PERFORMANCE EVALUATION OF ROAD SAFETY MEASURES IN DHAKA-ARICHA HIGHWAY

SHAH MD MUNIRUZZAMAN

DEPARTMENT OF CIVIL ENGINEERING

BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY

DHAKA, BANGLADESH

PERFORMANCE EVALUATION OF ROAD SAFETY MEASURES IN DHAKA-ARICHA HIGHWAY

BY

SHAH MD MUNIRUZZAMAN

A thesis submitted to the Department of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka, in partial fulfillment of the requirements

for the degree of

Master of Science in Civil Engineering

APRIL 2004

PERFORMANCE EVALUATION OF ROAD SAFETY MEASURES IN DHAKA-ARICHA HIGHWAY

BY

SHAH MD MUNIRUZZAMAN

A THESIS APPROVED AS TO STYLE AND CONTENT BY

DR MD. SHAMSUL HOQUE
ASSOCIATE PROFESSOR
DEPARTMENT OF CIVIL ENGINEERING
(SUPERVISOR)
BUET, DHAKA.

CHAIRMAN

DR. SK. SEKENDER ALI
PROFESSOR AND HEAD
DEPARTMENT OF CIVIL ENGINEERING
BUET, DHAKA.

MEMBER

DR. MD. MAZHARUL HOQUE
PROFESSOR
DEPARTMENT OF CIVIL ENGINEERING
BUET, DHAKA.

MEMBER

MR. SYED NOOR-UD-DEEN AHMED
ASSOCIATE PROFESSOR
DEPARTMENT OF CIVIL ENGINEERING
BUET, DHAKA.

MEMBER

DR. MD. NURUZZAMAN
PROFESSOR
DEPARTMENT OF CIVIL ENGINEERING
DUET, GAZIPUR, DHAKA.

MEMBER
(EXTERNAL)

CANDIDATE'S DECLARATION

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

Shah Md Muniruzzaman

ACKNOWLEDGEMENT

The author wishes to convey his profound gratitude to Almighty Allah for allowing him to bring this effort to fruition. The author would like to express his sincere appreciation and gratitude to his supervisor, Dr. Md. Shamsul Hoque, Associate Professor, Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET), for his constant guidance, generous help, invaluable suggestions, and remarkable patience throughout the progress of this research work. His fervent encouragement and constant supervision in every aspect of the work is precisely worthy of economics.

The author is grateful to Dr. Md. Mazharul Hoque, Professor, Department of Civil Engineering, BUET, for his valuable suggestions and keen interest about the topics. The author is also thankful to Mr. Syed Noor-Ud-Deen Ahmed, Associate Professor, Department of Civil Engineering, BUET, for his valuable advice and cooperation during the course of performance of this work. The author gratefully acknowledges the cooperation of all concerned persons of the Department, Traffic Engineering Laboratory, Civil Engineering Library and BUET Central Library for their assistance.

Sincere thanks to Mr. Matiur Rahman, SP, Dhaka District, Mr. Rafiqual Islam, ASP, Manikganj District, Mr. Nazrul Hossain, ASP, Savar Circle for their whole-hearted cooperation in collection of accident data. The author is also indebted to Mr. Mahbubul Alam and Mr. Abu Baker Siddique of Road Safety Cell, for providing valuable information on various aspects of road safety including accident data. Special thanks to Mr. Mohiuddin Ahmed, XEN, Manikganj Division, Mr. Zakir Hossain, XEN, Road Safety Division, Mr. Riaz Ahmed Jaber, SDE, HDM Division, Mr. Asif Hossain, SDE, Jamuna Bridge Access Road Project, Dr. Golam Mostafa of DDC, Mr. Atiquar Rahman of SARM Associates, Mr. Nurul Habib of BCL, Mr. Mostafizur Rahman of SMEC, Mr. Golam Mawla of FINROAD for their cooperation in extracting information on road safety and improvement works. The author is also thankful to Major Jahid of MIST for his help during preparation of the thesis.

Last but far from least the author wishes to express his gratitude to his beloved wife for her continuous encouragement and homage during this study.

ABSTRACT

In this study an attempt has been made to depict the accident scenario and evaluate the performances of safety features that have been installed along Dhaka-Aricha highway, during 1990 – 2003 observation periods. The study comprises a total length of 75.4 km of the nationally important Dhaka-Aricha highway corridor which passes through six Upazilas, namely Savar, Dhamrai, Saturia, Manikganj, Ghior and Shibalaya.

Data were collected both 'before' and 'after' implementation of safety improvement works undertaken along this highway. Accident data were directly retrieved from the Police records viz. FIR and Crime Index Register; data were also collected from the Hospital Road Traffic accident (RTA) register and Road Safety Cell (RSC) for verification purposes. Performance evaluation of safety measures is made by applying before-after technique, control-site method and standard statistical chi-square method. Economic assessment of black-spot improvement works is also carried out to see the effectiveness in monetary terms.

Findings of accident data recording/reporting, analysis and performance evaluation of safety measures are summarized bellow:

General Analysis of Accident Data

- In this corridor nearly 45% of total recorded accident data and 48% of fatal data are not reported to the road safety cell (RSC) by the police. In most of the accident events response time of police to the incidence is not prompt and police fills up the accident form much later after the actual incidence.
- During the study period total 1922 accidents occurred of which 1147 (60%) are fatal, 551 (28%) are grievous, 129 (7%) are simple and 95 (5%) are property damage (PD) type accident.
- Among six UZs, the Savar UZ experienced the highest number of accidents (902, 47%) followed by Dhamrai (290, 15%), Manikganj (251, 13%), Shibalaya (230,125), Ghior (151,8%) and Saturia (98, 5%) UZ. Ghior UZ has the highest severity index of 0.97; followed by Dhamrai (0.95), Saturia (0.93), Savar (0.88), Manikganj (0.82) and Shibalaya (0.81) UZ.
- Around 70% of accidents occurred at day and 30% at night. Relatively higher number of accidents occurred in between 1000 - 1200 and 1200 – 1400 hours and the January is the unsafe month for traveling along this corridor.
- Minibuses/buses and heavy trucks are involved in 45.6% and 31.6% of accidents, though they comprise 24.9% and 24.7% of total traffic respectively.
- The most predominant accident type is hitting pedestrian which accounts for 56.3% of all known accidents, it is followed by rear-end (12.5%) and head-on (11.9%) collisions.

- In the study area overturned type accidents has the highest fatality index of 2.1 followed by head-on (1.54) and hit object (1.42) type of accident. The top most three severe accidents are caused by overturned type accident where 24, 21 and 9 persons were killed.
- Within 16 intersections a total 207 (10.8%) number of accidents occurred, rest 1715 (89.2%) number of accidents occurred within the 16 links.
- A total 33 locations are isolated as black spots where 58.9% of total accidents and 59.4% of fatal accidents are occurred.

Evaluation of Safety Measures

- In Balitha site, safety situation improved significantly. The total and fatal accidents are reduced by 69% and 34% respectively. Before-after study of accident pattern shows that head-on, hit object, rear-end collisions are eliminated and hitting pedestrian accidents are reduced by 25%.
- In 2nd-Golara-bridge area, significant reduction of accidents took place after the implementation of improvement works. Fatal and total accidents are reduced by 63% and 67% respectively. Head-on, hit object, overturned and unidentified collisions are eliminated and pedestrian accidents are reduced by 40%.
- Before-After analysis of accident data shows that in Golara area though fatal accidents are reduced by 36% but grievous accidents are increased by five times resulting an overall increase of accidents by almost two times.
- After implementation of rehabilitation works along the Mirpur-Savar section, total number of accidents and grievous type of accidents are decreased by 10.0% and 20.0% respectively though fatal accidents are unexpectedly increased by 9.6%. Analysis of accident patterns shows that head-on type collision previously which was the most fatal one, is reduced by 60% and unidentified types of accidents are also reduced by 93%. On the other hand rear-end type, side-swipe, hit-pedestrian and over-turn types accidents are increased by nine times, eight times, 170% and 80% respectively.
- After implementation of improvement works along Savar-bazar to Aricha-Ghat segment it is revealed that the total and fatal accidents are reduced by 46% and 35% respectively. In terms of accident patterns - over-turn, hitting pedestrian, hit object and head-on type of accidents are drastically reduced by 75%, 36%, 23% and 18% respectively considering 4.25 years of time period after the implementation of the project.
- The cost-benefit analysis of three black spots improvement works reveals that the first year accident savings cost in percentage of investment for Balitha, 2nd Golara area and Golara area are 178.6%, 251.9% and 9.4% respectively.

Finally, based on the research findings of this study, several site specific recommendations are made in order to further improve safety situation along the Dhaka-Aricha highway.

CONTENTS

Chapter 3: STUDY DESIGN AND RESEARCH METHODOLOGY

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

LIST OF TABLES

LIST OF FIGURES

Page

LIST OF PHOTOGRAPHS

CHAPTER 1

INTRODUCTION

1.1 Background

An adequate and efficient transport system is a prerequisite for both initiating and sustaining economic development. The transport system in Bangladesh is extensive and diversified comprising about 140,000 km of roads in addition to railways and waterways (FINROAD, 2003). During the last 20 years there has been a significant shift from water and rail transport to road transport. Since independence of Bangladesh demand for passengers and freight in road sector has grown by about 400 and 350 % respectively. The road has share of passenger and freight of 79% and 73% respectively (Quazi, M.U.Z. 2003). By the end of 2002, 678,000 motor vehicles were operating on roads of which cars accounted for 24%, bus 9%, truck 7%, motorcycles 45% and auto rickshaw 12% (FINROAD, 2003). In addition 1.5 million NMVs were also operating. As can be seen, the road sector plays a major role on the transportation system of the country.

1.2 The Status of Road Safety Problem

1.2.1 The Global Accident Scenario

The road safety problem is a serious and increasing global public health and economic issue. The problem of deaths and injuries as a result of road traffic accident has now been recognized as a global phenomenon. In 1990 road accident was placed 9th as a cause of premature death. By 2020 its position will move up to the 3rd place. The Global Road Safety Partnership (GRSP) has estimated that nearly one million deaths and 15 million injuries occur on roads worldwide each year, (GRSP, 2000). Where as road accident situation is slowly developing in developed society most developing countries face a worsening situation. Over seventy-five percent of the road accident casualties occur in developing and emerging countries, which accounts for only 32% of total vehicle fleet. Accident rates in developing countries are often 10 to 70 times higher than in developed countries. Developing countries suffer staggering annual loss exceeding US $ 100 Billion for road trauma, which is nearly equivalent to double of all developing assistance (Hoque, M.M. 2000).

1.2.2 Road Safety Situation in Bangladesh

Road accident is a growing concern in Bangladesh and the safety problem is very serious by international standard. The Table 1.1 gives the national trend of police reported road accidents, fatalities and injuries for the period 1993-2000 of Bangladesh. It also includes the fatality rate, number of deaths per 10000 motor vehicles on road. It is clear that the number of fatalities have been rapidly increasing particularly in recent years, from 1945 in 1993 to 4046 in 2000, nearly three times in 8 years of period.

Table 1.1 Police Reported Road Accident Trends in Bangladesh (1993-2000)

Year	No of Accidents	No of Fatalities	No of Injuries	Total Casualties	Fatalities/10000 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	3310	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

The statistics reveals that Bangladesh has one of the highest fatality rates in road accidents, which are 160 deaths per 10000 motor vehicles on road every year compared with the rates of 2 in the USA and 1.4 in UK (Hoque, M.M. 2003). 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 cost the community in the order of 4000 crore (2% of GDP) per annum. 70-80% of accidents occur in highways and rural roads, 70% of victims are pedestrians alone (Hoque, M.M. 2003). Typically principal contributory factors of accidents are adverse roadside environment, dangerous overtaking, reckless driving, carelessness of road users, disregards to traffic rules, variety of vehicles characters and defects in vehicles. Others include a low level of awareness of safety problems by policy makers, inadequate and unsatisfactory education, safety rules and regulations and inadequate and unsatisfactory traffic law enforcement and sanction (Hoque, M.M. 2003).

1.3 Significance of the Study

The Dhaka - Aricha highway, a portion of historical Grand Trunk road, plays a vital role in inter- district and inter-regional transport as it connects the Southwestern and Western region of Bangladesh with Dhaka, the national capital. In 1991 Hoque, M.M. conducted a comprehensive study of accidents on Dhaka-Aricha highway, which is of 81.4 km length encompassing six upazillas. He recommended various low cost safety measures including shoulder improvement, delineation, installation of guardrails, provision of overtaking lanes and improvement of narrow bridge approach etc.

But unfortunately until very recently, road safety aspects could not attract as much the attention as it deserved, by concerned authorities, as such neither much effort nor resources were dedicated for this critical issue. However during 1995 to 1999 with the assistance of Denmark, a major rehabilitation work was completed from Aricha to Savar segment of the highway with a cost of 260 crore taka. In this major rehabilitation work accident reduction was one of the prime objectives. Besides, under Jamuna Bridge Access Road Project (JBARP) a portion of this highway (Aminbazar to Savar) was improved, through widening to dual carriageway with a median barrier to enhance road safety and to accommodate increasing traffic with an expenditure of 100 crore Taka. Again under the same project three black spots were improved on this highway.

All of the above mentioned widening, installation of median barrier and other safety related features were implemented on the basis of the recommendations of various government and research organizations and more importantly the donor agencies to improve the safety situation in this important inter-regional and inter-district major arterial highway. Besides these, few other road safety projects are on progress in different parts of the country. But unfortunately neither any government nor donor agency has so far made any attempt to monitor or evaluate the performance of these prescribed safety measures. Cost-benefit analyses of such works are yet to be conducted. Different organizations are working in isolation on this issue. The main reasons for not conducting such evaluation studies could be non-availability of relevant and detailed information over long period of time, especially the availability of detailed accident data, which could be amenable to scientific investigation. Moreover, as most of such projects are generally financed and implemented by donor agencies, as they leave after the implementation of works, hardly leaving behind to be any documents preserved by the users i.e. RHD and other relevant agencies for identification and detailed effectiveness evaluation as follow up which are very important for a developing country like Bangladesh. As such identifying details of such works become very difficult and strenuous task.

It is high time that the effectiveness of the prescriptions given by different donor agencies be evaluated and investigated in the context of roadway and traffic condition prevailing in Bangladesh in order to develop strategies to combat overall accident problem which is continually plaguing the nation and to set up pragmatic priority issues in this regard. It is imperative for country like Bangladesh to formulate policies and strategies gradually on the basis of established priorities and effectiveness of measures undertaken previously so as to get the best out of investment received from donor agencies on road safety issue.

In this study an attempt has been made to evaluate the effectiveness of the safety measures undertaken during 1990 to 2002 along Dhaka-Aricha highway. This would give a clear picture about the effectiveness of these safety measures in Bangladesh perspective, which may also be implemented on other similar high standard roads in Bangladesh.

1.4 Objectives of the Study

The main objective of this study is to assess the effectiveness of different safety improvement measures, which were implemented during the period of 1990 to 2002 along Dhaka-Aricha highway, so that it is possible to evaluate and recommend the cost effective appropriate accident remedial measures for the similar road traffic situations in other highways in Bangladesh. The specific objectives of the study are:

- To obtain detailed accident data for the period of 1990 to 2003 and records of various safety improvement measures which were undertaken during the aforesaid period along Dhaka-Aricha highway from relevant authorities
- To collect road geometric and operational inventories along this corridor
- To investigate the characteristics of accidents in particular relation to the safety improvement measures
- To study the effectiveness of specific safety improvement measure by conducting before-after analysis of accident data
- To propose recommendations based on the outcome of the research

1.5 Scope of the Study

1.5.1 The Study Area

The general area included in the thesis encompasses six upazillas namely Savar, Dhamrai, Ghior, Saturia, Manikganj and Shibalaya along Dhaka- Aricha highway. It starts from Aminbazar Bridge (Km reference 11.9) and ends at Aricha Ghat (Km 87.3) covering a length of 75.4 km. It is a part of national highway and designated as N-5 by RHD.

1.5.2 Time Period Included in the Study

Time period covered in the study is extended for thirteen and half year, from January 1990 to June 2003. Two previous studies covered period from 1982 to 1985 (Banik, G.C. 1987) and 1985 to 1989 (Hoque, M.M. 1991), no study was conducted since 1990 along this corridor and this would give us a clear picture of accident scenario from 1990 to 2003.

1.6 The Structuring of the Thesis

Apart from this chapter the thesis has been divided into six chapters.

Chapter 2 reviews the literature relevant and related to the theme of the study. This would help us to understand the road safety problem, strategies, costing, evaluation and monitoring process and techniques for developing effective countermeasures. An overview of the previous research work on road safety is also included in this chapter.

Chapter 3 outlines the theoretical and analytical aspects of study design as well as research methodology.

Chapter 4 illustrates various safety measures and rehabilitation works undertaken in the study area. It provides detail operational and geometric characteristics of the study highway as identified during field visit. Besides this chapter presents an overview of method and data sources used in the thesis. It also includes data recording system, data items, data collection procedure, development of transcript, secondary data sources and data limitation.

Chapter 5 presents the extensive analysis of accident data to depict the accident scenario and effectiveness of installed safety features. Result of before-after study, statistical analysis of data and comparison of various data sources are also presented here.

Chapter 6 presents the findings of the study, conclusions and various recommendations for improving the safety situation including adoption of appropriate safety measures on high standard road in Bangladesh perspectives. Direction for future research and major policy issues are also highlighted here.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Before carrying out performance evaluation of safety schemes along Dhaka-Aricha highway, it was necessary to conduct a review of literature on related aspects. While consulting pertaining literatures it reveals that, a fundamental problem in dealing with accidents in developing country like Bangladesh is that, not much is known about the accident problem characteristics and the impacts of road safety measures due to inadequate data. The important steps involved in road accident studies are identification of the factors contributing to accidents, reporting and collection procedure of accident data, nature of accident problems leading to prescription of effective countermeasures and then finally monitoring and evaluation of the safety schemes to assess their performances. In this chapter an attempt has been made to perceive the accident problem and contemporary issues. Various elements of road traffic system, accident investigation and subsequent development of countermeasures, evaluation and costing of accident, review of related research and definition of different terms related to accident are also discussed.

2.2 Standard Terminology

At the very outset of the study few important terms used in the text are described in order to aid in comprehension. Some widely used terms relating to accidents and accident locations are given below.

Accident:

The term 'accident' is used to mean an event that produces, or has the potential to produce an injury. An accident which occurred or originated on a road open to public traffic resulting in either injury or loss of life or damage to property, in which at least one moving vehicle was involved.

Fatal Accident:

An accident in which one or more persons are killed outright on the spot is called a fatal accident.

Grievous Injury Accident

An accident in which a person who has received injuries such as fractures, concussions, internal lesions, crushing, severe cuts and lacerations, severe general shock requiring medical treatment and detention in hospital.

Simple Injury Accident

An accident in which a person sustained injuries but need not to be admitted to the hospital. It can also include an accident victim who sustained injuries and was treated in hospital but not detained overnight.

Property Damage / Collision type accident

When motor vehicles hit pedestrian, another vehicle in traffic, parked vehicle, animal, fixed object, etc. in an accident.

Road

A thoroughfare open to public by right or custom is defined as road. It excludes off-street parking, access areas and other private property.

Carriage way

A portion of a road improved, designed or ordinarily used for vehicular traffic is termed as carriageway. It also includes shoulders and areas at the sides or center of the carriage way used for standing or parking of vehicles.

Intersection

A place where two or more road cross is termed as intersection. For this study it also includes 15 meters area within intersection.

Link/Midblock

The length of road beyond 15 meters of adjacent intersection is termed as mid Block.

2.3 Perception of Road Safety Problem

2.3.1 Road Accident Indices

In order to describe the accident problem and to ascertain the relative seriousness of the level of road traffic safety, many measures have been used viz number or deaths per 10,000 vehicles, per 100,000 persons and per million vehicle-kilometer etc (Hoque, 1993). The widely used indices include fatalities per capita (FPC), fatalities per vehicle (FPV) and the fatality index (FI), (Mohan and Muhlrad 2000). The FI is calculated by dividing the total number of recorded fatalities by the number of injured persons.

However, these indices cannot be used to compare or evaluate the level of safety in situations where the traffic conditions and vehicle usage are different among countries. The weaknesses in using these measures for international comparison purposes are well addressed in the literature (major problems are differences in definition of fatalities, reporting and recording level, vehicle composition, lack of reliable data etc.). Noting such inherent limitations, vehicles and population-based fatality rates are used to compare the traffic safety of different countries.

2.3.2 Traffic safety and Personal Safety

While the total number of deaths due to traffic accidents is a simple and common measure of the size of the traffic injury problem, it is more useful to refer to death rates when comparing one country with another. Two general categories of death rate are relevant to present purpose, one relates to traffic safety, the other to personal safety.

Traffic safety

Traffic safety is commonly measured in terms of deaths per 10,000 registered motor vehicles or per 100 million vehicle kilometers traveled. The latter is the better indicator of most forms of road use but it is difficult to estimate accurately and is not available for many countries.

Personal Safety

The death rate per 100,000 populations is a measure of personal safety, or the degree to which traffic accidents affect the safety of the population.

2.3.3 Classification of Accident

Uniform classification of traffic accident is extremely important to ensure attainment of uniform statistics by different agencies/organizations involved in reporting, investigation, research, enforcement etc.

Primary Classification:

Primary classification based on accident severity:

- Fatal.
- Injury (Grievous and simple injury).
- Proper damage only

The fatal and injury together represents "casualty" accident. Further classification is Urban or Rural and intersection or link.

Detail Classification

In terms of manner of collision accident may be classified as:

- Running off road
  - Hit Object
  - No object
- Non-collision on road
  - Overturning
  - Other non collision
- Collision on Road With
- Pedestrian
- Another motor vehicle
- Railroad train
- Bicycle
- Animal
- Fixed object
- Other object

Again collision between vehicles can be classified as angle, rear end, sideswipe etc. In this study all these above mentioned classifications are used.

2.4 Elements of Road Traffic Accident

2.4.1 General

Road traffic may be considered as a system, in which various components interact with each other. This system is often described as comprising three components- the human, the vehicle and the road (Ogden, 1996). An accident may be considered as a failure in the system.

In highway transportation, few accidents have been traced directly to mechanical failure of vehicles. Fewer have been attributed to "failure" of the roadway, except occasional direct involvement of potholes and other pavement conditions or defective traffic control devices. The cause-and-effect relationships are yet to be established because the driver is expected to comprehend design and control inadequacies and compensate for them in the driving task. The resultant attribution of large percentages of highway accident due to driver failure (from 60 to 90% in many studies) does serve the cause of safety. Human failure can as easily said to be the cause of all accidents, because it is human beings who not only drive or steer vehicles, but who design and construct them, and design, construct, and operate facilities that are used by vehicles of every mode. An often blaming the driver simply hides the real cause.

Some accidents are deemed to have more than one cause. For example 60 to 70 pedant of accidents are attributed solely to driver error, and another 20 of 30% may be attributed to a combination of driver error & road related deficiency. In general, human factors contribute to 85% of all accidents, road factors, to 16% and vehicle factor to 5% (Bryer, T.E. 1993).

2.4.2 The Haddon Countermeasure Matrix

Accident and injury countermeasures and research strategies should be developed systematically. One such useful approach is to consider each traffic injury problem as resulting from an interaction between several discrete factors, occurring over distinct phases in time and space. This can be done if we divide all time into three phases: before the injury-producing event, during the event and after the event. The physical universe can be divided into three factors: the human being (usually the victim), the vehicles and equipment potentiality involved in and injury event, and the environment (which consists of everything else). These can be used to create a 3 × 3 matrix as shown Table 2.1.

Table 2.1 Haddon Countermeasure Matrix

Element	Before Crash	In Crash	After Crash
Human	Training Education Behavior (e.g. drink driving) Attitudes Conspicuous clothing on pedestrians and cyclists	In-vehicle restraints fitted and worn	Emergency medical services
Vehicle	Primary safety (e.g. braking, roadworthiness, visibility) Speed Exposure	Secondary safety (e.g. impact protection)	Salvage
Road	Delineation Road geometry Surface condition Visibility Road safety audit	Roadside safety (e.g. frangible poles) Safety barriers	Restoration of road and traffic devices

Source: (Ogden 1996)

This is also often referred as the Haddon's Matrix, which combines three components of the road traffic system with the three phases in an accident (viz. pre-crash, in-crash and after crash) provides a useful framework for the accident analysis and prevention program. Each of the nine elements of the matrix represents a possible focus for road safety. Importantly, the road component remains a major consideration in the overall road safety management strategies.

2.4.3 The Road Component

Road Way Factors in Accident Process

Lassare (1994) discussed that the sequential structure of accident generating processes is the basis from which to identify the various road features that play an active part in the accident:

- Road alignment: horizontal (bends) and vertical (slopes),
- Road or lane surface and width,
- Shoulder surface and width,
- Road environment,
- Lateral obstacles (ditches, trees, barriers, etc.)
- Signing/signaling,
- Central and lateral markings,
- Junction design,
- Sidewalk/footway,
- Medians/refuge islands,
- Road structure/barrier,
- Pedestrian facilities,
- Non motorized vehicle facilities

In the normal traffic situation

The road user searches for information from the road and its environment through different channels (visual, auditory, etc.) and then treats the information collected in order to build up a representation of the driving situation, on the basis of which he will alter his movement by controlling speed and trajectory of the vehicle. The road features must help drivers to exert this control adequately and to foresee any hazard that may occur.

In the pre-crash situation

The pre-crash situation is a breaking point in a road user movement, occurring either because he has submitted his vehicle to exaggerated dynamic constraints (for example, loss of control of the vehicle in a road bend), or because there is a conflict with another road-user (for example, pedestrian crossing the road, other vehicle coming at a junction). Signing and marking indicate to the road-users the hazards they need to expect. Drivers then assimilate and treat this information to modify their behavior in relation to the environment.

In the emergency situation

The road must "forgive". Some failures in vehicle control should be recoverable. In particular, shoulders should provide sufficient space to make it possible to avoid frontal collisions by side maneuvers or to return to normal trajectory after a car has encroached or gone off the road. Both shoulder width and structure are important. Adequate road surfacing provides more efficient braking and may play a part in vehicle dynamics in emergency driving conditions.

In the crash situation

When a vehicle goes off the road, its trajectory may be stopped by obstacles producing strong deceleration, or may end in a rollover, both types of events generally leading to serious injuries. Through secondary safety measures, it is possible to reduce the severity of injuries resulting from a crash, by clearing road sides from hard obstacles, either by removing them or by protecting vehicles against them through restraint systems (guardrails or barriers).

Road Design Standard

Safety improves dramatically with design standard, and freeways/motorways are much safer per kilometer (mile) of travel than other roads. The precise safety advantage cannot be explicitly given because there is wide variation within road types, but freeways/motorways are at least 4 times as safe as other roads, and can be as much as 20 times as safe as other arterial roads Ogden,(1996). New freeways/motorways, built to contemporary standards, are the safest form of road, and may be twice as safe as older freeways/motorways built to lower standards.

Relationship Between Road Characteristics and Accident

The relationships between road characteristics and accidents are difficult to establish and quantify, due to the multi-factorial nature of accident processes and, often, to the lack of planning and reliable statistical studies. However, some of the relationships are described to accidents of particular characteristics of rural roads.

- ***Width Of Carriageway And Shoulders***

  Accident rates decrease with increases in lane and shoulder width. In terms of accidents eliminated per meter of added width, widening lanes has a bigger pay-off than widening shoulders. Optimal shoulder width depends upon traffic volumes and road alignment, but a two-meter width is a good average

- ***Horizontal Alignment***

  There is a strong link between radius of curves and accidents and short radiuses being more hazardous. If financial means are available, it is recommended to flatten the curve (increase the radius).

- ***Obstacles Along The Road***

  When coupled with near-by roadside hazards, encroachments can result in roadside accidents, which are usually serious: single vehicle against a fixed object or rollover accidents. The slopes of ditches (drainage facilities) affect the severity of accidents. Severities of impacts also vary with the different kinds of objects likely to be hit by vehicles leaving the carriageway (trees, buildings, fences, signposts, lamp-posts, utility poles), as well as with the size and mass of the vehicle. In general, maximizing clear-zone width (up to five meters) is the best solution to reduce accident severity.

2.4.4 The Human Component

The road user responsible for the accident may be:

- The driver of the vehicles.
- The pedestrians
- The cyclists

2.4.4.1 Drivers

Driver is one of the main road user elements to cause an accident. So, the driver fitness is a major factor for safe driving. The factors, which are associated with drivers to cause an accident, are given below:

Inefficient And Indiscipline Driving

Driving is a technique, which involves almost all the sensory organs at a time for its successful accomplishment. Educational background and professional skill together bring efficiency in driving. An inefficient driver is most likely to be in disciplined.

High-Speed Temptations

Generally a driver has a tendency to drive a vehicle with speed, which may go beyond design value and create dangerous situation. There may be many reasons for over speeding such as:

- To make more trips to maximize profit
- To make up the lost time
- Craze for speed

Overtaking

This is a normal phenomenon when a vehicle is on the road. Proper overtaking is not an offence and does not create accident. But dangers are involved in wrong overtaking or overtaking at places where it is prohibited.

Overloading

There is a high tendency among the driver of public transport vehicles (Such as, trucks, buses, etc.) to overload, which may cause accident in any of the ways as mentioned below:

- It increases momentum of the vehicle as well as the stopping sight distance. As a result brake failure may occur.
- Overloading makes the vehicle unstable.
- Continuous overloading damages the structural condition of the road.

Physical And Mental Condition Of The Driver

A driver should be both mentally and physically fit to perform his duties Fatigue and lack of concentration may arise due to continuous driving particularly at nighttime. These become dangerous to traffic safety.

2.4.4.2 Pedestrians

Pedestrian's lack of knowledge regarding road use, traffic rules and regulations, violation of regulations and carelessness in using the carriageway are the main reasons of the high incidence of pedestrian casualty. Inadequate pedestrian facilities can also lead to pedestrian accident.

2.4.4.3 Cyclists

Bicyclists, in general, have a misconception that the traffic rules do not apply to them. They often ride their bicycles on the sidewalks and also through the crosswalks while crossing the roadway. Another special factor contributing the crashes is the wobbling effects of the bicycles. Research showed that 80% of fatal injuries, and 75% of disabling injuries could be reduced by widespread use of bicycling helmets (Burden, 1993).

2.4.5 The Vehicle Component

The conditions and characteristics of vehicle may be responsible for causing road accidents. Improvements in vehicle design, occupant protection and vehicle maintenance have made a significant contribution to accident reduction in industrialized countries. In developing countries however, the safety design of vehicles sometimes lags behind that of developed countries, particularly when vehicles are locally manufactured or assembled. The vehicle fleet is usually older with many vehicles imported as second hand from other countries.

Vehicle Factor

The following are the few common vehicle factors contributing to accident.

Faults	Hazards
Worn out tires	Poor grip if road surface is wet and makes braking more difficult. Increases barking distance and sudden application of hard brake may cause skidding. Moreover possibility of bursting & puncturing increases.
Mixing radial & Cross ply tires	It is hazardous to use mixed tires on the same axle because of the difference in cornering behavior. For maximum safety, all four tires should be of the same make, size and tread pattern. However, it is safe to use cross ply tires on front wheels and radial tires on the real.
Incorrect tire pressure	Tires may perform poorly, over-heat and wear out rapidly if the pressure is too high or too low. Correct tire pressures will ensure good road holding, cool running and low rolling resistance. This will result in better fuel consumption and durability of tires.
Faulty indicator lights	Inability to indicate intention to turn or change lanes and induce surprise situation to the following vehicles.
Faulty headlights	Poor or no illumination of the road at night. Other road users may not see the vehicle.
Faulty stop lights	Inability to indicate while slowing down or stopping of vehicle and may cause vehicle, which is following closely to apply hard brake to avoid collision.
Faulty tail lights	Other road users may not see the vehicle is in front of them until it is too late.
Dirty lights	Reduces illumination on the road
Dirty windscreen along with faulty wipers	Poor visibility of the road both during day and night and make driving difficult especially during rainy or foggy days.
Misted rear windscreen	Poor visibility of vehicles traveling behind
Dirty mirrors	Inability to see the traffic behind
Faulty speedometer	Wrong perception of the traveling speed may result in violation of the legal speed limit.
Loose steering wheel	A loose steering wheel reduces the sensitivity of the front wheels to the steering.
Faulty horn	Inability to forewarn pedestrians and other road users.
Faulty brakes	Inability to halt or slow downs the vehicle effectively.

Local Problems

The most common defects of vehicles in Bangladesh are worn out tires, loose wheels, overloaded axle, faulty brake and indicator lighting system etc. A limited physical condition survey revealed that only 42 percent of trucks and buses observed had complete defect free lighting system and a nighttime survey on long distance buses found one thirds with one or no rear lights Hoque, M. S. (2003). Vehicle lighting is a very important safety aspect especially where street lighting, road marking and signs are inadequate and driving practice is poor.

Present Trend in Making Safer Vehicle

Introduction of advance safety vehicle – The main purpose of this vehicle is accident avoidance and damage reduction by highly intellectualization the vehicle through application of electronics technologies, thereby drastically improving the safety of the vehicle which the driver operate. The other objectives are:

- To improve vehicle safety by innovate design and construction of vehicles, incorporating built-in safety measures.
- To some extent to reduce driver's responsibility of handling safety issues
- To reduce accidents caused by random mechanical failures.

Various sensors, computers, electronics gadgets and devices, etc. will support the drivers of tomorrow's vehicles, which monitor the driver, the vehicle and the surrounding environment.

2.5 Accident Investigation

2.5.1 General

There are four main investigative approaches used to develop accident reduction programmers. These are: single site schemes; mass action programmers; route action programmers; and area action programmers. All involve four major planning steps: (a) data collection, storage and retrieval, (b) identification of hazardous locations for further study, (c) diagnosis of the accident problem(s) and (d) the final selection of sites to be included in the remedial implementation program.

2.5.2 Single Site Approach

This is probably the most commonly used approach, involves the identification of 'black spot' locations on the basis of the number of accidents clustered at single locations within a given period of time (usually three years). Black spot locations are typically individual intersections, short lengths (300-500m) of roadway, or small areas (100-200m squares). A large accident reduction (typically 33 per cent) and a high first-year economic rate-or-return (typically not less than 50 per cent) should be expected from black spots that are included in a final remedial action program for single sites.

2.5.3 Mass Action Approach

This, the second most commonly used approach, involves searching for sites that are clearly associated with a particular predominant type of accident for which there is a well-proven engineering remedy. Mass action programmers should be expected to achieve an average accident reduction of 15 per cent at treated sites and a first-year economic rate-of-return of not less than 40 per cent.

2.5.4 Route Action Approach

With this approach the main 'black sites' along a particular road are identified from an analysis of traffic data collected over a recent period (usually 1-3 years). Usually the search process involves dividing the road(s) into section lengths of 0.5-1.5 km and, typically, selecting for listing those sections with accident levels of 1-2 standard deviations above the norm or, alternatively, using a statistical test for a predetermined level of significance above the norm. Black sties treated should achieve average accident reductions of 15 per cent and first-year economic rates-of-return of not less than 40 per cent.

2.5.5 Area Action Program

In urban areas accidents are scattered and do not lend themselves to selection for treatment by the three previously described methods. In this case the distribution of accidents throughout the urban area is searched over a recent one-two-or three-year period in order to identify discrete areas, e.g. neighborhoods or 1 km Ordnance Survey gird squares, having accidents per unit area or per unit of population above a predetermined level. Traffic calming measures that are aimed at reducing traffic movement on local access roads within the identified areas are often the remedial outcomes of area action program. Appropriate objectives set for area action plans might be to achieve an accident reduction of 10 per cent and a first-year economic rate-of-return of 10-25 per cent within each area addressed.

2.5.6 Identification and Diagnosis of Hazardous Road Location Programs (Black Spots)

A hazardous road location (HRL) program is a formal process, which aims to identify location within the road system, which have an unacceptably high incidence of road accidents, in order to develop appropriate treatments to reduce the costs of accidents.

Need for HRL Identification

The need and overall goal of an HRL program is to

- Identify locations at which there is both an inherently high risk of accident losses and an economically justifiable opportunity for reducing this risk, and

- To identify countermeasure options and priorities which maximize the economic benefits from the HRL program,

Techniques for Identification of HRL

In order to identify a hazardous road location, it is necessary to

- Define the site (or route or area),
- Have explicit criteria for such identification,
- In some cases, the criteria will required the use of a measure of exposure to risk at the sites in question,
- Take account of accident severity, and
- Consider the time period for the analysis.
- **Criteria:** A number of criteria have been used to identify hazardous sites and routes. The principle methods are:
  - The number of accidents in a given period exceeding some set level.
  - The rate of accidents for a given period exceeding some set value.
  - The number of and rate of accidents both are exceeding some defined threshold value.
  - The rate of accidents exceeding a critical value derived form statistical analysis of rates at all sites.
  - The potential accident reduction method.
  - Rating by accident severity.
  - The hazardous index method.
  - Rating according to site features.
  - The current annual cost of accidents occurring at the site based upon an average cost of accident-by-accident type.

Clustering of Accidents

Central to the concept of HRL is that certain types of accidents are over-represented at specific sites. In order to identify this clustering, and develop a program to treat high accident frequency sites, a cluster analysis needs to be performed. Figure 2.1 gives such an analysis (Andreassen, 1989).

Here the cumulative percentage of accidents and cumulative percentage of sites (e.g. intersections) are plotted. The former is produced by the product of the number of accidents per site and the number of such sites. The example above shows that 50 percent of these particular accidents (accidents at intersections) occurred at about 23 percents of the sites and that these sites averaged about 2.4 accidents per site.

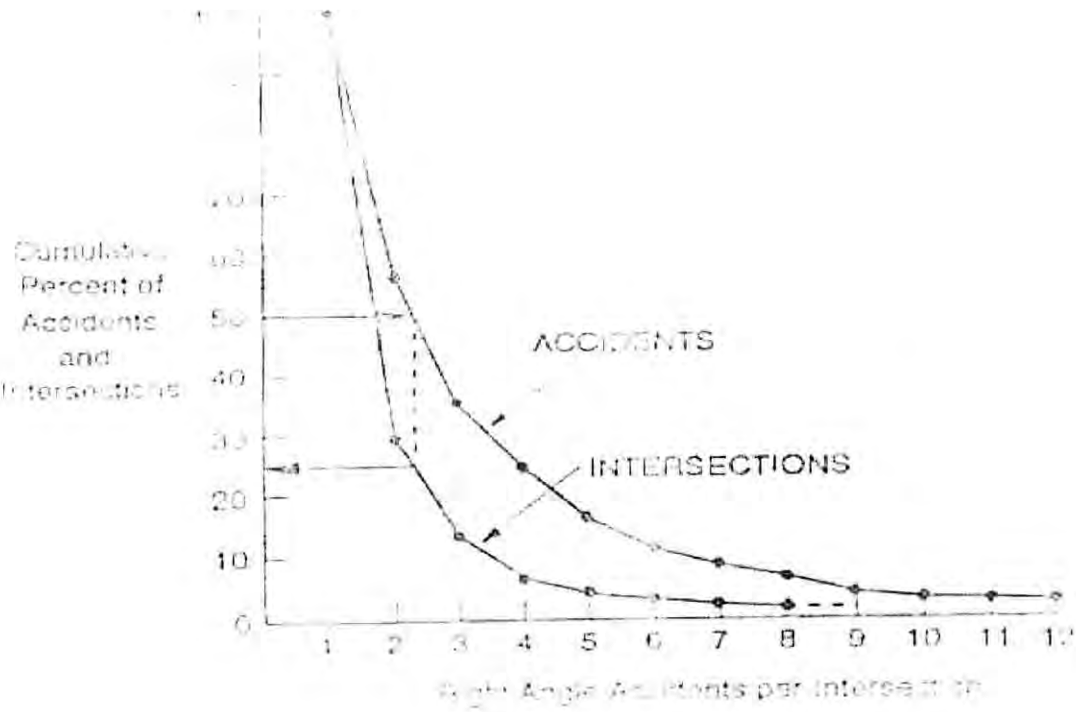


Figure 2.1: Clustering of Accidents

2.6 Development of Countermeasures

The process of countermeasure development should aim to (Ogden, 96):

- Determine the range of measures likely to influence the dominate accident types and road features,
- Select countermeasures which, on the basis of professional judgment and experience.
- Check that adopted countermeasures do not have undesirable consequences, either in safety terms (e.g. lead to an increase in the number or severity of another accident type) or in traffic efficiency or environmental terms,
- Be cost-effective, that is, maximize the benefits from the HRL program, and
- Be efficient, that is produce benefits, which outweigh the costs.

2.6.1 Countermeasures for Road Intersections:

The main design principles for intersections, suggested by Ogden (1999), are:

- Minimize the number of conflict points and hence the opportunities of crashes.
- Separate conflicts in space or time
- Minimize the angle of conflict
- Define and minimize conflict areas

- Define vehicle paths
- Ensure adequate sight distances
- Provide clear indications of right-of-way requirements
- Minimize road side hazards
- Simplify the driving task and Minimize the road user delay

2.6.2 Countermeasures for Road Links or Mid Block

For non-intersection locations (links), the principles for safe design and operation include (Ogden 1996):

- Ensure appropriate standards of horizontal and vertical alignment
- Develop roadway cross sections to suit road function and traffic volume
- Delineate roadway and vehicle paths.
- Ensure appropriate standards of access control from abutting land use
- Ensure clear roadside environment.

2.6.3 Selection of Countermeasures

It is seldom possible to establish a single cause for road accidents at a site. There will often be a number of remedial measures, which should be applied individually or in combination. The final choice will generally be based upon judgment and experience, utilizing countermeasures, which have been successful in similar circumstances.

2.7 Evaluation and monitoring of road safety Project

2.7.1 General

Through monitoring and evaluation the effectiveness of treatments can be assessed. Post-implementation monitoring and evaluation is therefore essential to ascertain the effects (positive or negative) of a treatment and thus improve the accuracy and confidence of predictions of that treatment's effectiveness in subsequent applications. The road safety engineering treatments are based on a sound scientific basis. For this approach to be productive and useful, the analyst must have a firm basis for believing that a particular treatment is likely to be effective or not effective. This in turn implies the need firstly for systematic observation of the effect of various treatments which affect road safety, and secondly a statistical analysis of those observations so that robust conclusions can be drawn from an analysis of the data. As such the requirements, of monitoring and evaluation, are of prime importance.

2.7.2 Purpose of Monitoring and Evaluation

The Institution of Highways and Transportation (1990) defines the purposes of monitoring as follows:

- Assess the effects on the distribution of traffic and speeds of motor vehicles.
- Assess the effects of accident occurrence in relation to
  - Safety objectives.
- Call attention to any unintended effects on traffic movements or accident occurrence.
- Assess the effects of the scheme on the local environment and
- Learn of public response to the scheme in terms of its acceptability in general and people's concerns about safety in particular.

2.7.3 Parameters Requiring Attention

- The number and type of accidents
- The severity of accidents
- The distribution of accidents over the road network
- Traffic flows and travel times
- Turning movements and delays at intersections
- Access times and distances within residential areas
- Routes taken by motorists, cyclists and pedestrians, and operation of buses

2.8 Costing of Road Accident

2.8.1 Costing Need

With the high growth of road accidents throughout the developing world, it is essential that adequate sums of money are spent in dealing with the problem. In the absence of an estimate of accident related economic issues, it is difficult to identify the sums of money that should be invested on road safety countermeasures. The first need for accident cost valuations, therefore, is at the level of national resource planning to ensure that road safety is given adequate priority in terms of investments. The second need is to ensure that the best & most appropriate safety improvements are introduced in terms of benefits they might generate in relation to their cost.

2.8.2 Accident costing Methodologies

The two basic accident costing methodologies are the Lost Output (or "human capital") and the Willingness to Pay (WTP) approach. Lost output focuses on the economical consequences of road accidents but also includes a component for the pain, grief and suffering caused by road accidents. The WTP method, considers the value of prevention, i.e. how much people would pay to avoid an accident altogether, and accordingly produces much higher cost estimates than the Lost Output Method. WTP has only been used in motorized countries and the Lost Output method has traditionally been recommended for developing countries whose primary objective is maximizing national economic growth. Lost Output methods can be further classified into Gross and Net Lost Output.

2.8.3 Accident cost component

Lost output

Lost output refers to the contribution Road Traffic Accident (RTA) victims were expected to make to the economy with future earnings weighted to present value with an inflation rate currently in use in the country. The "lost output" of RTA deaths is calculated as the average earnings multiplied by the number of working years lost (i.e. average retirement age minus the average RTA fatality age lost). Lost output for serious and slight injuries is the daily earning rate multiplied by the number of days off work.

Medical Cost

Medical costs include emergency medical service, both inpatient and out patient care, prescription cost, service fees (X-ray are operation) and rehabilitation cost (Including artificial limbs). Medical cost as estimated by World Bank in Bangladesh is shown in the Table 2.2 below.

Table 2.2 Medical cost per RTA casualty (Taka, 000)

	Per Casualty Cost	Fatal RTA		Grievous RTA		Simple RTA	
		No	Cost	No	Cost	No	Cost
Fatality	100	1.7	170	0	0	0	0
Grievous	4200	1.4	5880	1.7	7140	0	0
Simple	100	1.4	140	2.2	220	1.5	150
Total			6190		7360		150

Source: Consultants World Bank (1997).

Human costs (Pain, Grief and Suffering)

With the outset of social cost benefit analysis in 1970s, a notional value for pain, grief and suffering (PGS) was included in industrialized countries to reflect societies and the individual's aversion to death. In developed countries it value is high around 38% and in developed countries around 20% of total lost output.

Vehicle Damage Cost

In addition to vehicle damage, this component should also include other property damage costs and any lost business due to the vehicle being out of commission.

Administrative Cost

Administrative costs include the "handling costs" incurred by police. insurance companies and courts in investigation road accidents as well as prosecution and the settlement of insurance claims.

Cost Not Included

Some of the other costs not commonly factored in accident costing include.

- loss of earnings of career (i.e. family member must give up work to provide home care)
- work replacement cost, I.e. training
- travel time delay from accidents, including that from road blockades occasionally set up after accidents
- accident scene clear up
- leisure time lost in the post working years.
- life expectancy reduced of RTA casualties.

2.8.4 Average Accident Cost in Bangladesh

Table 2.3 shows the cumulative cost of the various cost components to each RTA severity as developed by consultants.

Table 2.3 Total Accident Cost By Severity Type & cost Component (TK, 000)

Component	Fatal	Grievous	Simple	PDO
Lost output	591.3	7.9	0.5	0.0
Medical costs	6.2	7.4	0.2	0.0
Human costs	354.8	4.7	0.3	0.0
Vehicle damage	100.0	75.0	50.0	2.5
Administration	0.5	0.5	0.5	0.5
Total	1052.8	95.5	51.4	3.0

Source: WB Consultants Working Estimates (1997)

According to these estimates, a fatal RTA costs 14 times that of a grievous RTA and 28 Times more than a simple RTA.

2.8.5 National Road Accident Cost

Table 2.4 sets out the sum of all accident cost components for the total number of estimated accidents in 1997.

Table 2.4 Annual National RTA Costs For 1997 (Taka)

Item	No. Accidents	Ave. cost per Accident (000)	Total Cost (Million)
Fatal RTA	5,432	1,053	5,719
Grievous RTA	9,528	95	910
Simple RTA	12,606	51	648
Total casualty RTA	27,565		7,276
PDO RTA	72,720	3	218
Total RTA	100,285		7,495
Average RTA			0.27

Source: Consultants Working Estimates (1997)

2.8.6 Benefits of costing

- Road safety Awareness
- Road Safety Funding
- Promotion of Cost Effective Road Safety.

2.9 Review of Related Research

The first study to provide some information on the character of accidents on selected highways in Bangladesh was undertaken by Flashy (1986). The study however did not include Dhaka-Aricha Highway. Elahi (1986) grouped accidents into three classes viz.

a. Single vehicle striking a pedestrian
b. Single vehicle leaving the road and/or striking a fixed object and
c. Multi-vehicle collision.

The percentages of accidents in the stated categories were 59 percent, 27 percent and 8 percent respectively. The accident type was unknown for the remaining 6 percent of the total accidents. About 75 percent of the accidents occurred during daytime.

Banik, G.C. (1987) in his M. Sc. Engineering Thesis in civil Engineering Department of BUET analyzed accidents on the Dhaka-Aricha highway using 1982-1985 accident statistics. Police stations included in this study were Savar, Dhamrai, Saturia, Manikganj, Ghior and Shibalaya. A total of 321 police-reported accidents served as the basis of his analysis. He found that of the total accidents, 35% occurred at bridge approaches, 34% at road links, 25% at road intersections. He identified 23 accident-prone locations on the basis of accident frequency. Accidents were grouped into three classes similar to those of Elahi (1986) viz. multivehicle collisions (36%), single vehicle leaving the road and/or striking a fixed object (29%) and single vehicle striking a pedestrian (27%). He also examined other characteristics of accidents in terms of hourly, daily and monthly variations as well as vehicles involved. Banik further identified that inadequate widths of road pavement and shoulders, inappropriate cross-slopes, road pavement as well as road shoulders and restricted sight distances are important cause of road accidents in Dhaka-Aricha highway. Suggested remedial measures included improvement of road geometries and elimination of obstructions from road right-of-Way (ROW).

Hoque, M.M. (1991) conducted another comprehensive study on Dhaka-Aricha Highway. In a total length of 81.4 km of the highway, 965 accidents (419 fatal, 504 injury and 22 property damage only) were recorded during the five-year period, 1985-1989. Data on accidents occurring on the highway and available to police during the aforesaid period were examined and the characteristics of those accidents were analyzed. The characteristics included those relating to locations, road user movements, vehicles, and time of accidents, accident rates, roadside hazards and road casualties. Analyses reveal that each year there are at least 114 fatalities and 968 injuries resulting in about 6 casualties per accident on the highway. Accidents occurred mostly on highway links. The most frequent accident types were determined by the use of Road User Movement (RUM) Codes. The predominant accident type was RUM (00-08) 'pedestrian' accounting for 34 percent of all accidents. This was followed by 'rear-end' accidents (14%), 'running-off-road/out-of-control' accidents (10%), and 'head-on' accidents (9%). The most vulnerable movements of pedestrians involved while crossing the highway and walking with traffic along the highway. A statistical quality control method was employed to identify hazardous sections. The highway links from Mirpur Maser road intersection to Hemayetpur intersection and from Golora road intersection to Harirumpur road intersection were determined to have the highest accident frequency with about 2 accidents per km per year. Buses and trucks were highly over represented in accidents. Most of the accident victims tended to be young and middle-aged in the 10-39 year age group. This group accounted for 50% of fatalities and 68% of injuries. Various low cost engineering treatments like shoulder improvements, delineation, installation of guardrails, provision of overtaking lanes, and improvements of deteriorating traffic lane and narrow bridge approaches were suggested by him.

Ahmed, N.U. (2002) in his BSc Engg thesis in BUET analyzed the accidents on Savar Thana along Dhaka Aricha highway. There were 210 road accidents in the study area during the five-year period (1997-2002). Of these total accidents 1.46% were fatal, 23.41% were light injury and 75.12% were property damage. He identified five black spots namely

Jahangirnagar University gate, Savar bazar bus stand, PATC gate, Nabinagar bus stand and Aminbazar. Predominant types of accident hitting pedestrian and rear end accidents, accounting for 77.63% and 14.28% of total accidents 65.03% of accidents occurred at day and 34.97% at height. He recommended few low cost engineering measures both for intersection and midblock. He identified carelessness of road users, reckless driving, overloading, and dangerous overtaking as main sources of accident.

2.10 Overview

From literature review it reveals that few studies have been conducted to perceive accident problem along this corridor and other parts of Bangladesh. But no attempt has yet been made to evaluate the performance of different safety measures to asses their effectiveness. So there is an urgent need to conduct a comprehensive evaluation study throughout the country to check the effectiveness of the prescriptions made by different foreign consultants in the existing road-traffic perspective of Bangladesh. It is seen that after 1990, no study is conducted along this corridor. Thus this study will also provide the accident scenario starting from 1982 that would enable to visualize the general picture of accident situation for more than twenty years along this corridor. Justification of countermeasures taken so far by different agencies and change of accident pattern with the implementation of these safety schemes can also be determined by effective evaluation technique as discussed.

CHAPTER 3

STUDY DESIGN AND RESEARCH METHODOLOGY

3.1 Introduction

The study can be broadly divided into two main themes, firstly analysis of the accidents and secondly evaluation of the performance of safety measures implemented in the study area. Knowledge on accident rate, severity, spatial and temporal distribution, collision pattern etc are essential to determine cost effective countermeasures for reducing both the number of accident and extent of seventy. A time series analysis of accident is needed for both micro and macro analysis of accident. Any road improvement work in general and safety scheme in particular, will have direct impact on the overall safety situation, particularly on collision pattern. As such there is an urgent need to evaluate their performance for developing a strategy to combat accident problem. Again accidents are also function of highway operating condition, road side development, land use pattern, road side activity, level of enforcement, traffic characteristics which is a peculiar combination of MV and NMV even in high standard national highways in Bangladesh. So accident patterns are also related to these functions. In this chapter methodological consideration in accident analysis, various techniques to represent accident problem, evaluation methods including various statistical tests to ascertain the effectiveness of safety scheme, etc are discussed.

3.2 The Road Inventory

The study location envisaged a total length of 75.4 km along Dhaka-Aricha highway, starting form 11.9 km reference at Aminbazar Bridge to 87.3 km at Aricha. It is a part of historical grand trunk road and presently an important portion of national highway network, forming the link between Dhaka and the ferry routes at Aricha, the main connection to the Western and Southwestern part of Bangladesh. This road is also a mentionable portion of Asian Highway. The road is constructed in 1960 and passes through six upazillas (UZ), namely Savar and Dhamrai UZ of Dhaka District and Saturia, Manikganj, Ghior and Shibalaya UZ of Manikganj District. It is within Dhaka zone of RHD, covering Dhaka and Manikganj Division.

