index. Geo coding creates a point feature for each crash record in the database. These point features are positioned at the mid-length of the road segment on which they occurred. To obtain better geo coding accuracy, the road links were broken into 500 m segments to generate smaller geo-referenced segments. Subsequently the two databases and were geo coded, and queries were performed on the mapped data such as identification of the site with the most severe crashes, locating the nearest emergency medical service center for a particular location, etc. Fig. 2.5 displays a thematic map of 500 m road segments displaying the number of accidents recorded in 1997 in the state of Queretaro.

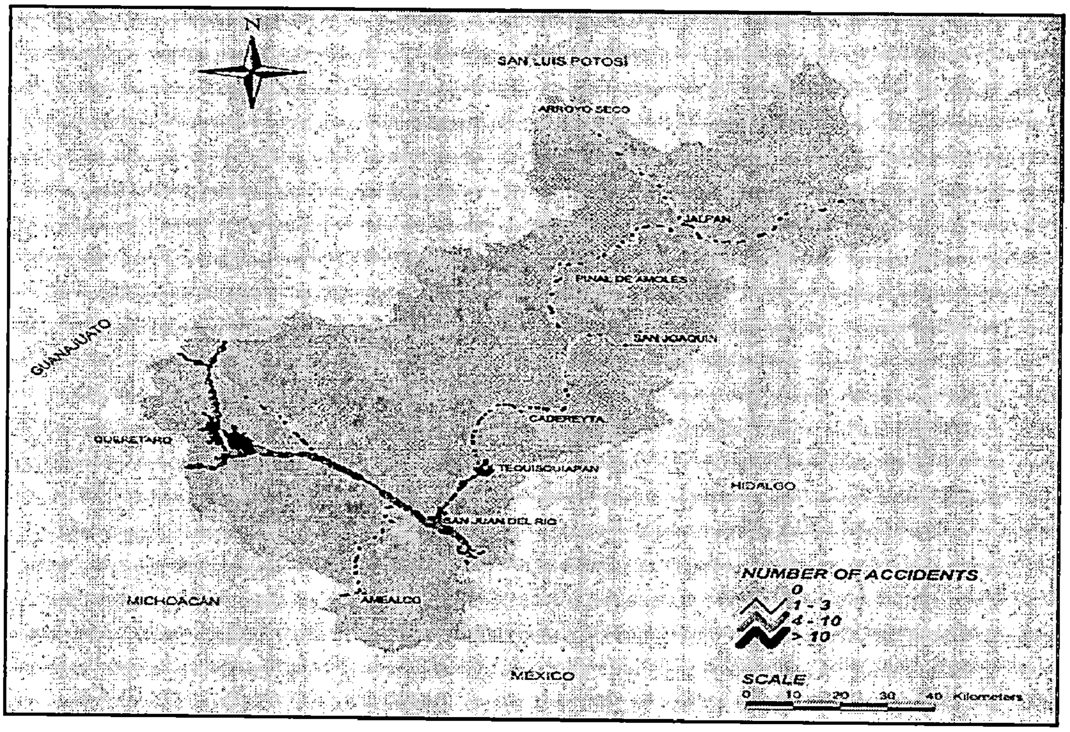

Fig. 2.5 Road Segments Thematically Mapped in Queretaro

2.4.6 Accident Rate, Accident Fatality Rate, Accident per Million Vehicles Kilometers or Accident Severity Index method

In this method the Identification Accident Black Spot is based on the Following four criteria:

(i) Accident Rate (AR)

(ii) Accident Fatality Rate (AFR)

(iii) Accidents per million veh. Km.

(iv) Accident Severity Index (ASI)

(i) Accident Rate (AR)

Accident rate is the total number of accidents per km per year on a given stretch. The location with high accident rate as compared to other is called as accident black spot. For this criterion all types of accident like fatal, injury and non injury accidents are considered.

Accident rate = Total accidents/ Km/ year

(ii) Accident Fatality Rate (AFR)

Accident fatality rate is defined as the total fatalities per accident per year. This criterion is similar to the previous one. In place of accident rate, fatality rate is used. This criterion helps to identify the site with more fatality.

Accident Fatality Rate = Fatalities / Total Accidents / Year / Km

(iii) Accidents per Million Vehicles Km (APMVK)

Exposure is one of the major factors responsible for higher rate of accidents. The black spot is identified based on the number of accidents per million vehicle kilometre travelled.

Accidents per 1, 000,000 Km = total accidents/ 1,000,000 veh km/per km /year

(iv) Accident Severity Index (ASI)

Accident severity index involves assigning certain pre-determined weightage to every accident depending upon the nature of accident. The location with high ASI value is termed as accident black spot.

The weight age factors suggested by TRL, UK for developing countries while studying accident black spot in Malaysia are given in Table 2.1

Table.2.1.The Accident Weight age as per the TRL Study

Type of Injury	Severity weight age
Fatality	6
Serious Injury	3
Minor Injury	0.8
Non-Injury	0.2

The critically of each section for various configurations is determined based on threshold values for AR, AFR, ASI and Number of accidents per 1,00,0000 veh. Km. These threshold values represent critical accident rate at 95% confidence level and are taken as average accident rate plus 1.5 times of standard deviation (i.e. $\overline{X} + 1.5\sigma$).

The accident locations where any one or more than one, of parameters (AR, AFR, ASI and Number of accidents per 1, 00,000 veh. kı threshold values are considered as Accident Black Spots.

CHAPTER 3

DATA COLLECTION

3.1 General

For the developing of Accident Information System using GIS, data has been collected from primary and secondary sources. Data which are gathered on the basis of field studies are primary data and the data which are collected from secondary sources like police stations, insurance agencies and hospitals are secondary data. Accident data has been collected from the police stations. Traffic data and road way geometry data were collected by field studies.

3.2 Primary data collection

Primary data were gathered on the basis of field study. From the field studies geometric data has been collected for parameters such as roadway width, shoulder width, sight distance, radii of horizontal curves, width of bridges, number of lanes, traffic volume and pavement characteristics.

3.2.1 Selection of Study Area

The development of Haridwar and Rishikesh as important tourist destinations in the international tourist map, expansion of new educational institutions at Roorkee and other industrial developments have resulted in increased traffic demand on the National Highway-58.

The Maha Kumbh and Ardh Kumbh at Haridwar and other festivals attract unmanageable number of pilgrims and during these events there is traffic chaos. During the rainy season, devotees of Lord Shiva (Karwaria) collect water from Haridwar and walk down to Pura Mahadeo near Meerut and almost for a period of one month the Highway is hardly available for traffic.

Besides its religious and economic importance, it provides access to china border and it is a road of strategic importance. Therefore, NH-58 has been selected for the identification of Accident Black Spots and develops Accident Information System

The primary data were collected for the two sections of National Highway No.58. The data were collected for a stretch of 63 Km from Km 75 to Km 138 on NH58.

The sites which have been studied are shown in Fig.3.1. The study has been done in following section.

(i) Section-1 from Km 75 to Km 138

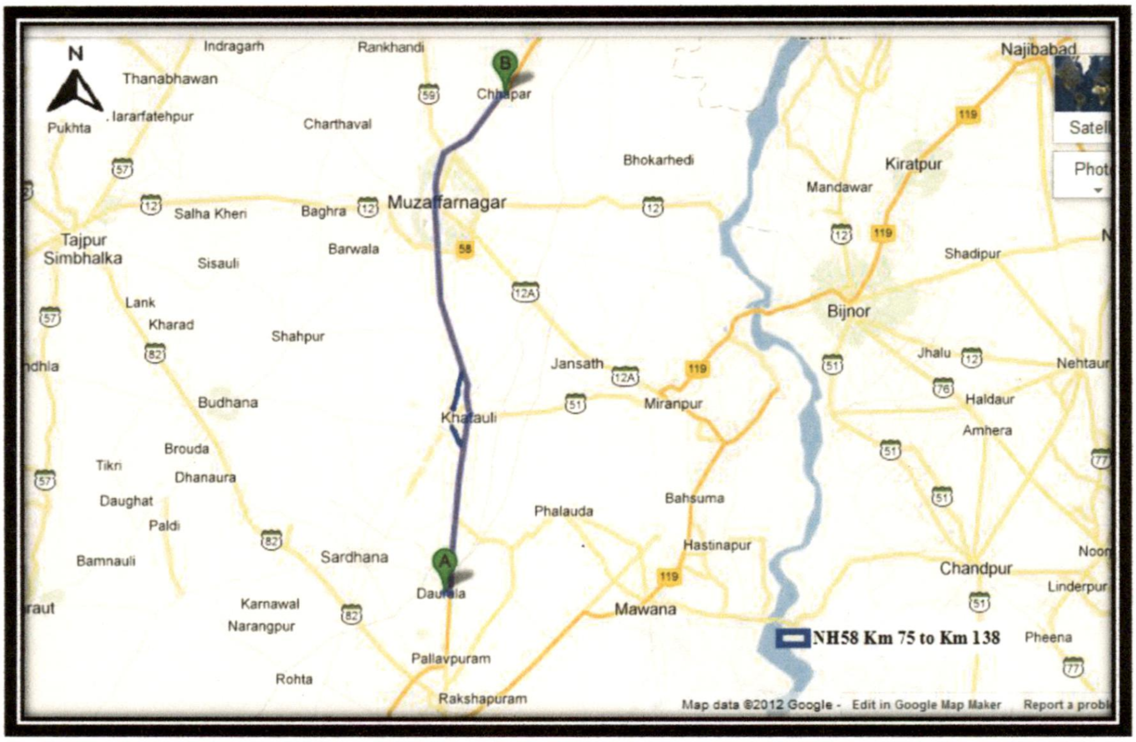

Fig. 3.1 Study Area on NH 58 (From Km75-Km 138)

3.2.2 Traffic Volume Count

Traffic volume was counted at two locations Km 77 (Toll plaza) and Km 114 for duration of 24 hours. Traffic volume is collected for different sections on NH58.

3.3 Collection of Spatial Data

The spatial data, i.e. the maps or images of the study area and other necessary information are collected from Google Earth.

3.4 Collection of Accident Data

The source of accident data are police records, insurance agencies, hospitals etc. for this particular study, the data of road accidents has been extracted from the police records with the prior permissions of the concerned S.H.O's. The police stations have their own FIR records for so many years. The Fir's related to road accidents are recorded under IPC No. 279/337/338/304A/247.

Accident data for the last five years (2007-2011) has been collected from the following police stations:

- Daurala Police station, Daurala
- Khatauli Police station, Khatauli
- Mansurpur Police station, Mansurpur
- Jansath Police station, Jansath
- Muzzafarnagar police station, Muzzafarnagar

The parameters collected from the police records are:

1. Date of Accident
2. Time of Accident
3. Location of Accident
4. Type of Accident
5. No: of Vehicles Involved in the Accident
6. Cause of the Accident
7. Number of Deaths and Injuries

Though a lot of details are required for every accident, the details available in the FIR reports are very limited. Depending upon the details available in the FIR reports, a performa was prepared to record the accident data. A sample copy of the Performa is shown in Annexure.

3.5 Software

Following are the software's used in the present study

1. ARC-GIS 9.3
2. COREL DRAW 11
3. MS OFFICE

4.1 General

The aim of the study is to develop an Accident Information System in GIS environment. Maps are the most commonly used tool to present spatial data and distribution. However, their use is significantly restricted by the following.

(i) Static and dynamic updating of maps is not possible.

(ii) Maps have difficulty to present uncertainty in the data. Very often this gives a false impression of accuracy.

Also data handling is very difficult. Using GIS most of these problems can be solved. GIS is a tool designed to support the capture, management, manipulation, analysis, modeling and display and spatially referenced data for solving complex planning and management problems.

4.2 Study Area

The study area NH-58(from Km 75-Km138), a stretch of 63 Km is selected for implementing the methodology involved, lies between 29°04'38"N to 29° 34'37"N latitude and 77° 42'30"E to 77° 46'25"E longitude. The study area is a four lane divided National Highway. The study area is shown in Fig. 4.1.

4.3 Geographic Information System

4.3.1 An Overview of GIS

Geographical Information System (GIS) is a collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS technology integrates powerful database functions such as querying and statistical analysis with the visualization and geographic analysis benefits offered by digital maps drawn with a computer mapping system.

With GIS, physical features such as city streets, county roads, building outlines, water lines have their own layer. This simplifies the process of drawing the maps and allows data to be attached to these layers. Each feature is then linked to its position on the graphical image of a map, which in turn links it to a database that contains information about it. Instead of a paper map limited by printing technology and the limits of human visual acuity, we have computer drawn maps and databases, linked together to provide a wide range of easily accessible information that allow users an unprecedented degree of tracking of physical data and events.

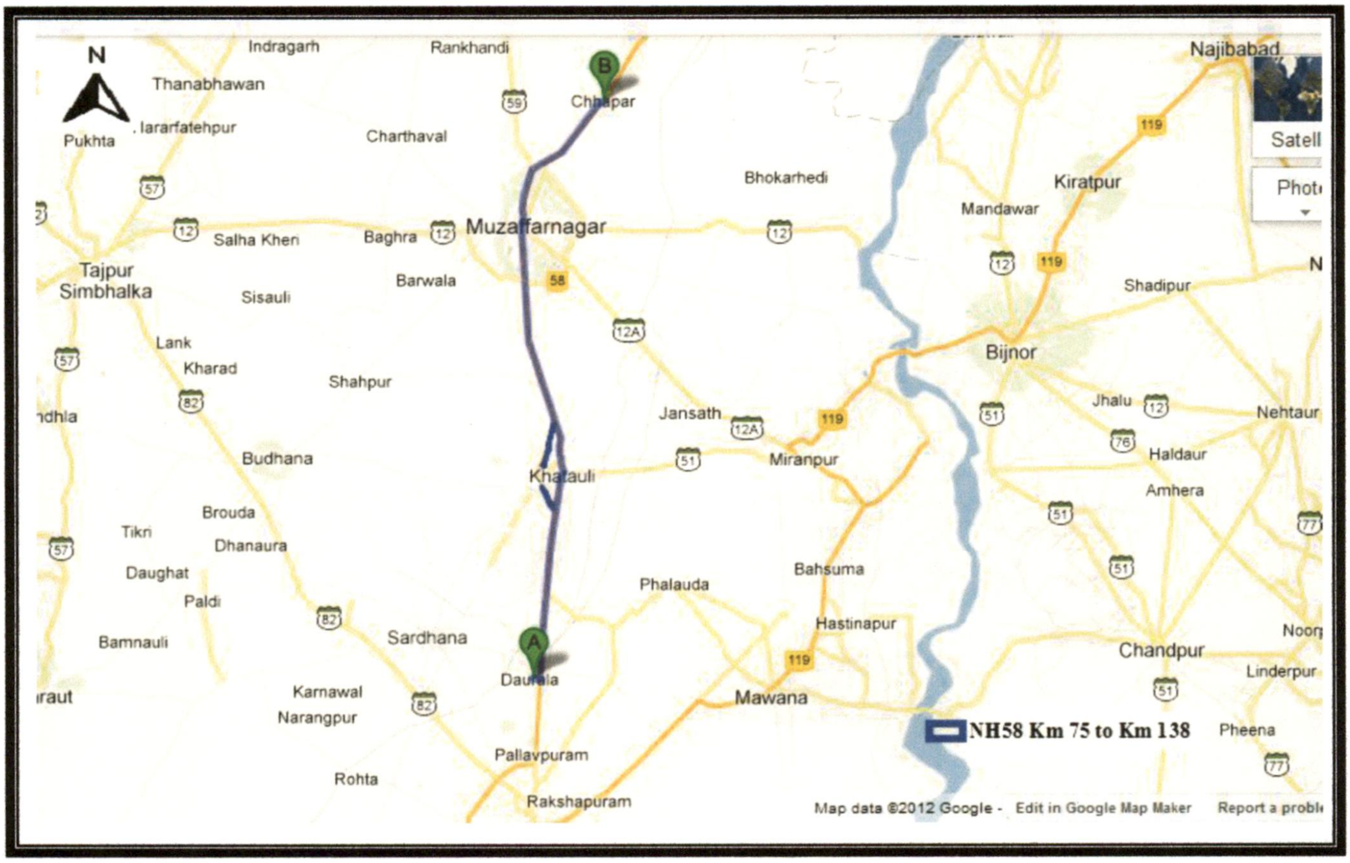

Fig. 4.1 Study Area on NH 58 (From Km75-Km 138)

The information that is part of the map is displayed with different layers. The layers can be selectively turned on and off to display various features of the map, so the same map can be useful to a variety of people. The user of the GIS software opens the database that is linked to the features displayed, and can turn layers on and off as needed. With a paper map, features cannot be selectively shown, and detailed information about the features cannot be included on the map, but with GIS, any configuration of layers can be displayed and the database information can be limitless. It is these qualities that allow GIS to be such a powerful tool for many fields of work.

What a GIS system can do easily would be extremely difficult and time consuming to accomplish by conventional methods. It is the power of GIS to link physical locations to the information in a database that makes complex analyses possible, and helps GIS users make better decisions. Because of its usefulness and success, GIS has become an indispensable software tool. In general a GIS has four major components and these are shown in Fig.4.2:

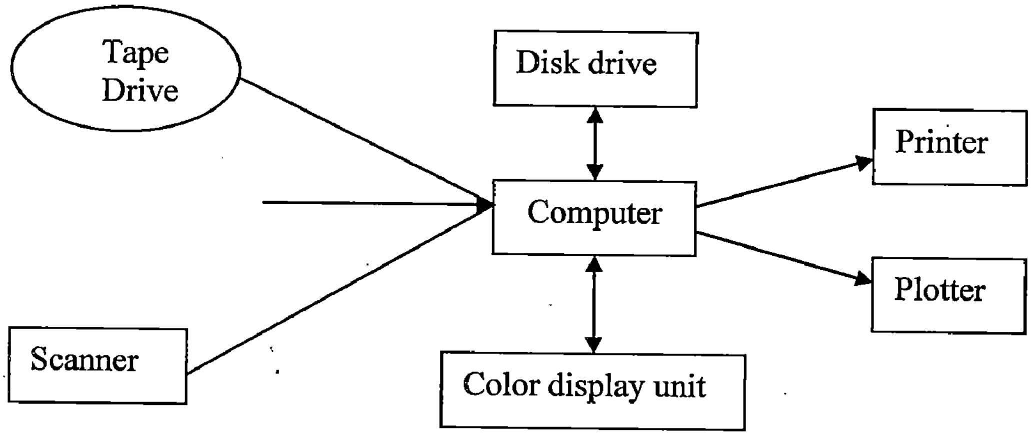

Fig. 4.2 Components of GIS

1. A data-input subsystem, which collects and processes the data derived from field exploration, tabular files, existing maps, aerial photographs and remote sensors. The sources of data input are shown in Fig.4.3.
2. A data-storage and data-retrieval subsystem that allows for rapid retrieval, rapid and accurate updating and correction.

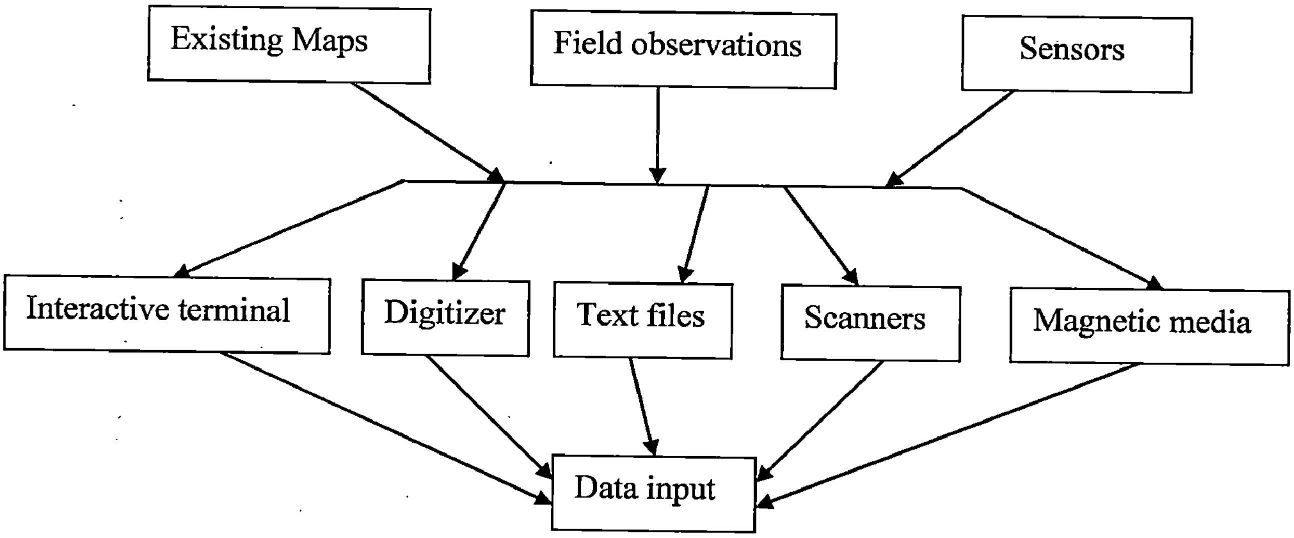

Fig.4.3 Sources of Data Input

3. A data-manipulation subsystem that allows the user to edit rapidly the data that have been stored.
4. A data reporting subsystem that is capable of displaying all or portions of the original database as well as the data generated by the manipulation subsystem in map form ,tabular form or both and it is shown in Fig.4.4.

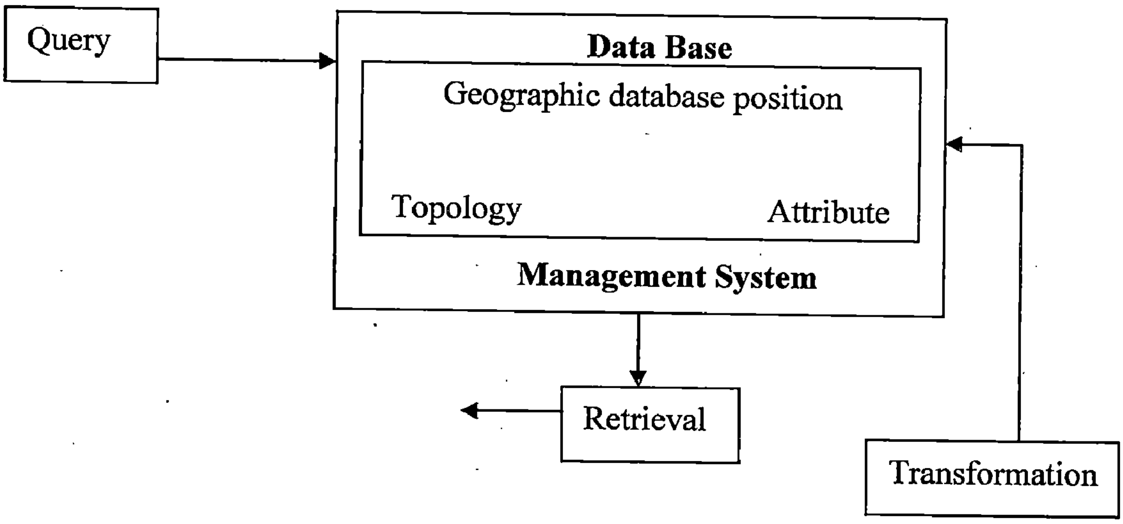

Fig. 4.4 Data Base Management System of a GIS

4.3.2 GIS Applications in Transportation

In recent years, there has been much discussion about GIS technology and applications across a wide variety of settings. Moreover, there have been many GIS-related developments in transportation planning and engineering. The power of them is rooted in the fact that GIS allows inferences to be drawn about the spatial nature of the data. Examples of GIS applications in transportation include pavement management systems that work with road segments, optimal vehicle routing, Automated mapping facilities management (AMFM) used for infrastructure management, drainage design, traffic modeling and accident analysis, demographic analysis for funding justification, and the option of displaying any form of tabular data that has a spatial component.

