Accident Black Spots Identification for Safety Improvement on a Section of Dhaka-Chittagong Highway

by

Mohammed Abdus Samad

A project thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF ENGINEERING (CIVIL & TRANSPORTATION)

Department of Civil Engineering

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

January, 2003

The thesis titled " **Accident Black Spots Identification for Improvement of Safety on a Section of Dhaka-Chittagong Highway** " submitted by **Mohammad Abdus Samad, Roll No: 9504404 (P), Session: 1994-95-96** has been accepted as satisfactory in partial fulfillment of the requirement for the degree of **Master of Engineering (Civil and Transportation)** in January, 2003

BOARD OF EXAMINERS

Dr. Md. Jobair Bin Alam — **Chairman**
Associate Professor — (Supervisor)
Department of Civil Engineering
BUET, Dhaka.

Dr. Md. Mazharul Hoque — **Member**
Professor, Department of Civil Engineering
And
Director, Accident Research Center
BUET, Dhaka.

Dr. Tanweer Hasan — **Member**
Associate Professor
Department of Civil Engineering.
BUET, Dhaka.

CANDIDATE'S DECLARATION

It is hereby declared that the research work reported in this thesis was performed by me as a research project in partial fulfillment of the requirements for the degree of Master of Engineering (Civil & Transportation) from Bangladesh University of Engineering and Technology (BUET).

This project report contain no material which has been accepted for the award of any other degree or diploma from any other institution. Further, to the best of my knowledge and belief, the project contains no material previously published or written by any other persons, except when due reference is made in the text.

January, 2003

Mohammed Abdus Samad

TABLE OF CONTENTS

Chapter 4: Data Collection and Analysis

Chapter 5: Conclusions and Recommendation

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

RTA	Road Traffic Accident
PDO	Property Damaged Only
PCE	Passenger Car Equivalent
RHD	Roads and Highways Department
ICMH	Institute of Child and Mother Health
ESCAP	Economic and Social Commission for Asia and the Pacific
AASHTO	American Association of State Highways and Transportation Officials
BUET	Bangladesh University of Engineering and Technology
CASR	Committee for Advanced Studies and Research
NRSC	National Road Safety Council
FIR	First Information Report
WB	World Bank
TRRL	Transport and Road Research Laboratory
GDP	Gross Domestic Product
GNP	Gross National Product
BTCE	Bureau of Transport Communication and Economics

ACKNOWLEDGMENT

The research was supervised by **Dr. Md. Jobair Bin Alam,** Associate Professor, Dept. of Civil Engineering, Bangladesh University of Engineering and Technology (BUET). The author is deeply obliged to him and wishes to express profound gratitude and acknowledgement for his constant guidance and patience.

Very special words of appreciation go to the members of examination committee Professor Dr. Md. Mazharul Hoque and Dr. Tanweer Hasan, Associate Professor, Department of Civil Engineering, BUET, for giving their valuable time and suggestions.

Special gratitude is expressed for Dr. Medhat Attia, Director General, Society of Social Reform (SSR), Kuwait (Bangladesh Office), for his assistance. The author is thankful to Dr. Md. S. Kiwan, Associate Professor, Dept. of Civil Engineering, Ahsanullah University of Science and Technology (AUST) for his assistance and advice regarding successful completion of the project work. The author is also thankful to Mr. Lokman, Project officer, Society of Social Reform (SSR), for cooperation extended by him for the realization of this work. The author also likes to thank staff members of Demra and Siddirgonj Police Stations, for providing accident data and other useful information.

Above all the author is indebted to his parents, wife (Suma) and family members for their deep concern, encouragement and blessings during this research.

ABSTRACT

This thesis presents the findings of the study concerned with accident blackspot identification for improvement of safety on the Jatrabari-Kanchpur Bridge section of Dhaka-Chittagong highway. The selected section of Dhaka-Chittagong highway is composed of three intersections and nine links. The study examines the trends and characteristics of the accident problem for identifying the dominant accident types which need to be addressed in future initiatives. A total of 356 Accidents occurred on this highway section in a time period of 4 years from January 1998 to December 2001. Out of total 356 reported accidents, 34% occurred at or near intersections and remaining 66% occurred on links of selected section of highway. The accidents occurring in the study area are classified as 49% fatal, 39% injury, 12% property damaged. The involvement of pedestrian in the accidents occurring in the study area is significant comprising 54.21 percent amongst the various classes of road users. Rear end accident is also identified as a dominant problem. In the study area, occurrence of accident is higher during day time than night time and the frequency of the occurrence of accident is the highest between 8 AM to 12 at Noon. Buses are involved in 40 percent of total accidents, followed by trucks and mini buses with 30 and 9 percent, respectively. Detailed investigation of black spots are made using available accident data, field investigations and video data.

For the purpose of the analysis, information available from FIR, Accident Report Forms and Register books is coded into a number of variables to correlate occurrence of accident with traffic system variables. Eight relevant variables are extracted and used in subsequent analysis. As blackspots are related with roadway environment related variables, on the basis of the variables mentioned above the involvement of road environment is analyzed by using 'Principal Component Analysis (PCA)' method. The aggregate factor weight of roadway environment in the total number of accidents occurring at a location is graphed onto the roadway section. The locations where the aggregate weight of roadway environment factor is more than the average is identified as blackspot.

From the analysis, five locations are identified as accident black spots. The locations are Jatrabari intersection, Dania College, ICMH at Matuil, Saddam market and Kanchpur Bridge (western part). The highest number of accident occurred at Jatrabari intersection which is followed by Kanchpur Bridge, ICMH at Matuil, Dania College and Saddam market.

In order to reduce the risk of accidents at the black spots, the study recommends construction of underpasses at the level of approaching road, grade separation for non-motorized traffic, construction of footpath for pedestrian movement, grade separated bus stops and channelization of traffic at intersections in the study area.

CHAPTER 1
INTRODUCTION

1.1 Study Background

The role of road transport in the movements of both passenger and freight in Bangladesh is very significant. Since independence of Bangladesh demand for passenger and freight transport demand in road sector has grown by about 400 and 350 respectively. With the increasing shift of traffic from other modes (viz. rail, water) to road, the road safety problems have been growing alarmingly. About 11538 persons were killed and 13547 were severely injured in over 20,308 reported road accidents during the last five-years. According to a recent report by World Bank as many as 5000 people die every year in Bangladesh due to road accidents. Personal injuries and property damages are very significant (Rahman, 2002).

Road safety in metropolitan Dhaka city emerges as a serious issue as the total number of accident as well as other resulting casualties is increasing steadily over the years. During the last five years there were about 2049 fatalities and 4714 injuries in 5660 reported road accidents in metropolitan Dhaka. Hoque and Alam (2002) reported that pedestrian as a proportion of road accident deaths increased from 43 percent in 1986-1987 to 67 percent in 1991-1992. In recent years (1996-1998) the number of pedestrian casualties (fatalities and injuries) has increased markedly, from 433 in 1996 to 588 in 1998, an increase of about 29 percent. Pedestrians now make up approximately 63 percent of road accident fatalities and 32 percent of injuries and are involved in about 20 percent of all reported accidents. In the case fatal accidents 70 percent are caused by collision between pedestrian and motorized vehicle.

Considering the magnitude of the problem and its socio-economic impact, comprehensive efforts are deemed necessary for alleviating the problem. The Government of Bangladesh has taken several steps in this regard, which include the establishment of National Road Safety Council. Recently the government has established the Accident Research Center at BUET in order to investigate the causes of accident and develop the remedial measures.

Road traffic accidents are integrally related with the components of road traffic system, which include vehicle, users and roadway environment. In this regard, the causes of road accident frequently become site specific and effective remedial measures need to be designed considering site-specific measures. It is well recognized that site-specific measures for preventing accidents are more effective than area-wide measures. To develop effective accident remedial measures it is essential to focus on site-specific details of accident phenomena.

In Bangladesh, most of the relevant studies focused on aggregate accident information and thereby assist in assessing the extent and nature of road accidents. Only few studies have been done considering detail spectrum of factors of road accidents for a comprehensive understanding of the characteristics of accident problems. Hoque (1991) conducted in depth study regarding the causes of road accidents on Dhaka-Aricha road and suggested remedial measures on the basis of microscopic factors. More studies of this category are required which should focus on the relationships among user behavior, vehicular characteristics, roadway geometry etc. through the analysis of accident clusters based on location, time and environmental features. These analysis will provide in depth information regarding black spots and result in development of effective accident pre-counter measures.

1.2 Objectives of the Study

The major objective of the study is to understand the interaction among road traffic accident and traffic system variables. The study also aims at the identification of the causes of accident on selected section Dhaka Chittagong highway between Jatrabari and Kanchpur Bridge.

The specific objective of the study can be summarized as follows:

- Identification of the accident black spots on Dhaka Chittagong highway between Jatrabari and Kanchpur Bridge.
- Analyze relationships among characteristics of accident and traffic systems variables.
- To investigate the accident causation factors
- Develop accident preventive measures on the basis of the analysis.

1.3 Organization of the Thesis

The reminder of the thesis is divided into five chapters:

Chapter 2 reviews the literature relevant and related to the theme of this study. This review sets out to understand the factors involved in road accidents, accident investigations, and road traffic accidents in Bangladesh and in other countries.

Chapter 3 presents an overview of the methods of identifying accident clustering and black spots. This chapter also shows interaction among roadway environment, traffic and accident occurrences.

Chapter 4 presents data collection and the analysis of accident data to represent the overall accident situation in the study area. This chapter outlines the clusters of accidents (such as spatial cluster, temporal cluster and accident type based cluster), identifications of black spots, field observations and findings of the study.

Chapter 5 outlines the conclusions and recommendation of the study. Directions for future research are also discussed in this chapter.

The reference chapter provides the various references used within this thesis.

The appendix chapter provides terminology, traffic flow tables and some photographs of the black spots.

An overview of the study procedure and layout is presented in Figure 1.1.

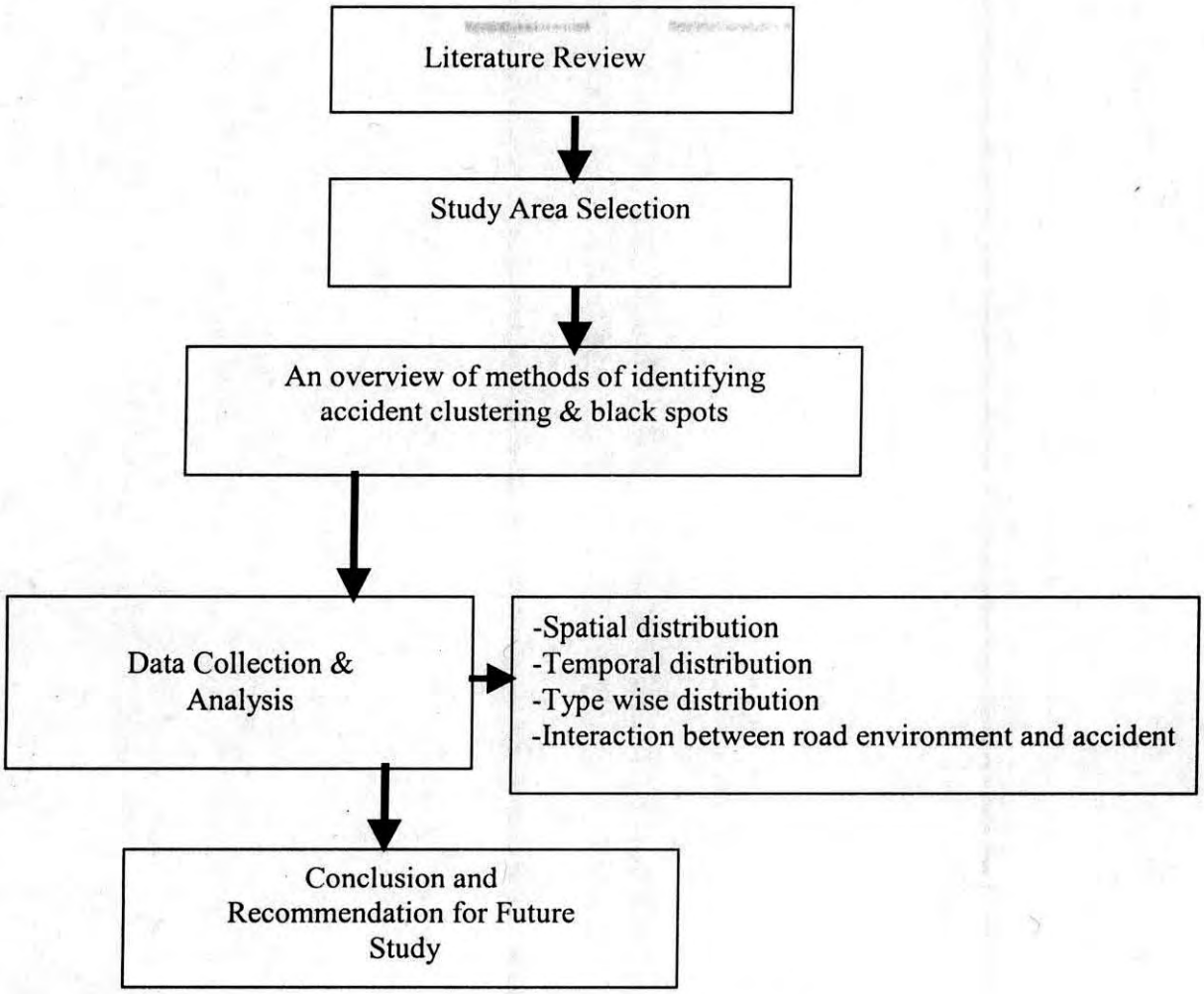

Figure 1.1: Flow Chart Showing Outline of the Thesis

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

The literatures reviewed in connection with this study are summarized in this chapter. These include studies on accident investigation methodology as well as past studies on accident in Bangladesh and abroad. This chapter also deals with the general understanding of accident phenomenon and its characteristics. Finally, a comprehensive review of the need for site-specific accident analysis and its implications in designing accident counter measures are presented.

2.2 Global Perspective of Road Traffic Accidents

Transportation is imperative for economic activities and facilitates movement of passenger and goods. Traffic accidents are not modern phenomena and have been transport hazards from very beginning of human movement. With the recent increase of mobility, caused by increased economic activities, the number of accident has also increased.

Hoque (2000) suggests that currently road accident is the ninth biggest cause of premature death in the world, which is estimated to be responsible for around 500,000 deaths and 15 million injuries every year. Together with the social impact in terms of sufferings of the people, the economic loss of accident to the developing countries alone is estimated to be around US$ 100 billion. By the year 2020, it is expected that road traffic accident will become the third highest cause of death and liability in the world.

Current statistics indicates that at least 500,000 people are killed each year in road accidents around the globe. The majority of these, about 70 percent (350,000 deaths), occur in developing countries at a cost of 1-2 percent of GNP. The data on the distribution of road accident fatalities by region is shown in Table 1 (Ross Silcock and TRL 1996).

Table 2.1: Number of Annual Road Accident Fatalities by Region (1992 - 93)

Continent	Number of fatalities
Europe	97,500
Africa	74,000
North America	45,000
South America	38,500
Asia and Middle East	240,000
Oceania	4,000
TOTAL	**499,300**
Developing Countries	**352,500**
Industrialized Countries	**146,800**

Source: Hoque and Ahsan, 2000

Recent studies showed that whilst road accident death rates (the number of death from road accidents per annum per 10,000 vehicles licensed) in Western Europe and North America are often less than 2, some developing countries have a rate exceeding 150 (Jacobs and Baguley, 1997 and Rolt, 1997). Through trend analysis it is observed that over the period 1968-1990, the number of deaths in some developed countries fell on average by 30 percent. Conversely in some Asian and African developing countries there were increase of about 200 and 350 percent respectively. The problem has been aggravated since many countries are experiencing annual growth rates of the vehicles of around 16 and 17 percent. The number of death in Asian developing countries is rising at alarming rates. A major regional study (Ross Silcock and TRL, 1996) has provided a detailed overview of the problems and the priority actions needed in Asian Pacific developing countries where there are currently 235,000 deaths and economic losses of over US$20 billions each year. During the last 10 year period (1984-1993) over 2 million persons have been killed and over 17 millions have been injured in road accidents in the region with an annual increase of almost 60 percent. It is predicted

that unless effective and urgent action is taken, the number of deaths, on present trend, will rise to around 450,000 per year within 10 years.

Apart from the magnitude of the problem, the following problem characteristics are evident in many developing (particularly less motorized) countries, which should be given increased consideration in safety strategies (Mohan 1993):

- Mixed traffic conditions with predominance of non-motorized transport (walk, bicycle, cycle, rickshaw etc.)
- The vast majority of road users (VRU) viz. pedestrians, bicyclists and motorized two-wheeler riders.
- Trucks and buses are involved in a majority of fatal accidents.

Clearly the above statistics demonstrate that road accidents are a very serious problem in developing countries. There remains much scope for improving their safety situation and for that there is obviously need for much effort and investment in safety measures to reverse the trend- as has been the case in the developed world (Jacobs and Baguley, 1997). It is possible to significantly reduce the number of road accidents by implementing an effective and coordinated safety policy and actions which require significant improvements in the relevant sectors viz. better enforcement, better roads (including the treatment of accident black spots) and improved public programs.

Only in a few of cities in developing countries accident data were collected such that a detailed analysis of accident characteristics in relation with roadway environment, user characteristics and traffic variables could be conducted (Jacobs and Sayer, 1984). The class of road user was often divided simply into "pedestrian" and "Vehicle Occupant". As shown in Figure 2.2 that the proportion of pedestrian casualties is substantially higher in the cities of developing countries than in urban areas in a developed country like Britain.