The highway under study encompasses varied geometric and environmental conditions. Owing to close proximity in traffic volume and composition characteristics, land use pattern, geometric and operational condition the highway is divided into three main sections/major links, which are named as section 1, 2 and 3 (Figure 3.1), these are also known as link 32, 33, and 34 respectively by RHD. Section1 is of 22.1 km length, which originates from Aminbazar Bridge (11.9 Km) and ends at Nabinagar (34.0 Km); Section 2 extends from Nabinagar up to Manikganj Town bus stand, which is of 29.3 km length and Section 3 is of 30 km length stretching from Manikganj bus stand up to Aricha Ghat (87.3Km). Again for detailed accident analysis purpose, the highway is divided into 32 locational codes comprising of 16 intersections (2x Staggered T, 11xT and 3x Y type) and 16 links (Mid block locations) to identify accidents by locations (Figure 3.2 - Figure 3.4).

3.1 Approaches of Accident Analysis

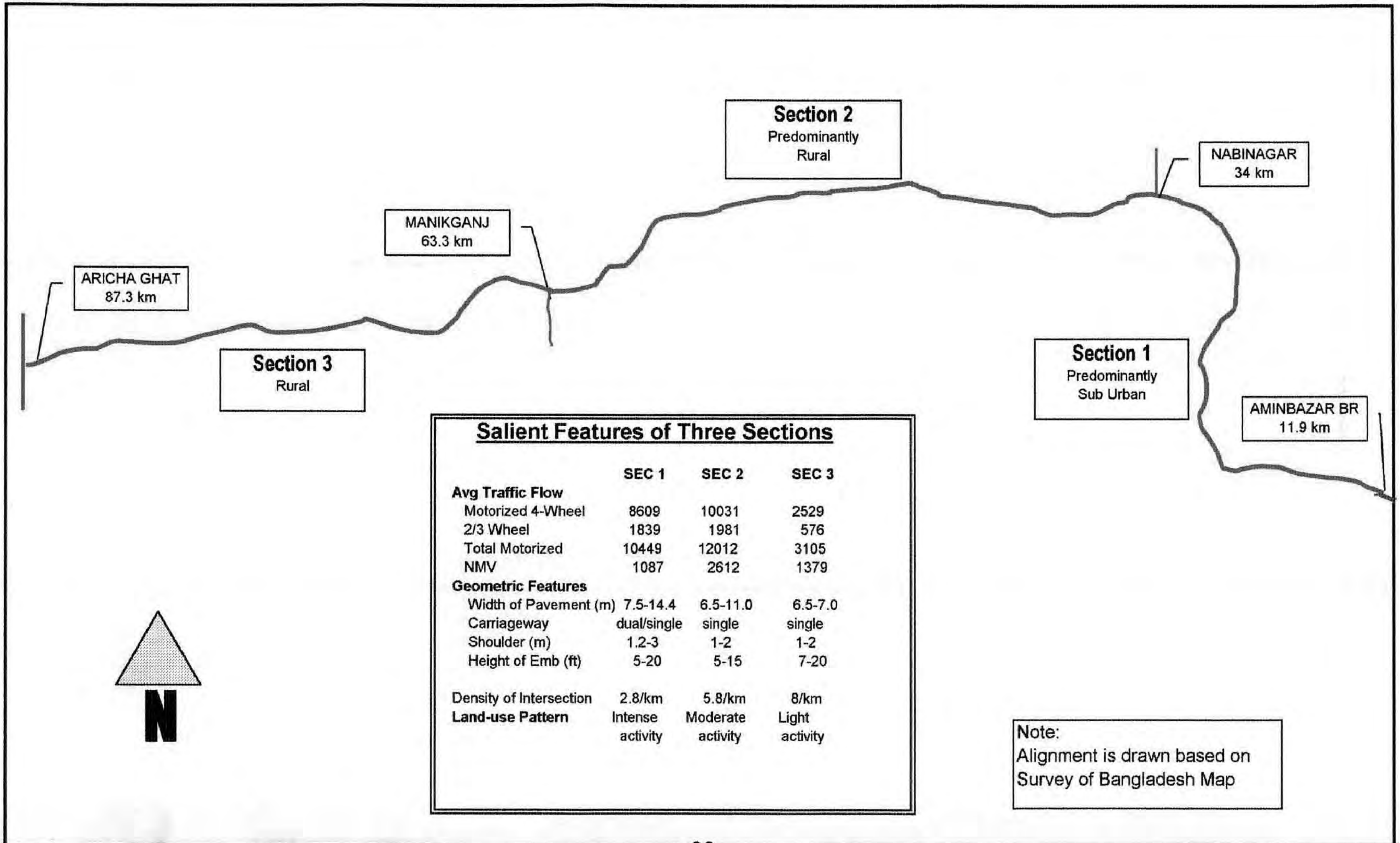
Accident analysis is conducted both at micro and macro level. Macro scale considers accident occurrence in a town, country, region, state or worldwide. On the micro scale, concentration is on accidents occurring on a specific network, facility, or location (curve, or intersection, airport, train station highway exit, interchange).

3.3.1 Macro scale Analysis.

On the macro scale, accidents are summarized in tabular or chart form, providing a record of the performance of a region or a country in terms of one or more transport modes. Accident occurrence, severity (in terms of fatality, injuries, or property damage), and rates provide a statistical illustration of safety performance. Rates are intended to provide a yardstick of safety related to the amount of exposure to danger involved in the transport mode. For instance, the common rate used in highway traffic safety is "accidents (or injuries or fatalities) per 100 million vehicle-miles," on the assumption that the number of vehicles, multiplied by the number of miles (estimated) driven by those vehicles, is a reasonable measure of the exposure to danger of the occupants of the vehicles. At highway intersections, a rate based on number of vehicles entering the intersection is more appropriate.

In this study, these methods are adopted in order to understand trends in accident occurrences.

Figure 3.1 The Study Highway Showing Main Three Sections



Salient Features of Three Sections

	SEC 1	SEC 2	SEC 3
Avg Traffic Flow			
Motorized 4-Wheel	8609	10031	2529
2/3 Wheel	1839	1981	576
Total Motorized	10449	12012	3105
NMV	1087	2612	1379
Geometric Features			
Width of Pavement (m)	7.5-14.4	6.5-11.0	6.5-7.0
Carriageway	dual/single	single	single
Shoulder (m)	1.2-3	1-2	1-2
Height of Emb (ft)	5-20	5-15	7-20
Density of Intersection	2.8/km	5.8/km	8/km
Land-use Pattern	Intense activity	Moderate activity	Light activity

Fig 3.2 Alignment Details of Section 1

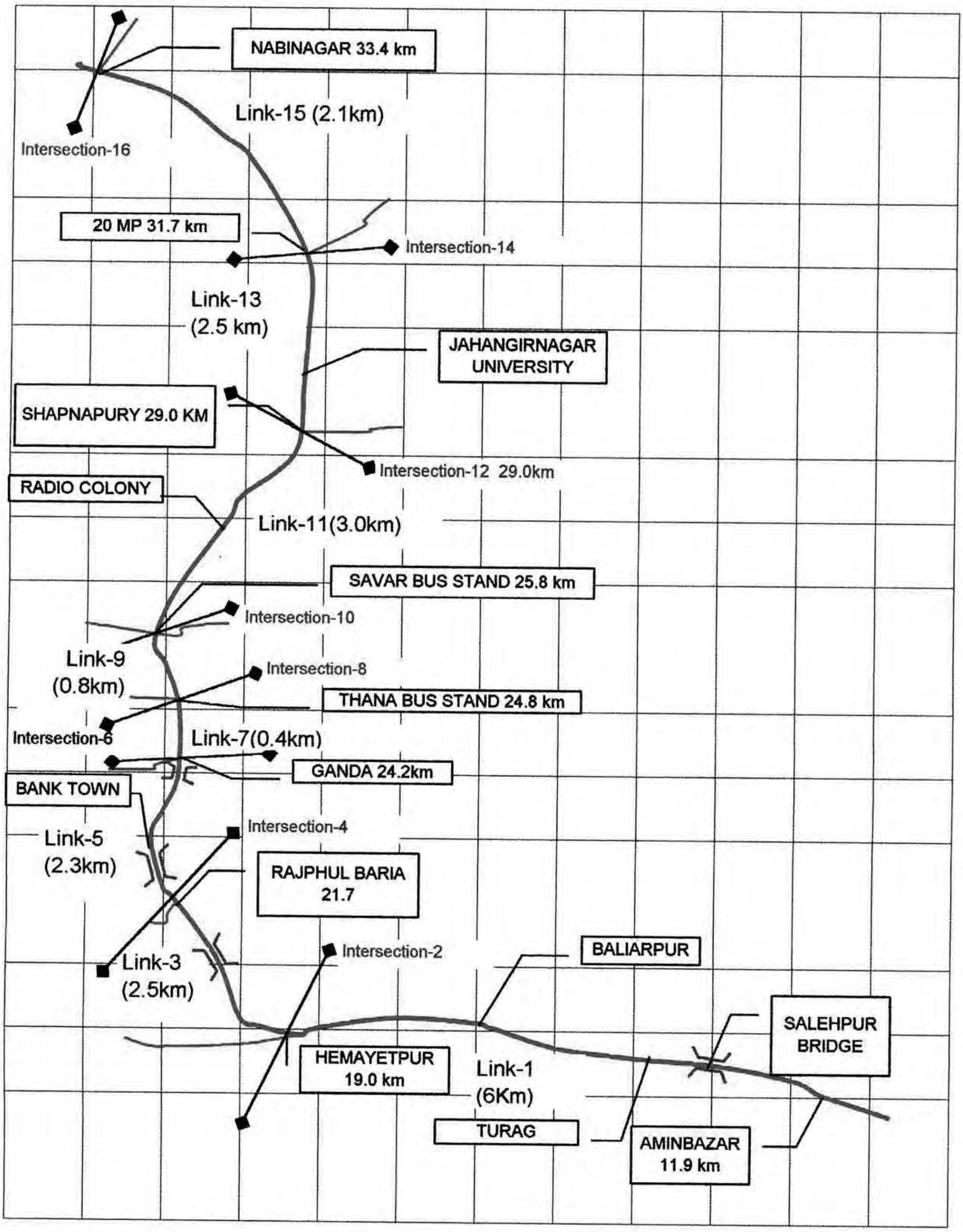


Fig 3.3 Alignment Details of Section 2

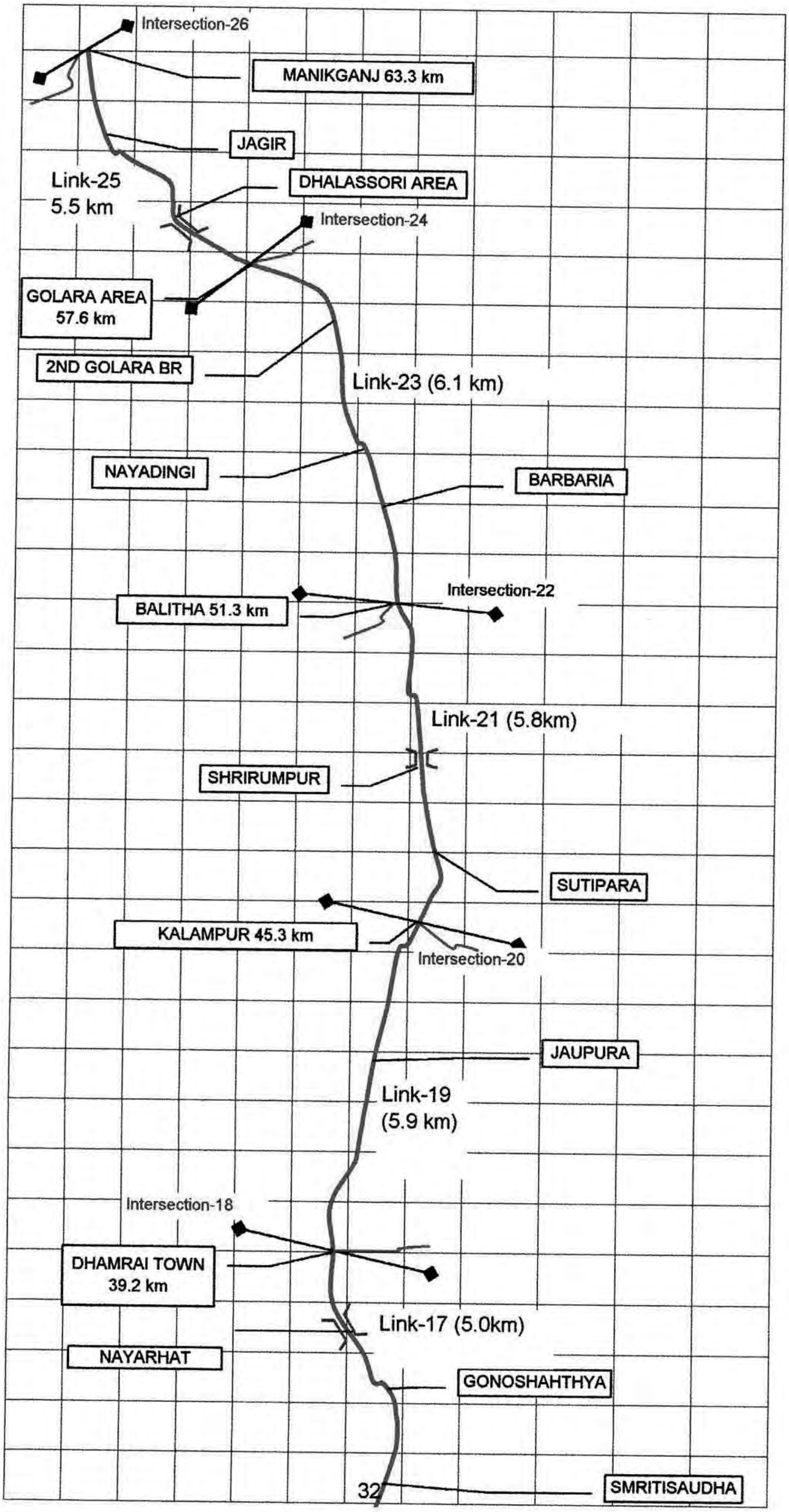
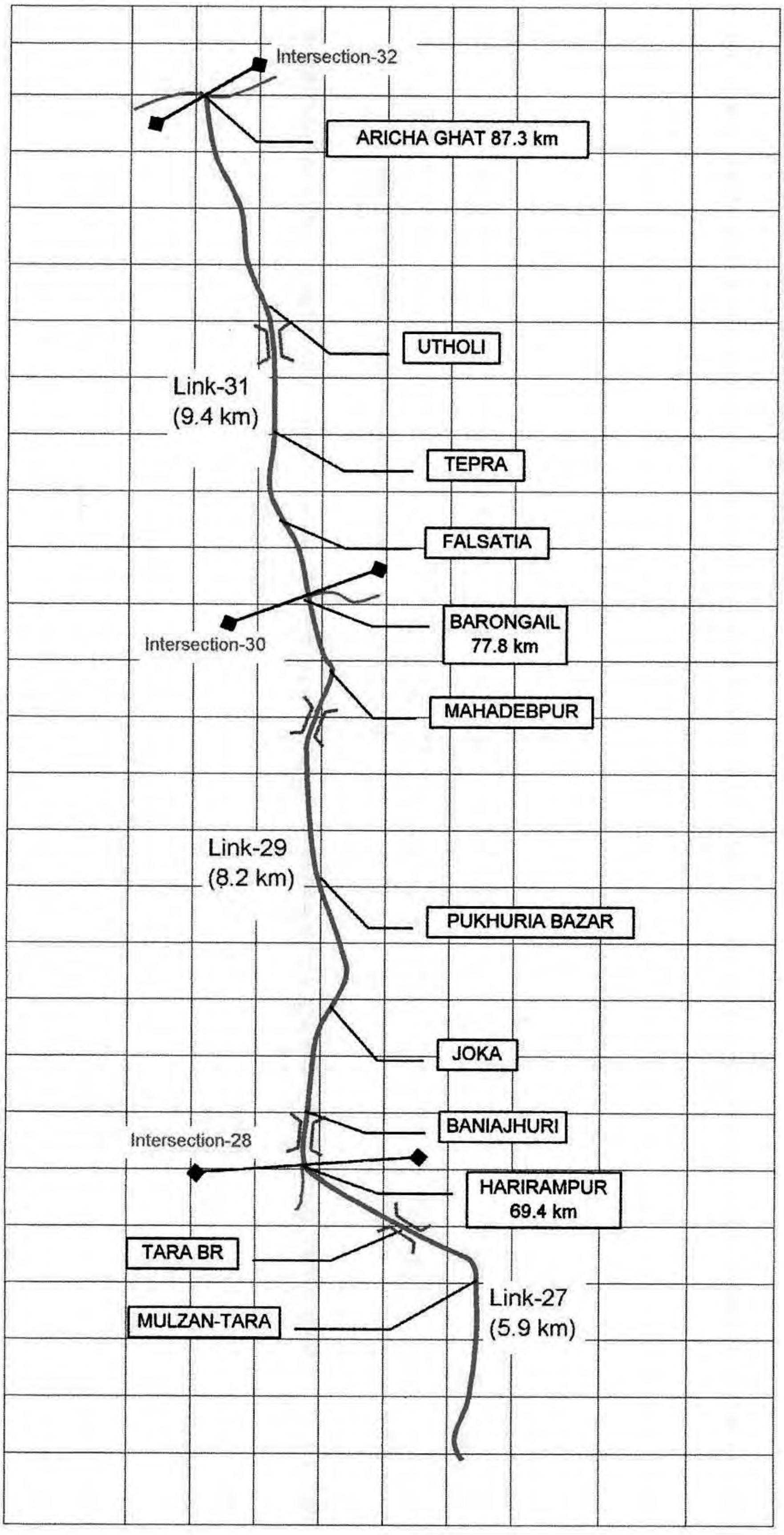


Fig 3.4 Alignment Details of Section 3



3.3.2 Micro scale Analysis.

Micro scale accident studies can be subdivided into the study of individual accidents, known as "accident reconstruction," and the study of "high accident locations, " as they are known in traffic engineering. In this latter analysis, patterns of occurrence and types are analyzed for clues to causation, generally related to design and control elements at the location in question. In USA accident reconstruction is performed in all transportation modes and practiced at all governmental levels.

Locational analysis is conducted at high-accident-frequency locations. The studies are based upon the individual accident report as a basic document. This procedure has developed to its fullest in highway traffic safety, because the method requires relatively large numbers of accidents to occur at or near the same location, or for relatively large numbers of the same type of accident to occur on a facility or stretch of roadway. In this study all these three types of analysis are conducted while investigating causes of accidents.

3.3.3 Methodologies for Expressing Accident Rate

Moreover different methods are in practice through which accident rate can be expressed. Few of these are described in the subsequent articles.

Accident Rate Per Kilometer

On this basis, the total accident hazard is expressed as the number of accidents of all types per kilometer of each highway and street classification.

$$R = A/L$$

Where R = total accident rate per kilometer for one year

A = total no of accidents occurring in one year

L = length or control section in kilometers

Death Rate based on Population

The traffic hazard to life in a community is expressed as the number of traffic fatalities per 100,000 populations. This rate reflects the accident exposure for the entire area.

$$R = \frac{B*100,000}{P}$$

Where R = Death per 100,000 population

B = total no of traffic deaths in one year

P = population of area

Death Rate Based on Registration

The traffic hazards of life in a community can also be expressed as the number of traffic fatalities per 10,000 vehicles registered. This rate reflects the accident exposure for the entire area and has a use similar to death rate based on population.

$$R = (B*10{,}000)/M$$

Where R = death rate per 10,000 vehicles registered

B = total no of traffic deaths in one year

M = number of motor vehicles registered in the area.

Accident Rate Based on Vehicle-Kilometers of Travel

The accident hazard in this case is expressed as the no of accidents per 100 million vehicle kilometers of travel. The true exposure to accidents is probably more nearly approximated by the kilometers of travel by vehicles than by either the population or registration. Here the accident rate is expressed.

$$R = (C* 100000000)/V$$

Where R = accident rate per 100 million vehicle kilometers

C = no of accidents (Deaths or injuries or total accidents) in one year

V= Vehicle km of travel in one year

Among these methods, accident rate based on vehicle-km of travel is more accepted and popular for comparison purpose, as it takes into cognizance of the traffic flow in a way degree of exposure. In this study, traffic flow for the entire study duration is estimated with the available RHD traffic data and using this flow accident rate is determined in terms of vehicle-km of travel for the entire highway.

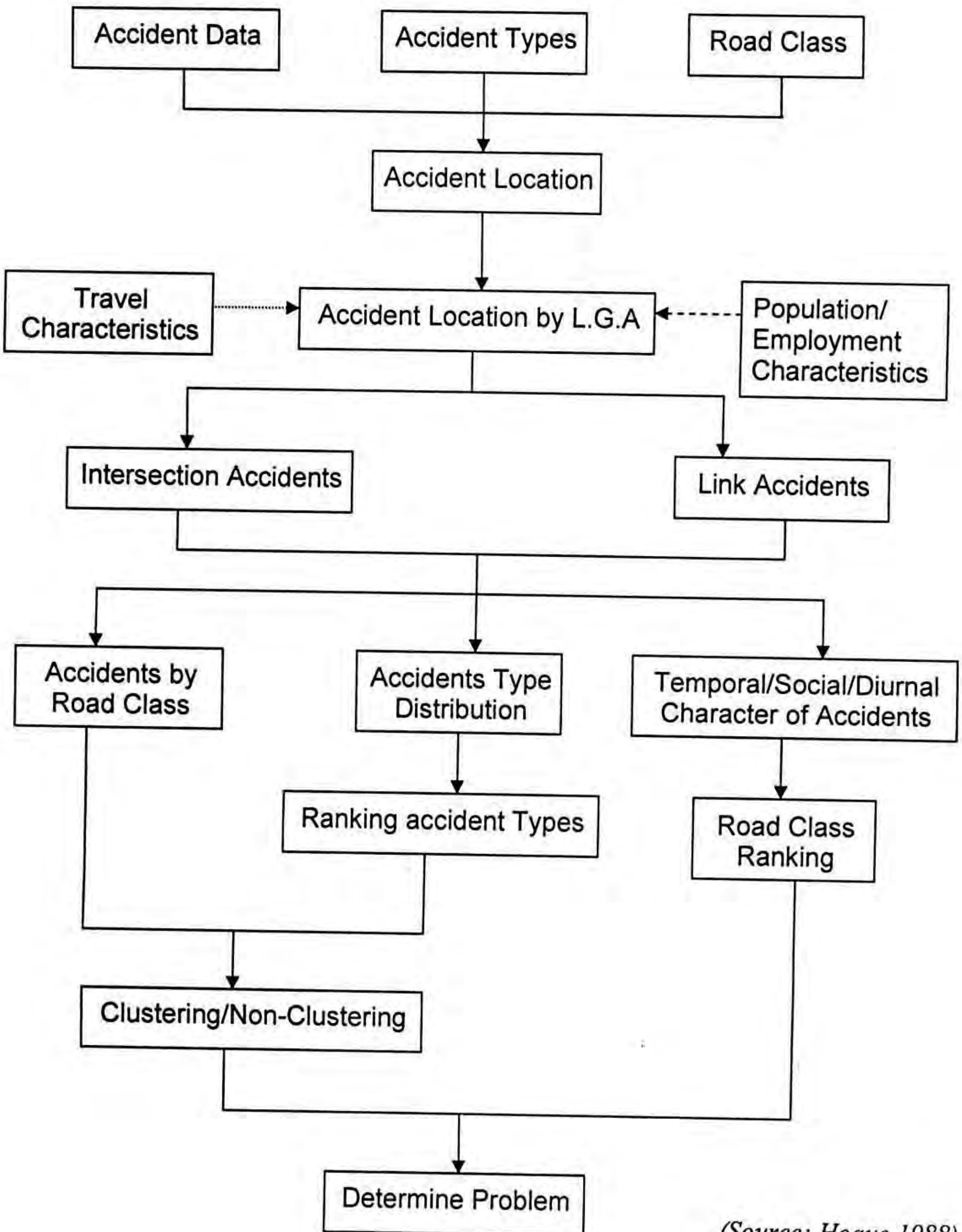
3.3.4 Framework of Accident Analysis

The necessary steps and the systematic process involved in the framework of accident analysis, developed by Hoque, M.M. (1988) are outlined in Fig. 3.1. This framework of accident analysis systematically divides accident problems into component parts starting from the occurrence of accident events and ending up with site-specific treatments. Basic steps involved in the analysis of accident data by using framework are:

- To collect relevant crash data with specific details of objective information.
- To identify hazardous location with respect to crash types and road class.
- To sub-divide the hazardous location into intersections and links to determine the distributions of crash types, distributions of crashes by road class and/or by temporal, diurnal and social characteristics.
- To develop ranking of locations on priority basis.
- To determine specific nature of crash problem and develop countermeasures.

In this study accident types and locations are identified and are further divided into links/intersections/major links as shown in the framework but further division into local government areas (LGA) by inserting population/employment characteristics is not conducted due to non-availability of relevant data. Clustering/non-clustering of accidents including determination of problem is also conducted.

Figure 3.5 Steps Involve in Determining Accident Problem



(Source: Hoque 1988)

3.4 Evaluating the Performance of Safety Schemes

Through monitoring and evaluation the effectiveness of treatments can be assessed. During evaluation a comparison is made with what would expected to be happened if the treatment had not been introduced. Post-implementation monitoring and evaluation is therefore essential to ascertain the effects (positive or negative) of a treatment and thus improve the accuracy and confidence of predictions of that treatment's effectiveness in subsequent applications. However there are several experimental design challenges in doing this, which are described below:

- There may be change in road environment such as change in traffic flow, speed limit, land use etc.
- Because accidents are rare and randomly occurring events there will be fluctuations year by year, which have nothing to do with the treatment being analyzed.
- It is necessary to monitor all significant factors, which could possibly affect the outcome.
- Statistical correlation does not necessarily imply logical Correlation.
- Seasonal factors must be taken into account.
- Accident reporting levels may change over time, and there may be inconsistencies in the accident data, which need to be considered.

3.4.1 Methods of Evaluation

There are basically four ways in which the performance of any safety scheme may be evaluated (Ogden, 1996). These are explained in the subsequent Articles.

Controlled Experimentation

In which all other factors are held constant except the factor whose effect is being investigated; this approach is rarely if ever applicable in road safety engineering because in the real world it is not possible to hold everything constant, and it will not be discussed further.

Before and After Studies

The simplest method is to compare the accident record at the site before and after the implementation of the scheme. It essentially involves:

- Determining in advance the relevant objectives (e.g. accident types intended to be affected) and the corresponding evaluation criteria (e.g. accident frequency, accident rate)
- Monitoring the site or area to obtain numerical values of these criteria before the treatment and again after the treatment
- Comparing the 'before' and 'after' results, and

- Considering whether there are other plausible explanations for the changes, and correcting for them if possible.

Comparisons Using Control Sites

The process involves:

- Determining in advance the relevant objectives (e.g. accident types intended to be affected) and the corresponding evaluation criteria (e.g. accident frequency, accident rate)
- Identifying a control site or (preferably) a set of control sites where no remedial works have been or are intended to be introduced
- Monitoring both the treated site (s) and the control site (s) to obtain numerical values of these criteria before the treatment and again after the treatment
- Comparing the 'before' and 'after' results at both the treated and control sites,
- Considering whether there are other plausible explanations for the changes, and correcting for them if possible.
- Selection of the control sites is obviously of key importance. Ideally, they would be randomly selected. However, this is rarely possible, unless a large number of control sites can be identified and a random selection made from these.

The control sites should satisfy the following criteria (Ward and Allsop, 1982)

- be similar to treated sites in general characteristics (network, geometry, land use, enforcement)
- be geographically close
- have similar traffic flow
- not affected by treatment at test site
- not treated within before-after period
- have accident data

Time Trend Comparisons

This method, which usually involves the development of a model for estimating the trend in accidents over time, is an alternative method of accounting for time-dependent changes without using control sites. It involves:

- Determining in advance the relevant objectives (e.g. accident types intended to be affected) and the corresponding evaluation criteria (e.g. accident frequency, accident rate)
- Obtaining data on each of the criteria for an extended period of time, both before and after implementation of the treatment,
- Developing a model based on the 'before' period,
- Comparing whether there are other plausible explanations for the changes, and correcting for them if possible.

In this study before-after studies and control site technique are adopted for evaluating the performances of safety schemes implemented along Dhaka-Aricha highway.

3.4.2 The Final Approach in Evaluation

It may be mentioned that sometimes conduct of careful statistical analysis is warranted, to correct for external factors in before-after analysis lasting over longer period of time and in many cases the accident frequencies may be so low that any observed changes in accidents may not be statistically significant. The final approach therefore is to focus upon the accident types, which the treatment was intended to correct, and assess whether these have in fact declined. This technique is also applied in this study to see changes of accident pattern due implementation of safety measures.

3.4.3 Statistical Analysis

A number of statistical methods may be applied in analyzing the effectiveness of accident preventive measures. Table 3.1 summarizes few statistical tests that may be undertaken if adequately supported by data.

Table 3.1 Guide to Statistical Tests

Evaluation design	Criteria	Tests
Before and after	Frequency	X^2 for Poisson
	Rates	Paired t- test
	Properties	z-test
	Variance	F-test
	Distribution shifts	RIDT
Before and after with randomized control, comparison group, with correction for regression means	Frequency	X^2 for Poisson paired t-test for before after t- test for group Vs group Analysis of covariance Median test Mann Whitney
	Properties	z-test for properties
	Rates	paired t-test for before after t- test for group Vs group Analysis of covariance
	Variance	F-tests
	Distribution shifts	F tests Kolmogorov-Smirnov

Chi-Squared Test

Among these statistical tests, Chi-squared test is very common in road safety engineering to undertake a before-after evaluation. In order to assess the effectiveness of a corrective measure, estimated Chi-square value need to be compared with the critical value for a particular significant level and degree of freedom. Chi-square value is determined in following manner:

Let b = number of accident before the improvement

a = number of accident after the improvement

b.c = number of accidents expected if no improvement have been carried out

c = control factor (which indicates general accident trend)

Then X^2 (estimated) = $(a - b.c)^2/b.c$

If X^2 (est.)> ^{2} (critical), indicates change due to the improvement

If X^2 (est.) ≤ ^{2} (critical), indicates no change due to the improvement

From past experience the expected number of accident and confidence limit can be established. If observed number of accidents at a particular site falls beyond these limits it can be deduced that there is a significant change in the accident causation.

In this study X^2 test is conduced extensively to determine the effectiveness of installed safety measures.

3.5 Methodology Used in the Study

The study is predominantly concerned with extensive analysis of accident data, countermeasures and improvement work, highway operational and geometric condition along this corridor to determine the effect of these on accident causation and subsequently suggest cost effective safety measures on other roads of similar standard in Bangladesh perspective. The detail methodology involves are discussed in following steps:

- Collection of Accident data from police, road safety cell and hospital covering the period from 1990 to 2003, along Dhaka –Aricha highway to develop a year wise and road segment wise database for the aforesaid period.
- Collect and compile traffic volume data to determine the change of traffic volume pattern especially with the inauguration of Jamuna multipurpose bridge (JMB).
- Collect and compile information on road safety schemes and other improvement works along this corridor.

- Conduct a detailed survey to identify highway geometric and operational condition.
- Preparation of record of observations on geometric and operational condition along this corridor.
- Estimating year wise and segment wise traffic volume and corresponding vehicle-km run.
- Conduct both micro and macro analysis of accident using the collected accident data.
- Identify high accident locations along this corridor.
- Conduct a time series analysis using the accident data and relate it with the improvement work to asses their performance.
- Conduct various statistical analyses like before-after analysis, X^2 test, and accident cost analysis to evaluate the safety improvement schemes.
- Conduct before-after accident pattern analysis to assess the impact of safety measures.

3.6 Overview

In this chapter various aspect of accident data analysis to depict/present the accident scenario and various techniques used to evaluate the performances of the installed safety schemes are discussed. Different statistical analyses used in this regard are highlighted. Besides detail methodologies followed in the study are also presented sequentially. All these would form the basis of subsequent analysis conducted later.

CHAPTER 4

DATA COLLECTION

4.1 Introduction

Collection of accurate and comprehensive information on highway geometric/ operational condition, traffic flow and accident record is of paramount importance in any accident study. Various improvements work in general and safety schemes in particular, have direct impact on accident occurrence and pattern. So there is a need to determine all these parameters in any comprehensive accident study. This chapter presents the detail record of improvement and safety works, existing geometric and operating condition, traffic volume, accident data collection etc along Dhaka-Aricha Highway.

After its construction in 1960, two major rehabilitation projects were under taken along this highway, besides three black spots were also improved under road safety project. It has a varying operating and geometric conditions along its length. To collect all these information number of trips were made along this highway, besides contact was made with RHD, SARM Associates, DDC and consultants working in these projects. A considerable amount of time was spent for this purpose.

To collect accident data at the very outset of the research correspondence was made with DIG of Dhaka range. According to his suggestion the author met Superintendent of police (SP) of Dhaka and Manikganj district. Accident data were required from 1990 to 2003, to develop a comprehensive database from 1982 along this corridor. The previous studies contain data from 1982 to1989, which were collected by Banik, G. C. (1987) from 1982 to 1985 and Hoque, M. M. (1991), from 1985 to 1989. Since data needed were of long time back and longer duration (about 14 years), the police officers suggested that, data for such prolonged period can only be collected accurately from the Crime Index of the respective circle/district. In the circle/district police office, crime Index is prepared for each Thana, summarizing information from the FIR send by respective Thanas and it is well-maintained and preserved for inspection or future reference. However the author also visited respective Thanas, but it was difficult for them to provide fruitful information before 5-6 years as previous documents were not properly maintained. Besides the author also visited Madigan Sadder hospital for collecting accident record. But only current year registers could be found. Considerable amount of time was spent for this purpose.

4.2 Improvement Works and Safety Measures Along Dhaka-Aricha Highway

4.2.1 General Information

According to RHD source, during 1990 to 2003 period, two major rehabilitation works were undertaken along this highway, one with the assistance of Danish Government, through Danish International Development Assistance (DANIDA) and the other by Asian Development Bank (ADB), under Jamuna Bridge Access Road Project (JBARP). Besides three black spots were also improved with the assistance of ADB under JBARP. Details of these works are described in subsequent Articles.

4.2.2 Dhaka-Aricha Highway Rehabilitation Project

4.2.2.1 Project Description

About 61km of the highway from Savarbazar (26km) up to Aricha (87.0) was rehabilitated under this project, which included 48.90 km of pavement construction, 12.10 km of overlay, repair/construction of bridges and culverts, installation of safety features etc. The construction cost of the project was Tk. 260 crores out of which Tk 220 crores was grant from Denmark (DANIDA) and Tk 40 crores from GOB. Though the process started in 1991, actual construction started in October 1995 and completed in 1999. M/S Carl Boro International of Denmark implemented the project, in association with SARM Associates Ltd of Bangladesh.

4.2.2.2 Objectives of the Project

The overall development objective of this project was to support general development in Bangladesh by ensuring adequate and dependable road infrastructure between Dhaka and the ferry routes originating from Aricha (Project Data Sheet, SARM Associates, 2000).
The immediate objectives of the project were:

- To reduce period of closure or speed limitation due to collapse of structures.
- To reduce vehicle operation cost caused by high roughness and delays.
- To reduce cost of recurrent maintenance to a financially sustainable level.
- To reduce accident rate.

4.2.2.3 Salient Safety Features of the Project

- Installation of road sign, pavement marking, km and guard post.
- Provide paved shoulder for 7.5 km length.
- Repair of shoulder.
- Correction of alignment.
- Construction of new bridges/ culverts.
- Provision of crash barrier, parapets, footways/ verges, approach slab etc.
- Protective works for bridge/ roads.

4.2.3 Rehabilitation of Mirpur-Savar Section of Dhaka-Aricha Highway

4.2.3.1 Description of the Project

Under JBARP Mirpur-Savar section of Dhaka-Aricha highway was rehabilitated. The work started on October 1997 and completed on December 2000. It included 14.4km of highway from 11.9 km to 26.3 km. Total cost of the project was Tk. 100.93 crore of which 51.73% was provided by ADB, 96.51% by GOB and 1.76% by Nordic development fund (JBARP Project Summary, 2001).

4.2.3.2 Objectives of the project

- To reduce constraints and increase efficiency of road transport
- To optimize the utilization of the Jamuna Bridge through strengthening the eastern main access roads.
- To contribute to the stabilization of people's livelihood through development of a road network, this is less prone to failure during weather, related disturbances.
- To assist sustainable economic development through enhancement of transport linkages between agricultural centers and industrial areas.
- To enhance road safety measures.

4.2.3.3 Salient Safety Features of the Project

- Construction of median Barrier (Appendix A Figure 4.1)
- Widening of road to 4-lane dual carriageway.
- Embankment widening (Appendix A Figure 4.2)
- Construction of Bus Bay.
- Construction of safety Barrie, Guard post.
- Installation of traffic sign, road marking and guard rail.
- Improvement of shoulder.

4.2.4 Black Spot Improvement Work

General Information

In early 1999, nationwide 27 black spots were identified by RHD using police reported data of which 10 were selected for immediate improvement. Three of those were located along Dhaka-Aricha Highway. Table 4.1 gives details of these locations

Table 4.1: Description of Improved Black Spots along Dhaka-Aricha Highway

Sly. No.	RHD Ref.	Location	UZ	km Ref.	No of Fatal & Grievous Accident						Cost of Work
					In 1998		In 1997		In 1996		
					F	G	F	G	F	G	
1.	AR 4	Balitha/ Bethuli Bus Stand	Dhamrai	50.7-52	2	4	5	2	1		7,24,449
2	AR 6	2nd-Golara Bridge	Saturia	56-56.7	4	1	1	-	3		7,10,292
3	AR 7	Golara Bus stand & Bridge	Saturia	57.2-57.7	4	2	1	-	2		1,17,46,078

Note: The safety schemes were completed by June 2002.

Salient Features

- Construction of side bridge for rickshaw/ pedestrian (Appendix A Figure 4.3)
- Installation of speed reducer, road hump, gate etc (Appendix A Figure 4.4), Speed reducing hump was not found on ground, only speed limiting sign was found, (Appendix B Figure 4.1).
- Construction of bus bay.
- Improvement of junction.
- Installation of road signs and marking (Appendix A Figure 4.5).
- Construction of pedestrian guardrail, sub grade drain and retaining wall (Appendix A Figure 4.6).

4.2.5 Summary of Improvement Works

A summary of improvement/safety works along this corridor undertaken by RHD under different funded programs is furnished in Table 4.2.

Table 4.2 Summaries of Improvement Works

Sl No	Time		Location		Km distance		Salient Feature	Remarks
	Start Time	Complete Time	From	To	From	To		
1.	Oct-95	Mar-99	Savar	Aricha	26	87	1. Pavement reconstruction and overlay. 2. Paved shoulder construction and repair. 3. Correction of alignment. 4. Provision of footway, verge, crash barrier, etc. 5. Road sign, marking, guard post, etc.	The project was named as Dhaka-Aricha Highway Rehabilitation Project with a cost of Tk. 220 crore. One of the main objectives was to reduce accidents.
2.	Nov-97	Dec-00	Aminbazar	Savar	11.9	26.3	1. Median barrier. 2. 4-Lane dual carriageways. 3. Embankment widening. 4. Traffic sign, marking. 5. Shoulder improvement.	Under ADB, within JBARP with Tk. 100 crore.
3.		Jun-02	Balitha		50.7	52.0	1. Speed Reducer (Only Gate with sign found) 2. Widening of pavement (5-10 ft, 2-3 m). 3. Bus Bay. 4. Marking, Signs. 5. Passenger shed (damaged)	Under ADB, within JBARP known as AR-4 with a cost of Tk. 7,24,449/=.

Continued Table 4.2 ....

Sl No	Time		Location	Km distance		Salient Feature	Remarks
4.		Jun-02	2nd Golara Bridge	56.0	56.7	1. Construction of guard post. 1. Sign, marking. 3. Widening of pavement & Embankment. 4. Sub grade and rainwater drain.	Under ADB known as AR-6. Total improvement Cost Tk. 7,10,292/=
5.		Jun-02	Golara Area	57.2	57.7	1. Separate pedestrian/ rickshaw lane. 2. Widening of pavement and embankment 3. Bus Bay. 4. Marking, signs 4. Speed Reducer (Not found). 5. Improvement of Bridge. 6. Improvement of intersection. 7. Guard rail. 8. Passenger shed. 9. Construction of retaining wall, sub grade and rainwater drain.	Under ADB, within JBARP known as AR-7. Total improvement Cost Tk.1,17,46,078/=

4.3 Highway Operating Condition

To determine existing highway operating condition number of trips were made along the highway. Information gathered regarding highway geometric, operational, road adjacent land use patterns and striking observations on various aspects, covering all sections, links/intersections and main locations are presented in Appendix A Table 4.1. The salient observations on highway geometric and operational conditions are summarized in subsequent Articles.

4.3.1 Roadway infrastructure

Roadway infrastructure is hazardous by itself owing to following reasons:

- High embankment height, which varies from 5-20 ft (2-7 m) along the highway (Appendix B Figure 4.2).
- Absence of recovery area, along the length of the highway, 90% area lacks adequate recovery space (Appendix B Figure 4.3).
- Road adjacent areas along most of the highway remain fully or partially water logged rounds the year (Appendix B Figure 4.4).

4.3.2 Pavement Features

- Dual carriageway portion ends suddenly short of Savar bazar without adequate sign/marking, which presents hazard by itself.
- Pavement has smooth non-skid surface, which gets slippery with little rain (Appendix B Figure 4.5).
- Shoulder drop is excessive along most of the highway, which is very hazardous especially when a loaded vehicle reaches the edge (Appendix B Figure 4.6).

4.3.3 Roadside Land Use Pattern

- Up to Dhamrai there are number of industries, commercial areas, housing projects, educational institutions, dairy farms, recreational institutions and military installation along this highway which invites lot of roadside activities.
- Few big residential areas work is in progress by filling the nearby low laying areas up to Savar.

4.3.4 Signs/ Marking

- Though condition of signs are better in relation to any other highways in Bangladesh but these are inadequate, inappropriate, inconsistent in height/ information content in most of the cases.
- No sign was found for pedestrian crossing, school, hospital etc.
- Area speed limit zone was missing for many of the places containing built up area, bazar, bus stand etc.

- Outer/ inner edge line marking is missing along most of the highway for dual carriageway portion, besides centerline marking is unclear for rest of the highway.
- Some of the signs/ markings do not have night visibility.

4.3.5 Highway Operating Environment

Major observations on highway operating environment are furnished below:

- Mixing of MV and NMV along the highway is one of the serious problems.
- There are 11 nos T, 3 nos Y and 2 nos Staggered T type junction along this corridor.
- Two over bridges exists on this highway, over bridge at Savar is widely used.
- Hardly any pedestrian facilities exist along this highway though intense pedestrian activities exhibits especially along the bus stop areas.
- Pedestrian barrier exists at Savar and Jahangirnagar university area, still few pedestrians cross the barrier (Appendix B Figure 4.7) possibly due to easily mountable base of the barrier.
- Conflict between local and through traffic.
- Only six separate bus bays are found among 60 to 70 bus stoppages along this corridor. But these are not also used by the some of the Buses, mounting / dismounting of passengers take place on the carriageway (Appendix B Figure 4.8).
- Few bus stands are located near the approach of the bridges especially near Tara and Dhalessery Bridge, which is very hazardous.
- Around 30 locations contain sharp bends (Appendix B Figure 4.9) and on three locations superelevation is high.
- Most of the places shoulder is occupied by temporary market (Appendix B Figure 4.10), illegal parking which reduces the effective width of the pavement.
- Illegal truck parking near Aminbazar, Nayarhat area is very hazardous (Appendix B Figure 4.11).
- Frequent violation of no overtaking marking, through the busy areas especially by trucks and long distance buses.
- Low height of guard posts, which upon hitting likely to increase impact..
- Bus stopping near the intersection is hazardous.
- Headlight glaring is a serious problem despite the median barrier
- Taking the passenger at the rooftop of bus and truck (Appendix B Figure 4.12).
- Traffic enforcement is very poor along this highway. Except Manikganj, Savar bazar, Nabinagar no traffic police are found along this highway.
- Hardly any street lighting facility is available along this corridor except Savar, cantonment and Manikganj bus stand.
- Dangerous contra flow by trucks engaged in earth filling activities due to median (Appendix B Figure 4.13).

- Large number of garments and other industries, poultry farms etc invites huge pedestrian activities along this highway.

4.3.6 Highway Inventory
Inventory showing the different geometric and design characteristics as identified by RHD are shown in Appendix A Table 4.2.

4.3.7 Traffic Flow Data
As mentioned in Article 3.3.2 expressing the accident rate in terms of veh-km of travel is widely accepted indices for comparison purpose. To estimate veh-km data traffic volume is essential. Traffic volume including motorized, non-motorized vehicles along Dhaka-Aricha highway is collected from RHD, JBARP and Jamuna bridge project evaluation reports. RHD started nationwide traffic census during 1995/1996. This was designed to collect data on traffic volume on all RHD road link and establish a process for annual updating of this data to provide reliable and comprehensive data for road planning in Bangladesh. Since then each year this data is updated and a compiled report is prepared and circulated by HDM circle of RHD. Previous counts were rather sporadic in nature and have often been conducted at different locations and times of year making them unreliable for time series comparisons (RHD, 1995/96).

4.4 Accident Record Keeping System in Bangladesh

4.4.1 Introduction
Accurate and comprehensive accident data is the cornerstone on which all road safety activities should be based. A rigorous database facilitates analysis in both microscopic and macroscopic perspective. An accident data system should establish procedures for the collection, storage, analysis and dissemination of data for all traffic accidents. The system should ensure that all road safety works whether engineering, enforcement, education or publicity should be data led.

4.4.2 Accident Reporting System
In Bangladesh only the police department records the nationwide accident data with the exception of JMB area, where the JOMAC also in parallel maintains record of accident data. In the police station any road traffic accident is recorded as First Information Report (FIR) or general diary and then entered into the 'Khatian Register', a book maintained in all the Thanas to record all types of cases. Then the copy of FIR, being attached with the application or 'Ejhar' either made by the Investigating police Officer (IO) or by the relatives of the victims are send to respective circles and Superintendent of police (SP) offices. A sample of filled up FIR is shown in Figure 4.7 of Appendix A. In the circle and

office, Crime Index is prepared from the FIR and month wise FIRS are preserved as case document. Subsequent development in the process of inquiry is also entered in both the FIR book and Crime Index. Once disposal is obtained from the court about any case, FIRS are send to the court inspector and only the crime Index remain available for any reference. Both Crime Index and FIR is used to record all crimes under respective jurisdiction. So accident data also enter serially with all other crimes and no separate sequence is maintained. Columns of the crime Index is shown below:

Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
FIR no date & time	Place of occurrence, date, time & distance/ direction from Thana	Name address of accused & victims	Dhara of law and costing	Presence of police at site & time	Name of IOs

Col 7	Col 8	Col 9	Col 10
Date of final report	Final order by magistrate	Sign of SP/circle ASP	Remarks

The police officers after filling up the FIR, fills up the newly introduced Accident report form (Appendix A Fig 4.8), and then send it to SP office each month. In practice, all road accident cases are recorded in the FIRs as Bangladesh Penal Code Dhara 279, expressed under following sections:

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

As all types of cases are recorded in the Crime Index/FIR date wise, considerable time was spent to sort out accident cases from all other cases/incidents.

In each month consolidated accident report from respective police stations are routed through Circle and Superintendent of police (SP), to Deputy Inspector General of Police (DIG) of respective range and finally reaches Assistant Inspector General (AIG) crime at police Headquarter. Besides since 1997, all accidents recorded in the newly introduced form are send from police stations through SP to DIG office where these are entered in the MAAP5 (Micro Computer Accident Analysis Package-5) Software in the Accident Data unit (ADU) established in DIG office. This work is then forwarded to police Headquarter, Assistant Inspector General (AIG) crime who in turn delivers it to Road Safety Cell (RSC), who maintains the national accident database since 1997.

4.4.3 Accident Data Item

Introduction

Accuracy and magnitude of accident analysis depend on the availability of data on which it is based. The basic data items required for any scientific investigation of the accident problem can be summarized fewer than three categories of variables (Andersen and Evangel on 1990) viz, the road user variables, the vehicle variables and environmental and other variables. In Bangladesh recording of accidents with greater details started from 1997 by police, but due to lack of knowledge, negligence in filling up the specified Form (Appendix A Figure 4.8) and widespread underreporting still it could not achieve the desired goal.

Accident Database Managed by Road Safety Cell (RSC)

RSC maintains a nationwide accident database from 1997, with the consolidated data received from the police Headquarter. RSC has a specific responsibility to bring out annual road traffic accident report. Two of such reports have already been published. RSC has an inventory (Appendix A Table 4.4) of all national and regional highways, with easily identifiable landmark, within each kilometer section of highway. These landmarks are located as a measured distance (displacement) from a fixed reference point. Any location within a national highway can be Geo coded with respect to a fixed reference point. But due to lack of knowledge and negligence by police persons involved in recording this geo coding is not done accurately, as such identification of exact location of accident becomes difficult which is very essential for identifying high accident location and subsequent development of countermeasures. Moreover, RSC data is also not comprehensive and complete due to following reasons (Alam, 2003):

Under Recording: A large no of accidents are not recorded due to following reasons:

- Ignorance of law by common people.
- Pressure created by vehicle owner or driver.
- Fear of harassment by vehicle owner, driver or their associations or by police.
- Compensation given by driver /owner to the victim.
- Uncertainty of punishment of the offender.
- Very minor punishment, maximum 2 years of jail to the offender.

Under Reporting: Alam, 2003 also mentioned there is wide variation of police reported FIR and MAAP data due to following reason:

> *"Police initially fills up the FIR, then sends the monthly report to higher authority but they are reluctant in filling up the new form as such around 20-30% data remain missing in the MAAP database at RSC (Alam, 2003)".*

Revealing these facts RSC database is not used for this study and it was a great challenge for the study to develop a comprehensive, complete, accurate, error free and informative database. Transcription of record from Crime Index, available FIR, RSC road inventory, field visit etc will give an opportunity to develop an accurate database. Thereby it forms the basis of evaluating existing accident data reporting system and comparing RSC database with that carefully developed by the author.

4.4.4 Transcription of Accident Record

In this study primary accident data collected from the Crime Index and available FIR of Circle/Thana are used in different analysis. An accident Transcription sheet is prepared to transcribe each of the elements of accident information from Crime Index and FIR. For this study following data elements are collected from the Crime Index and FIR:

- Accident location (mouza, village, UZ, prominent landmark, intersection, link etc)
- Accident severity (fatal, grievous injury, simple injury, property damage only)
- Time of accident (hour, daylight/dark time)
- Date of accident (month of the year)
- Accident type (head on, hitting pedestrian, rear end, side swipe, overturn etc)
- Types of vehicles involved in the accident (car, bus, truck, minibus, rickshaw, etc.)
- Number of persons killed or injured.
- Damage costs (vehicle, property damage)

The methods adopted in data transcription are narrated below:

- First from Crime Index accident cases are identified, among all other cases by studying the relevant Dhara and Section as mentioned in Article 4.4.2. After collecting available information from Crime Index, the case number is noted to identify concerned FIR and attached Ejhar for more information.
- Approximately 3500 Crime index and FIR registers are consulted to find out details of 1922 accidents occurred during the study duration (1990-2003). It is found that insects damaged many of these records.
- Then accident locations are geo coded using RSC road Inventory. But for those locations, which were not available in the inventory, visit was made along the highway to identify their positions. It revealed that local names were used in many cases and instead of particular location Mouza, village etc were used. Huge amount of time was needed to convert these descriptional items into numerical figures to make it in usable format.

Transcription sheet is prepared in Microsoft Excel format comprising a total of 17 columns and 1922 rows. Original transcript sheet is of 432 KB size, together with separate data of various sections, links/intersections file size become 23.0 MB.

Observation on Existing Record Keeping System

During data collection and transcription work, it is observed that existing record keeping system has the following weaknesses:

- Filling up of the newly introduced form is improper, inaccurate and incomplete due to lack of understanding of contents of the form by police personnel.
- Collision diagram is either missing or improperly drawn in most of the cases.
- In most cases the newly introduced form is not filled up immediately with the FIR, rather at much later stage by some other persons, which results in delay in reporting to RSC. Three months up to one year of time is required for RSC to receive data.
- Response time to an incidence is high, which results in missing of witnesses in many cases.
- Different flaws in reporting as shown below:
    - Incorrect location of accident.
    - Description of accident
    - Causes of accident
- All these irregularities happened may be due to lack of feedback from accident data user group. Besides practical problem of understaffing, no training, absence of dedicated staff, lack of proper working facility at the Thana level is continuously worsening the situation.

For data mining operation several trips are made to Police Station (PS) of six UZs, SP office and circles and considerable time was needed for this work. A sample of Transcription Sheet is presented in Table 4.3 and Detail is presented in Appendix A Table 4.3.

4.4.5 Supplementary Data Source

In this study hospital record data are used as supplementary data to compare primary data collected from Thana/Circle. By regulation any death case is immediately informed to the police by the hospital authority. Minor injured are treated in the outdoor and seriously injured are admitted in the hospital. Normally accident victims are admitted in the orthopedic, surgical, woman and child ward. All these wards maintain a separate Road Traffic Accidents (RTA) register. Name of the patient, age, sex, address, date of admission/ discharge, treatment given including referring to other hospitals are recorded in this register. However only six months (Jan-June 2003) registers could be found. In the register patients particulars and treatment given are recorded but no information is available about the occurrence of accident. Details of hospital accident record are compiled under the following heading.