GIS further helps in analyzing various "what if scenarios" and helps to analyze future scenarios under various conditions which are taken as basic inputs for the effective decision making compatible to future developments.

4.3.3 GIS based Traffic Accident Analysis

The aim of the traffic accident analysis is to investigate the cause of accidents, to determine hazardous locations and to determine to enhance road features, to evaluate traffic safety after enhancement. This kind of system often includes a database query tool to store and analyze information about accidents mainly to identify high crash locations, in other words hazardous locations along the road.

Traditional databases can also perform many queries such as crash statistics for locations during the specified time periods, types of accidents, drivers involving certain type of accidents etc. In addition to these outputs can be printed out by integrating the traditional data management system with GIS offers spatial referencing system. Therefore many files in the system can be merged and interconnected. Therefore it allows us to query of any kind with respect to spatial coordinates. However, location "node numbers" corresponding to the intersections, bridges, highway/rail crossing etc. is difficult to identify. However, GIS technology which allows defining spatial analysis needs to be used to enhance highway safety analysis.

4.3.4 Benefits of Using GIS in Traffic Accident Analysis

The user can create the desired node, link or interchange through a map based on

Graphical user interface (GUI). GIS can easily create tables or maps or graphics to display query results. Road characteristics, demographic and socio-economic data to enhance highway safety analysis can also be integrated into the analysis.

Other benefits of GIS technology:

- Maintainability: The system can easily be updated to accommodate new or improved data and data format can easily be altered. The data can be stored in daily, weekly or monthly bases depending on the sensitivity of the department.
- Compatibility: The system is compatible with other software such as Microsoft EXCEL, Microsoft WORD etc.
- Query capabilities: The user is able to define his/her own queries based on any fields in the database.
- Spatial query capabilities: User is able to query actual crash locations as shown in the roadway such as milepost.
- Maps: The system provides the user maps of crashes along the roadway, pie diagrams for any query.
- Performance: The system responds quickly and efficiently.
- Report generation: The user is able to obtain reports after any query.

4.4 Methodology

4.4.1 Analysis using GIS

The following methodology was adopted for the study area NH-58 from Km 75 to Km 138. Fig. 4.5 showing the flow chart for methodology adopted.

Phase–1 involved the data collection from various sources mentioned the previous chapter.

Phase–2 involved the processing of the spatial data and the accident data for the crash analysis in GIS, for this the topo-sheets collected are scanned and are geographically registered using ARC-GIS 9.3. These registered maps are used for the digitization of necessary features that are used in the crash data analysis in ARC-GIS 9.3.

Phase-3 involved the theme generation, i.e. preparing the GIS based crash database, for this the accident data is attached to the map feature wherein the different layers considered in the database are present.

Phase-4 is the performing various queries on the GIS based crash database, these queries are based on the different layers of the map feature and also the based the accident data that is attached to the map feature.

Phase-5 is final analysis on crash data in GIS keeping in view the objectives of the study and presenting the results.

4.4.2 Registration and Digitization of Maps

Registration is the process of locating all the spatial data with respect to a common frame of reference. Digitization is a process of encoding geographic features in digital form, as x, y coordinates. It is carried out in order to create spatial data from existing hardcopy maps and documents.

In the present work the topo-sheets of the study area has been scanned in pieces and then mosaic. This scanned image should be geometrically registered to a generally accepted and properly defined coordinate system and coded so that they can be stored in the internal database structure of the GIS. Registration is also important so that all data are referenced to the same coordinate system. In registration the projection parameters are also to be defined, so that the image gets converted into a geocoded /georefferenced image. Hence the registration of the scanned image has been done using the Projective Registration Method. In this method a minimum of four-ground control points are required for registration.

For crash analysis, only the road feature is required, hence the road feature has been digitized. It is easy and realistic to carry query-based analysis on a vector data rather than on a raster data. Also, attribute tables can only be attached on a vector data. Hence, after registering the topo-sheets in ERDAS 8.6, the road feature on the map has been digitized in ARC-GIS 9.3. Since the topo sheets were old, satellite data has been used to identify the newly developed roads, bypasses, settlement etc in the study area. These have been also digitized so that a complete and latest road map of the NH-58(from Km 75-Km138) is obtained.

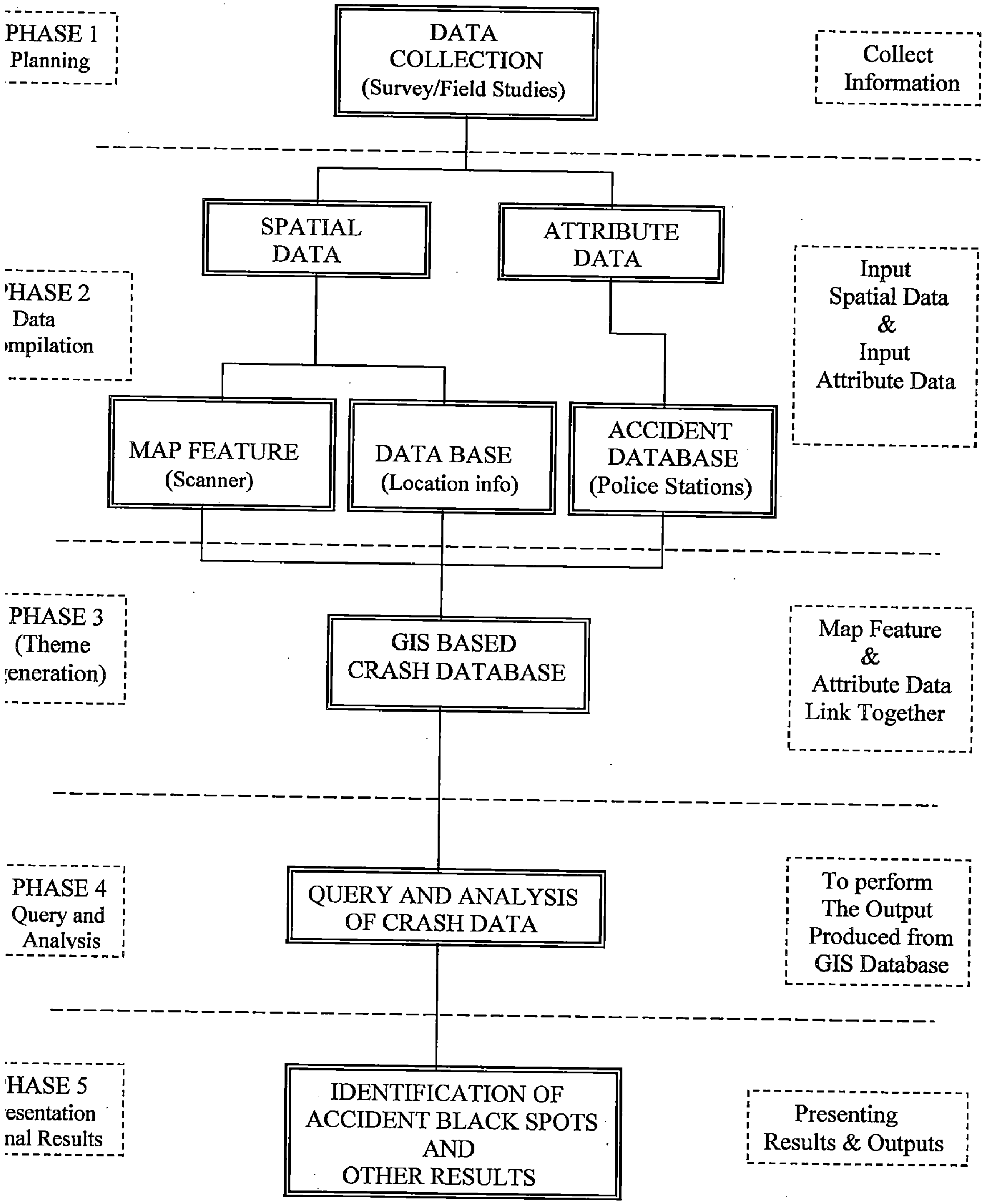

Fig. 4.5 Flow Chart for Methodology

4.4.3 Theme Generation

All the necessary information for each feature is to be entered into its theme's attribute table, to be used in analysis it in the later stage. This is done by adding required number of fields to the table and entering the data for all the features in their corresponding records. However the data can also be added to the attribute table by attaching the data from a "Dbase IV" file containing all the required data to be used. The different themes or layers considered in this project are

(i) National Highway58 -Line feature

Since the topo-sheets were old. In the National Highway 58 theme, all the newly constructed bypasses have been updated from the satellite image and have been digitized according to the image on the topo-sheets. The whole stretch is then divided into equal sections of 0.2 km. All the sections of the study area have been identified and the crash data stored in the database.

In the settlement theme, all the newly developed settlements have been updated from the satellite image and are digitized on the topo-sheets. These have been identified and located in the digitized image and a database was created for the same in ARC-GIS 9.3. The digitized map of the study area is shown in Fig. 4.6. The digitization map shows the digitization of road, median are line features. Digitization police stations, hospitals, insurance offices, road accidents are point features.

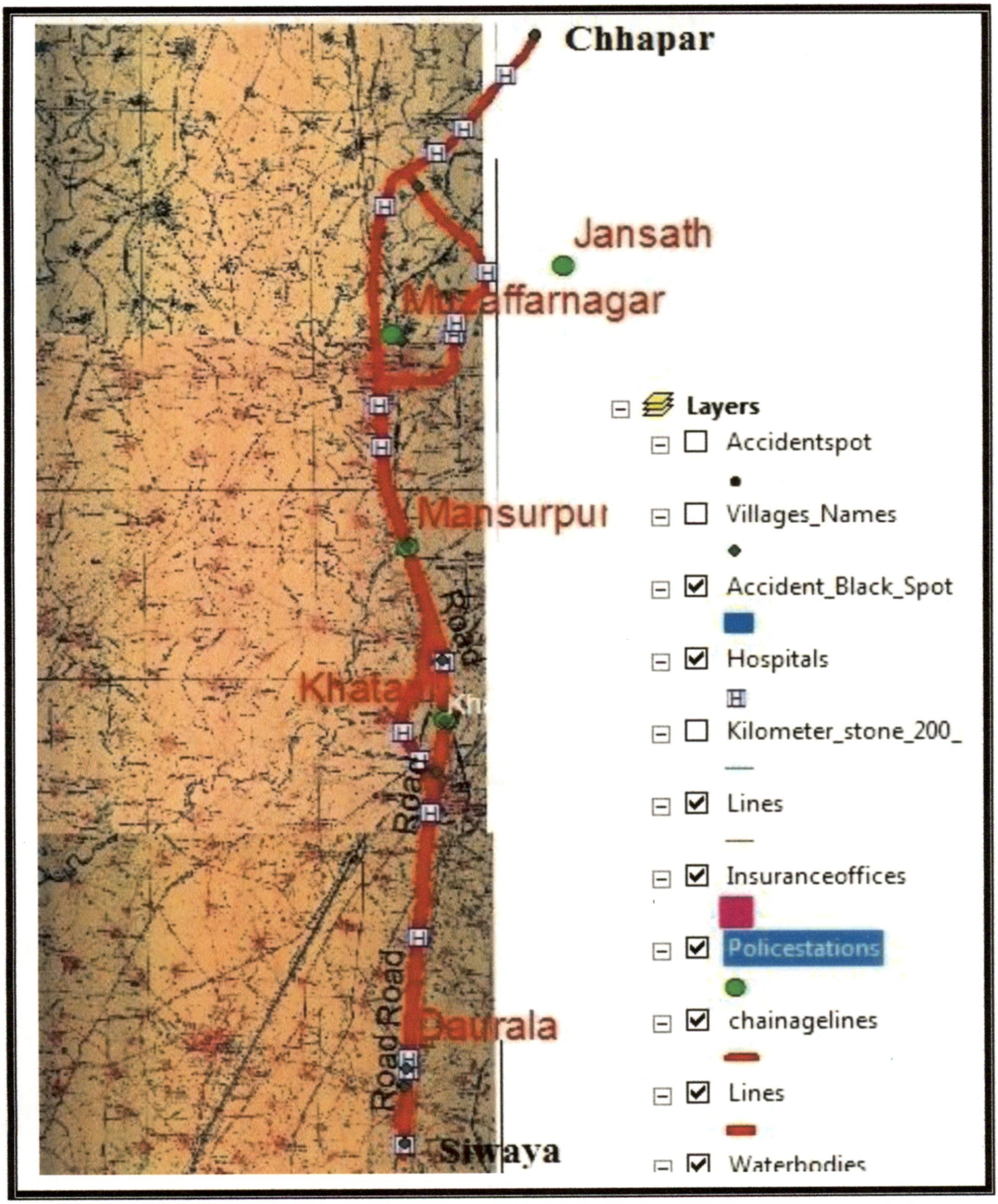

Fig. 4.6 Digitized Maps of NH-58 (Km 75 to Km 138)

4.5 Developing of Accident Information System

The development of an integrated traffic accident information system is prompted. Organizational restructuring wit focus management has to be adopted by government in order to delineate and relegate certain function which is integral to the overall system. Recent developments in computer technologies can be utilized in order to aid manual work in the work of traffic accident data warehousing. A central site shall maintain the database and map server. Te central sit shall also be equipped with plotting and external storage devices for achieving purposes. In such a system, information from the traffic accident investigation report forms is directly encoded via an interface program. Reporting police stations shall only need to forward their reports to the district office for proper processing and input. Thus, accident reports can be updated on a daily or weekly basis to prevent backlog. The system shall also update the master database at the central site. The central site, on the other hand, shall prepare accident' black spots' and data processing and report preparation for the whole coverage area. And it shall also give the all the information about the road accidents along the study area on National Highway. It includes type of accident, date of accident, type of vehicle involved, number injuries and deaths etc.

4.6 Criteria for Accident Black Spots Identification

Accident black spot is a location, whether link or node, on a highway where accidents repeatedly occur or a large number of accidents occur over a period of time. Accident black spots were identified by using critical crash rate factor method.

4.6.1. Critical Crash Rate Factor Method

A location whether link or node that experiences abnormal crash frequencies, rates is considered as an Accident Black Spot. The technique that is used the study to identify hazardous locations is known as the critical crash rate factor method. Since traffic crashes are random occurrences and can be considered as "Rare Events" it is not possible to identify hazardous locations simply on the basis of the number of crashes. Rather, the critical rate method incorporates the traffic volume to determine if the crash rate at a particular location is significantly higher than the average for the type of facility. If the crash rate of a particular location is significantly higher than the average crash rate for other locations in the jurisdiction having similar characteristics, the location is classified as an Accident Black Spot.

The steps involved in this method are as follows.

1. Determination of the location's crash rate: It is determined on the basis of exposure data, such as traffic volume and the length of road section being considered. Rate per 100 million vehicle kilometers (RMV) is the number of crashes per 100 million vehicle kilometers of travel. It is obtained from expression

$$RMV = \frac{Ax100{,}000{,}000}{VT} \qquad \text{.............................. (4.1)}$$

A= No: of crashes, total at the study location during a given period.

VT= vehicle kilometers of travel during the given period.

= ADT x (No: of days in study period) x (No: of Years) x (length of road Segment)

2. Determining the critical crash rate: The critical crash rate factor method Involves the following expression:

$$CR = AVR + \frac{0.5}{TB} + TF\sqrt{AVR/TB} \qquad \text{...................... (4.2)}$$

Where,

CR= critical crash rate, per 100 million vehicle-Km

AVR= Average crash rate for the facility type.

TF= Test factor, standard deviation at a given confidence level

(TF= 1.96 for 95% confidence level)

TB= Traffic base, Veh/Km 100 million Vehicle-Kms

$$= \frac{\text{No. of Years x ADT x (length of Road Segment) x 365 Days per year}}{\text{100 million}}$$

Where,

ADT = Average daily traffic

3. Compare the location's crash rate to the critical crash rate. If the crash rate exceeds the critical crash rate, classify the location as an Accident Black Spot.

5.1 General

The crash data has been collected from FIR records in police stations and it is analyzed using the methodology described in the previous chapter. The data is inputted to ARC-GIS 9.3 by assigning the attributes to different features of the digitized maps and comprehensive analysis has been done on sections of one kilometer each on NH-58(from Km 75-Km138). Crash rate, traffic base, critical crash rate and crash ratio has been calculated and those sections whose Crash rate exceeding the Critical crash rate have been identified as Accident Black Spots and Developed Accident Information System using GIS.

5.2 Yearly Variation of Total Crashes

Histogram of year wise total crashes has been presented from the Fig. 5.1. From the analysis it is established that the total crashes on NH58 for last five years.

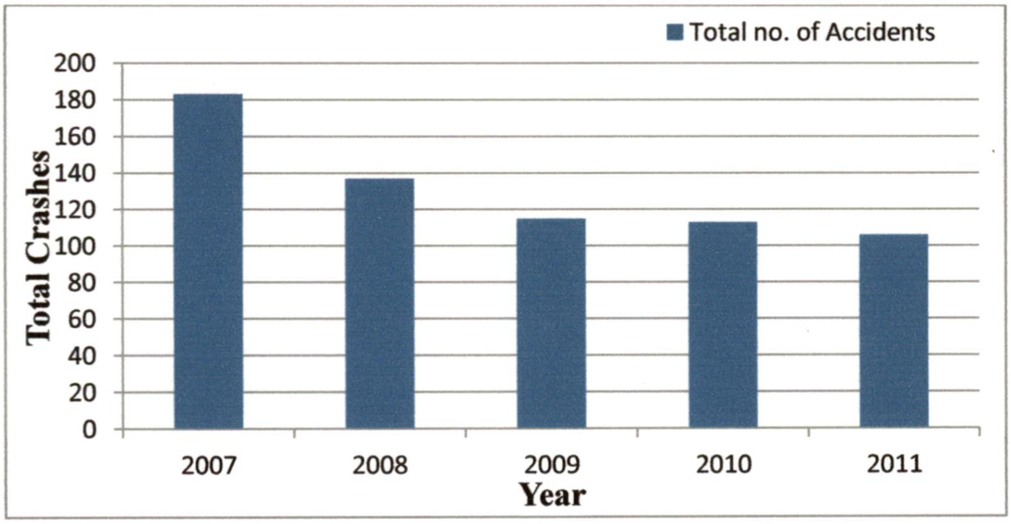

Fig. 5.1 Total Crashes According to Yearly Variation on NH-58 (Km 75 to Km 138)

5.3 Kilometer-Wise Analysis of Total Crashes

Histograms of kilometer wise total crashes have been presented from the Figures 5.2 to 5.6. It is established that no particular section on NH58 (from Km 75- Km 138) is free from crashes.

5.4 Day and Month-wise Analysis of Total Crashes

Day-wise analysis of total crashes has been presented in Fig.5.7. From the Table 5.1 it is observed that maximum number of crashes occur during the weekends (Saturday, Sunday) and on Monday. This may be due to the increase in the number of tourists visiting Haridwar and Rishikesh.

Further, Month-wise histogram for total crashes has been presented in Fig. 5.8. From Table 5.2 it is established that maximum number of crashes occurs in the months of August and December.

5.5 Time-wise Analysis of Total Crashes

Time-wise analysis of total crashes has been presented in Fig. 5.9. From Table 5.3 It is established that maximum number of crashes occur between 14.00 to 16.00 hrs.