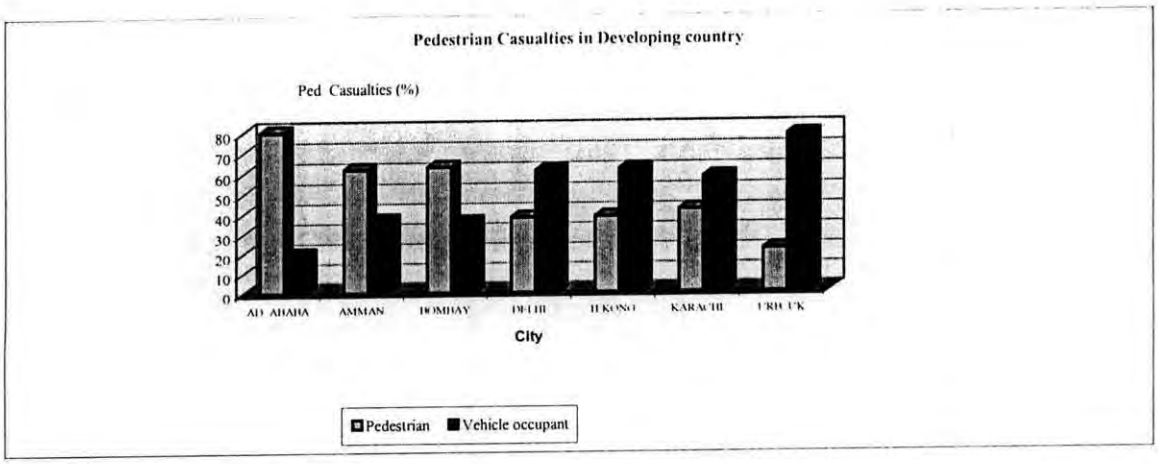

Figure 2.2: Pedestrian Casualties in Developing Countries Source: Kiwan, 1988

2.3 Road Traffic Accident in Bangladesh

Road safety in Bangladesh is rapidly deteriorating with increasing number of road accidents, casualties and injuries. As shown in Table 2.2, the numbers of fatalities have been increasing very rapidly, particularly in the recent years. The number of casualties has increased in recent years by more than 60 percent and Fatalities per thousand vehicles increased by more than 30 percent in the last eight years. In addition to increased rate of accident, it can be attributed to increased accident reporting and improved accident data collection procedure.

Table 2.2: Reported Road Accident Trends in Bangladesh (1993 - 2000)

Year	No. of accident	No. of fatalities	No. of injuries	Total casualties	Fatalities/100 00 vehicles
1993	3140	1495	2409	3904	122.1
1994	3013	1597	2686	4283	107.1
1995	3346	1653	2864	4517	110.1
1996	3727	2041	3301	5342	112.1
1997	5453	3162	5076	8238	138.2
1998	4769	3085	3997	7082	128.1
1999	3942	3314	2620	5934	140.4
2000	3970	4046	2270	6316	162.9

Source: Bangladesh Bureau of Statistics (1993-2000)

It is important to note that the number of fatalities has been rapidly increasing particularly in the recent years, from 1495 in 1993 to 4046 in 2000, i.e. nearly three times in eight years period. The statistics reveal that Bangladesh has one of the highest fatality rate in road accidents, higher than 160 deaths per ten thousand registered motor vehicles on road every year compared with rates of 2.0 in the USA and 1.4 in UK, for example. Together with the social impact in terms of pain, grief and suffering, there is a serious economic burden. In current prices, road accidents in Bangladesh costing community in the order of Tk.4000 crore (at nearly 2.0% of GDP) per annum. Between 70-80 percent of accidents occur on highways and rural rods. Upto 70 percent of urban road accident deaths are pedestrian alone. Trucks and buses are a major contributor to road accident fatalities, upto 80 percent, particularly responsible for pedestrian fatalities. Besides pedestrians, buses and trucks are most frequently involved in "running-off- road" (and hitting roadside objects), "head-on" and "out of control" accident types. In terms of vehicle-km traveled, motor cycles are much more dangerous than other vehicle types, at least five times the rate of rickshaw. Typically the principal contribution factors of accidents are adverse roadside environment, poor detailed design of junctions and road sections, excessive or inappropriate speeding, overloading, dangerous overtaking, reckless driving, careless of road users, failure to obey mandatory traffic regulations, variety of vehicle characteristics, and defects in vehicles. Others include a low level of awareness of the safety problem by senior officers and policy makers, inadequate and unsatisfactory education, safety rules and regulations and inadequate and unsatisfactory traffic law enforcement and sanctions.

2.4 Traffic Accident in Jatrabari–Kanchpur Bridge Area

Hoque (1981) reports that in three and half years period (Jan.1977- June1980) on the section of Dhaka-Demra and Dhaka-Narayangong road under Demra P.S., out of the 345 reported accidents, 20% were fatal accidents, 49% were injury accidents and 31% were property damage accidents

Chowdhury (1996) reports that in three and half years period (Jan.1992 - June1995) on the section of Dhaka-Chittagong highway between Jatrabari–Kanchpur Bridge under Demra P.S., out of the 113 reported accidents, 35% were fatal accidents, 46% were injury accidents

and 19% were property damage accidents. The study also reveals that on the combined sections of Dhaka-Demra, Dhaka-Narayangong and Dhaka-Chittagong under Demra P.S., out of the 517 reported accidents, 34% were fatal accidents, 48% were injury accidents and 18% were property damage accidents.

The studies mentioned above suggest that within fifteen years, the time difference between the two studies, traffic accident in the area increased by about fifty percent and the percentage of fatal accident increased by seventy five percent. The statistics presented above imply that further studies are necessary to identify the causes of accident occurring in the area incorporating a broader spectrum of traffic system variables.

2.5 Need for Site-Specific Studies

Hoque and Andreassen (1982) emphasized on the significance of accident types, accident location and road types in the analysis of accidents. The exact location of accident is a pre-requisite in the identification of hazardous location or black spots in the network. Accident locations should be classified into two basic categories namely such as intersections and link, because accident types at intersections generally stem from different conflicts to those on links. Hoque (1982) suggested that in the application of countermeasures, intersection accident must be separated from link accidents. Furthermore, in order to get an indication of exactly where the accident at intersection has occurred, the intersection zone should be sub-divided into specific section with respect to the position of vehicle/pedestrians involved in the accidents.

To design an effective counter measures, it is essential to determine whether specific accident types are exhibiting 'Clustering' or non-clustering by location on various road classes. The term clustering refers to the existence of a couple of neighboring locations having similar characteristics. Where clustering occurs it demonstrates that large number of accidents are occurring at a small number of sites and that application of remedial treatments, appropriate to the accident types and road classes to these few sites will effect a comparatively large reduction in the total number of accident. Alternate site-specific treatments must be investigated to alleviate the problem at these clustered accident sites.

Little (1970) and Babkov (1975) reported about the efficiency of site-specific measures and their design considerations. It suggested that most site-specific treatments are effective in preventing only one kind of crash. Many black spots are dangerous because of a high frequency of one type of crash. Crash specific design measures are required to produce any effect at such spots.

BTCE (1995) provides an elaborate evaluation of black spot identification and treatment procedures followed in Australia. The report suggests that in the capital cities sealing of road shoulders, marking edge lines, improving pedestrian facilities, and erecting signs did not have a statistically significant effect on road crashes. Although, sealing of road shoulders did not produce a statistically significant effect, expenditure on this treatment was the fifth most popular and accounted for almost seven percent of urban black spot treatment expenditure. Attempts to improve lighting in the capital cities appear to have had a counter productive effect. There is moderate evidence that improved lighting in capital cities increased crash numbers. In regional areas, traffic islands on approach, indented right and left turn lanes, non-skid surfaces and improving pedestrian facilities did not produce statistically significant effect on road crushes. These may be caused by the fact of lack congruence between the actual causes of accident and their counter measures.

Roundabouts and new traffic lights with no turn arrows appeared to be very successful in improving safety in some areas. New traffic lights with turn arrows, medians and non-skid surfaces were similarly successful in capital cities. There is very strong evidence that traffic islands on approaches and indented right and left hand turns improved safety in capital cities.

All these evidences do not mean that particular engineering treatments improved or failed to improve road safety in all cases. However, it does indicate that road engineers should consider using one of the more generally successful treatments if there is more than one feasible way of trying to fix or improve a particular traffic hazard.

There are four possible reasons why treatments may appear to have had no effect on treated sites. The first is that the treatments may not be coorelated with the actual causes of accident. Secondly, traffic flow may have changed at some of the treated sites. Because of poor traffic count data, these changes in traffic flow can affect the reliability of the analysis. For example, an instance where the road was widened after the treatment to cater for an increased

traffic flow, due to the construction of a new shopping complex. Unless accurate traffic flow figures in the periods before and after treatment was provided, to calculate crash rates, the analysis would not be reliable. Thirdly, the period over which casualty crash data are collected after treatment is relatively short to produce any conclusion. The probability of observing a significantly typical crash rate over a given period is higher when the data collection period is short. Fourthly, as described above, some treatments may have been used too seldom to generate statistically significant effects in the time available. For these treatments, traffic engineers may need to take a 'wait and see' approach. Small samples may generate statistically insignificant results even if the treatments are working well.

From the discussions presented above it is evident that site specific measures have the potential to produce highly beneficial impacts on reduction of accidents. But they are required to be designed properly in congruence with the actual causes of accident.

2.6 Summary

It is evident that problem of road safety will increase with increasing number of roads, passengers, goods and vehicles. Road accident black spot investigations and subsequent treatments can result in significant accident reductions and high economic returns by implementation of low-cost engineering countermeasures. These measures are affordable, and can be implemented at the local level.

This chapter presented an overview of the traffic accident problem. In the chapter the extent of the problem was described through global as well as local perspective. The chapter also presented the scope of site specific measures in improving accident situation.

The literature reviewed in connection with the study suggested that microscopic analysis of accident phenomenon is required to design commensurate site specific accident counter measure. The next chapter describes the procedure for accident data analysis in microscopic details and its application in the design of accident remedial measures.

CHAPTER 3
STUDY DESIGN AND METHODOLOGY

3.1 Introduction

This chapter presents the methodology for identification of causes of accidents, their clustering and their relationships with transport and traffic system variables. The methodology is then applied to identify black spots in the study area and to design appropriate site-specific measures.

3.2 Selection of Study Area

The section, from Jatrabari to Kanchpur Bridge, of Dhaka-Chittagong highway is one of the major roadways of the country carrying traffic of about 3100 vehicles during peak period. It plays a highly significant role in national economy. The number of accident on the roadway is also very high. Considering the frequency, extent of damages and consequence of the accidents, design and implementation of appropriate measures are deemed necessary. As described in the earlier chapter site specific design measures prove to be highly beneficial for improving traffic safety. In this connection, it is required to study different sections of the highway microscopically to identify the site specific causes of accidents and design counter measures accordingly. Considering the extent of the issue and the need for an elaborate study it is limited to a section of the highway from Jatrabari intersection to Kanchpur Bridge. From preliminary observation of the accident records it seems to be the most accident-prone section along the roadway. It is also observed that there exists couple of high frequency accident locations in the selected section.

The roadway is also important for economic point of view, as there exist many important establishments, which include educational institutions, hospitals and market places along the road. Considering the high volume of traffic, particularly the commercial vehicles and large buses, lack of adequate facilities to cross the road and use roadside establishments exposes the road users to traffic accidents. The study aims at identifying the locations of accident

occurrence and their interaction with road users behavior and roadside activities. A map of the study area is presented in Figure 3.1.

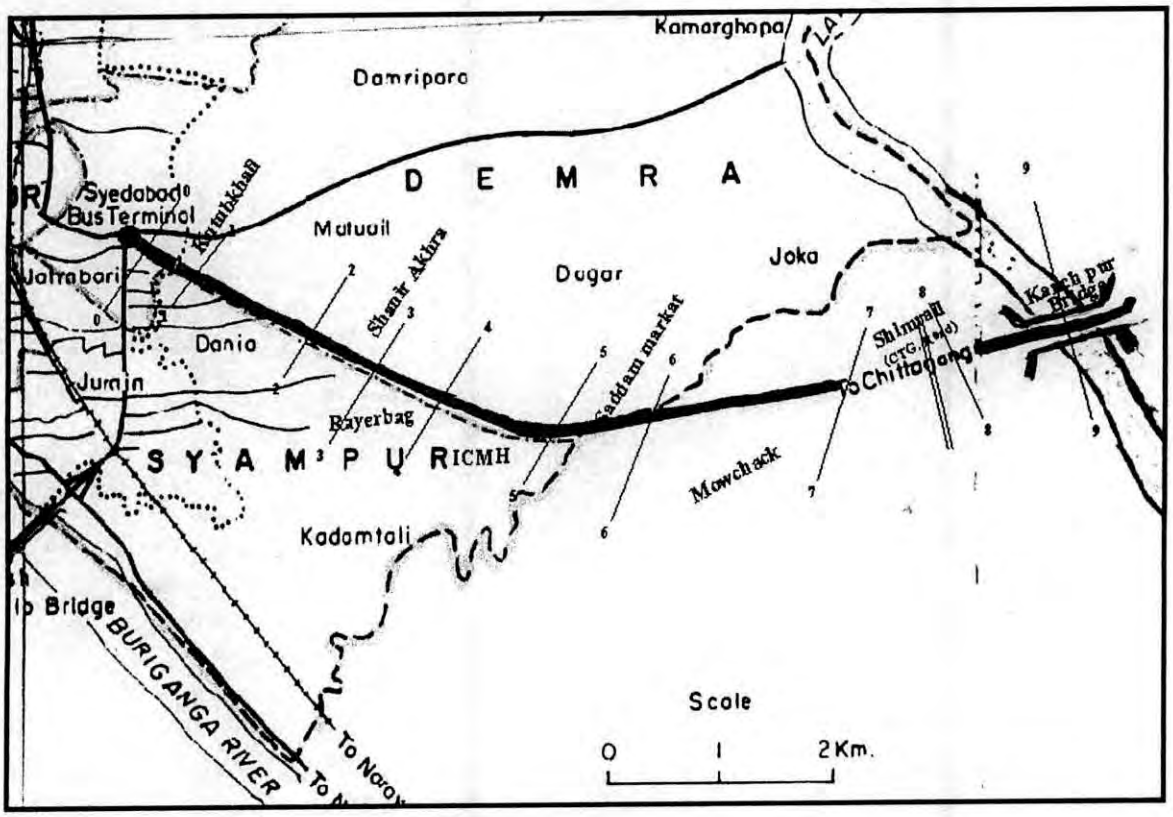

Figure 3.1: A Map of the Study Area Showing Different Sections

3.3 Identification of Accident Clustering and Blackspots

The methodology for the identification of black spots on a section of Dhaka-Chittagong highway between Jatrabari and Kanchpur Bridge and design of remedial measures can be divided into a couple of distinct stages which include analysis of data information on road inventory, geometry, environment and information regarding road user characteristics.

The importance of detailed data on accident cannot be over emphasized in its analysis. Information regarding microscopic details of the accident phenomenon and its surroundings are required to understand the underlying causes of accident, their implications in the occurrence of the phenomena and the mechanism for their prevention. The data elements required in this regard include the following:

- accident location (intersection, link, others)
- accident severity and involvement (fatal, injury, property damage)
- time of accident (hour, daylight/dark time)
- date of accident (month of the year, day of week)
- type of vehicles involved in accident (bus, truck, car, minibus, rickshaws/vans etc.)
- casualties (age and sex of casualties)
- damages (vehicle, property damages)
- road users involved in accident

The road inventory including geometric features and surrounding environment affect accident phenomena. The roadway inventory includes information regarding geometric characteristics of road and road surface condition. Road environment include surrounding features of roadway as well as roadside activities. These factors are required to be analyzed in relation to the type, frequency and severity of accidents.

Road users include drivers, passengers as well as pedestrians, which comprise most significant component of road traffic accidents. The human factor has always been identified as the main contributor to road hazards. Road user error was identified as the main cause in at least 70% of the road accidents (Jacobs, et al 1981). Lack of public awareness on road safety and use has always, negative effects on the road user behavior and thereby increasing the hazards of road accident. On the other hand, lack of facilities for using the road safely compels road users to take risks and induce accidents. For the purpose of study, road user characteristics will be investigated in relation to road accidents.

In the analysis all these information will be integrated and correlated to identify the underlying cause of accident at particular location and propose an effective counter measure.

Hazardous road location (Black spot) is usually defined as the locations that experiences abnormal high accidents frequencies, rates and severity of accidents. In any program of hazardous road location or black spot identification, it is necessary to define a unit of road location. The unit might be individual site (e.g. intersection, a spot or a road link). Black spots are that sections or links where greater number accidents occurred repeatedly. Black spots can still be created where accident preventive measures are constructed without proper

safety checks or audits. It is important that road safety audits should be systematically implemented for preventing many road accidents and resulting casualties in developing countries (Jacobs and Baguley, 1997).

The process of identification of the black spots involve spatial, temporal and characteristic analysis of accident. It would lead to the analysis of accident on the basis of place, time, vehicle, user, and environment etc. and thereby resulting in identification of the underlying cause of accident. It would also result in designing low cost accident reducing solutions.

"Clustering" is a term used to describe the situation when a number of sites, within a small area, are identified with high frequency of accidents (Hoque and Andreassen 1986). The detection of accident clustering is significant in relation to the planning of accident countermeasures because the application of remedial treatments, appropriate to accident type, to a comparatively small number of accident-sites could give a big overall reduction of accidents. The systematic review of the accident problem in the area concerned enables devising most-effective countermeasures aimed at specific accident types (e.g. intersection accidents, single vehicle collisions with roadside objects, head-on collisions) or specific user groups (e.g. pedestrians, bicyclists, trucks) (Vaughan et al 1992). Thus it is increasingly recognized that different categories of road users and accident types should be explicitly considered as there are specific needs and problems peculiar to each category that can and should be adequately taken into consideration in the engineering road safety solution strategies. A key factor in this regard is to determine weather particular accident types are exhibiting "clustering" or non-clustering on the road network.