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8
Sl no	Date	Time	Gender	Ward	Age	No of grievous Injury from a single accident	Remarks

Table 4.3 Sample of Data Transcription Sheet

UZ	Year	Date	Time	Day/ Night	Location	Km Ref	Veh Type	Severity	Collision type	Killed	Seriou sly Injured	Injured	Property Damage	Intersection Link (Mid Block)	Remarks
Savar	1990	1-Jan	0635	D	Hemayetpur	19.5	Bus	Fatal	Unknown	1	1			Link	
Savar	2002	7-Jan	1405	D	Salepur Br	13.5	Bus	Fatal	Over Turned	24	10	1		Link	Overturned in the river near the bridge
Dhamrai	2001	25-Jul	2045	N	Dhamrai Thana Rd	38.5	1*Truck & 1* Bus	Fatal	Head On	2	5			Link	
Saturia	2001	22-Oct	1945	N	Nyadingi	55.8	Truck	Fatal	Over Turned	3	5	4		Link	
Manikganj	2003	27-Jan	1015	D	Biscic	58.4	1* Truck & 1* Bus	Fatal	Head On	1	5			Link	
Ghior	1996	9-Jun	1230	D	Joka	72.0	Bus	Fatal	Over Turned	21	45			Link	
Shibalaya	2003	11-Jun	Unknown	N	Falsatia	80.3	Unidentified	Fatal	Pedestrian	1				Link	

4.4.6 Limitations of Data

The scope of this study is confined, as many important aspects were not available due to data limitations. These problems relating to data availability and reliability are summarized below:

- As most of the accident data are extracted from crime Index and FIR many important features like road conditions, lighting conditions the road surface etc are not available.
- Difficulties in identifying the exact location. Most of these are mentioned as village, Mouza or other prominent landmark and as a directional distance from Thana, which varies widely for the same location. Same name covers a wide area; as such it was difficult to locate exact position of accident, some times local name is used which creates confusion.

4.5 Overview

Two major rehabilitation works were undertaken during the entire study duration (1990-2003), along Dhaka-Aricha highway by DANIDA and ADB, reduction of accident being one of the immediate objectives. Besides three black spots were improved under JBARP, with the assistance of ADB. A summary of improvement works and operating condition is prepared, to facilitate in order to draw plausible relationship between accident occurrences, the effectiveness of the implemented safety schemes and the highway operating and geometric condition in subsequent analysis.

A comprehensive traffic accident database is an integral part of any accident related research, design of remedial counter measures and assessment of their performance. It facilitates the availability of the elements of analysis for locating accident, identifying the causes and mechanisms and selecting the best solutions. In Bangladesh police department only records the accident data, which are again preserved by the RSC as a national database since 1997. Police records the accidents in FIRs and fills the MAAP5 report forms, at Circle/ District the Crime Index is prepared using FIRS. For this study 1922 accident data is collected from Crime Index and FIRS for the entire study duration (January 1990 - June 2003), besides hospital data are collected for six months (January 2003-June 2003). A Transcription sheet is prepared to transcribe each of the elements of accident information from original report forms. Analysis of accident database is presented in the subsequent chapters.

CHAPTER 5

DATA ANALYSIS AND INTERPRETATION

5.1 Introduction

This chapter presents estimation of traffic, comparison of accident database, detail analysis of accident and traffic data and result of various approaches used to evaluate the performance of safety measures, undertaken during the study duration (1990-2003), along Dhaka - Aricha highway. As discussed in Chapter 3, depending on traffic characteristics, land use pattern, geometric design considerations and as per RHD existing practice, the study area is divided into three major sections for comparison purpose, besides it is further divided into 16 links and 16 intersections. The factors considered for analysis are location, accident severity, vehicles involved in accident, type of collision, clustering of accidents, date and time of occurrence, casualties, evaluation of road safety features, before-after analysis including statistical test, change of accident pattern, costing of accidents etc.

5.2 Estimation of Traffic Volume

For this study traffic data were needed from 1990 to 2003, to estimate veh-km of travel, a widely used indices to express accident rate. As mentioned in Article 4.5 RHD started nationwide traffic census from 1995/1996, since then each year this data is updated and a compiled report is prepared and circulated by RHD. ADT are reported for thirteen different categories by RHD as shown in Table 5.1.

Table 5.1 Vehicle Categories for Traffic Counting

Category	Type	Description
1	Heavy Truck	Three or more axles including multi- axle tandem trucks, containers etc
2	Medium Truck	All two axle truck over 3 ton payload
3	Light Truck	Small truck up to 3ton
4	Large Bus	More than 40 seats on 36 foot or longer chassis
5	Mini Bus	Between 36 and 39 seats
6	Microbus	Up to 16 seats
7	Utility	Pickup, jeep etc
8	Car/Taxi	All types of car
9	Auto Rickshaw	All motorized three wheel vehicles like baby taxi, Tempo, Mishuk etc.
10	Motor Cycle	All two wheeled motorized vehicle
11	Bicycle	All pedal cycles
12	Rickshaw	All three-wheeled non- motorized vehicles.
13	Cart	All animal and manually driven drawn/pushed cart

Source: RHD database 1995/96.

However in this study, for simplicity, easy understanding and in cognizance with available accident data all types of trucks are termed as trucks, all minibuses and buses as buses, Microbuses, utilities, cars as light vehicles (LV), Auto rickshaw, tempo and motorcycles as 2/3 Wheeled vehicles and rickshaws, bicycles, carts as Non motorized Vehicles (NMV).

5.2.1 Estimation of Missing data

In this study owing to non-availability of traffic data prior to1995 and for any missing data estimation is made basing on the projected growth rate in national highways traffic (Table 5.2), which was developed by consultants working with RHD. For this study the truck traffic is considered as freight traffic and bus, LV, NMV are considered as passenger traffic.

Table 5.2 Projected Growths in National Road Traffic

Forecast	Low	Central	High
Passenger Traffic			
1990-1995	6.1%	9.5%	11.2%
1995-2000	5.8%	8.5%	10.2%
2000-2005	5.5%	8.1%	10.3%
2005-2010	5.1%	7.7%	9.6%
Overall	**5.6%**	**8.3%**	**10.5%**
Freight Traffic			
1990-1995	5.6%	8.2%	10.8%
1995-2000	5.6%	8.2%	9.7%
2000-2005	5.6%	7.2%	8.7%
2005-2010	5.6%	7.2%	7.6%
Overall	**5.6%**	**7.7%**	**9.2%**

Source: Road Material Standard Study (RMSS), 1995

In this study, using central projected growth rate of Table 5.2 and available RHD traffic data, traffic volume is estimated for section 1, 2 and 3 from 1990 to 2005, which are presented in Table 5.3 to 5.5. It reveals that due to opening of JMB and commissioning of Tongi-Ashulia road in 1998, 15.8%, 6.5% and 8.2% of traffic was shifted from Section 1, 2 and 3 of this corridor. In an average 10.3% of traffic was shifted from the whole corridor in 1998. Traffic growth in subsequent year was also very insignificant in this corridor, which is 1.7%, 1.4% and 2.8% in 1999 and 4.1%, 3.1% and 2.9% in 2000, for section 1, 2 and 3 respectively, this growth rate is very less as compared to the projected growth of 8.2% for national highways (Table 4.6). NMV/MV ratio is found to be 10%, 25% and 42% for section 1,2 and 3 respectively. It is much less than that predicted by RHD in 1995 (60%) for national highways. In order to validate estimated ADT presented in Table 5.3 to 5.5, limited field volume count survey was conducted along all three sections of this corridor. Result of this volume survey is presented in Appendix A Table 5.1. From this limited survey it is revealed that, in Section 1, this volume is 5% more then estimated value, in section 2 it is 4.5% less than the estimated value and in Section 3 it is 1.5% more than the estimated value.

Table 5.3 Estimated Average Daily Traffic (ADT) Volume for Section 1

Sl No	Year	Truck	Bus/ Mini-Bus	Light Veh (LV)	Motorized 4-W Veh	2/3-W Veh	Total MV	NMV	Total Traffic (ADT)	Growth Rate (%)	Remark
1	1990	2442	1379	1919	5740	1393	7133	718	7851	9.4	Based on projected growth rate factor
2	1991	2661	1512	2105	6278	1527	7805	787	8592	9.4	
3	1992	2899	1658	2308	6865	1675	8540	862	9402	9.4	
4	1993	3158	1818	2531	7507	1836	9343	944	10287	9.4	
5	1994	3440	1994	2775	8209	2014	10223	1033	11256	9.4	
6	***1995***	***3747***	***2186***	***3043***	***8976***	***2208***	***11184***	***1130***	***12314***		***Ref Yr.***
7	*1996*	*4279*	*2245*	*2257*	*8781*	*2572*	*11353*	*1224*	*12577*	*1.5*	Based on actual RHD data
8	*1997*	*4630*	*2435*	*2449*	*9514*	*2790*	*12304*	*1318*	*13622*	*8.4*	
9	*1998*	*2760*	*3808*	*2202*	*8770*	*1584*	*10354*	*1420*	*11774*	***-15.8***	
10	*1999*	*3893*	*3278*	*1932*	*9103*	*1426*	*10529*	*1529*	*12058*	*1.7*	
11	*2000*	*1650*	*3649*	*3806*	*9105*	*1855*	*10960*	*941*	*11901*	*4.1*	
12	*2001*	*1769*	*3929*	*4099*	*9797*	*1499*	*11296*	*1017*	*12313*	*3.1*	
13	2002	1896	4232	4414	10542	1620	12162	1100	13262	7.7	Based on projected growth rate factor
14	2003	2032	4558	4754	11344	1752	13096	1189	14285	7.7	
15	2004	2179	4909	5120	12208	1894	14102	1285	15387	7.7	
16	2005	2336	5287	5515	13138	2047	15185	1389	16574	7.7	

Table 5.4 Estimated Average Daily Traffic (ADT) Volume for Section 2

Sl No	Year	Truck	Bus/ Mini-Bus	Light Veh (LV)	Motorized 4-W Veh	2/3-W Veh	Total MV	NMV	Total Traffic (ADT)	Growth Rate (%)	Remark
1	1990	2547	2894	1597	7038	1378	8416	1566	9982	9.2	Based on projected growth rate factor
2	1991	2775	3174	1746	7695	1493	9188	1717	10905	9.2	
3	1992	3023	3480	1914	8417	1617	10034	1883	11917	9.2	
4	1993	3293	3815	2099	9207	1752	10959	2064	13023	9.2	
5	1994	3588	4183	2301	10072	1898	11970	2264	14234	9.2	
6	***1995***	***3908***	***4587***	***2523***	***11018***	***2057***	***13075***	***2482***	***15557***		***Ref Yr.***
7	1996	4258	5497	2758	12513	2228	14741	2713	17454	12.7	Based on actual
8	*1997*	*4638*	*6008*	*3014*	*13660*	*2415*	*16075*	*2965*	*19040*	*9.0*	

9	*1998*	*4216*	*5462*	*2740*	*12418*	*2616*	*15034*	*3240*	*18274*	*-6.5*	RHD data
10	*1999*	*4220*	*5110*	*3403*	*12733*	*2514*	*15247*	*3541*	*18788*	*1.4*	
11	*2000*	*4194*	*4818*	*4001*	*13013*	*2710*	*15723*	*3870*	*19593*	*3.1*	
12	*2001*	*4120*	*4983*	*4075*	*13178*	*2787*	*15965*	*4168*	*20133*	*1.5*	
13	2002	4416	5386	4405	14207	3002	17209	4489	21698	7.8	Based on projected growth rate factor
14	2003	4735	5823	4762	15320	3232	18552	4835	23387	7.8	
15	2004	5075	6306	5147	16528	3482	20010	5207	25217	7.9	
16	2005	5440	6829	5565	17834	3750	21584	5608	27192	7.9	

Table 5.5 Estimated Average Daily Traffic (ADT) Volume for Section 3

Sl No	Year	Truck	Bus/ Mini-Bus	Light Veh (LV)	Motorized 4-W Veh	2/3-W Veh	Total MV	NMV	Total Traffic (ADT)	Growth Rate (%)	Remark
1	1990	1152	519	225	1794	203	1997	1307	3304	9.4	Based on projected growth rate factor
2	1991	1152	570	246	1968	222	2190	1433	3623	9.4	
3	1992	1255	624	270	2149	244	2393	1572	3965	9.4	
4	1993	1367	684	296	2347	267	2614	1723	4337	9.3	
5	1994	1489	750	325	2564	292	2856	1890	4746	9.4	
6	***1995***	***1623***	***823***	***356***	***2802***	***321***	***3123***	***2072***	***5195***		***Ref. Yr***
7	*1996*	*1756*	*892*	*387*	*3035*	*348*	*3383*	*1111*	*4494*	*-15.6*	Based on actual RHD data
8	*1997*	*1188*	*867*	*696*	*2751*	*684*	*3435*	*912*	*4347*	*1.5*	
9	*1998*	*1006*	*780*	*626*	*2412*	*742*	*3154*	*990*	*4144*	*-8.2*	
10	*1999*	*1016*	*788*	*632*	*2436*	*805*	*3241*	*1074*	*4315*	*2.8*	
11	*2000*	*1026*	*796*	*639*	*2461*	*873*	*3334*	*1165*	*4499*	*2.9*	
12	2001	1100	860	690	2650	944	3594	1255	4849	7.8	Based on projected growth rate factor
13	2002	1179	929	747	2855	1020	3875	1351	5226	7.8	
14	2003	1264	1005	807	3076	1103	4179	1455	5634	7.8	
15	2004	1355	1086	873	3314	1193	4507	1567	6074	7.8	
16	2005	1452	1174	943	3569	1289	4858	1688	6546	7.8	

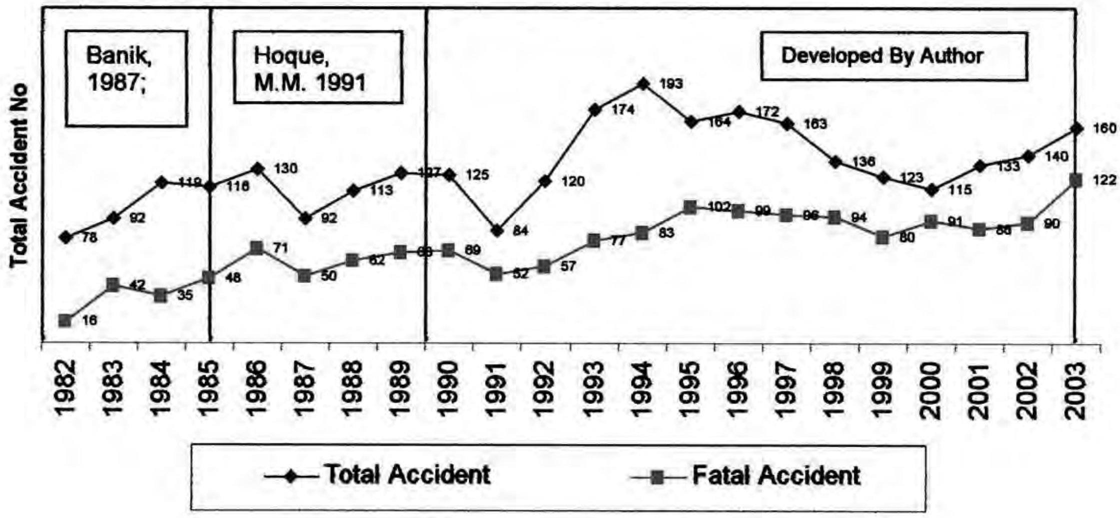
Note: Actual RHD data is presented in Table 5.2 and 5.3 of Appendix A

5.3 Comparison of Accident Database with other Sources

5.3.1 Comparison with Previous Studies

As discussed in Article 4.1, previous studies along Dhaka-Aricha highway contain accident data from 1982 to1989, collected by Banik, G.C (1987) from 1982 to 1985 and Hoque, M.M. (1991), from 1985 to 1989. Figure 5.1 shows accident statistics along Dhaka-Aricha highway from 1982 to 2003. It shows that total accident is doubled and fatal accident is increased by more than seven times along this corridor. Average accident and fatal accident frequency per year along this corridor during different study durations are 101.25 and 35.25 (1982-1985); 115.5 and 62.75 (1982 to1989) and 143 and 85.5 (1990-2003).

Fig 5.1 Yearwise Accident Statistics Along Dhaka-Aricha Highway



5.3.2 Comparison with Hospital Record

As discussed in Article 4.4.5 accident record from Manikganj Sadar hospital is collected and complied for comparison purpose. Table 5.6 shows the general statistics of hospital-recorded accident data, it reveals that in an accident more than one person are admitted in hospital. Normally the victims are treated either in orthopedic (17%) or surgical word (83%). Table 5.6 discloses that vulnerable accidents victims are male (78.3%), female accounts for 21.7% of total victims. Within age group, 15 to 35 years are worst sufferer (55.4%), followed by 35-50 years (20%) and 0-15 years (15%).

Comparison of hospital record with police report is displayed in Table 5.7, it indicates that police reported casualty accidents (fatal and grievous) are 30% and number of seriously injured persons requiring hospital admission are 20% of hospital record only. However this hospital being the district hospital also covers the Manikganj town and may include accidents of other types of roads in the district. In the hospital a separate Road Traffic Accidents (RTA) register is maintained. In the register patients particulars and treatment given are recorded but no information is available about the occurrence of accident. The data recording may be computerized and should include place of occurrence and little description of accident. It is learnt from attached Ejhar with FIR that, accident victims are immediately evacuated to the hospital before arrival of police in most of the cases; as such many seriously injured cases may remain unreported.

Table 5.6 General Statistics of Road Traffic Accidents in Manikganj Sadar Hospital

Month	No of Casualty Accident	Admitted to Hospital					Nature of Treatment				Distribution of Victims by Age Group							
		Male		Female		Total	Orthopedic		Surgery		0-15		15-35		35-50		50+	
		No	%	No	%		No	%	No	%	No	%	No	%	No	%	No	%
Jan	21	20	71.4	8	28.6	28	10	36	18	64	3	11	19	68	5	18	1	4
Feb	18	24	92.3	2	7.7	26	5	19	21	81	9	35	9	35	6	23	2	8
Mar	16	17	73.9	6	26.1	23	7	30	16	70	4	17	12	52	6	26	1	4
Apr	11	11	78.6	3	21.4	14	2	14	12	86	0	0	7	50	4	29	3	21
May	15	20	83.3	4	16.7	24	2	8	22	92	2	8	15	63	3	13	4	17
Jun	24	31	73.8	11	26.2	42	1	2	41	98	5	12	25	60	8	19	4	10
Total	**105**	**123**	**78.3**	**34**	**21.7**	**157**	**27**	**17**	**130**	**83**	**23**	**15**	**87**	**55**	**32**	**20**	**15**	**10**

Table 5.7 Comparison of Hospital data with Police data (Jan 2003-June2003)

Month	Total Casualty Accident (Fatal and Grievous)			Total Series Injured Persons		
	Police Record	Hospital Record	Comparison (%)	Police Record	Hospital Record	Comparison (%)
January	8	21	38.1	17	28	60.7
February	7	18	38.9	6	26	23.1
March	3	16	18.8	0	23	0.0
April	5	11	45.5	1	14	7.1
May	4	15	26.7	0	24	0.0
June	5	24	16.7	6	42	14.3
Total	**31**	**105**	**29.6**	**30**	**157**	**19.1**

5.3.3 Comparison with Road Safety Cell (RSC) Database

RSC started maintaining nationwide accident database since 1997 using MAP5 software (Article 5.2). Table 5.8 presents the comparison of accident statistics of RSC with the primary data collected by the author from respective Thana/Circle; data of 1997 was not used due to its unreliability as learnt from RSC. Table 5.8 reveals that, around 45% of total accident data, 48% of fatal accident, 26% of grievous accidents is not reported to RSC. It indicates a widespread under reporting within the police recorded and reported accident data, which implies that RSC database is even more under reported in this corridor which is overall 20-30% estimated by Alam, 2003 (Article 4.4.3)

Table 5.8 Comparison of Collected Primary Accident Data with RSC Database

Year	Fatal Accident Data			Grievous Accident			Simple Accident			PD Accident			Total Accident		
	RSC	Police	Comparison (%)	RSC	Police	Comparison (%)	RSC	Police	Comparison (%)	RSC	Police	Comparison (%)	RSC	Police	Comparison (%)
1998	59	94	62.8	16	25	64.0	5	5	100	2	17	12	82	141	58.2
1999	50	80	62.5	20	31	64.5	3	9	33	3	3	100	76	123	61.8
2000	52	91	57.1	18	13	138.5	2	10	20	0	1	0	72	115	62.6
2001	39	86	45.3	14	27	51.9	4	13	31	3	7	43	60	133	45.1
2002	29	89	32.6	34	41	82.9	4	5	80	0	5	0	67	140	47.9
Total	**229**	**440**	**52.0**	**102**	**137**	**74.5**	**18**	**42**	**43**	**8**	**33**	**24**	**357**	**652**	**54.8**

5.4 General Accident Statistics

In this study accidents reported by the police covering the period from Jan 1990 to June 2003 are used. In total, 1922- police recorded accidents data are collected from Crime Index and FIR of six UZs namely Savar, Dhamrai, Saturia, Manikganj, Ghior, and Shibalaya. The broad statistics of accident data are shown in Table 5.9. UZ wise yearly and total accident statistics are shown in Figure 5.2 and Figure 5.3. From Table 5.9, it can be seen that maximum 193 accidents occurred in 1994, which gradually decreased in subsequent years. Yearly change of accident rate is given in Table 5.10 and Figure 5.4, which reveals that there was a sharp decrease of total, fatal and grievous accidents by 17%, 21% and 57% respectively after 1998. This decreasing trend continued up to 2000. The possible main reason could be diversion of large volume of traffic (11%) from this corridor, with the commissioning of JMB and Tongi-Ashulia road in 1998 (Article 4.5 and 5.2). However the accident occurrence started increasing after 2000. Table 5.10 also reveals that average accident increase in this corridor is 4.1% and 6.2% for total and fatal accident respectively.

Table 5.9 General Statistics of Accident Data along Dhaka-Aricha Highway (Jan 1990 - Jun 2003)

UZ	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	TOTAL
Savar	52	24	57	94	114	84	88	78	60	44	47	57	68	35	**902**
Dhamrai	21	14	20	22	25	14	18	37	28	25	17	24	15	10	290
Saturia	7	9	5	3	4	7	8	7	15	8	7	3	8	7	98
Manikganj	17	16	16	26	23	19	16	18	11	20	22	17	20	10	251
Ghior	10	7	9	6	10	16	19	11	11	16	8	13	11	4	151
Shibalaya	18	14	13	23	17	24	23	12	11	10	14	19	18	14	230
Total	**125**	**84**	**120**	**174**	**193**	**164**	**172**	**163**	**136**	**123**	**115**	**133**	**140**	**80**	**1922**

Figure 5.2 Year-wise General Statistics of Accident Along Dhaka-Aricha Highway

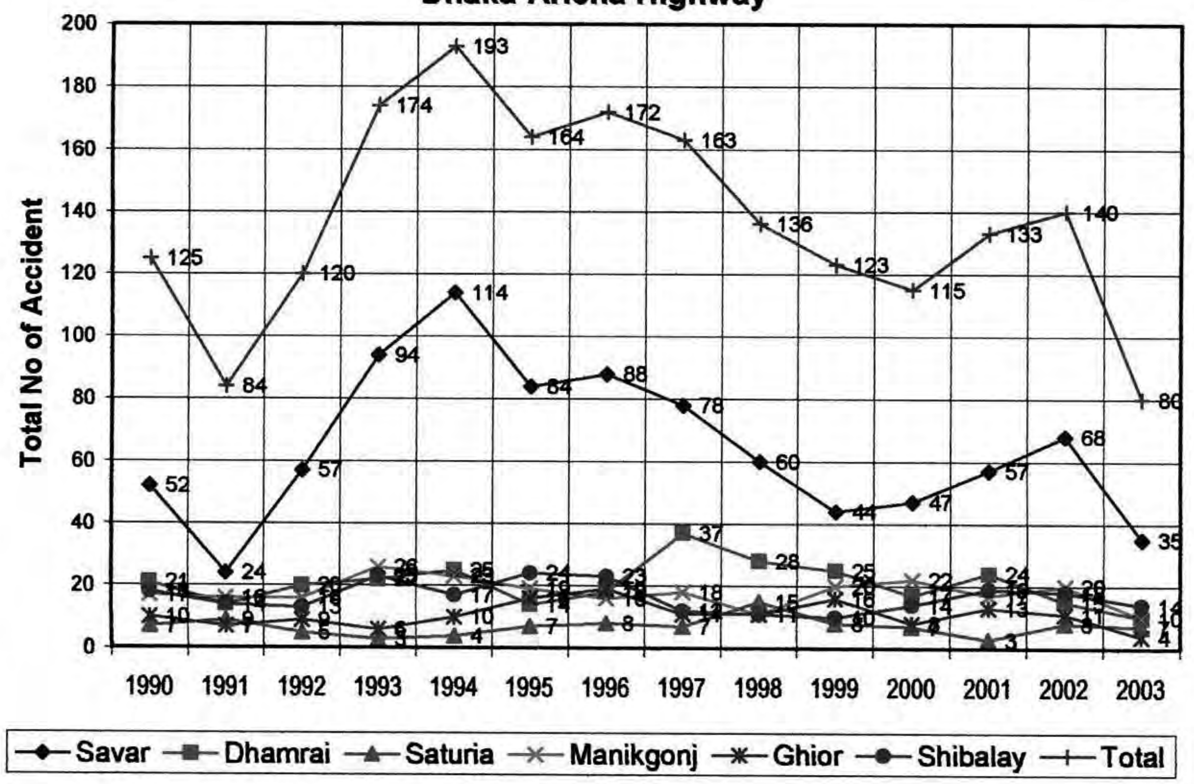


Figure 5.3 UZ-Wise Total Accident Along Dhaka-Aricha Highway (1990-2003)

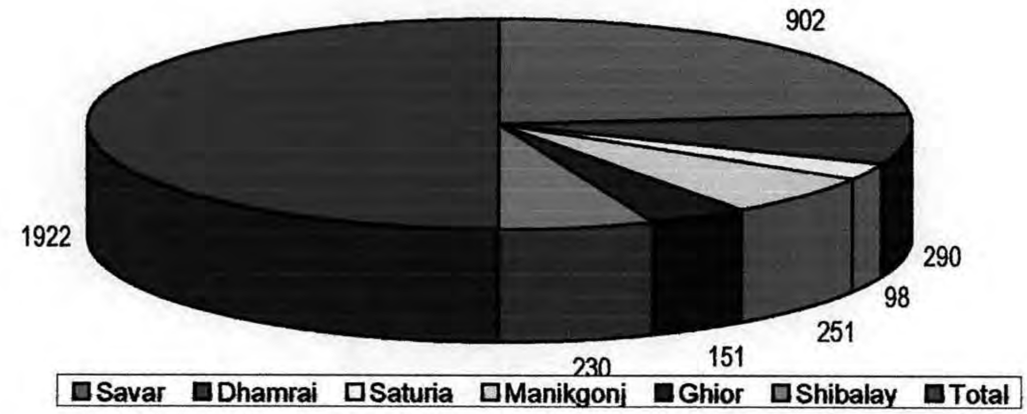


Figure 5.4 Yearly Change of Accident

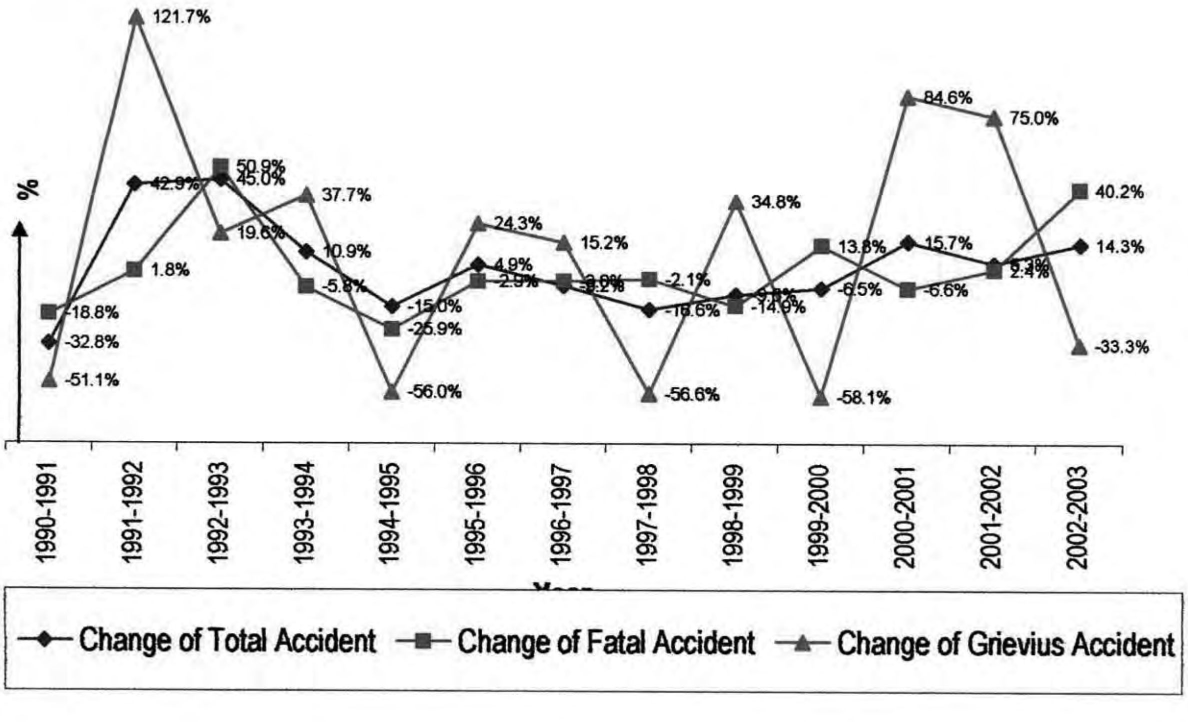


Table 5.10 Yearly Change of Accident

Accident Type	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	Cumulative Change	Average Change / year
Change of Total Accident	-32.8%	42.9%	45.0%	10.9%	-15.0%	4.9%	-5.2%	-16.6%	-9.6%	-6.5%	15.7%	5.3%	14.3%	53.2%	4.1%
Change of Fatal Accident	-18.8%	1.8%	50.9%	-5.8%	-25.9%	-2.9%	-3.0%	-2.1%	-14.9%	13.8%	-6.6%	2.4%	40.2%	80.7%	6.2%
Change of Grievous Accident e	-51.1%	121.7%	19.6%	37.7%	-56.0%	24.3%	15.2%	-56.6%	34.8%	-58.1%	84.6%	75.0%	-33.3%	158.0%	12.2%

Note: 1. For 2003, equivalent yearly data is estimated by converting six monthly data.

2. Negative (-) sign indicates decreasing trend.

5.5 Accident Distribution by Severity

Accident severity represents the most severe casualty class received by any individual involved in that accident. Severity can be categorized as fatal, grievous, property damage only (PD) accidents (Article 2.10). The severity index (ratio of fatal plus grievous accident to total accidents) is another indicator of accident severity used for comparison purpose.

The severity index of six UZs is shown in Table 5.11 and Figure 5.5, which reveals that highest severity index is in Ghior UZ (0.97), followed by Dhamrai (0.95), Saturia (0.93), Savar (0.88), Manikganj (0.82) and lowest in Shibalaya UZ (0.81).

Table 5.11 Statistics of Accident Data by Severity

Upazilla	Fatal		Grievously Injured		Simple injury		Property Damage		Total	Severity Index
	No	%	No	%	No	%	No	%		
Savar	**531**	46.3	263	47.7	25	27.9	72	75.8	902	0.88
Dhamrai	189	16.5	87	15.8	4	3.1	10	10.5	290	**0.95**
Saturia	61	5.3	30	5.4	4	3.1	3	3.2	98	0.93
Manikganj	117	10.2	88	16.0	38	29.5	8	8.4	251	0.82
Ghior	82	7.1	64	11.6	3	2.3	2	2.1	151	**0.97**
Shibalaya	167	14.6	19	3.4	44	34.1		0.0	230	0.81
Total	**1147**	**100.0**	**551**	**100.0**	**129**	**100.0**	**95**	**100.0**	**1922**	**0.88**

Figure 5.5 Distribution of Accident By Severity Index

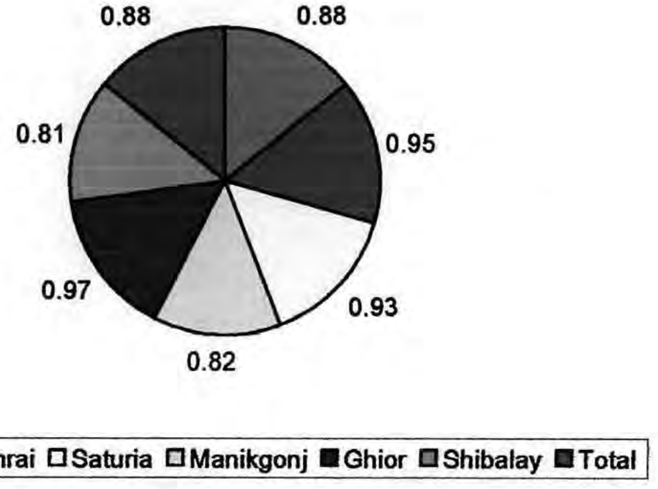


Figure 5.6 and Table 5.12 shows consolidated distribution of accidents by severity. It reveals that, out of 1922 accidents, 1147 (60%) are fatal, 551 (28%) grievous, 129 (7%) simple and 95(5%) property damage accidents. This statistics indicates that 95% of reported accidents on this corridor are of casualty types.

Again Table 5.12 discloses that among six UZs, Savar UZ experienced the highest number of accidents (902, 47%), with maximum fatal cases (531, 46%), this could be due to intense road side land use, pedestrian activities with suburban characteristics as revealed during field visit (Article 4.3.3). Savar UZ was followed by Dhamrai (290, 15%), Manikganj (251, 13%), Shibalaya (230,125), Ghior (151, 8%) and Saturia (98, 5%) UZ.

The critical observation from Table 5.11 and 5.12 reveals that though in terms of fatality number Savar UZ is at the top but severity index wise Ghior leads the list with 2nd lowest minimum number of fatal accidents. Analysis of accident patterns reveals that at Ghior UZ, the frequency of overturn and hitting pedestrian type accidents is higher than that of other UZs. Geometric and operating condition survey reveals that along this segment there are four sharp bends and two undivided large bridges without climbing lanes, which suffer from obstructed vision. The situation is aggravated further due to the presence of few bus-stoppages at the bends and near the bridges. Moreover, it is also observed that existence of roadside trees is making the sight distance problems worse. Besides, traffic data shows that a significant number of NMVs ply in this segment of the highway. It is found that NMV comprises 42% of traffic stream. All these together may be responsible for high severity index of Ghior UZ.

Figure 5.6 Distribution of Accident by Severity

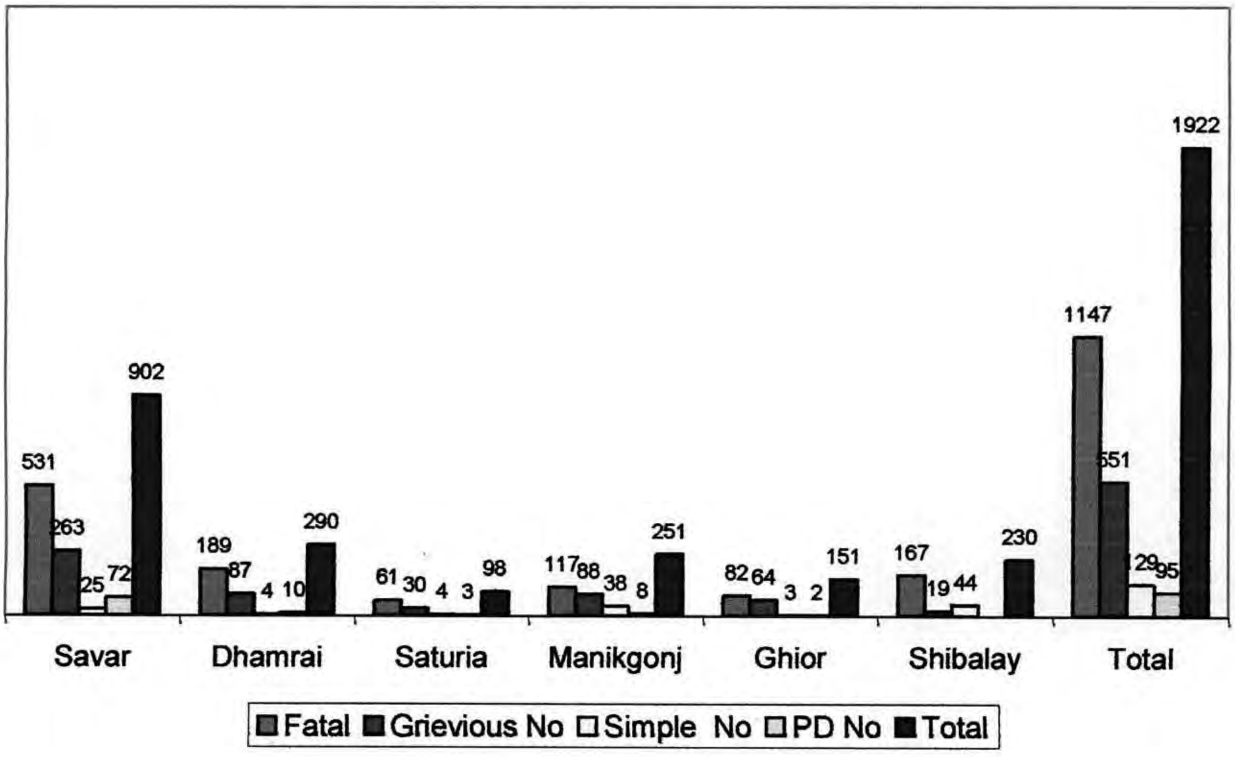


Table 5.12 Year wise Statistics of Accident data by Severity for all UZs Along Dhaka - Aricha highway

UZ	Severity	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
Savar	Fatal	34	21	24	39	47	42	49	51	34	32	44	38	49	27	531
	Grievous	18	3	26	36	49	26	24	27	8	9	3	10	17	7	263
	Simple	-	-	6	8	4	9	3	-	1	2	-	2	1	0	36
	PD	-	-	1	11	14	7	12	-	17	1	-	7	1	1	72
	Total	**52**	**24**	**57**	**94**	**114**	**84**	**88**	**78**	**60**	**44**	**47**	**57**	**68**	**35**	**902**
Dhamrai	Fatal	13	9	12	15	11	12	9	16	22	15	14	22	11	8	189
	Grievous	4	5	8	7	13	1	5	18	6	9	3	2	4	2	87
	Simple	3	-	-	-		-	-	1	-	-	-	-	-	-	4
	PD	1	-	-	-	1	1	4	2	-	1	-	-	-	-	10
	Total	**21**	**14**	**20**	**22**	**25**	**14**	**18**	**37**	**28**	**25**	**17**	**24**	**15**	**10**	**290**
Saturia	Fatal	5	6		2	2	4	6	5	11	6	5	2	1	6	61
	Grievous	1	1	4	1	1	3	1	2	4	2	1	1	7	1	30
	Simple	1	-	-	-	1	-	1	-	-	-	1	-	-	-	4
	PD		2	1	-	-	-	-	-	-	-	-	-	-	-	3
	Total	**7**	**9**	**5**	**3**	**4**	**7**	**8**	**7**	**15**	**8**	**7**	**3**	**8**	**7**	**98**
Manikganj	Fatal	4	7	11	12	5	13	9	9	6	8	12	8	7	6	117
	Grievous	13	9	5	12	13	1	4	2	5	7	3	5	8	1	88
	Simple	-	-	-	2	5	5	3	6	-	4	6	4	1	2	38
	PD	-	-	-	-	-	-	-	1	-	1	1	-	4	1	8
	Total	**17**	**16**	**16**	**26**	**23**	**19**	**16**	**18**	**11**	**20**	**22**	**17**	**20**	**10**	**251**
Ghior	Fatal	3	3		4	3	10	12	5	11	11	5	7	6	2	82
	Grievous	7	4	8	2	7	6	7	4		4	2	6	5	2	64
	Simple	-	-	1	-	-	-	-	-	-	1	1	-	-	-	3
	PD	-	-	-	-	-	-	-	2	-	-	-	-	-	-	2
	Total	**10**	**7**	**9**	**6**	**10**	**16**	**19**	**11**	**11**	**16**	**8**	**13**	**11**	**4**	**151**
Shibalaya	Fatal	10	10	10	14	13	21	14	10	10	8	11	9	15	12	167
	Grievous	4	1	-	3	1	-	5	-	-	-	1	3	-	1	19
	Simple	4	3	3	6	3	3	4	2	1	2	2	7	3	1	44
	PD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	18	14	13	23	17	24	23	12	11	10	14	19	18	14	230
G Total		**125**	**84**	**120**	**174**	**193**	**164**	**172**	**163**	**136**	**123**	**115**	**133**	**140**	**80**	**1922**

5.6 Temporal Distribution of Accident

Usually the occurrence of accidents varies considerably with hour of the day, day or nighttime, day of the week and month of the year. The variation of accidents considering these factors, are presented in the subsequent articles.

5.6.1 Hourly Variation of Accidents

The distribution of accidents by hours of the day for all 3 sections and along the whole length of the highway is shown in Table 5.13 and Figure 5.7. The table shows that there are peaks between 1000 - 1200 and 1200 - 1400 along the whole highway. In section 1 peak exists between 0800 to 1000 hours, in section 2, 1200 to 1400 and in section 3, 1000-1200 hours. Accidents tend to remain above average from 0800 to 1800 hours and below average for the remainder of the period.

5.6.2 Distribution of Accidents by Month of the Year

The numbers of accidents are likely to vary with months of the year. This variation is shown in Table 5.14 and Figure 5.8. It reveals that highest number of accidents for the whole highway occurred in January, followed by May and April. In section 1, 2 and 3 the highest number of accidents occurred during January, April and May respectively. The number of fatalities and grievous injuries are also high in January. It may be caused by poor visibility and high number of recreational trips during this month.

5.6.3 Distribution of Accidents by Day and Night Time.

From Table 6.15 and Figure 5.9, it reveals that around 69.6% and 30.4% of accidents occurred by day and night respectively for the whole length of the highway. Table 6.15 also identifies that in section 1, 2 and 3, total 61.5%. 71.5% and 74.6% of the accidents took place during hours of daylight, rest being at nighttime. This may be due to high concentration of roadside activities, presence of NMVs, mixing of high proportion of through and local traffic during daytime.

Table 5.13 Two Hourly Distribution of Accident

Hours of Day	Section 1		Section 2		Section 3		Whole Alignment	
	No	%	No	%	No	%	No	%
0000-0200	23	2.77	19	3.04	6	1.29	48	2.50
0200-0400	22	2.65	16	2.56	19	4.09	57	2.97
0400-0600	50	6.02	36	5.75	20	4.31	106	5.52
0600-0800	67	8.06	57	9.11	37	7.97	161	8.38
0800-1000	109	13.12	72	11.50	49	10.56	230	11.97
1000-1200	90	10.83	90	14.38	100	21.55	280	14.57
1200-1400	81	9.75	91	14.54	71	15.30	243	12.64
1400-1600	94	11.31	73	11.50	43	9.27	210	10.93
1600-1800	98	11.79	67	10.70	45	9.70	210	10.93
1800-2000	68	8.18	44	7.03	28	6.03	140	7.28
2000-2200	74	8.90	36	5.75	24	5.17	134	6.97
2200-2400	44	5.29	18	2.88	16	3.45	78	4.06
Unknown	*11*	*1.32*	*8*	*1.28*	*6*	*1.29*	25	*1.3*
Total	**831**	**100.00**	**627**	**100.00**	**464**	**100.00**	**1922**	**100.00**

Figure 5.7 Accident Occurrence by Time of the Day

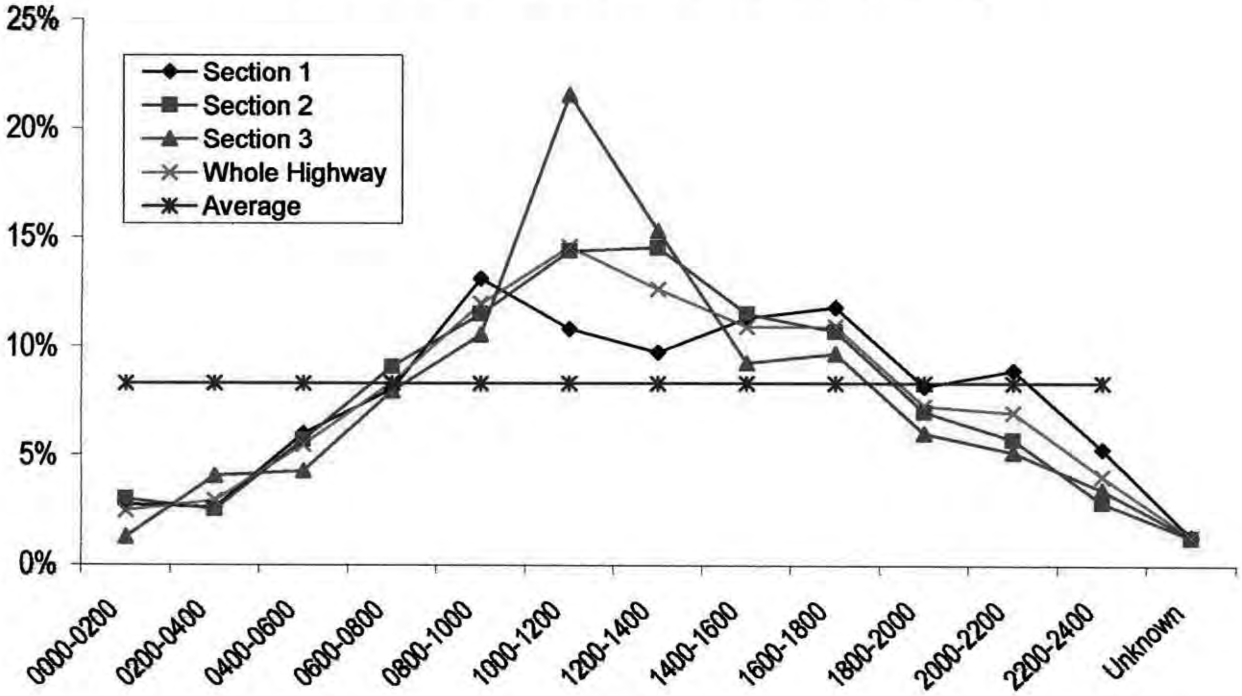


Table 5.14 Distribution of Accident by Month of the Year

Month	Section 1		Section 2		Section 3		Whole Highway	
	No	%	No	%	No	%	No	%
January	96	11.55	59	9.41	46	9.91	201	10.46
February	73	8.78	48	7.66	31	6.68	152	7.91
March	64	7.70	58	9.25	31	6.68	153	7.96
April	74	8.90	63	10.05	36	7.76	173	9.00
May	68	8.18	54	8.61	56	12.07	178	9.26
June	69	8.30	58	9.25	44	9.48	171	8.90
July	67	8.06	54	8.61	43	9.27	164	8.53
August	68	8.18	48	7.66	42	9.05	158	8.22
September	69	8.30	55	8.77	28	6.03	152	7.91
October	71	8.54	50	7.97	38	8.19	159	8.27
November	69	8.30	39	6.22	33	7.11	141	7.34
December	43	5.17	41	6.54	36	7.76	120	6.24
Total	**831**	**100.00**	**627**	**100.00**	**464**	**100.00**	**1922**	**100.00**

Figure 5.8 Monthly Distribution of Accident

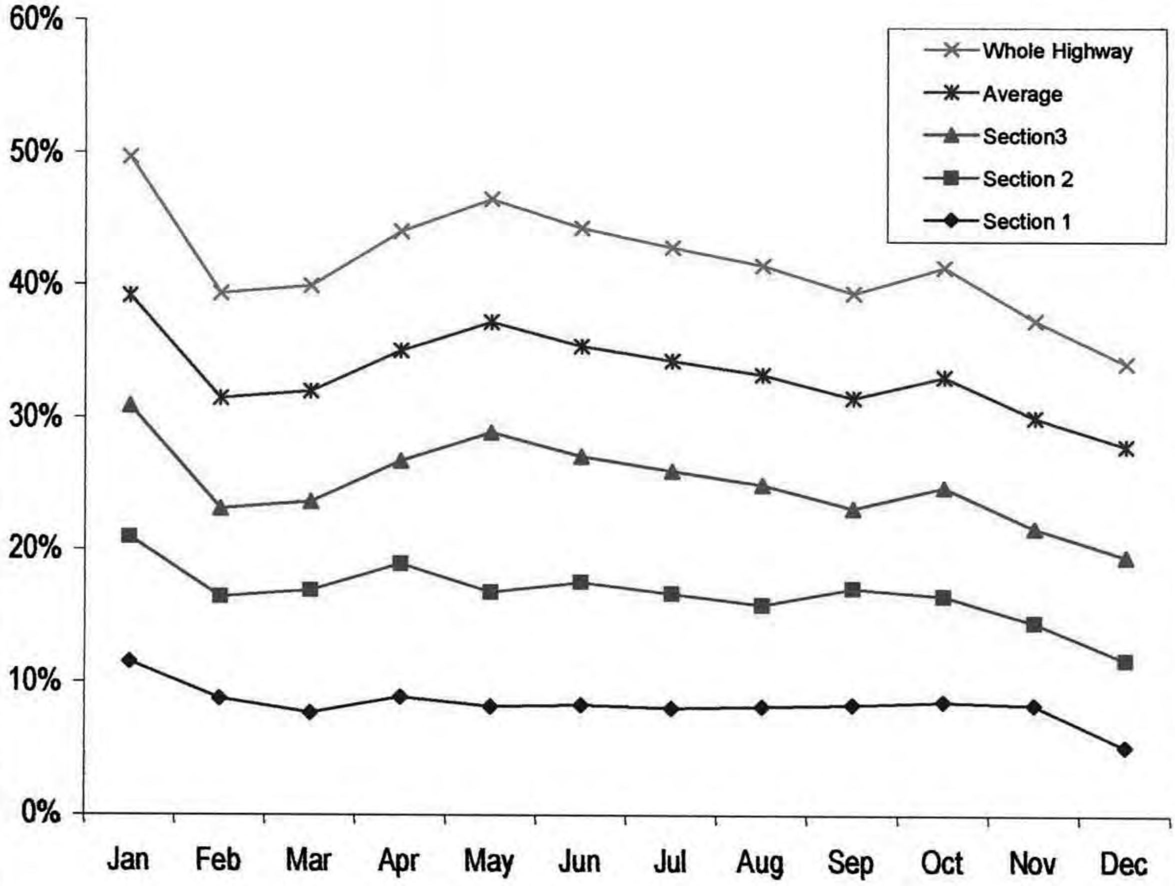
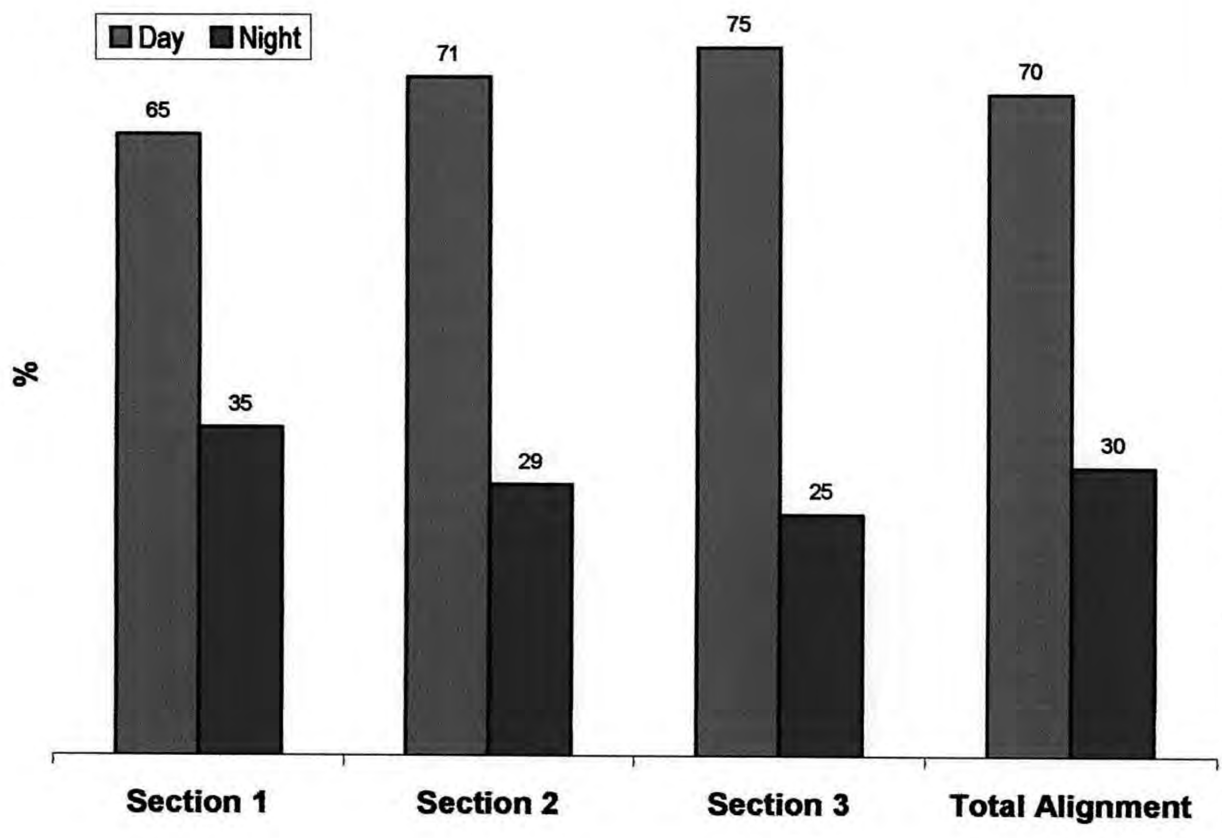


Table 5.15 Distribution of Accident by Day and Night Time

Day	Section 1		Section 2		Section 3		Whole Highway	
	No	%	No	%	No	%	No	%
Day	544	65.5	448	71.5	346	74.6	1338	69.6
Night	287	34.5	179	28.5	118	25.4	584	30.4
Total	**831**	**100.0**	**627**	**100.0**	**464**	**100.0**	**1922**	**100.0**

Figure 5.9 Distribution of Accident by Day and Night Time



5.7 Vehicle Involvement in Accidents

For developing appropriate counter measures and to assess their effectiveness it is important to classify the accidents in terms of single and multi vehicle accident, motorized and non motorized accidents and number, type of vehicles involved in the accident.