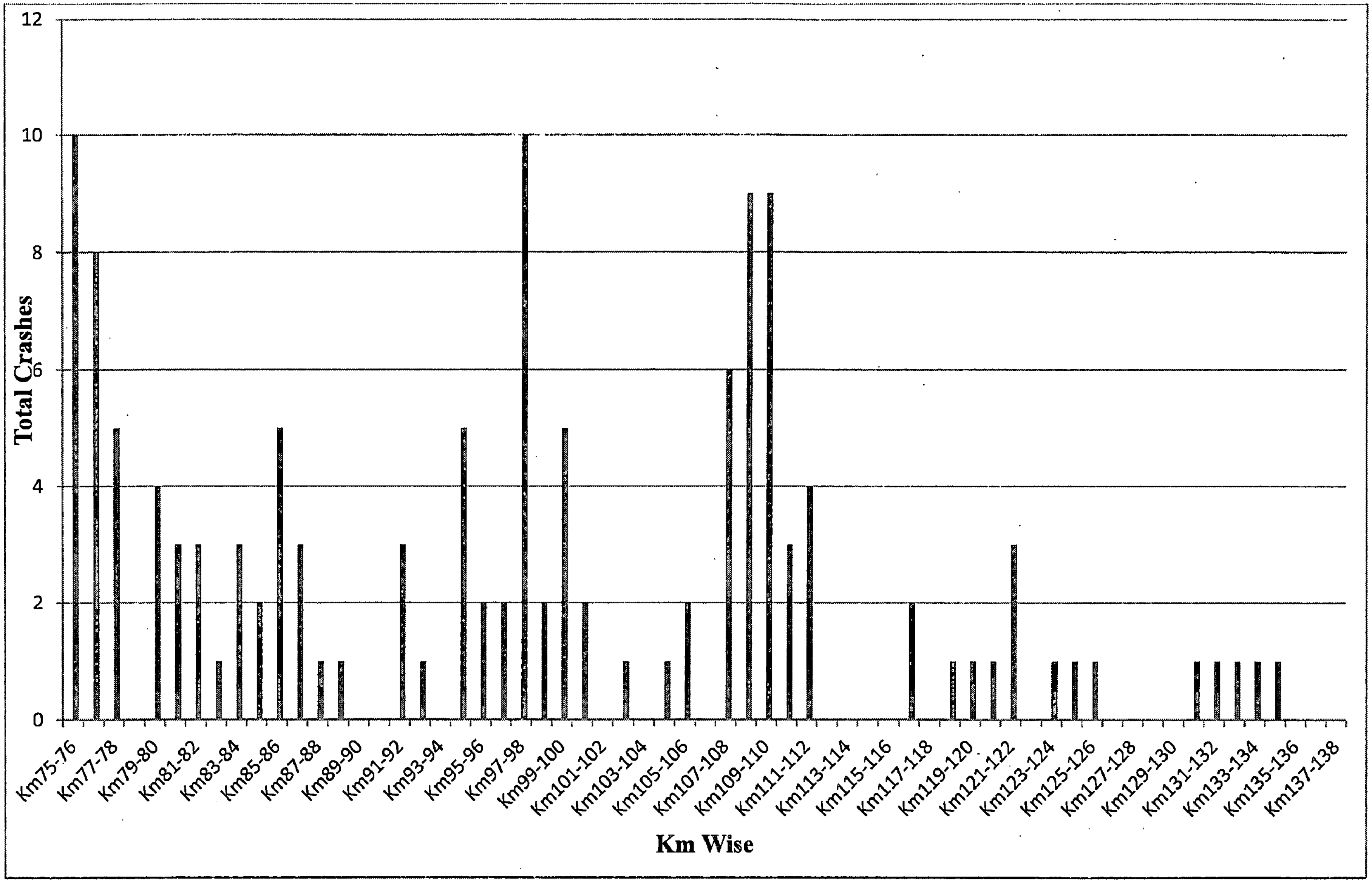

Fig. 5.2 Km-wise Crashes on NH 58 (from Km 75-Km 138) in 2007

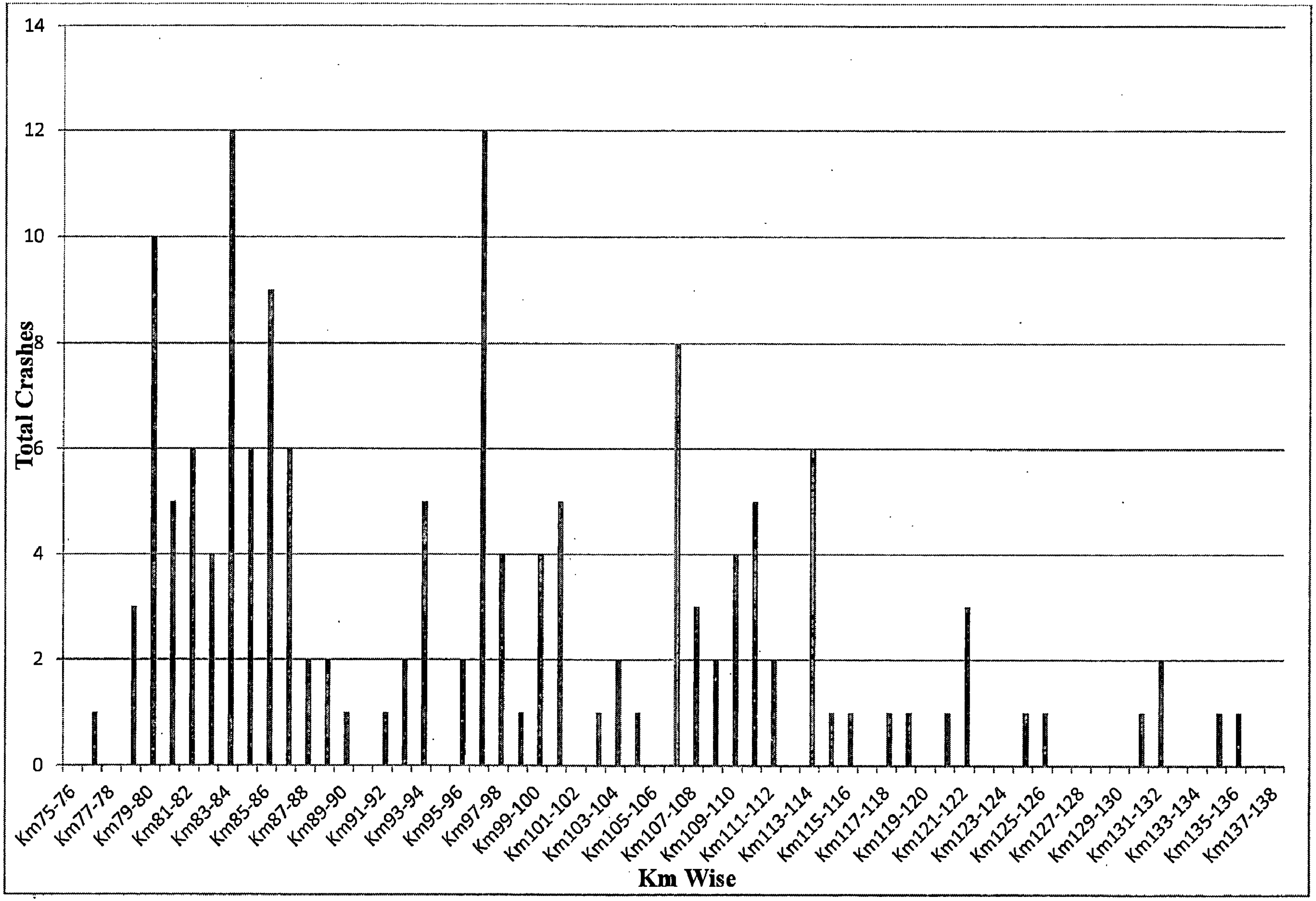

Fig. 5.3 Km-wise Crashes on NH 58 (from Km 75-Km 138) in 2008

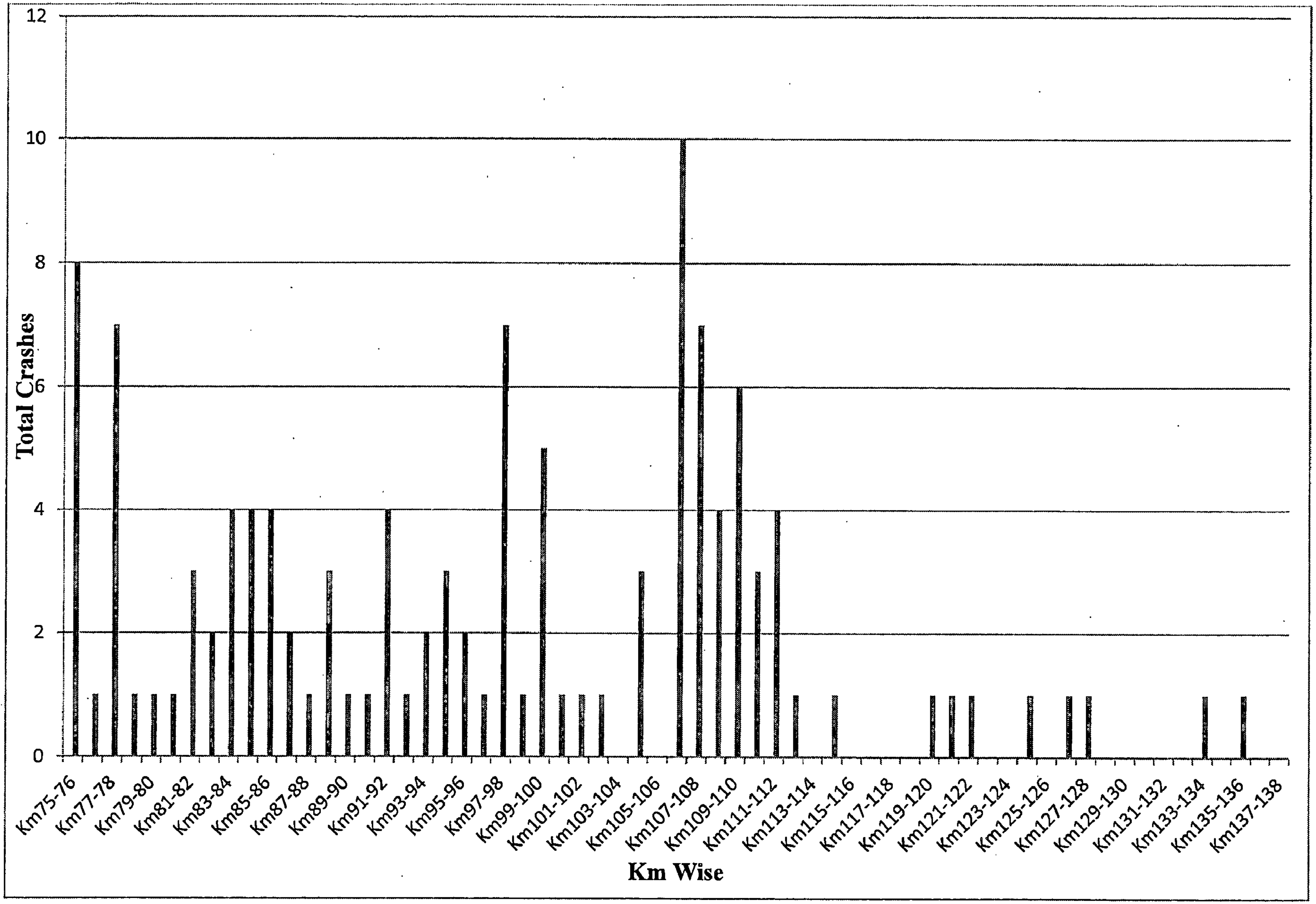

Fig. 5.4 Km-wise Crashes on NH 58 (from Km 75-Km 138) in 2009

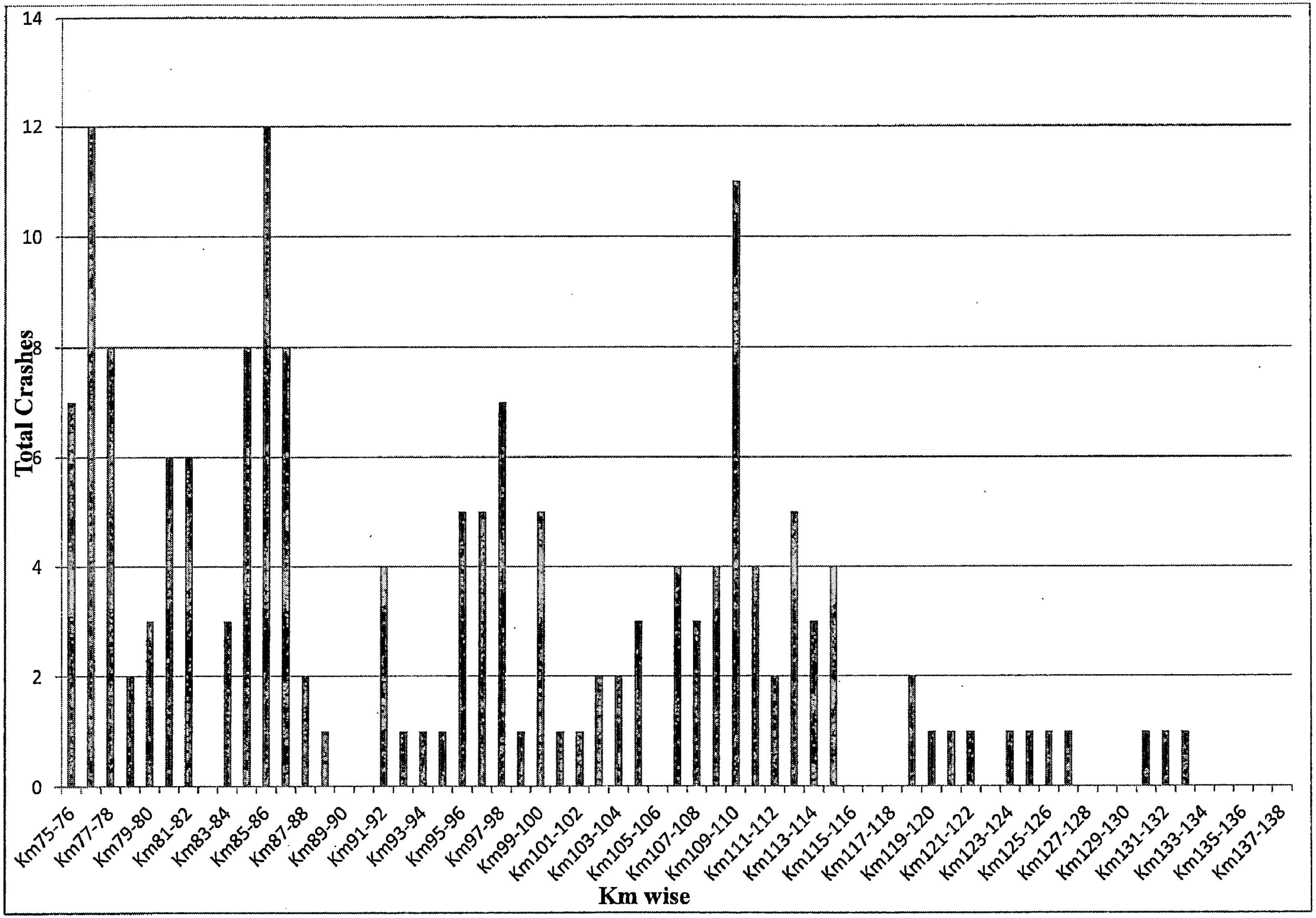

Fig. 5.5 Km-wise Crashes on NH 58 (from Km 75-Km 138) in 2010

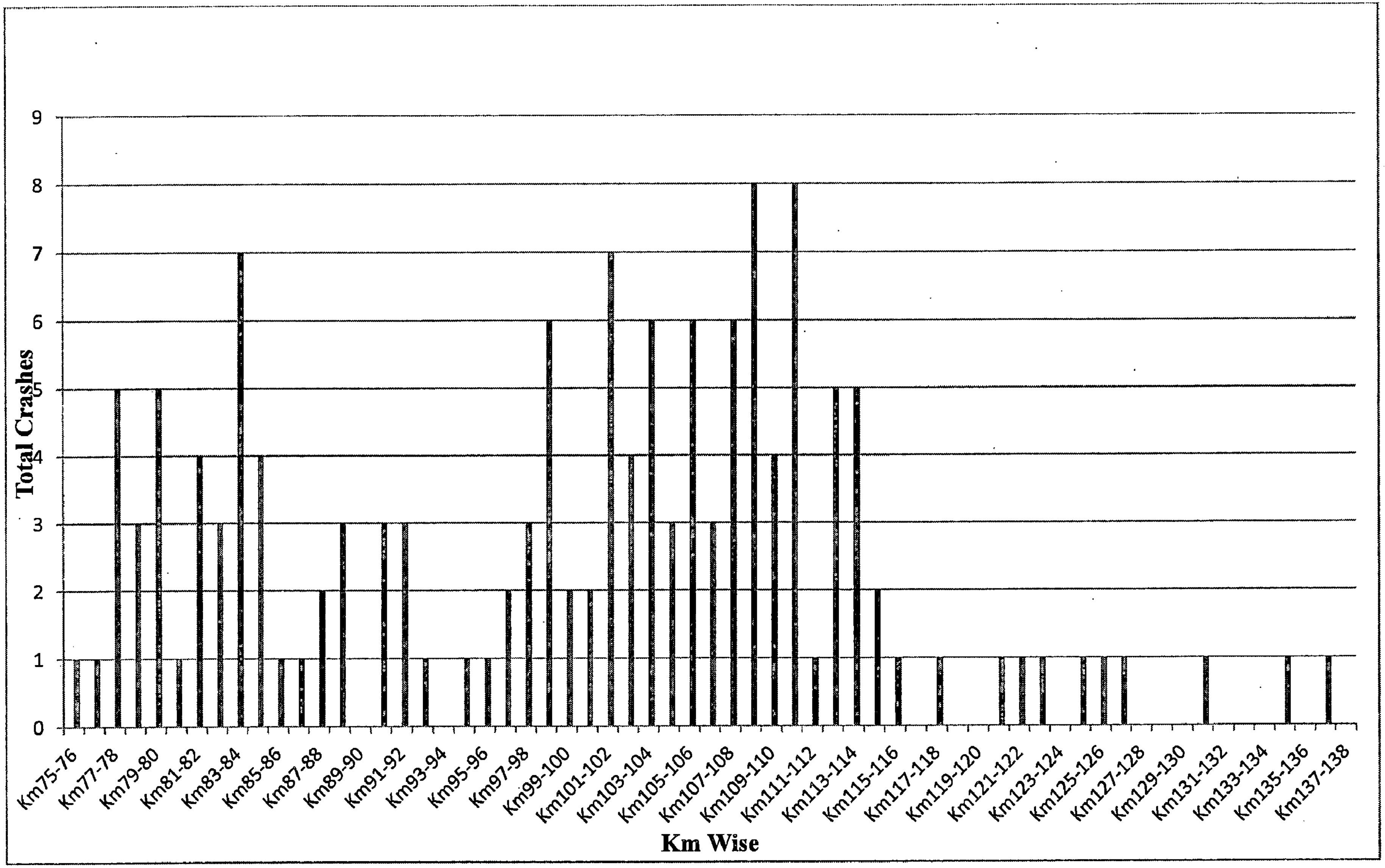

Fig. 5.6 Km-wise Crashes on NH 58 (from Km 75-Km 138) in 2011

Table 5.1 Day-Wise Crashes on NH-58 (Km 75 – Km 138)

Weekday	Crashes (%)				
	2007	2008	2009	2010	2011
Monday	17.5	17	11	13	16.5
Tuesday	13.5	16	15	12	10
Wednesday	13	8.5	12	11	9
Thursday	10.5	10	13	15.5	14
Friday	13	11	13	14	12
Saturday	14	16.5	14	16.5	18.5
Sunday	18.5	21	22	18	20

Table 5.2 Month-Wise Crashes on NH-58 (Km 75 – Km 138)

Month	Crashes (%)				
	2007	2008	2009	2010	2011
January	10.5	11	9	9	9.5
February	9	10.5	4	7	6
March	3.5	7	4.5	4	5.5
April	6	4	6	6.5	7
May	7	8.5	6	10	8.5
June	7	5	7	10.5	7
July	8	7	9	8	9
August	10	13	12	8	9.5
September	9	5	10	11.5	7
October	9	8	8.5	9	9
November	11	8	11	8	10
December	10	13	13	8.5	12

Table 5.3 Time-Wise Crashes on NH-58 (Km 75 – Km 138)

Time (in Hours)	Crashes (%)				
	2007	2008	2009	2010	2011
0 to 2	2.6	2.2	2.4	2.8	3.1
2 to 4	1.6	1.7	3	2	1.9
4 to 6	4.1	4	4.6	4.2	4.1
6 to 8	7.5	7.4	7.2	7.5	7.9
8 to 10	10.2	9.5	8.6	9.2	10.2
10 to 12	11	10.2	9.4	10.2	10.1
12 to 14	8.4	8.2	9.2	8.2	8.6
14 to 16	13	15	16	14	14.1
16 to 18	12	12.8	11	13	11.2
18 to 20	13	12	13	12	11.6
20 to 22	9.2	9.8	8.6	9.5	9.6
22 to 24	7.4	7.2	7	7.4	7.6

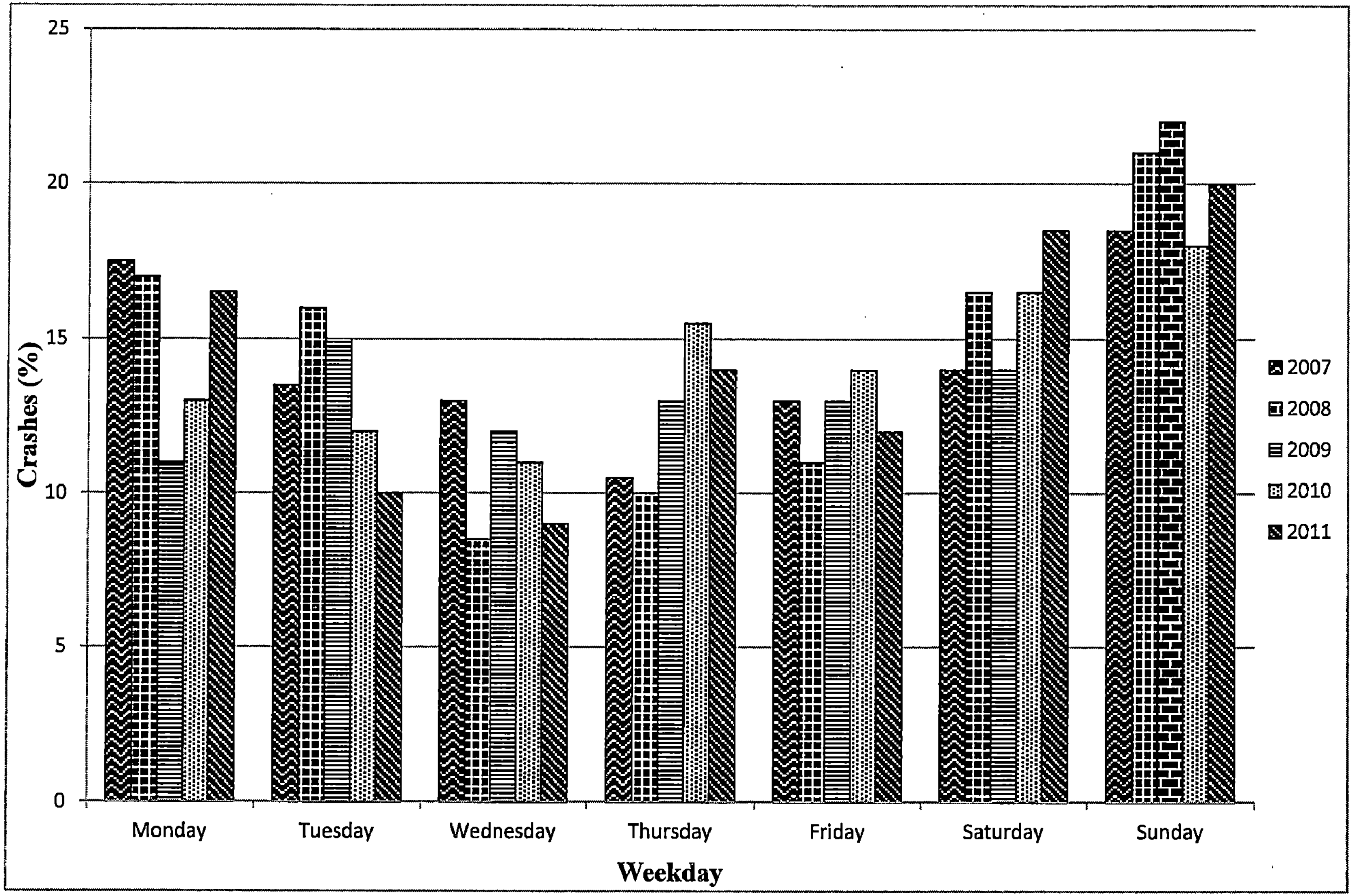

Fig. 5.7 Day-Wise distribution of Crashes on NH-58 (Km 75 – Km 138)