Proven low cost engineering countermeasures suggested for correcting the hazards of the roadway sections as well as reducing accidents. Some examples of low cost engineering countermeasures for reducing the accident hazards are outlined below:

- **Introduction of roundabout, islands and channels:** When turning movements of greater traffic cannot be handled by the diamond intersection, then roundabout intersections are introduced. It occupies a relatively small area of land and allows easy u-turns to be made. A traffic control island is a defined area between traffic lanes for control of vehicle movements or for pedestrian refuge. Within an intersection a median or an outer separation is considered as an island. An at-grade channelized

intersection in which traffic is directed into definite paths by islands is called channel. Roundabouts, islands and channels reduce conflict of movement and increase traffic safety.

- **Improvement of traffic signal:** A highway traffic signal is any power – operated traffic control device by which traffic is warned or directed to take some specific action. Different types of signals are traffic control signals, pedestrian signals, beacons (flashing light), lane-use control signals, traffic signals for one lane, two-way facilities, etc. Improvement of traffic signals increases the traffic–handling capacity of the intersection. They can reduce the frequency of certain types of accidents, especially the right-angle type accidents.
- **Modifications to signals phasing:** Timing of the phase and cycle can be changed according to the traffic needs.
- **Channelization:** Channelization is done for speed reduction, segregation of through and turn traffic and reduction of unnecessary conflict area.
- **Parking restrictions:** In many cases it is observed that truck remains parked on the road for hours together. This reduces the effective roadway, create congestion, encourage other vehicles to use illegal means and induce accident. To eliminate such parking, tolls may be imposed in addition to construction of parking place.
- **Advanced warning signs:** Warning signs call attention to conditions on, or adjacent to, a highway or street that are potentially hazardous to traffic operations.
- **Pavement markings:** Markings have definite and important functions to perform in a proper scheme of traffic control. In some cases, they are used to supplement the regulations or warning of the other devices such as traffic signs and signals. In other instances, they are used alone and produce results that cannot be obtained by the use of any other device.
- **Pavement resurfacing:** Worn out pavement resurfacing is very much essential to make the roadway hazardless.
- **Improved street lighting:** Highway lighting is more important particularly at intersections, bridge sites, level crossings and other places where there are restraints on traffic movements. Road lighting gives added sense of security to the vehicular traffic also. For night driving on roads, although all the vehicles have their own

headlights, which are quite significant, still adequate lighting on roads is essential from other considerations. A push cart driver, a bullock cart driver, a cyclist, pedestrians do not have their own lights.

- **Removal or relocation of obstruction:** Removal of construction materials and other obstacles from the carriageway and shoulder is essential. It creates bottleneck of the roadway and induced accidents.
- **Improved super elevation and alignment:** To reduce the tendency of the vehicle to topple or skid, the outer edge of the road pavement is raised with respect to the inner edge at the curve places, this lateral inclination to the road surface is known as super elevation. The value of super elevation at curve should be improved on the basis of vehicle speed.
- **Skid resistant treatment:** Skid resistant is improved by providing rough surface on the roadway.
- **Segregation of traffic on the basis of speed and size:** Vehicles are segregated on the basis of speed to avoid the rear end collisions.
- **Segregation of pedestrian from vehicle:** To reduce the pedestrian vehicle conflicts, separate lane is very necessary for pedestrian movement.

3.4 Involvement of Traffic System Variables in Accident

Road traffic accidents result from failures in the interaction of humans, vehicles and the road environment- the elements that produce the road traffic system. The combination of these various elements to produce road accidents means that the road safety itself has to be tackled in a multi-functional manner in order to break the chains of events that lead to accidents and the eventual injuries of road users. An integrated, multi-disciplinary approach is required to reduce road accidents and consequent injuries and economic losses. Importantly, the road component remains a major consideration in the overall road safety management strategies. The potential of the road safety engineering approach is well recognized, as this approach can aid and influence road users to change their behavior, and can make the road environment safer through reducing conflicts. Evidence suggested that road related factors contribute to about 30 percent of accidents. However various studies (Ogden 1996) indicated

that even a greater proportion, perhaps 40 percent or more, of accident reductions could reasonably be expected to accrue from the provision of safer road environment.

These observations are especially cogent to realize that road environmental factors are significant in road accidents. Thus the accident reduction program through improvements/modification of the road environment is clearly important and has very often proved to be highly cost effective particularly through the accident black spot treatment involving a wide range of low-cost engineering countermeasures. In fact, in the industrialized countries, one of the most consistently successful and cost effective areas of investment for achieving safety benefits has been the field of road planning, design and traffic engineering. Lay (1988) argued, "Real advances in road safety can be best guaranteed, as in the past- through building greater safety into roads and vehicles". The Japanese success in the 1970s in halving its traffic accidents was brought about mainly by traffic engineering measures to improve the road and roadside environment (Koshi 1986). In the UK, program established in 1987 to reduce road accident casualties by one-third by the year 2000, road safety engineering measures were expected to deliver at least one-third of this target reduction (Burrough 1991).

3.5 Analytical Framework of Blackspot Identification

As mentioned earlier that identification of the accident-prone locations or blackspots is the first step in any highway-safety improvement project. An accident-prone location (link or intersection) is defined as any location that exhibits a higher potential for accidents than an established norm. The higher potential of accident is usually expressed in terms of any accident measure, such as accident frequency, rate, severity, or a combination of these measures. Traditionally the total number of accident is used to calculate the accident measure. A 'Blackspot' has been identified as an area where a number of crashes occur over a defined period, typically three or more casualty crashes within three years. A 'Blacklength' is a short section of road with a certain number of crashes per kilometer over a defined period. Usually the terms 'Blackspot' and 'Blacklength' are used synonymously.

Considering the variation of the magnitude of accident problem among different countries, the absolute value of the measure for blackspot identification can vary widely. In this regard Sayed et al (1995) suggests that for a location to be identified as accident prone it must exhibit a higher accident occurrence than an established 'norm' applicable to the study area. Also, due to the random nature of accident occurrence, statistical techniques have been devised to ensure that only locations that have a true higher potential for accident are identified as accident prone. These techniques are based on the hypothesis that accidents occur as random events with a known statistical distribution. Usually Poison's Distribution is widely used in this connection.

However, since the accident prone location involve many accidents that are not treatable by road improvements, the locations identified by this method may not be truly hazardous or accident prone from highway agency's point of view. There are three components of traffic system – the driver, the vehicle and the road environment. Accidents may result from failure of any of these components or their combination. Therefore identification of accident prone locations should be based on the factors that contributed to accidents. For example, accidents that occur due to adverse road design or environment should have a greater influence in defining accident prone location than those resulting from impaired driving. Most of the accident research focused on enhancing the statistical tools to predict accidents and identify accident prone locations. Very little attention has been paid to the causes or contributing factors. The lack of research in this regard can be attributed to the analytical and computational complexity in the relationship among the factors of accident and its occurrence as well as lack of adequate data.

Sabey and Taylor (1980), Treat (1980) and Sayed et al (1995) suggests that a wide range of information, encompassing all the components of road traffic system, is required to analyze the weightage of the contributing factors and thereby identify the accident prone locations. The contributing factors range from driver related factors such as alcohol involvement and driving without care, to vehicle related factors such as engine or brake failure, to road related factors such as road obstruction and pavement surface deficiencies. A full list of these factors is provided below.

Table 3.1 List of Contributing Factors in the Occurrence of Accident

Sl. No	Factor	Sl No	Factor
1	Alcohol Involvement	31	Road/Intersection Design
2	Driver Inexperience	32	Roadside Hazard
3	Drugs	33	Wild Animal
4	Extreme Fatigue	34	Weather
5	Fell Asleep	35	Visibility Impaired
6	Illness	36	Accelerator Defective
7	Sudden loss of consciousness	37	Brakes Defective
8	Preexisting physical disability	38	Defective Brake Light
9	Prescribed Medication	39	Defective Head Light
10	Attempted Suicide	40	Defective Turn Signal
11	Driving Without due care	41	Oversize Vehicle
12	Failing to Signal	42	Steering Failure
13	Ignoring Traffic Officer	43	Tires Failure Inadequate
14	Previous Traffic Accident	44	Two Hitch Failure
15	Following too closely	45	Driverless Vehicle
16	Improper Overtaking	46	Suspension Defect
17	Unsafe Speed	47	Windshield defective
18	Avoiding Vehicle/Pedestrian/Cycle	48	Engine Failure
19	Reversing Unsafely	49	Restraint System
20	Cutting In	50	Insecure Load
21	Driving on the Wrong Side of road	51	Dangerous Good
22	Improper Turning	52	Vehicle Modification
23	Failing to Yield Right of Way	53	Glare Artificial
24	Ignoring Traffic Control Device	54	Glare Sunlight
25	Pedestrian Error Confusion	55	Domestic Animal
26	Obstruction on Road	99	Others
27	Defective Pavement Surface		
28	Road Maintenance and Construction		
29	Sign Obstruction		
30	Insufficient Traffic Control		

On the basis of these variables, the contribution of the different components of road traffic system in the occurrence of accident at any location is extracted by using statistical principal component analysis and fuzzy pattern recognition techniques.

3.5.1 Blackspot Identification Procedure

While investigating the accident reporting forms and FIR it is observed that only limited information is available from those sources. Also, many a times bulk of the necessary information is not recorded due to negligence. Under the circumstances the following eight variables, listed in Table 3.2, could be extracted from available data sources. The existence of the involvement of these variables in any casualty accident is notified.

Table 3.2 Variables Used in the Study for Blackspot Identification

Sl. no.	Variable
1	Pedestrian Involvement
2	Obstruction on Road
3	Road Side Hazard
4	Over Speed
5	Unsafe Driving
6	Faulty Vehicle Maneuvering
7	Involvement of bus/Truck
8	Involvement of Mixed Traffic

On the basis of the available data, the contribution of these variables are categorized in three components by using Principal Component Analysis Technique (Nakamura, 1994). A Principal Component Analysis is concerned with explaining the variance covariance matrix with a few linear combinations of the original variables. Its general objectives are:

i) data reduction.

ii) new interpretation.

If there are p-variables, p principal components are required to reproduce the total system variation. But often much of these variations can be explained by a smaller number of principal components which evolve as a linear combination of the initial variables. A principal component analysis usually reveals the underlying relationship that is not apparent otherwise. Principal Component Analysis is an explanatory multivariate technique leading to logical understanding of the phenomenon proving the data.

In Principal Component Analysis, the components or factors are identified by using variance-covariance matrix and eigenvalues. For example, if two components are created from two variables (X_1 and X_2), the components are calculated using the following mathematical framework.

Initially the following equation is solved to estimate the eigenvalues.

Resulting in t=L_1 and L_2 ($L_1 \geq L_2 \geq 0$)

$$t^2 - (S_{11} + S_{22}) * t + S_{11} * S_{22} - S_{12}^2 = 0$$

Where, S_{11} is the variance of X_1

S_{22} is the variance of X_2

S_{12} is the covariance of X_1 and X_2

L are the eigen values of variance covariance matrix.

The components are obtained as follows

1st Principal Component, $Z_1 = a_1 * X_1 + a_2 * X_2$

2nd Principal Component, $Z_2 = -a_1 * X_1 + a_2 * X_2$

Where, $a_1 = S_{12} / (S_{12}^2 + (L_1 - S_{11})^2)^{0.5}$

and, $a_2 = (L_1 - S_{11}) / (S_{12}^2 + (L_1 - S_{11})^2)^{0.5}$

After identification of the three factors in the analysis they are interpreted for their involvement with road environment, vehicle and driver. Later relative weights are estimated as follows.

Relative weight of each factor, $W_i = \dfrac{\exp(factor\ component_i)}{\sum_k \exp(factor\ component_k)}$

For the purpose of identifying the blackspots the weights of road environment factor is plotted along the roadway section under study. The locations where roadway environment factor weighs more than the average is identified as accident blackspot.

3.6 Summary

It is evident that importance of road safety will be more and more pressing as number of roads and vehicles continue to increase. All the concerned authorities including the government must play their appropriate roles in taking up road safety programs. This chapter described the procedure for identification of the black spots and counter measures required for reducing accidents at the black spots. It also illustrated the selection of the study area. The following section presents collection of accident information as well as other relevant information for microscopic analysis of accidents in the study area.

CHAPTER 4
DATA COLLECTION AND ANALYSIS

4.1 Introduction

This chapter presents the traffic as well as accident data collected from field survey and police stations for the selected section of highway (Dhaka-Chittagong highway between Jatrabari and Kanchpur Bridge). Traffic volume accounted from video and accident data were collected from Demra and Siddirgong police stations. To extract microscopic details regarding accident phenomena the scope of data collection framework has been expanded to police FIRs, literacy descriptions and interviews with the local people.

4.2 Description of Study Area

Dhaka-Chittagong Highway between Jatrabari and Kanchpur Bridge is the study area of this project. This area is surrounded and directed by major roads that function as main traffic routes for both local and considerably large volume of through traffic. Both sides of the selected area are densely populated except northern side of Rayerbag and Matuial. There are many commercial, residential, educational and factory buildings on either side of the selected part of highway. The presence of shops and market increases the pedestrian activity on the highway and the problems of pedestrian-vehicular interaction and other traffic problems are very pronounced. The length of the study area is around 8.7 km. This highway forms part of the major arterial system of the country and are place of the occurrence of numerous accidents causing huge loss of life and property. To find out the reasons behind road accidents and to take appropriate measures for safety improvement, the study is conducted on particular section of Dhaka-Chittagong highway.

By examining consistency in geometric features and traffic characteristics the study area is to be divided into few mid-blocks section (link) for accident analysis purposes. Figure 4.1 shows the road network of Dhaka city. Study area also located on the Figure 4.1 with bold line. According to the Figure 4.1 a significant part of the study area is under the jurisdiction of Dhaka Metropolitan Area (DMA). The study area includes three major intersections and a

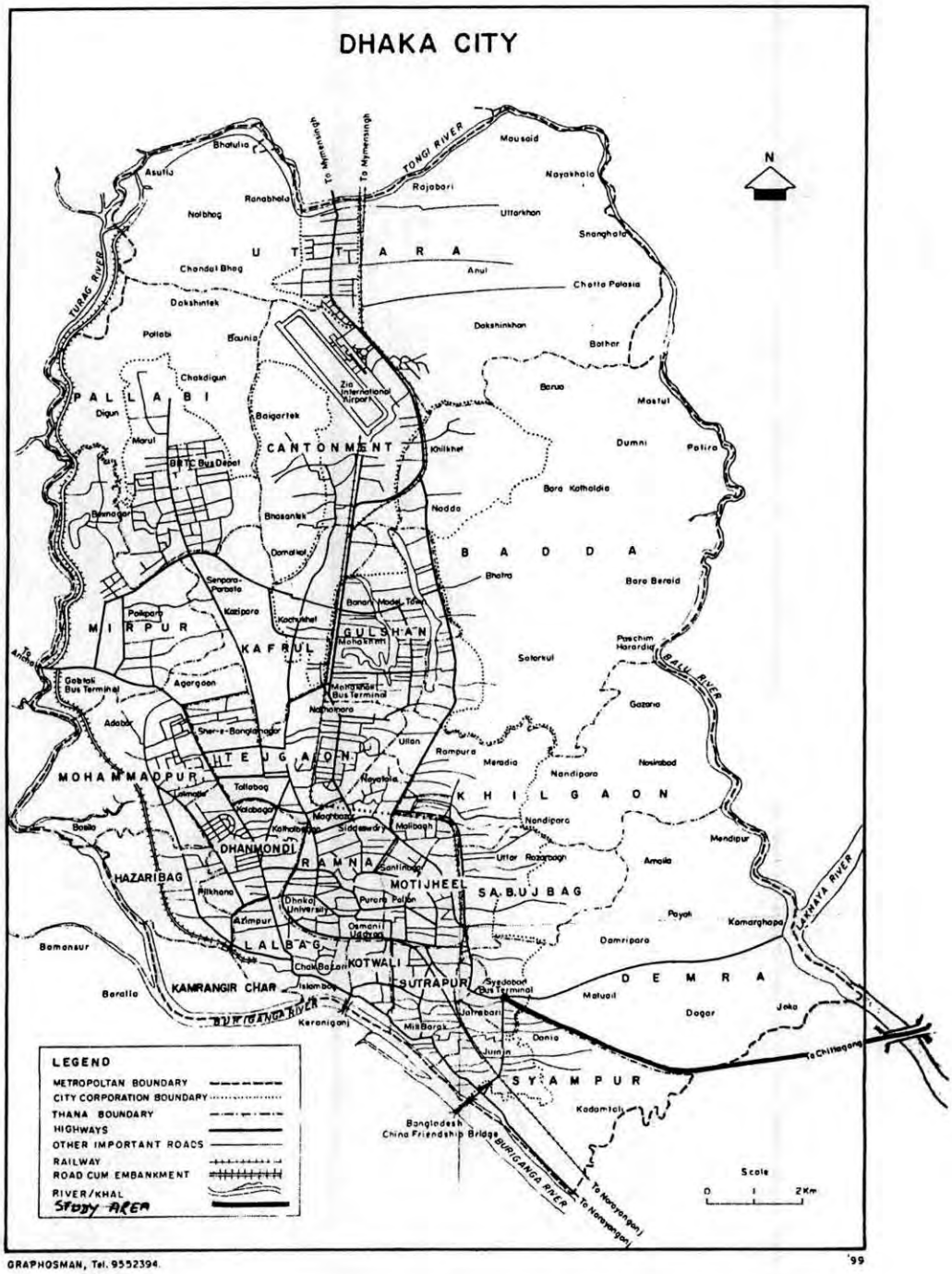

Figure 4.1: Road Network of Dhaka City Showing the Study Area

link, which is divided into nine homogenous sections for the purpose of analysis. The geometric features of the sections are described later in this chapter.