5.7.1 Single and Multi Vehicle Accident.

When a single vehicle involved in the accident it is termed as single vehicle accident and when more than one vehicle are involved in any accident it is termed as multi vehicle accident. Distribution of single and multi vehicle accidents are furnished in Table 5.16 for all sections and whole highway, it reveals that around 81% accidents are of single vehicle and 19% multi vehicle type for the whole highway. From critical observation of database it can be seen that most of single vehicle accidents are hitting pedestrian, hitting object and out of control type due to mechanical failure. Percentage of single vehicle accidents in section 1,2 and 3 are 84.2%, 79.1% and 79.9% respectively.

5.7.2 Distribution of Accident by Vehicle Type.

From Table 5.17 and Figure 5.10 it can be seen that total 2297 numbers of vehicles are involved in 1922 accidents for the entire study duration (1990-2003). There are 254 cases of reported accidents for which vehicle types are unknown. Table 5.17 and Figure 5.10 also disclose that buses/minibuses and trucks are involved in 45.6% and 31.6% of accidents respectively. These are followed by motorcycle (2.44%), car (2.4%) and micro (1.26%).

Table 5.18 and Figure 5.11 show the relative involvement of different types of vehicles in accidents as a proportion of ADT. It reveals that though bus/minibuses and trucks share 24.9% and 24.7% of total traffic, but they contribute to 45.6% and 31.6% of accident. Bus and truck are over involved in accidents with values per unit being 1.8 and 1.3. In this study minibuses are considered as bus; micro, car, jeep, pickup, ambulance as light vehicle; tempo, baby taxi, motor cycle as 2/3 wheeler; rickshaw, van, cycle as NMV (Article 5.2, Table 6.1).

5.7.3 Distribution of Accidents by Motorized and Non-Motorized Vehicle (NMV)

Table 5.19 shows that NMVs are involved in total 2.4% of accidents in the highway. But many accidents involving NMVs did not enter in the vehicle-involved column of FIR, which revealed later while reviewing attached Ejhars.

Table 5.16 Single and Multi Vehicles Accident Distribution

Section	Single Vehicle		Multi Vehicles		Total
	No	%	No	%	No
Section 1	699	84.12	132	15.88	831
Section 2	496	79.11	131	20.89	627
Section 3	371	79.9	93	20.04	464
Total Alignment	**1566**	**81.48**	**356**	**18.52**	**1922**

Table 5.17 **Distribution of Accident by Vehicle Type**

Vehicles	Section 1		Section 2		Section 3		Whole Alignment	
	No	%	No	%	No	%	Total	%
Bus	295	30.41	308	40.63	268	47.10	871	37.92
Mini Bus	84	8.66	46	6.07	46	8.08	176	7.66
Truck	294	30.31	266	35.09	166	29.17	726	31.61
Micro	9	0.93	12	1.58	8	1.41	29	1.26
Car	30	3.09	20	2.64	5	0.88	55	2.39
Jeep	1	0.10	2	0.26	3	0.53	6	0.26
Pickup	16	1.65	7	0.92	2	0.35	25	1.09
Tempo	8	0.82	3	0.40	9	1.58	20	0.87
Baby taxi	7	0.72	0	0.00	8	1.41	15	0.65
Motorcycle	20	2.06	16	2.11	20	3.51	56	2.44
Rickshaw	13	1.34	2	0.26	9	1.58	24	1.04
Cycle	8	0.82	6	0.79	6	1.05	20	0.87
Van	5	0.52	3	0.40	3	0.53	11	0.48
Others	6	0.62	2	0.26	1	0.18	9	0.39
Unknown	174	17.94	65	8.5	15	2.64	254	11.06
Total	**970**	**100.00**	**758**	**100.00**	**569**	**100.00**	**2297**	**100.00**

Figure 5.10 Distribution of Accident by Veh Type

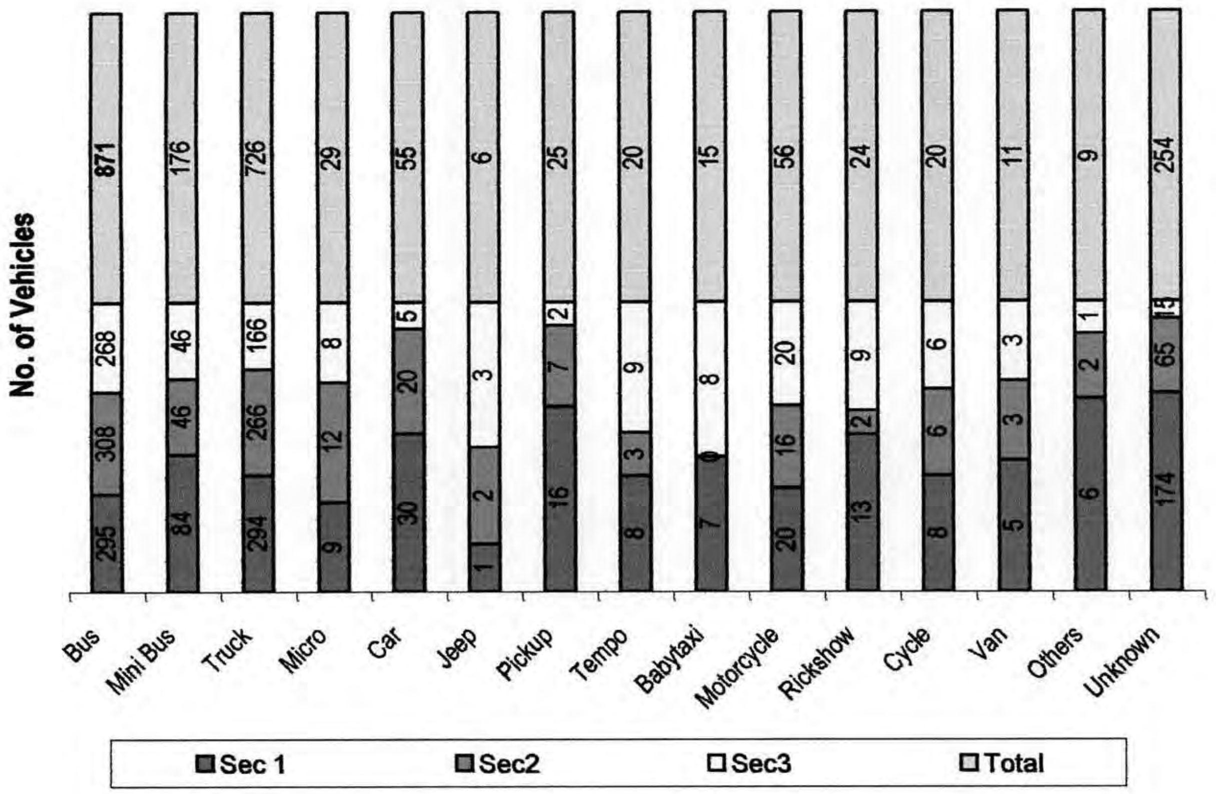


Table 5.18 Relative Accident Involvement of Different Vehicles

Vehicle Type	Average ADT*	Composition (%)	Accident Involvement ** (%)	Accident Involvement per Vehicle Class
Bus	2539	24.9	45.6	1.8
Truck	2524	24.7	31.6	1.3
Light Vehicle	1993	19.5	5.0	0.3
2/3-Wheeler	1465	14.3	4.0	0.3
NMV	1693	16.6	2.8	0.2

*Note: * Based on 13 years vehicular yearly flow data*

*** Based on Table 5.17*

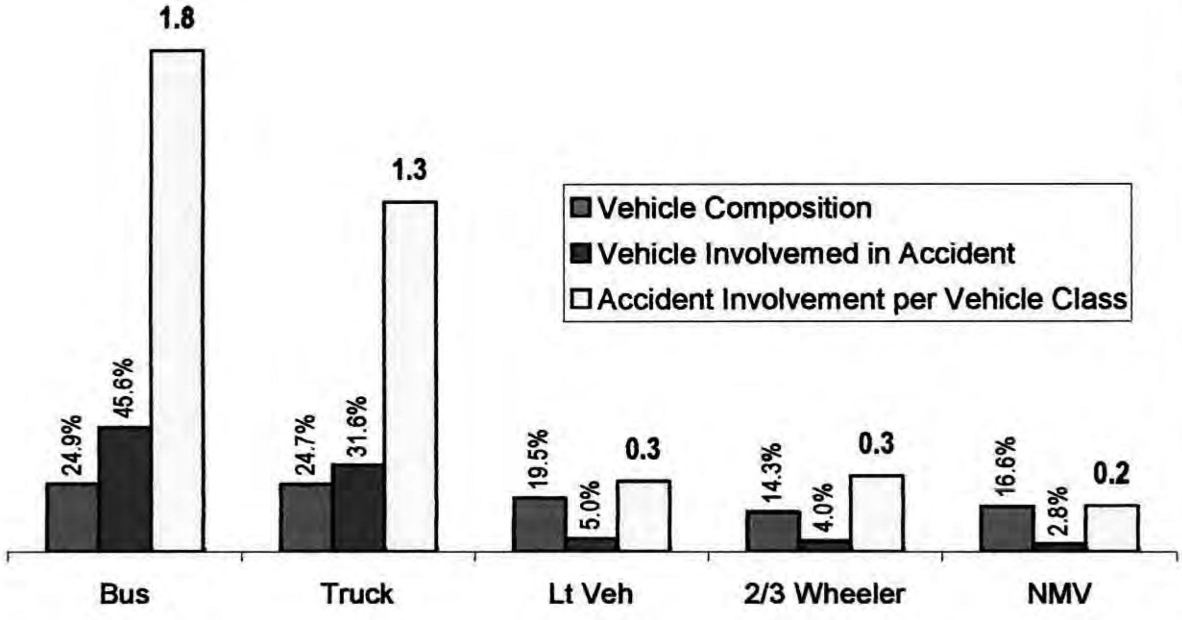


Table 5.19 Distribution of Accidents by Motorized and Non motorized Vehicle Type

Type	Section 1		Section 2		Section 3		Total Highway	
	No	%	No	%	No	%	No	%
Motorized Vehicle	944	97.3	747	98.5	551	96.8	2242	97.6
Non-Motorized Veh	26	2.7	11	1.5	18	3.2	55	2.4
Total	**970**	**100.0**	**758**	**100.0**	**569**	**100.0**	**2297**	**100.0**

5.8 Distribution By Accidents Type

Accident types indicates the manner of collision leading to the occurrence of accident, such as rear end collision, hitting pedestrian, head on collision etc. Table 5.20 shows that most predominant accident along Dhaka-Aricha highway is hitting pedestrian, which accounts for 55.6%, 50.8%, 62.9% and 56.3% of known accidents for Section 1, 2, 3 and whole highway. It is followed by rear-end collision for Section 1 (17.7%) and head-on collision for Section 2 (15.5%) and Section 3 (12.9%). However, accident types of 797 (41.5%) reported cases were not available. Figure 5.12 shows the graphical distribution of various types of accidents. Again Figure 5.13 shows the distribution of accident types in percentage along the whole highway.

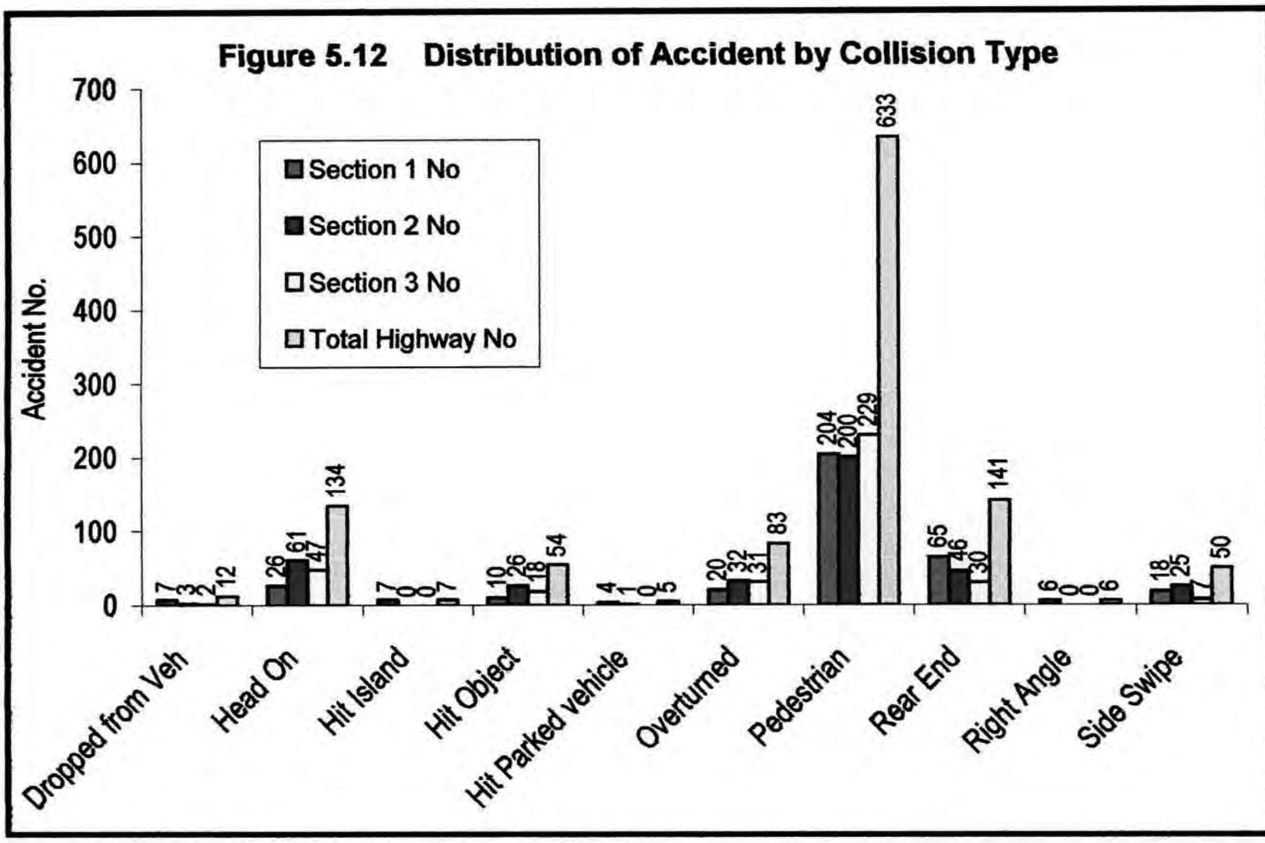
It is to be mentioned here that dropped from vehicle typed accident includes both passenger fall-down from vehicle roof top or freight top and as well as passenger occasionally get-off from the vehicles particularly from buses.

From critical observation of the accident database it reveals that, in rear-end typed collisions a considerable number of NMVs and 2/3 wheelers are involved. Which is usually occurred when larger typed vehicles attempt aggressive overtaking operation and thereby goes to extreme edges of the carriageway, they often hit the most vulnerable users groups, like NMV and 2/3 wheelers, which usually occupy left side of the road.

While visiting the highway it is found that there is hardly any facility for pedestrians along this highway. In the absence of safe protective facilities, most of the places along the alignment they had to wait on the carriageway for buses and thereby endangering their lives.

Table 5.20 Distribution of Accidents by Types

Collision Patterns	Section 1		Section 2		Section 3		Total Alignment	
	No	%	No	%	No	%	No	%
Dropped from Veh	7	1.9	3	0.8	2	0.5	12	1.1
Head On	26	7.1	61	**15.5**	47	**12.9**	134	11.9
Hit Island	7	1.9	0	0.0	0	0.0	7	0.6
Hit Object	10	2.7	26	6.6	18	4.9	54	4.8
Hit Parked vehicle	4	1.1	1	0.3	0	0.0	5	0.4
Overturned	20	5.4	32	8.1	31	8.5	83	7.4
Pedestrian	**204**	**55.6**	**200**	**50.8**	**229**	**62.9**	**633**	**56.3**
Rear End	65	**17.7**	46	11.7	30	8.2	141	**12.5**
Right Angle	6	1.6	0	0.0	0	0.0	6	0.5
Side Swipe	18	4.9	25	6.3	7	1.9	50	4.4
Known	367	-	394	-	364	-	1125	-
Unknown	464	55.8	233	37.2	100	21.6	797	41.5
Total	**831**	**100.0**	**627**	**100.0**	**464**	**100.0**	**1922**	**100.0**



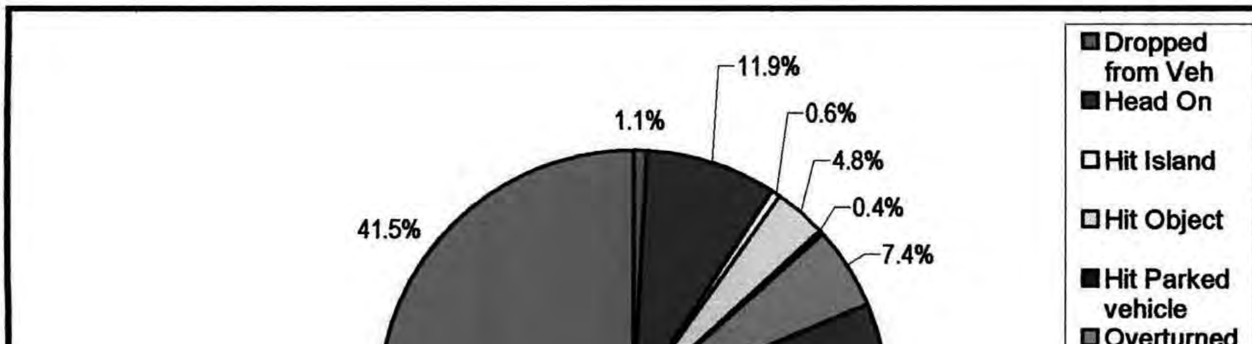


Figure 5.13 Distribution of Accidents by Collision Type For the Whole Alignment

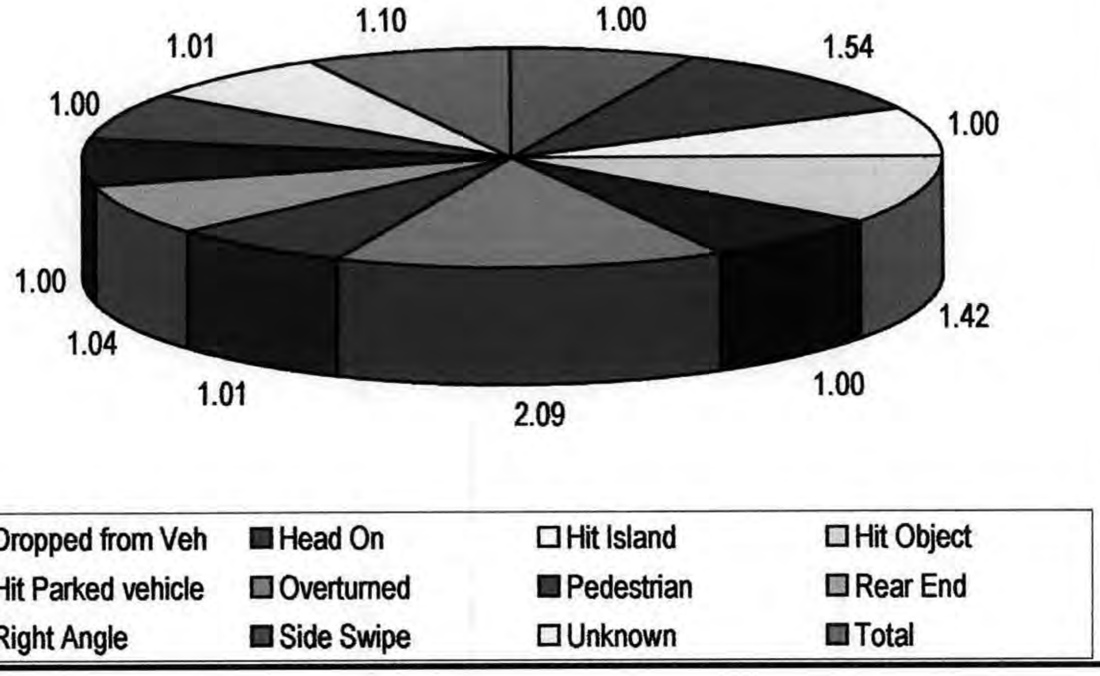
Table 5.21 and Figure 5.14 show the fatality Index among the different types of accidents. Table 5.21 reveals that overturned accident has the highest fatality index of 2.1 followed by head-on (1.54) and Hit object (1.42) type of accident. Table 5.21 also reveals that fatality index of overturn accident is higher by a big margin of 1.5 times than the next higher one. During the field visit it is found that height of the embankment varies from 5-25 ft (2-8 m), with steep slope almost throughout the length of the highway, having very less safe recovery area (Article 4.4). So for any errant vehicle overturning leaving the carriageway and falling into the unprotected ditches is likely to suffer serious consequences.

By critical comparison of Figure 5.11 and 5.12 reveals that though pedestrian and overturn accident contribute to 56.3 and 7.4% of accidents along the highway but in terms of fatality index overturn accident is more than two times severe than pedestrian (1.01) accident.

Table 5.21 Fatality Index By Accident Collision Type

Accident Type	No of Fatalities	No of Fatal Accident	Fatality Index
Dropped from Veh	10	10	1.00
Head On	109	71	1.54
Hit Island	6	6	1.00
Hit Object	34	24	1.42
Hit Parked vehicle	4	4	1.00
Overturned	119	57	**2.09**
Pedestrian	**490**	486	1.01
Rear End	72	69	1.04
Right Angle	6	6	1.00
Side Swipe	21	21	1.00
Unknown	396	393	1.01
Total	**1267**	**1147**	**1.10**

Figure 5.14 Fatality Index of Different Accident CollisionTypes



Most Severe Fatal Accidents

Table 5.22 shows ten most severe fatal accidents occurred during the entire study duration. It reveals that top most three fatal accidents are caused by overturned accident due to high embankment without any safety barrier, where 24, 21 and 9 persons were killed. This figure confirms the discussion in the previous Article, showing how serious can be the consequence, in terms of severity, in one single overturn accident in the study area. Most importantly it can be seen that these accidents are of single vehicle types of accidents and buses are the ill-fated vehicles. This finding definitely suggests that roadside barrier is very urgent particularly where embankment height is more, to confine the derailed vehicle or redirect the vehicle safely towards the carriageway. It is worth mentioning that according to AASHTO (1990) for embankment height greater than 8 ft (2.5 m), safety barrier is warranted.

Again on 04 April, 8 people were killed and 60 seriously injured when an over loaded bus overturned and fall into the nearby ditch due to tire burst. This figure further confirms the severity of overturn accident along this corridor.

Table 5.22 **Ten Most Severe Fatal Accidents Occurred Along the Alignment (During 1990 – 2003)**

Location	UZ	Year	Date	Time	Veh Type	Accident Type	No of Fatalities
Salehpur Bridge	Savar	2002	7-Jan	1405	**Bus**	**Over Turned**	**24**
Joka	Ghior	1996	9-Jun	1230	**Bus**	**Over Turned**	**21**
Mulzan	Manikganj	1997	1-Mar	1515	**Bus**	**Over Turned**	**9**
Dautia	Dhamrai	1995	10-May	2315	Bus	Hit Object	7
Golara	Saturia	1998	17-Mar	920	1-Truck & 1-Bus	Head-on	7
Uchutia	Manikganj	2002	26-Jun	0545	1-Truck & 1-Micro	Head-on	7
Radio Colony	Savar	2002	27-Jul	0735	1-Truck & 3-Buses	Head-on	6
Dhamrai Dokhin Para	Dhamrai	1992	13-Dec	1300	2-Buses	Head-on	5
PATC	Savar	2003	17-Apr	0915	1-Truck & 1-Pickup	Head-on	4
2nd Golara Bridge Area	Saturia	1998	28-Feb	0445	Truck	Hit Object	4

5.9 Distribution of Accidents by Location

From engineering point of view, the most important element of road accident information is the identification of exact location to determine the hazardous locations or black spot. But main weakness of police data is that location is not geo coded, normally given as Mouza or village and as directional distance from Thana. In this study it was a great challenge to get an accurate geo coded accident data. For this a considerable time is invested to make it possible (Article 4.4).

As discussed in Article 3.2, for simplification of analysis depending on traffic and geometric characteristics and land use pattern the highway is divided into three major links/sections. Besides, for detail analysis it is further divided into 16 links and 16 intersections (comprising 11 no T, 3 no Y and 2 no Staggered-T typed), which are graphically displayed in Figures 3.2 to 3.5.

5.9.1 Distribution of Accidents at Different Intersections and Links

Distributions of accidents at intersections are furnished in Table 5.23 and Figure 5.15. It can be seen that total 207 number of accidents occurred in 16 intersections, which are 10.8% of total accidents in this corridor. Table 5.23 identifies that T- intersection at 20 Mile Post (20MP) located in section 1, highest 38(18.4%) accidents took place of which 21 are fatal. During field visit it reveals that few intersections bus stoppage near the intersection, absence of adequate warning on side road etc may be contributed on accident occurrence.

Table 5.24 and Figure 5.16 shows the distribution of accidents at links. Total 1715 accidents occurred in 16 links, which are 89.2% of total accidents. Table 5.24 reveals that, highest number of accidents occurred in the link between Aminbazar to Hemayetpur, 227 (13.24%), of which 145 (14.24%) are fatal. The next highest number of accidents occurred in the link between Barongail and Aricha Ghat 186 (10.97%), Golora to Manikganj Town 160 (8.27%) and Savar bazar to Shapnapury link 153 (8.9%).

Table 5.24 also reveals that among links Savar to Shapnapury has highest accident rate of 3.8 accident/km/year. In this direction carriageway changes from dual to single at Km reference 26.3 without proper sign/marking and adequate warning which disturbs drivers expectancy and presence of few sharp bend with obstructed vision as observed during field visit (Article 4.3) may be responsible for such high rate of accident. Besides presence of industrial, commercial, residential area on both side of the road creating a semi urban environment within a rural setup with huge through traffic may also be responsible for such high rate of accidents. Top five links in terms of accident rate per kilometer of length per year, which can be seen in Table 5.24, are furnished below. All of these five links have much higher per km accident frequency than that of the average rate 1.8/km/year and it is to be noted that four of these are located in Section 1.

- Savar to Shapnapury link (3.8 accident/km/Year)
- Thana road to Savar bazar link (2.9 accident /km/Year)
- 20 Mile Post (20MP) to Nabinagar link (2.6 accident/km/Year)
- Rajphulbaria to Ganda link (2.5 accident/km/Year)
- Golara to Manikganj link (2.2 accident/km/Year)

Comparison of accidents at links and intersections are furnished in Table 5.25 and Figure 5.17, which show that 88.2% of fatal, 91.3% of grievous, 86.8 % of simple and 86.3 % of property damage (PD) typed accidents occurred in the links, which implies that most of the accidents are occurring in the links as compared to intersections.

Table 5.23 Distribution of Accidents at 16 Intersections

Locational Code	Location	Junction Type	km Ref.	Fatal	Grievous	Simple	PD	Total Accident	Distribution (%)
2	Singair (Hemayetpur) Intersection	Y-Type	19.0	13	2	2	1	18	8.70
4	Raj Phulbaria	T-Type	21.7	11	3	1	2	17	8.21
6	Ganda Intersection	T-Type	24.2	16	4	0	0	20	9.66
8	Thana Road	T-Type	24.8	8	4	0	3	15	7.25
10	Savar Bazar	Staggered T	25.8	7	6	1	1	15	7.25
12	Shapnapury Intersection	T-Type	29.0	1	0	0	0	1	0.48
14	Tongi Road (20 Mile Post)	T-Type	31.7	21	12	1	4	**38**	**18.36**
16	Tangail Intersection (Nabinagar)	T-Type	34.0	11	0	1	0	12	5.80
18	Dhamrai Town Intersection	T-Type	39.2	0	1	0	0	1	0.48
20	Saturia (Kalampur) Intersection	Y-Type	45.3	6	3	0	1	10	4.83
22	Rajnagar (Balitha) Intersection	Staggered T-Type	51.3	7	4	1	0	12	5.80
24	Saturia (Golara) Intersection	T-Type	57.6	7	6	1	0	14	6.76
26	Manikganj Town Intersection	T-Type	63.3	5	3	4	0	12	5.80
28	Harimampur Intersection	Y-Type	69.4	0	1	0	0	1	0.48
30	Ghior-Daulatpur(Barongail) Intersection	T-Type	77.8	3	1	3	0	7	3.38
32	Aricha Ghat More	T-Type	87.3	12	0	2	0	14	6.76
Total				128	50	17	12	**207**	100.00

Note: In this analysis accidents occurred within 15m up and down of an intersection is considered.

Table 5.24 Distribution of Accidents at 16 Links

Code No	Location	Link Details			No of Accidents by Severity				Accident No		Accident Rate	
		From (km)	To (km)	Length (km)	Fatal	Grievous	Simple	PD	Total (No)	%	No/km	No/km /Yr
1	Aminbazar-Hemayetpur	11.9	18.9	7.0	145	54	7	21	**227**	13.24	32.4	2.4
3	Hemayetpur - Raj Phulbaria	19.1	21.6	2.5	39	14	6	6	65	3.79	26.0	1.9
5	Raj Phulbaria-Ganda	21.8	24.1	2.3	48	22	2	6	78	4.55	33.9	2.5
7	Ganda -Thana road	24.3	24.7	0.4	3	1	0	0	4	0.23	10.0	0.7
9	Thana Road - Savar Bazar	24.9	25.7	0.8	20	8	1	2	31	1.81	38.8	2.9
11	Savar-Shapnapury	25.9	28.9	3.0	71	70	3	9	153	8.92	51.0	**3.8**
13	Shapnapury-20 MP	29.1	31.6	2.5	34	18	4	7	63	3.67	25.2	1.9
15	20 MP -Nabinagar	31.8	33.9	2.1	38	25	6	5	74	4.31	35.2	2.6
17	Nabinagar-Dhamrai	34.1	39.1	5.0	72	36	1	5	114	6.65	22.8	1.7
19	Dhamrai - Kalampur	39.3	45.2	5.9	74	24	1	4	103	6.01	17.5	1.3
21	Kalampur-Balitha	45.4	51.2	5.8	53	28	2	3	86	5.01	14.8	1.1
23	Balitha -Golara	51.4	57.5	6.1	71	35	3	5	114	6.65	18.7	1.4
25	Golara - Manikganj	57.7	63.2	5.5	77	50	27	6	160	9.39	29.1	2.2
27	Manikganj-Harimampur	63.4	69.3	5.9	57	47	7	3	114	6.65	19.3	1.4
29	Harirumpur - Barongail	69.5	77.7	8.2	80	53	9	1	143	8.34	17.4	1.3
31	Barongail - Aricha Ghat	77.9	87.3	9.4	137	16	33	0	186	11.66	19.8	1.5
	Total			72.4	1018	503	112	82	**1715**		23.7	1.8

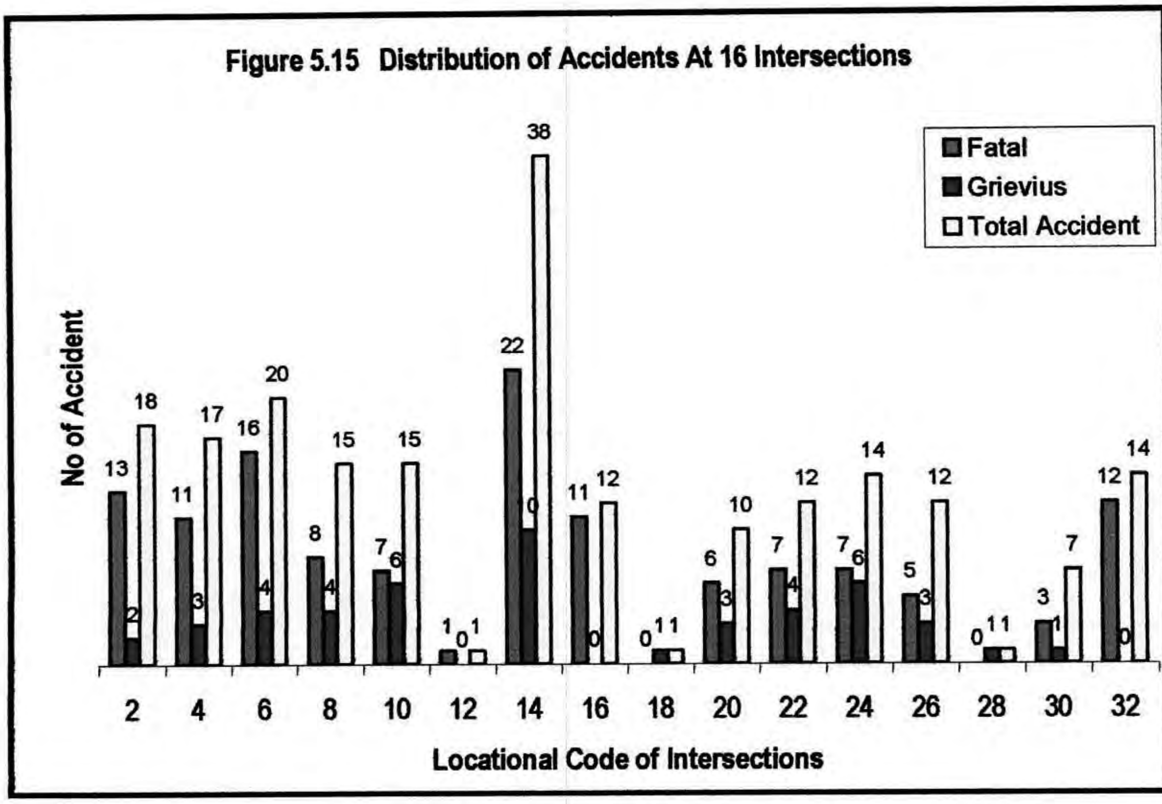


Figure 5.15 Distribution of Accidents At 16 Intersections

Note: All are unsignalized (i.e. major/minor typed) 3-legged junction.

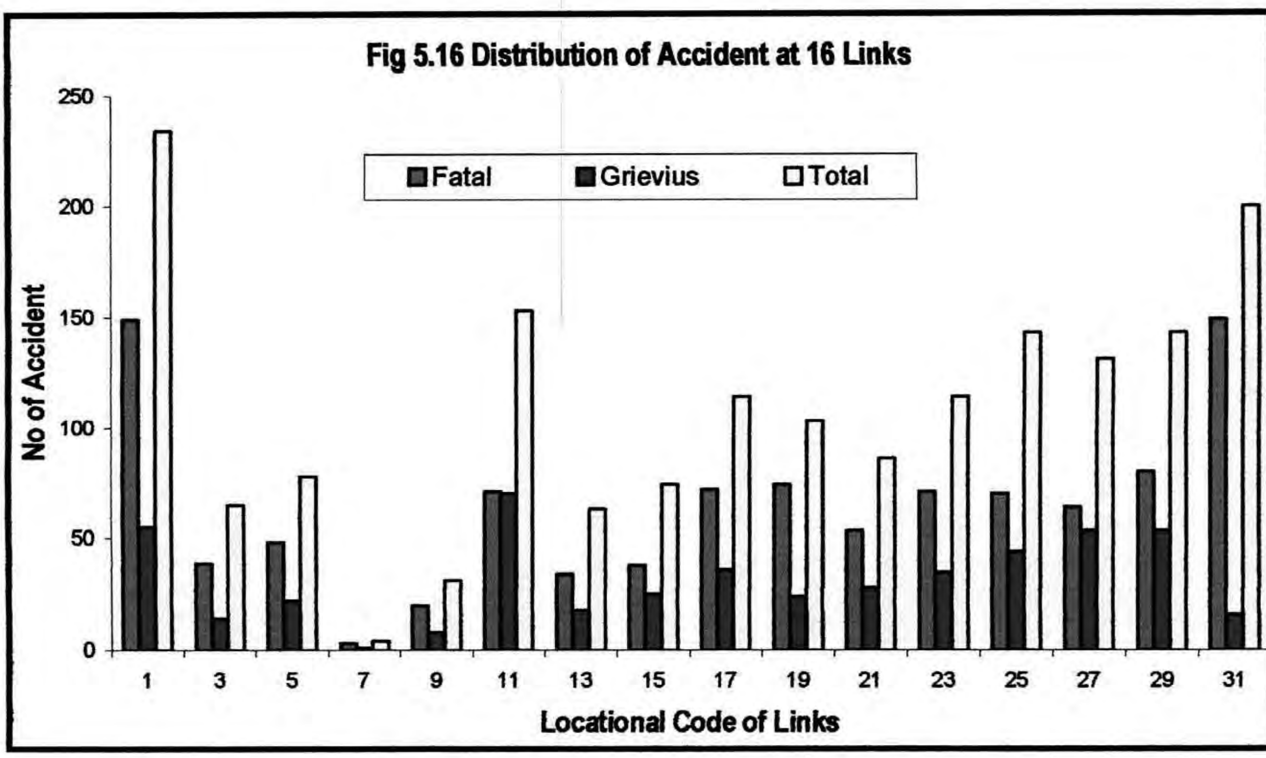
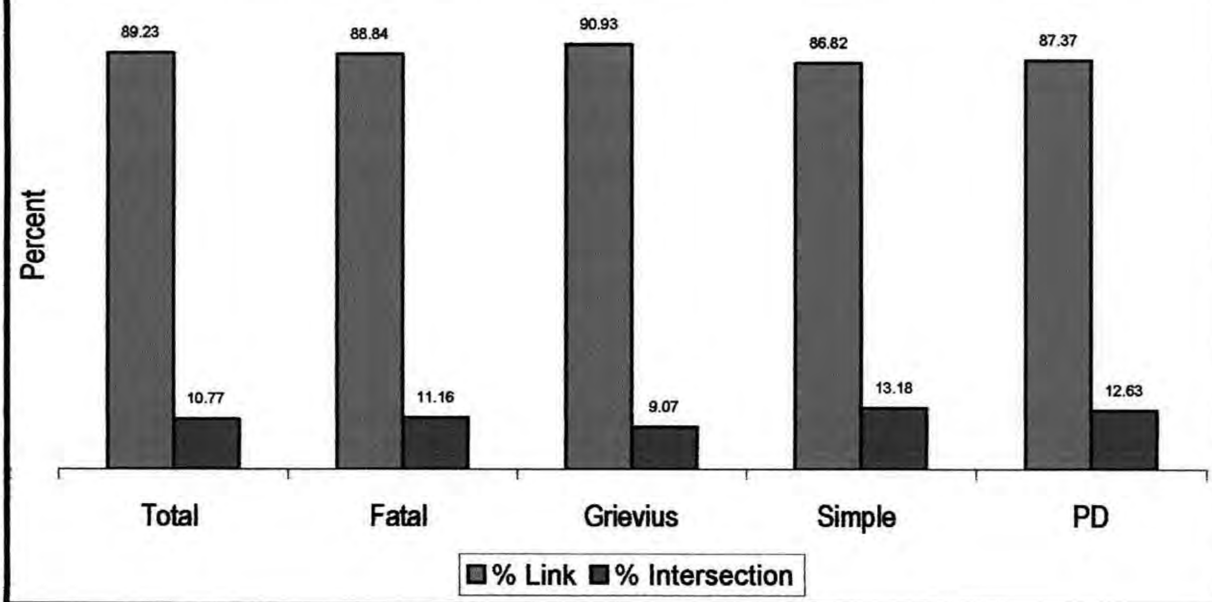


Fig 5.16 Distribution of Accident at 16 Links

Table 5.25 Distribution of Accidents Among Links and Intersections

Accident Type	Accidents at Links		Accidents at Intersection		Total No
	No	%	No	%	
Total No of Accident	1715	89.23	207	10.77	25
Fatal Accident	1018	88.75	128	11.25	1147
Grievous Accident	503	91.29	50	8.71	551
Simple Accident	112	86.82	17	13.18	129
PD Accident	82	86.32	12	13.68	95

Figure 5.17 Distribution of Accidents Among Links and Intersections



5.9.2 Distribution of Accidents Within Sections/Major Links

As discussed in Article 3.2 basing on consistency in traffic characteristics, land use pattern and geometric characteristics for comparison purpose, in accordance with RHD existing practice the study highway is divided into three sections/major links. Distributions of accidents among three sections are presented in Table 5.26, it reveals that highest 831 accidents occurred in Section 1, followed by Section 2 (626) and Section 3 (465).

Table 5.26 Distribution of Accidents Among Three Sections

Year	Section-1					Section-2					Section-3				
	Fatal	Grievous	Simple	PD	Total	Fatal	Grievous	Simple	PD	Total	Fatal	Grievous	Simple	PD	Total
1990	31	18	0	0	49	22	14	4	1	41	16	15	4	0	35
1991	20	2	0	0	22	21	12	0	2	35	15	9	3	0	27
1992	23	25	6	1	55	20	17	0	1	38	14	9	4	0	27
1993	34	33	7	11	85	28	14	3	0	45	24	14	6	0	44
1994	43	42	4	13	102	22	30	5	2	59	16	12	4	0	32
1995	34	24	9	7	74	31	7	4	1	43	37	6	4	0	47
1996	44	23	3	9	79	27	9	3	7	46	28	14	5	0	47
1997	47	24	0	0	71	29	25	6	3	63	20	4	3	2	29
1998	32	8	1	16	57	40	13	0	1	54	22	2	1	0	25
1999	29	8	2	1	40	29	15	4	2	50	22	8	3	0	33
2000	42	3	0	0	45	30	6	6	1	43	19	4	4	0	27
2001	36	9	2	7	54	31	8	2	0	41	19	10	9	0	38
2002	44	17	1	1	63	23	17	1	3	43	22	8	3	1	34
2003	27	7	0	1	35	19	4	2	0	25	15	3	1	1	20
Total	**486**	**243**	**35**	**67**	**831**	**372**	**191**	**40**	**24**	**626**	**289**	**117**	**54**	**4**	**465**

By incorporating the traffic volume with accident number the accident rate in terms of vehicle km of travel can be determined, which is more representative and widely accepted indices to present road traffic accident. Detail procedure for determination of traffic volume is explained in Article 5.1. As 2/3 wheelers make short trips and do not cover the whole section, in order to calculate veh-km it is assumed based on field observation and drivers interrogation that 1/3rd of section distance is covered by these vehicles and NMVs are excluded from calculation of vehicle km.

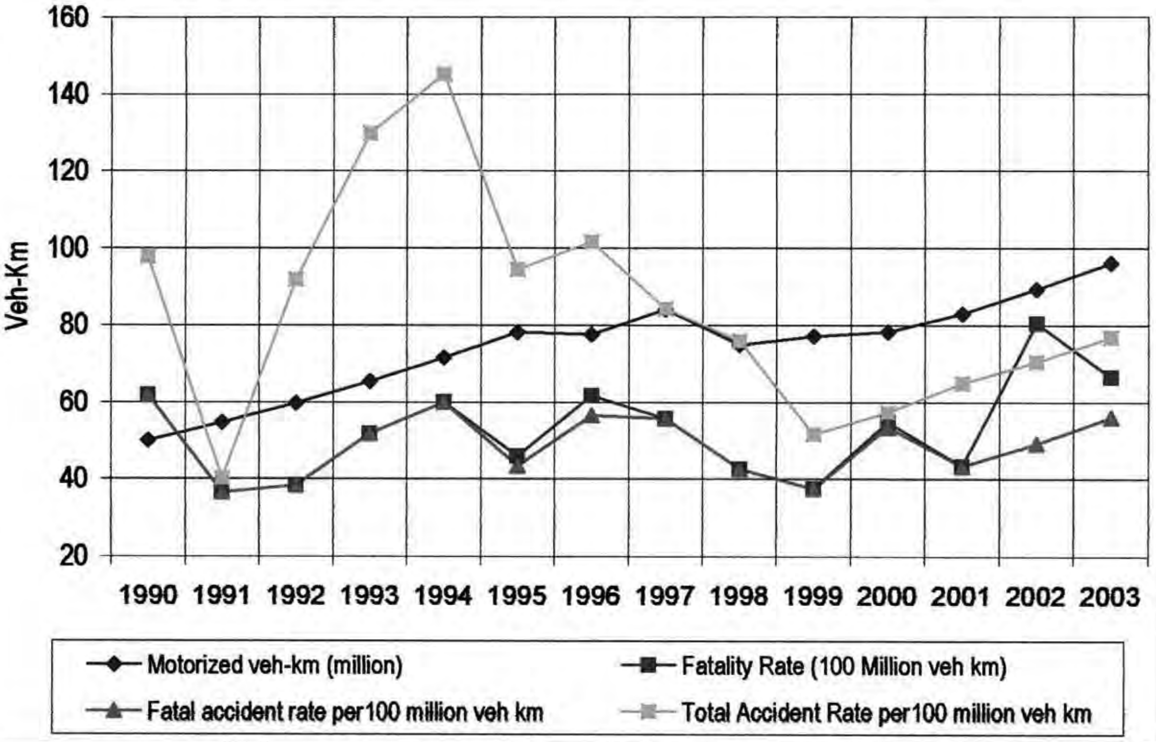
Figure 5.18, 5.19, 5.20 and Appendix A Table 5.4, 5.5, and 5.6 show the accident rate in terms of 100 million veh-km of travel for Section 1, 2 and 3. Figure 5.18 and Appendix A Table 5.4 reveals that in Section 1, fatality rate varied form 36 to 80 with an average of 52.73 per 100 million-vehicle km of travel for the entire study duration. Average increase in fatality rate and accident rate are 5.7% and 6%. From Figure 5.18 it can be seen that in 1998 and 1999 traffic volume and accident rate decreases, may be due to shift of large volume of traffic specially the long distance buses and trucks form this corridor. Again in 2001 both fatality and accident rate decreases may be due to completion of JBARP project, which included construction of median barrier and 4 lane dual carriageway up to Savar Bazar and improvement of Shoulder, Signs, Marking etc.

barrier and 4 lane dual carriageway up to Savar Bazar and improvement of Shoulder, Signs, Marking etc.

Figure 5.19 and Appendix A Table 5.2 reveals that in Section 2, accident rate varied from 25 to 51 with an average of 25.5 per 100-million vehicle km of travel. Average increase of fatality and fatal accident rate is 1.4% and 2% respectively. However the total accident rate is decreased by 3.1% in this Section. Figure 5.20 and Appendix A Table 5.3 discloses that in Section 3, average increase of fatality and total accident rate are 10% and 1.22%. Average value of fatality, fatal accident and total accident rates are 94, 87 and 139 per 100 million veh-km of travel in this section.

Table 5.27 provides detail comparison of accident scenarios of these sections, providing ranking is terms of various indices. Though Section 1 has maximum accidents in number (831) and per km per year (2.8), for which Section 3 has the minimum value (465 and 1.4/km/year) but in terms of veh-km of travel Section 3 has the worst situation (accident rate of 139.6 per100 Million veh-km of travel), in comparison to Section 1 (accident rate of 84.5 per100 Million veh-km of travel) and Section 2 (accident rate of 36.7 per100 Million veh-km of travel).

Figure 5.18 Accident Rate in Veh-Km of Travel for Section 1



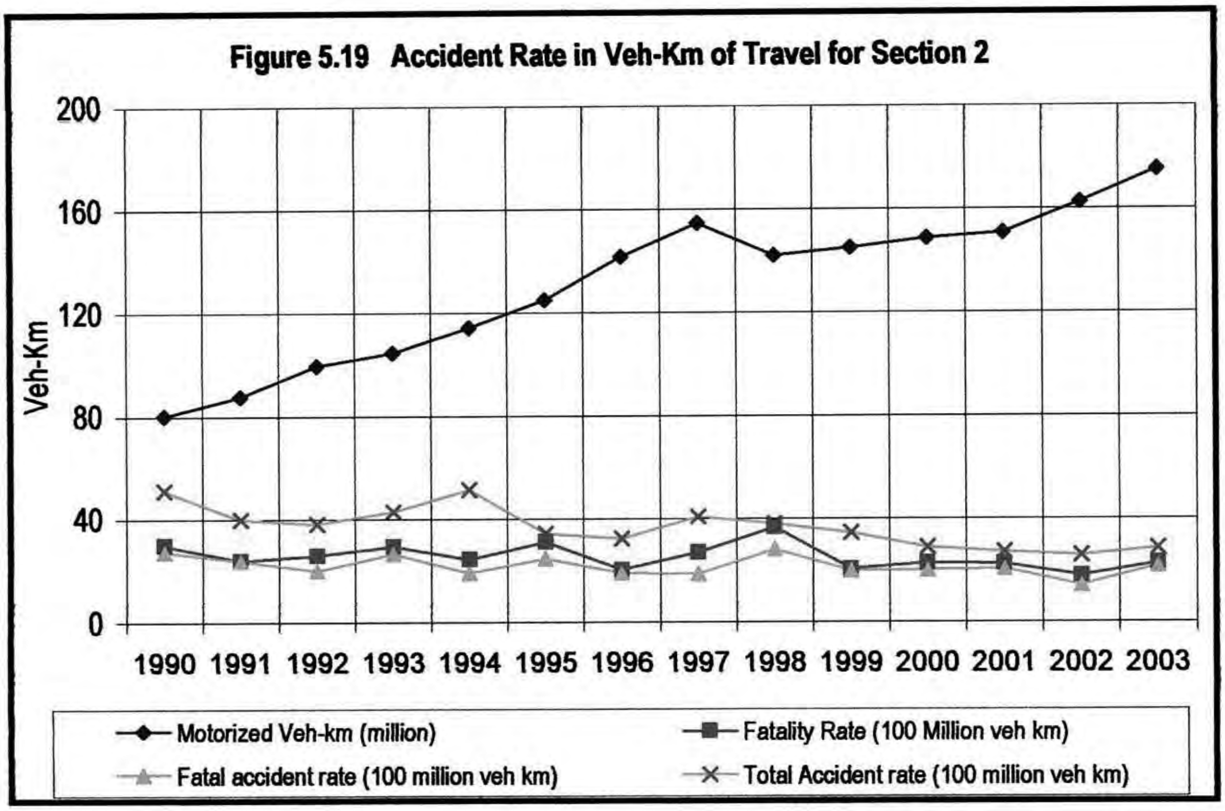


Figure 5.19 Accident Rate in Veh-Km of Travel for Section 2
200
160
120
80
40
0
Veh-Km
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
Motorized Veh-km (million)
Fatality Rate (100 Million veh km)
Fatal accident rate (100 million veh km)
Total Accident rate (100 million veh km)

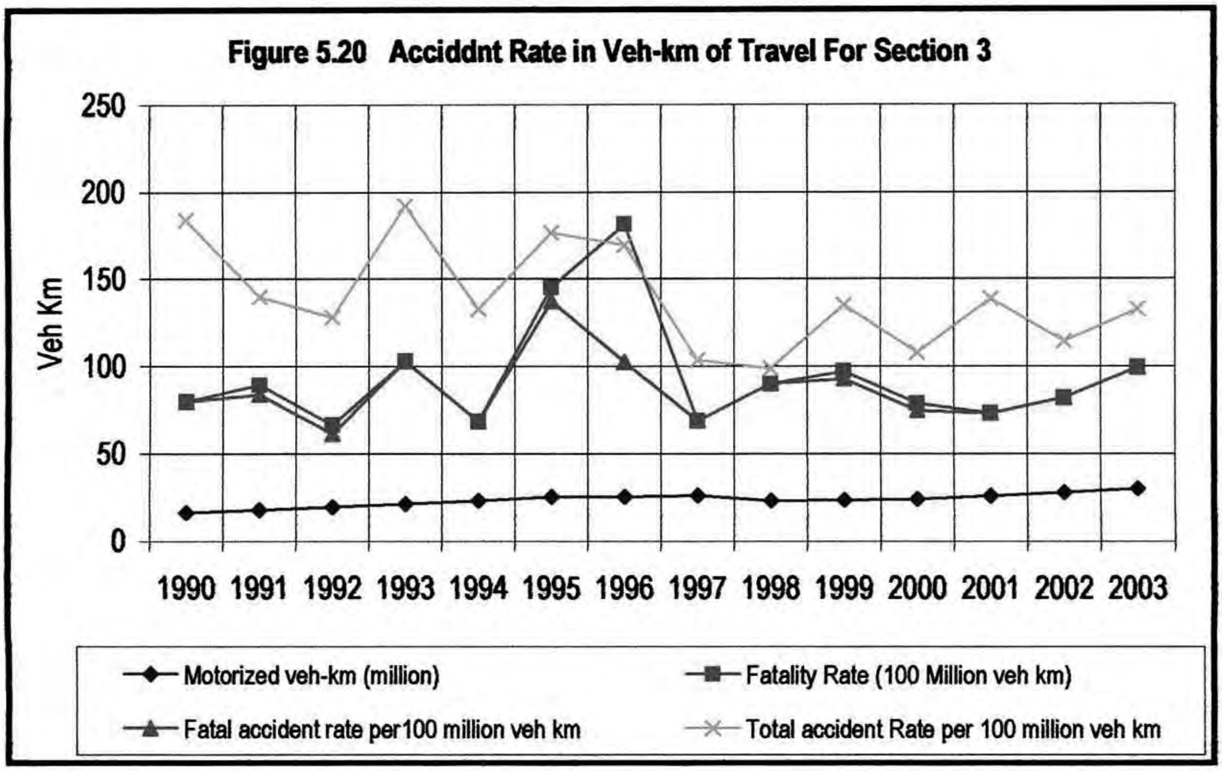


Figure 5.20 Acciddnt Rate in Veh-km of Travel For Section 3
250
200
150
100
50
0
Veh Km
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
Motorized veh-km (million)
Fatality Rate (100 Million veh km)
Fatal accident rate per100 million veh km
Total accident Rate per 100 million veh km

Table 5.27 Comparison of Accidents Among Three Sections

Item	Section 1 (Link 32)	Section 2 (Link 33)	Section 3 (Link 34)
Basic Data			
Length of each Section (km)	22.1	29.3	24
Motorized 4-Wheel Vehicles/Day	8609	11490	2503
2/3-Wheel Vehicles/Day	1839	2264	576
Average Daily Traffic (ADT)	10448	13754	3079
Veh-km (Million)	74.3	130.9	23.6
Comparison: Based on Accident No/Year			
Accident per year (Avg of 1990-2003)	62.3	46.4	34.6
Fatal Accident/Year	36.6	27.9	21.7
Grievous Accident/Year	18.3	13.9	8.6
Simple Accident/Year	2.5	3.0	3.9
PD/Year	4.9	1.6	0.4
Fatalities/Year (Avg of 1990-2003)	39.9	32.8	24.2
Grievous Injuries/Year (Avg of 1990-2003)	52.0	59.0	32.4
Comparison: Based on Accident No/km/Year			
Accident/km/year	2.8	1.6	1.4
Fatal Accident/km/year	1.7	1.0	0.9
Grievous Accident/km/year	0.8	0.5	0.4
Comparison: Based on Accident No/100 Million km			
Avg Accident Rate/100 Million veh-km	84.5	36.7	139.6
Fatal Accident Rate/100 Million veh-km	49.1	21.8	87.1
Fatality Rate/100 Million veh-km	52.7	25.6	94.6
Grievous Injury Rate/100 Million veh-km	69.9	45.1	137.4
Ranking: Based on Different Rates			
Accident/km/year	1	2	3
Fatal Accident/km/year	1	2	3
Grievous Accident/km/year	1	2	3
Accident Rate/100 Million veh-km	2	3	1
Fatal Accident Rate/100 Million veh-km	2	3	1
Fatality Rate/100 Million veh-km	2	3	1
Grievous Accident/100 Million veh-km	2	3	1

5.10 Identification of Black Spot

Black spots are accident-prone locations where accidents occurred repeatedly. It is very important to identify high accident locations for developing effective countermeasures. In order to identify black spots complete and comprehensive dot diagrams are prepared by considering all geo-coded accident data along the whole length of the highway, which are presented in three dot-maps in Figure 5.21 to 5.23 covering all three sections. At a coursery glance of these Figures one can easily identify the accident prone locations based on the clustering of dots along this corridor.