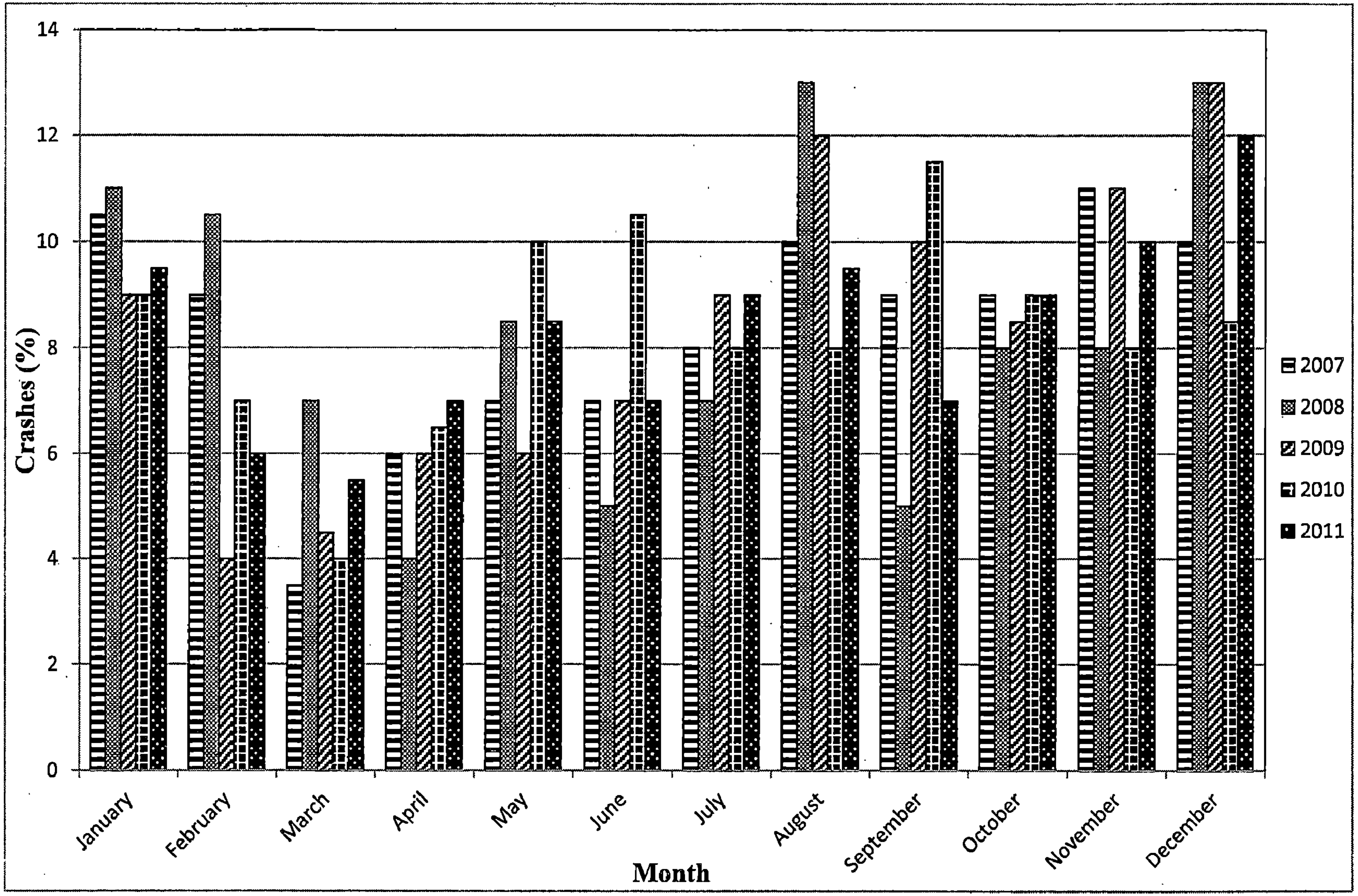

Fig. 5.8 Month-Wise distribution of Crashes on NH-58 (Km 75 – Km 138)

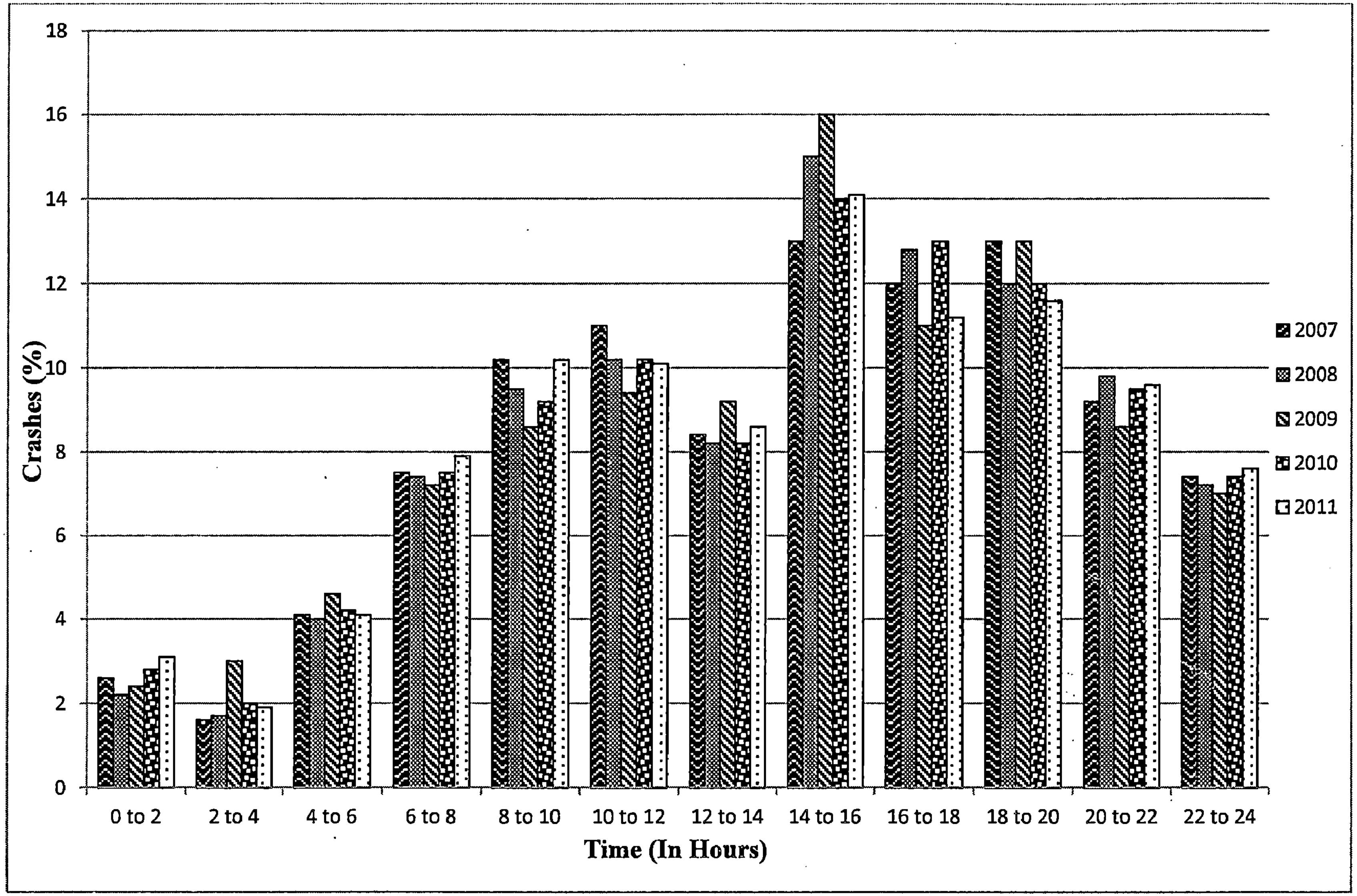

Fig. 5.9 Time-Wise distribution of Crashes on NH-58 (Km 75 – Km 138)

5.6 Development of Accident Information System (Data Base)

Accident information system is a computer-based system that compiles information on traffic collisions occurring on National highways. This information is captured from traffic collisions reporting by highway police agencies and auto claims made to SGI. Accident information system provides valuable information for many traffic safety programs that SGI develops and has done. The report's main purpose is to help reduce the number and severity of traffic accidents. And it shall also give the all the information's about the road accidents along the on National Highway. It includes type of accident, date of accident, type of vehicle involved, number injuries and deaths, time of accident, reason for accident etc are shown in fig.5.10.

5.7 GIS based Queries on Crash Data

5.7.1 Query on an Average daily Traffic

Fig. 5.11 shows the ARC-GIS results for the average daily traffic based queries on crash data. The inputs for the queries are:

Layer: NH58

Method: Create a New Selection

Field: ADT

Query-1: ("ADT" >10000 AND "ADT <=20000)

For this analysis, the selection toolbox is used. The query is done on the road layer (NH58) by "Create a selection" method. Firstly the field is selected from the attributes of the feature, and then by using the query builder, the query is applied on the layer.

5.7.2 Query on Shoulder Width

Figures 5.12 to 5.14 show the ARC-GIS results for the shoulder width based queries on crash data. The inputs for the queries are:

Layer: NH58

Method: Create a New Selection

Field: SHOULDER_WIDTH

Query-1: ("SHOULDER_WIDTH "<= 0.5)

Query-2: ("SHOULDER_WIDTH" > 0.5 AND "SHOULDER_WIDTH" <= 1)

Query-3: ("SHOULDER_WIDTH" > 1 AND "SHOULDER_WIDTH" <= 2)

Attributes of Accidentspot

OBJECTID	SHAPE*	FIR_NUMBER	Location_of_accidents	Time_date_month	Type_of_accidents	No_of_Lanes	No_of_accidents	No_of_deaths	No_of_injuries	Distance_from_police_station_to_spot	Police_station_direction_to_spot	KM	Distance_to_hos
7	Point	432/11	TollPlaza (3 ways)	8/1/2011	Rear	4 Lane Divided	1	1	1	1	S	77.7	<Null>
8	Point	464/11	Daurala Intersection	7/8/2011	Rear	4 Lane Divided	1	0	1	1	S	77.7	<Null>
9	Point	654/11	Daurala Road	10/6/2011	Front	4 Lane Divided	1	0	1	1	S	77.7	<Null>
12	Point	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
24	Point	753/11	Daurala	11/6/2011	Rear	4 Lane Divided	1	0	1	3	N	81.3	<Null>
14	Point	466/11	Gram Sivaya	7/8/2011	Rear	4 Lane Divided	1	0	1	3	S	75.5	<Null>
71	Point	143/11	Dasharpur	3/9/2011	Rear	4 Lane Divided	1	1	2	10	N	85.5	<Null>
16	Point	495/11	Daurala	7/26/2011	Rear	4 Lane Divided	1	0	1	3.4	N	75.6	<Null>
17	Point	491/11	Pandit Hotel	7/23/2011	Rear	4 Lane Divided	1	0	0	0.8	N	79.4	<Null>
18	Point	287/11	G.T.Road (Deepak Hotel)	4/21/2011	Front	4 Lane Divided	1	1	1	1	N	79.5	<Null>
19	Point	422/11	N.T.P.C Deurala	5/31/2011	Rear	4 Lane Divided	1	0	1	1	N	79.5	<Null>
20	Point	96/11	Chowdary Hotel	2/7/2011	Rear	4 Lane Divided	1	1	0	1.5	N	83	<Null>
21	Point	137/11	Matour	3/5/2011	Rear	4 Lane Divided	1	0	1	1.5	N	<Null>	<Null>
13	Point	577/11	Daurala	9/2/2011	Rear	4 Lane Divided	1	0	1	0.5	S	77.9	
82	Point	464/11	Daurala Intersection	7/8/2011	Rear	4 Lane Divided	1	0	1	1	N	96	<Null>
45	Point	656/11	Dasharpur	10/6/2011	Rear	4 Lane Divided	1	0	1	8.2	N	84.6	<Null>
46	Point	<Null>	Highway Road	4/15/2011	Rear	4 Lane Divided	1	0	1	7	N	85.5	<Null>
76	Point	112/11	Dasharpur	2/15/2011	Rear	4 Lane Divided	1	1	0	6	S	91	<Null>
77	Point	656/11	Dasharpur	10/6/2011	Front	4 Lane Divided	1	0	1	8	N	91	<Null>
78	Point	223/11	G.T.Road	4/19/2011	Rear	4 Lane Divided	1	1	0	5	S	92	<Null>
79	Point	593/11	Pandit Hotel	9/8/2011	Rear	4 Lane Divided	1	0	1	3	N	87.5	<Null>
80	Point	348/11	Lowya Village	5/13/2011	Rear	4 Lane Divided	1	0	2	5	N	92	<Null>
40	Point	112/11	Dasharpur	2/15/2011	Rear	4 Lane Divided	1	1	0	5.8	N	84.2	<Null>
83	Point	466/11	Gram Sivaya	7/8/2011	Rear	4 Lane Divided	1	0	1	3	N	97	<Null>
84	Point	477/11	Dadri	7/15/2011	Rear	4 Lane Divided	1	0	0	3	N	97	<Null>
85	Point	495/11	Daurala	7/26/2011	Rear	4 Lane Divided	1	0	1	3.1	N	97.1	<Null>
86	Point	577/11	Daurala	9/2/2011	Rear	4 Lane Divided	1	0	1	3.5	N	97.5	<Null>
87	Point	491/11	Pandit Hotel	7/23/2011	Rear	4 Lane Divided	1	0	0	3.6	N	97.6	<Null>
88	Point	287/11	G.T.Road (Deepak Hotel)	4/21/2011	Front	4 Lane Divided	1	1	1	1	S	93	<Null>
146	Point	124/11	Muzaffarnagar Bypass	4/12/2011	Rear	4 Lane Divided	1	0	1	3.2	N	110.2	<Null>
32	Point	342/11	Daulara police station	5/8/2011	Rear	4 Lane Divided	1	0	1	5	N	85.5	<Null>
69	Point	422/11	N.T.P.C Deurala	5/31/2011	Rear	4 Lane Divided	1	0	1	1	N	95	<Null>
72	Point	763/11	Dadri	<Null>	Front	4 Lane Divided	1	1	0	10	N	83.5	<Null>
73	Point	268/11	Khedi Road	4/15/2011	Front	4 Lane Divided	1	1	0	12	N	93.5	<Null>
74	Point	745/11	Daurala Check post	11/17/2011	Front	4 Lane Divided	1	1	1	12	N	93.5	<Null>
75	Point	761/11	Dadri	12/4/2011	Front	4 Lane Divided	1	1	1	12	N	93.5	<Null>
26	Point	556/11	Panjabidaba Dasharathpur	8/20/2011	Rear	4 Lane Divided	1	1	0	4.0	N	82.5	<Null>
44	Point	419/11	Pandit Hotel	8/16/2011	Rear	4 Lane Divided	1	0	1	3.1	N	84.5	<Null>
31	Point	223/11	G.T.Road	4/19/2011	Rear	4 Lane Divided	1	1	0	4.8	N	85.3	<Null>
41	Point	365/11	G.T.Road	6/7/2011	Rear	4 Lane Divided	1	1	1	5.8	N	84.2	<Null>

Record: 1 Show: All Selected Records (0 out of 505 Selected) Options

Fig. 5.10 Accident Details on NH-58 (Km 75 – Km 138)

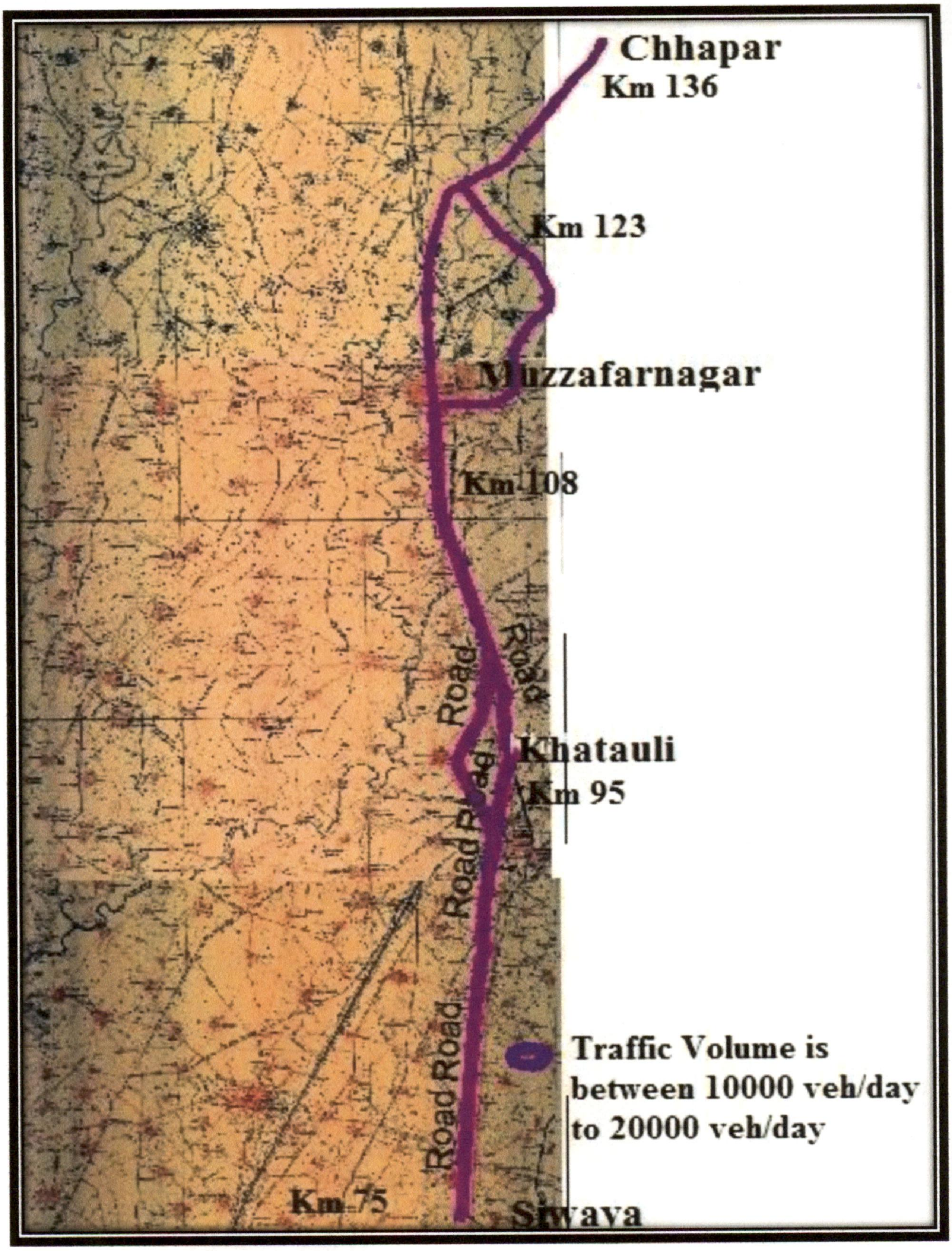

Fig. 5.11 Stretches on NH-58(Km 75-Km 138) with Average daily Traffic between 10,000 Veh/day to 20,000 Veh/day

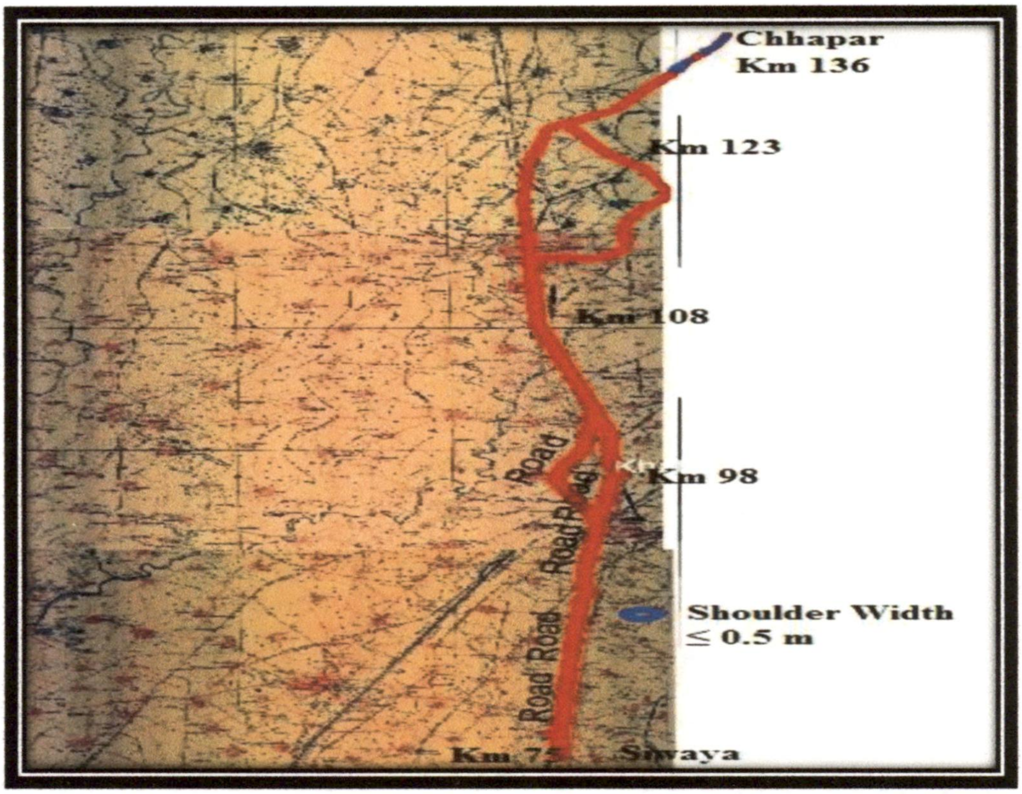

Fig. 5.12 Stretches on NH-58(Km 75 - Km 138) having Shoulder Width ≤ 0.5m

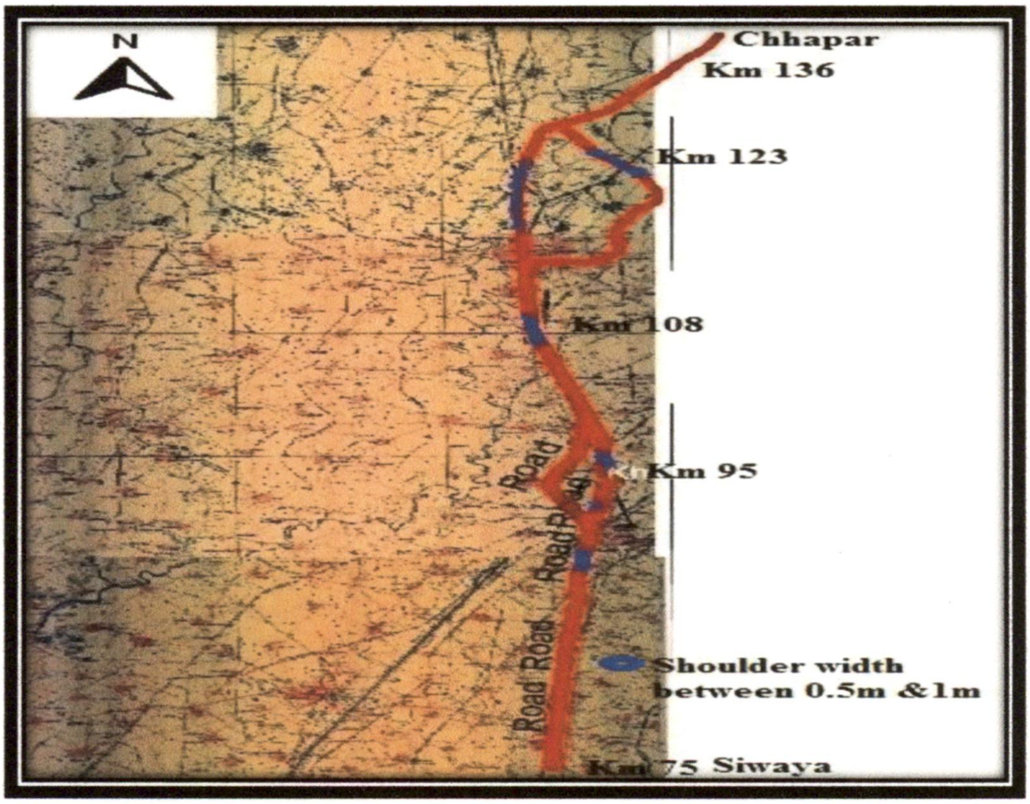

Fig. 5.13 Stretches on NH-58(Km 75 - Km 138) having Shoulder Width between 0.5m to 1m