4.3 Collection of Data

Data on road accidents were collected from different police stations along the selected highway, which include Demra and Siddirgonj. To collect information regarding traffic a detailed video survey was conducted. For the purpose of collecting information regarding road environment a field survey was conducted.

Road accident data for about four years period starting from January 1998 to December 2001, as recorded in the above mentioned police stations were collected. During this period a total of 356 road accidents were recorded and available for analysis in this investigation. The present day accident reporting system as followed by the Police has considerable deficiency and weakness with respect to information on accident variables. It is envisaged that major revisions of the existing accident report form be made to provide accurate, informative and useful data for use in accident analysis and in the evolution of the road safety initiatives. Not withstanding this deficiency, efforts will be made to get factual information from narratives in the accident report form.

From the reported accidents, the following essential elements of information were investigated:

- Accident location: Intersection, link etc.
- Accident severity: Fatal, injury and property damage.
- Time of accident: Hour, day light/dark time etc.
- Date of accident: Month of the year, day of week etc.
- Vehicles types: Car, bus, truck, minibus, rickshaw etc.
- Number of persons killed
- Number of persons injured
- Objects hit: Tree, electrical pole, bridges, ditches etc.
- Damage costs: Vehicle, property damages etc.
- Age and sex of casualties
- Direction of vehicular travel

4.3.1 Accident Reporting Procedure in Police Stations

Any accident case filed in police stationed is first entered in a book called 'Khatian Resister'. Then the details of the case are written in another book called 'FIR Book'. From the Khatian Resister, the following information's are available:

- Location
- Date
- Severity of accident

From the FIR Book other information's are available, namely

- Time of day
- Type of vehicle involved in the accident.

In practice, all road accident data are filed under Bangladesh Penal Code, mentioned as follows:

- Section 304B stands for fatal case
- Section 338A stands for severe personal injury
- Section 337 stands for light personal injury
- Section 427 stands for property damage only

In many instances, time of occurrence of road accidents was not mentioned and sometimes accident locations were not specifically mentioned, but mentioned by the name of the road only. In such cases accident time and location were treated as unknown. In some cases, due to the unavailability of several FIR books, accident time and type of vehicle involved could not be collected and hence were treated as unknown.

4.3.2 Transcription of Accident Information

Accident transcription sheet was prepared to transcribe each of the elements of information as mentioned above. A sample accident transcription sheet is shown in Table 4.1. The table includes date, time of day, place of occurrence, and nature of accident, type of vehicles involved in the accident.

Table 4.1 Sample Transcription Sheet for Road Accident Data from Police Station.

ACCIDENT DATA

Police Station: Demra

Highway: Dhaka-Chittagong

279/304 (B) = death case; 279/338 (A) = serious injured case;
279/337 = ordinary injured case; 279/427 = property damaged
Y = Type of accident happened

DATE	TIME	NATURE OF ACCIDENT				TYPE OF VEHICLE	LOCATION	REMARKS
		279/427	279/337	279/338A	279/304B			
2. 1 .01	9.30 p.m	-	-	Y	-	Minibus	Western side of jattra-bari mour on the northern road. Aprx. 1/6 km. From thana	Minibus hit pedestrian during crossing the road
3. 1. 01	10.30 a.m	-	-	-	Y	Bus/Truck	Near the B'desh timber shops at Rayerbag road. Aprx. 3 km. East From thana	Truck hit pedestrian While he was waking along the carriageway
5. 1. 01	2.30 p.m	Y	-	-	Y	Bus	Adjacent to saddam market at near the filling station. Aprx. 6 km. east From thana	Bus pushed van cart from back and damaged van & van driver died at hospital
5. 1. 01	9.30 a.m	-	-	-	Y	Truck	In front of saidabad truck station. Approximately 1 km. west From thana	Truck passed over the pedestrian during crossing the road & spot died
5. 1. 01	2.30 p.m	Y	Y	-	-	Bus	In front of Osman Gonis house at Matuyal. Aprx. 1km. west From thana	Bus hit electric post during overtaking to the other one. Consequently 10 persons injured & damaged front side of one bus
6. 1. 01	3.00 p.m	-	-	-	Y	Truck/Bus	In front of Fatema petrol pump. Aprx. 3 km. East From thana	Truck/Bus hit pedestrian from back side and one person (male) died (80 yrs old)
9. 1. 01	8.45 a.m	-	-	-	Y	Bus	Adjacent to the mother and child hospital on the Dhaka-Ctg highway. Aprx. 5 km. East From thana	Bus hi pedestrian during crossing the road and died at hospital
12.1.01	12.00 at night	-	-	-	Y	Bus/Truck	Besides of Badhua community center. 1/2 km. West From thana	Bus/Truck passed over the pedestrian at night and on the spot died (during accident nobody observed)
12.1.01	7.30 p.m	Y	-	-	Y	Bus	In front of Dhania college. Aprx. 2 km. From thana.	By hitting rickshaw from back side damaged rickshaw and passenger fallen down. Initially serious injured and later on died at hospital
13.1.01	6.00 p.m	-	-	-	Y	Bus	Southern side of Demra thana. 1/6 km. From thana	Bus passed over the pedestrian during crossing the road and 16 yrs old boy died

4.3.3 Road Inventory in the Study Area

The study was made on the sections of Dhaka-highway from Jatrabari to Kanchpur Bridge which is about 8.7 km in length. The width, surface, geometric condition of the roads markedly affects traffic accidents. Poor geometric standards of roads are quite dangerous for movement of motor vehicles. Figure 4.2 presents the details road layout of study area. Figure 4.2 also shows that many filling stations situated on southern side of the highway. The highway under study encompasses varied geometrical and environmental conditions. For accident analysis purposes, the selected part of the highway is to be divided into 9 major sections (extending links). Traffic and roadway characteristics and their relationship with occurrence and characteristics of accident will be investigated in the analysis.

4.3.4 Accident Statistics in the Study Area

Accidents reported only by the traffic police during the period January 1998 to December 2001 (four years) on the selected highway (Dhaka-Chittagong Highway) were used in this study. Total 356-recorded accidents were analyzed in detail in this study. There were 91, 92, 76 and 97 accidents occurred during the period of Jan. 1998, 1999, 2000 and 2001 (up to December) respectively which is shown in Table 4.3. It is also important to note that number of fatalities has been rapidly increasing particularly in the recent years, rising from 37 in 1998 to 69 in 2001, i.e. nearly two times in four years period.

Table 4.2: Road and Traffic Characteristics on Different Sections of Selected Highway

SECTION	GEOMETRIC FEATURES	TRAFFIC CHARACTERISTICS
0-1 (0.45 km)	Pavement width=22' No. of lane = 4 Earth shoulder of varying widths =6' to 8' and at present water logged in northern side	Hourly volume during peak period = 1858 (motorized vehicles) and 988 (non-motorized vehicles) % of commercial vehicle (truck & buses) = 59% % of rickshaw & van =29%
1-2 (1.18 km)	Pavement width=22' No. of lane = 4 Earth shoulder of varying widths =6' to 8'	Hourly volume during peak period = 1578 (motorized vehicles) and 600 (non-motorized vehicles) % of commercial vehicle (truck & buses) =59.5% % of rickshaw & van =26%
2-3 (0.35 km)	Pavement width=22' No. of lane = 4 Eroded earth shoulder of varying widths =6' to 8'	Hourly volume during peak period = 1602 (motorized vehicles) and 502 (non-motorized vehicles) % of commercial vehicle (truck & buses) = 69% % of rickshaw & Van =11.1%
4-5 (1 km)	Pavement width=22' No. of lane = 4 Earth shoulder of varying widths =6' to 8' and at present water logged in part of the shoulder in southern side shown in photograph	Hourly volume during peak period = 1080 (motorized vehicles) and 493 (non-motorized vehicles) % of commercial vehicle (truck & buses) = 55% % of rickshaw & van =16.43%
5-6 (0.75 km)	Pavement width=22' No. of lane = 4 Earth shoulder of varying widths =6' to 8'	Hourly volume during peak period = 1393 (motorized vehicles) and 240 (non-motorized vehicles) % of commercial vehicle (truck & buses) =71.1% % of rickshaw & van =11%
8-9 (1 km)	Pavement width=17' at Bridge approach Narrow paved shoulder of varying widths 4to 6'	Hourly volume during peak period = 1200 (motorized vehicles) and 99 (non-motorized vehicles) % of commercial vehicle (truck & buses) =77% % of rickshaw & van=3.23%

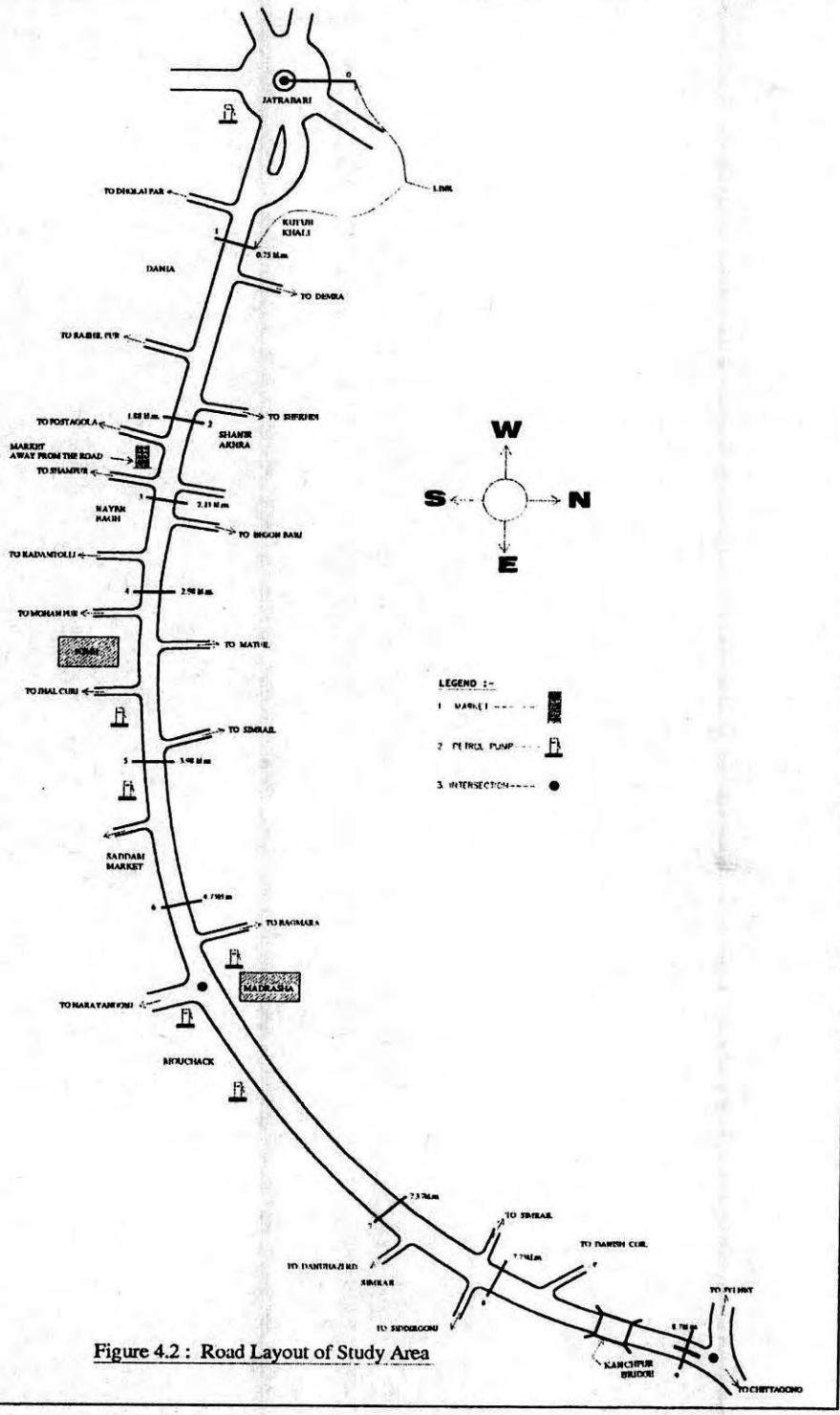

Figure 4.2 : Road Layout of Study Area

Table 4.3: Number of Accidents by Severity in the Study Area (1998- 2001)

Year	Fatal	Grievous	Simple	Collision	Total
1998	37	42	3	9	91
1999	36	29	16	11	92
2000	34	26	4	12	76
2001	69	17	3	8	97
Grand total	176	114	26	40	356

Source: Demra Metropolitan P.S and Siddirgonj P.S.

4.4 Spatial Distribution of Accidents

Accident-prone locations/hazardous locations (Black spots) were selected at places where accidents had occurred repeatedly. Table 4.4 shows the distribution of accidents with features of accident-prone locations in different section of the selected highway from January 1998 to December 2001 (4 years). From Table 4.4 it is evident that there are five locations where the rate of occurrence of traffic accident is much higher than the rest of the locations. These include Jatrabari intersection, Dania College, ICMH, Saddam market and Western part of Kanchpur Bridge.

Table 4.4: Distribution of Accidents with Features of Accident-Prone Locations

Accident prone locations	No. of accident	Percentage (%)	Observations regarding features of roadway and surrounding which may influence accident
Jattrabari intersection	64	18.181	Though the Jatrabari chourastha name implies a 4-leggged intersection, it is infact a 5-legged intersection. 1. Whole intersection is surrounded by shops and attracts large number of people and they also restrict the sight distance to extend. 2. Buses stop right on the intersection just across the central circular island 3. Floating market called bazar is held beside one road, occupying shoulder

Cont. to the next page

Table 4.4 Cont.

Accident prone locations	No. of accident	Percent	Observations regarding features of roadway and surrounding
Kutubkhali	19	5.30	1. Many wood shops are present on the right side of the road and on the both side fisheries aroths are present. The hawkers occupy the shoulder area of the left side and even sometimes pavement area 2. Local bus stops are right on this market places. 3. Absences of footpath for pedestrian movements.
Dania road crossing	41	11.37	1. There is big college on the southern side of the highway. About 4500 students studied in that college. 2. Because of narrow footpath, students & other peoples are bound to move along the carriageway. 3.Near the college there exist small median crossing which is not sufficient because both side of the highway densely populated area. 4. No separate lane for rickshaw .
Shanirakhra intersection	30	8.34	1. Both side of the highway, bus stop right on the intersection 2. A market place locally called 'bazer' is situated on each side of the road. 3. Hawkers and other floating shops are present on the left side of the road. 4.Two-approach road interact highway perpendicularly. 5. The facilities for pedestrian are very poor at this intersection and those scenes are caught into the video camera. 6. Traffic movement at this intersection also haphazard.
Rayerbag	27	7.56	1. There are many timber shops are situated on the southern side of the highway and a narrow approach road connected with the market. 2. No sufficient shoulder width for comfortable movements.

Cont. to the next page

Table 4.4 Cont.

Accident prone locations	No. of accident	Percent	Observations regarding features of roadway and sorrounding
ICMH at Matuail	45	12.88	1. Near the ICMH two approach roads are connected with the highway and formed T-junctions. One from northern side and other one from southern side. 2 Bus stop right on the intersection. There are small crossing through the divider. And huge number of mother with their child come to the hospital for the treatment and here no crossing facility properly.
Saddam market1.	38	10.61	1. There is market near the highway and also approach road is connected with the highway perpendicularly. There is a small crossing through the divider and that crossing is used as a u-turn especially by the rickshaw, loaded van & pushcart. 2. Absence of walking facility and insufficient shoulder width.
Kancpur Bridge	57	15.91	1. In the western side of the bridge truck stands are situated on either side of the highway 2. No divider up to 300m from the bridge approach and people cross the road haphazardly. 3. Because of steep grade of the bridge approach always vehicles speeds remain high 4. The presence of shops near the approach increases the pedestrian activity. 5. Vehicles on the minor road are not visible from the top of the bridge approach. All the above factors seem to play significant role inducing accident.
Sanarpar bus stand	35	9.85	1. Many shops are found to be present at the intersection area. 2. Bus-stops are also right on the intersection area
Grand total	356	100	

Source: Demra Metropolitan Police Station and Siddirgonj Police Station

It is evident from the Figure 4.3a and Figure 4.3b that the greatest percentage 18.18% of total accidents occurred in the Jatrabari intersection. This may be primarily due to very haphazard traffic movement and lack of pedestrian movement facilities at intersection. The second and third highest percentages are 15.91% and 12.88% occurred at Kanchpur Bridge approach and near ICMH at Matuil respectively. The frequency of accident at Dania, Saddam market and Sanarpar are also significant.