Accordingly 41 locations are identified where accidents are clustered and at least one accident per year occurred during the entire study period (1990-2003). Figures 5.24 to 5.26 depicted conventional pin-maps, showing detailed accident statistics of these locations. Close observations of these Figures reveals that these 41 high accident prone locations represent 72.4% of total accidents and 72.2% of all fatal accidents occurred in the study area. This finding shows that a very significant number of accidents are occurring frequently at particular locations of this highway. This definitely suggests that most of the accidents along this alignment are not occurring merely by chance rather external factors are responsible behind these accidents. Which deserves proper accident investigations.

Moreover, looking at Figures 5.24 to 5.26 it can be conclude that the remaining non-clustered accidents, which accounts for 27.6% of total accidents are happening randomly and by chance. Which implies that the reasons behind these naturally occurring accidents could be the unpredictable random factors like road uses errors, mechanical faults, inclement weather etc.

In this study, accident black spots are identified based on the definition followed by RHD {RHD Report, 1999). The RHD considers a location as black spot if at least three fatal accidents taken place at a particular location during 3 years observation periods. Accordingly, a total 33 locations out of 41 sites are isolated as black spots. Detail accident statistics of these locations are presented in Table 5.28. The table shows that 58.9% of total accidents, 59.4% of fatal accidents occurred within these 33 locations of the highway. It can also be seen that in the study area the Aminbazar site is the most hazardous location with 67 accidents including 42 fatal accidents which occurred during the last 13.5 years period. The next most accident prone locations are Savar Bazar (60), Balitha (57) and Radio Colony area (56).

Table 5.29 exhibits the ranking of identified black spots in descending order. The ranking is done according to the guidelines proposed by the RHD consultants in which they suggested 34 and 1 weightage point for each fatal and injury accident respectively (RHD document, 2000). Based on these ranking, it can also be seen from the Table 5.29 that still Aminbazar hold the top raking position with total 1442 and per year 106.8 weight points, followed by Hemayetpur (1100, 81.48/year), Nabinagar (1098, 81.48/year) and Balitha (1041,77.11/year).

In order to find out the underlying reasons behind the frequent occurrence of accidents at these locations, several visits have been made during the study period. During this field visits, observations were made both qualitatively and quantitatively which are summarized in Table 5.30 along with accident statistics at these locations. It can be seen from Table 5.30 that, accidents are generally occurring at bus stops particularly near bridges, bazars, sharp bends, intersections, places with high pedestrian concentration especially where vision is obstructed. In the Table these are highlighted with bold lettering. This definitely suggests that safety improvement measures are essential at these locations. In order to improve accident situations at these sites, low cost treatment like segregation of pedestrians and local traffic movements from that of high speed through traffic movements, provision of service/frontage road, widening of carriageway and correction of alignment, could be very cost-effective measures. Moreover, these sites also be treated with other low cost field proven measures like installation of properly designed speed calming devices, appropriate sign/marking at side roads entries etc. It is to be mentioned here that during field visit no special (mandatory octagonal stop or giveaway) signs and markings are seen at any of the junctions where the side road met with the main highway, though all of these are un-signalized major/minor typed junctions.

From the field observation it is found that among the 16 intersections along this corridor the busiest intersection situated in Nabinagar, though it connects two major highways namely Dhaka-Aricha and Nabinagar-Chandra still it is operating like a major-minor type junction and above all it is also deficient in appropriate signs and markings. It is found from the Table 5.28 that at this junction a total of 48 accidents including 32 fatal accidents are occurred in the last 13.5 year and Table 5.29 reveals that this is 3rd in ranking among the 33 black spots. Heavy traffic movements in both the connecting highways and large number of accident events at this junction indicate that the existing priority-control type operation is not appropriate regulation for safe functioning of the junction. Construction of properly design roundabout, which is also a priority type junction, would be a functionally better solution

Table 5.30 reveals that, in all black spots pedestrian accident is the most predominant one accounting for 61% of all known accidents within these spots, followed by rear end 12%, head on 8% and overturned 7%. However, a large number of accident types could not be determined especially before 1998 due to non-availability of relevant document and improper recording.

Figure 5.21 Dot-Map Showing The Accidents in Section - 1

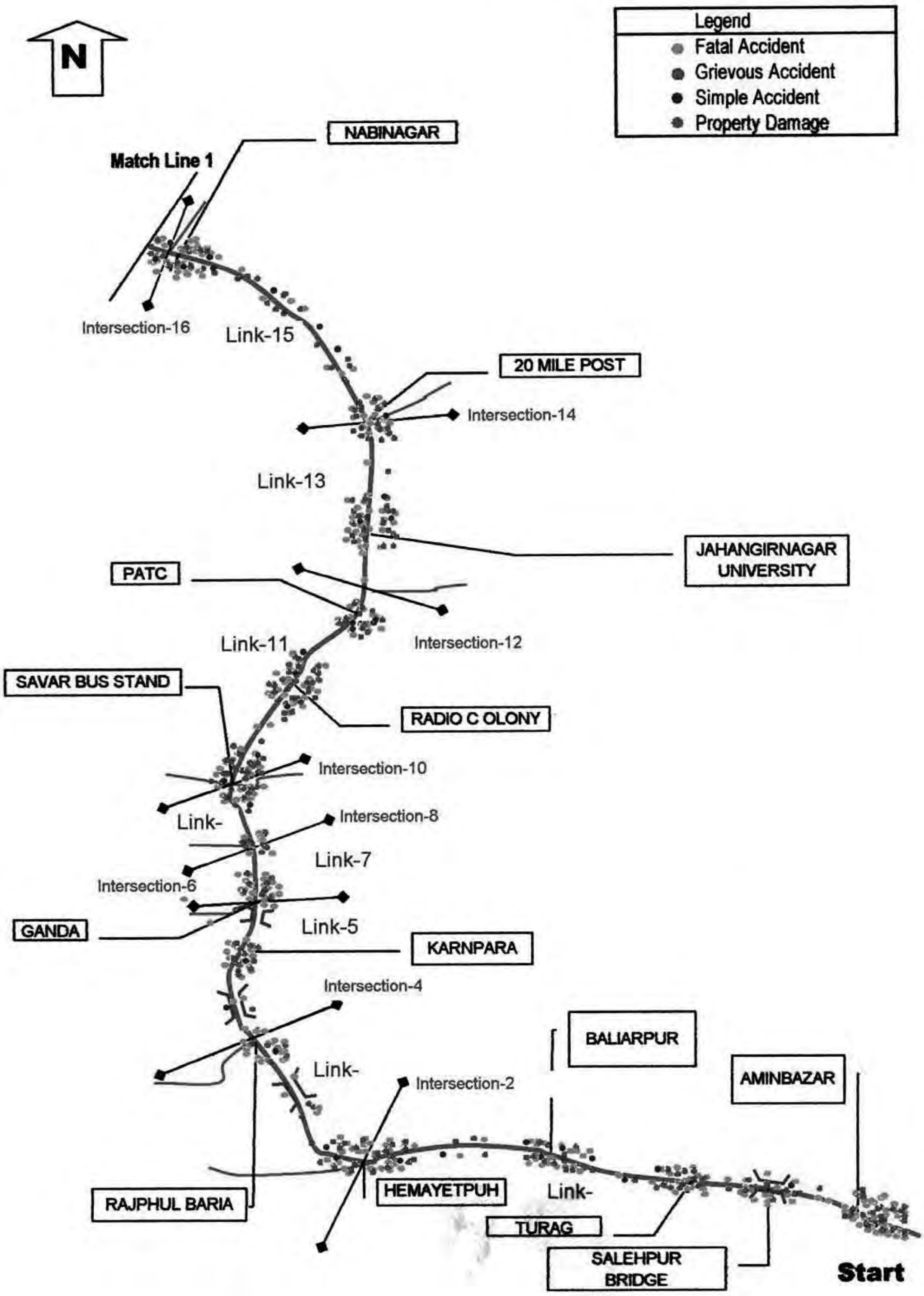


Figure 5.22 Dot-Map Showing The Accidents in Section - 2

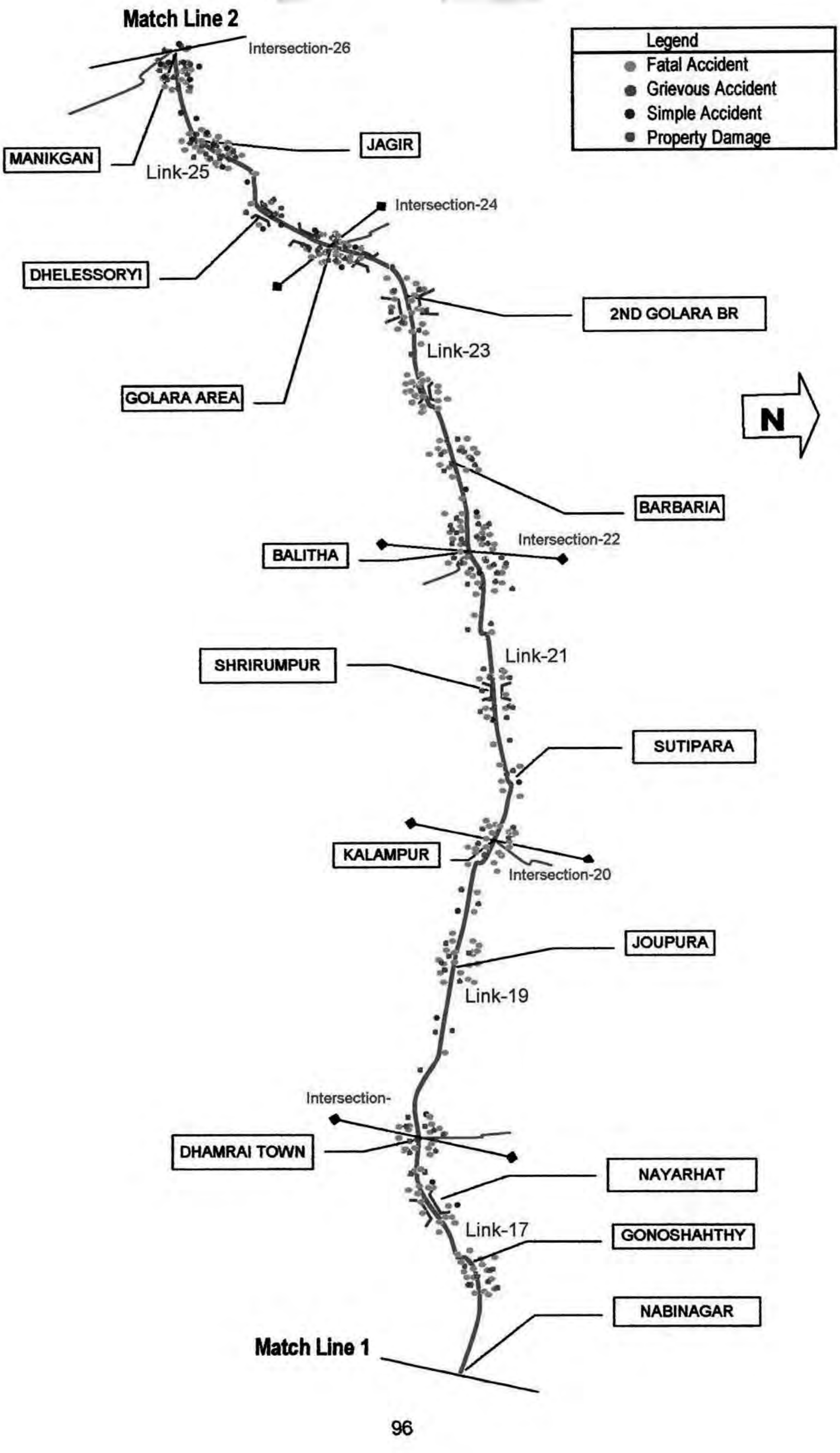
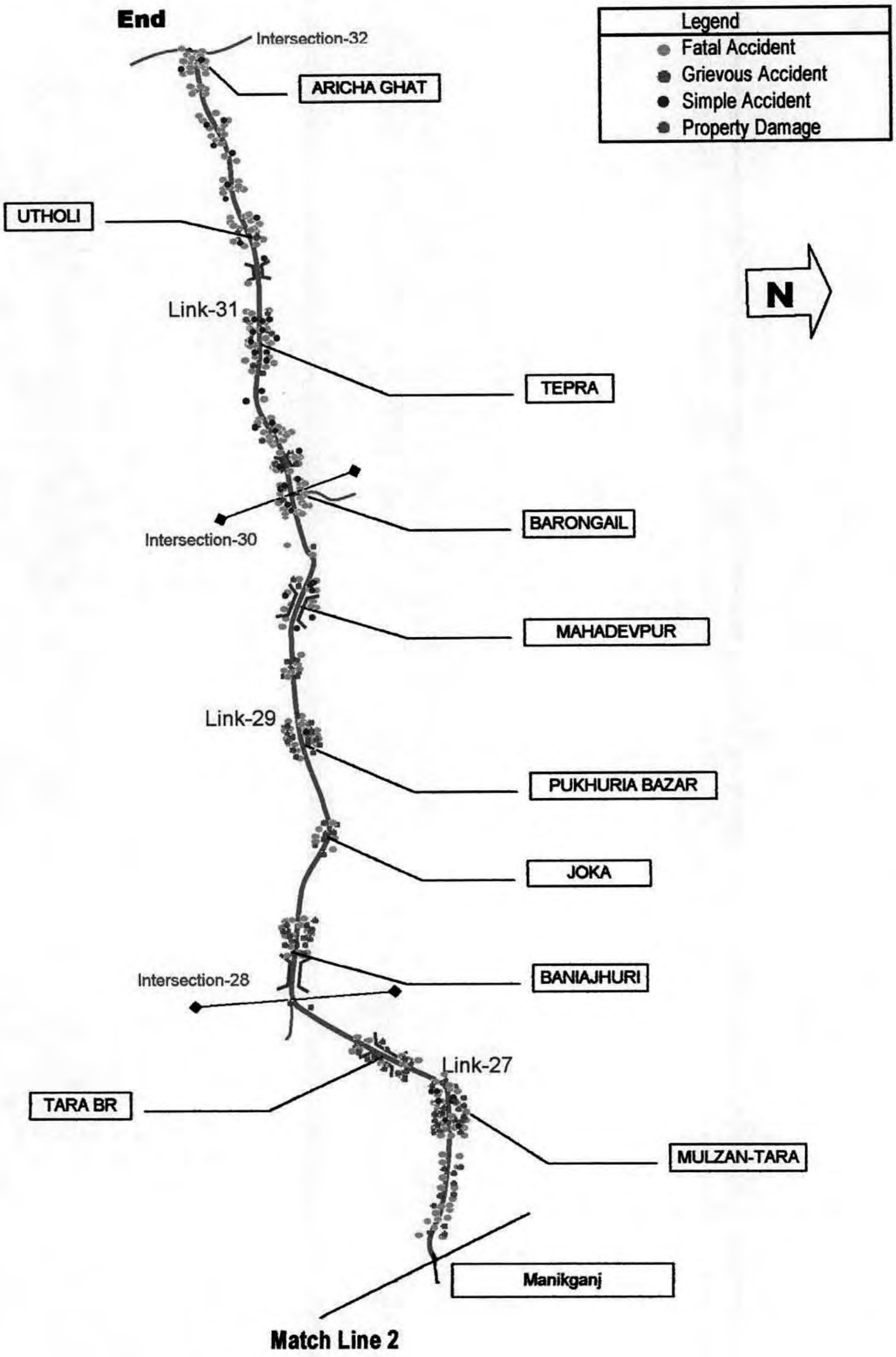


Figure 5.23 Dot-Map Showing The Accidents in Section - 3



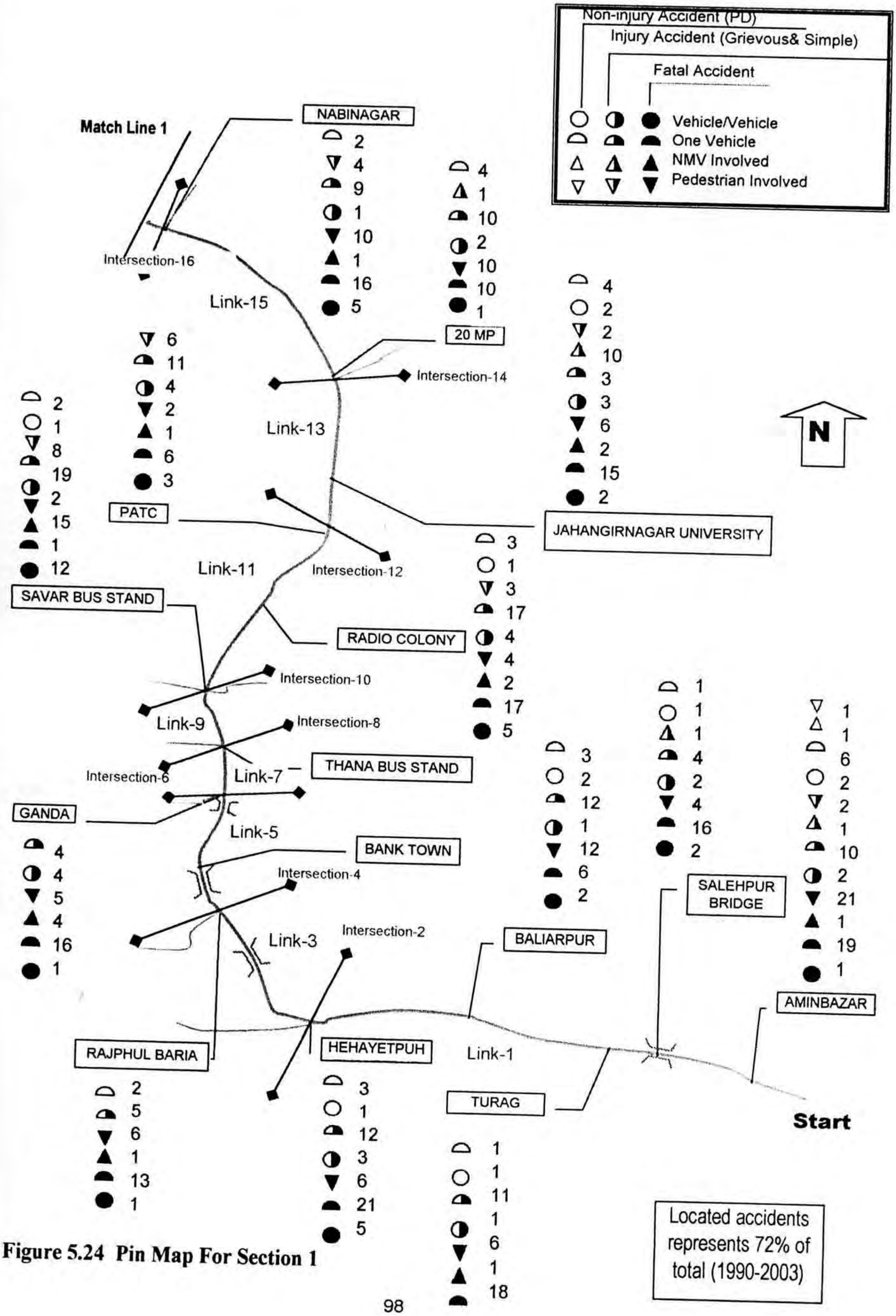


Figure 5.24 Pin Map For Section 1

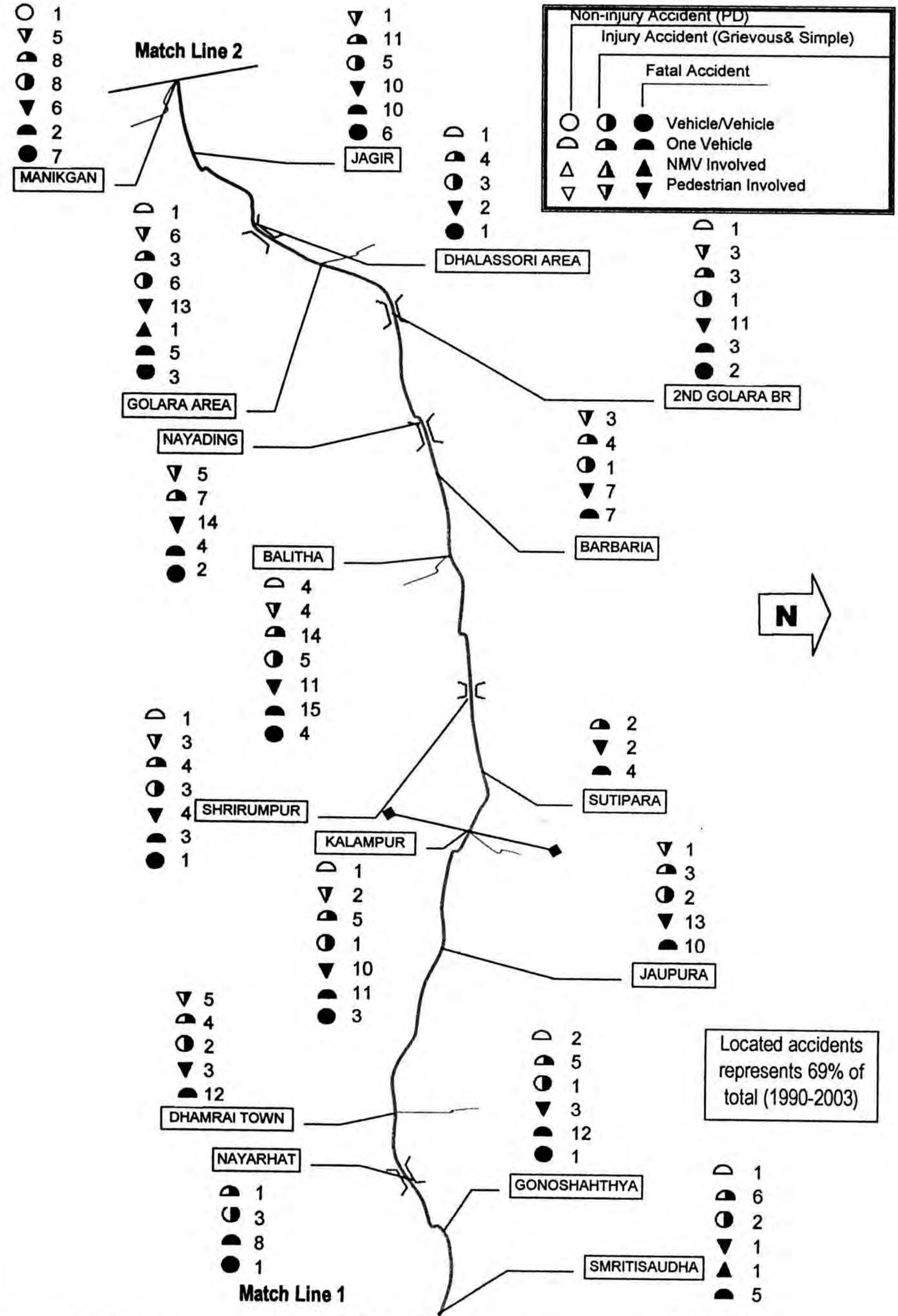


Figure 5.25 Pin Map For Section 2

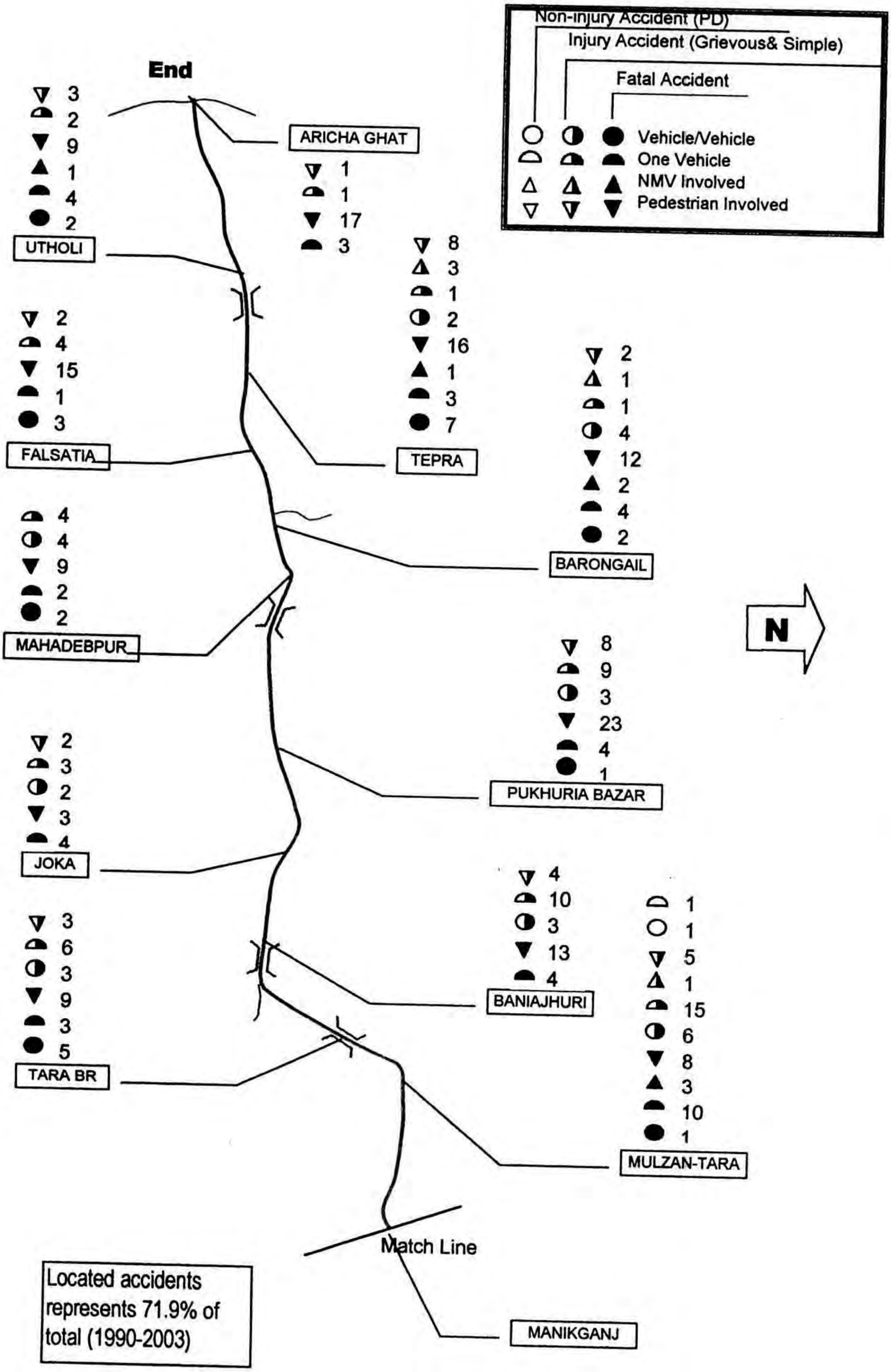


Figure 5.26 Pin Map For Section 3

Table 5.28 Accident Statistics Of Black Spots Along Dhaka-Arihca Highway

Sl No	Name	F	G	Simple	PD	Total	Killed	SI	Comparing With Total Accident Along This Highway(%) F	G	Simple	PD	Total	Killed	SI
1	Amin Bazar	42	14	1	10	67	42	46	3.66	2.54	0.78	10.52	3.28	3.06	1.75
2	Salehpur Br	22	6	1	2	31	45	53	1.92	1.09	0.78	2.11	1.61	3.53	2.38
3	Turag	25	11	1	2	39	25	32	2.18	2.00	0.78	2.11	2.03	1.96	1.44
4	Baliarpur	20		4	5	38	21	28	1.74	0.00	3.10	5.26	1.98	1.65	1.26
5	Hemayetpur	32	12	3	4	51	32	51	2.79	2.18	2.33	4.21	2.65	2.51	2.29
6	Raj Phulbaria	21	4	1	2	28	21	26	1.83	0.73	0.78	2.11	1.46	1.65	1.17
7	Kampara	16	9	1	2	28	16	22	1.39	1.63	0.78	2.11	1.46	1.26	0.99
8	Ganda	26	8	0	0	34	29	32	2.27	1.45	0.00	0.00	1.77	2.28	1.44
9	Savar Bs	28	26	3	3	60	29	46	2.44	4.72	2.33	3.16	3.12	2.28	2.07
10	Radio Colony	28	24	0	4	56	33	78	2.44	4.36	0.00	4.21	2.91	2.59	3.51
11	J/University	25	15	3	6	49	25	33	2.18	2.72	2.33	6.32	2.55	1.96	1.48
12	20 Mp	21	12	1	4	38	22	28	1.83	2.18	0.78	4.21	1.98	1.73	1.26
13	Nabinagar	32	10	4	2	48	32	39	2.79	1.81	3.10	2.11	2.50	2.51	1.75
14	Gonoshasta	16	6	0	2	24	16	20	1.39	1.09	0.00	2.11	1.25	1.26	0.90
15	Dhamraitown	15	10	1	0	26	15	28	1.31	1.81	0.78	0.00	1.35	1.18	1.26
16	Joupura	23	6	0	0	29	23	21	2.01	1.09	0.00	0.00	1.51	1.81	0.94
17	Kalampur	24	8	0	1	33	26	43	2.09	1.45	0.00	1.05	1.72	2.04	1.93
18	Balitha	30	21	2	4	57	33	105	2.62	3.81	1.55	4.21	2.97	2.59	4.72
19	Barbaria	14	8			22	14	17	1.22	1.45	0.00	0.00	1.14	1.10	0.76
20	Nayadingi	20	12	0	0	32	24	55	1.74	2.18	0.00	0.00	1.66	1.88	2.47
21	2Nd Golara Br	16	6	0	0	22	23	44	1.39	1.09	0.00	0.00	1.14	1.81	1.98
22	Golara Area	22	12	3	1	38	28	75	1.92	2.18	2.33	1.05	1.98	2.20	3.37
23	Jagir	26	12	5	0	43	29	66	2.27	2.18	3.88	0.00	2.24	2.28	2.97
24	Manikganj Bs	15	14	7	1	37	15	23	1.31	2.54	5.43	1.05	1.93	1.18	1.03
25	Mulzan-Tara	22	22	5	2	51	31	85	1.92	3.99	3.88	2.11	2.65	2.43	3.82
26	Tara Bridge	17	12	0	1	30	18	74	1.48	2.18	0.00	1.05	1.56	1.41	3.33
27	Baniajhuri	17	17	0	0	34	17	75	1.48	3.09	0.00	0.00	1.77	1.33	3.37
28	Pukuria Bazar	28	17	3		48	28	144	2.44	3.09	2.33	0.00	2.50	2.20	6.47
29	Barongail	20	2	6	0	28	20	11	1.74	0.36	4.65	0.00	1.46	1.57	0.49
30	Falsatia	19	1	5		25	19	6	1.66	0.18	3.88	0.00	1.30	1.49	0.27
31	Tepra	27	5	9	0	41	29	17	2.35	0.91	6.98	0.00	2.13	2.28	0.76
32	Utholi	16	3	2		21	17	3	1.39	0.54	1.55	0.00	1.09	1.33	0.13
33	Aricha Ghat	20	0	2	0	22	20	0	1.74	0.00	1.55	0.00	1.14	1.57	0.00
TOTAL BLACK SPOTS		681	325	71	46	1132	730	1327	59.37	62.61	55.04	48.42	58.90	57.30	63.80
GRAND TOTAL H/WAY		1147	551	129	95	1922	1274	2224	100.00	100.00	100.00	100.00	100.00	100.00	100.00

NOTE: F - Fatal, G - Griveious, PD - Property Damage Accident

Table 5.29 Ranking of Identified Black Spots Along Dhaka-Aricha Highway

Sl No	Name	UZ	From (km)	To (km)	Length (km)	Fatal	Grievius	Total Weighted Point	Per Year Weighted Avg Point
1	Amin Bazar	Savar	11.9	12.8	0.9	42	14	1442	106.81
2	Hamayetpur	Savar	18.6	19.5	0.9	32	12	1100	81.48
3	Nabinagar	Savar	33.7	34.1	0.4	32	10	1098	81.33
4	Balitha	Dhamrai	50.7	52.0	1.3	30	21	1041	77.11
5	Savar Bus Stand	Savar	25.5	26.1	0.6	28	26	978	72.44
6	Radio Colony/ Mil Farm	Savar	27.5	28.1	0.6	28	24	976	72.30
7	Pukhuria Bazar	Ghior	73.4	73.7	0.3	28	17	969	71.78
8	Tepra	Shibalaya	81.9	82.7	0.8	27	5	923	68.37
9	Jagir	Manikganj	61.1	61.6	0.5	26	12	896	66.37
10	Ganda	Savar	23.7	24.5	0.8	26	8	892	66.07
11	Jahangirnagar University	Savar	29.4	30.0	0.6	25	15	865	64.07
12	Turag	Savar	13.8	14.8	1.0	25	11	861	63.78
13	Kalampur	Dhamrai	45.1	45.5	0.4	24	8	824	61.04
14	Joupura	Dhamrai	41.6	42.0	0.4	23	6	788	58.37
15	Mulzan-Tara	Manikganj	67.0	67.9	0.9	22	22	770	57.04
16	Golara Area	Saturia	57.2	57.7	0.5	22	12	760	56.30
17	Salehpur Bridge	Savar	13.5	13.7	0.2	22	6	754	55.85
18	20 Mp	Savar	31.6	31.8	0.2	21	12	726	53.78
19	Raj Phulbaria	Savar	21.5	22.0	0.5	21	4	718	53.19
20	Nayadingi	Saturia	55.7	55.8	0.1	20	12	692	51.26
21	Baliarpur	Savar	16.7	17.7	1.0	20	9	689	51.04
22	Barongail	Shibalaya	77.6	78.0	0.4	20	2	682	50.52
23	Aricha Ghat	Shibalaya	87.2	87.3	0.1	20	0	680	50.37
24	Falsatia	Shibalaya	80.1	80.4	0.3	19	1	647	47.93
25	Baniajhuri	Ghior	70.2	70.7	0.5	17	17	595	44.07
26	Tara Bridge	Ghior	68.0	68.3	0.3	17	12	590	43.70
27	Kampara	Savar	22.9	23.5	0.6	16	9	553	40.96
28	Gonoshasthya Cen	Savar	35.3	35.5	0.2	16	6	550	40.74
29	2Nd Golara Bridge	Saturia	56.0	56.7	0.7	16	6	550	40.74
30	Utholi	Shibalaya	83.1	83.4	0.3	16	3	547	40.52
31	Manikganj Bus Stand	Manikganj	63.0	63.7	0.7	15	14	524	38.81
32	Dhamrai Town	Dhamrai	39.1	40.0	0.9	15	10	520	38.52
33	Barbaria	Dhamrai	54.1	54.3	0.2	14	8	484	35.85

Table 5.30 Predominant Accident Types and General Operational Condition of Black Spots

Sl No	Name of Black Spot	Total Accident	% of Accident	Predominat Accident Type										Observation of Physical and Operational Features of Black Spots
				Pedestrian	Head-on	Over turn	Rear end	Hit object	Side swipe	Dropped	Hit Island	Right Angle	Unidentified	
1	Amin Bazar	67	3.3	24			4		1			1	36	**Dual Carriageway**, 2x7.4 m width. Median started after a distance from bridge, no separate bus bay, bus stops on Carriageway, no crossing facility for pedestrian.Intense pedestrian & NMV Activities.
2	Salehpur Br	31	1.6	5		4	4						15	2x 6.5 m Carriageway on **bridge**,width is not consistent with approach location. Some guard posts are broken, no NMV lane & safety barrier on bridge approach. Low height guard post on approach of bridge , some of them are damaged.
3	Turag	39	2.0	6			3						29	**Frequent U turning** provisions invite risks, no separate bus bay, **bus stops** on Carriageway, no crossing facility for pedestrian, no parking facility for buses & trucks often crates conflict with through traffic.Dual Carriageway, 2x7.4 m width.
4	Baliarpur	38	2.0	12			3						22	**Bazar** activities on right side invites huge pedestrian activities across the road no separate bus bay, bus stops on Carriageway, no crossing facility for pedestrian , no parking facility for buses & trucks often crates conflict with through traffic. Dual Carriageway, 2x7.4 m width.
5	Hemayetpur	51	2.7	8	2		3				2		34	Bus bay exists but hardly used, **bus stops** on Carriageway / shoulders, huge trucks and NMV park on paved shoulder, bus stops at intersection creating bottlenecks specially for through traffic. Dual Carriageway, 2x7.4 m width.
6	Raj Phulbaria	28	1.5	6		2	1				1		16	**Intersection** exists on curve, No bus bay, bus stops on Carriageway / shoulder, road side features are both at grade & down level.Superelevation is high.

Continued Table 5.30 ....

Sl No	Name of Black Spot	Total Accident	% of Accident	Predominat Accident Type										Observation of Physical and Operational Features of Black Spots
				Pedestrian	Head-on	Over turn	Rear end	Hit object	Side swipe	Dropped	Hit Island	Right Angle	Unidentified	
7	Kampara	28	1.5	7			3						16	Encompasses both side of the **bridge**; No bus bay, bus stops on Carriageway / shoulder; road side features are at down level.
8	Ganda	34	1.8	6		3	6						16	**Intersection exists on curve**, connects two minor road both on southern & northern side at 90 deg ;Bus bay exists without shelter but not used; road side features are at grade; wide median gap of 40 m at intersection without sign/ marking invites huge NMVs/ 2/3 wheeler & creates trouble for through traffic.
9	Savar Bs	60	3.1	23			4						30	It connects two minor road on northern & southern side at 90 deg; no bus bay exists, **Bus stops** on carriageway to pick up & drop passengers, Truck, buses , NMV parks on both side of road/ shoulder; Steel fencing exists for 250 m but people tends to cross it ; One foot over bridge exists but very few people use it; road side features are at little down grade; median gap of 20 m at intersection without sign/ marking invites hazards; conflict between through & local traffic is prominent; at the end of Savar bus stand area the two lane undivided highway starts
10	Radio Colony	56	2.9	7			6		2				37	No bus bay exists, **Bus stops** on carriageway to pick up & drop passengers, Pedestrians has to wait long time to cross for high speed through traffic. Intense pedestrian & NMV Activities
11	Jahangir N. Univ.	49	2.5	8	3	2	5						28	Two bus bay exists but hardly used, bus stops on Carriageway / shoulders, **Foot over bridge** exists but underutilized;No sign/ marking/ painting for median & kerb creates hazard specially at night. **Huge trees and ditch on both side.**

Continued Table 5.30 ....

Sl No	Name of Black Spot	Total Accident	% of Accident	Predominat Accident Type										Observation of Physical and Operational Features of Black Spots
				Pedestrian	Head-on	Over turn	Rear end	Hit object	Side swipe	Dropped	Hit Island	Right Angle	Unidentified	
12	20 MP	38	2.0	10			2			2		3	23	**Intersection** connecting **Ashulia** road, Two small bus bay exists but not used,Huge trees and ditch on both side.Intense pedestrian & NMV Activities.
13	Nabinagar	48	2.5	14			2			2		3	25	**Major intersection** connecting Dhaka-Aricha & Nabinagar -Chandra highway, but no facility exists for safe interchange of traffic flow specially for right turning vehicles though huge traffic use this intersection. Insufficient parking place at right side. Huge NMV, Pedestrian 2/3 wheeler activities are seen in this area.
14	Gonoshasta	24	1.2	3			1		1	1			18	Section is on **curve** without bus bay bus stops on Carriageway / shoulders. Some guard posts are broken in the bridges in this area.
15	Dhamraitown	26	1.4	9	2								15	An **Intersection**. Bus stops on carriageway to pick up & drop passengers, Pedestrians has to wait long time to cross for high speed through traffic
16	Joupura	29	1.5	14			1						14	Located on **curve**. No bus bay, bus stops on carriageway to pick up & drop passengers
17	Kalampur	33	1.7	12	4		1						16	An **Intersection** connecting Saturia with minor traffic on cross road. Bus stops on carriageway to pick up & drop passengers, Pedestrians has to wait long time to cross for high speed through traffic
18	Balitha	57	3.0	15	4	8	2	8					16	Bus bay with passenger shed exists but shed allready damaged. **Intersection** with minor traffic . Drying of paddy on road & cattle may create hazard.
19	Barbaria	22	1.1	10						1			11	Located on **curve.** No bus bay, bus stops on carriageway to pick up & drop passengers
20	Nayadingi	32	1.7	19	2	5		2					4	**Bus stops** near the **bridge** which is very dangerous. Some guard posts are broken in the bridges in this area.

Continued Table 5.30 ....

Sl No	Name of Black Spot	Total Accident	% of Accident	Predominat Accident Type										Observation of Physical and Operational Features of Black Spots
				Pedestrian	Head-on	Over turn	Rear end	Hit object	Side swipe	Dropped	Hit Island	Right Angle	Unidentified	
21	2nd Golara Br	22	1.1	14	2	1		3					4	**Bridge with sharp bend and vertical curve**. Bus stops near the bridge.
22	Golara Area	38	2.0	19	6	4	3	1					4	Features on right side **at grade** but on left side at down grade.**Intersection** exists, pedestrian and students has to wait to cross the road.
23	Jagir	43	2.2	11	5		3		7				14	Located on **curve.** Superelevation varies appreciably, no bus bay. Bus stops at bridge approaches, which is very narrow.
24	Manikganj Bs	37	1.9	10	1		9		3				9	On left side though no bus bay exists but adequate space avaialable for parking but on right side **bus stands** on carriageway creating conflict with through traffic. Traffic management by police is poor.
25	Mulzan-Tara	51	2.7	13		4	9		5				18	On **curve**. No bus bay, bus stops on carriageway to pick up & drop passengers
26	Tara Bridge	30	1.6	12	7	3							8	A **long bridge** over river kaligonga without any side walk. Vertical drop near bridge is excessive. Bus stop very near to the bridge.
27	Baniajhuri	34	1.8	17	3	2							12	Bus stand with insufficient space. Bus stops near **bridge approaches**.Some guard posts are broken in the bridges in this area.
28	Pukuria Bazar	48	2.5	33	5	2							12	On **curve**. No bus bay, bus stops on carriageway to pick up & drop passengers
29	Barongail	28	1.5	14		3	7						2	**Bus stand** at lower grade with insufficient space

Continued Table 5.30 ....

Sl No	Name of Black Spot	Total Accident	% of Accident	Predominat Accident Type										Observation of Physical and Operational Features of Black Spots
				Pedestrian	Head-on	Over turn	Rear end	Hit object	Side swipe	Dropped	Hit Island	Right Angle	Unidentified	
30	Falsatia	25	1.3	17	3	2							2	**On curve**. No bus bay, bus stops on carriageway to pick up & drop passengers
31	Tepra	41	2.1	24	8		2	3					3	**No bus bay**, bus stops on carriageway to pick up & drop passengers
32	Utholi	21	1.1	12	2	2		1					4	**The Section is on curve**. No bus bay, bus stops on carriageway at bridge approaches
33	Aricha Ghat	22	1.1	18									4	Includes **intersection**. Improper speed breakers, difficult for car to cross as such tends to go to edge thus creates accident.
Gross Total		1230		432	59	47	84	18	19	6	3	7	517	
As % of known accident				61	8	7	12	2.5	2.7	1	0.4	1		

5.11 Evaluation of the Safety Schemes

The government and different donor agencies undertook, two major rehabilitation works and three black spot improvement schemes, along this highway during the entire study duration (Article 4.2). Different safety features were implemented under these projects, on the basis of the recommendations of various government and research organizations and more importantly by the donor agencies to improve the safety situation in this important inter-regional and inter-district major arterial highway. But unfortunately neither any government nor donor agency has so far made any attempt to monitor or evaluate the performance of these prescribed safety measures. Cost- benefit analyses of such works are yet to be conducted. The main reasons for not conducting such evaluation studies could be non-availability of relevant and detailed information over long period of time, especially the availability of detailed accident data, which could be amenable to scientific investigation. Moreover, as most of such projects are generally financed and implemented by donor agencies, as they leave after the implementation of works, hardly leaving behind to be any documents preserved by the users i.e. RHD and other relevant agencies for identification and detailed effectiveness evaluation as follow up which are very important for a developing country like Bangladesh. As such identifying details of such works become very difficult and strenuous task. In this study according to the objectives set out in Article 1.4, an attempt has been made to evaluate the performances of these improvement works.

To assess the performances of these safety measures, various methods are adopted such as before after studies, comparison using control sites etc (Article 3.4). Besides chi-squared (X^2) test is used in order to evaluate the performance of safety schemes (Article 3.4.3). From economic point of view cost effectiveness of different safety measures is also assessed. In this study return is estimated by quantifying the gain in accident reduction in terms of economic value. This would justify the investment for safety improvement works.

5.11.1 Before-After Analysis

This is the simplest method used to compare the accident records at any site before and after the implementation of safety schemes. In this method total numbers of accidents occurred before and after the treatment are considered to evaluate its performance. In this study change of accident patterns before and after implementation of improvement works also studied to see the impact of the safety measures.

5.11.2 Before After Analysis of Black Spots

In 1999, nationwide 27 black spots were identified by RHD using accident data reported by Police, of which 10 were selected for immediate improvement. Three of those are located along Dhaka-Aricha Highway, namely Balitha area that is also known as Bethuli bazar (km reference 50.7-52.0), 2nd Golara bridge Area (km reference 56.0-56.7) and Golara area (km reference 57.2-57.7). It is to be mentioned here that Balitha is situated in Dhamrai UZ and other two black spots are in Saturia UZ and all these three spots are located in Section 2 of the Savar-Aricha highway. These treated locations are shown in Figure 5.25 presented in the previous Article. These black spots are improved under ADB financing, through Jamuna Bridge Access Road Project (JBARP). The project commenced on 2001 and completed on June 2002. In this analysis while considering the before period, two sets of timings are used, one from the beginning of the study duration up to commencing of the projects (1990-2000) and the other considered by RHD while undertaking these projects (1996-1998). For after period one year data is considered. Before-after analysis of these improvement schemes is furnished in the subsequent Articles.

Improvement of Balitha Area (km Reference 50.7-52.0, Treated Site 1)

Brief description of the treated site - Balitha area, which is also known as Bethuli bazar and Ballya to the local people, is located on curve. It also includes a staggered-T type, unsignalized 3-legged intersection. The pavement in this section is single carriageway with 6.5 m width having smooth-non-skid surface. Embankment height varies from 1.5 to 4m (5-12 ft). Average shoulder width varies from 2.5-5.0m paved and 2.0-2.5m earthen on each side. There are few big trees near the shoulder.

Improvement measures undertaken - Major improvement features includes widening of pavement along with alignment correction, construction of separate bus bay, installation of warning gate with speed reducing sign on both entry and exit etc (Appendix B Figure 4.1).

Observations - Table 5.31 presents the before-after analysis of Balitha area, (Treated site 1), which reveals that in Balitha area significant improvement in accident reduction has taken place due to the improvement work. It can be seen from the Table 5.31 that in this area accident has reduced by 59% and 69% considering the 1990-2000 (the total period) and 1996-2000 (RHD period) as before periods. From the close observation of Table 5.31 it can also be seen that, grievous, PD and simple accidents are eliminated and fatal accidents are reduced by 22% and 34% for total (1990-2000) and RHD (1996-2000) considered period.

Table 5.31 Before-After Analysis of Balitha/Bethuli Area (50.7-52.0km) Treated Site 1

Basis of Before-After Comparison	Before Period				After period		Change of Accident (%)	
	Considering total period (1990-2000)		RHD Considered Period (1996-1998)		(Jun2002-Jun2003)			
	Total No	Avg/Year	Total No	Avg/Year	Total No	Avg/Year	Considering total period	Considering RHD period
Based on Severity								
Fatal	28	2.55	9	3.00	2	2	-21.43	-33.33
Grievous	18	1.64	7	2.33	0	0	-100.00	-100.00
Simple	2	0.18	1	0.33	0	0	-100.00	-100.00
PD	6	0.55	2	0.67	0	0	-100.00	-100.00
Total	**54**	**4.91**	**19**	**6.33**	**2**	**2**	**-59.26**	**-68.42**
Based on Collision type								
Pedestrian	14	1.27	4	1.33	1	1	--21.43	-25.00
Head On	8	0.73	2	0.67	0	0	-100.00	--100.00
Hit Obi	8	0.73	3	1.00	0	0	-100.00	-100.00
Over T	7	0.64	2	0.67	1	1	57.14	50.00
Side Swipe		0.00	-	-	-	-		
Rear End	1	0.09	-	-	-	-	-100.00	
Doped from bus		0.00	-	-	-	-		
Unidentified	16	1.45	8	2.67	0	0	-100.00	-100.00
Total	54	4.91	19	6.33	2	2	-59.26	-68.42
Based on Casualty								
Killed	29	2.64	10	3.33	3	3	13.79	-10.00
Serious Injured	98	8.91	27	9.00	6	6	-32.65	-33.33
Total	127	11.55	37	12.33	9	9	-22.05	-27.03
Based on Time of Day								
Day	36	2.67	14	4.67	1	1	-62.50	-78.57
Night	18	1.33	5	1.67	1	1	-25.00	-40.00

As regards to accident pattern Table 5.31 discloses that head-on, hit object and rear end collisions are eliminated and pedestrian accidents are reduced by 22% and 25% for total and RHD period respectively. However overturned accidents is increased by 50%.

As only one year "after period" is considered in this analysis for definite conclusion continuous further monitoring is essential.

The section being located on curve widening of pavement along with alignment correction apparently proves to be effective in reducing accidents, especially eliminating multi vehicle collision as discloses in Table 5.31. During field visit (Article 4.3), it reveals that though the speed limiting sign is installed but it is generally violated especially by the through traffic, which is still very hazardous. Buses hardly use the bus bay; instead they stop on the carriageway. Newly constructed bus shed is already damaged. Shoulder is occupied by drying of paddy. Careless pedestrian movement across the road is observed.

Installation of properly designed speed reducing devices at or little ahead of entry/exit gates, coupled with speed limiting sign at the gates would possibly be more effective in reducing the accidents.

Improvement of 2nd Golara Bridge Area (km Reference 56.0-56.7 km, Treated Site 2)

Brief description of the treated site - The area includes a bridge with sharp bend and vertical curve. Sometimes it is difficult to perceive the bend from both directions especially at night. The pavement in this section is of single carriageway with 6.5 m width having smooth-non-skid surface. Embankment height varies from 10 to15 ft. Average shoulder width varies from 1.5-2.5m paved and 1.0-1.5m earthen on each side (Article 4.3). The bridge width is less than the approach width of pavement. There are few big trees near the shoulder. Vertical sight distance in the area is inadequate.

Improvement measures undertaken - Major improvement features include widening of pavement and embankment along with alignment correction; installation of marking, signs and guard post, improvement of Bridge, which include construction of sub grade and rainwater drain etc.

Observations - Table 5.32 presents the before-after analysis of 2nd Golara bridge area (treated site-2). It can be seen from the Table that, significant improvement has taken place in accident reduction due to the improvement work. Table 5.32 reveals that, in 2nd Golara bridge area accident has reduced by 67% and 50% considering the 1990-2000 (the total period) and 1996-2000 (RHD period) as before periods. Close insight of Table 5.32

discloses that, grieves, PD and simple accident are eliminated and fatal accident is reduced by 27% and 63% for total (1990-2000) and RHD (1996-2000) analysis period.

Regarding accident pattern Table 5.32 reveals that head on, hit object, overturned and unidentified collisions are eliminated and pedestrian accidents are reduced by 9% and 40% for total (1990-2000) and RHD (1996-2000) considered period.

Table 5.32 Before-After Analysis of 2nd Golara Bridge Area (56.0-56.7 km, Treated Site 2)

Basis of Before-After Comparison	Before Period				After period		Change of Accident (%)	
	Considering total period (1990-2000)		RHD Considered Period (1996-1998)		(Jun2002-Jun2003)			
	Total No	Avg/Year	Total No	Avg/Year	Total No	Avg/Year	Considering total period	Considering RHD period
Based on Severity								
Fatal	15	1.36	8	2.67	1	1	-26.67	-62.5
Grievous	5	0.45	1	0.33	0	0	-100.00	-100.00
Simple	1	0.09			0	0	-100.00	0.00
PD	1	0.09			0	0	-100.00	0.00
Total	22	2.00	9	3.00	1	1	-50.00	-66.67
Based on Collision type								
Pedestrian	12	1.09	5	1.67	1	1	-8.33	-40.00
Head On	2	0.18	1	0.33	0	0	-100.00	-100.00
Hit Object	3	0.27	2	0.67	0	0	-100.00	-100.00
Over T	1	0.09	1	0.33	0	0	-100.00	-100.00
Unidentified	4	0.36					-100.00	0.00
Total	22	2.00	9	3.00	1	1	-50.00	-66.67
Based on Casualty								
Killed	14	1.27	11	3.67	1	1	-21.43	-72.73
Serious Injured	29	2.64	23	7.67			-100.00	-100.00
Total	43	3.91	34	11.33	1	1	-74.42	-91.18
Based on Time of Day								
Day	13	1.18	4	1.33	1	1	-15.38	-25.00
Night	9	0.82	5	1.67			-100.00	-100.00

Table 5.32 also discloses that night accidents are eliminated from this area. As only one year "after period" is considered in this analysis for definite conclusion continuous further monitoring is essential.