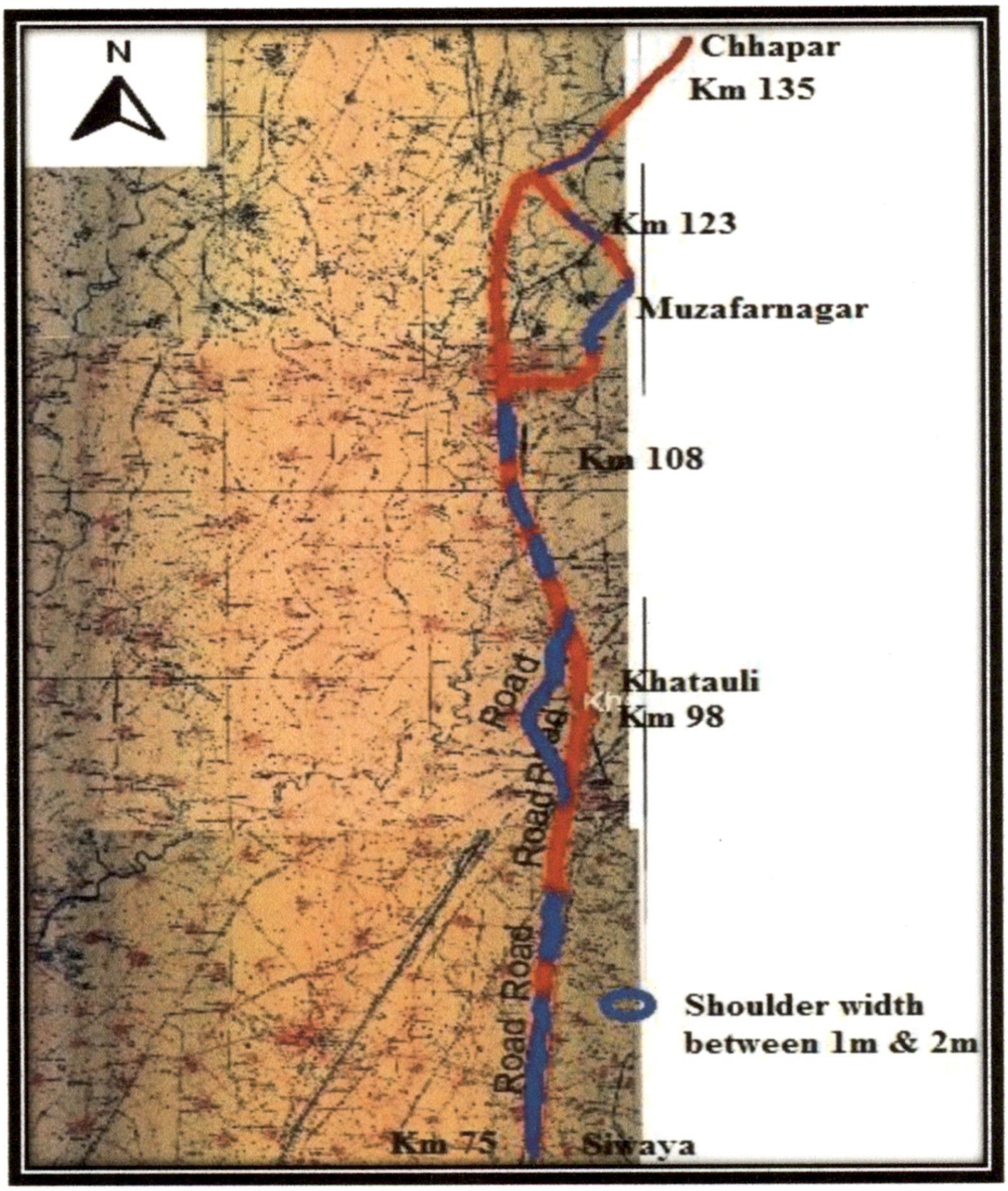

Fig. 5.14 Stretches on NH-58(Km 75 - Km 138) having Shoulder Width between 1m to 2m

5.7.3 Query on Shoulder Type

Fig. 5.15 and Fig. 5.16 shows the ARC-GIS results for the shoulder type based queries on crash data. The inputs for the queries are:

Layer: NH58

Method: Create a New Selection

Field: SHOULDER_TYPE

Query-1: ("SHOULDER_TYPE = 'Brick')

Query-2: ("SHOULDER_TYPE" = 'Earthen')

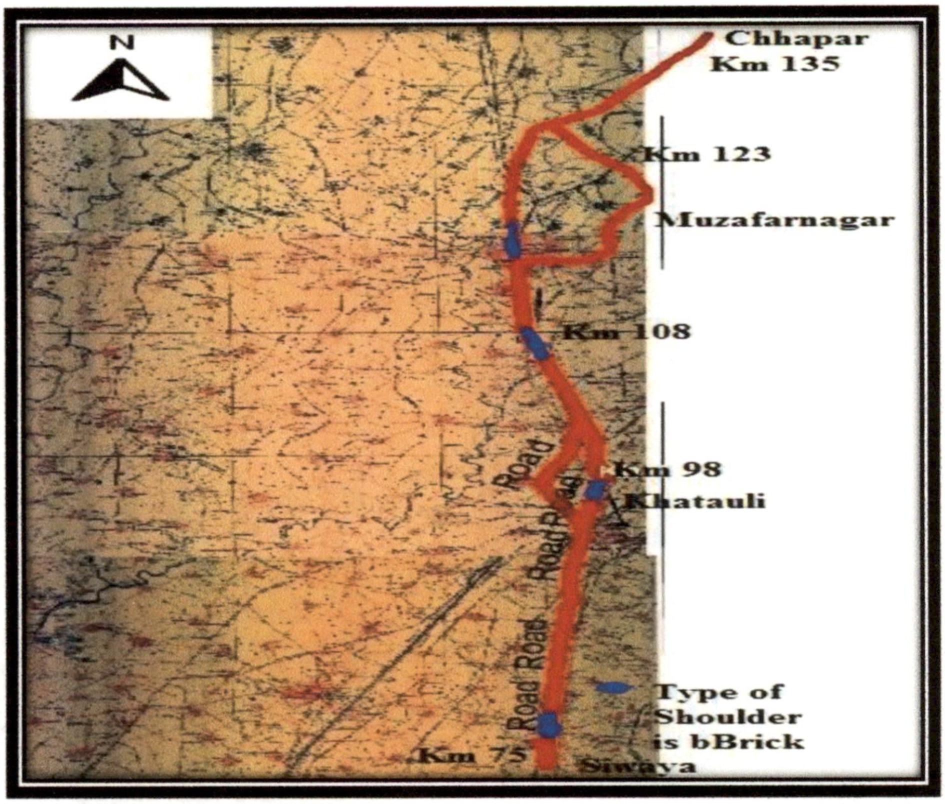

Fig. 5.15 Stretches on NH-58(Km 75 - Km 138) with Shoulder Type = "Brick"

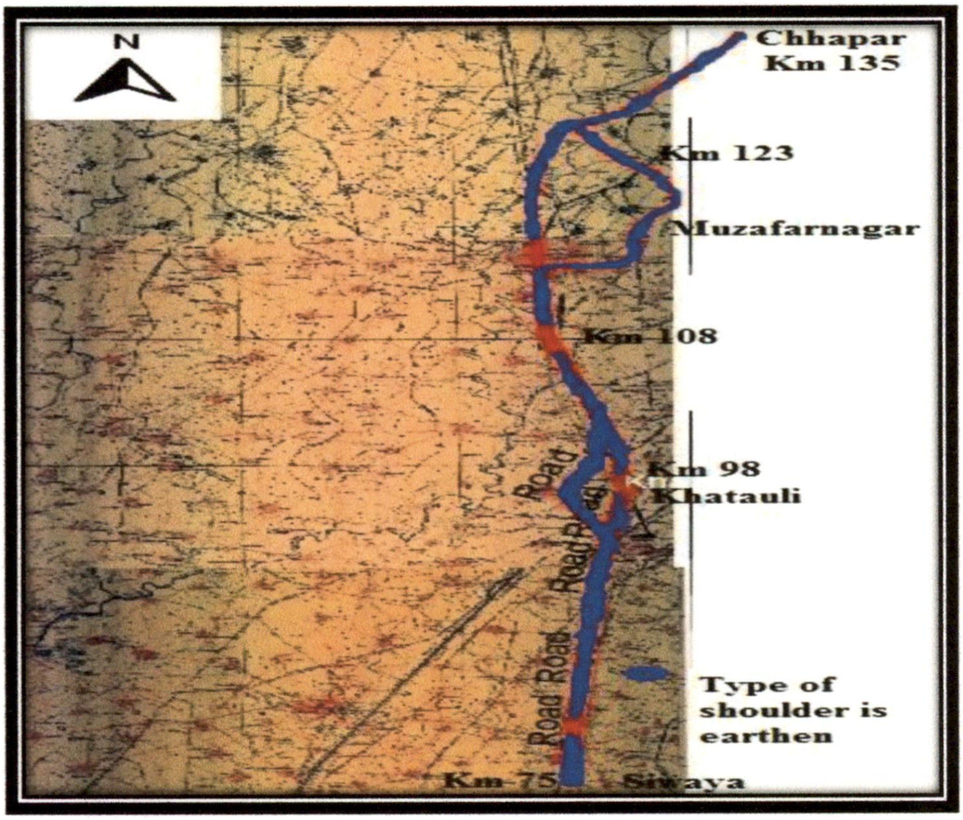

Fig.5.16 Stretches on NH-58(Km 75 - Km 138) with

Shoulder Type = "Earthen"

5.7.4 Query on Median

Fig. 5.17 and Fig. 5.18.shows the ARC-GIS results for the median based queries on crash data. The inputs for the queries are:

Layer: NH58

Method: Create a New Selection

Field: MEDIAN

Query-1: ("MEDIAN" = 'No')

Query-2: ("MEDIAN" = 'Yes')

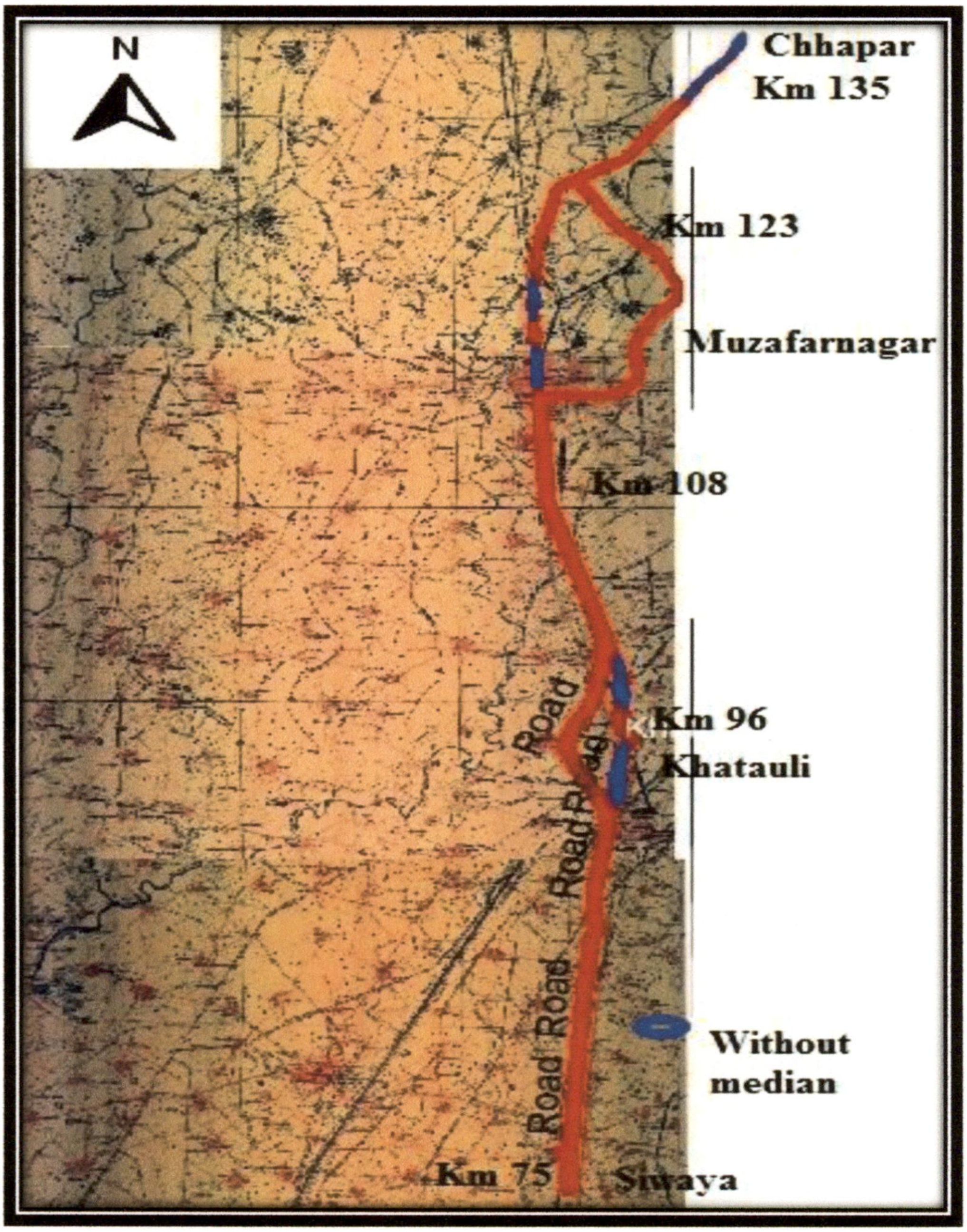

Fig. 5.17 Stretches on NH-58(Km 75 - Km 138) without a Median

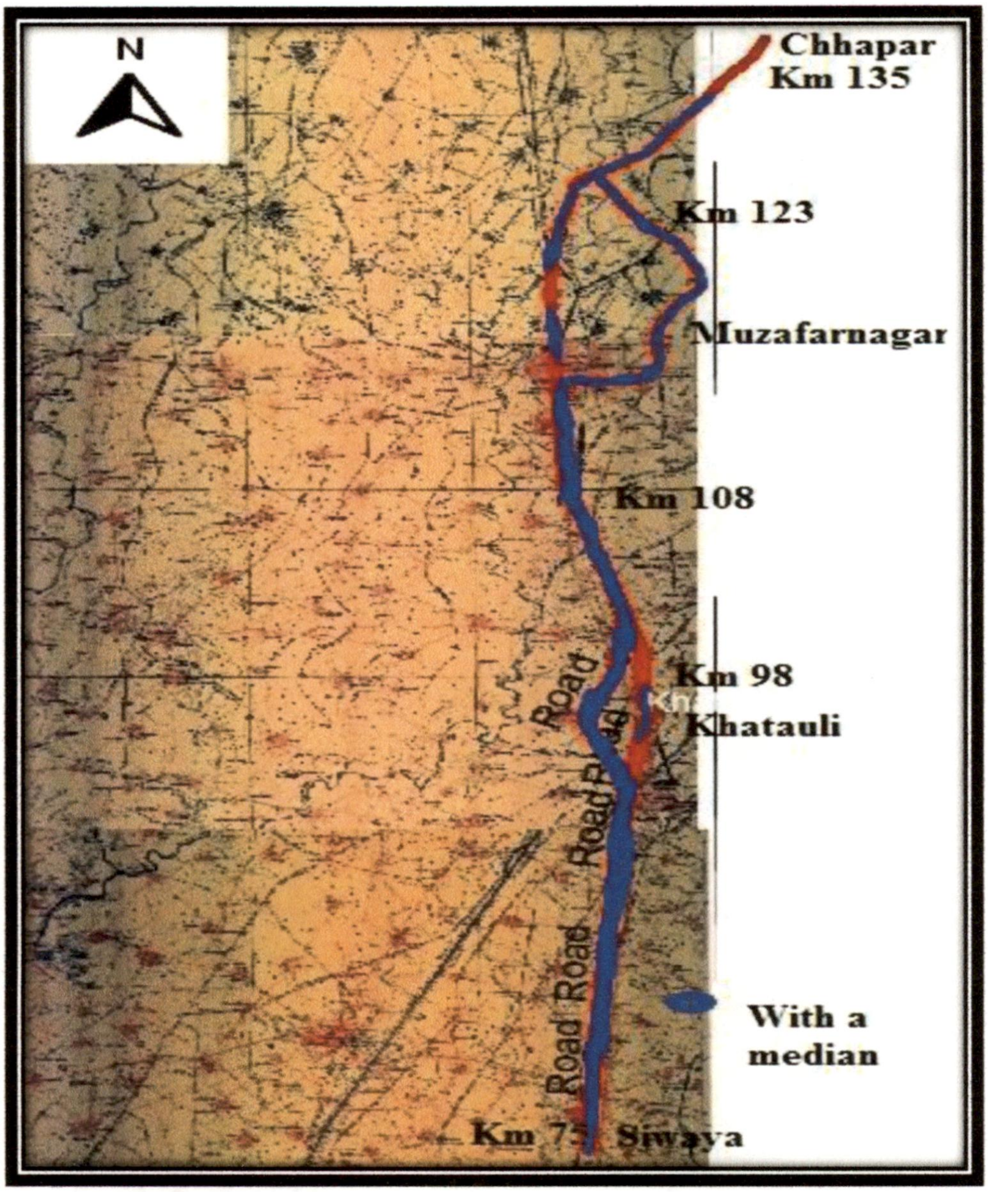

Fig. 5.18 Stretches on NH-58(Km 75 - Km 138) with a Median

5.7.5 Query on Date/ Month/Year Wise

Fig. 5.19 shows the ARC-GIS results for date/month/year based queries on crash data. The inputs for the queries are:

Layer: NH58

Method: Create a New Selection

Field: TIME_MONTH_YEAR

Query-1: ("TIME_DATE_MONTH" <= '12/2/2011')

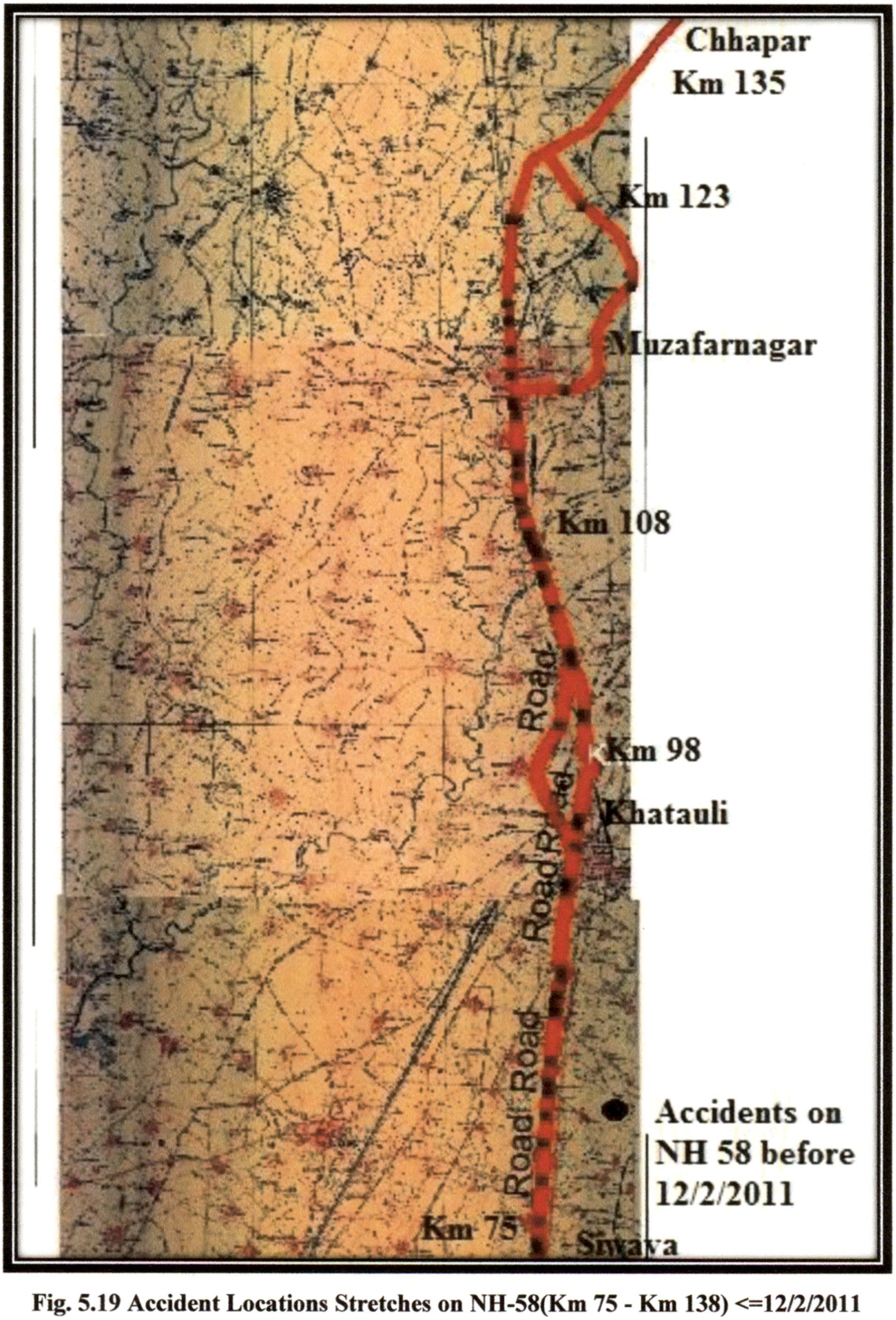

Fig. 5.19 Accident Locations Stretches on NH-58(Km 75 - Km 138) <=12/2/2011

5.8 Queries on Accident Black Spots

As mentioned in the previous chapter, Accident Black spots are identified by using the "Critical Crash rate factor method".