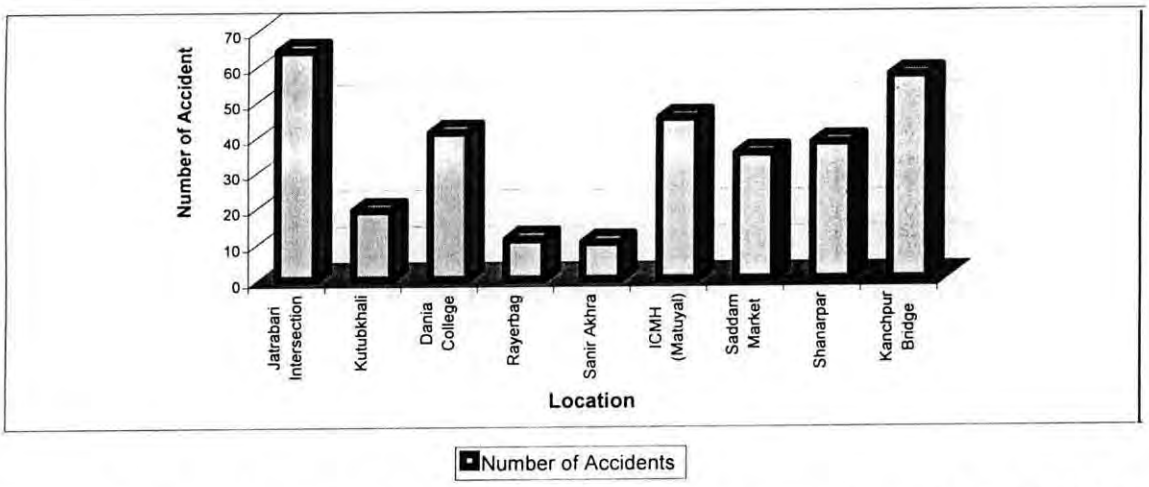

Figure 4.3a: Total Number of Accident in Different Locations on Selected Highway Section

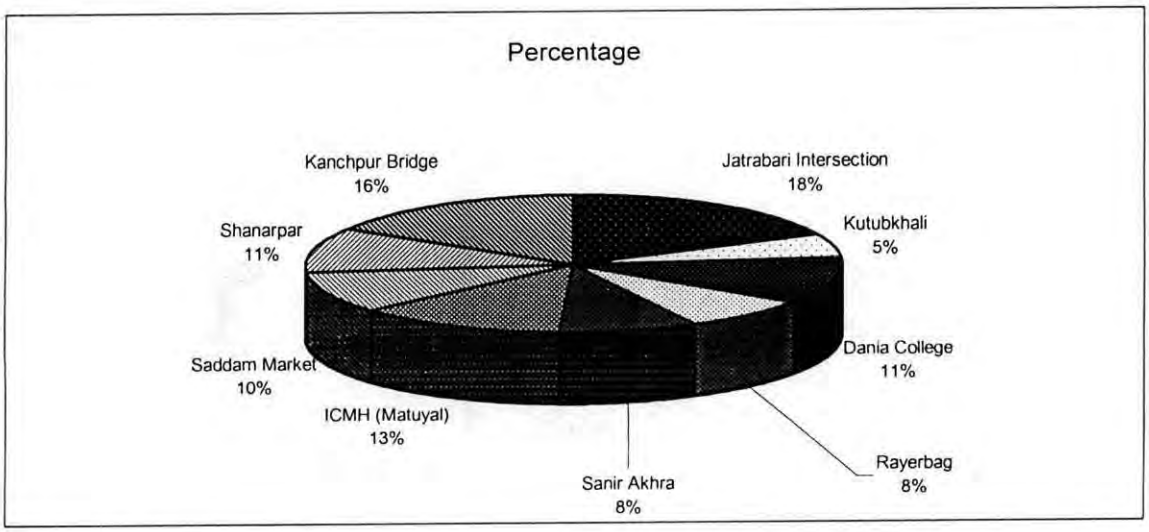

Figure 4.3b: Percentage of Accident in Different Locations on Selected Highway Section

4.5 Distribution of Accidents by Types

In order to study the distribution of accidents by types, they are classified as Fatal, Grievous, Simple and Collision. Figure 4.4a shows type of accident in different police stations (Demra and Siddirgonj) during the period January 1998 to December 2001. It is evident from Figure 4.4a that Fatalities have occurred in majority number of cases. Figure 4.4b shows that about 50 percent of the accidents occurring in the roadway section is fatal type of accident.

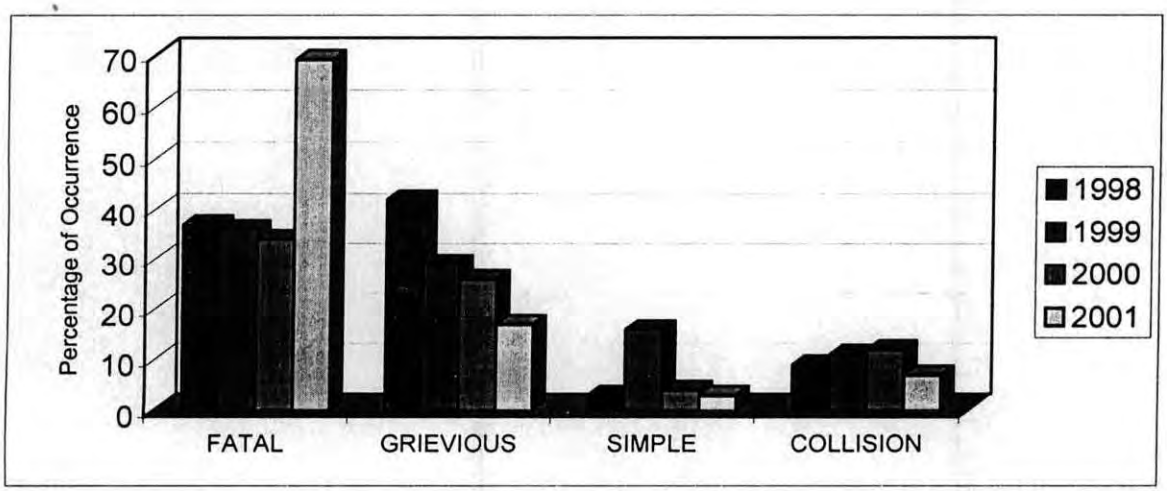

Figure 4.4a: Different Types of Road Accident on Selected Highway Section

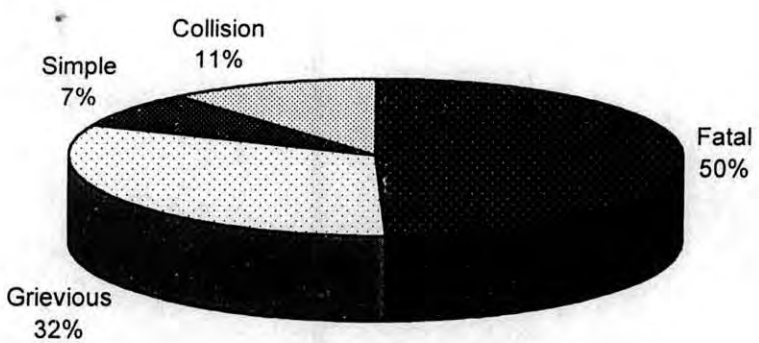

Figure 4.4b: Type of Road Accidents (Percentage) on Selected Highway Section

The frequency of accident types is listed in Table 4.5. It is evident from the Table 4.5 and Figure 4.5 that pedestrian is involved in 54.21 percent of the total road accident in the study area which is the highest with respect to involvement. The second highest accident type is Rear-end collision (26.96%).

Table 4.5 Frequency of Accident Types on a Section of Selected Highway (1998-2001)

Accident Type	Frequency				Total frequency	Percentage (%)
	1998	1999	2000	2001		
Pedestrian	45	47	36	65	193	54.21
Rear-end	28	26	23	19	96	26.96
Head-on	4	4	5	2	15	4.21
Parked vehicle	4	0	0	3	7	1.96
Over taking	3	2	5	3	13	3.65
Side swipe	5	6	3	3	17	4.77
Fixed object	0	1	0	2	3	0.84
Unknown type	2	6	4	0	12	3.37
Total	91	92	76	97	356	100

Source: Demra and Siddirgonj Police Stations

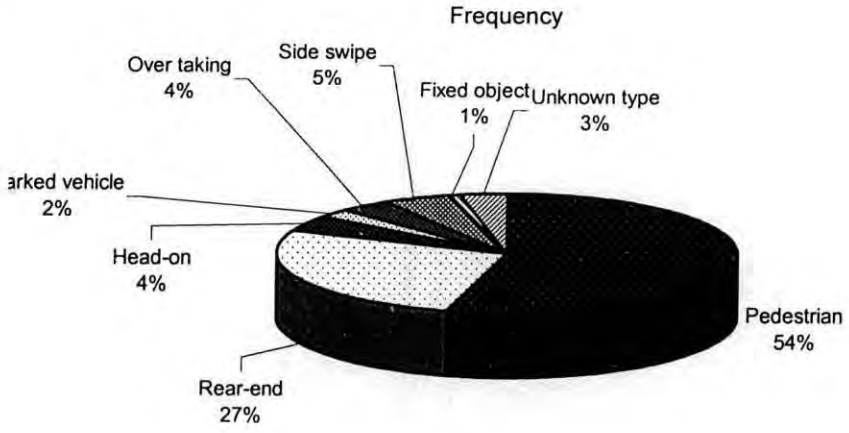

Figure 4.5: Frequencies of Accident Types (percent) on Selected Highway Section

4.6 Temporal Distribution of Accidents

4.6.1 Distribution of Accident by Time of Day

Daily patterns of road accidents data indicate that traffic accidents vary considerably by hour of day. During certain hours in a day, accidents are at the highest level when the traffic volume is also supposed to be at the highest level. The daily time pattern of accidents occurring in the study area is shown in Table 4.6 for the data accumulated during January 1998 to December 2001. The occurrence of accidents during the day and night time also tabulated. About 56 percent of accidents occurred in day time (6 AM to 6 PM) and about 44 percent occurred during night time (6 PM to 6AM). Figure 4.6 shows that the maximum number of accidents occurred during 5.0 am to 2.0 pm. This figure also shows that the frequency of daytime accidents are higher than nighttime accidents.

Table 4.6: Two Hourly Distribution of Road accidents (1998 – 2001).

Hours of Day	Number of Accidents				Total Accidents	Percentage (%)
	1998	1999	2000	2001		
00-02	4	8	7	2	21	5.74
02-04	2	6	3	10	21	5.74
04-06	8	7	7	11	33	9.01
06-08	5	6	12	8	31	8.47
08-10	15	8	6	3	32	14.03
10-12	10	10	5	12	37	10.11
12-14	9	9	3	7	28	7.65
14-16	11	7	7	8	33	9.01
16-18	5	6	8	13	32	8.74
18-20	6	6	7	9	28	7.65
20-22	10	10	3	8	31	8.47
22-24	6	9	8	6	29	7.65
Total	91	92	76	96	356	100

Source: Demra and Siddirgong Police Stations

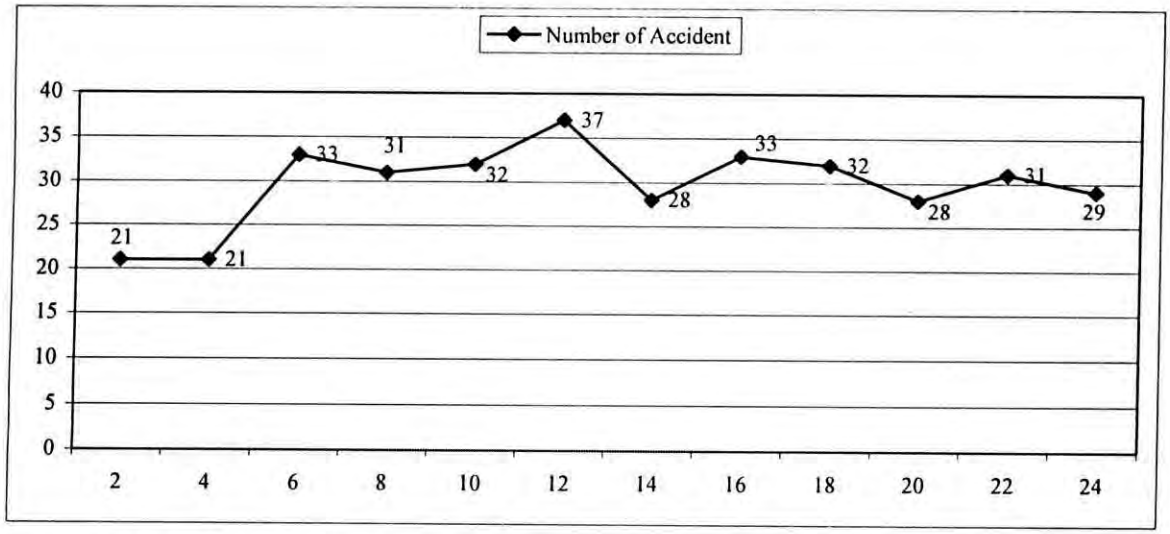

Figure 4.6 Two Hourly Distribution of Road accidents on Selected Highway Section

4.6.2 Distribution of Time by Day of Week

From Table 4.7 and Figure 4.7 it is evident that highest percentage of accidents (19.33%) occurred on Monday. During the other days the rate of accidents is almost uniform and varies between 12 to 14 percent. It implies that about 13 percent accidents are related with regular traffic. In the study area Monday is the day for 'Hut', the weekly marketing day which involve gathering of rural people for buying and selling goods.

Table 4.7: Distribution Accident by Day of Week during 1998 up to 2001

Day	Number of Accident				Total no. of Acc.	Percentage (%)
	1998	1999	2000	2001		
Monday	14	18	15	22	69	19.33
Tuesday	13	12	9	14	48	13.45
Wednesday	15	15	8	11	49	13.73
Thursday	13	8	14	6	41	11.76
Friday	11	14	6	19	50	14.00
Saturday	11	12	11	16	50	14.00
Sunday	14	13	13	9	49	13.73
Total	91	92	75	97	356	100

Source: Demra and Siddirgonj police station

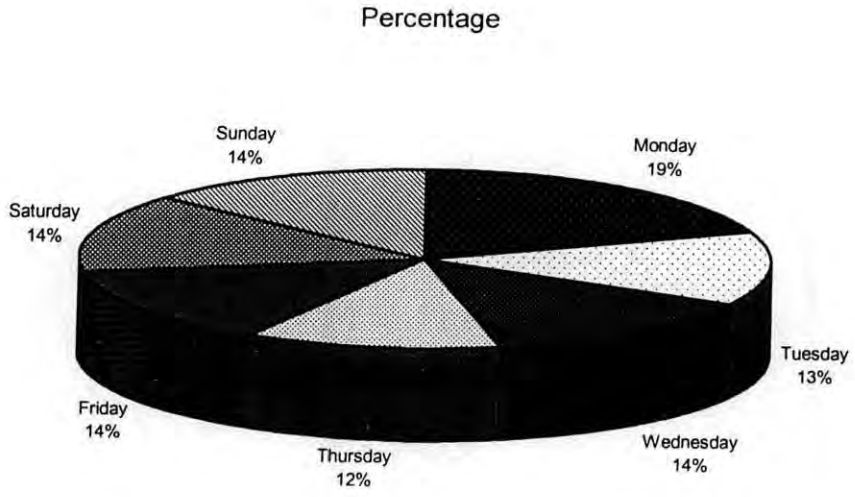

Figure 4.7: Distributions of Road Accidents by Day of Week in Percentage.

4.6.3 Distribution of Accidents by Month of Year

The numbers of accidents are likely to vary with months of the year. The variation is shown in Table 4.8 the average number of accidents per month is 29.5. The highest percentage of accidents is observed in the month of January which accounted for about 17 percent. It is followed by November, April and July with about 13, 10 and 10 percent of the total number of accidents. The number of fatalities and grievous injury in January is also very high. It may be caused by low visibility during the month.

Table 4.8: Distributions of Accident by Month of Year (1998 – 2001)

Month	Total road accidents	Fatalities	Grievous	Simple	Collision
January	60	40	13	4	3
February	19	10	5	3	1
March	19	7	8	2	2
April	36	25	6	2	3
May	26	17	4	3	2
June	27	19	5	2	1
July	35	26	4	2	3
August	17	13	2	1	1
September	27	23	2	1	1
October	26	20	2	2	2
November	46	22	12	5	7
December	18	12	3	2	1
Grand total	356	234	66	29	27

Source: Demra and Sidirgongj Police Stations

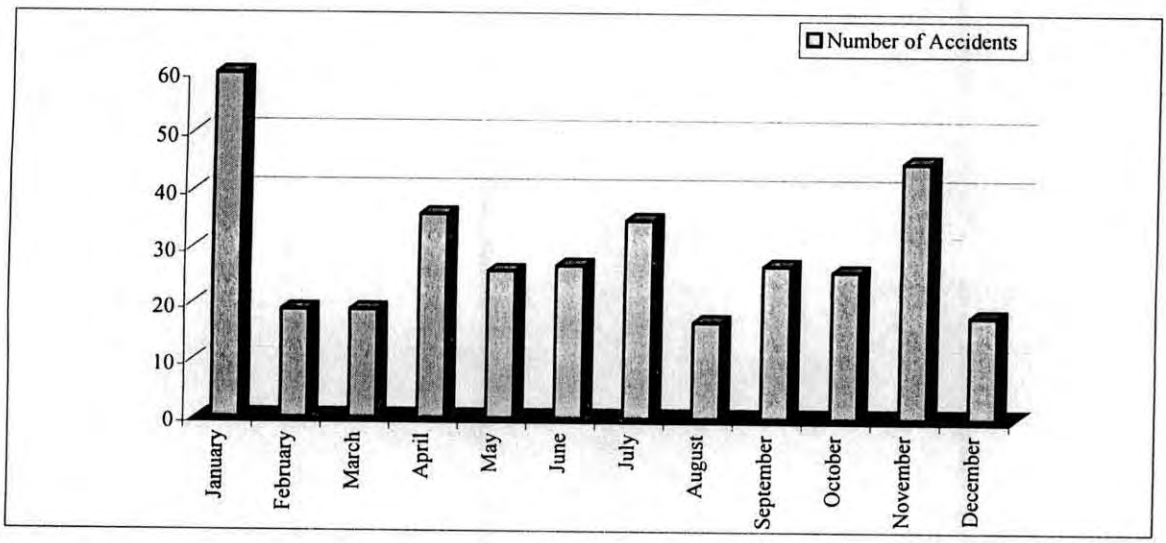

Figure 4.8 Monthly distributions of road accidents on Selected Highway Section

4.7 Vehicles Involved In Accidents

It is found that a total of 397 vehicles are involved in 356 road accidents on the particular section of highway during January 1998 to December 2001. The Figure 4.9 shows the type of vehicles involved in road accidents. It is evident that Buses and Trucks are involved in most of the accidents.