The section being located on curve widening of pavement with alignment correction appears to be very effective in accident reduction. During field visit it is found that few local buses pick passengers from near the bridge, which is hazardous.

Still in this section combination of sharp bend and vertical curve is an unsafe geometry by itself. Construction of guardrail near the bridge and segregation of MV and NMV on bridge, properly designed speed reducing device near bridge may further improve the situation.

Improvement of Golara Area (km Reference 57.2-57.7, Treated Site 3)

Brief description of the treated site – Golara area is located on sharp curve. The area includes a T-type unsignalized i.e. major/minor intersection. There are two bridges within this area on eastern and western side, at entry/exit to this section. The pavement in this section is single carriageway with 7.0 m width having smooth-non-skid surface. Embankment height varies from 3 to 5 m. Average shoulder width varies from 2.0-3.5m paved and 1.5 -2.5m earthen on each side. There are few big trees near the shoulder. On the southern side there is deep ditches at a very steep slope.

Improvement measures undertaken - Major improvement features include widening of pavement and embankment along with correction of alignment, construction of retaining wall, bus bay, passenger shed, construction of separate lane for NMV and MV traffic on the bridge at eastern side, installation of marking, signs, improvement of intersection etc.

Observations - Table 5.33 presents the before-after accident analysis of Golara area (Treated site 3). The Table reveals that in Golara area though fatal accidents are reduced by 36% and 58% for total (1990-2000) and RHD (1996-1998) considered period but grievous accidents are increased by five times causing an overall increase of accidents almost by two times.

Regarding accident pattern Table 5.33 shows that hitting pedestrian and head on accidents are increased by more than two and three times respectively considering RHD period (1996-1998) but over turned, sideswipe and rear end collisions are eliminated. Table 5.33 discloses evolving a new accident type of dropping from the bus in this area.

Table 5.33 Before-After Analysis Golara Area (57.2-57.7 km, Treated Site 3)

Basis of Before-After Comparison	Before Period				After period		Change of Accident (%)	
	Considering total period (1990-2000)		RHD Considered Period (1996-1998)		(Jun2002-Jun2003)			
	Total No	Avg/Year	Total No	Avg/Year	Total No	Avg/Year	Considering total period	Considering RHD period
Based on Severity								
Fatal	17	1.55	7	2.33	3	1	-35.29	-57.14
Gravies	7	0.64	2	0.67	4	4	528.57	500.00
Simple	3	0.27	1	0.33	0	0	-100.00	-100.00
PD	1	0.09			0	0	-100.00	
Total	28	2.55	10	3.33	7	7	175.00	110.00
Based on Collision Type								
Pedestrian	13	1.18	4	1.33	3	3	153.85	125.00
Head On	3	0.27	2	0.67	3	3	1000.00	350.00
Hit Object	1	0.09			0	0	-100.00	-100.00
Over Turn	4	0.36	1	0.33	0	0	-100.00	-100.00
Side Swipe	1	0.09	1		0	0	-100.00	0.00
Rear End	2	0.18	1		0	0	-100.00	0.00
Dropped from bus		0.00			1	1	0.00	0.00
Unidentified	4	0.36	1	0.33			-100.00	-100.00
Total	28	2.55	10	3.33	7	7	175.00	110.00
Based on Casualty								
Killed	23	2.09	13	4.33	4	4	91.30	-7.69
Serious Injured	51	4.64	16	5.33	22	22	374.51	312.50
Total	74	6.73	29	9.67	26	26	286.49	168.97
Based on Time of Day								
Day	19	1.73	8	2.67	5	5	189.47	87.50
Night	9	0.82	2	0.67	2	2	144.44	200.00

As pedestrian and head-on accidents are increased significantly, Zebra crossing for pedestrian may be installed, besides overtaking should be prohibited in this section and a divider may be constructed to eliminate head on accident.

During field visit it is found that, both side of the pavement especially on northern side there are shops, mosque, office etc. On southern side presence of trees still restrict the sight distance, which may be removed. A primary school is located near the road, necessitating the children to cross the busy road. Unlike treated site 1, at this site there is no gate at entry and exit is installed. The bridge at Western side has poor sign/marking. Construction of retaining wall seems to be not very effective in improving safety, rather construction of warning gate at entry/ exit with speed reducing signal coupled with properly designed speed reducing device closer to the intersection would be more effective. Separation of traffic on the bridge located on eastern side appears to be effective in reducing conflicts in the bridge area. Since mixing of NMV and MV cannot be avoided even in high standard national highways in Bangladesh due to land use pattern and densely populated area, as such on major bridges such segregation of traffic may be undertaken, where portion of NMV and 2/3 wheeler is high.

However as only one year "after period" is considered in this analysis for definite conclusion continuous further monitoring for next two years is essential.

Before-After Analysis of Aminbazar to Savar Section (under JBARP program)

- With the assistance of ADB, Mirpur - Savar section of Dhaka - Aricha highway is rehabilitated under JBARP with a cost of Tk. 100 crore. Improvement of road safety along this corridor is one of the major objectives of this project. Major safety elements include construction of median barrier, 4-lane dual carriageway, embankment widening along with correction of alignment etc. The construction process started in Nov 97 and completed on Dec 2000 (Article 4.2.3). In this study for before-after analysis, the before period is of 3 years duration (1995-1997), construction period is of three years duration (1998-2000) and two and a half years have elapsed after the completion of this project. This area exhibits a semi-urban nature with intense roadside activities. Lots of industries, commercial areas, housing projects etc are located on this busy section of Dhaka- Aricha highway.

- After implementation of these improvement works it can be seen from Table 5.34 that that total number of accidents and grievous type of accidents are decreased by 10.0% and 20.0% respectively but fatal accidents are unexpectedly increased by 9.6%. Close observation of accident database it is found that mostly pedestrian fatality is increased significantly.

- As regards to pattern of accident Table 5.34 shows that, head-on type collision previously which was the most fatal accident is reduced by 60% and unidentified types of accidents are also dramatically reduced by 93%. On the other hand rear-end type, side-swipe, hit-pedestrian and over-turn types accidents are unusually increased by nine times, eight times, 170% and 80% respectively. A close observation of Table 5.34 reveals that, there are completely two new forms of accident namely hit-island and right-angle collision emerges after implementation of the improvement works.

- In this study estimated ADT data and limited traffic flow survey data reveals that in recent year vehicular movements along this section has increased considerably. Realizing this issue, assessment of performance evaluation of overall improvement works is made by taking account of real usages of the highway in terms of veh-km, which is a widely accepted approach in comparing before-after data in equal footing. For this section of the highway accident rate in veh-km is shown in Table 5.35 and Figure 5.27. Again changes in accident rate before construction period, during construction period and after construction period is presented in Table 5.36. From Table 5.36 it is found that after implementation of improvement works total number of accidents is decreased by 19.2%, which is nearly double the figure (10.0%) calculated considering merely the accident number. In case of fatal accidents the veh-km analysis shows more encouraging results i.e. no increase of fatal accident against 9.6% increased in terms of absolute fatal accident number.

- Significant reduction of head-on collision suggests that the median is very effective in reducing this specific type of accident. Though it is expected that in dual carriageway there will be no head-on type collision but in this study area it is revealed that still this type of accident is taking place. This is happening because of the fact that from field observations it is found that installation of continuous median indulges some local truck drivers, particularly who are engaged in roadside brick-fields and intense earth filling activities, to make shortcut by using the wrong-side of the carriageway and thereby to avoid detouring needed for going to their desired direction. This type of contra-flow in the divided high-speed road like this often surprises the oncoming drivers and leads to unexpected head-on collision. It is worth mentioning here that in Jan 2004 in this section of the highway, this type of collision is occurred in the early foggy-morning between a Dhaka bound coach and a truck moving in the wrong direction and resulting 8 spot deaths and high number of casualties. This grime picture definitely tells that only expansive engineering measures like widening of carriageway and installation of median is not sufficient to prevent accident from happening. There is strong need for enforcement to catch this type of violators in order to establish disciplined traffic operation and thereby improve overall safety situation.

Table 5.34 Before-After Analysis of Savar-Aminbazar Segment (11.9-26.3 = 14.4km)

Basis of Before-After Comparison	Before Period (1995-1997), 3 years			After period (2001-Jun2003), 2.5 years				Fatality Index
	Total No	Avg No/Year	Accident/ km/year	Total No	Avg No/Year	Accident/ km/year	Change (%)	
Based on Severity								
Fatal	81	27.0	1.9	74	29.6	2.06	9.6	
Grievous	32	10.7	0.7	17	6.8	0.47	-36.3	
Simple	10	3.3	0.2	2	0.8	0.06	76.0	
PD	9	3.0	0.2	6	2.4	0.17	-20.0	
Total	132	44.0	3.1	99	39.6	2.75	-10.0	
Based on Collision type								
Pedestrian	20	6.7	0.5	45	18	1.25	170	
Head On	3	1.0	0.1	1	0.4	0.03	-60	
Hit Island				2	0.8	0.06	200	
Hit Object				1	0.4	0.03		
Hit parked veh				1	0.4	0.03		
Over Turned	2	0.7	0.05	3	1.2	0.08	80.0	
Side Swipe	1	0.4	0.03	8	3.2	0.22	850	
Rear End	3	1.0	0.08	26	10.4	0.72	940	
Dropped from bus				2	0.8	0.06		
Right Angle				4	1.6	0.11	400	
Unidentified	104	34.6	2.45	6	2.4	0.17	- 93.1	
Total	132	44.0	3.12	99	39.6	2.75	- 10.0	
Based on Casualty								
Killed	84	28.0	1.9	99	39.6	2.75	41.1	
Serious Injured	111	37.0	2.6	111	44.4	3.08	20.0	
Total	195	65.0	4.5	210	84	5.83	29.2	
Based on Time of Day								
Day	81	27.0	1.9	56	22.4	1.56	-17	
Night	51	17.0	1.2	43	17.2	1.19	1.2	
Based on Predominant Accident Type								
Pedestrian	20	6.7	0.5	45	18	1.25	170	1.01
Head On	3	1.0	0.1	1	0.4	0.03	-60	1
Hit Object				1	0.4	0.03		1
Over Turned	2	0.7	0.05	3	1.2	0.08	80.0	2.67
Rear End	3	1.0	0.1	26	10.4	0.72	900	1.04

- After implementation of improvement works, phenomenal increase of rear-end, side-swiping, hit-pedestrian and over-turn types of accidents may be due to the following reasons:
    - Random pedestrian crossings (Appendix B Figure 5.3), particularly near bus-stoppages, bridge approaches, road adjacent garment industries, satellite towns, educational institutions etc., may be the source of many surprise situations for high speed on coming vehicles and resulting rear-end type collision with the closely following vehicle.
    - Sideswipe type of accident may be instigated by aggressive overtaking operations with inadequate roadway width. Field observation reveals that though width of the carriageway is adequate (7.0 m excluding 1.25 m shoulder in each direction) for high speed 2-lane operation but intense roadside parking activities, particularly by empty trucks (Appendix B Figure 5.4), takes the whole shoulder as well as a part of the pavement thereby reduces the effective width of the roadway and makes overtaking operation hazardous.
    - Pedestrian-hit may be due to undue conflicts between vehicles and intense pedestrians crossing activities along this section of the highway (Appendix B Figure 5.3). Moreover, it is learnt from the local road users that most of the hit-pedestrian type accidents are the consequence of aggressive overtaking maneuver. Overtaking vehicle forces the overtaken vehicle to go to the extreme edge (Appendix B Figure 5.5) of the carriageway and resulting run-over type accident. From the field observations it is evident that high concentration of pedestrians (Appendix B Figure 5.2) at certain sections of the highway, namely Amin-bazar, Hemayetpur, Rajphulbaria, Savar-bazar etc. typically characterized them like urban road-traffic situation and thereby it demands protective walking and crossing facilities like footpath, elevated zebra-crossing as well as lighting facilities.
    - High increase of over-turn type accident may be due to the consequence of aggressive overtaking operation (Appendix B Figure 5.5) coupled with detoriated condition and excessive drop (30-50mm) of shoulder which act as catalyst in inducing this type of accident particularly while heavily and eccentrically loaded vehicles goes to extreme left of the carriageway. This type of accident may be due to unexpected mechanical failure of the vehicles, particularly tire-burst. It is worth mentioning here that in this corridor a serious over-turn type accident is occurred on 2/4/2004 when a house-full bus fall a victim of tire-busting and in consequence there were 8 spot deaths and 60 severe injuries. This high number of casualties occurred not only that it was a bus full of passengers but also due to excessive rolling and falling impact induced by high embankment height.

- Considering the increasing number and excessively high fatality index of over-turn type collision as compared to other types of collision it warrants for installing appropriate counter measure to arrest this type of accidents.

- As most of the Dhaka-Aricha highway passes through low-lying area, the roadway is constructed on a high embankment (2 to 8m) and without any road adjacent at-grade recovery (Appendix B Figure 5.6). This type of embankment not only pose great hazard due to high falling impact potential but also causes serious consequence in case of plunge into nearby ditches (Appendix B Figure 5.7). Which definitely demonstrate that the roadway with high embankment height is itself unsafe particularly for derailed and uncontrolled vehicles about to leave the carriageway. As such, this type of roadway needs safety barrier for lateral protection. According to AASHTO design guidelines, it is recommended that safety barrier in the form of W-beam (Appendix B Figure 5.8) type guard-rail need to be installed if the height of the embankment exceeds 2.4 m (8 ft). Though, in many places particularly at bridge approaches and outer curve of bends, guard-post like safety devices are installed along this corridor but from the field observations it is found that many of them are broken (Appendix B Figure 5.9) because of their rigid and discrete in nature. From this evidence it can be inferred that functionally these guard-posts are merely acting as a reflecting type device causing huge impact force, instead of inducing deflection action, which is helpful for redirecting any derailed vehicle. As continuous W-beam (Appendix B Figure 5.8) type guard-rail safety barrier has the potential to redirect derailed vehicle without adding any adverse affect, this type of barrier is urgently need to be installed along this highway particularly where the height of the embankment is very high (Appendix B Figure 5.6) namely around Aminbazar, Salehpur bridge, Rajphulbaria, Mulzan, Tara, Pukhuria area.

- After implementation of the improvement works, occurring of hit-island and right-angle type collisions, which are completely new in nature indicates that this may the side effects of conversion of single carriageway to dual carriageway. From the field observation it is found that along this segment the median is constructed with varying heights and shapes (Appendix B Figure 5.10). Though most of places height of the median is found to be 200 mm in high but at some places particularly at some old bridges it is as low as 75 mm and both of which are constructed with mountingable curbs. Whereas on the new bridges median is New-Jersey type (Appendix B Figure 5.11) with 1050 mm height. Field visit at hit-island type accidents site revels that due to low height mountingable median it is most likely that any high speed derailed vehicle could easily climb the island and may causes serious consequence including property damage. Hitting island particularly at the noses may be due to its ill design and obscurity. It is also found that chevron (Appendix B Figure 5.13) is not proper it should be continuous. Besides excessive drop near the bridge is hazardous (Appendix B Figure 5.14).

- The frequent openings (Appendix B Figure 5.12) in the median may be reason for inducing right-angle type collisions in this section of the highway.
- From the literature it is found that the New-Jersey type median is most appropriate barrier to prevent climbing up problems particularly for high-speed road. Besides it has the potential not only to redirect any errant vehicle towards it path but also eliminate headlight-glaring problems. In order to reduce impact of hitting nose of the median island, instead of existing vertical shape median-termini should be given wedge-shape along with retro-reflective signs.

Table 5.35 Accident Rate in 100 million veh-km of Travel of Savar-Aminbazar Sec.

Year	Motorized veh-km (million)	Fatality Rate /100 Million veh-km	Change of Fatality Rate	Total Accident Rate /100 Million veh-km	Change of Accident Rate	Fatal Accident Rate /100 Million veh-km	Change of Fatal Accident Rate	Grievous Accident Rate /100 Million veh-km	Change (%)
1990	32.6	61.4		89.0		61.4		27.6	
1991	35.6	39.3	-36.0	39.3	-55.9	36.5	-40.6	2.8	-89.8
1992	39.0	43.6	11.0	100.0	154.7	43.6	19.6	48.7	1637.1
1993	42.6	58.6	34.5	138.4	38.3	58.6	34.5	51.6	5.9
1994	46.6	57.9	-1.3	141.5	2.3	57.9	-1.3	55.7	8.1
1995	51.0	39.2	-32.3	82.3	-41.8	39.2	-32.3	17.6	-68.3
1996	50.6	81.0	106.6	112.6	36.8	75.1	91.5	25.7	45.6
1997	54.8	41.9	-48.2	60.2	-46.6	41.9	-44.1	18.2	-29.0
1998	48.8	32.8	-21.9	57.3	-4.7	32.8	-21.9	4.1	-77.5
1999	50.3	35.8	9.2	45.7	-20.3	35.8	9.2	9.9	142.7
2000	51.1	64.6	80.6	70.5	54.2	64.6	80.6	5.9	-40.9
2001	54.1	55.5	-14.2	77.6	10.2	55.5	-14.2	7.4	25.9
2002	58.2	77.3	39.4	77.3	-0.4	53.2	-4.0	22.3	202.0
2003	62.7	54.3	-29.7	51.1	-33.9	47.9	-10.1	3.2	-85.7
Total	678.2	743.1	97.7		92.8		66.9		1675.8
Avg	48.4	53.1	**7.5**		**7.1**		**5.1**		128.9

Figure 5.27 Accident Rate in Veh-Km Travel For Aminbazar-Savar Segment (Km Reference, 11.9-26.3, JBARP)

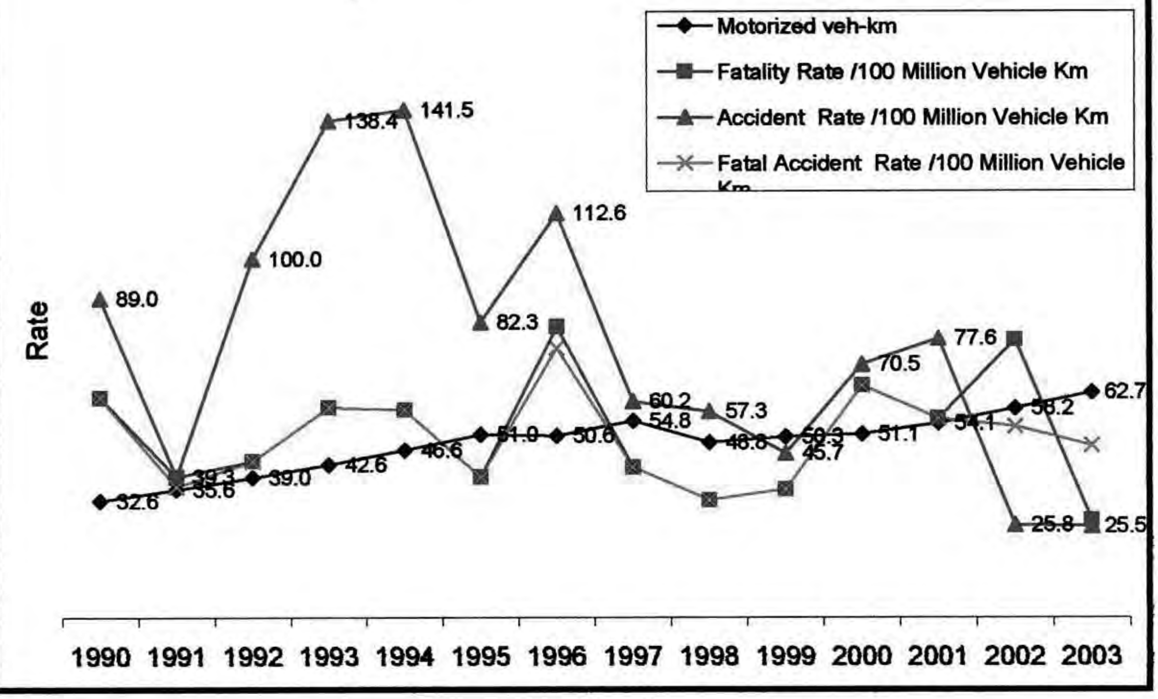


Table 5.36 Change of Accident Rate (Estimated in 100 Million veh-km of Travel) Along Aminbazar-Savar Section (Km Reference 11.9-26.3, JBARP)

Type of Change	Before Construction Period (1990-1997)	During Construction Period (1998-2000)	After Construction Period (2001-2003)	Remarks
Change of Total Accident Rate /100 Million Vehicle Km of Travel	12.5	9.7	-8.3	
Change of Fatal Accident Rate /100 Million Vehicle Km of Travel	3.9	3.9	-9.4	
Change of Fatality Rate /100 Million Vehicle Km of Travel	4.9	4.9	-1.5	

Note: (-) Sign indicates decrease.

Before After Analysis of Savar-Aricha Section of Dhaka-Aricha Highway (DANIDA Project)

- With the assistance of Danish Government, through Danish International Development Assistance (DANIDA), about 61km of the highway from Savar-bazar (26km) up to Aricha (87.0) is rehabilitated. The project includes, 48.90 km of pavement construction, 12.10 km of overlay, repair/construction of bridges and culverts, installation of safety features etc. Major objective of the project was to reduce accident. The construction cost of the project is Tk. 260 crores out of which Tk 220 crores grant from Denmark (DANIDA) and Tk 40 crores from GOB. Though the process started in 1991, actual construction started in October 1995 and completed in 1999.

- Salient safety features of the Project include, provision of road sign, pavement marking, km and guard post, repair of shoulder, pavement reconstruction, correction of alignment, provision of crash barrier, parapets, footways/ verges, approach slab, protective works for bridge/ roads etc.

- This portion of the highway is of single carriageway; width of the pavement and shoulder varies from 6.5-7m and 1-1.5m. The height of the embankment varies from 2 to 6 m (5-20 ft). Table 5.37 shows the before-after accident analysis of this area, which indicates improvement of accident scenario after this rehabilitation project

- 'Before-after' analysis as shown in Table 5.37 discloses that the accident situation along this segment of highway is improved significantly after implementation of this project. It is observed from Table 5.37 that the total and fatal accidents are reduced by 46% and 35% respectively. In terms of accident patterns Table 5.37 discloses that, over-turn, hitting pedestrian, hit object and head-on type of accidents are drastically reduced by 75%, 36%, 23% and 18% respectively considering 4.25 years of time period after the implementation of the project. The significant improvement of accident situation clearly indicates that the improvements of roadway operating conditions undertaken in this segment are very effective in reducing these types of accidents. On the other hand it is also shows that even after implementation of these improvement measures rear-end and side-swiping type of accidents are increased by 92% and 81% respectively. Though fatality contribution of these types of accident is not significant.

- Again Table 5.38 compares the before-after accident scenario in terms of accident rate expressed as veh-km of travel, which indicates increase of accident rate in 2001 and 2003. Fatal accident rate decreases immediately after the completion of the project but from 2002 the situation started getting worse. Increasing of careless and reckless driving, absence of adequate marking and signs, increase of pedestrian, NMV activities are possibly responsible for such increasing trend.

Table 5.37 Before-After Accident Analysis of Savar-Aricha Segment (DANIDA Proj)

Basis of Before-After Comparison	Before Period (1990- 1995), 6 year			After period (April 1999-Jun2003), 4.25 years			Change/Km/Year (%)
	Total No	Avg /Year	Rate/yr/km	Total No	Average	Rate/yr/km	
Severity							
Fatal	337	56.17	0.92	157	36.94	0.60	**-34.23**
Grievous	227	37.83	0.62	54	12.71	0.21	-66.42
Simple	51	8.50	0.14	26	6.12	0.10	-28.03
PD	17	2.83	0.05	6	1.41	0.02	-50.17
Total	632	105.33	1.72	243	57.18	0.93	**-45.72**
Collision type							
Pedestrian	214	35.67	0.58	97	22.82	0.37	**-36.01**
Head On	57	9.50	0.15	33	7.76	0.13	**-18.27**
Hit Object	20	3.33	0.05	11	2.59	0.04	**-22.35**
Over T	40	6.67	0.11	7	1.65	0.03	**-75.29**
Side Swipe	7	1.17	0.02	9	2.12	0.03	**81.51**
Rear End	22	3.67	0.06	30	7.06	0.12	**92.51**
Dropped from bus	2	0.33	0.01	1	0.24	0.00	-29.41
Unidentified	270	45.00	0.73	55	12.94	0.21	-71.24
Total	632	105.33	1.72	243	57.18	0.93	-45.72
Casualty							
Killed	355	59.17	0.97	297	69.88	1.14	18.11
Seriously Injured	847	141.17	2.30	424	99.76	1.63	-29.33
Time							
Day	477	79.50	1.30	283	66.59	1.09	-16.24
Night	155	25.83	0.42	144	33.88	0.55	31.16

- From the field observations it is found that besides significant proportion of NMV, there are a large number of non-standard vehicles like Nosimon, Vodboty etc. ply on this section of the highway. Unrestricted movements of these slow moving and non-standard vehicles frequently induces conflicts with the high speed through traffic and often this lead to rear-end and side-swiping type of accidents within the traffic stream.

This may be one of the reasons for increasing these particular types of accidents along this segment of the highway.

- The rehabilitation work being the first major repair after construction of Dhaka- Aricha highway in 1960, possibly all other improvement works along with safety features have contributed positively in improving overall safety situation. During any future rehabilitation project on any major highway safety deficiencies must be taken care of.

Table 5.38 Accident Rate (100 Million veh-km) of Savar-Aricha Section

Year	Total Motorized Veh-Km (million)	Total Accident Rate Per 100 Million Veh-Km	Change (%)	Fatal Accident Rate Per 100 Million Veh-Km	Change (%)	Fatality Rate Per 100 Million	Change (%)
1990	38.2	118.1		58.1		58.5	
1991	41.7	74.2	-37.23	47.7	-25.00	49.6	-15.18
1992	46.9	83.8	12.95	40.2	-15.88	43.9	-11.55
1993	49.9	121.6	45.14	59.4	47.95	60.4	37.60
1994	54.5	126.1	3.76	55.0	-7.39	56.8	-5.96
1995	59.6	109.7	-13.04	71.1	29.15	76.5	34.67
1996	65.1	103.6	-5.54	52.6	-25.95	80.3	5.07
1997	70.4	90.3	-12.83	56.2	6.74	58.3	-27.40
1998	64.1	84.9	-5.97	61.6	9.63	64.4	10.41
1999	65.6	80.4	-5.32	51.7	-15.99	53.6	-16.76
2000	67.1	56.4	-29.83	42.4	-17.97	45.7	-14.80
2001	68.9	71.3	26.35	39.0	-8.03	39.7	-13.09
2002	74.3	68.0	-4.62	46.4	18.79	52.7	32.89
2003	80.1	92.4	35.95	65.7	41.69	73.3	39.06
Total	846.4	1280.9		747.1		813.6	
Avg	60.5	91.5		53.4		58.1	

5.11.3 Evaluation of Improvement Measures using Control Sites

One of the popular and useful methods of evaluation is to compare the accidents of treated sites with other sites of similar geographic and traffic condition, where no improvement has taken place; such sites are known as control sites. Following steps are followed in selecting control sites:

- Determining in advance the relevant objectives (e.g. accident types intended to be affected) and the corresponding evaluation criteria (e.g. accident frequency, accident rate).
- Identifying a control site or (preferably) a set of control sites where no remedial works have been or are intended to be introduced.
- Monitoring both the treated site (s) and the control site (s) to obtain numerical values of these criteria before the treatment and again after the treatment.
- Comparing the 'before' and 'after' results at both the treated and control sites,
- Considering whether there are other plausible explanations for the changes, and correcting for them if possible.
- Selection of the control sites is obviously of key importance. Ideally, they would be randomly selected. However, this is rarely possible, unless a large number of control sites can be identified and a random selection made from these.
- The control sites should satisfy the following criteria (Ward and Allsop, 1982):
    - be similar to treated sites in general characteristics (network configuration, geometry, land use, enforcement)
    - be geographically close
    - have similar traffic flow
    - not affected by treatment at test site
    - not treated within before-after period
    - have accident data

For this study are Shrirampur area (control site1), Barbaria (Control site 2) and Jagir area (control sites 3) are selected as control sites (Figure 5.25) having similar traffic and geographic condition. Accidents statistics of these sites are furnished in Table A 5.7 to A 5.9 Comparisons of accidents of these improved sites with treated sites are shown in Table 5.39 to 5.41.

- Table 5.39 reveals that in treated-site-1 both fatal and total accident are decreased by 22% and 60% considering total (1990-2000) period whereas in control-site-1 and 2 fatal accidents are increased by 57.1% and 120% respectively. Total accidents in control control-site-2, are increased by 37.5% and in control-site-1 though decreased by 35.29% but this decrease is much lower than the corresponding decrease in treated site (59.3%). Critical observation from Table 5.41 implies that safety improvements in treated-site-1 are apparently very effective in reducing accident in comparison to untreated sites both in terms of frequency and severity.
- Table 5.40 shows that in treated-site-2 total accidents are reduced by 50% considering total period (1990-2000) but corresponding figure for control-site-2 are increased by 37.5% and in control-site-3, decreased at a lower rate of 40%. It can be seen from Table 5.40 that fatal accident in treated-site-2 is decreased by 62.5% by considering RHD

period (1996-1998) though corresponding figure for control-site-2 is increased by 16.67% and in control-site-3, decreased by 50%. This statistics implies that safety improvements in treated-site-2, apparently prove to be effective in reducing accidents in comparison to untreated sites both in terms of frequency and severity.

- Table 5.41 discloses that in treated-site-3 accidents are increased by 110% whereas in control-site-1 and 3 accidents are decreased by 50% and 14% considering RHD period (1996-1998). Table 5.43 discloses that in treated-site-3 fatal accidents are reduced by 57.1% considering RHD period (1996-1998), whereas corresponding figures for control-site-2 is increased by 16.67% and for control-site-3 decreased by 50%. A detail insight of Table 5.41 indicates that in treated-site-3, total accidents are increased and though fatal accidents are reduced but the reduction is not significant in comparison to the control sites. This implies that safety measures in treated-site-3 apparently do not indicate any significant improvement in relation to the untreated sites in the network.
- From the above discussion it is evident that in treated site 1 and 2 accident reduction is very effective in comparison to control sites but accident scenario in treated site 3 is not effective in comparison to control sites.

Table 5.39 Comparison of Before-After Result for Treated Site1 Using Control Sites

Accident Type	Treated Site 1 (%)		Control Site 1(%)		Control Site 2 (%)	
	Total period	RHD period	Total period	RHD period	Total period	RHD period
Fatal	-21.43	-33.33	57.14	-2500.00	120.00	16.67
Grievous	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
Simple	-100.00	-100.00	-100.00	0.00	0.00	0.00
PD	-100.00	-100.00	-100.00	-100.00	0.00	0.00
Total	-59.26	-68.42	-35.29	-50.00	37.50	-50.00

Table 5.40 Comparison of Before-After Result for Treated Site 2 Using Control Sites

Accident Type	Treated Site 2 (%)		Control Site 2(%)		Control Site 3(%)	
	Total period	RHD period	Total period	RHD period	Total period	RHD period
Fatal	-26.67	-62.50	120.00	16.67	-47.62	-50.00
Grievous	-100.00	-100.00	-100.00	-100.00	0.00	200.00
Simple	-100.00		0.00	0.00	-100.00	0.00
PD	-100.00	0.00	0.00	0.00	0.00	0.00
Total	-50.00	-66.67	37.50	-50.00	-40.54	-14.29

Table 5.41 Comparison of Before-After Result for Treated Site 3 Using Control Sites

Accident Type	Treated Site 3 (%)		Control Site 2 (%)		Control Site 3 (%)	
	Total period	RHD period	Total period	RHD period	Total period	RHD period
Fatal	-35.29	-57.14	120.00	16.67	-47.62	-50.00
Grievous	-100.00	-100.00	-100.00	-100.00	0.00	200.00
Simple	-100.00	-100.00	0.00	0.00	-100.00	0.00
PD	0.00	0.00	0.00	0.00	0.00	0.00
Total	175.00	110.00	37.50	-50.00	-40.54	-14.29

5.11.4 Evaluation of Improvement Measures using Chi-Square Statistical Method

Chi-square test is frequently conducted to test whether the adopted measures are really effective in reducing the number of accidents or the desired parameters intended to reduce. Normally accident rate in before-after analysis are tested at 10% significance level, for which Chi-Square (X^2) critical value is 2.71 at 10% LOS (level of Significance) with 1 degree of freedom (DOF).

In this study Chi-Square value for different before after items like total accident, fatal accident, type of accident, casualty state, accident rate expressed in terms of veh-km of travel etc are estimated, to test the effectiveness of the adopted measures. Here two-analysis period are used, one from the beginning of the study (1990-200) and another RHD (1996-1998) considered period for testing the black spots.

Table 5.42 shows the estimated Chi-Square value for total accidents, accident severity, different types of accidents etc for Balitha area. Table 5.42 reveals that in Balitha area (Treated–site-1), there is strong evidence that the improvement at this black spot is significant and that the reduction of total number of accidents is not merely due to chance only, considering the RHD (1996-1998) period, at 10% LOS with 1 DOF. Other improvements during this period in this area might have arisen due to chance only.

Table 5.42 reveals that, in 2nd Golara area (Treated–site-2), as regards to head-on collision, there is a strong evidence that the improvement at this black spot is significant and that the reduction of head-on collision is not merely due to chance only, considering the RHD (1996-1998) period, at 5% LOS with 1 DOF. Other improvements during this period in this area might have arisen due to chance only.

Table 5.42 further discloses that, in Golara area (Treated–site-3) the improvements are not significant, rather increase of head-on collision is significant considering both total and RHD period.

Table 5.42 presents the Chi-Square value for two major rehabilitation works, Mirpur-Savar (JBARP) and Savar-Aricha (DANIDA Proj.) area. For JBARP project, as regards to accident rate expressed in terms of veh-km of travel Table 5.43 reveals that, there is a strong evidence that the improvement at this segment is significant and that the reduction of total accident rate (in veh-km of travel) is not merely due to chance only, at even 0.1% LOS with 1 DOF. Other improvements during this period in this section of highway are not significant and might have arisen due to chance only.

Table 6.42 Evaluation of Black Spot Improvement Works by Using Chi-Square Method

Basis of Evaluation	Chi-square (est) for Balitha Area				Chi-square (est) for 2nd Golara Bridge				Chi-square (est) for Golara Area			
	Total period	Remark	RHD period	Remarks	Total period	Remark	RHD period	Remark	Total period	Remark	RHD period	Remark
Based on Type of Accident												
Total accident	1.79	Not Significant	3.72	Significant at 10% LOS	0.52	Not Significant	1.68	Not Significant	2.50	Not Significant	1.60	Not Significant
Fatal Accident	0.17	Not Significant	0.48	Not Significant	0.13	Not Significant	1.24	Not Significant	0.38	Not Significant	0.90	Not Significant
Grievous Accident	1.69	Not Significant	2.58	Not Significant	0.46	Not Significant	0.36	Not Significant	1.68	Not Significant	1.47	Not Significant
Predominant Accident Type												
Pedestrian	0.10	Not Significant	0.14	Not Significant	0.28	Not Significant	0.36	Not Significant	2.30	Not Significant	1.68	Not Significant
Head On	0.79	Not Significant	0.72	Not Significant	3.31	Significant at 5% LOS	0.36	Not Significant	24.97	Not Significant	7.10	Not Significant
Hit Object	0.79	Not Significant	1.09	Not Significant	0.10	Not Significant	0.72	Not Significant		Not Significant		
Over T	0.14	Not Significant	0.10	Not Significant				Not Significant	0.40	Not Significant	0.36	Not Significant

Note: Critical values of Chi-Square are: 2.7 at 10% LOS, 3.84 at 5% LOS, 5.02 at 2.5% LOS, 6.63 at 1% LOS, 7.88 at 0.5% LOS and 10.8 at 0.1% LOS

For Savar-Aricha (DANIDA) segment, as regards to accident rate expressed in terms of veh-km of travel Table 5.43 reveals that, there is a strong evidence that the improvement at this section is significant and that the reduction of total accident rate (in veh-km of travel) is not merely due to chance only, at even 0.1% LOS with 1 DOF. Other improvement during this period in this section of highway is not significant and might have arisen due to chance only.

For three black spots only one-year time has elapsed after the implementation of the project. So at least 3 years monitoring of after result is needed, for any concrete decision about their performance.

Table 5.43 Evaluation of Rehabilitation Works by Using Chi-Square Method

Basis of Evaluation	JBARP Project		DANIDA Project	
	Chi-Square (est)	Remarks	Chi-Square (est)	Remarks
Total accident	0.04	Not Significant	0.01	Not Significant
Fatal Accident	0.07	Not Significant	0.14	Not Significant
Grievous Accident	0.31	Not Significant	0.34	Not Significant
Based on Type of Accident				
Pedestrian	0.91	Not Significant	0.1	Not Significant
Head On	0.056	Not Significant	0.063	Not Significant
Hit Object		Not Significant	0.04	Not Significant
Over T		Not Significant	0.07	Not Significant
Rear End		Not Significant	0.047	Not Significant
Based on Casualty				
Killed	0.59	Not Significant	0.008	Not Significant
SI	0.6	Not Significant	0.3	Not Significant
Based on Accident Rate /100 Million veh-km Travel				
Fatality Rate	0.0014	Not Significant	0.08	Not Significant
Total Accident	19.5	Significant at 0.1% LOS	15.4	Significant at 0.1% LOS
Fatal Accident	-	Not Significant	-	Not Significant

Note: Critical values of Chi-Square are: 2.7 at 10% LOS, 3.84 at 5% LOS, 5.02 at 2.5% LOS, 6.63 at 1% LOS, 7.88 at 0.5% LOS and 10.8 at 0.1% LOS.

5.11.5 Economic Evaluation of the Safety Measures

In this study an attempt is made to evaluate the effectiveness of safety measures in economic point of view as well. As indicated in Article 1.3 in chapter-1, one of the events leading to initiation of this study is to estimate the cost-benefit analysis of the implemented safety schemes. In order to conduct economic analysis, determination of economic losses through costing of accident is important; this would justify the expenditure / investment involved in developing countermeasures.

Accident Cost Component

Accident cost comprises main five components as described below:

1. Lost output

Lost output refers to the contribution Road Traffic Accident (RTA) victims were expected to make to the economy with future earnings weighted to present value with an inflation rate currently in use in the country. The "lost output" of RTA deaths is calculated as the average earnings multiplied by the number of working years lost (i.e. average retirement age minus the average RTA fatality age lost). Lost output for serious and slight injuries is the daily earning rate multiplied by the number of days off work.

2. Medical Cost

Medical costs include emergency medical service, both inpatient and out patient care, prescription cost, service fees (X-ray are operation) and rehabilitation cost (Including artificial limbs). Medical cost as estimated by World Bank in Bangladesh is shown in the Table 5.44 below:

Table 5.44 Medical Cost per RTA Casualty (Taka, 000)

	Per Casualty Cost	Fatal RTA		Grievous RTA		Simple RTA	
		No	Cost	No	Cost	No	Cost
Fatality	100	1.7	170	0	0	0	0
Grievous	4200	1.4	5880	1.7	7140	0	0
Simple	100	1.4	140	2.2	220	1.5	150
Total			**6190**		**7360**		**150**

Source: Consultants World Bank (1997).

3. Human costs (Pain, Grief and Suffering)

With the outset of social cost benefit analysis in 1970s, a notional value for pain, grief and suffering (PGS) was included in industrialized countries to reflect societies and the individual's aversion to death. In developed countries it value is high around 38% and in developed countries around 20% of total lost output.

4. Vehicle Damage Cost

In addition to vehicle damage, this component should also include other property damage cost and any lost business due to the vehicle being out of commission.

5. Administrative Cost

Administrative costs include the "handling costs" incurred by police, insurance and courts in investigating accidents as well as prosecution and the settlement of insurance claims. Basing on the average costing of accidents developed by WB consultants (Table 5.45), the cost- benefit analysis of black spot improvements is estimated (Table 5.46). Table 5.46 reveals that the 1st year accident savings cost in percentage of investment for Balitha, 2nd Golara area and Golara area is 178.6%, 251.9% and 9.4% considering RHD analysis period of three years and 102.9%, 60.1% and 2.3% considering total analysis period (1990-2000) respectively. This high rate of return justifies installation of properly designed safety features to reduce economic losses due to accident. However as 1997 costing is used the return will be much more in present pricing.

Table 5.45 Average Accident Cost By Severity Type and cost Component (TK, 000)

Component	Fatal	Grievous	Simple	PDO
Lost output	591.3	7.9	0.5	0.0
Medical costs	6.2	7.4	0.2	0.0
Human costs	354.8	4.7	0.3	0.0
Vehicle damage	100.0	75.0	50.0	2.5
Administration	0.5	0.5	0.5	0.5
Total	**1052.8**	**95.5**	**51.4**	**3.0**

Source: WB Consultants Working Estimates (1997)

Table 5.46 Cost Benefit Analysis of Black Spots Improvement

Name of the Black Spot	Before Improvement Yearly Loss (000 TK))		After Improvement Yearly Loss (000 TK))	Benefit of Improvement (000 TK))		Cost of Improvement (000 TK)	1st yr. Return (%)	
	Total period (1990-2000)	RHD Period (1996-1998)		Total period (1990-2000)	RHD Period (1996-1998)		Total period (1990-2000)	RHD Period (1996-1998)
Balitha Area	2851.8	3399.89	2106	745.8	1293.89	724.4	103.0	**178.6**
2nd Golara Area	1479.7	2842.49	1053	426.7	1789.49	710.3	60.1	**251.9**
Golara Area	1707	2533.97	1433	274	1100.97	11746.1	2.3	**9.4**

Again total accident cost gives a clear picture of loses due to accident along this network. Table 5.47 estimates that, total accidents along Dhaka-Aricha highway cost 1267 million taka for entire study duration (jan1990-Jun2003) and 93.86 million taka per year. Among six UZ's maximum losses take place at Savar UZ amounting 43.42 million taka/year, followed by Dhamrai (15.4 million) and Shibalaya (13.3 million).

Table 5.46 and 5.47 implies that economic loss due to accident in this corridor is very high and significant improvement has taken place due to local investment. So there is lot of scopes to improve the overall accident situation of this corridor. Considering this grime findings of on going significant economic losses as well as evidence of good economic return from the investment related to safety improvement measures undertaken at selected black-spots of this corridor, it can be said that if the same type of improvement projects is undertaken for the other black spots, particularly those 33 sites which are identified in this study, it is likely to bring considerable economical benefits.

Table 5.47 Costing of Accident Along Dhaka- Aricha Highway

Upazilla	Fatal accident			Grievous Accident			Simple Accident			PD Accident			Total Accident	
	No	Cost (Millions)		No	Cost (Millions)		No	Cost (Millions)		No	Cost (Millions)		Grand Total Cost (Million)	
		Total	Per year		Total	Per year		Total	Per year		Total	Per year	Total	Per year
Savar	531	559	41	263	25	1.86	36	1.85	0.14	72	0.2	0.02	586	43.42
Dhamrai	189	199	15	87	8	0.62	4	0.21	0.02	10	0.0	0.00	208	15.37
Saturia	61	64	5	30	3	0.21	4	0.21	0.02	3	0.0	0.00	67	4.99
Manikganj	117	123	9	88	8	0.62	38	1.95	0.14	8	0.0	0.00	134	9.89
Ghior	82	86	6	64	6	0.45	3	0.15	0.01	2	0.0	0.00	93	6.86
Shibalaya	167	176	13	19	2	0.13	44	2.26	0.17		0.0	0.00	180	13.33
Total	**1147**	**1208**	**89**	**551**	**53**	**3.90**	**129**	**6.63**	**0.49**	**95**	**0.3**	**0.02**	**1267**	**93.86**

6.12 Overview

In this chapter an endeavor has been made to exhibit a detail insight of accident scenario along Dhaka-Aricha highway, by providing a comprehensive analysis of primary accident data collected from Thana/circle. Comparison of collected accident data with other sources, distribution of accidents among UZ, link, intersection, section/major link; fatality index to identify most severe accident, possible contribution of geometric/operational deficiencies in causing accidents have been highlighted. To evaluate the performance of implemented safety schemes various methods like before-after analysis, use of control sites, statistical tests etc have been adopted. Besides, an attempt has been made to identify high accident locations along with their major deficiencies. Costing of accidents along with cost-benefit analysis is done to assess the performances of the safety features, along this corridor.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

In this study an attempt has been made to depict the accident scenario and evaluate the performances of installed safety features, along Dhaka-Aricha highway, for the entire study duration (1990 - 2003). The study area passes through six UZs namely Savar, Dhamrai, Saturia, Manikganj, Ghior and Shibalaya, covering a total length of 75.4 km.

In order to study accident characteristics and to determine the effectiveness of different safety improvement measures, data were collected for both 'before' and 'after' implementation of these works. Accident data were directly retrieved from the Police records viz FIR and Crime Index registrar as well as data is also collected from the Hospital Road Traffic Accident (RTA) registrar and Road Safety Cell (RSC) for verification purposes. In order to supplement accident database, as a secondary source, data also gathered from previous studies. Inventories of different safety improvement measures undertaken at various locations of Dhaka-Aricha highway is collated getting information from the relevant parties, involved with the improvement works, such as RHD and Consulting Firms namely SARM Associates, SMEC, DDC, BCL etc. For detail analysis of accident data, site-specific roadway geometric and operational inventories were also collected by field survey.

Accident data was analyzed both at macro and micro level as well as qualitatively by observing data and field conditions critically. Performance evaluation of safety measures is made by applying before-after technique, control-site method and standard statistical chi-square method. Economic assessment of black-spot improvement works is also carried out to see the effectiveness in monetary terms.

In the previous chapter detailed analysis of the study has been discussed elaborately. Based on these, the summary of findings of this study, conclusions and understanding of the factors contributing to the frequent occurrence of accidents, which may lead to better design of safer highway in the future, are presented in the following articles.

6.2 Findings of Accident Data Record Keeping System

General findings on existing practice of accident data recording and reporting by police are summarized bellow:

- During several field visits discussion with police personnel and consulting relevant documents, it revealed that in most of the accident events response time of police to the incidence is not prompt and thereby when they eventually reach to the accident spot they missed most of the circumstantial evidences. Particularly, for night accident the response time is unusually high, in some cases it is about 8-10 hrs. As such, in general their reported data lacks completeness.
- It appears that police fills up the accident form much later after the actual incidence and sometimes they fills up many pending records at a time hurriedly. As such there are strong possibilities that recorded information may not depict the actual accident event.
- It is found that, many recorded accidents in the FIRs are not filled up by police in the newly introduced accident report form and thereby remain unreported.
- In the main FIR Form and Crime Index, most of the time number of person killed/ injured and cause of accident are not filled up properly.
- From the FIRs it is found that in general the police have a tendency to report over loading or reckless driving as a common cause of accident though it does not match with the "Ejhar" which is more elaborate in nature.
- Most of the time exact location of the accident is not mentioned in the FIR/newly introduced Form.
- During visit it reveals that at the grass root level i.e. at Thanas, hardly any feedback reaches regarding the importance of proper recording of accident data or any complain about improper/incorrect way of filling accident report forms. As such the persons involved in recording are not aware of the importance of their duties and responsibilities. Also they tend to believe that whatever they will report it will go unscrutinized and unchecked. This feeling make them very casual in recording accident data.
- During field visits it is seen that in the Thana there is no dedicated person(s) to collect accident data from the accident spot and to report it properly. Moreover, whoever involved in the record keeping system he has not got any formal training on this subject. More importantly it is observed that in each Thana there is an acute shortage of

manpower and all of them are heavily overloaded with other assorted duties particularly related to the law and order situations. As such, accident data reporting related issues gets least priority among their duties. Moreover, it is also found that Thanas do not have any computer facilities for proper recording and preservation of data. They also seriously lacking transport facilities to reach the accident site promptly. Above all during field visit it is observed that the working environment in the Thana is not at all healthy. Besides, it is also learnt that in the absence of any km reference or any standard accident location identification guidelines, police personnel face difficulties in locating the accident spot accurately.

- During this study it is also discovered that not only accident data are poorly maintained by the police department but also found sheer negligence in keeping improvement related documentations by other departments like Roads and Highways Department (RHD) who own the roadway infrastructures. Systematic way of preserving road improvement works related documentations is vital to carryout any after work investigation particularly performance evaluation of the works. During data collection it is observed that after implementation of road improvement or rehabilitation related works hardly any information, viz project paper, tender documents, as-built drawing etc., related to the project could be found from the head office. Since during the design and implementation phase a specific project division deals all the project works, when the improvement work is completed there is no specific guidelines how to preserve the particular project related documents in the head office. As such, later on a continuity problem arises if it becomes necessary to retrieve any information related to the project after some period of time. This problem is more acute with the projects funded and implemented by foreign contractors. After the completion of the project as they depart the country, virtually leaving behind no information to the client i.e. RHD. Their local counterparts are also found to be reluctant in preserving the records.

6.2.1 Comparison of Accident Database

In this research works an attempt has been made to compare accident database developed in this study with that of database used in previous studies and to verify police recorded data with the nearby hospital data and finally to check the accuracy of accident data reported by police to the road safety cell (RSC) are furnished in the subsequent Articles.

Comparison with Previous Studies

- In order to see the change of accident frequency pattern along Dhaka-Aricha highway over the last two decades a comprehensive database is developed using two previous studies comprising accident data between 1982 to 1985 and 1985 to1989 respectively.

- From the database it appears that during this period (1982 – 2003), total accident is doubled and fatal accident is increased by more than seven times.

Comparison with RSC and Hospital Accident Record

- By comparing database developed in this study it is seen that around 45% of total recorded accident data and 48% of fatal accident data are not reported to the RSC.
- As per hospital records, it is revealed that the degree of under recording by police is 30% and 20% in case of casualty accidents and seriously injured persons respectively.

6.3 Findings of Accident data Analysis

General Accident Statistics

- A total of 1922 number of accidents occurred during the study period, of which 1147 (60%) are fatal, 551 (28%) are grievous, 129 (7%) are simple and 95 (5%). are property damage (PD) type accidents.
- During the study period, the average per year rate of increase of total and fatal accident is 4.1% and 6.2% respectively; there is a sharp decrease of total and fatal accidents by 17% and 21 % in 1998, with the commissioning of JMB and Tongi-Ashulia road.
- Among six UZs the Savar UZ experienced the highest number of accidents (902, 47%) with maximum number of fatalities (531, 46%). Savar UZ is followed by Dhamrai (290, 15%), Manikganj (251, 13%), Shibalaya (230,125), Ghior (151,8%) and Saturia (98, 5%) UZ.
- Again in terms of severity index (ratio of fatal plus grievous accident to total accidents), Ghior UZ has the highest severity index of 0.97; it is followed by Dhamrai (0.95), Saturia (0.93), Savar (0.88), Manikganj (0.82) and Shibalaya (0.81) UZ.

Temporal Characteristics of Accident

- It is found that along this corridor, around 69.6% of accidents occurred by day and 30.4% by night.
- From the close observation of accident distribution over time, it is seen that relatively higher number of accidents occurred between 1000 - 1200 and 1200 – 1400 hours along this corridor.
- From monthly distribution, it is clearly seen that January is the most unsafe month for travel as compared to that of other months.

Vehicle Involved in Accident

- Total 2297 numbers of vehicles are involved in 1922 accidents, of which minibuses/buses and heavy trucks are involved in 45.6% and 31.6% of accidents respectively. It is followed by motorcycle (2.44%), car (2.4%) and micro (1.26%). Again minibuses/bus and trucks comprises 24.9% and 24.7% of total traffic, thus it can be said that buses and trucks are over involved in accidents with 1.8 accident/bus and 1.3 accident/truck.

- NMVs are involved in total 2.8% of accidents in the highway. Though NMVs are most vulnerable vehicle type but this low figure is due to the fact that many accidents involving NMVs are not reported in the FIR.
- The study reveals that, in this corridor single-vehicle and multi-vehicle type accidents are 81% and 19% respectively.

Predominant Accident Type

By Number

It is found that in this corridor the most predominant accident type by number (frequency) is hitting pedestrian, which accounts for 56.3% of all known accidents along the whole highway. Pedestrian accident is followed by rear-end collision (12.5%) and head-on collision (11.9%).

By fatality Index

Analysis of accident data shows that in the study area overturned type accidents has the highest fatality index of 2.1 followed by head-on (1.54) and hit object (1.42) type of accident. It is evident from the accident data that mainly buses are involved in most of the overturned type accidents. As such, consequence is expectedly high because of large number of passenger fatalities resulting form tremendous rolling and falling impact induced by high embankment height.

Most Severe Fatal Accident

In this study, in order to find out the most severe fatal accident occurred along this corridor during the study period, all accident records are sorted in descending order. Sorted database clearly shows that the top most three severe accidents are caused by overturned type accidents where 24, 21 and 9 persons were killed. Next severe accidents are found to be caused by head-on and hit object type accidents. This figure confirms the discussion in the previous Article and signifies that how serious can be the consequence of overturn type accident.

Locational Characteristic

- The study area is divided into 16 links and 16 intersections. Within 16 intersections a total 207 accidents occurred, which account for 10.8% of total accidents, rest 1715 number of accidents occurred within the 16 links, which are 89.2% of total accidents.

- Among 16 intersections, maximum 38 (18.4%) number of accidents took place at 20-Mile Post T-typed intersection, of which 22 are fatal.

- In contrast, among the links, maximum 227 (13.24%) number of accidents occurred in the link between Aminbazar to Hemayetpur, of which 145 (12.7%) are fatal. The next highest number of accidents occurred in the link between Barongail and Aricha Ghat 186 (11.66%), Golora to Manikganj Town 160 (8.27%) and Savar to Shapnapury link 153 (8.9%). On the other hand, in terms of accident rate per km per year, it is found that among the links, Savar to Shapnapury link has the highest accident rate of 3.8 accident/km/year.