A location is classified as an Accident Black spot if the ratio of the Crash rate of the section to the Critical crash rate of the particular type of facility is greater than 1.5.

Figures 5.20 to 5.22 show the ARC-GIS 9.3 results for Accident Black Spots. For this analysis, all the crash data is attached to the attribute table of the NH58 layer. The crash rate, traffic base, critical crash rate and crash ratio for all the sections have been calculated and are attached to the NH58 road layer.

The inputs for the queries are:

Layer: NH58

Method: Create a New Selection

Field(s): CRASH_RATIO, KM

Query-1: ("KM" > 'Km83-84' AND "KM" < 'Km85-86' AND
"CRASH_RATIO" >1.5)

Query-2: ("KM" > 'Km97-98' AND "KM" < 'Km108-110' AND
"CRASH_RATIO" >1.5)

Fig. 5.23 and Fig. 5.24 shows the details of two identified Accident Black Spots in ARC-GIS 9.3 Table 5.4 shows the details of all the identified accident black spots on NH58 (from Km 75-Km 138).

5.9 Remedial Measures

The remedial measures are needed to be undertaken for all the Accident Prone stretches and locations. Through onsite investigations it is established that most of the accident black spots are situated on the curves or near intersection, wherein shoulder width happens to be the most important factor governing the accidents. The traffic volume, mix of the volume and spot speed are amongst the other important factors responsible for accidents. The remedial measures for three sample accident prone spots have been suggested based on the causes of accidents and through onsite investigations in Table 5.5.

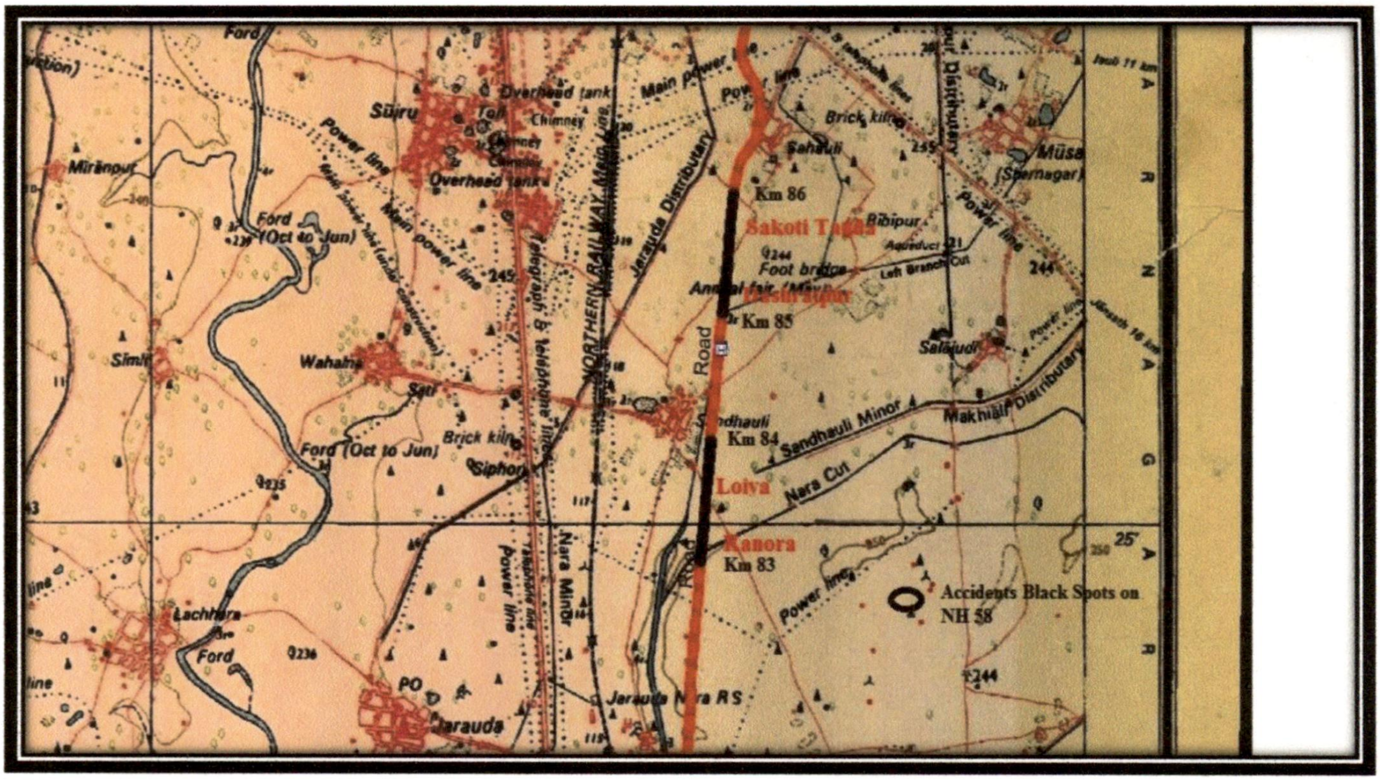

Fig. 5.20 Accident Black Spots on NH-58 (between Km 83 –Km 86)

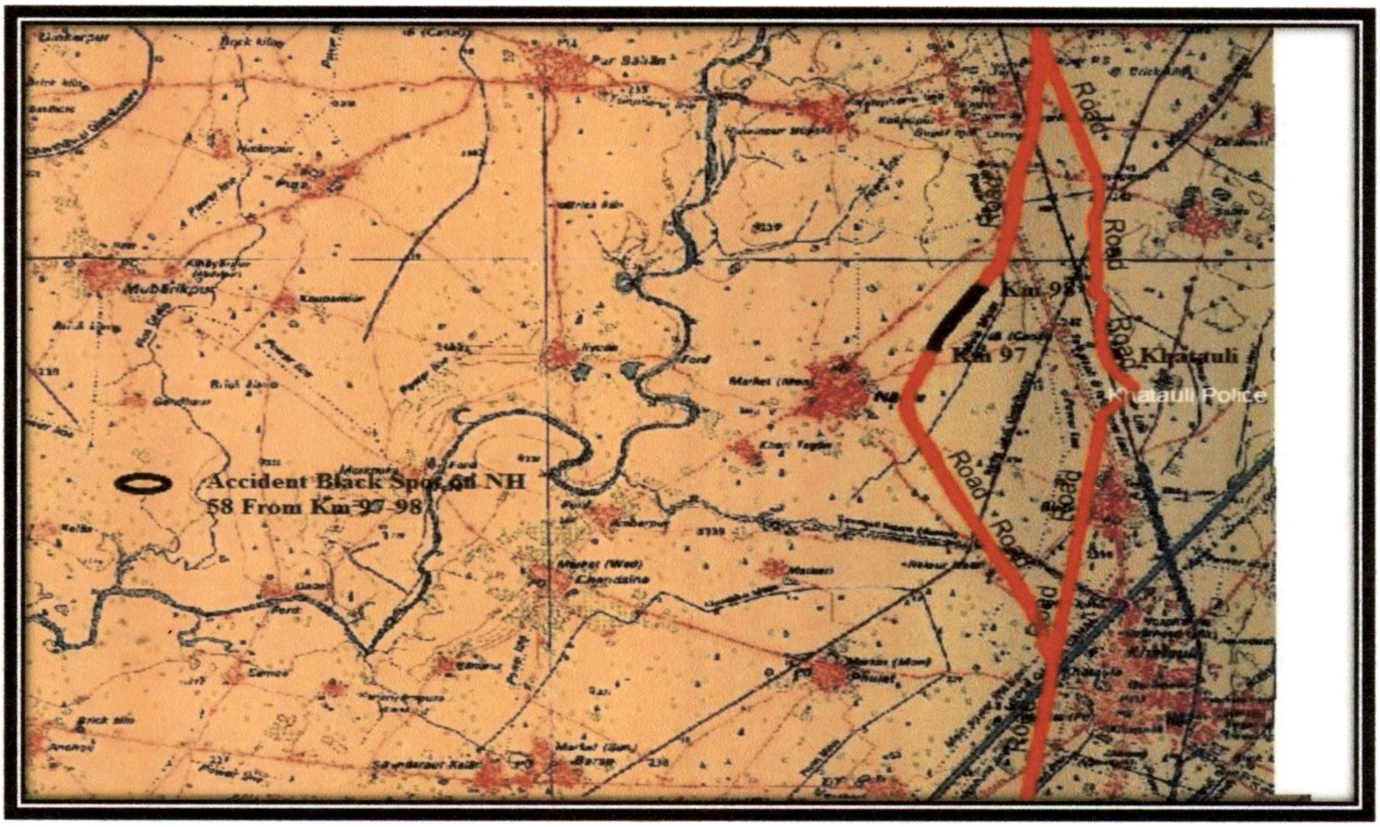

Fig. 5.21 Accident Black Spots on NH-58 (between Km 97 –Km 98)

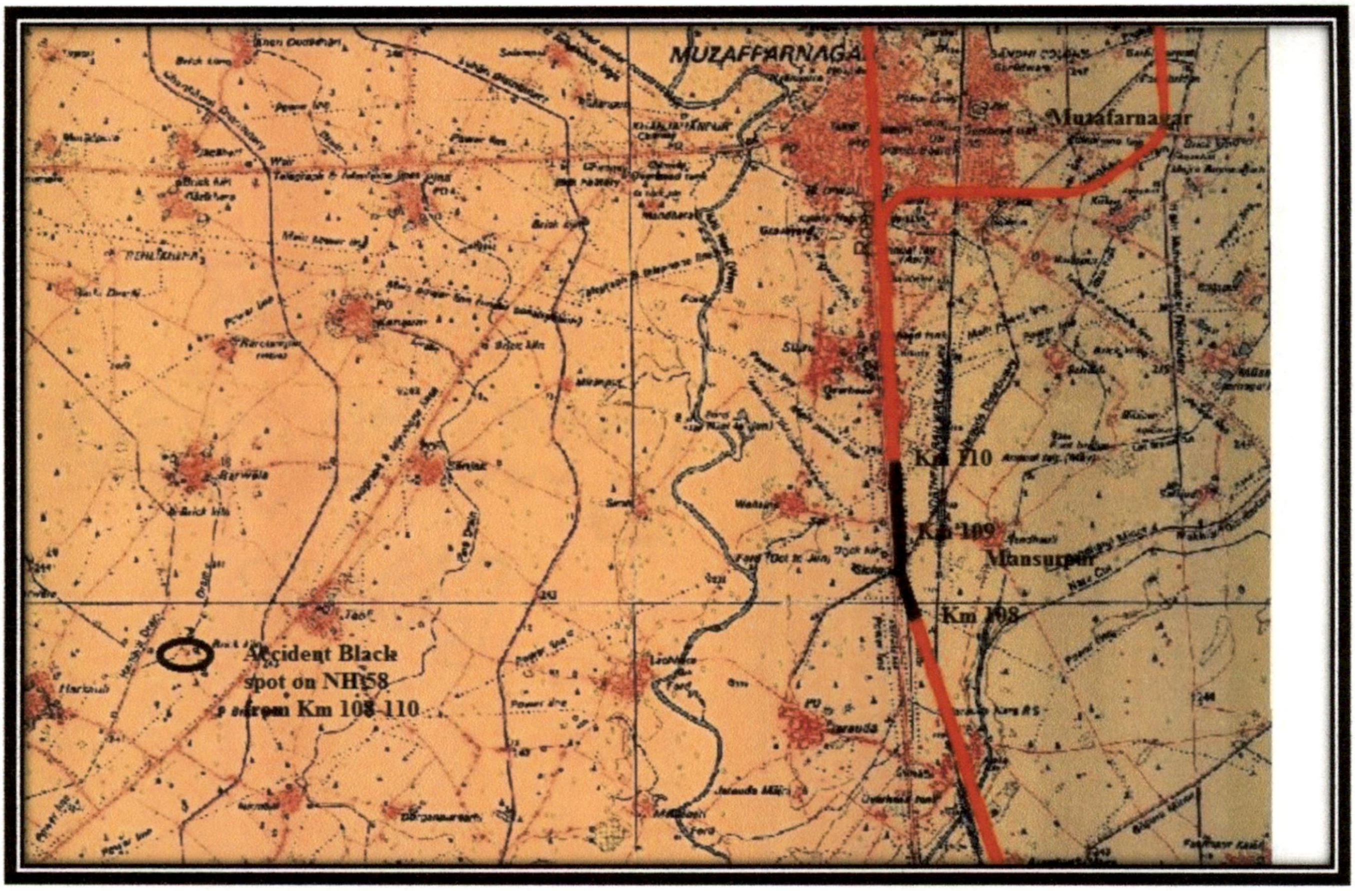

Fig. 5.22 Accident Black Spots on NH-58 (between Km108-Km110)

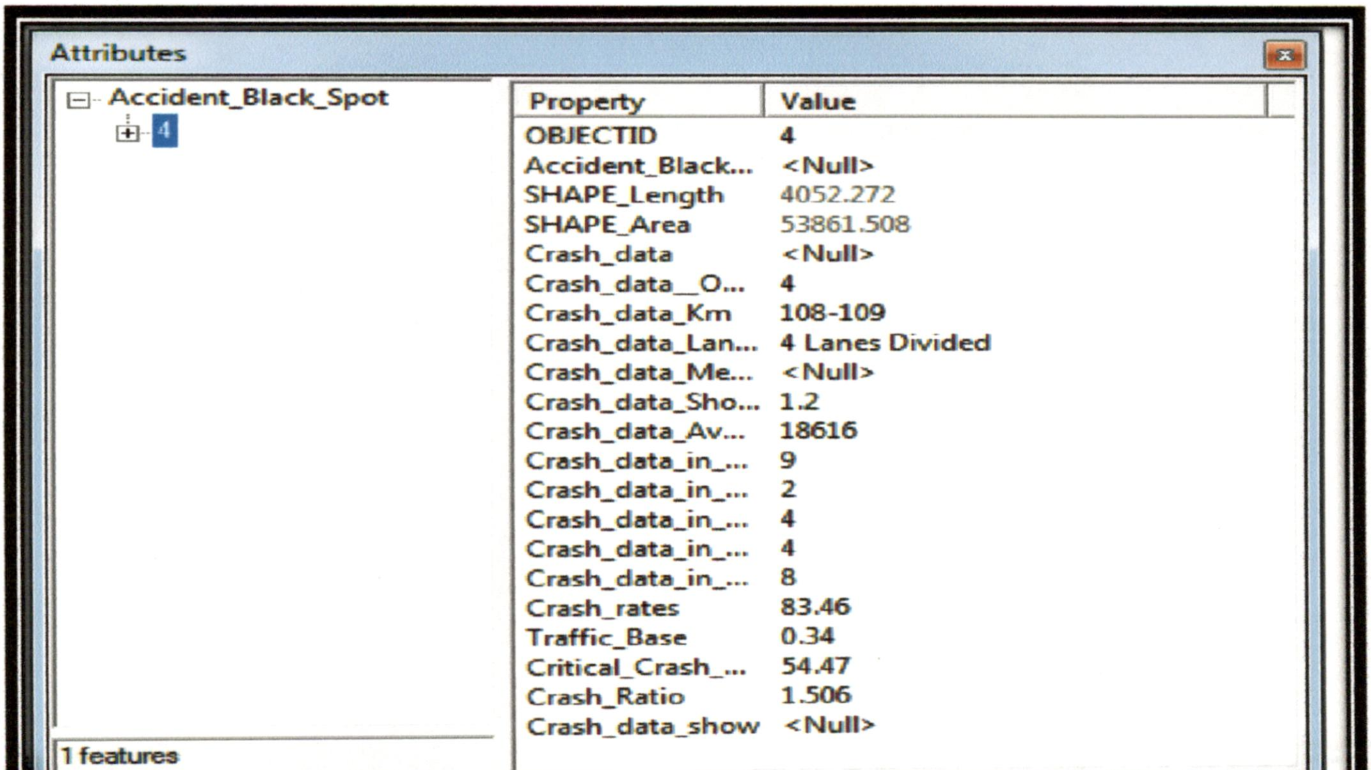

Fig. 5.23 Details of an Accident Black Spot (Km 108-109)

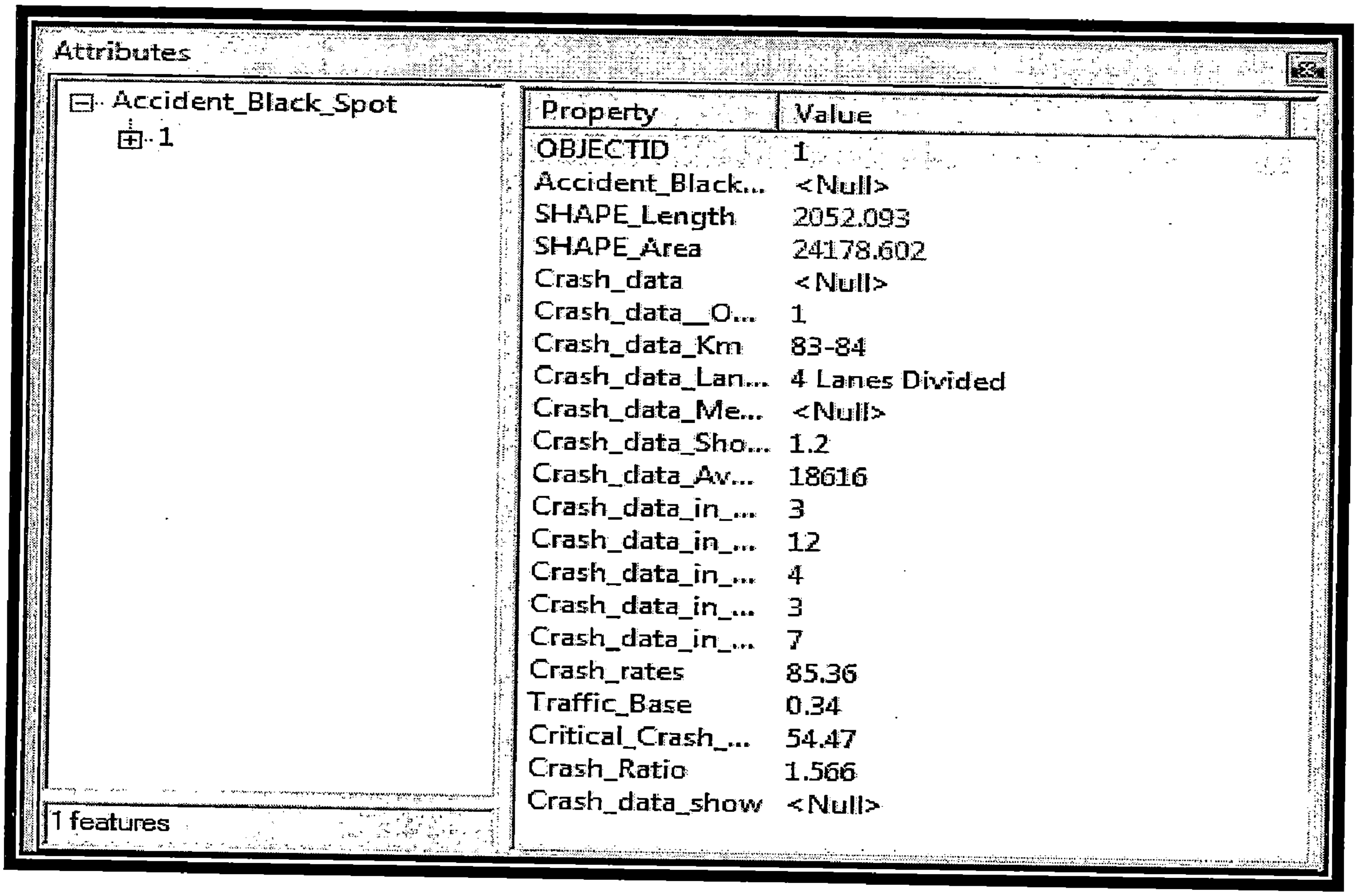

Fig. 5.24 Details of an Accident Black Spot (Km 83-84)

Table 5.4 Details of the Accident Black Spots on NH58 (from Km75-Km138)

S.No	Km	Shoulder length (in m)	Average Volume (Veh/Day)	Crashes in 2007	Crashes in 2008	Crashes in 2009	Crashes in 2010	Crashes in 2011	Total Crashes (2007-2011)	Crash Rate (Crashes/100 million veh/Km per 5 years)	Critical Crash Rate (Crashes/100 million veh/Km per 5 years)	Crash Ratio
1	Km 83-84	1.2	18616	3	12	4	3	7	29	85.36	54.47	1.56
2	Km 85-86	1.2	18616	5	9	4	12	1	31	91.25	54.47	1.67
3	Km 97-98	1.8	18616	10	4	7	7	3	31	91.25	54.47	1.67
4	Km 108-109	1.2	18616	9	2	4	4	8	27	83.46	54.47	1.51
5	Km 109-110	1.2	18616	9	4	6	11	4	34	100.08	54.47	1.83

Table 5.5 Remedial Measures Evolved

S. No	Accident Black Spots on NH58 (from Km 75-Km 138)	Cause of Accident	Remedial Measures	Location Name
1	Km 83-86	1. Mixed traffic volume is high (No of vehicles=**12580 veh/day** and 47.982% Trucks composition) 2. Trucks are parked on the road shoulder. 3. Steep left hand curve @86.00 is dangerous.	1.Separation of mixed traffic and provision of service road for segregating ADV's & other small motor vehicles 2. Truck lay byes required 3 Geometric design of the road should be improved.	@Km 83.40 – Kanora Village @Km 83.60 – Loiya Village @Km 84.20 – Ruhasa Village @Km 85.00 – Dashratpur @ Km85.30 – Jamalpur Village @Km 85.60 – Sakoti Village @Km 85.80 – Nagli Village
2	Km 97-98	1. No cautionary signs for curve (left turn) indication. 2. Profile of the road is not good for both vertical and horizontal curve 3.Shoulders are in sufficient (0.4 m)	1. Cautionary signs are required. 2. Profile of the road needs to be improved. 3. Increase the shoulders width (1.5m)	@Km 97.50 – Kheri Village
3	Km 108-109	1. Two wheelers, cycles and pedestrians are crossing over the median.	1. Median opening is required.	@Km 108.40 – Muzaffarnagar Electrical main station

4	Km 109-110	1. No cautionary signs at curve areas. 2. No lane marking 3. High pedestrian movement over the median. 4. Shoulders are insufficient	1. Cautionary signs are required. 2. Lane marking is required. 3. Provide underpass or overpass for pedestrians 4. Increase the shoulder width.	@Muzaffarnagar Electrical Station

CHAPTER-6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the present study, following conclusions have been drawn:

1. In the last five years (2007-2011), the total crashes are decreased on NH58 from Km 75 to Km 138 and also kilometer wise road accidents are decreased and these are shown in Fig.5.1 and Fig.5.2 - 5.6 respectively.
2. The critical crash rate factor method is an easy-to-use statistical test method, which is very effective in identifying accident-prone stretches for four lanes divided National Highways.
3. From Fig. 5.7 it is clear that maximum number of crashes occur during the weekends, this may be due to the large number of tourists coming to Haridwar and Rishikesh.
4. From Fig. 5.8 it is evident that maximum number of crashes occurs in the months of August and December. This may be due to the onset of rainy season in august and due to the fog in the month of December.
5. The peak period for crashes comes out to be between 14.00 - 16.00 hrs.
6. On the basis of "Critical Crash Rate factor Method", following sections of 1Km each have been identified as accident black spots on NH58(from Km 75-Km138) and are given in Table 6.1.