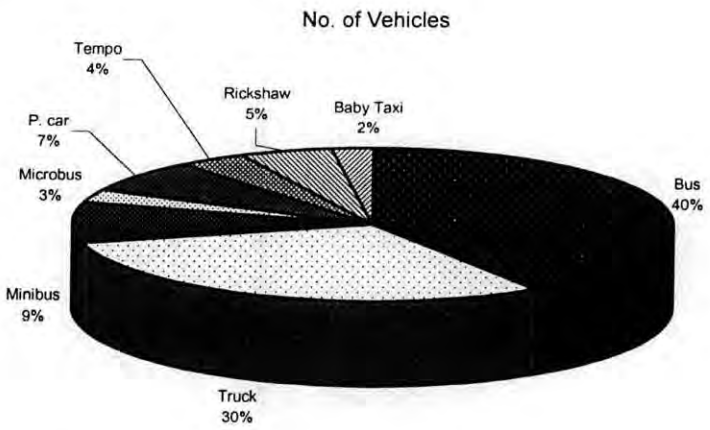

Figure 4.9: Type of Vehicles Involved in Road Accidents in Percentages

4.8 Comparison with Previous Studies

Hoque (1982) and Chowdhury (1996) conducted detail studies on accident in the study area. As shown in Table 4.9, the proportion of fatal accidents occurring in the study area has increased by about 150 percent. Such a phenomenal increase can be attributed to the increase of population and economic activities, increase of number of vehicles and their speed as well as improvement in accident data collection system.

Table 4.9 Comparison with Previous Studious

Name of Study	% of Fatal Accident	% Injury Accident	% of Property Damage Accident	No of Accidents	Study Period
Hoque (1982)	20	49	31	345	1977-1980
Chowdhury (1996)	35	46	19	517	1992-1995
Samad (2003)	49	39	12	356	1998-2001

4.9 Identification of Black Spots

4.9.1 Factor Weights

Factor weights, explained in section 3.5, are analyzed on the basis of available information and shown in Table 4.9 below. Three factors are included in the analysis and 64.8 percent of the total variance is explained by the three factors included in the analysis. The first factor explains 28.3 percent of the total variance and the other two factors explain about 18 percent each.

Table 4.10 Factor Weights for Blackspot Identification

Variable	Factor 1	Factor 2	Factor 3
Pedestrian	0	0.087	0
On Road Obstruction	0	0.547	0.119
Road Side Hazard	0	0.193	0.819
Over Speed	0.844	0	0.025
Faulty driving	0.881	0	0.029
Improper Maneuvering	0	0.163	0
Involvement of Bus and Truck	0.373	0.762	0
Mixed Traffic	0	0	0.795

Total Variance Explained						
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.544	28.267	28.267	2.544	28.267	28.267
2	1.662	18.461	46.729	1.662	18.461	46.729
3	1.626	18.061	64.790	1.626	18.061	64.790
4	1.120	12.446	77.236			
5	0.822	9.134	86.370			
6	0.519	5.765	92.135			
7	0.405	4.502	96.637			
8	0.303	3.363	100.000			

Extraction Method: Principal Component Analysis.

From observation on the factors it is evident that the first factor relates to drivers' involvement, the second factor relates to vehicle and on road obstruction and, the third factor relates to roadway environment. The relative weight of each of the factor is calculated and the involvement of the third factor is graphed along the roadway section under study. A location is identified as blackspot where the total weight of the third factor weighs more than average. On the basis of the analysis the locations identified as blackspot are described below.

4.9.2 Blackspot in the Study Area

Road traffic accidents result from failures in the interaction of humans, vehicles and the road environment- the elements that produce the road traffic system. The involvement of these elements to produce road traffic accidents imply that the road safety problem has to be tackled in a multi-functional manner in order to break the chains of events that lead to accidents as well as death and injury of road users. In this section the interaction among traffic system elements is examined in order to identify the causes of traffic accident in the study area.

From Figure 4.3a it is evident that there are five locations where the rate of occurrence of traffic accident is much higher than the rest of the locations. These include Jatrabari intersection, Dania College, ICMH, Saddam market and Western part of Kanchpur Bridge. Figure 4.10 presents the spatial distribution of occurrence of accident on the selected highway section. From this figure it is observed that most of the accident occurred on southern side of the highway and most of the fatalities occurred in the above-mentioned locations.

At Jatrabari intersection 5-approach road interact. Although there exist a round about at the center of the intersection, traffic movement is very haphazard. The facilities for pedestrian movement are very poor at the intersection. Although there exist an overpass for pedestrian movement which is not comfortable for pedestrian movement. The adjacent bazar at the intersection attract large number of people to haphazard movement. Bus stop right on the intersection just across the central circular island aggravate the situation.

At Dania, there exist approach roads on either side of the highway. There is a large college in southern side and a school in the northern side. Also, there exist lot of residences on either side of the highway. There are about 4500 college students and about 1000 school students. Also either side of the highway is densely populated area and there does not exist any crossing facilities for students and people. Usually the local people facilitates crossing of highway by breaking the medians. Most of the accident happened near the Dania College because absence of speed breaker and lack of traffic control. Also there is no service road on either side of road along the highway. It is observed that in many cases vehicles, particularly rickshaws move in opposite (wrong direction) to get the passengers and cause accidents.

At ICMH two-approach road interact from both side of the highway and formed T-Junctions. One is coming from Jhalkuri (south) and other one from Matuil (north). Adjacent to the highway there exist Institute of Mother and Child Health (ICMH) and many women with their children come to the hospital for treatment. But near the hospital there does not exist any road crossing facilities. Usually people cross the road through a 3 ft wide opening in the median. Also buses stop on the intersection, which obstruct sight distance. Absence of Zebra crossing and lack of control on the speed of vehicles causes accident.

Near the Saddam market one approach road (southern side) is connected perpendicularly with the highway. This approach road is lower than the highway that obstructs the sight distances. Saddam market is situated adjacent to the highway without any road crossing facilities.

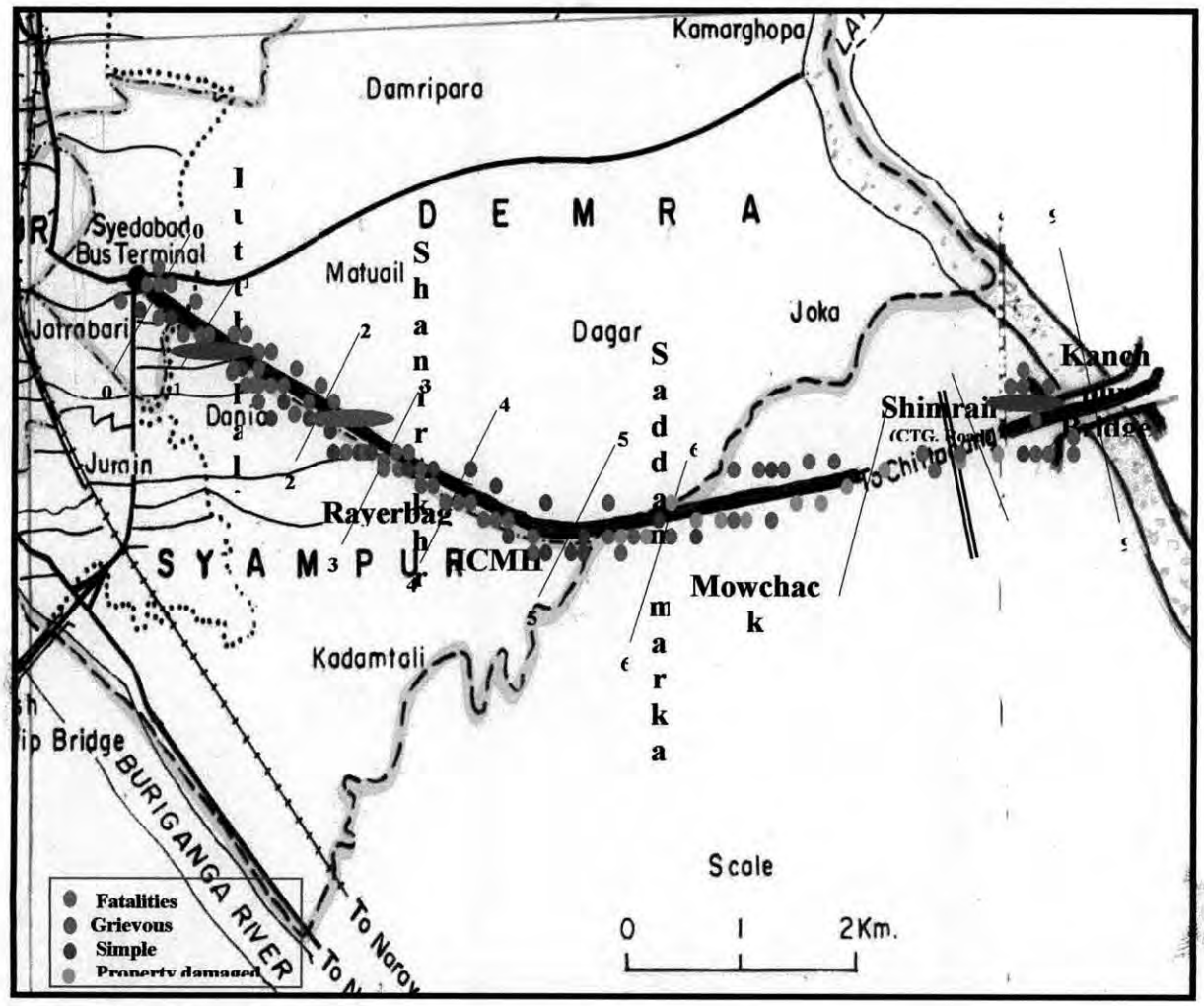

Figure 4.10: Spatial Distribution of Occurrence of Accident on Selected Highway Section

There is a 5 feet wide opening through the median island through which rickshaws and vans take u-turn and buses usually stop on the intersection thereby inducing accident. Most of the accidents at this intersection were caused by vehicles taking u – turns.

At Kanchpur Bridge (western part), the highway pavement width is 17 feet on either side of Median Island at Bridge approach, which is much less than specified width of 22 feet set by planning commission (1980) for national highway. The shoulder widths are 4 feet to 6 feet, which is much less than standard width. There is a minor approach road connected with highway. Also truck stands are situated on either side of the highway, which obstruct the sight distances of minor road. The presence of shops and factory (northern side) near the

bridge approach increase the pedestrian activity. Because of steep grade of the bridge, usually vehicle speed remains high. Since there is no median island up to 300 meter from bridge approach, people cross the road haphazardly thereby causing accidents.

4.10 Recommendation to Reduce Accidents

From the above analysis it is evident that most of the accidents involve pedestrian. This is caused by the lack of facilities for the pedestrian to cross the road. Also facilities for safe loading and unloading of passengers do not exist. In this connection the following recommendations are proposed to reduce traffic accident involving pedestrian.

i. Construction of Pedestrian underpass at the selected locations. The most effective locations for building the underpasses would be the places identified as black spot in the study. Underpasses are recommended because it is observed that a significant portion of people cross the road carrying heavy overhead loads. For these people underpass would be more beneficial than the overpass.

ii. Development of off-road bus stops. These bus stops may be segregated from the main road by developing them at a lower grade. Such grade separated bus stops should be developed at the black spots.

iii. Prevent non-motorized vehicles to enter into the main road. This can be achieved by eliminating direct access from the approach roads into the highway section. For this purpose a frontage road, at a lower grade can be constructed.

iv. The intersection should be channelized with appropriate islands and channels. Such channels would eliminate the conflicting points and help in reducing accidents. For example, at Jatrabari intersection one of the major reasons of accident is haphazard vehicular traffic movement. Appropriate channels would streamline traffic flow and reduce accident. For Jatrabari intersection it is also recommended to increase pedestrian facility and improve the facility of road crossing. For Kanchpur Bridge approach (western side) it is recommended to extend median upto the approach of the Bridge to eliminate the haphazard roadway crossing. Typical section of Jatrabari intersection and Kanchpur Bridge approach are shown in Figure 4.11 and Figure 4.12 respectively.

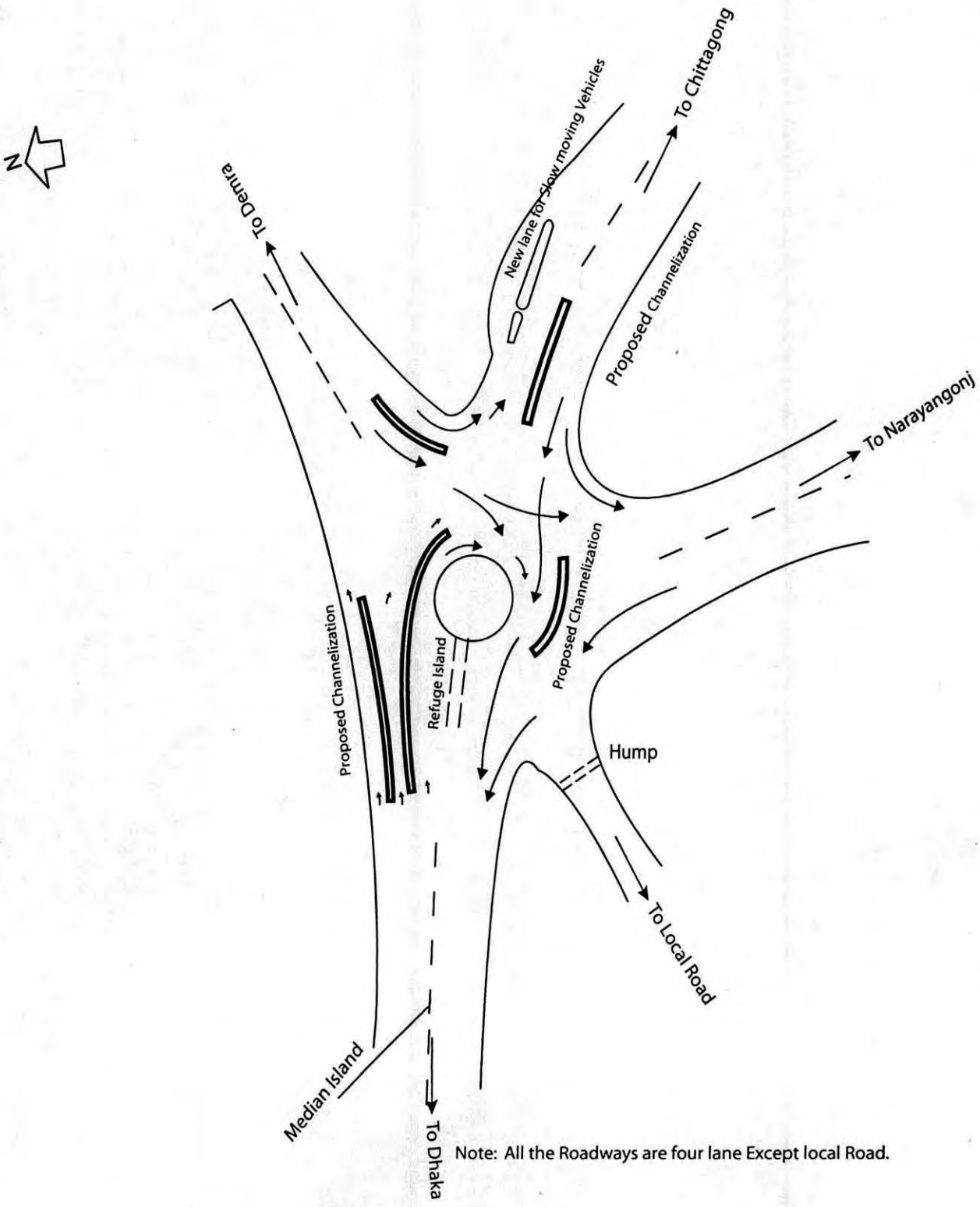

Figure 4.11: Proposed Layout of Jatrabari Intesection

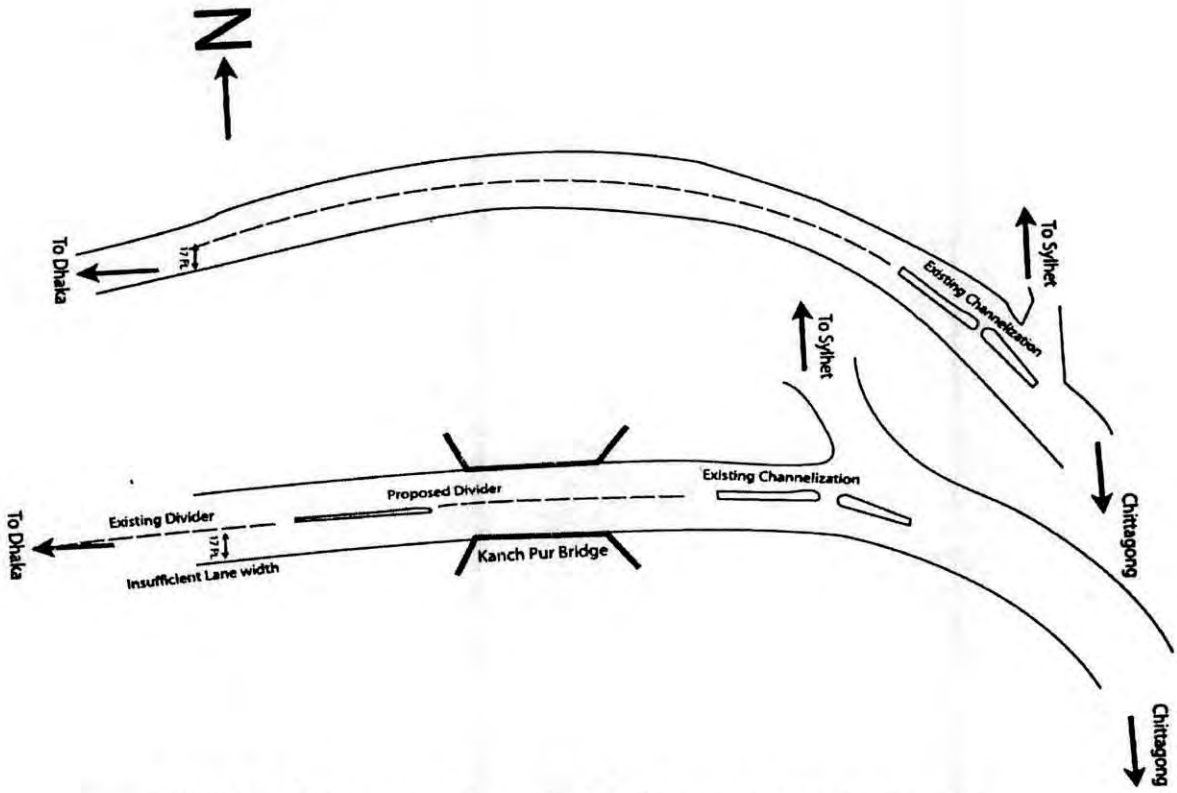

Figure 4.12: Proposed Layout of Kanchpur Bridge Approach

v. In many cases it is observed that trucks remain parked on the road for hours together. This reduces the effective roadway, create congestion, encourage other vehicles to use illegal means and induce accident. To eliminate such parking, tolls may be imposed in addition to construction of parking place.