- From the viewpoint of accident distribution among the three Sections, it is seen that total 831, 626 and 465 number of accidents occurred in Section-1, Section-2 and Section-3 respectively.

- In terms of veh-km it is found that average accident rates for Section- 1, Section-2 and Section-3 are 84.5, 36.7 and 139.6 respectively. From this observation it can be concluded that among three sections though in absolute terms minimum number of accidents (465) occurred in Section-3 but from the viewpoint of relative rate it is the worst section of the whole highway.

Identification of black Spots

- In order to identify black spots along this highway, dot diagrams are prepared by considering all geo-coded accident data. These dot diagrams clearly show that there are total 41 locations where accidents occurrence are clustered in nature.

- For further analysis of these identified locations, pin-maps are drawn showing detailed accident statistics viz number of accidents, severity and types of collision for a particular location. From these maps it is found that clustered type accident at the identified 41 locations accounts for 72.4% of total accidents and 72.2% of all fatal accidents occurred in the whole study area.

- From the dot diagrams it can be seen that accidents are also occurring randomly along the highway. The amount of this non-clustered type accident is found to be 27.6% of total accidents.

- In this study, black spots are identified by using both per year accident rate as well as ranking methods. Here, a location is considered as black spot, using RHD criteria of occurrence of at least three fatal accidents in 3 years periods. Accordingly, total 33 locations out of 41 sites are isolated as black spots where 58.9% of total accidents and 59.4% of fatal accidents are occurred. Among these locations it is found that the Aminbazar site is the most hazardous location with 67 accidents including 42 fatal accidents. The next most accident-prone locations are Savar Bazar (60), Balitha (57) and Radio Colony area (56).

- Examination of black-spots accident data reveals that pedestrian related accident is the most predominant one which accounts for 61% of all known accidents within these spots, followed by rear-end 12%, head-on 8% and overturned 7%.

- In order to find out the underlying reasons behind the frequent occurrence of accidents at these locations, several visits have been made during the study period. Field observations were made both qualitatively and quantitatively. It is seen that accidents are generally occurring at bus stops particularly which are near the bridges, bazars, sharp bends, intersections and places with high pedestrian concentration especially where vision is obstructed. This definitely suggests that safety improvement measures are essential at these locations.

6.4 Evaluation of Safety Measures

One of the main objectives of the study is to investigate the effectiveness of various safety measures undertaken along this highway during the study period. During these period three black spots namely Balitha, 2nd Golara Bridge and Golara Area and Amin-bazar to Savar segment of the Dhaka-Aricha highway are improved under the Jamuna Bridge Access Road Project (JBARP). Savar to Aricha segment of the highway is also rehabilitated under the DANIDA financial support program where improvement of safety was one of the prime objectives. In order to determine the performance of these improvement measures accident data are segregated considering the 'before' and 'after' period with respect to the implementation of these measures. In this study 'before-after' analysis of accident data are conducted in different ways. Summary of findings of this study are presented in the following Articles.

6.4.1 Evaluation by Before-After Analysis

This is the simplest method used to compare the accident records at any site before and after the implementation of safety schemes. In this method total number of accidents occurred before and after the treatment is considered to evaluate its performance.

Balitha Area Improvement Works

- Balitha improvement area comprises nearly 0.75 km of roadway segment and it includes one bend and one staggered-T intersection. Major improvement features include widening of pavement along with alignment correction, construction of separate bus bay and installation of warning gate with speed reducing sign at the entry and exit of the area.

- From before-after analysis of accident data it is found that in Balitha site safety situation improved significantly. The total and fatal accidents are reduced by 69% and 34% respectively. Before-after study of accident pattern shows that head-on, hit object, rear-end collisions are eliminated and hitting pedestrian accidents are reduced by 25%. It is worth mentioning here that in this analysis only one year is considered as 'after' observation period. Moreover, detail geometric changes of the roadway segment could not be studied due to unavailability of previous drawings.
- Even then from the considerable improvement of safety situation at this location it appears that widening of curve as well as correction of alignment and construction of separated bus-bay appears to be very effective in reducing accident frequency.
- From the field observation it is found that though the speed limit signs are installed but these are frequently violated especially by the through traffic. Moreover, most of the cases bus drivers do not use the properly designed bus-bay and perform passenger picking and dropping operation on the main carriageway endangering road users' safety, which suggests that effective enforcement is warranted in order to further improvement of safety situation at this site.

2nd Golara Bridge Area Improvement Works

- In this area, the improvement works stretches around 0.5 km of roadway segment and it comprises one sharp bend and one undivided bridge. Since the bridge is located at the bent it is difficult to perceive by the drivers traveling from either direction particularly at night. Major safety improvement features includes widening of pavement with alignment correction, improvement of sub-surface drainage facilities, installation of signs, markings, guard posts at the bridge approaches etc.
- In this area significant reduction of accidents took place after the implementation improvement works. Fatal and total accidents are reduced by 63% and 67% respectively. Head-on, hit object, overturned and unidentified collisions are eliminated and pedestrian accidents are reduced by 40%.
- In the location, significant reduction of accidents implies that widening of carriageway at bend, alignment correction and installation of guard posts with retro- reflecting markings are very effective measures and has the potential to improve safety situation.
- During field visit it is found still there is lot of scopes to improve the roadway operating conditions by dividing the bridge and if possible with special provision of separate NMV lane and more importantly by introducing effective enforcement measures with the of highway patrol police.

Golara Area Improvement works

- This area is situated nearly 0.6 km west of 2nd Golara bridge and it includes one sharp curve and one T-intersection. Moreover, there are one road-adjacent primary school, many small shops on both sides of the highway, temporary bazar and two undivided bridges at the boundary of this area. In this site, improvement works are undertaken within 0.5 km segment of highway. Major safety improvement features includes widening of embankment and with alignment correction, one separate bus-bay with passenger shed, construction of separate lane for NMV and MV traffic on one the bridges (Eastern side), improvement of intersection, installation of signs/marking etc with an investment of 1.0 crore taka. It appears that this site gets the highest level of treatment among the three black spots.

- Before-After analysis of accident data shows that in Golara area though fatal accidents are reduced by 36% but grievous accidents are increased by five times resulting an overall increase of accidents by almost two times. Looking at the accident patterns it is observed that on one hand overturn and rear-end type collisions are eliminated, on the other hand hitting pedestrian and head-on type accidents are increased by two and three times respectively.
- From the above findings it is revealed that though a large number of countermeasures are implemented in this section but they could not improve the situation expectedly. It also tentatively appears that though in this site number of accident considerably increased during the one year 'after' observation period but most importantly severity of accidents is reduced substantially.
- As even after implementation of safety measures at this location, pedestrian and head-on type accidents increased significantly, it suggests that there is a need for installation of self-enforcing speed calming devices particularly near the school area. Moreover, in this segment of the road in order to prevent dangerous overtaking operations, installation of median-island with barrier could be a useful solution. This will not only eliminate the head-on type collision but also will act as a refuge for the pedestrians while crossing the high-speed road. In this particular site, intense road adjacent non-motor activities particularly during hut-day also indicates that there is a need for construction of frontage road along with pedestrian guardrails to confine local activities from the through traffic. However, before further improvement of this location, accident situation should be closely monitored at least for the next two years period.

Aminbazar to Savar Area Improvement Works

- In 2000 a major rehabilitation works is completed along the Mirpur-Savar section of Dhaka-Aricha highway under Jamuna Bridge Access Road Project (JBARP). In this road improvement works major safety features were construction of median barrier, widening and correction of alignment and thereby converting the carriageway from 2-lane single-way to 4-lane dual-way, installation of signs/marking, guard posts both at sharp bends and bridge approaches. In the before-after analysis 3 years as 'before' period and 2.5 years as 'after' period is considered.

- After implementation of these improvement works it is observed that total number of accidents and grievous type of accidents are decreased by 10.0% and 20.0% respectively but fatal accidents are unexpectedly increased by 9.6%.
- Analysis of accident patterns shows that head-on type collision previously, which was the most fatal accident, is reduced by 60% and unidentified types of accidents are also dramatically reduced by 93%. On the other hand rear-end type, side-swipe, hit-pedestrian and over-turn types accidents are unusually increased by nine times, eight times, 170% and 80% respectively. After implementation of the improvement works, hit-island and right-angle type collisions have emerged.
- It is also found that in this segment of highway overturn accidents have highest fatality index of 2.67, which is nearly 2.5 times than the 2nd highest (1.04) rear-end type collision.
- In terms of veh-km travel, which is a widely accepted approach in comparing before-after data in equal footing, it is found that after implementation of improvement works total number of accidents is decreased by 19.2%, which is nearly double, the figure (10.0%) calculated considering merely the accident number. In case of fatal accidents the veh-km analysis shows more encouraging results i.e. no increase of fatal accident against 9.6% increased in terms of absolute fatal accident number.
- Significant reduction of head-on collision suggests that the median is very effective in reducing this specific type of accident. However there is a need for strong enforcement to eliminate illegal contra flow by local trucks.
- After implementation of improvement works, phenomenal increase of rear-end, side-swiping, hit-pedestrian and over-turn types may be due to the following reasons:
    - Random pedestrian crossings.
    - Sideswipe type of accident may be instigated by aggressive overtaking operations with inadequate roadway width.
    - Pedestrian-hit may be due to undue conflicts between vehicles and intense pedestrians crossing activities along this section of the highway.
    - High increase of over-turn type accident may be due to the consequence of aggressive overtaking operation coupled with detoriated condition and excessive drop (30-50mm) of shoulder.

- Considering the increasing number and excessively high fatality index of over-turn type collision as compared to other types of collision it warrants for installing appropriate counter measure to arrest this type of accidents.

- High embankment (2 to 8m) without any road adjacent at-grade recovery area warrants lateral confinement in the form of W-beam type guardrail. The installed guard-posts are merely acting as a reflecting type device causing huge impact force, instead of inducing deflection action, which is helpful for redirecting any derailed vehicle. As continuous

W-beam type guard-rail safety barrier has the potential to redirect derailed vehicle without adding any adverse affect, this type of barrier is urgently need to be installed along this highway particularly where the height of the embankment is very high namely around Aminbazar, Salehpur bridge, Rajphulbaria, Mulzan, Tara, Pukhuria area.

- It is found that along this segment the median is constructed with varying heights and shapes, which is mountainable. From the literature it is found that the New-Jersey type median is most appropriate barrier to prevent climbing up problems particularly for high-speed road.

Savar to Aricha Area Improvement Works

- With the assistance from Denmark about 61 km of the highway stretching from Savar-bazar to Aricha-Ghat was rehabilitated in 1999, one of the main objectives of the project was to reduce accident rate. Salient safety features includes provision of road signs, markings, guard post, repair of shoulder, pavement reconstruction and resurfacing, provision of crash barrier (New-Jersey type) and correction of alignment etc.
- 'Before-after' analysis of data discloses that the accident situation improved significantly after implementation of this project. Total and fatal accidents are reduced by 46% and 35% respectively. Over-turn, hitting pedestrian, hit object and head-on type of accidents are drastically reduced by 75%, 36%, 23% and 18% respectively. Rear-end and sideswiping type of accidents is increased by 92% and 81% respectively. Though fatality contribution of these types of accident is not significant. Huge number of NMV and non-standard vehicles may be responsible for this.

6.4.2 Evaluation by Using Control Sites

One of the popular and useful methods of evaluation is to compare the accidents of treated sites with other sites of similar geographic and traffic condition, where no improvement has taken place. In this study, three control sites are selected for analyzing performance evaluation of treated sites namely Balitha, 2nd Golara and Golara area. Each site is tested against two adjacent control sites.

- Like 'before-after' analysis, with this method of evaluation it is found that in Balitha and 2nd Golara sites considerable safety improvements is achieved after implementation of improvement works. From the analysis it is revealed that compared to untreated controlled sites at these locations total accidents are reduced by 36% and 107% respectively
- But unlike Balitha and 2nd Golara sites, in Golara site accident statistics shows no effect of improvement works rather accident frequency is increased by a big margin. This

finding also matches with the 'before-after' analysis. From the control site analysis it is seen that though on average accident number is reduced by 36% in the nearby-untreated sites during the observation period but in the treated sites it is increased by 110%. The underlying reasons for this unexpected increase of accident number are already explained in the previous article of 'before-after' analysis.

6.4.3 Evaluation by Using Statistical Chi-Square Method

The Chi-square test is frequently conducted to check whether the adopted counter measures are really effective in reducing the number of accidents or the desired parameters intended to reduce by comparing before-after data. In this analysis it actually tests if sample means observed over two different intervals of time period is from the same population or not. This statistical test is normally performed at 10% significance level.

- From Chi-square test results it is found that in Balitha area there is strong evidence that the improvement at this black spot is significant at 10% level of significance LOS with 1degree of freedom (DOF) and that the reduction of total number of accidents is not merely due to chance.
- In 2nd Golara area as regards to head-on collision, there is a strong evidence that the improvement at this black spot is significant and that the reduction of head-on collision is not merely due to chance only, considering the RHD (1996-1998) period, at 5% LOS with 1 DOF. All other improvements during this period in this area are not significant and might have arisen due to chance only.
- Like other methods, the Chi-square test also confirms that in Golara area the improvements are not significant and may be due to chance only rather increase of head-on collision is significant considering both total and RHD periods.
- For Mirpur-Savar (JBARP) project, as regards to accident rate expressed in terms of veh-km of travel, there is a strong evidence that the improvement at this segment is significant at 10% LOS and that the reduction of total accident rate (in veh-km of travel) is not merely due to chance only. Other improvements during this period in this section of highway might have arisen due to chance only.
- For Savar-Aricha (DANIDA) segment, as regards to accident rate expressed in terms of veh-km of travel there is a strong evidence that the improvement at this section is significant and that the reduction of total accident rate (in veh-km of travel) is not merely due to chance only, at even 0.1% LOS with 1 DOF. Other improvements during this period in this section of highway are not significant and might have arisen randomly instead of incrementally.

6.4.4 Economic Evaluation of Road Safety Measures

In this study an attempt is made to evaluate the effectiveness of safety measures in economic point of view. Determination of economic losses through costing of accident is important for justification of investment involved in developing countermeasures.

Economic analysis is performed based on the accident costing data developed by the World Bank (WB) consultants for Bangladesh perspective. This analysis is conducted for three black spots improvement works as well as for the whole length of the highway. Economic evaluation of other two major rehabilitation works could not be performed due to finding difficulties in isolating the cost involvement of safety features from the other improvement features. It reveals that the concerned authorities had no intention to assess the performance evaluation of a particular measure after implementation of the total project. The findings of the limited economic studies are summarized bellow:

- The cost-benefit analysis of three black spots improvement works reveals that the 1st year accident savings cost in percentage of investment for Balitha, 2nd Golara area, Golara area are 178.6%, 251.9% and 9.4% respectively and.
- In this study an attempt is also made to estimate the total accidental losses incurred during the entire observation period (1990-2003) for the whole Dhaka-Aricha highway. In is found that due to road-traffic accident along this corridor the nation has economically lost an amount of Tk. 1,267 million during the last 13.5 years period which is Tk. 93.86 million annually.
- Further analysis reveals that among six UZ's maximum losses incurred in Savar UZ amounting Tk. 43.42 million /year, followed by Dhamrai (Tk. 15.4 million/yr) and Shibalaya (Tk. 13.3 million/year).
- Considering this grime findings of on going significant economic losses as well as evidence of good economic return from the investment related to safety improvement measures undertaken at selected black-spots of this corridor, it can be said that if the same type of improvement projects is undertaken for the other black spots, particularly those 33 sites which are identified in this study, it is likely to bring considerable economical benefits.

6.5 Recommendations of the Study

Based on Data Collection

On Accident Recording / Reporting

A systematic way of collecting, recording and reporting of accident data is very important for making accident investigation and counter measures evaluation meaningful and accurate. In order to ensure quality of accident data as well as to minimize under-reporting of data, the following measures should be addressed immediately:

- Formation of separate accident data collection unit at each Thana/Circle level.
- The unit should be equipped with well-trained police personnel along with dispatch vehicles to reduce response time to the accident spot. At the same time they should be

given camera to take photographs of the accident event, which may be invaluable supplementary information for post-incidence investigation.

- They should be given proper training on how to describe accident events both by description as well as graphically by drawing collision diagram and most importantly they must understands different modes of collisions and their underlying mechanics.
- Strict monitoring should be introduced so that accident event is responded quickly and it is recorded on the very same day it happens. Most importantly, it should be ensured that newly introduced accident report form and FIR are filled up at the same time and a copy of accident reporting form is attached with the FIR.
- Concerned authority should urgently prepare a user-friendly standard accident location identifying referencing system for the whole network of the country. In this regard installation of km-post at 0.5 km interval could be a better option. In the absence of this system, presently available accident data are found without proper locational information, which is a major problem in identifying black spot as well as in evaluating improvement works.
- Last but not the least, continuous feed back from the all user groups of accident data should be communicated to the Police authority so that they know the value of the data and realized that someone is critically scrutinizing his recorded data.

On Accident Record Keeping at Hospitals

- In the road traffic accident (RTA) related hospital register, the place of accident should be written for the purposes of relating as well as verifying police data with that of hospital data.
- The register should be preserved permanently and for systematic way of preserving accident data computer based record keeping may be introduced.
- There should a system of exchanging information regarding RTA related number of persons admitted and death between police and hospital authority.

On Maintaining Information by RHD

- RHD should systematically preserve all construction and improvement related documents like feasibility study, design report, tender document, as-built drawing etc.
- They should have their own post-improvement monitoring and evaluation programs in order to make an assessment on the effectiveness of a particular countermeasure.

Based on Findings of the Accident Analysis

Sight Specific Improvements Measures

In order to protect local vehicular and pedestrian activities from the high speed through traffic stream as well as to make accident prone sites safer, along this corridor there is a need for:

- Construction of parallel service road on both sides of Savar-bazar, Aminbazar and Manikganj areas.
- Construction of protective walking and crossing facilities like footpath, elevated zebra crossing as well as lighting facilities particularly at Amin-bazar, Hemayetpur, Rajphulbaria, Savar-bazar areas.
- Construction of properly designed roundabout at Nabinagar intersection for smooth interchange of traffic between two major highways meeting at this intersection.
- Correction of alignment to improve the curve sections at Rajphulbaria, Gonoshastha center, Joupura, Barbaria, Mulzan, Pukhuria bazar and Falsatia areas.
- Prohibition of bus stopping near bridge approaches particularly at Utholi, Tara, Nayadingi, Karnpara and Dhalessery Bridge sites.
- Trimming of extended tree branches at 20 Mile Post, Barbaria, Mahadevpur, Mulzan and Baniajhuri areas to improve sight distance problem.
- Installation of median barrier and speed calming devices at Golara area.
- Construction of W-beam type guardrail safety barrier around Aminbazar, Salehpur bridge, Rajphulbaria, Mulzan, Tara, Pukhuria sites.
- Construction of truck terminals particularly near the Amin-bazar, Turag and Nayarhat areas, to control road side parking by heavy vehicles.
- Effective enforcement at Aminbazar, 20 MP, Nabinagar, Dhamrai town, Manikganj and Aricha Ghat areas, particularly during hut-days at Golara area to ensure traffic discipline.
- Introduction of highway surveillance team involving community leaders to control conflicting use of roadway space viz:
    - Temporary bazar
    - Drying of crops on shoulder
    - Parking on the shoulder
    - Contra-flow
    - Keeping domestic animals near the highway for grazing etc.

General Improvements Measures

- Reduction of frequent opening in the median barrier to minimize turning opportunity and introduction of strict enforcement to prevent resulting contra-flow type movements.
- Replacing old signs/markings by retro-reflective signs and markings particularly near the 33 identified black spots. Most importantly signs should be writing in Bengali.
- Discrete type Chevron marking at the bends should be replaced with continuous retro-reflective type Chevron marking.
- Discrete type guard-post safety device should be replaced with W-beam type continuous guard-rail deflecting type barrier
- Low height mountainable median barrier should be replaced with New-Jersey type crash barrier.

- In order to minimize tilting and sudden impact problems, vertical drops between pavement and shoulder as well as between pavement and bridge deck should be reduced.
- Separate bus bay with pedestrian barrier and if possible construction of passenger shed.
- Movements of NMV and non-standard type vehicles should be controlled and if possible restricted.

Based on Economic Evaluations

Considering the apparent findings of good economic return from the investment related to safety improvement measures undertaken at selected black-spots of this corridor, it is strongly recommended that other black spots, particularly those 33 sites which are identified in this study should be objectively treated immediately.

6.5.1 Recommendations for Future Research

Though in this research work it is attempted to make the study comprehensive but due to time and economic constrains, few important aspects could not be addressed. If the following issues could have been considered in this thesis works, it would have been more comprehensive and complete.

- A detail accident investigation may be conducted at the 33 black spots identified in this study.
- Monitoring the treated black spots for at least three years and conducting before-after analysis to evaluate performance of implemented safety measures more conclusively.
- Since trucks and buses are over involved in accidents, separate studies may be conducted to identify the factors leading to accidents involving these heavy vehicles.
- To understand drivers' contribution in accidents occurrence, a questionnaire survey particularly on heavy vehicle drivers may be conducted.
- An impact study of road adjacent existing uncontrolled land use development on traffic safety may be conducted.

The above issues could be the potential topics for future research on the Dhaka-Aricha highway.

BIBLIOGRAPHY

Ahmed, N. U. (2002), " *Investigation of Traffic Accident and Involvement of Pedestrians and Non Motorised Vehicles in Accidents in Dhaka-Savar highway,*" B. Sc. Engineering thesis BUET, Dhaka.

Alam, M. J. B. (2003), " *Use of Accident Data and Accident Database,*" Paper Presented on Road Safety Training Course at ARC, BUET, Dhaka.

Alam, M. U. (2003), "*Status of Accident database Management in Bangladesh in Bangladesh,*" Paper Presented on Road Safety Training Course at ARC, BUET, Dhaka.

Alam, M. U. (2003), "*Road Safety Organization in Bangladesh,*" paper presented on national workshop on road safety management in Bangladesh organized by Accident Research Center, in BUET, on April 2003.

Asian Development Bank,(1998), *Road Accident Costing for the Asian and Pacific Region*, A Paper by Asian Development Bank, 1998.

AASHTO (1990), "*A policy on Geometric Design of Highways and Streets,*" American Association of State Highway and Transportation Officials, Washington, D.C.

Banik, G.C. (1987), " *Aspects of Road Geometry's in Relation to Traffic and Road Accidents; a Case Study of Dhaka-Aricha road* ," M Sc. Engineering thesis BUET, Dhaka.

Hoque, M. M, Habib, M. K.M. and Alam. J.B, (2003), "*The Challenges of Addressing Road Safety Problems,*" IEB paper 2003.

Contract Agreement (1997), for "Improvement and Rehabilitation of Mirpur- Savar Road Section," under JBARP.

Elahi, S. M. (1986), " *A Study of Road Accidents on Selected Highways in Bangladesh,*" M. Sc. Engineering thesis, Department of Civil Engineering, BUET, Dhaka.

Flaherty, C.A.O. (2002) "*Highways - The Location, Design, Construction and Maintenance of Road Pavements,*" 4th Edition, edited by Coleman A.O Flaherty, UK, 2002.

Flaherty, A.O. (1997), Transportation Planning and Traffic Engineering edited by Coleman A.O Flaherty, UK, 1997.

Hoque, M.M (1981), "*Traffic accident in Dhaka, a study on roadway safety,*" Bangladesh University of Engineering and Technology (BUET), Department of Civil Engineering, Dhaka

Hoque, M.M. (1991), " *Accident Investigation for the Safety Improvement of Dhaka – Aricha Highway (A Section of Asian Highway,*" Bureau of Research testing and Consultation, Bangladesh University of Engineering and Technology (BUET), Department of Civil Engineering, December, 1991, Dhaka.

Hoque, M.M (1993), "*Road safety: Potential of engineering countermeasures,*" J. Traffic Med. Vol. 21, No 1.

Hoque, M.M. (1997), "*Road Safety Audit in Developing Countries,*" Bangladesh University of Engineering and Technology (BUET), Department of Civil Engineering, Dhaka, Bangladesh

Hoque, M.M. (2003), " *Understanding Road Traffic Accident Problem,*" A Paper Presented on Road Safety Training Course at ARC, BUET, Dhaka.

Hoque, M.M. (2003), " *The Road Component: Road Factors and Element of Safer Road,* " Paper Presented on Road Safety Training Course at ARC, BUET, Dhaka.

Hasan, T. (2003), " *The Human Component: Human Factors, Safety of Road Users,*" Paper Presented on Road Safety Training Course at ARC, BUET, Dhaka.

Hoque, M. S. (2003), " *The Vehicle Component: Vehicle Factors and Vehicle Safety,*" Paper Presented on Road Safety Training Course at ARC, BUET, Dhaka.

Hoque, M.M, Habib, K. M. N. and Abdullah, S.Z. (2003), " *Hazardous Road Location Program: Identification and,*" A Paper Presented on Road Safety Training Course at ARC, BUET, Dhaka.

Inception Report (2003), Road Safety Component of southwest road Network Development Project, by FINNROAD, August 2003.

Mohan, D. " *Road Traffic Injuries – A Neglected Pandemic,*" Bulletin of world Health Organization. 2003

National Road Safety Council (2000), "*National Road Safety Strategies Action Plan 2002-200.5*".

Ogden K. W (1994), "*Traffic Engineering Road Safety; A practitioner Guide,*" Department of Civil Engineering, Monish University, Melbourne, Australia.

Ogden K. W (1996), "*Safer Roads: A Guide to Road Safety Engineering,*" institute of Transport Studies, Department of Civil Engineering, Monish University, Melbourne, Australia.

Pignataro, L.J. (1996), "*Traffic Engineering, Prentice,*" Hall, Inc., /Englewood Cliffs, New Jersey.

Project Summary, (1997), of Jamuna Bridge Access Road Project (JBARP).

National Daily Newspaper , (2004), "*Prothom Alo*", published on 04 April 2004.

Searles, B. and Jamieson, J. (1983), "*Accident Data: Other Sources,*" Proceeding of the Workshop on Traffic Accident Evaluation, Monash University, Australia.

O'Flaherty, C.A (1974), "*Highways and Traffic,*" Vol.1. Second Edition, Edward Arrold (Publishers), U.K.

Road Safety Cell (2003), " *National Road Traffic Accident Report 2002*".

RHD Road Network database Report for 1995/1996 (1996), Volume 2, Full Survey Result, Planning and Development Wing, June 1996.

RHD Road Network Database Annual Report for 1996-1997 (1997), Volume1: Main Report, Planning and Development Unit, July 1997.

RHD Road Network Database Annual Report for 1997/1998 (1998), Volume2: Detailed Zone Report Part C: Dhaka, Planning and Development Unit, August 1998

RHD Road Network Database Dhaka Zonal Report 2002 (2003), HDM Circle, Sarak Bhaban, Ramna, Dhaka-1000, March 2003.

Road Safety Measures on National and Regional Roads (2000), Status Report and Monthly Progress report No. 26, RHD.

RHD, (1999), "*The Draft List of the Pilot Project Areas for Analysis to Identify the Black Spots on the Dhaka – Aricha Highway,* " March, 1999.

Safety Effectiveness of Highway Design Feature Volume 2, (1992), US Department of Transportation Federal Highway Administration.

Safety Effectiveness of Highway Design Feature Volume 3, (1992), US Department of Transportation Federal Highway Administration.

Safety Effectiveness of Highway Design Feature Volume 4, (1992), US Department of Transportation Federal Highway Administration.

Sharmeen, S. (1996), " T*ruck Involvement in Road Accident in Metropolitan Dhaka,*" M Sc Engineering thesis, BUET, Dhaka.

Transport Research Laboratory (TRL, 1990) "*Towards Safer Roads In Developing Countries.*"

Thomas, A.A, "*Under – Reporting of Road Traffic Casualties in Low Income Countries,*" DFID, Unpublished Project Report, 1999/2000.

Tanvir, M. A. (2003) "*Black Spot Identification for Safety Improvement on a Section of Dhaka-Chittagong Highway,*" M Sc. Engineering thesis BUET, Dhaka.

Transportation and Traffic Engineering Handbook, 2nd Edition, Institute of Transportation Engineers, New Jersey.

Tender Document, (1994) " *Rehabilitation of Works between Savar to Aricha Segment of N5 Highway,*" Funded by Government of Denmark, 1994.

World Bank, (1993), "*Economic Evaluation of Jamuna Bridge Project,*" A Document of World Bank, December 1993.

World Bank, (2002), "*Progress Report of Road Safety Projects under World Bank,*" June 2002

World Bank, (1997), "*Economics Working Paper E8 on Accident Cost,*" RHD, December 1998.

APPENDIX - A
TABLES AND FIGURES

Table A 4.1 Highway Operating and Geometric Condition and Observation During Field Visit

Section	Link and Intersection	Prominent Location	Geometric Features			Operating Condition								General Observations
			Pavement Width, carriageway	Shoulder	Height of Embankment	Degree of Exposure	Roadside Land Use pattern	Sight distance (SD)	Condition of Sign & marking	Vertical (SD) near bridge	Pedestrian activity	NMV Activity		
Section 1	Link1 and Intersection 2	AMIN BAZAR	Dual Carriageway, 2x7.4 m width, smooth-non skid surface	Avg 1.2 m paved and 1-1.5 earthen shoulder on each side, Drop excessive	15-20 ft, steep slope (less than 1:2)	water logged ditch on open left side, commercial building, school on right side.	market, school, residential area etc	good	no marking of inner & outer edge line, sign inadequate	good	intense	intense		Median started after a distance from bridge, no separate bus bay, bus stops on Carriageway, no crossing facility for pedestrian.
Section 1	Link1 and Intersection 2	SALEHPUR BR	2x2.6.5 m Carriageway on bridge, smooth-non skid surface	Avg 1.0 m paved and 0.5-1.1m earthen shoulder on each side, Drop excessive	20-25	25-40 F deep stream on both side		average	no marking of inner & outer edge line, sign inadequate	good	medium	high		Some guard posts are broken, Width is not consistent with approach location, no NMV lane & safety barrier on bridge approach, Improperly reflected. Low height guard post on approach of bridge , some of them are damaged.

Section 1	Link1 and Intersection 2	TURAG	Dual Carriageway, 2x7.4 m width, smooth-non skid surface	Avg 1.0 m paved and 0.5-1.1m earthen shoulder on each side, Drop excessive	15-20 steep slope	open water logged ditch,	new housing, brick field.	average	no marking of inner & outer edge line , sign inadequate	good	high	high	Frequent U turning provisions invite risks, no separate bus bay, bus stops on Carriageway, no crossing facility for pedestrian , no parking facility for buses & trucks often crates conflict with through traffic.
Section 1	Link1 and Intersection 2	BALIARPUR	Dual Carriageway, 2x7.4 m width, smooth-non skid surface	Avg 1.0 m paved and 0.5-1.1m earthen shoulder on each side, Drop excessive	10-20 ft	open water logged ditch and few trees	bus stand, industry, housing, madrasha	good	no marking of inner & outer edge line , sign inadequate	good	intense	intense	bazar activities on right side invites huge pedestrian activities across the road no separate bus bay, bus stops on Carriageway, no crossing facility for pedestrian , no parking facility for buses & trucks often crates conflict with through traffic
Section 1	Link1 and Intersection 2	HEMAYETPUR	Dual Carriageway, 2x7.4 m width, smooth-non skid surface	Avg 1.0 m paved and 0.5-1.1m earthen shoulder on each side, Drop excessive	5-15ft	open water logged ditch and few trees	Intersection, bus stand, industry, residential area, school	average	no sign for bus bay, pedestrian, parking, no marking of inner & outer edge line ,	good	intense	intense	Bus bay exists but not used, bus stops on Carriageway / shoulders, huge trucks and NMV park on paved shoulder, bus stops at intersection creating bottlenecks specially for through traffic

Section 1	link 3 & intersection 4	RAJPHULBARIA	Dual Carriageway, 2x7.4 m width, smooth-non skid surface	Avg 1.0-1.2 m paved and 0.75-1.0 earthen shoulder on each side, Drop excessive	10-20 ft, steep slope on each side (less than 1:2)	open ditch, water logged during monsoon moderate trees on both side	Intersection on northern side (right). Bus stand industry madrasha school & one paved road, on southern side;	restricted	no marking of inner & outer edge line , sign inadequate	average	intense	intense	Intersection exists on sharp curve, No bus bay, bus stops on Carriageway / shoulder, road side features are both at grade & down level.Superelevation is high.
Section 1	link 5 & intersection 6	KARN PARA	Dual Carriageway, 2x7.4 m width, smooth-non skid surface	Avg 1.0-1.2 m paved and 0.75-1.0 earthen shoulder on each side, Drop excessive	10-25 ft, steep slope on each side (less than 1:2)	Huge trees on both side followed by ditch, water logged during monsoon ,	An intersection, Both sides are industrial area	average	no marking of inner & outer edge line , sign inadequate	Average	intense	intense	Encompasses both side of the bridge; No bus bay, bus stops on Carriageway / shoulder; road side features are at down level.
Section 1	link 5 & intersection 6	GANDA	Dual Carriageway, 2x7.5 m width, smooth-non skid surface	Avg 1.0-1.2 m paved and 0.75-1.0 earthen shoulder on each side, Drop excessive	10-25 ft, steep slope on each side (less than 1:2)	open ditch, water logged during monsoon moderate trees on both side	An intersection, Both sides are developed residential & industrial area	average	inadequate , wrongly positioned & non reflective signs; no marking;no speed limit sign/ marking	Average	intense	intense	Intersection exists on curve, connects two minor road both on southern & northern side at 90 deg ;Bus bay exists without shelter but not used; road side features are at grade; wide median gap of 40 m at intersection without sign/ marking invites huge NMVs/ 2/3 wheeler & creates trouble for through traffic.

Section 1	link 7 & intersection 8	THANA BUS STAND	Dual Carriageway, 2x7.5 m width, smooth-non skid surface	Avg 1.0-1.2 m paved and 1-1.5 earthen shoulder on each side, Drop excessive	10-15 ft, steep slope on each side (less than 1:2)	Ditch & moderate trees on both side	An intersection, Both sides are developed residential & market area	average	inadequate , wrongly positioned & non reflective signs; no marking;no speed limit sign/ marking	NA	medium	high	Intersection exists on curve, connects minor road on northern side at 90 deg; no bus bay exists, road side features are at little down grade; median gap of 20 m at intersection without sign/ marking invites hazards
Section 1	link 9 & intersection 10	SAVAR BUS STAND	Dual Carriageway, 7.5-10 m width on left (south),7.5 m on right side; Another 15 ft right of way on both side, smooth-non skid surface	Avg 2.0-4.0 m paved and 3.0-4.5m earthen shoulder on each side, Drop excessive	5-10 ft,	Ditch & moderate trees on both side	An intersection, Both sides are developed residential , commercial, industrial & market area	average	Inadequate, wrongly positioned & non reflective signs; no marking; no speed limit sign/ marking	NA	intense	intense	It connects two minor road on northern & southern side at 90 deg; no bus bay exists, Bus stops on carriageway to pick up & drop passengers, Truck, buses , NMV parks on both side of road/ shoulder; Steel fencing exists for 250 m but people tends to cross it ; One foot over bridge exists but very few people use it; road side features are at little down grade; median gap of 20 m at intersection without sign/ marking invites hazards; conflict between through & local traffic is prominent; at the end of Savar bus stand area the two lane undivided highway starts

Section 1	link 11 & intersection 12	RADIO COLONY/ MIL FARM	Single carriageway of 7.5 m width, smooth-non skid surface	Avg 1.0-1.5 m paved and 2.0-3.5 m earthen shoulder on each side, Drop excessive	5-10 ft,	trees and ditch on both side	Large residential area on south (left), military farm on north (right) side, of the road besides there are school & markets.	good	Inadequate , wrongly positioned & non reflective signs; no marking; no speed limit sign/ marking	NA	intense	intense	No bus bay exists, Bus stops on carriageway to pick up & drop passengers, Pedestrians has to wait long time to cross for high speed through traffic
Section 1	link 11 & intersection 12	PATC	Single carriageway of 7.5 m width, smooth-non skid surface	Avg 1.0-1.5 m paved and 1.0-1.5 m earthen shoulder on each side, Drop excessive	5-10 ft,	Huge trees and ditch on both side	schoool,PATC complex on left & end of Dairy farm on right side	average	Inadequate , wrongly positioned & non reflective signs; no marking;no speed limit sign/ marking	NA	intense	intense	This section is located is on curve section, Bus bay exists but not used, bus stops on Carriageway / shoulders, left side bus bay on down slope,
Section 1	link 13 & intersection 14	JAHANGIRNAGAR UNIVERSITY	Carriageway of 7.5 m width divided by new jersey type median, both lane divided by kerb type barrier, smooth-non skid surface	Avg 1.0-1.5 m paved and 1-1.5 earthen shoulder on each side, Drop excessive	7-10 ft,	Huge trees and ditch on both side	University on left & dairy farm on right side	average	Inadequate , wrongly positioned & non reflective signs; no marking; no speed limit sign/ marking	NA	intense	intense	Two bus bay exists but not used, bus stops on Carriageway / shoulders, Foot over bridge exists but underutilized;No sign/ marking/ painting for median & kerb creates hazard specially at night

Section 1	link 13 & intersection 14	20 Mile Post (20MP)	Single carriageway of 7.5 m width, smooth-non skid surface	Avg 1.0-1.5 m paved and 1-1.5 earthen shoulder on each side, Drop excessive	7-10 ft,	Huge trees and ditch on both side	On left side staff quarter & market area, on right side Ashulia road & shops	average	Inadequate, wrongly positioned & non reflective signs; no marking; no speed limit sign/ marking	NA	intense	intense	Intersection connecting Ashulia road, Two small bus bay exists but not used,
Section 1	link 15 & intersection 16	CANTT AREA	Single carriageway of 7.5 m width, smooth-non skid surface	Avg 1.0-1.5 m paved and 1-1.5 earthen shoulder on each side, Drop excessive	5-10 ft,	Ditch & moderate trees on both side	cantt area, public school on left side, golf ground , office on right	average	Inadequate, wrongly positioned & non reflective signs; Inadequate marking;	NA	intense	intense	Traffic is more disciplined but still in front of public school accidents occurred specially hitting pedestrian; The speed breakers are not well marked
Section 1	link 15 & intersection 16	NABINAGAR	Single carriageway of 7.5 m width, smooth-non skid surface	Avg 1.5-2.5 m paved and 1.5-2.5 earthen shoulder on each side, Drop excessive	5-10 ft,	Ditch & moderate trees on both side	On northern (right) side market & on left side Parking area	average	Inadequate, wrongly positioned & non reflective signs; Inadequate marking;	NA	intense	intense	Major intersection connecting Dhaka-Aricha & Nabinagar -Chandra highway, but no facility exists for safe interchange of traffic flow specially for right turning vehicles though huge traffic use this intersection. Insufficient parking place at right side. Huge NMV, Pedestrian 2/3 wheeler activities are seen in this area.

Section 2	link 17 & intersection 18	SMRITI SAUDHA	Single carriageway of 7.0 m width, smooth-non skid surface	On left side 3.0-10.0 m and right side 2.5-5.0 paved shoulder. On left side brick footpath of 5 m width up to gate exists.	5-10 ft,	Huge trees on both side	Monument on left & parjatan restaurant on right side	average	Inadequate signs & marking;	NA	intense	intense	Attract lot of public during national occasion but enforcement/ management of traffic is poor. Few electric pilon exists on paved shoulder on both sides.
Section 2	link 17 & intersection 18	GONOSHASTHYA CANTER	Single carriageway of 6.5 m non-non skid surface	Avg 1.0-1.5m paved and 1.0-2.5 earthen shoulder on each side, Drop excessive	5-10 ft,	Huge trees on both side particularly on left side	Pharmaceutical factory, Gono Bishaviddalaya on right side & College on left side	average	Inadequate signs & marking;	NA	high	high	Section is on curve without bus bay bus stops on Carriageway / shoulders. Some guard posts are broken in the bridges in this area.
Section 2	link 17 & intersection 18	NAYARHAT	Single carriageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-2.5 earthen shoulder on each side, Drop excessive	5-10 ft,	Huge trees on both side	Market & illegal Truck parking on both side	average	Inadequate signs & marking;	good	high	high	Huge number of illegal truck parking. No bus bay exists, Bus stops on carriageway to pick up & drop passengers, Pedestrians has to wait long time to cross for high speed through traffic

Section 2	link 17 & intersection 18	DHAMRAI TOWN	Single carriageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	8-12 ft,	Huge trees on both side	Filling station, built up area, shops on both side	average	Inadequate signs & marking;	average	intense	high	An Intersection. Bus stops on carriageway to pick up & drop passengers, Pedestrians has to wait long time to cross for high speed through traffic
Section 2	link 19 & intersection 20	JOUPURA	Single carriageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	10-15 ft,	Big trees on both side ,very near to the pavement	Bazar, mosque etc	average	Inadequate signs & marking;	average	high	high	On curve. No bus bay, bus stops on carriageway to pick up & drop passengers
Section 2	link 19 & intersection 20	KALAMPUR	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	8-12 ft,	Huge trees on both side	Bazar,school, mosque etc	average	Inadequate signs & marking;	average	high	high	An Intersection connecting Saturia with minor traffic on cross road. Bus stops on carriageway to pick up & drop passengers, Pedestrians has to wait long time to cross for high speed through traffic
Section 2	link 21 & intersection 22	BALITHA	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 2.5-5.0m paved and 2.0-2.5 earthen shoulderon each side, Drop moderate	8-12 ft,	Trees on both side	Bazar,school, mosque etc	average	warning sign near gate at both at entry & exists of the area, marking good	average	high	high	Located on curve. Bus bay with passenger shed exists but shed allready damaged. Intersection with minor traffic . Drying of paddy on road & cattle may create hazard.

Section 2	link 23 & intersection 24	BARBARIA	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	8-12 ft,	Trees on both side	Bazar,school, mosque etc	average	Inadequate signs & marking;	average	high	high	On curve. No bus bay, bus stops on carriageway to pick up & drop passengers
Section 2	link 23 & intersection 24	NAYADINGI	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	8-12 ft,	Trees on both side	Bazar,shops,school, mosque etc	Restricted	Inadequate signs & marking;	average	high	high	Bus stops near the bridge which is very dangerous. Some guard posts are broken in the bridges in this area.
Section 2	link 23 & intersection 24	2ND GOLARA BRIDGE	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 2-2.5m paved and 1.5 - 2.5 earthen shoulderon each side, Drop moderate	10-15 ft,	Trees on both side	houses, shops etc	Restricted	warning sign near the entry & exists of the area with good marking	average	intense	high	Combination of sharp bend and vertical curve is problematic and difficult to perceive the bend from both direction esecilly at night.Sight distance is inadequate. Few bus pick passengers near bridge
Section 2	link 23 & intersection 24	GOLARA AREA	Single cariageway of 7.0 m width,smooth-non skid surface	Avg 2-3.5m paved and 1.5 - 2.5 earthen shoulderon each side, Drop moderate	10-15 ft,	Trees on both side	schools. houses, shops etc on both side	Restricted	warning sign near the entry & exists of the area with good marking.	average	intense	intense	Features on right side at grade but on left side at down grade.intersection exists, pedestrian and students has to wait to cross the road.

Section 2	link 25 & intersection 26	JAGIR	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	10-15 ft,	Trees on both side	titas gas office, schools. houses, shops etc on both side	Restricted	Inadequate signs & marking;	average	high	high	Located on curve. Superelevation varies appreciably, no bus bay. Bus stops at bridge approaches, which is very narrow.
Section 2	link 25 & intersection 26	MANIKGANJ BUS STAND	Cariageway of 8-11 m width ,smooth-non skid surface	Avg 3.0-4.5m paved shoulder on both side and 1.0-2.5 earthen shoulder on right & 4m on right, drop high	10-15 ft,	Trees on both side	bus stand, market on left, cinema hall, police box on right	average	Inadequate signs & marking;	NA	intense	intense	On left side though no bus bay exists but adequate space avaialable for parking but on right side bus stands on carriageway creating conflict with through traffic. Traffic management by police is poor.Few electric pilons on both side of the pavements.
Section 3	link 27 & intersection 28	MULZAN-TARA	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	10-15 ft, steep slope on each side (less than 1:1.6)	Trees on both side	Bazar,shops,school, mosque etc	average	Inadequate signs & marking;	NA	intense	intense	On curve. No bus bay, bus stops on carriageway to pick up & drop passengers

Section 3	link 27 & intersection 28	TARA BRIDGE	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	10-15 ft, steep slope on each side (less than 1:1.6)	Trees on both side	bazar near a long bridge	average	Inadequate signs & marking;	restricted	intense	high	A long bridge over river kaligonga without any side walk. Vertical drop near bridge is excessive. Bus stop very near to the bridge.
Section 3	link 29 & intersection 30	BANIAJHURI	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	8-15 ft, steep slope on each side (less than 1:1.6)	Trees on both side at the edge of the pavement	Market, mosque, residential area etc	average	Inadequate signs & marking;	average	high	high	Bus stand with insufficient space. Bus stops near bridge approaches.Some guard posts are broken in the bridges in this area.
Section 3	link 29 & intersection 30	PUKHURIA BAZAR	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	8-15 ft, steep slope on each side (less than 1:1.6)	Trees on both side of the pavement	Market, mosque, residential area etc	average	Inadequate signs & marking;	average	high	high	On curve. No bus bay, bus stops on carriageway to pick up & drop passengers

Section 3	link 29 & intersection 30	BARONGAIL	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	8-15 ft, steep slope on each side (less than 1:1.6)	Trees on both side at the edge of the pavement	Bazar,Market, mosque, residential area etc	average	Inadequate signs & marking;	average	high	high	Bus stand at lower grade with insufficient space
Section 3	link 31 & intersection 32	FALSATIA	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	8-15 ft, steep slope on each side (less than 1:1.6)	Trees on both side at the edge of the pavement	Market, mosque, residential area etc	average	Inadequate signs & marking;	average	high	high	On curve. No bus bay, bus stops on carriageway to pick up & drop passengers
Section 3	link 31 & intersection 32	TEPRA	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	8-15 ft, steep slope on each side (less than 1:1.6)	Trees on both side at the edge of the pavement	Bazar, TNO offfice, BRAC, BRTC old bus depo	average	Inadequate signs & marking;	average	intense	intense	No bus bay, bus stops on carriageway to pick up & drop passengers
Section 3	link 31 & intersection 32	UTHOLI	Single cariageway of 6.5 m width,smooth-non skid surface	Avg 1.0-1.5m paved and 1.0-1.5 earthen shoulder on each side, Drop excessive	8-15 ft, steep slope on each side (less than 1:1.6)	Trees on both side at the edge of the pavement	Bazar,Market, mosque, residential area etc	average	Inadequate signs & marking;	average	intense	intense	On curve. No bus bay, bus stops on carriageway at bridge approaches

Section 3	link 31 & intersection 32	ARICHA GHAT	Single cariageway of 6.5 m width divided by new jersy barriersmooth-non skid surface	Avg0.8- 1.0 paved on each side, Drop excessive	8-15 ft, steep slope on each side (less than 1:1.6)	Trees on both side at the edge of the pavement	Bazar,Market, mosque, residential area etc	average	Inadequate signs & marking;	average	intense	intense	Includes intersection. Improper speed breakers, difficult for car to cross as such tends to go to edge thus creates accident.