Table 6.1 Accident Black Spots based on "Critical Crash Rate factor Method"

S.No:	Km Range	Crash Ratio
1	83-84	1.57
2	85-86	1.67
3	97-98	1.67
4	108-109	1.51
5	109-110	1.83

7. The above sections have been identified has Accident Black Spots based on the last 5-years (2007-2011) accident data.

8. The crash ratio developed for the sections can be used for prioritizing safety development program.

6.2 Recommendations

I. An accident rating scheme for sample stretches on NH-58 can be developed to prioritize accident improvement measures.

II. In view of lack of awareness many a time important in formations like collision diagrams and exact location of accident is not recorded. Effort is made to record each accident as well as type of accidents and design a data base for better analysis with simplified data input performa. This will be useful to analyze the accidents in a rational manner to increase the safety on roads.

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I. mallikarjunareddy, P., Govind, V., Kumar, C.N., Parida, M. and Jain, S.S., "**Identification of Accident Black Spots for National Highway using GIS**", presented at International Conference on **Emerging Trends in Engineering and Technology** held at TMU, Moradabad from April 6 to 7, 2012.

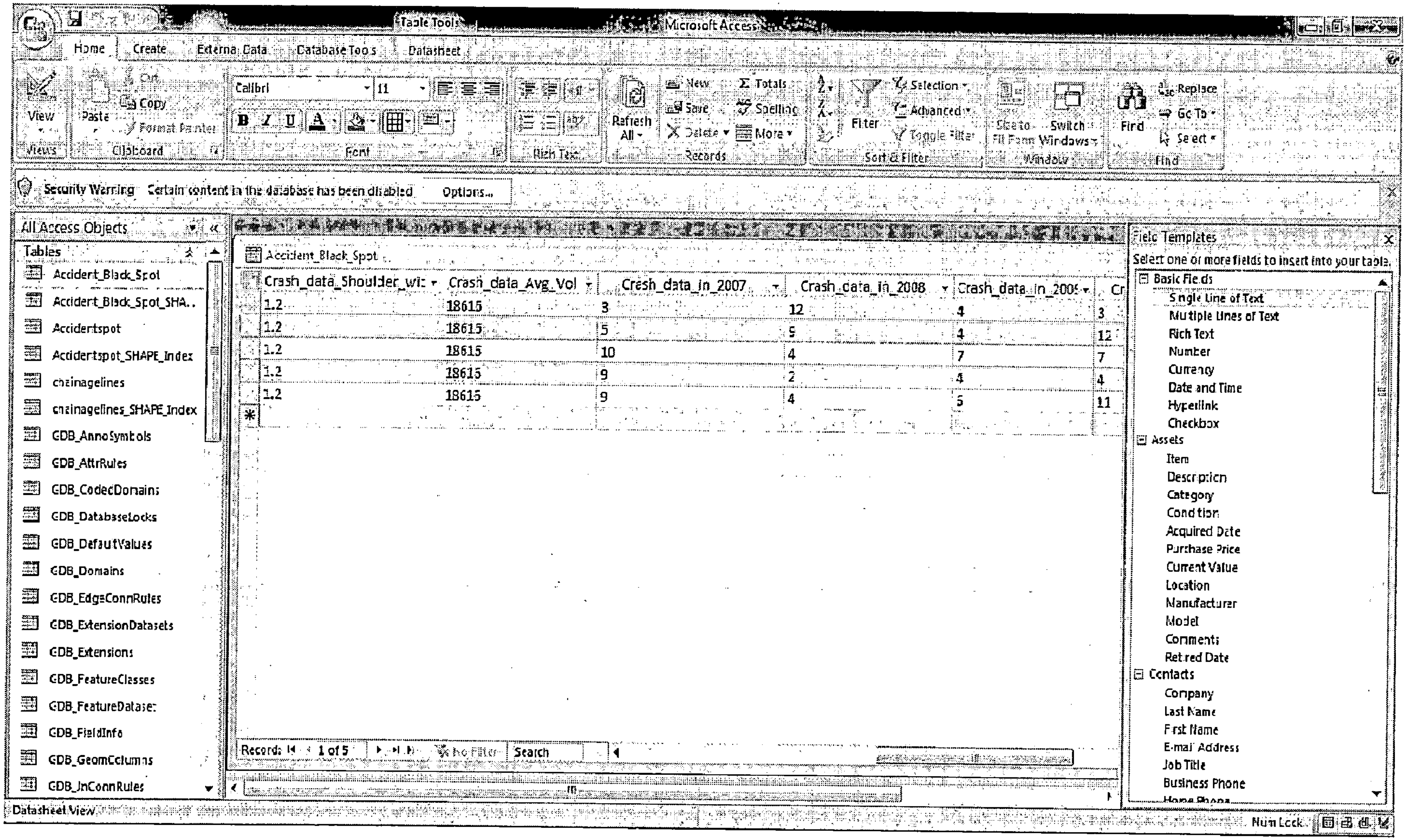
ANNEXURE-1: Performa for Accident Data

CIVIL ENGINEERING DEPARTMENT

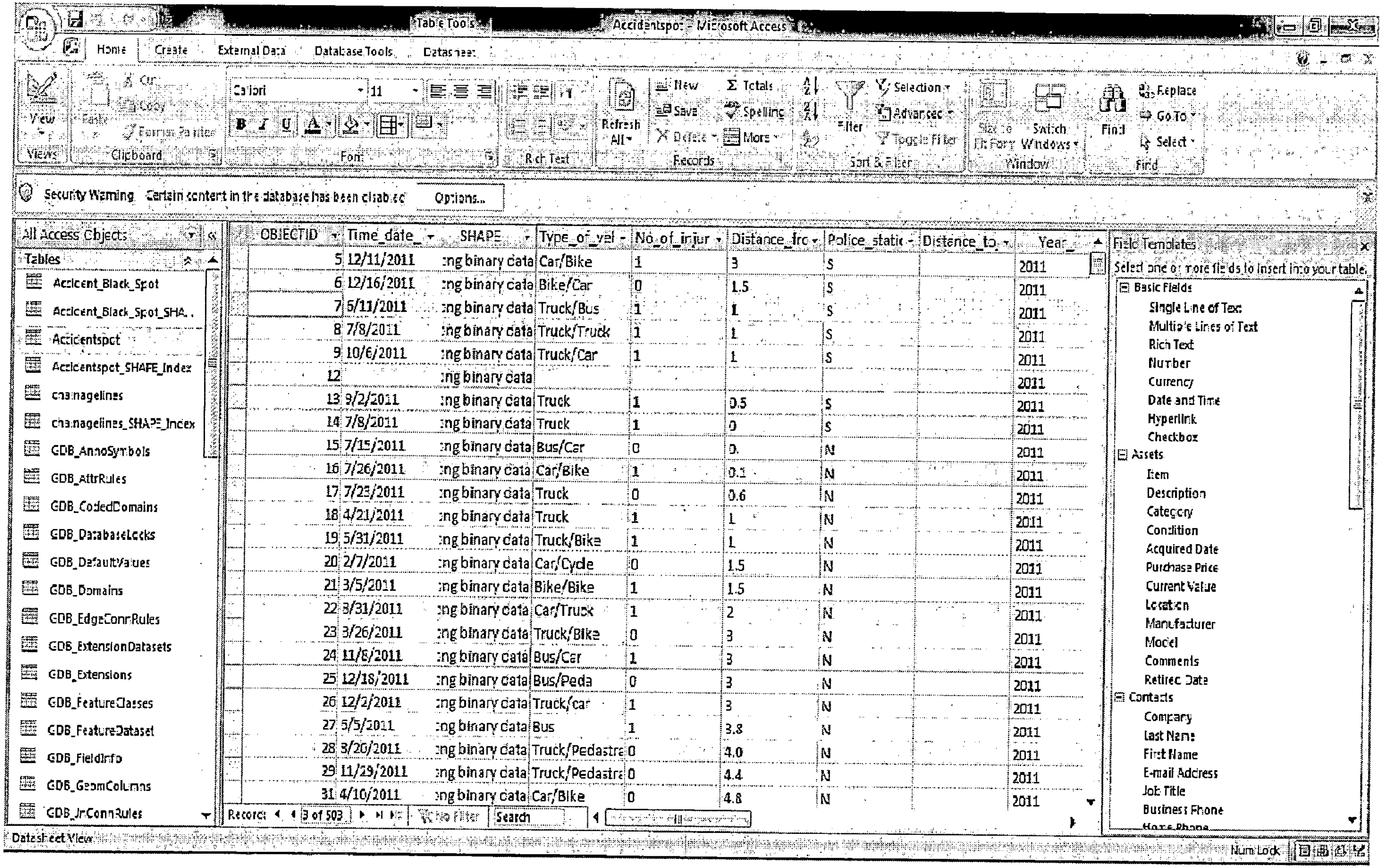
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE, ROORKEE

FIR No.	Date/Day/Time	Location of Accident	Details of Accident	Vehicles involved	Possible Reasons	Any Other information(s)

ANNEXURE-2: Accident Black Spot Attributes

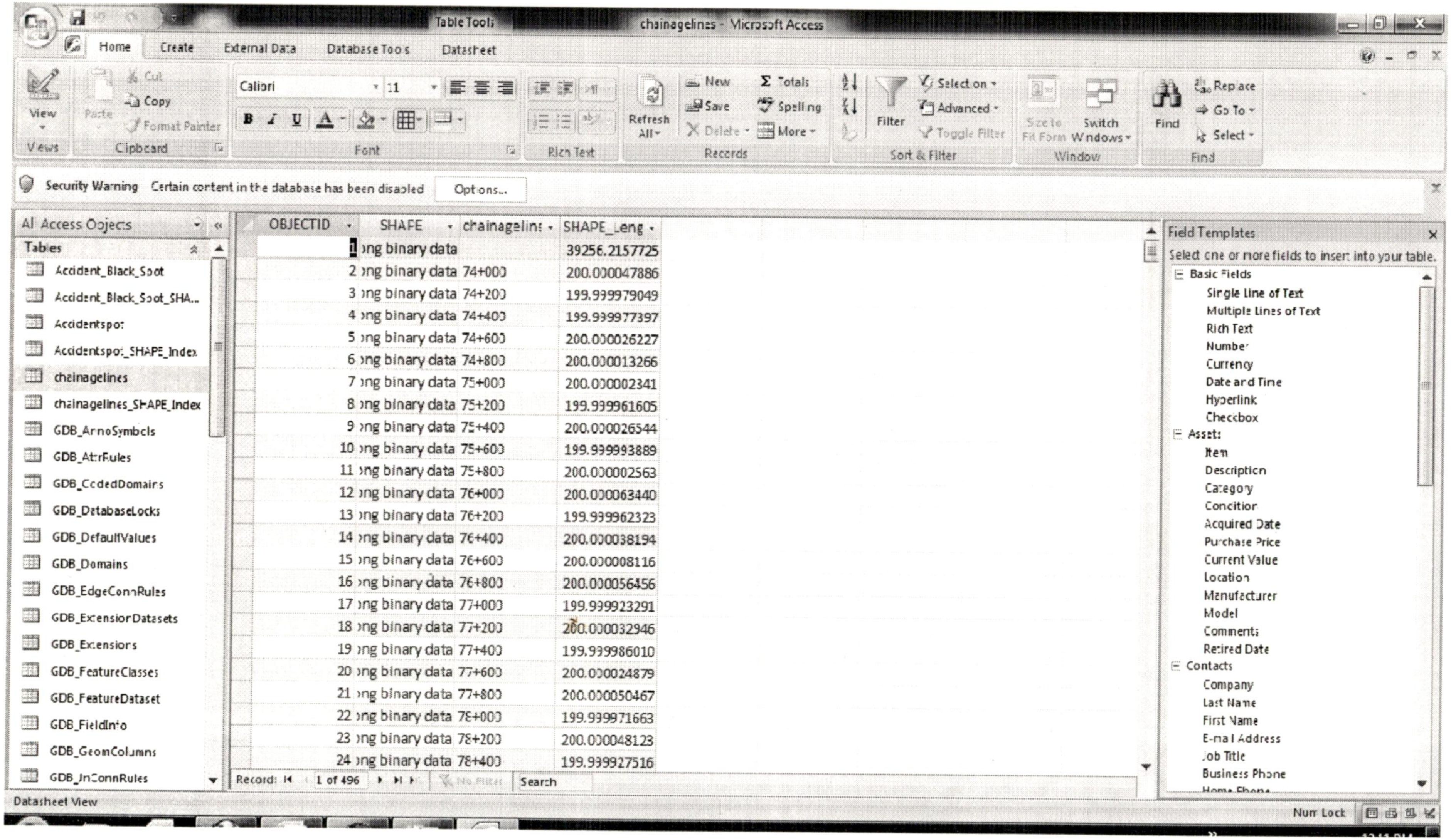


ANNEXURE-3: Accident Attributes

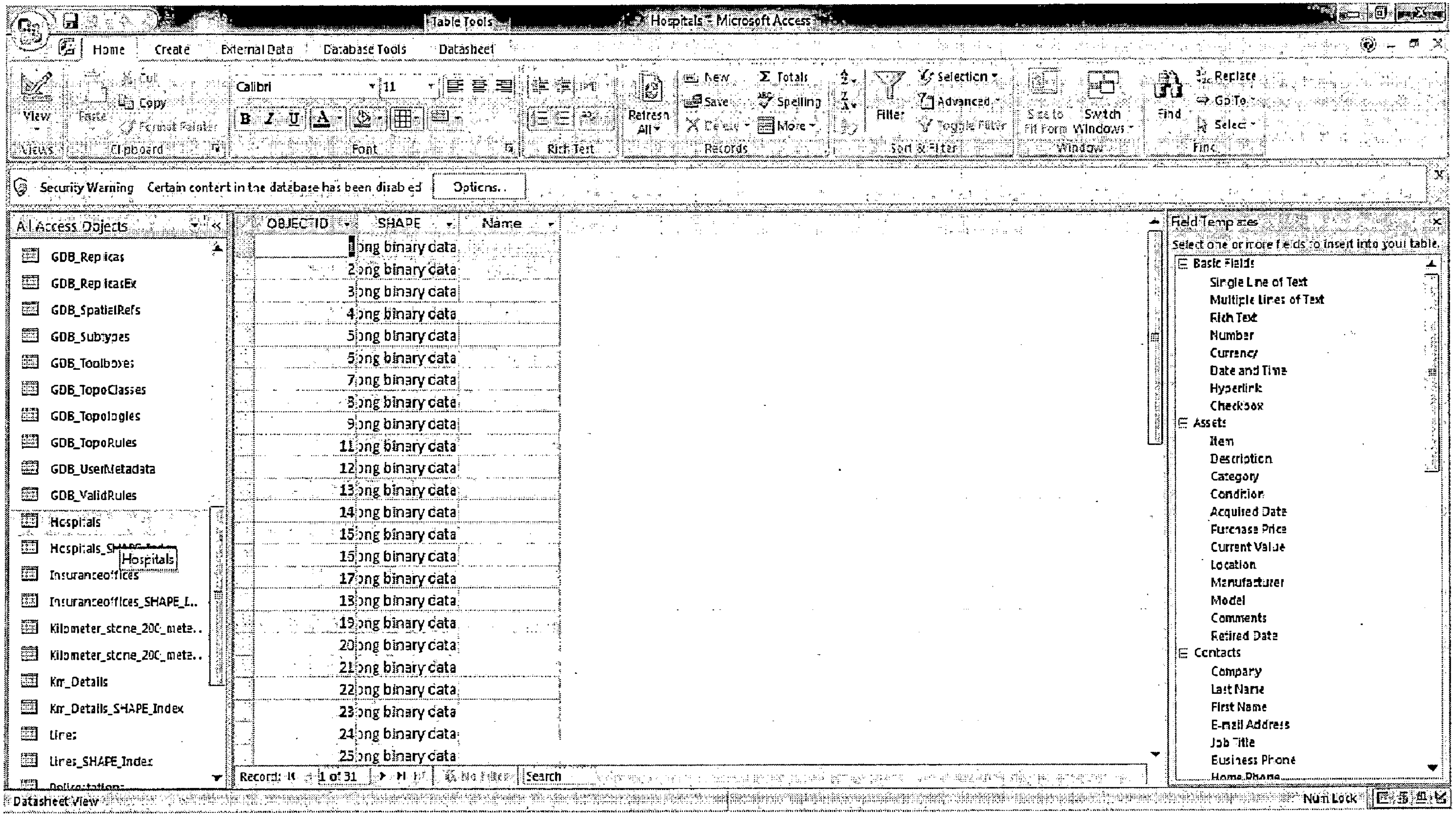


OBJECTID	Time_date_	SHAPE	Type_of_vel	No_of_injur	Distance_fro	Police_static	Distence_to	Year_
5	12/11/2011	:ng binary data	Car/Bike	1	3	S		2011
6	12/16/2011	:ng binary data	Bike/Car	0	1.5	S		2011
7	5/11/2011	:ng binary data	Truck/Bus	1	1	S		2011
8	7/8/2011	:ng binary data	Truck/Truck	1	1	S		2011
9	10/6/2011	:ng binary data	Truck/Car	1	1	S		2011
12		:ng binary data						2011
13	9/2/2011	:ng binary data	Truck	1	0.5	S		2011
14	7/8/2011	:ng binary data	Truck	1	0	S		2011
15	7/15/2011	:ng binary data	Bus/Car	0	0.	N		2011
16	7/26/2011	:ng binary data	Car/Bike	1	0.1	N		2011
17	7/23/2011	:ng binary data	Truck	0	0.6	N		2011
18	4/21/2011	:ng binary data	Truck	1	1	N		2011
19	5/31/2011	:ng binary data	Truck/Bike	1	1	N		2011
20	2/7/2011	:ng binary data	Car/Cycle	0	1.5	N		2011
21	3/5/2011	:ng binary data	Bike/Bike	1	1.5	N		2011
22	3/31/2011	:ng binary data	Car/Truck	1	2	N		2011
23	3/26/2011	:ng binary data	Truck/Bike	0	3	N		2011
24	11/8/2011	:ng binary data	Bus/Car	1	3	N		2011
25	12/18/2011	:ng binary data	Bus/Peda	0	3	N		2011
26	12/2/2011	:ng binary data	Truck/car	1	3	N		2011
27	5/5/2011	:ng binary data	Bus	1	3.8	N		2011
28	3/20/2011	:ng binary data	Truck/Pedastre	0	4.0	N		2011
29	11/29/2011	:ng binary data	Truck/Pedastre	0	4.4	N		2011
31	4/10/2011	:ng binary data	Car/Bike	0	4.8	N		2011