4.11 Summary

In this chapter a detail analysis of characteristics of accidents occurring in Jatrabari to Kanchpur Bridge section of Dhaka Chittagong highway in presented. It also illustrated the procedure for identification black spots along the roadway and its correlation with the causes of occurrence of accidents. On the basis of the analysis several counter measures are proposed to reduce traffic accidents in the most effective way.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATION

The conclusions that can be drawn from this research work presented in the thesis are summarized in this chapter. It also includes suggested measures for minimizing accidents at intersections and links of roads based on such factual findings are highlighted. This chapter also suggests some recommendations that can be addressed in future studies.

5.1 Conclusions

5.1.1 Findings of the Study

The main objective of the research is to identify the black spots and analyze the characteristics of accidents. In this connection accident data of four calendar years from 1998 – 2001 is collected. Accident information includes temporal and spatial characteristics. The Characteristics of the accidents are summarized below:

The study suggests that 356 accidents occurred in the study during the study period of three years. As compared to the study of Chowdury (1996) traffic accidents has increased by 3 times. Such a phenomenal increase in accident rate can be attributed to the improvement of accident reporting framework implemented by National Road Safety Council and the introduction of MAAP software based data collection system.

Out of the 356 reported accidents, 49% were fatal accidents, 39% were injury accidents and 12% were property damage accidents.The study realized that 56% accident occurred during daytime and 44% during night. Also the frequency of accident is higher during morning peak hours from 8.00 am to 12.0 am. It is also found that pedestrian-vehicle conflicts are the greatest problem with significant involvement of buses and trucks. Also it is found that out of 356 accidents 34% took place at intersection and rest 66% at links of selected section of highway. Based on the results of accident analysis and findings of the study and from physical inspections, the following conclusions can be drawn for hazardous intersections (black spots) and mid-blocks.

The average annual increase in accident rate in metropolitan area is 14.5 percent during the period of 1996 to 1998. In most recent years the average annual increase in accident rate on the selected highway is 21% percent during the period of 2000 to 2001.

On the basis of number of occurrences, highway accidents may be categorized into classes, such as accident involving vehicle and pedestrian, vehicular collisions and vehicle striking a fixed object, with number of occurrences of 54.21%, 33.87% and 0.9% respectively. Daytime (6.00 am to 6.00 pm) accident rate is found to be higher than that of nighttime (6.00 pm to 6.00 am) on the highway studied 56% accidents occurred during daytime.

5.1.2 Procedure for Identification of Blackspots

Location of blackspot is closely related with involvement of roadway environment variables in the occurrence of accident. In this connection the relative weightages of roadway environment related variables were identified by using 'Principal Component Analysis'. Later this weight is graphed along the roadway section under study and the locations where the weights are more than the average are identified as blackspots.

5.1.3 Intersection Blackspots in the Study Area

Most hazardous intersections such as Jatrabari intersection, Kanchpur Bridge and Mukti sarani have deficiencies in geometric design standards (inadequate shoulder width, pavement width less than standard and restricted sight distance), signal and pedestrian crossing facilities. Other physical features that affect vehicular traffic and road safety include uncontrolled movement of pedestrians, presence of roadside shops, bus stoppage at or very close to intersections on roadways causing obstruction to through traffic, absence of proper parking places for rickshaws. Traffic is not strictly controlled due to the lack of enforcement resulting from absence of adequate number of traffic police. Considerable number of slow moving vehicles such as rickshaws and vans also create situation conducive to the occurrence of accident involving fast moving vehicles at these intersections, particularly at the Jatrabari intersection. The increased pedestrian accident implies vehicle-pedestrian conflict and clearly indicates the problem of pedestrian movement. It was observed that the pedestrian facilities

are lacking in these hazardous intersections. The study reveals that Jatrabari intersection is the most hazardous intersection with five approach roads that meet at the intersection.

5.1.4 Link Blackspots in the Study Area

The hazardous sections in the study area include ICMH link at Matuail, Kanchpur Bridge Approach (western) Saddam market road link and Dania College have deficiencies in geometric design standards and pedestrian crossing facilities. Most hazardous section is western part of Kanchpur Bridge with 57 accidents (15.91%) occurring in this section among which 40 is fatal, 12 grievous and 5 property damage accident. It is followed by ICMH and Dania College section respectively with respect to the number of accident occurrence.

Finally, from field observation, it is observed that one of the major factors causing accidents is presence of large number of rickshaws which are not dominantly involved in the accidents but create situation at initial event leading to accidents of fast moving vehicles in the hazardous links and intersections of the selected section of highway. Un-regulated pedestrian movements, curbside parking, parking of vehicles and frequent number of petrol pumps at the side of roads also create hazards to through movements in the hazardous links of selected roads.

5.1.5 Recommended Measures to Reduce Traffic Accident

Considering the location, time and environment of the occurrence of accident in the study area the following design measures are recommended

1) Underpass should be constructed at grade at the level of approaching road for safe pedestrian crossing.
2) Prevent non-motorized vehicles to enter into the main road. For this purpose a frontage road, at lower grade can be constructed.
3) The intersections should be channelized with appropriate islands and channels.
4) To eliminate illegal parking on the road tolls may be imposed in addition to construction of parking place.

5.3 Recommendation for future Study

This study covers small section of selected highway. Such microscopic investigation may be made on other sections of the highway as well as on other highways of Bangladesh to identify black spots and investigate their causes. The possibility of using a different design features for roadway geometry of links as well as intersections can be studied in more details considering the slow and fast moving vehicles in the same traffic stream.

The present accident reporting and recording systems seem to be inadequate and inefficient. Data that are available from police stations do not include all the characteristics of accidents, particularly the locational and environmental features. Each accident report should contain all necessary information.

Correlation of accident occurrence, frequency and types with layout features of the links and intersections together with the road environmental characteristics are required to be analyzed on nationwide basis to identify and understand the actual causes of accident.

REFERENCES

AASHTO (1986), A Policy on Geometric Design of Rural Highways, American Association of State Highway Officials, Washington.

Babkov, V.F (1975), Road Conditions and Traffic Safety (1975) MIR Publishers; Moscow.

BTCE (1995), Evaluation of Black Spot Program, Report 90, Bureau of Transport and Communication Economics, Canberra, Australia.

Burrough P. (1991) Procedure for the Road Safety and Audit of Trunk Road Schemes. UK Dept of Transport.

Chowdhury, Z.C. (1996), A Study on Low Cost Safety Improvement of Selected Arterial Roads in Metropolitan Dhaka City, Unpublished M.Engg. Thesis, Department of Civil Engineering, BUET.

Grayson, G.B. (1987), "Pedestrian Risk in Crossing Roads: West London Revisited", Traffic Engineering + Control, vol. 28, pp. 27-30.

Hoque, MM and Alam, JB (2002), Strategies For Safer And Sustainable Urban Transport In Bangladesh, 10th Conference on Urban Transportation, CODATU-X, Lome, November, 2002.

Hoque, MM and Alam, JB (2000), "Investigation of Traffic Accidents in Bangladesh on the basis of Haddon's Framework for Assigning Responsibilities", ninth International Conference on Safe Communities, ICMH, Dhaka, 26-28 February 2000.

Hoque, M.M. (1998) The Accident Problem in Highways, Vol. 26, and No: 1, June 1998, Journal of Civil Engineering, Institute of Engineers, Banglades.

Hoque M.M. Ahsan H.M. and McDonald M. (1997) Traffic congestion and safety: some contemporary issues and options in Bangladesh. Proceedings of the ASCE Conference on Traffic Congestion and Traffic Safety in the 21st Century. Chicago.

Hoque, M.M. (1993), The Road Accident in Bangladesh, Technical Paper, Conference on Asian Road Safety, Kuala Lumpur, 23-28 October, 1993.

Hoque, MM (1991), Accident Investigation on Safety Improvement of Dhaka-Aricha Highway, A Section of Asian Highway, Final Report, Dept. of Civil Engineering, BUET, Dhaka, December, 1991.

Hoque, M.M., (1982), Accidents and Geometric Design Features of Two Lane Urban Highways in Dacca, Indian Highways, July 1992.

Hoque M.M and Ahsan H.M. (2000) "Road Safety Management in Urban Areas of Developing Country" Ninth International Conference on Safe Communities, ICMH, Dhaka, 26-28 February 2000.

Hossain, M. I. (2000), Reducing Road Accidents, Workshop on Land Transport Policy, Seminar Paper held at Pan Pacific Sonargaon Hotel, Dhaka, August 2000

Jacobs G.D. and Baguley C.J. (1997) Towards a strategy for improving road safety in developing countries. Annual review 1996. Transport Research Laboratory, UK.

Jacobs, G. D. Sayer, P and Downing, R.(1981), "A Preliminary Study of Road User Behavior in Developing Countries", TRRL Report SR 646, Dept. of Transport, Crowthorne, UK.

Jacobs, G. D. and Sayer, I.A. (1984), "Road Accidents in Developing Countries – Urban Problems and Remedial Measures", TRRL, Report, SR 839, Department of Transport, Crowthorne (TRRL).

Khoshi M. (1986) Road safety-success and failure in Japan. 13th ARRB/5th REAAA Conference proceedings, 13(1).

Kiwan, Mohammad, S.A.A. (1988), "Pedestrianization in Dhaka City: Problems and Prospects", Unpublished MURP Thesis, Dept. of urban and regional Planning, BUET, Dhaka.

Little, A.D. (1970), The State of the Art of Traffic Safety, Paraeger publishers, New York.

Nakamura, F. (1994), Multivariate Analysis for Human Settlement Planning Volume I and Volume II, HSD Reference Material 29-2, Human Resources Development Program, School of Environment, Resources and Development, Asian Institute of Technology, Bankok, Thailand.

O'Flaherty, C.A. (1974), Highways, and vol. 1: Highways and Traffic, Edward Arnold, London.

Ogden K.W. (1996) Safer Roads: a Guide to Road Safety Engineering Avebury Technical, England.

Rahman K.A. (2002), Safety in Road Transport Sector, Seminar on Safety in Road Transport and Industrial Sector- An Acme Crisis, IEB, Dhaka.

Ross Silcock & TRL (1996) Road safety guidelines for Asia Pacific Region. Regional Technical Assistance Project Draft 2 Report, Asian Development Bank.

Sabey, B.E.. and Taylor, H. (1980) The Known Risk We Run: The Highway, 'Social Risk Assessment – How Safe is Safe Enough?' R.E. Schwing and W.A. Alberts eds. Plenum Press, New York N.Y.

Sayed, T., Abdelwahab, W. and Navin, F. (1995) Identifying Accident Prone Locations Using Fuzzy Recognition, Journal of Transportation Engineering ASCE, Vol 121 No4 P 352-358.

Shahabuddin AKM, Islam, F. and Ahmed T. (2000), "Road accidents in Bangladesh and law of the Land". Ninth International Conference on Safe Communities, ICMH, Dhaka, 26-28 February 2000.

Sarker M.S.A. (2000), "Road Traffic Accidents in Bangladesh" Ninth International Conference on Safe Communities, ICMH, Dhaka, 26-28 February 2000.

Singha, H. K. (1975), Methods in Accident Study's, Indian Highways, Vol. 3, No. 7 New Delhi.

Treat, J.R. (1980) A Study of Pre-Crash Factors Involved in Traffic Accidents, Rep. HSRI 10/11, Highway Safety Research Inst. (HSRI) Ann Arbor, Mich.

Vaughan R., Barnes J. and Schnerring F. (1992) Systematic crash investigation. Sixteenth ARRB conference proceedings, 16(4).

Appendix-A

TERMINOLOGY

It is important to describe some of the terms in the text in order to aid in comprehension. Some of the more important terms relating to accidents and accident locations are given in the following sections:

Terms relating to Accidents

Road Traffic Accident (RTA): An accident, which follows from the movement of at least one road vehicle on a road and resulted in casualty or non-casualty.

Road Traffic Casualty: A person who either died or injured at the time of road traffic accident.

Fatal Casualty: Recorded when any person is killed at the time road traffic accident.

Grievous Casualty: Recorded when any person is injured and admitted in Hospital

Simple Injury Casualty: when a person is injured but need not to admit in Hospital

Road Traffic Fatal Accident: Recorded when one or more death as defined as fatal occurs as a result of the accident.

Road Traffic Grievous Accident: is an accident in which one or more become grievous casualty as a result of the accident.

Simple Injury Accident: is an accident in which any person is injured as defined a simple injury above.

Property Damage Accident or Road Traffic non-injury Accident: is recorded for an accident when no fatality, grievous or simple injury has occurred. This referred to as the property damage only (PDO)

Severity level vs. Casualty class: This requires some clarification. There exists a difference between severity level and casualty class while the casualty class refers to a person involved in an accident, the severity level refers to an accident, which is classified based on the most severe casualty class received by any person involved in that accident. The severity levels (fatal, injury and PDO) are used to classify accidents.

Pedestrian volume and density

Pedestrian volume is defined as the number of persons passing a given unit width of section in a unit of time. Pedestrian density can either be expressed in number of pedestrians per square meter or its reciprocal; the number of square meters of area per pedestrian.

The Passenger Car Equivalent (PCE)

A way of accounting for the interaction of various kinds of traffic is express the capacity of roads in terms of a common unit. The unit generally employed is the "passenger car equivalent ". The values of PCE adopted for the conversion in this research are those adopted by ESCAP (Economic and Social Commission for Asia the Pacific), except for cycle-rickshaw and pushcart. The ESCAP value of 2 was considered excessive by some agencies and would lead to overestimation of traffic flow compared with the practical capacity of the road. Roads and Highways department (RHD) suggests 0.5 as a practical value for cycle-rickshaw. This value implies underestimation of the impact of this particular vehicle on road capacity in terms of time and space, which significantly requires more than that of passenger car. This value is also not supported by practical analysis. The Indian road congress (1976) recommended 1.5 a practical value as a result of extensive field tests and analysis. It also recommended 6 as the PCE value for pushcart. The PCE values adopted for data analysis are shown in Table A:

Table A: Passenger car equivalent of vehicle types

Vehicle type	P.C.E (Passenger Car Equivalent)
Car, Jeep, Pick-up, Microbus	1
Truck	3
Bus	3
Auto-rickshaw	1
Motor-cycle	0.5
Pedal-cycle	0.5
Cycle-rickshaw	1.5
Push-cart	6
Van	1.5

Source: Kiwan, 1988

Terms Relating to Accident Location

For the purposes of this study the following locational definitions are used and extracted from Hoque (1987).

Road: A thoroughfare open to public by right or custom. Excludes off-street parking, access areas and other private property not regarded as a thoroughfare, e.g. railway yards, sports areas etc.

Carriageway: Portion of a road improved, designed or ordinarily used for vehicular traffic and includes the shoulders.

Intersection: a place where two or more roads intersect or join

Link: A section of a road between two consecutive intersections.

Intersections Accidents: Intersections type accidents are regarded as having occurred within 50 feet of the intersection.

Between-Intersection Accidents: All other accidents except those as defined as intersection accident. These are referred to as link accidents.

Arterial Road: Arterial roads are such roads, which are designed to carry through traffic. They pass through city limits and link state or national highway system with a limited access. Most of the existing Arterial roads come across highways or roads. The traffic on cross road is regulated by stop sign or signals.

Major roads (major arterials): Provide unity throughout continuous urban area. Usually from boundaries for neighborhoods. Minor access control, chanelized intersections and parking generally prohibited.

Secondary roads (minor arterials): Main feeder streets. Signals where needed, stop signs on side streets. Occasionally from boundaries for neighborhoods.