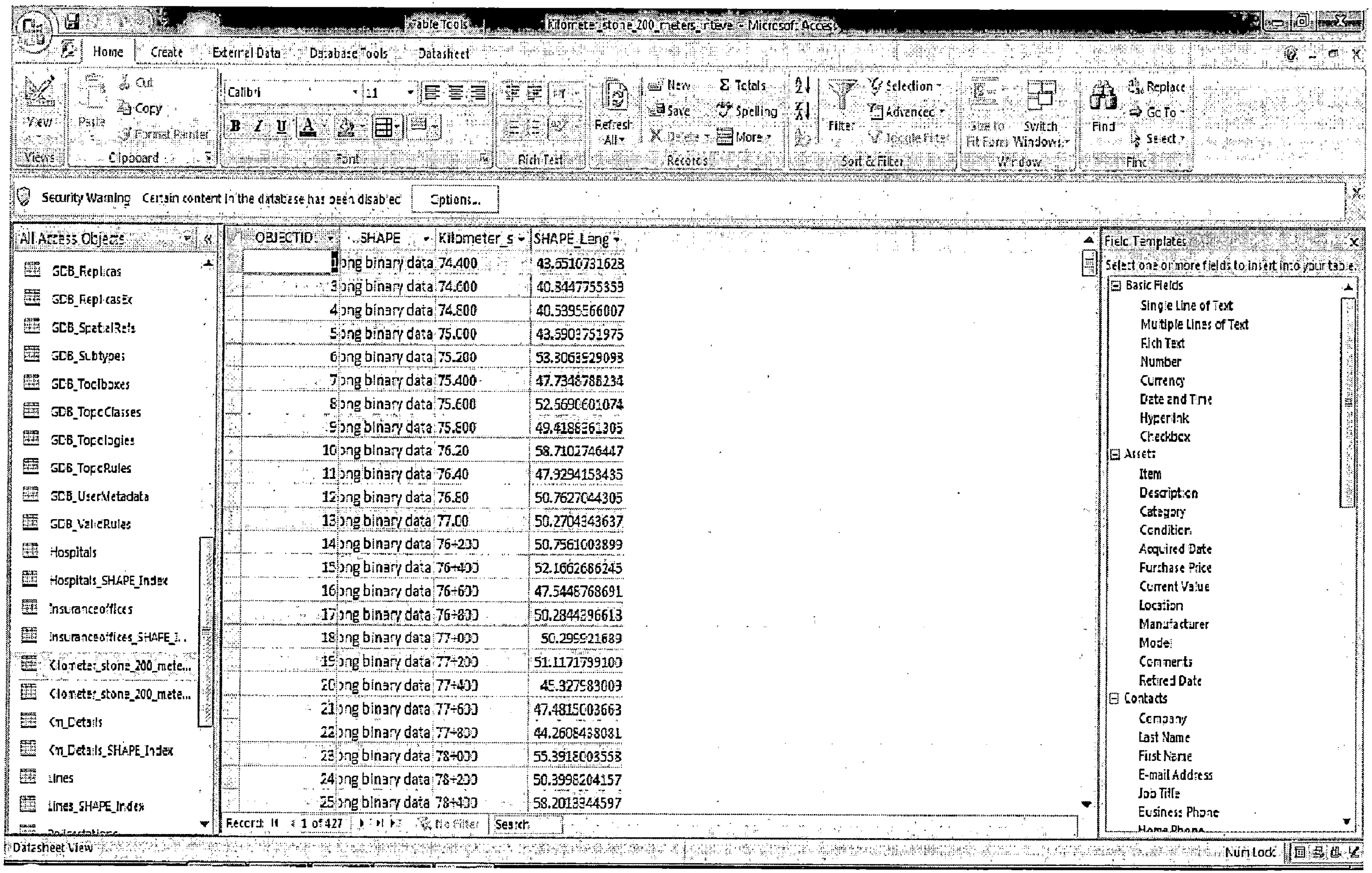
ANNEXURE-4: Chainage lines Attributes



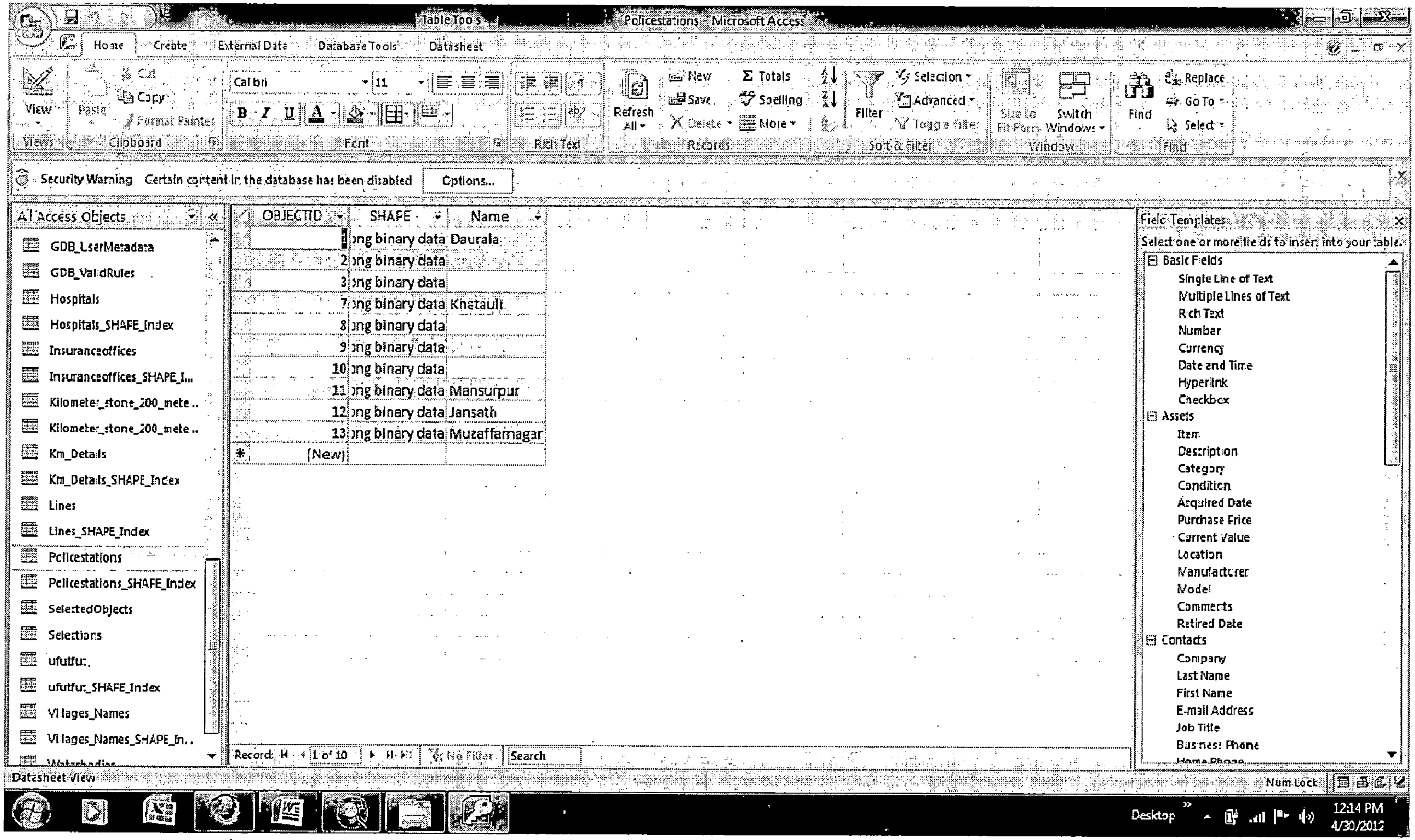
ANNEXURE-5: Hospital Attributes



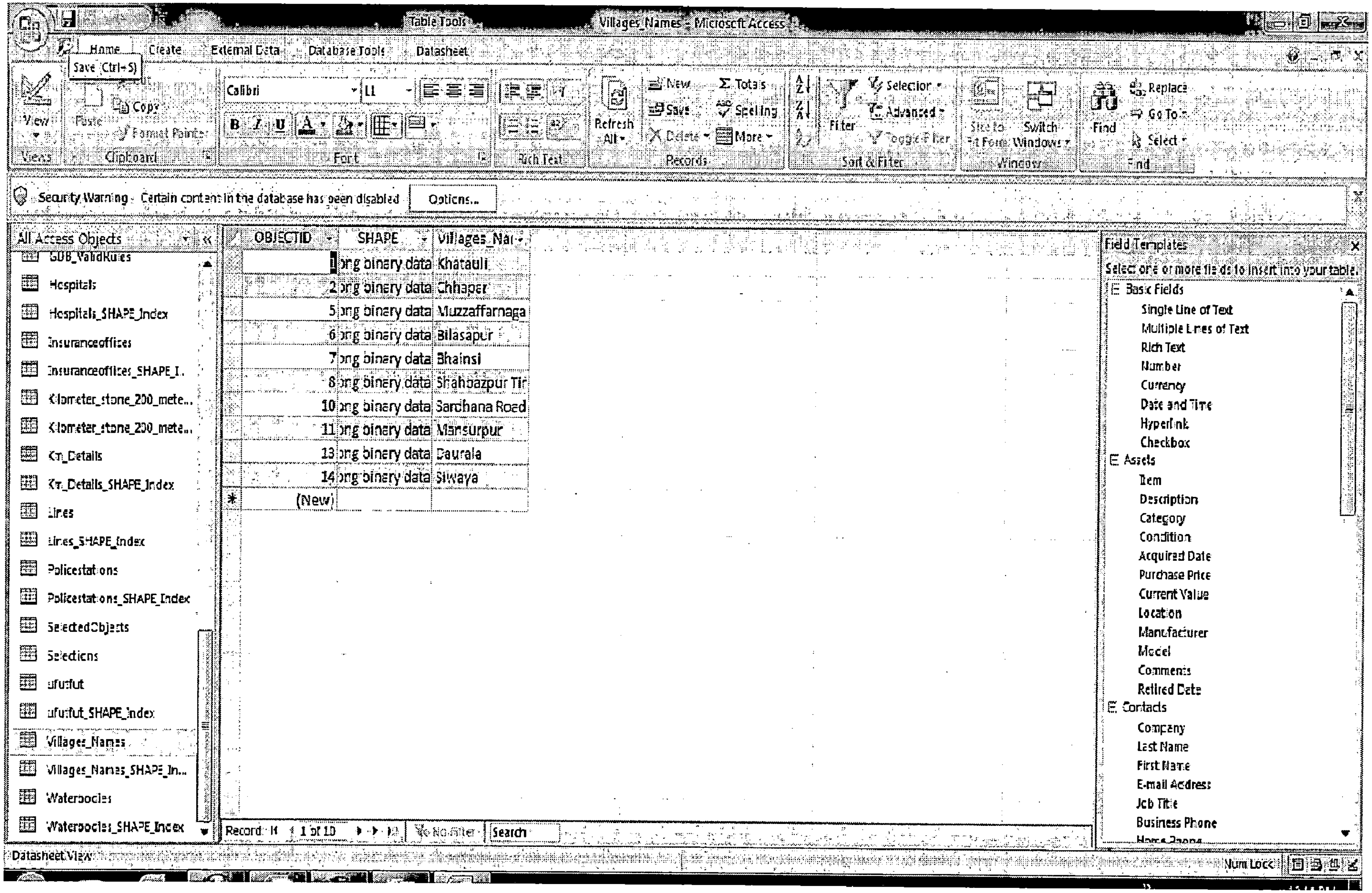
ANNEXURE-6: Km lines@200 meters Attributes



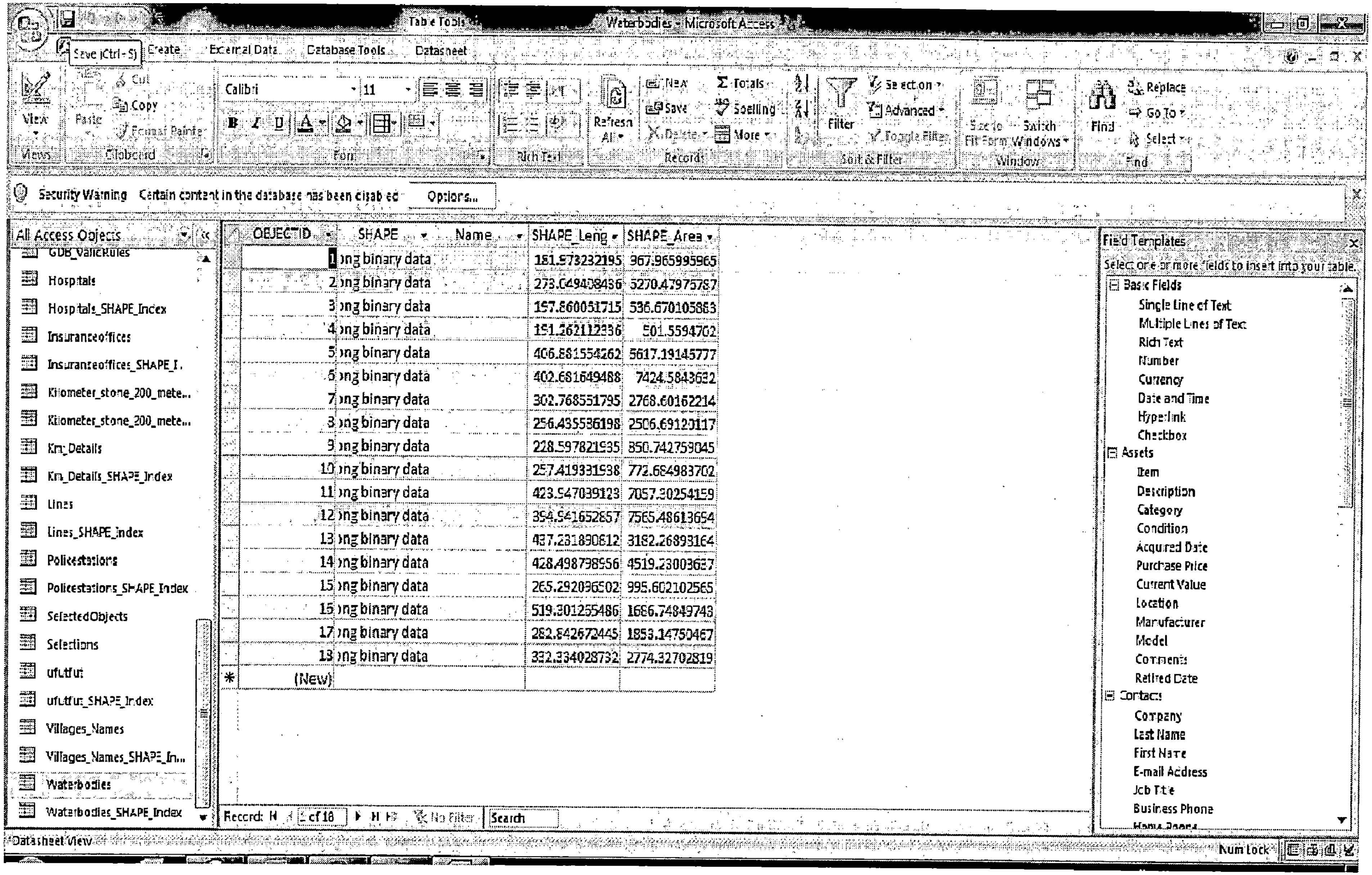
ANNEXURE-7: Police Stations Attributes



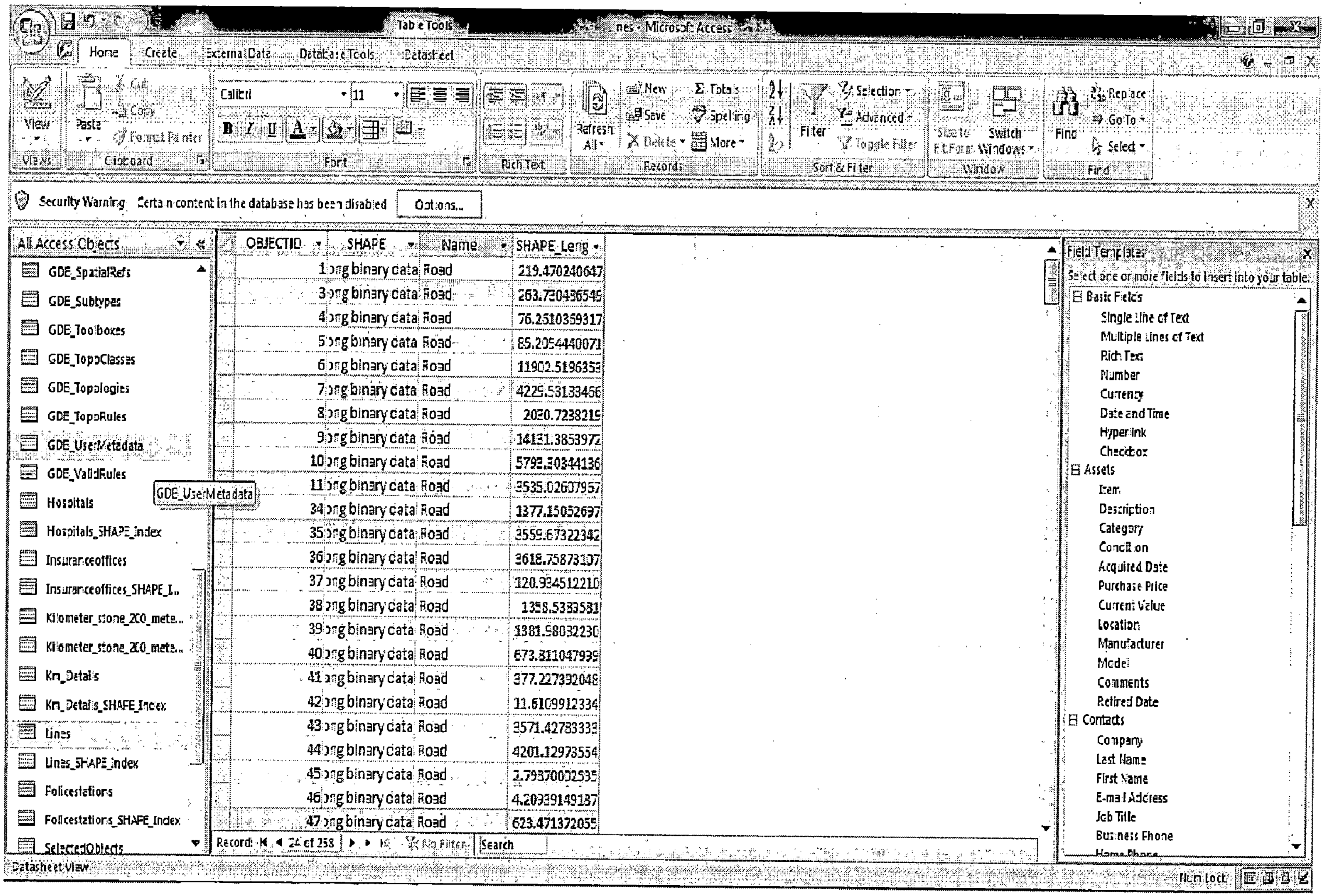
ANNEXURE-8: Villages Names Attributes



ANNEXURE-9: Water Bodies Attributes



ANNEXURE-10: Median and Road Attributes



ANNEXURE-11: Kilometer Wise Details of Crash Data on NH58 (From Km75-Km138)

S.No	KM	NO.OF LANES	PRESENCE OF MEDIAN	SHOULDER TYPE	SHOULDER LENGTH (in	A.D.T (Veh/day)	TOTAL CRASHES	CRASH RATE (crashes/100million veh/Km per 5 years)	CRITICAL CRASH RATE (crashes/100million veh/Km per 5 years)	CRASH RATIO
1	75-76	4 Lane Divided	YES	EARTHEN	2.5	18616	26	76.529	52.73	1.451
2	76-77	4 Lane Divided	YES	EARTHEN	2.5	18616	23	67.698	52.73	1.284
3	77-78	4 Lane Divided	YES	EARTHEN	2.5	18616	25	73.585	52.73	1.396
4	78-79	4 Lane Divided	YES	EARTHEN	2.5	18616	9	26.491	52.73	0.502
5	79-80	4 Lane Divided	YES	EARTHEN	2.5	18616	23	67.698	52.73	1.284
6	80-81	4 Lane Divided	YES	EARTHEN	2.5	18616	16	47.095	52.73	0.893
7	81-82	4 Lane Divided	YES	EARTHEN	2.5	18616	22	64.755	52.73	1.228
8	82-83	4 Lane Divided	YES	EARTHEN	2.5	18616	10	29.434	52.73	0.558
9	83-84	4 Lane Divided	YES	EARTHEN	2.5	18616	29	85.359	52.73	1.619
10	84-85	4 Lane Divided	YES	EARTHEN	2.5	18616	24	70.642	52.73	1.340
11	85-86	4 Lane Divided	YES	EARTHEN	2.5	18616	31	91.246	52.73	1.731
12	86-87	4 Lane Divided	YES	EARTHEN	2.5	18616	20	58.868	52.73	1.116
13	87-88	4 Lane Divided	YES	EARTHEN	2.5	18616	8	23.547	52.73	0.447
14	88-89	4 Lane Divided	YES	EARTHEN	2.5	18616	10	29.434	52.73	0.558
15	89-90	4 Lane Divided	YES	EARTHEN	2.5	18616	2	5.887	52.73	0.112
16	90-91	4 Lane Divided	YES	EARTHEN	2.5	18616	4	11.774	52.73	0.223
17	91-92	4 Lane Divided	YES	EARTHEN	2.5	18616	15	44.151	52.73	0.837
18	92-93	4 Lane Divided	YES	EARTHEN	2.5	18616	6	17.660	52.73	0.335
19	93-94	4 Lane Divided	YES	EARTHEN	2.5	18616	8	23.547	52.73	0.447
20	94-95	4 Lane Divided	YES	EARTHEN	2.5	18616	10	29.434	52.73	0.558
21	95-96	4 Lane Divided	YES	EARTHEN	2.5	18616	12	35.321	52.73	0.670
22	96-97	4 Lane Divided	YES	EARTHEN	2.5	18616	22	64.755	52.73	1.228
23	97-98	4 Lane Divided	YES	EARTHEN	2.5	18616	31	91.246	52.73	1.731
24	98-99	4 Lane Divided	YES	EARTHEN	2.5	18616	11	32.378	52.73	0.614

25	99-100	4 Lane Divided	YES	EARTHEN	2.5	18616	21	61.812	52.73	1.172
26	100-101	4 Lane Divided	YES	EARTHEN	2.5	18616	11	32.378	52.73	0.614
27	101-102	4 Lane Divided	YES	EARTHEN	2.5	18616	9	26.491	52.73	0.502
28	102-103	4 Lane Divided	YES	EARTHEN	2.5	18616	9	26.491	52.73	0.502
29	103-104	4 Lane Divided	YES	EARTHEN	2.5	18616	10	29.434	52.73	0.558
30	104-105	4 Lane Divided	YES	EARTHEN	2.5	18616	11	32.378	52.73	0.614
31	105-106	4 Lane Divided	YES	EARTHEN	2.5	18616	8	23.547	52.73	0.447
32	106-107	4 Lane Divided	YES	EARTHEN	2.5	18616	25	73.585	52.73	1.396
33	107-108	4 Lane Divided	YES	EARTHEN	2.5	18616	25	73.585	52.73	1.396
34	108-109	4 Lane Divided	YES	EARTHEN	2.5	18616	27	79.472	52.73	1.507
35	109-110	4 Lane Divided	YES	EARTHEN	2.5	18616	34	100.076	52.73	1.898
36	110-111	4 Lane Divided	YES	EARTHEN	2.5	18616	23	67.698	52.73	1.284
37	111-112	4 Lane Divided	YES	EARTHEN	2.5	18616	13	38.264	52.73	0.726
38	112-113	4 Lane Divided	YES	EARTHEN	2.5	18616	11	32.378	52.73	0.614
39	113-114	4 Lane Divided	YES	EARTHEN	2.5	18616	14	41.208	52.73	0.782
40	114-115	4 Lane Divided	YES	EARTHEN	2.5	18616	8	23.547	52.73	0.447
41	115-116	4 Lane Divided	YES	EARTHEN	2.5	18616	2	5.887	52.73	0.112
42	116-117	4 Lane Divided	YES	EARTHEN	2.5	18616	2	5.887	52.73	0.112
43	117-118	4 Lane Divided	YES	EARTHEN	2.5	18616	2	5.887	52.73	0.112
44	118-119	4 Lane Divided	YES	EARTHEN	2.5	18616	4	11.774	52.73	0.223
45	119-120	4 Lane Divided	YES	EARTHEN	2.5	18616	3	8.830	52.73	0.167
46	120-121	4 Lane Divided	YES	EARTHEN	2.5	18616	5	14.717	52.73	0.279
47	121-122	4 Lane Divided	YES	EARTHEN	2.5	18616	9	26.491	52.73	0.502
48	122-123	4 Lane Divided	YES	EARTHEN	2.5	18616	1	2.943	52.73	0.056
49	123-124	4 Lane Divided	YES	EARTHEN	2.5	18616	2	5.887	52.73	0.112
50	124-125	4 Lane Divided	YES	EARTHEN	2.5	18616	5	14.717	52.73	0.279
51	125-126	4 Lane Divided	YES	EARTHEN	2.5	18616	4	11.774	52.73	0.223
52	126-127	4 Lane Divided	YES	EARTHEN	2.5	18616	3	8.830	52.73	0.167
53	127-128	4 Lane Divided	YES	EARTHEN	2.5	18616	1	2.943	52.73	0.056
54	128-129	4 Lane Divided	YES	EARTHEN	2.5	18616	0	0.000	52.73	0.000
55	129-130	4 Lane Divided	YES	EARTHEN	2.5	18616	0	0.000	52.73	0.000
56	130-131	4 Lane Divided	YES	EARTHEN	2.5	18616	4	11.774	52.73	0.223

57	131-132	4 Lane Divided	YES	EARTHEN	2.5	18616	4	11.774	52.73	0.223
58	132-133	4 Lane Divided	YES	EARTHEN	2.5	18616	2	5.887	52.73	0.112
59	133-134	4 Lane Divided	YES	EARTHEN	2.5	18616	2	5.887	52.73	0.112
60	134-135	4 Lane Divided	YES	EARTHEN	2.5	18616	3	8.830	52.73	0.167
61	135-136	4 Lane Divided	YES	EARTHEN	2.5	18616	2	5.887	52.73	0.112
62	136-137	4 Lane Divided	YES	EARTHEN	2.5	18616	1	2.943	52.73	0.056
63	137-138	4 Lane Divided	YES	EARTHEN	2.5	18616	0	0.000	52.73	0.000