APPENDIX-B

Table A-2.1a

Pedestrian Crossing Flow (S ⇄ N)

Location: Jatrabari Intersection

Date: 04.07.02

Time: 4.00 to 5.00 pm

Weather: Cloudy

TIME (Min.)	UNCONTROLLED CROSSING THROUGH MID-BLOCK		
	N-S	S-N	TOTAL
00.00-15.00	54	33	87
15.00-30.00	68	30	98
30.00-45.00	78	45	123
45.00-60.00	54	32	86
TOTAL	254	140	394

Source: Field survey, August 2002

Table A-2.1b=

Pedestrian Flow along the sidewalk (S ⇄ N)

Location: Jatrabari Intersection

Date: 04.07.02

Time: 4.00 to 5.00 am

Weather: Cloudy

TIME (Min.)	TRAFFIC FLOW ALONG THE SIDEWALK		
	E-W (To Dhaka)	W-E (To Ctg.)	TOTAL
00.00-15.00	90	63	153
15.00-30.00	89	69	158
30.00-45.00	108	77	185
45.00-60.00	93	62	155
TOTAL	380	271	651

Source: Field survey, 2002

Note: Taking 50m strip

Table A-2.2a

Pedestrian Crossing Flow (S ⇄ N)

Location: Dania College

Date: 19.08.02

Time: 11.36 to 12.36 AM

Weather: Fine

TIME (Min.)	UNCONTROLLED CROSSING THROUGH MID-BLOCK		
	N-S	S-N	TOTAL
00.00-15.00	36	42	78
15.00-30.00	45	37	82
30.00-45.00	51	35	86
45.00-60.00	57	10	67
TOTAL	189	124	313

Source: Field survey, August 2002

Table A-2.2b=

Pedestrian Flow along the sidewalk (S ⇄ N)

Location: Dania College

Date: 19.08.02

Time: 11.36 to 12. 36 AM

Weather: Fine

TIME (Min.)	TRAFFIC FLOW ALONG THE SIDEWALK		
	E-W (To Dhaka)	W-E (To Ctg.)	TOTAL
00.00-15.00	126	111	237
15.00-30.00	99	108	207
30.00-45.00	114	105	219
45.00-60.00	119	99	218
TOTAL	458	423	881

Source: Field survey, 2002

Note: Taking 50m strip

Table A-2.3a

Pedestrian Crossing Flow (S ⇄ N)

Location: Shanir Aakhra

Date: 19.08.02

Time: 8.00 to 9. 00 AM

Weather: Fine

TIME (Min.)	UNCONTROLLED CROSSING THROUGH MIDBLOCK		
	N-S	S-N	TOTAL
00.00-15.00	349	190	539
15.00-30.00	379	217	596
30.00-45.00	365	202	567
45.00-60.00	332	206	538
TOTAL	1425	815	2240

Source: Field survey, August 2002

Table A-2.3b=

Pedestrian Flow along the sidewalk (S ⇄ N)

Location: Shanirakhra

Date: 19.08.02

Time: 8.00 to 9. 00 AM

Weather: Fine

TIME (Min.)	TRAFFIC FLOW ALONG THE SIDEWALK		
	E-W (To Dhaka)	W-E (To Ctg.)	TOTAL
00.00-15.00	299	107	406
15.00-30.00	253	99	352
30.00-45.00	263	90	353
45.00-60.00	292	84	376
TOTAL	1103	380	1383

Source: Field survey

Table A-2.4a

Pedestrian Crossing Flow (S ⇄ N)

Location: ICMH at Matuail

Date: 19.08.02

Time: 9.05 to 10.05 AM

Weather: Fine

TIME (Min.)	UNCONTROLLED CROSSING THROUGH MIDBLOCK		
	N-S	S-N	TOTAL
00.00-15.00	39	42	81
15.00-30.00	30	48	78
30.00-45.00	49	35	84
45.00-60.00	44	29	73
TOTAL	162	154	316

Source: Field survey, August 2002

Table A-2.4b

Pedestrian Flow along the sidewalk (S ⇄ N)

Location: ICMH at Matuail

Date: 19.08.02

Time: 9.05 to 10.05 AM

Weather: Fine

TIME (Min.)	TRAFFIC FLOW ALONG THE SIDEWALK		
	E-W (To Dhaka)	W-E (To Ctg.)	TOTAL
00.00-15.00	36	14	50
15.00-30.00	27	19	46
30.00-45.00	42	30	72
45.00-60.00	57	24	81
TOTAL	162	87	249

Source: Field survey, August 2002

Table A-2.5a

Pedestrian Crossing Flow

(S ⇄ N)

Location: Saddam Market

Date: 20.08.02

Time: 11.25 to 12. 25 AM

Weather: Fine

TIME (Min.)	UNCONTROLLED CROSSING THROUGH MID-BLOCK		
	N-S	S-N	TOTAL
00.00-15.00	26	10	36
15.00-30.00	30	11	41
30.00-45.00	32	15	47
45.00-60.00	105	15	120
TOTAL	193	51	244

Source: Field survey, August 2002

Table A-2.5b

Pedestrian Flow along the sidewalk

(S ⇄ N)

Location: Saddam Market

Date: 20.08.02

Time: 11.25 to 12. 25 AM

Weather: Fine

TIME (Min.)	TRAFFIC FLOW ALONG THE SIDEWALK		
	E-W (To Dhaka)	W-E (To Ctg.)	TOTAL
00.00-15.00	19	12	31
15.00-30.00	18	14	32
30.00-45.00	24	12	36
45.00-60.00	21	9	30
TOTAL	82	47	129

Source: Field survey, 2002

Note: Taking 50m strip

Table A-2.6a

Pedestrian Crossing Flow (S ⇄ N)

Location: Kanchpur Bridge

Date: 19.08.02

Time: 10.15 to 11.15 AM

Weather: Fine

TIME (Min.)	UNCONTROLLED CROSSING THROUGH MID-BLOCK		
	N-S	S-N	TOTAL
00.00-15.00	15	29	44
15.00-30.00	17	35	52
30.00-45.00	23	31	54
45.00-60.00	15	36	51
TOTAL	70	131	201

Source: Field survey, August 2002

Table A-2.6b

Pedestrian Flow along the sidewalk (S ⇄ N)

Location: Kanchpur Bridge

Date: 19.08.02

Time: 10.15 to 11. 15 AM

Weather: Fine

TIME (Min.)	TRAFFIC FLOW ALONG THE SIDEWALK		
	E-W (To Dhaka)	W-E (To Ctg.)	TOTAL
00.00-15.00	29	39	68
15.00-30.00	59	41	100
30.00-45.00	63	31	94
45.00-60.00	58	46	104
TOTAL	209	157	366

Source: Field survey, 2002

Note: Taking 50m strip

APPENDIX-B

Traffic Volume Count

Table A-2.1

Vehicular traffic flow

Date: 04.07.02

Time: 4.00 PM to 5.00 PM

Weather: Rainy

(East ⟷ West)

Location: Jatrabari Intersectin

TIME	MOTORIZED VEHICLES							NON-MOTORIZED VEHICLES					Grand total vehicles	Grand total PCE
	Bus	Truck	Light Vehicle	Three Wheeler	Motor Cycle	Total Vehicles	Total PCE	Rick/ van	Bi-cycle	Push cart	Total Vehicles	Total PCE		
00.00-15.00	192	42	120	96	15	465	924	243	8	2	253	378	718	1302
15.00-30.00	202	45	123	90	16	476	968	223	8	0	231	339	707	1307
30.00-45.00	186	34	113	101	19	452	883	248	10	3	261	395	713	1278
45.00-60.00	199	44	105	105	12	465	950	234	9	0	243	355	708	1305
Total	779	165	459	392	63	1858	3625	2484	35	5	988	1221	2846	4839

Source: Field Survey with Video, August 2002

Note:

Bus= All type of buses (minibus, single decker bus and double decker-bus).
Light vehicle= Car, Jeep, Taxi, Pajero, Microbus, Pick-up, Duranta and Maxi
Three Wheeler= Tempo, Baby-taxi and Mishuk
Truck= All type of Trucks

Table A-2.2

Vehicular traffic flow

Date: 19.08.02

Time11.36 AM to 12.16 AM

Weather: Fine

(East ⟷ West)

Location: Dania College

TIME	MOTORIZED VEHICLES							NON-MOTORIZED VEHICLES					Grand total vehicles	Grand total PCE
	Bus	Truck	Light Vehicle	Three Wheeler	Motor Cycle	Total Vehicles	Total PCE	Rick/ van	Bi-cycle	Push cart	Total Vehicles	Total PCE		
00.00-15.00	130	18	98	30	6	282	575	99	10	0	109	153.5	391	728.5
15.00-30.00	126	9	88	22	9	254	519.5	87	8	1	96	140.5	394.5	660
30.00-45.00	110	10	92	29	8	249	485	94	5	2	101	155.5	350	640.5
45.00-60.00	114	14	96	28	15	267	515.5	90	4	0	94	137	361	652.5
Total	480	51	374	109	38	1052	2095	370	27	3	400	586.5	1452	2681.5

Source: Field Survey with Video, August 2002

Note:

Bus= All type of buses (minibus, single decker bus and double decker-bus).
Light vehicle= Car, Jeep, Taxi, Pajero, Microbus, Pick-up, Duranta and Maxi
Three Wheeler= Tempo, Baby-taxi and Mishuk
Truck= All type of Trucks

Table A-2.3

Vehicular traffic flow

Date: 19.08.02

Time: 8.00 AM to 8.40 AM

Weather: Fine

(East ⟷ West)

Location: Shanirakhra

TIME	MOTORIZED VEHICLES							NON-MOTORIZED VEHICLES					Grand total vehicles	Grand total PCE
	Bus	Truck	Light Vehicle	Three Wheeler	Motor Cycle	Total Vehicles	Total PCE	Rick/ van	Bi-cycle	Push cart	Total Vehicles	Total PCE		
00.00-15.00	142	7	92	34	10	285	578	81	16	2	99	101	381	679
15.00-30.00	138	10	88	26	4	266	560	61	10	1	72	72	332	632
30.00-45.00	132	8	81	24	5	250	527.5	73	12	2	97	91	341	618.5
45.00-60.00	139	9	86	27	6	267	560	68	11	0	79	73.5	341	633.5
Total	551	34	347	111	25	1068	2205.5	283	49	5	347	337.5	1395	2542.5

Source: Field Survey with Video, August 2002

Note: Bus= All type of buses (minibus, single decker bus and double decker-bus).
Light vehicle= Car, Jeep, Taxi, Pajero, Microbus, Pick-up, Duranta and Maxi
Three Wheeler= Tempo, Baby-taxi and Mishuk
Truck= All type of Trucks

Table A-2.4

Vehicular traffic flow

Date: 19.08.02

Time: 9.05 AM to 9.45 AM

Weather: Fine

(East ⇄ West)

Location: ICMH at Matuil

TIME	MOTORIZED VEHICLES							NON-MOTORIZED VEHICLES					Grand total vehicles	Grand total PCE
	Bus	Truck	Light Vehicle	Three Wheeler	Motor Cycle	Total Vehicles	Total PCE	Rick/ van	Bi-cycle	Push cart	Total Vehicles	Total PCE		
00.00-15.00	92	6	66	22	8	194	386	60	4	2	66	104	260	490
15.00-30.00	76	2	44	12	6	140	293	66	1	1	68	105.5	208	398.5
30.00-45.00	92	4	52	26	10	184	371	92	4	0	96	140	280	511
45.00-60.00	78	2	76	32	14	202	355	96	1	2	99	156.5	301	511.5
Total	338	14	238	92	38	720	1405	314	10	5	329	506	1049	1911

source: Field Survey with Video, August 2002

Note: Bus= All type of buses (minibus, single decker bus and double decker-bus).
Light vehicle= Car, Jeep, Taxi, Pajero, Microbus, Pick-up, Duranta and Maxi
Three Wheeler= Tempo, Baby-taxi and Mishuk
Truck= All type of Trucks

Table A-2.5

Vehicular traffic flow

Date: 20.08.02

Time: 11.25 AM to 12.05 AM

Weather: Fine

(East ⟷ West)

Location: Saddam Market

TIME	MOTORIZED VEHICLES							NON-MOTORIZED VEHICLES					Grand total vehicles	Grand total PCE
	Bus	Truck	Light Vehicle	Three Wheeler	Motor Cycle	Total Vehicles	Total PCE	Rick/ van	Bi-cycle	Push cart	Total Vehicles	Total PCE		
00.00-15.00	92	34	76	16	1	219	427	22	0	1	23	39	242	466
15.00-30.00	104	24	76	24	12	240	490	48	2	0	50	73	290	563
30.00-45.00	112	13	90	18	4	237	485	40	0	1	41	66	278	551
45.00-60.00	108	20	82	20	2	232	487	46	0	0	46	69	278	533
Total	416	91	324	78	19	928	1890	156	2	1	160	247	1080	2137

Source: Field Survey with Video, August 2002

Note: Bus= All type of buses (minibus, single decker bus and double decker-bus).
Light vehicle= Car, Jeep, Taxi, Pajero, Microbus, Pick-up, Duranta and Maxi
Three Wheeler= Tempo, Baby-taxi and Mishuk
Truck= All type of Trucks

Table A-2.6

Vehicular traffic flow

Date: 19.08.02

Time10.15 AM to10.55 AM

Weather: Fine

(East ⇄ West)

Location: Western side Kanchpur Bridge

TIME	MOTORIZED VEHICLES							NON-MOTORIZED VEHICLES					Grand total vehicles	Grand total PCE
	Bus	Truck	Light Vehicle	Three Wheeler	Motor Cycle	Total Vehicles	Total PCE	Rick/ van	Bi-cycle	Push cart	Total Vehicles	Total PCE		
00.00-15.00	38	32	38	16	8	132	268	10	2	0	12	16	148	284
15.00-30.00	56	40	34	14	4	148	338	20	1	2	23	42.5	171	380.5
30.00-45.00	66	74	68	22	9	239	514.5	14	0	1	15	27	254	541.5
45.00-60.00	86	86	74	28	7	281	625	16	0	0	16	24	305	649
Total	246	232	214	80	28	800	1745.5	60	3	3	66	109.5	866	1855

Source: Field Survey with Video, August 2002

Note: Bus= All type of buses (minibus, single decker bus and double decker-bus).
Light vehicle= Car, Jeep, Taxi, Pajero, Microbus, Pick-up, Duranta and Maxi
Three Wheeler= Tempo, Baby-taxi and Mishuk
Truck= All type of Trucks

Appendix-C

Photo : Haphazard Movement of Traffic and Pedestrian at Jatrabari

Photo: Water Logged on the Shoulder at Jatrabari

Photo: Pedestrans, Rickshaws and Buses are Moving Haphazardly

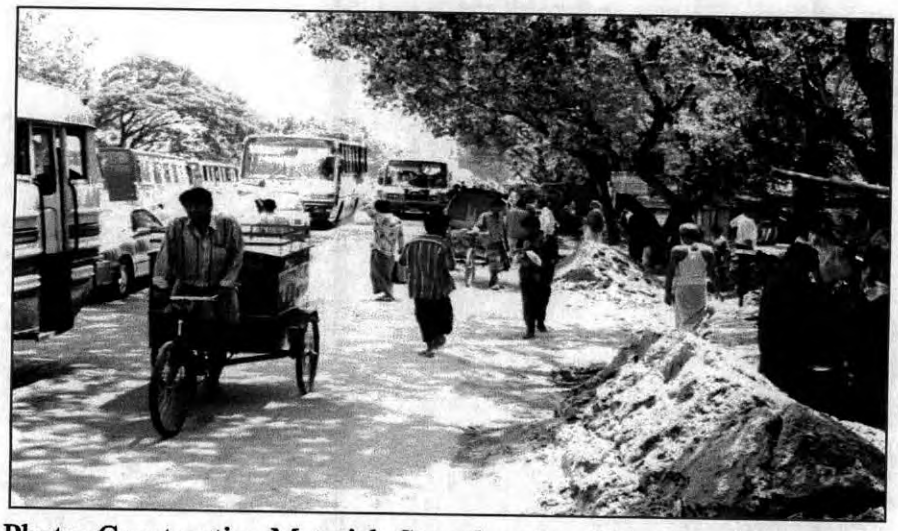

Photo: Construction Materials Stored on the Shoulder at Rayerbagh

Photo: Gas Pipes Kept on the Shoulder and Carriageway at Rayerbagh

Photo: Floating market on the shoulder and Bus stop on the Carriageway at Sanarpar Bus Satand

Photo: Inadequate Crossing facilities near the ICMH at Matuil

Photo: Wrong pedestrian movement adjacent to the island near the ICMH at Matuil.

Photo: Pedestrian injured while she was crossing the median island and taken to the Hospital near the ICMH at Matuial

Photo: Illegally Pedestrian crossing over the median near the ICMH at Matuial

Photo: New frontage road (southern side) at lower grade at Shanirakhra.

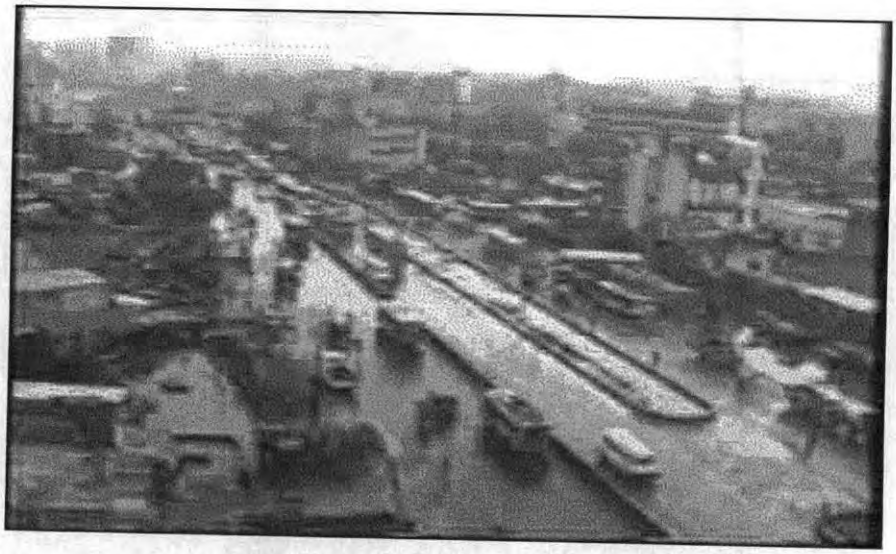

Photo: Separate lane for slow moving Vehicles at Jatrabari