Table 4.2 Km Wise Highway Inventory of Dhaka- Aricha Highway

Road Code No	Link No	Link Name	Link Length	Survey Year	Start Km	End Km	Surface Type	Shoulder Type	Carriageway width	L_Shoulder	R_Shoulder	L_Embankment	R_Embankment
N5	32	MIRPUR BR-NABINAGAR	22	2001	0	1	Asphalt Concrete	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2001	1	2	Asphalt Concrete	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2001	2	3	Asphalt Concrete	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2001	3	4	Asphalt Concrete	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2001	4	5	Asphalt Concrete	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2001	5	6	Asphalt Concrete	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2001	6	7	Asphalt Concrete	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2001	7	8	Surface Treatment	Unknown	14.64	0.8	0.8	0	0
N5	32	"	22	2001	8	9	Surface Treatment	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2001	9	10	Surface Treatment	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2001	10	11	Surface Treatment	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2001	11	12	Surface Treatment	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2002	12	13	Surface Treatment	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2002	13	14	Surface Treatment	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2002	14	15	Surface Treatment	Earth	14.64	0.8	1	0	0
N5	32	"	22	2002	15	16	Surface Treatment	Earth	14	1	1	0	0
N5	32	"	22	2002	16	17	Surface Treatment	Earth	14.64	0.8	0.8	0	0
N5	32	"	22	2002	17	18	Surface Treatment	Earth	6.5	1	1	0	0
N5	32	"	22	2002	18	19	Surface Treatment	Earth	4.06	0	0	0	0
N5	32	"	22	2002	19	20	Asphalt Concrete	Earth	14.64	0	0	0	0
N5	32	"	22	2002	20	21	Asphalt Concrete	Earth	14.64	0	0	0	0
N5	32	"	22	2002	21	22	Asphalt Concrete	Earth	14.64	0	0	0	0

N5	33	NABINAGAR-MANIKGANJ	29	1999	0	1	Asphalt Concrete	Earth	6.7	2.7	1.8	1.2	1
N5	33	"	29	2000	1	2	Seal Coat	Earth	6.7	1.8	1.8	0.3	0.3
N5	33	"	29	2000	2	3	Seal Coat	Earth	6.7	1.8	1.8	0.3	0.3
N5	33	"	29	2000	3	4	Seal Coat	Earth	11.6	1.8	1.8	2.3	2.4
N5	33	"	29	2000	4	5	Seal Coat	Earth	6.7	1.2	1.2	3.7	3.65
N5	33	"	29	2000	5	6	Seal Coat	Earth	6.7	2.4	2.4	4.3	4
N5	33	"	29	2000	6	7	Seal Coat	Earth	6.7	1.8	1.8	4	4
N5	33	"	29	2000	7	8	Seal Coat	Earth	6.7	1.8	1.8	5	4.65
N5	33	"	29	2000	8	9	Seal Coat	Earth	6.7	1.8	1.8	4.9	4.8
N5	33	"	29	2000	9	10	Seal Coat	Earth	6.7	1.8	1.8	4.8	2.4
N5	33	"	29	2000	10	11	Seal Coat	Earth	6.7	2	3	2.4	2.4
N5	33	"	29	2000	11	12	Seal Coat	Earth	6.7	3	3	2	2
N5	33	"	29	2000	12	13	Seal Coat	Earth	6.7	1.8	1.8	2.5	2.65
N5	33	"	29	2000	13	14	Seal Coat	Earth	6.7	2	2	1.8	2
N5	33	"	29	2000	14	15	Seal Coat	Earth	6.7	2	2	1.8	2
N5	33	"	29	2000	15	16	Seal Coat	Earth	6.7	1.8	1.8	3.5	3.4
N5	33	"	29	2000	16	17	Seal Coat	Earth	6.7	1.8	1.2	1.6	3.65
N5	33	"	29	2000	17	18	Seal Coat	Earth	6.7	2	2	2.4	2.2
N5	33	"	29	2000	18	19	Seal Coat	Earth	6.7	2	1.2	2.8	3.6
N5	33	"	29	2000	19	20	Seal Coat	Earth	6.7	2	1.2	2.1	2.8
N5	33	"	29	2000	20	21	Seal Coat	Earth	6.7	2.7	2.8	3.6	3.65
N5	33	"	29	2000	21	22	Seal Coat	Earth	6.7	3.6	2	2	2
N5	33	"	29	2000	22	23	Seal Coat	Earth	6.7	3	3	2	1.2
N5	33	"	29	2000	23	24	Seal Coat	Earth	6.7	1.6	1.8	1.8	3.65
N5	33	"	29	2001	24	25	Asphalt Concrete	Earth	6.7	2.13	2.44	4	3
N5	33	"	29	2001	25	26	Asphalt Concrete	Earth	6.7	2.5	2.4	3.2	2.5
N5	33	"	29	2001	26	27	Asphalt Concrete	Earth	6.7	2.5	2.44	3	6.1

N5	33	"	29	2001	27	28	Asphalt Concrete	Earth	6.7	2	1.9	3	4
N5	33	"	29	2001	28	29	Asphalt Concrete	Earth	6.7	2.46	2.44	3	7
N5	33	"	29	2001	29	30	Seal Coat	Earth	6.7	2.46	2.44	3	3.2
N5	34	**MANIKGANJ-ARICHA**	24	2000	0	1	Asphalt Concrete	Earth	6.7	2.25	2.5	3.65	6.1
N5	34	"	24	2000	1	2	Asphalt Concrete	Earth	6.7	2.15	2	3.6	6.1
N5	34	"	24	2000	2	3	Seal Coat	Earth	6.7	2.5	2.4	3.66	6.1
N5	34	"	24	2000	3	4	Seal Coat	Earth	6.7	2.7	2.74	4.6	2.9
N5	34	"	24	2001	4	5	Seal Coat	Earth	6.7	2.3	2.74	4.5	4.95
N5	34	"	24	2002	5	6	Asphalt Concrete	Earth	6.7	2.74	2.74	2.4	3.66
N5	34	"	24	2002	6	7	Asphalt Concrete	Earth	6.7	2.4	2.74	2.4	3.66
N5	34	"	24	2002	7	8	Asphalt Concrete	Earth	6.7	2.15	1.5	2.4	4.25
N5	34	"	24	2002	8	9	Seal Coat	Earth	6.7	2.44	2.13	2.74	3.66
N5	34	"	24	2002	9	10	Asphalt Concrete	Earth	6.7	2.15	1.55	2.75	3.66
N5	34	"	24	2002	10	11	Seal Coat	Earth	6.7	2.43	1.2	1.9	3.05
N5	34	"	24	2002	11	12	Seal Coat	Earth	6.7	1.82	1.55	2.4	2.5
N5	34	"	24	2002	12	13	Seal Coat	Earth	6.7	1.8	1.2	2.4	3.65
N5	34	"	24	2002	13	14	Seal Coat	Earth	6.7	2.4	2.2	2.2	3.1
N5	34	"	24	2002	14	15	Seal Coat	Earth	6.7	1.75	1.75	2.15	3.25
N5	34	"	24	2002	15	16	Asphalt Concrete	Earth	6.7	2	2	2.4	3.5
N5	34	"	24	2002	16	17	Asphalt Concrete	Earth	6.7	2.4	2.3	2.3	1.75
N5	34	"	24	2002	17	18	Asphalt Concrete	Earth	6.7	2.3	2.3	2.4	2.4
N5	34	"	24	2002	18	19	Asphalt Concrete	Earth	6.7	1.75	2.5	1.75	1.75
N5	34	"	24	2002	19	20	Asphalt Concrete	Earth	6.7	2.5	1.5	2.4	3.5
N5	34	"	24	2002	20	21	Asphalt Concrete	Earth	6.7	2	2	2.4	3.5
N5	34	"	24	2002	21	22	Asphalt Concrete	Earth	6.7	2.2	1.75	2.3	3.6
N5	34	"	24	2002	22	23	Asphalt Concrete	Earth	6.7	2	2	2.4	3.6
N5	34	"	24	2002	23	24	Asphalt Concrete	Earth	12.2	2.75	2.75	2.4	3.65
N5	34	"	24	1990	24	24.5	Seal Coat	Unknown	10	0.3	0.3	0	0

Table A 4.3 Snap Shot of Transcription Sheet

Serial	UZ	Year	Date	Time	Day (D)/Night (N)	Location	Km Reference	Veh Type	Severity	Collision type	Killed	Seriously Injured	Injured	Property Damage	Intersection(Int)/ Link(Mid Block)	Remarks
1	Savar	1990	1-Jan	0635	D	Hemayetpur	19.5	Bus	Fatal	Unknown	1	1			Link	
2	Savar	1991	11-Jul	1715	D	Cantt Golf Club	33.5	Unidentified	Fatal	Pedestrian	1	1			Link	
3	Savar	1991	25-Dec	0725	D	Rajphulbaria	21.7	T	Fatal	Unknown	1	1			Int	
4	Savar	1992	24-Apr	2000	N	Aminbazar	12.7	1*T & 1*Bus	Grievous	Unknown		1		TK 40000	Link	
5	Savar	1993	28-Jan	1130	D	Hemayetpur	19.4	1*T & 1*MC	Grievous	Rear End		2			Link	
6	Savar	1994	6-Oct	0930	D	Hemayetpur	19.2	1*Bus & 1*MC	Fatal	Unknown	1	1			Link	
7	Savar	1995	16-Apr	UNKNOWN	N	Hemayetpur	19.5	Unidentified	Grievous	Pedestrian		1			Link	
8	Savar	1995	16-Dec	1400	D	Cantt MP Check Post-2	33.6	MB	Grievous	Unknown		1			Link	
9	Savar	1996	22-Feb	1100	D	Shritisaudha	34.2	T	Grievous	Unknown		1			Link	
10	Savar	1997	20-Jan	2000	N	Thana Road	24.8	Bus	Fatal	Pedestrian	1				Int	
11	Savar	1998	30-Mar	1000	D	Nabinagar	34.0	2*T	Fatal	Side swipe	1	1			Int	
12	Savar	1998	24-Jul	1040	D	Zorepool	20.3	Unidentified	Fatal	Pedestrian	1	1			Link	

13	Savar	1999	2-Jul	0400	N	Nabinagar	33.7	Bus	Fatal	Dropped	1	1			Link	
14	Savar	1999	9-Sep	1300	D	Rajphulbaria	21.9	2*Bus	Fatal	Hit Park Veh	1	1			Link	
15	Savar	1999	23-Sep	0705	D	Gonoshaisyha Center	35.4	Bus	Fatal	Drop from Roof	1	1			Link	
16	Savar	1999	15-Oct	1900	N	Kornpara	23.2	Unidentified	Fatal	Pedestrian	1				Link	
17	Savar	2000	5-May	1200	D	Turag	14.3	T	Fatal	Over Turned	1	1			Link	
18	Savar	2001	23-Jan	2200	N	Chistia Pump	12.8	Unidentified	Fatal	Pedestrian	1				Link	
19	Savar	2001	30-Jan	0830	D	Aminbazar	12.5	1*Bus & 1*Rickshaw	PD	Rear End				PD	Link	
20	Savar	2001	17-Feb	0715	D	Radio Colony	28.0	Unidentified	Fatal	Pedestrian	1				Link	
21	Savar	2002	7-Jan	1405	D	Salehpur	13.5	Bus	Fatal	Over Turned	24	10	1		Link	overturned in the river near the bridge
22	Savar	2002	31-Dec	1345	D	Savar BS	25.6	Bus	Grievous	Pedestrian		1			Link	
23	Savar	2003	8-Apr	0630	D	PATC	28.3	Bus	Fatal	Unknown	1	1			Link	
24	Savar	2003	31-May	0600	N	Mil Farm	28.1	1*T & 1*CYCLE	Fatal	Rear End	1	1			Link	
25	Dhamrai	1990	14-Aug	0900	D	Dhulivita	40.0	MB	Simple	Pedestrian			5		Link	
26	Dhamrai	1991	12-Aug	0750	D	Kalachanpur	42.5	Bus	Fatal	Unknown	1				Link	7 month RI & 3000 TK Fine
27	Dhamrai	1992	25-Oct	0900	D	Barbaria	54.3	Bus	Fatal	Unknown	1	2			Link	

28	Dhamrai	1993	17-Jun	2000	N	Shrirampur	48.0	Car	Fatal	Pedestrian	1				Link	
29	Dhamrai	1994	25-Feb	2030	N	Balitha	50.7	Unidentified	Fatal	Pedestrian	1				Link	
30	Dhamrai	1995	12-Aug	0400	N	Islampur	37.3	Unidentified	Grievous	Unknown		1			Link	
31	Dhamrai	1996	1-Aug	1030	D	Dautia	44.6	Bus	Fatal	Pedestrian	1			PD	Link	
32	Dhamrai	1997	5-May	0630	D	Balitha	51.5	T	Fatal	Pedestrian	1	1			Link	
33	Dhamrai	1998	21-Mar	1400	D	Joupura	41.8	T	Fatal	Pedestrian	1	1			Link	
34	Dhamrai	1999	28-Sep	2115	N	Dhulivita	39.6	1*T & 1*Bus	Grievous	Head On		3			Link	
35	Dhamrai	2000	18-Jun	0515	N	Dhamrai Dakhin Para	38.1	2*T	Fatal	Rear End	1	1			Link	
36	Dhamrai	2001	25-Jul	2045	N	Dhamrai thana Rd	38.5	1*T & 1*Bus	Fatal	Head On	2	5			Link	
37	Dhamrai	2002	8-Aug	1100	D	Choto kalampur	46.3	1*Bus & 1*Micro	Fatal	Head On	1	1		2E+05	Link	
38	Dhamrai	2003	13-May	1500	D	Islampur	37.5	Bus	Fatal	Pedestrian	1				Link	
39	Saturia	1991	10-Jun	1920	N	Golara	57.3	T	PD	Unknown				PD	Link	
40	Saturia	1991	15-Aug	1500	D	Golara	57.2	T	Grievous	Unknown		1			Link	
41	Saturia	1992	6-Jan	1815	N	Golara	57.4	T	Grievous	Pedestrian		1			Link	
42	Saturia	1993	29-Nov	1735	N	Nyadingi	55.8	Bus	Fatal	Pedestrian	1				Link	

43	Saturia	1994	27-Mar	1845	N	Golara	57.6	T	Simple	Unknown			2		Int	
44	Saturia	1996	24-Apr	1600	D	2nd Golara Br Area	56.2	T	Fatal	Pedestrian	1	1			Link	
45	Saturia	1997	17-Dec	0500	N	Golara	57.2	Unidentified	Fatal	Pedestrian	1				Link	
46	Saturia	1998	5-Oct	1500	D	Golara	57.6	T	Fatal	Pedestrian	1				Int	
47	Saturia	1999	7-Nov	0430	N	2nd Golara Br Area	56.2	T	Grievous	Pedestrian		1			Link	
48	Saturia	2000	16-May	1145	D	Nyadingi	55.8	Car	Grievous	Pedestrian		1			Link	
49	Saturia	2001	22-Oct	1945	N	Nyadingi	55.8	T	Fatal	Over Turned	3	5	4		Link	
50	Saturia	2002	12-Sep	1130	D	Golara	57.5	2*Bus	Grievous	Head On		7			Link	
51	Saturia	2002	12-Dec	1100	D	Nyadingi	55.8	Bus	Grievous	Pedestrian		1			Link	
52	Saturia	2003	17-Apr	2215	N	Golara	57.5	Unidentified	Fatal	Pedestrian	1				Link	
53	Saturia	2003	20-May	1100	D	Nyadingi	55.7	Bus	Fatal	Pedestrian	1				Link	
54	Manikgonj	1990	26-Apr	1300	D	Jagir	61.2	Bus	Grievous	Unknown		3			Link	
55	Manikgonj	1991	22-Jun	1015	D	Jagir	61.2	Bus	Fatal	Unknown	1	5			Link	
56	Manikgonj	1992	15-Jul	1100	D	Bus Stand Area	63.1	T	Fatal	Over Turned	1				Link	
57	Manikgonj	1993	12-Apr	0930	D	Mulzan	67.2	Bus	Fatal	Unknown	1				Link	
58	Manikgonj	1994	1-Jul	1705	D	Uchutia	62.1	Bus	Fatal	Pedestrian	1	3			Link	

59	Manikgonj	1995	23-Mar	1005	D	Uchutia	62.1	Bus	Simple	Unknown			2		Link	
60	Manikgonj	1999	5-Jan	1015	D	Morundai	66.0	1*T & 1*MC	Grievous	Rear End		1			Link	
61	Manikgonj	2001	13-Feb	1500	D	BTC	58.9	Bus	Fatal	Pedestrian	1				Link	
62	Manikgonj	2002	5-May	1100	D	Mulzan	67.4	Micro	Grievous	Hit Object		1	4		Link	Hit Tree
63	Manikgonj	2003	27-Jan	1015	D	Bisic	58.4	1*T & 1*Bus	Fatal	Head On	1	5			Link	
64	Manikgonj	2003	25-Feb	0830	D	Akiz Factory	67.8	Bus	Fatal	Pedestrian	1				Link	
65	Ghior	1990	1-Apr	0910	D	Joka	71.9	1*T & 1*MB	Grievous	Rear End		1			Link	
66	Ghior	1992	2-Oct	1010	D	Baniajhuri	70.5	T	Grievous	Unknown		2			Link	
67	Ghior	1996	9-Jun	1230	D	Joka	72.0	Bus	Fatal	Over Turned	21	45			Link	
68	Ghior	1997	31-Jan	0750	D	Joka	71.9	Bus	Fatal	Over Turned	1	7			Link	
69	Ghior	1998	15-Oct	1445	D	Baniajhuri	70.5	Bus	Fatal	Pedestrian	1				Link	
70	Ghior	1998	8-Dec	1500	D	Pukhuria	73.4	Bus	Fatal	Pedestrian	1				Link	
71	Ghior	1999	30-Dec	0735	D	Joka	72.0	Bus	Fatal	Pedestrian	1				Link	
72	Ghior	2001	9-Mar	1030	D	Dhulundai	75.2	Bus	Fatal	Pedestrian	1				Link	
73	Ghior	2002	25-Jun	0945	D	Baniajhuri	70.5	T	Grievous	Unknown		5			Link	
74	Ghior	2003	18-May	1530	D	Pukhuria	73.5	Bus	Fatal	Over Turned	1				Link	
75	Shibalaya	1990	25-Sep	1235	D	Mahadevpur	76.9	Bus	Fatal	Pedestrian	1				Link	
76	Shibalaya	1992	29-Sep	0950	D	Aricha Ghat	87.2	Bus	Fatal	Pedestrian	1				Link	
77	Shibalaya	1994	19-Jan	1540	D	Barongail Bus Stand	77.8	T	Fatal	Over Turned	1	2	3		Int	

78	Shibalaya	1998	9-Feb	0550	N	Tepra	82.3	2*Bus	Fatal	Head On	1	2			Link	
79	Shibalaya	1999	30-Nov	0350	N	Barongail	78.0	Bus	Fatal	Unknown	1	1			Link	
80	Shibalaya	2000	8-Nov	1145	D	Shibalaya	86.3	T	Fatal	Pedestrian	1				Link	
81	Shibalaya	2001	24-Jul	1000	D	Aricha Ghat Junt	87.3	T	Fatal	Pedestrian	1				Int	
82	Shibalaya	2002	15-Sep	1100	D	BRIDGE	79.9	Bus	Fatal	Pedestrian	1				Link	
83	Shibalaya	2003	11-Jun	UNKNOWN	N	Falsatia	80.3	Unidentified	Fatal	Pedestrian	1				Link	

Table A 4.4 Inventories of National Highways

	Landmark		Kilometre Value
	Amin Bazar Bridge (Turag River)		11.9
	Amin Bazar(R)		12.5
	Mafid-E-Alam High School (R) Chistia Petrol Pump(L)		12.7
	Bridge		13.6
	Katcha Road Intersection (L)		14.5
	Raj Filling Station (Jamuna) (R)		15.7
	Bridge		16.6
	Baliapur Islamia Madrasa (R)		16.9
	Baliapur Bus Stand		17.0
	Bridge		17.8
KM	Aricha 70 Savar 8 Sugandha Property Development (R)	Dhaka 18	18.0
	Petrol Pump (Padma) (R)		18.1
	Sony Petrol Pump (jamuna) (L)		18.3
	Nasim Filling Station (L) Anwar Filling Station (R)		18.5
	Masjid Baitul Habib (R)		18.7
	Bangladesh Rubber Roll Industries (R)		18.8
	Hemayetpur Bus Stand Singair (L) Intersection		19.0
	Culvert Zia (DAEWOO) workshop (R)		19.2
	Chalantica Property Development (L)		19.7
	Auto Rice Mill (R)		19.9
	Bridge		20.2
	Culvert Tetuljhara Bus Stand		20.4
	SINGER Industries (R)		20.5
	United Phosphoras Ltd.		20.7
	Seema Pharmaceuticals (L)		21.0
	Raj Phulbaria Bus Stand Bengal Oil Mills Ltd. (R)		21.7
	Bally Keds (L)		21.9
	Police Officers Co-operative Residential area (R)		22.1
	Bridge		22.4
	Savar Municipally stand		22.5
	Bank Town Resedential area (R)		22.7
	Bridge		22.9
	IMI Factory (L)		23.1
	H.R Textile (L)		23.2
	Karnapara Bus stand		23.2
	Anlima Yarn Dyeing Factory (R)		23.4
	Culvert Madhumoti Ceramics (R)		23.7
	Koreshi Plants (L)		24.0
	Ganda Bus Stand TNO Office (L) Intersection		24.2
	Chowdhury Filling Station (Meghna) (R) Savar Thana Bus Stand		24.7
	Savar College (L) Intersection		24.8
KM	Dhamrai 13 Padma Printers (L)	Dhaka 25	25.0

Dhaka.xls/N-5

N5

	Landmark		Kilometre Value
KM	Manikganj 20 Aricha 44	Savar 18 Dhaka 44	44.0
	Munia PVC Industries (R) Madrasa Al Manara (R)		44.3
	Deep Textile Mills (R)		44.6
KM	Manikganj 19 Aricha 43	Savar 19 Dhaka 45	45.0
	Saturia Intersection (R) Kalampur Bus Stand		45.3
KM	Manikganj 18 Aricha 42	Savar 20 Dhaka 46	46.0
	Culvert		46.1
	Bridge		46.3
	Culvert		46.5
KM	Manikganj 17 Aricha 41	Savar 21 Dhaka 47	47.0
	Sutipara Bus stand		47.1
	Sutipara Bridge		47.2
	Shrirumpur Bazar/ Bus Stand Shirumpur Bridge		48.0
	Culvert		48.4
	Bridge		48.7
KM	Manikganj 15 Aricha 39	Savar 23 Dhaka 49	49.0
	Culvert		49.3
	Bridge		49.7
	Bridge		50.0
KM	Manikganj 14 Aricha 38	Savar 24 Dhaka 50	50.0
	Culvert		50.8
KM	Manikganj 13 Aricha 37	Savar 25 Dhaka 51	51.0
	Bethuli Bus Stand Rajnagar (L) Intersection		51.3
	Culvert		51.9
KM	Manikganj 12 Aricha 36	Savar 26 Dhaka 52	52.0
KM	Manikganj 11 Aricha 35	Savar 27 Dhaka 53	53.0
KM	Manikganj 10 Aricha 34	Savar 28 Dhaka 54	54.0
	Barobaria Bazar / Bus Stand		54.3
	Dhaka-Manikganj District boundary		54.3
	Bridge		54.4
	Culvert		54.9
KM	Manikganj 9 Aricha 33	Savar 29 Dhaka 55	55.0
	Nayadingi Bus Stand		55.8
	Bridge		55.8
KM	Manikganj 8 Aricha 32	Savar 30 Dhaka 56	56.0
	Bridge		56.6
KM	Manikganj 7 Aricha 31	Savar 31 Dhaka 57	57.0

DHAKA - ARICHA NATIONAL HIGHWAY

N5

	Landmark		Kilometre Value
KM	Aricha 8	Dhaka 80 Manikganj 16	80.0
	Falsatia Bazar / Bus Stand		80.2
	Bridge		80.9
KM	Aricha 7 REB Sub Station (L)	Dhaka 81 Manikganj 17	81.0
	Titas Gas (L)		81.7
	REB Office (L)		81.9
KM	Aricha 6	Dhaka 82 Manikganj 18	82.0
	Tepra Bus Stand Shibaloy TNO Office (R)		82.3
	BRAC (L)		82.7
	BRTC Old Bus Dipo (L)		82.8
	Shibaloy High School (R)		83.0
KM	Aricha 5	Dhaka 83 Manikganj 19	83.0
	Shibaloy Thana Health Complex		83.1
	Utholi Bridge		83.3
	Truck Stand		83.9
KM	Aricha 4	Dhaka 84 Manikganj 20	84.0
	Bridge		84.5
KM	Aricha 3 Bridge	Dhaka 85 Manikganj 21	85.0
	Bridge		85.3
	Bridge		85.7
KM	Aricha 2	Dhaka 86 Manikganj 22	86.0
	Sadar Uddin College (L)		86.0
	Culvert		86.6
	Shibaloy Govt. High School (L) Shibaloy Govt. Primary School (L)		86.9
	Agrani Bank (L)		87.0
	BIWTA Office (L)		87.2
	Aricha Ghat Toll Box (L) Eidgah (L)		87.2
	Aricha ghat Traffic more Shibaloy Police Station (L)		87.3

Table A 5.1 Result of Limited Field Volume Survey

Section	Year	Traffic Volume						Estimated Traffic	Change
		Truck	Bus/Minibus	Light Veh	2/3 Wheeler	NMV	Total Traffic		
Section-1	2003	2087	4693	5020	1709	1528	15037	14285	5.00
Section-2	2003	4508	5659	4879	2987	4346	22379	23387	-4.50
Section-3	2003	1210	942	811	1215	1542	5720	5634	1.50

Note: Three days limited count was conducted for 0800 to 1000 hours and 1800 to 2000 hours

Table A 5.1 Actual Traffic Volume of section-1

Sl.	Year	Truck	Bus/minibus	Light Veh (LV)	Motorized 4Wheel	2/3 Wheel Veh	Total Motorized	NMV	Total Traffic	change of Traffic(%)	Remark
6	1995	3747	2186	3043	8976	2208	11184	1130	12314		Based on actual RHD data.
7	1996	4279	2245	2257	8781	2572	11353	1224	12577	1.5	
8	1997	4630	2435	2449	9514	2790	12304	1318	13622	8.3	
9	1998	2760	3808	2202	8770	1584	10354	1420	11774	-15.8	
10	1999	3893	3278	1932	9103	1426	10529	1529	12058	1.69	
11	2000	1650	3649	3806	9105	1855	10960	941	11901	4.03	
12	2001	1769	3929	4099	9797	1499	11296	1017	12313	3.06	

Table A 5.2 Actual Traffic Volume of section-2

Sl.	Year	Truck	Bus/minibus	Light Veh (LV)	Motorized 4Wheel	2/3 Wheel Veh	Total Motorized	NMV	Total Traffic	change of Traffic(%)	Remark
6	1995	3747	2186	3043	8976	2208	11184	1130	12314		Based on actual RHD data.
7	1996	4279	2245	2257	8781	2572	11353	1224	12577	1.5	
8	1997	4630	2435	2449	9514	2790	12304	1318	13622	8.37	
9	1998	2760	3808	2202	8770	1584	10354	1420	11774	-15.8	
10	1999	3893	3278	1932	9103	1426	10529	1529	12058	1.69	
11	2000	1650	3649	3806	9105	1855	10960	941	11901	4.03	
12	2001	1769	3929	4099	9797	1499	11296	1017	12313	3.06	

Table A 5.3 Actual Traffic Volume of section-3

Sl.	Year	Truck	Bus/minibus	Light Veh (LV)	Motorized 4Wheel	2/3 Wheel Veh	Total Motorized	NMV	Total Traffic	change of Traffic(%)	Remark
6	1995	3747	2186	3043	8976	2208	11184	1130	12314		Based on actual RHD data.
7	1996	4279	2245	2257	8781	2572	11353	1224	12577	1.51	
8	1997	4630	2435	2449	9514	2790	12304	1318	13622	8.37	
9	1998	2760	3808	2202	8770	1584	10354	1420	11774	-15.8	
10	1999	3893	3278	1932	9103	1426	10529	1529	12058	1.69	
11	2000	1650	3649	3806	9105	1855	10960	941	11901	4.09	
12	2001	1769	3929	4099	9797	1499	11296	1017	12313	3.06	

Table A 5.4 Accident Rate in terms of Veh-Km Travel for Section 1

Year	Total Motorized Veh Km (million)	Fatality Rate per 100 Million veh km	Fatal accident rate per100 million veh km	Total Accident Rate per100 million veh km	Change in Fatality Rate	Change in Fatal Accident Rate	Change in Total Accident Rate
1990	50.01	61.99	61.99	97.98			
1991	54.71	36.56	36.56	40.21	41.02%	41.02%	58.96%
1992	59.84	38.44	38.44	91.92	-5.14%	-5.14%	-128.57%
1993	65.44	51.95	51.95	129.88	-35.16%	-35.16%	-41.30%
1994	71.58	60.07	60.07	145.29	-15.63%	-15.63%	-11.86%
1995	78.28	45.99	43.43	94.53	23.45%	27.70%	34.94%
1996	77.68	61.79	56.64	101.70	-34.37%	-30.42%	-7.59%
1997	84.17	55.84	55.84	84.35	9.64%	1.42%	17.06%
1998	74.96	42.69	42.69	76.04	23.55%	23.55%	9.85%
1999	77.23	37.55	37.55	51.80	12.03%	12.03%	31.88%
2000	78.38	54.86	53.58	57.41	-46.09%	-42.69%	-10.84%
2001	83.02	43.36	43.36	65.05	20.95%	19.07%	-13.30%
2002	89.35	80.58	49.24	70.51	-85.83%	-13.56%	-8.40%
2003	96.17	66.55	56.15	76.95	17.42%	-14.02%	-9.13%
Total	1040.81	738.23	687.51	1183.63	-0.74	-0.32	-0.78
Avg	74.34	52.73	49.11	84.54	-5.70%	-2.45%	-6.02%

Note Fatality rate decreases in 2001 after completion of JBARP project, also decreses in 1998 may due to shift of large vol of traffic from this corridor

Table A 5.5 Accident Rate in terms of Veh-Km of Travel for Section 2

Year	Total Motorized Veh Km (million)	Fatality Rate per 100 Million veh km	Fatal accident rate per100 million veh km	Total Accident rate per100 million veh km	Change in Fatality Rate	Change in Fatal accident rate	Change in Total Accident Rate
1990	80.1	30.0	27.5	51.2			
1991	87.6	24.0	24.0	40.0	19.9%	12.6%	21.9%
1992	99.6	26.1	20.1	38.2	-8.9%	16.2%	4.5%
1993	104.6	29.6	26.8	43.0	-13.4%	-33.2%	-12.7%
1994	114.4	24.5	19.2	51.6	17.4%	28.1%	-19.9%
1995	125.1	31.2	24.8	34.4	-27.4%	-28.9%	33.3%
1996	141.7	20.5	19.1	32.5	34.3%	23.1%	5.6%
1997	154.6	27.2	18.8	40.7	-32.7%	1.6%	-25.5%
1998	142.0	36.6	28.2	38.0	-34.8%	-50.1%	6.7%
1999	145.0	20.7	20.0	34.5	43.5%	29.0%	9.3%
2000	148.7	22.9	20.2	28.9	-10.5%	-0.9%	16.1%
2001	150.8	22.5	20.6	27.2	1.4%	-1.9%	6.0%
2002	162.5	17.8	14.2	25.8	20.8%	31.1%	4.9%
2003	175.2	22.8	21.7	28.5	-27.9%	-53.2%	-10.4%
Total	1832.1	356.3	304.8	514.4	-18.3%	-26.4%	39.9%
Avg	130.9	25.5	21.8	36.7	-1.4%	-2.0%	3.1%

Table A 5.6 Accident Rate in terms of Veh-Km travel for Section 3/ Major link 34

Year	Total Motorized Veh Km (million)	Fatality Rate (100 Million veh km)	Fatal accident rate per100 million veh km	Total accident Rate per 100 million veh km	Change in Fatality Rate	Change in Fatal accident rate	Change in Total Accident Rate
1990	16.30	79.74	79.74	184.02			
1991	17.88	89.48	83.89	139.81	-12.21%	-5.19%	24.03%
1992	19.53	66.56	61.44	128.00	25.61%	26.76%	8.44%
1993	21.33	103.13	103.13	192.20	-54.94%	-67.85%	-50.15%
1994	23.30	68.66	68.66	133.02	33.43%	33.43%	30.79%
1995	25.47	145.25	137.40	176.65	-111.56%	-100.13%	-32.80%
1996	25.36	181.40	102.53	169.57	-24.89%	25.38%	4.01%
1997	26.08	69.03	69.03	103.54	61.95%	32.67%	38.94%
1998	23.27	90.23	90.23	98.82	-30.71%	-30.71%	4.56%
1999	23.67	97.18	92.96	135.21	-7.71%	-3.03%	-36.82%
2000	24.08	78.90	74.74	107.96	18.82%	19.59%	20.15%
2001	25.94	73.24	73.24	138.77	7.17%	2.02%	-28.53%
2002	27.96	82.27	82.27	114.46	-12.33%	-12.33%	17.52%
2003	30.13	99.55	99.55	132.74	-21.02%	-21.02%	-15.97%
Total	330.32	1324.61	1218.80	1954.79	-128.39%	-100.41%	-15.84%
Avg Value	23.59	94.62	87.06	139.63	-9.88%	-7.72%	-1.22%

Table A 5.7 Accident Statistics of Shrirumpur area (47.9-48.7km, Control Site 1)

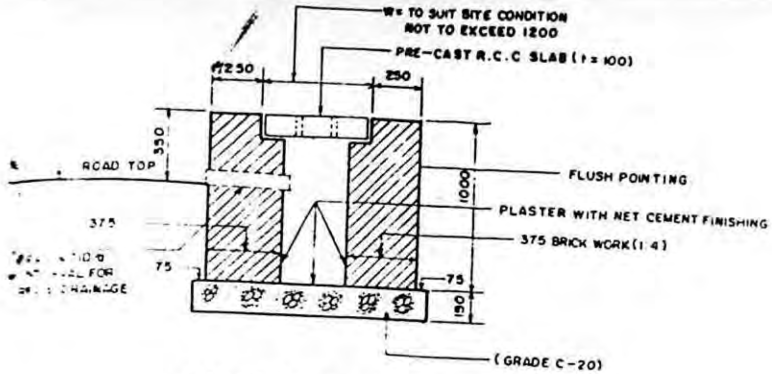
Accident	Before Period				After period		Change of Accident	
	Total (1990-2000)		RHD Considered Period (1996-1998)		(July 2002-Jun2003)			
Severity	Total No	Average/Year	Total No	Average/Year	Total No	Average/Year	Total period	RHD period
Fatal	7	0.64	3	1.00	1	1	57.14	. 0.00
Gravies	8	0.73	2	0.67		0	-100.00	-100.00
Simple	1	0.09	0	0.00		0	-100.00	0.00
PD	1	0.09	1	0.33		0	-100.00	-100.00
Total	17	1.55	6	2.00	1	1	-35.29	-50.00

Table A 5.8 Accident Statistics of Barbaria area (54.1-54.3 km, Control Site 2)

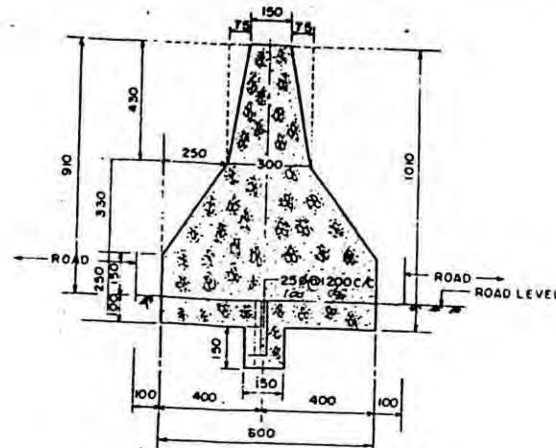
Accident	Before Period				After period		Change of Accident	
	Total (1990-2000)		RHD Considered Period (1996-1998)		(July 2002-Jun2003)			
Severity	Total No	Average/Year	Total No	Average/Year	Total No	Average/Year	Total period	RHD period
Fatal	10	0.91	5	1.67	2	2	120.00	16.67
Gravies	6	0.55	4	1.33			-100.00	-100.00
Simple							0.00	0.00
PD							0.00	0.00
Total .	16	1.45	9	3.00	2	2	37.50	-50.00

Table A 5.9 Accident Statistics of Jagir area (61.1-61.6 km, Control Site 3)

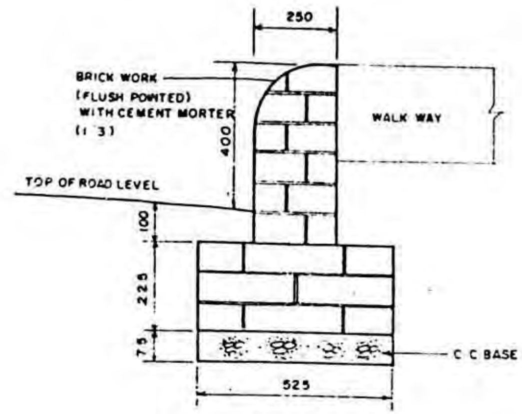
Accident	Before Period				After period		Change of Accident	
	Total (1990-2000)		RHD Considered Period (1996-1998)		(July 2002-Jun2003)			
Severity	Total No	Average/Year	Total No	Average/Year	Total No	Average/Year	Total period	RHD period
Fatal	21	1.91	6	2.00	1	1	-47.62	-50.00
Gravies	11	1.00	1	0.33	1	1	0.00	200.00
Simple	5	0.45		0.00			-100.00	0.00
PD		0.00		0.00			0.00	0.00
Total	37	3.36	7	2.33	2	2	-40.54	-14.29



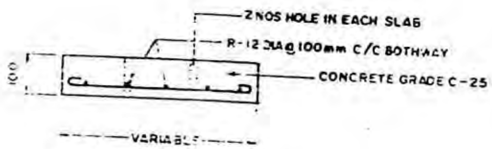
RAISED FOOT PATH & DRAIN



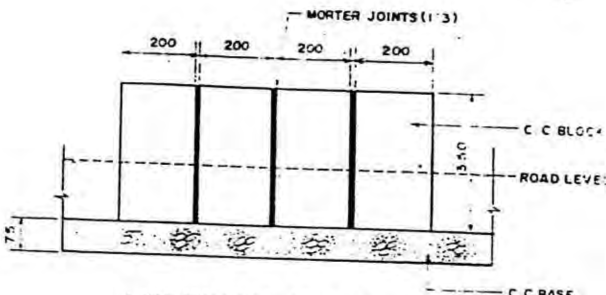
CONCRETE MEDIAN BARRIER



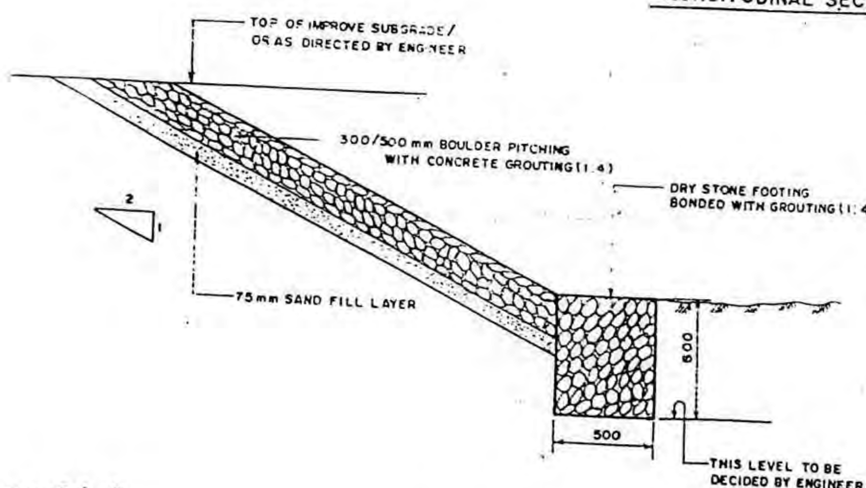
KERB DETAIL FOR WALK WAY



DETAIL OF PRE-CAST SLAB (L=500)



LONGITUDINAL SECTION

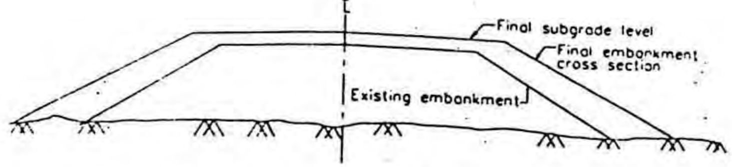


BOULDER PITCHING ON SLOPES

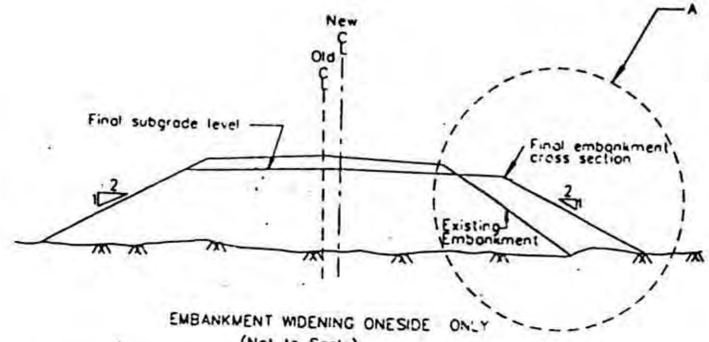
Figure A4.1

(YAN XIAOLIN)
Authorised Representative
CNC-MN J/V

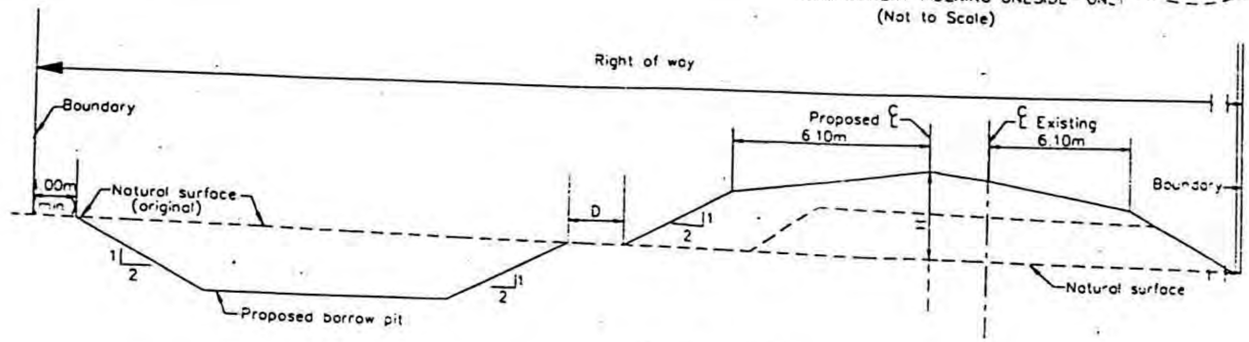
	CONTRACT NO. 5
GOVERNMENT OF THE PEOPLES REPUBLIC OF BANGLADESH MINISTRY OF COMMUNICATIONS ROADS AND HIGHWAYS DEPARTMENT.	
JAMUNA BRIDGE ACCESS ROAD PROJECT. (FINANCED BY ASIAN DEVELOPMENT BANK)	
MISCELLANEOUS DETAIL (TYPICAL)	
APPROVED BY: CHECKED BY: R.I	DATE: APRIL 1996
PACIFIC CONSULTANTS INTERNATIONAL Tokyo Japan TAMS CONSULTANTS INC. New York U.S.A	SCALE: NOT TO SCALE



EMBANKMENT WIDENING BOTH SIDES
(Not to Scale)



EMBANKMENT WIDENING ONESIDE ONLY
(Not to Scale)



NOT TO SCALE

CONTRACT	WIDTH W(m)
01,02,03,04,06 07,08,09,10 & 11	25.00m–36.00m
05	33.00m–40.00m

TABLE 2
RIGHT OF WAY WIDTH
(without borrow pit)

H	D	h
<1.00	<1.50	>2H
1.00–2.50	<2H	>1.5H
>2.50	<3H	>H

TABLE 1
BORROW PIT DIMENSIONS

NOTE

1. Depth of the borrow pit, h, is measured from the general original natural surface of the area regardless of whether borrow pits already exist.
2. The engineer may increase D or reduce h or prohibit borrow activities completely if in his opinion the stability of the road embankment will be reduced unacceptably.
3. No borrow pit will be permited adjacent to bridge approches. For this purpose a bridge approach is defined as that length of road between the bridge abutment and the tangent point of the vertical curve where the road profile changes from the general level of the alignment.
4. Right of way widths shown are approximate only and may be subjected to adjustment.

(YAN XIAOLIN)
Authorised Representative
CNC-MN J/V

GOVERNMENT OF THE PEOPLES REPUBLIC OF BANGLADESH MINISTRY OF COMMUNICATIONS ROADS AND HIGHWAYS DEPARTMENT	
JAMUNA BRIDGE ACCESS ROADS PROJECT (FINANCED BY ASIAN DEVELOPMENT BANK)	
ROAD NAME : MIR PUR – SAVAR	CONTRACT NO. 05
EMBANKMENT WIDENING AND BORROW PIT	CHAINAGE : As Above
APPROVED BY : CHECKED BY :	DATE : Sept. 1995
PACIFIC CONSULTANTS INTERNATIONAL, Tokyo, Japan. TAMS CONSULTANTS, INC. New York, U.S.A. in association with. SHELADIA ASSOCIATES, INC. Maryland, U.S.A. DEVELOPMENT DESIGN CONSULTANTS LTD. House No. 70, Road No. 7, Gulshan, Dhaka-1217	SCALE : AS SHOWN
	DWG NO :BP/ST-I

Figure: A 4.2 WIDENING OF PAVEMENT

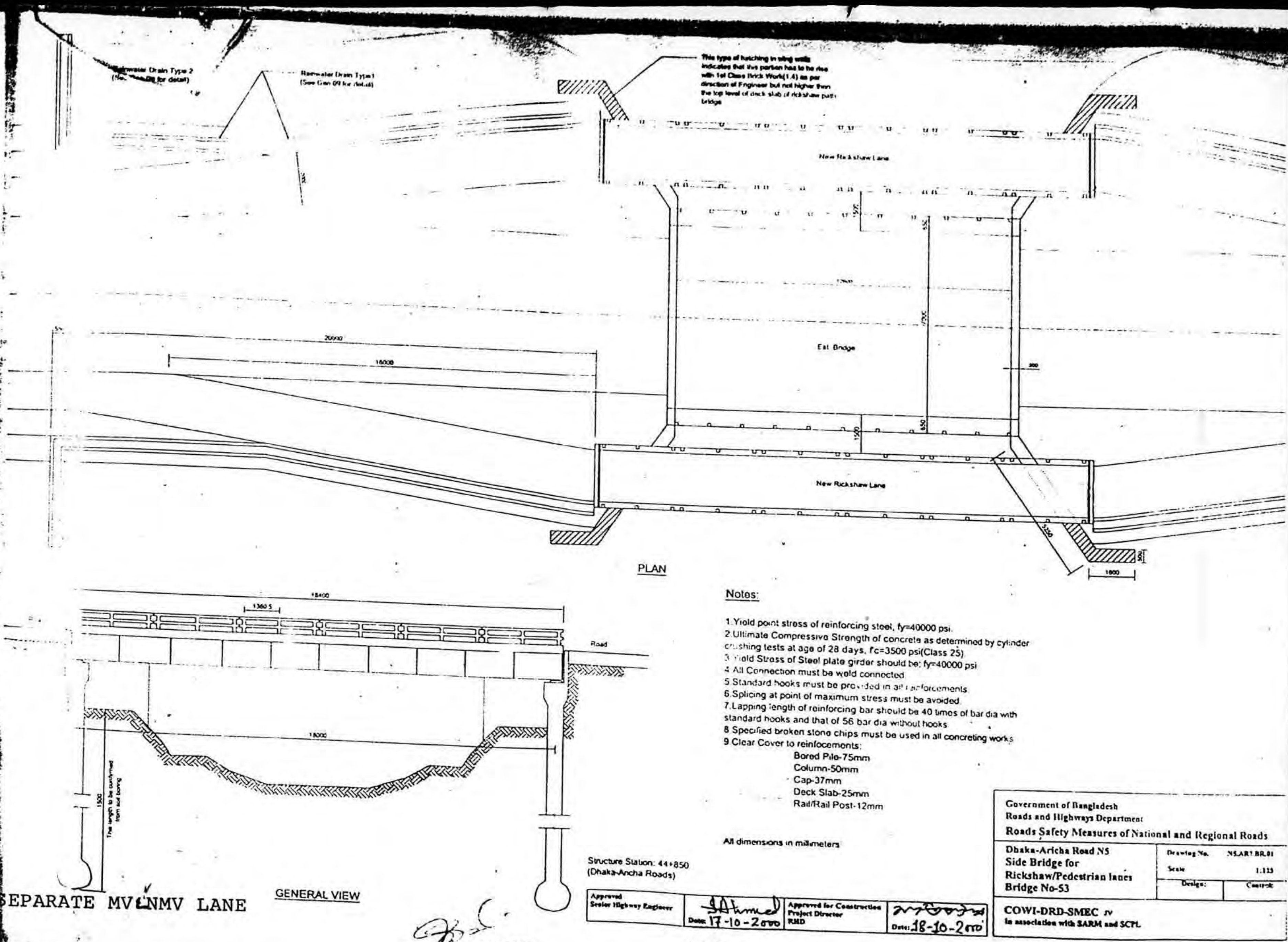
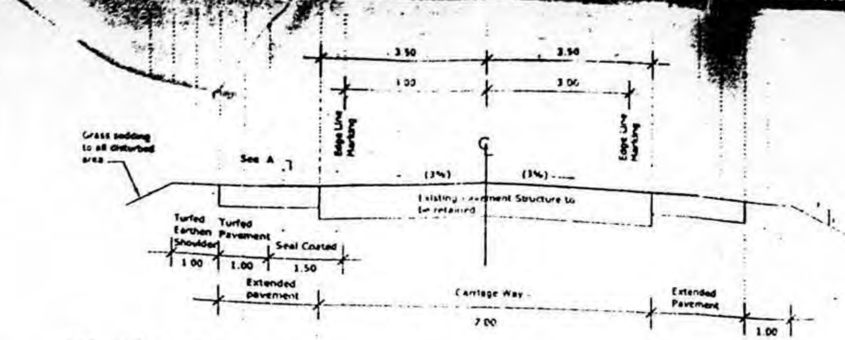
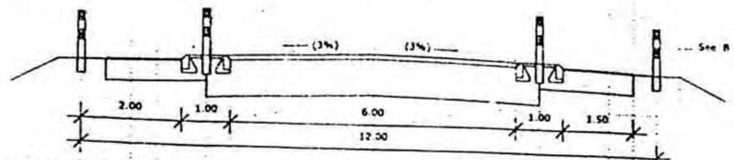


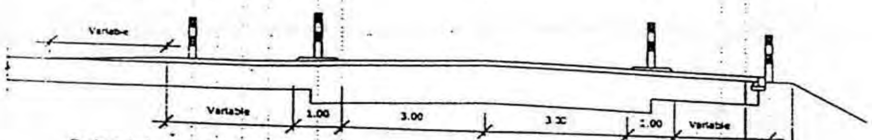
FIGURE 4.3 SEPARATE MV/NMV LANE



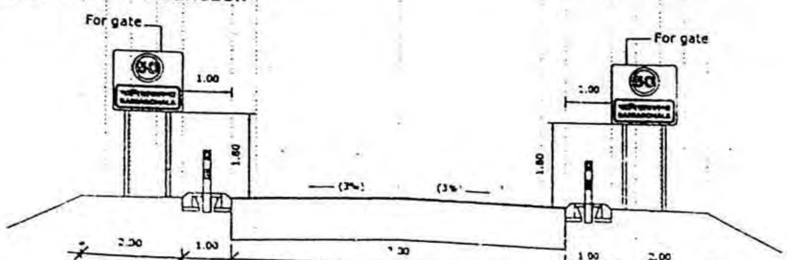
Urban Cross Section



Speed Reducer(Hump)

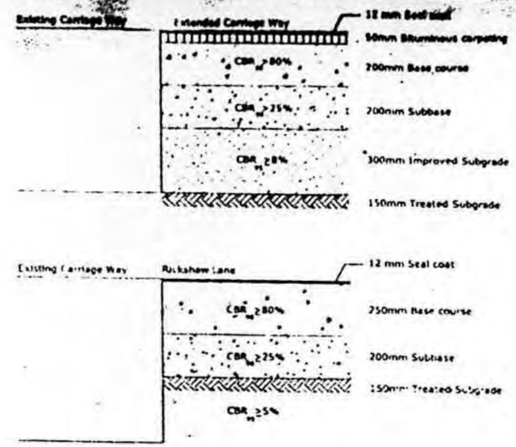


Raised Area on T-Junction



Gate

Scale 1:100

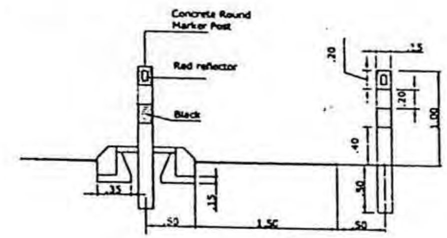


*To be increased as directed by the Engineer if the CBR value of the treated Subgrade is less than 5%.

CBR values at 98% or 95% degree of compaction in soaked condition.

A : Bituminous Concrete Pavements

(Not to scale)



B : Details, Posts (See Trffic Sign Manual for detail of posts)

(Not to scale)

Dimensions which is not mentioned is in meters.

Amendment No.	Short description	Design	Control	Date
A	Guide Post Changed	IFA		

Government of Bangladesh
Roads and Highways Department
Roads Safety Measures of National and Regional Roads

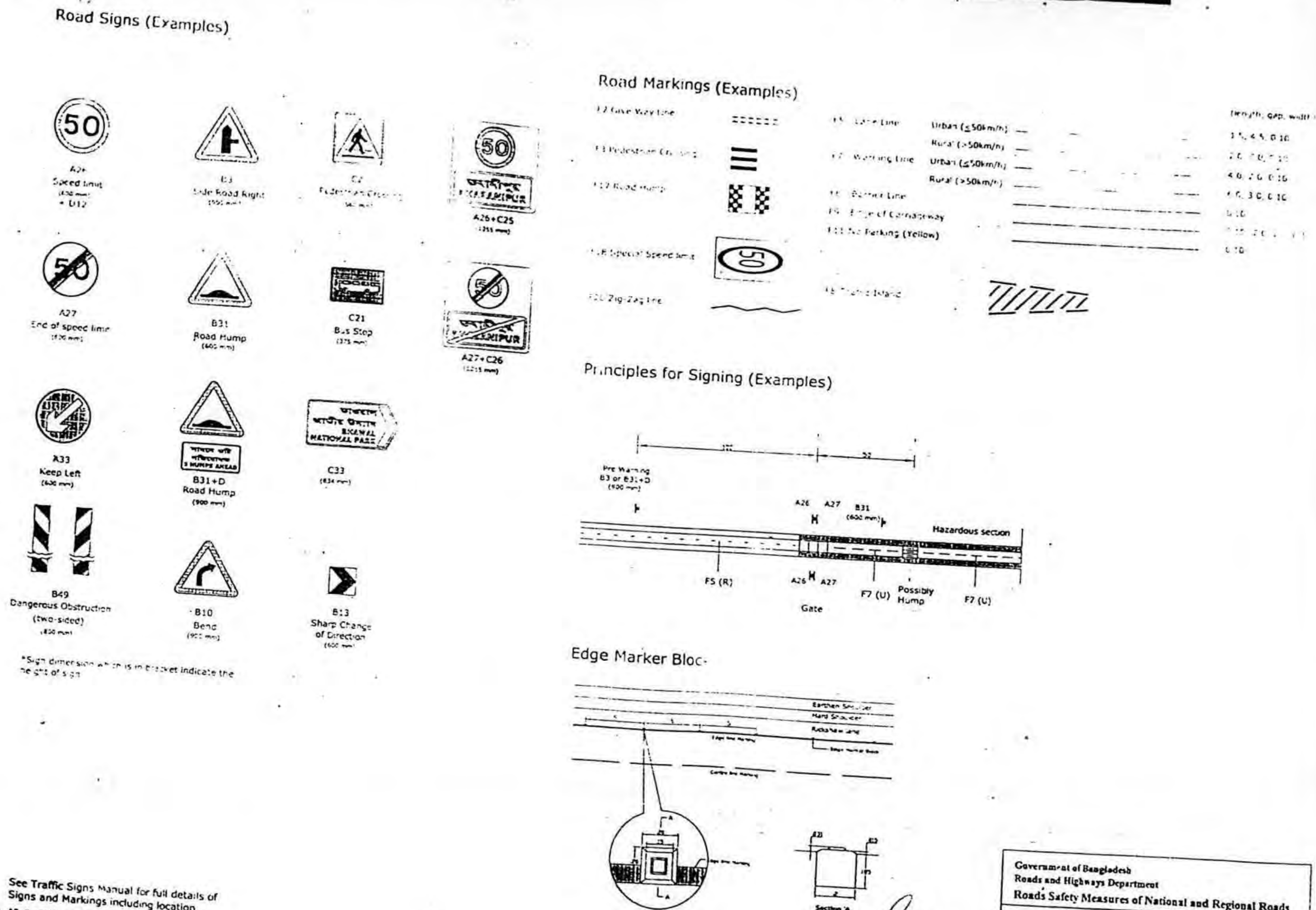
Cross Sections, General — Drawing No. GEN. 01/A; Scale: As Shown; Design: MAH/IFA/RR; Control: FCP

Approved: Senior Highway Engineer — Date: 2-11-2000
Approved for Construction: Project Director RHD — Date: 2.11.2000

COWI-DRD-SMEC JV in association with SARM and SCPL

FIGURE A4.4 Speed Reducing Hump

[redacted]



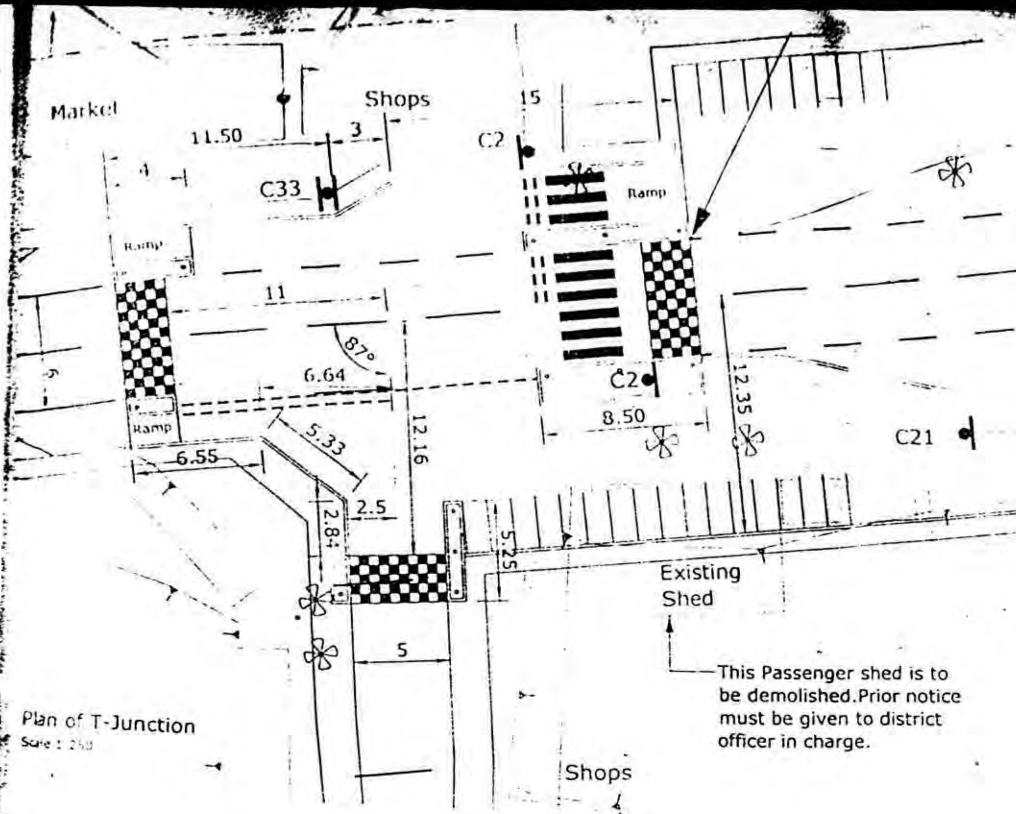
See Traffic Signs Manual for full details of Signs and Markings including location.
All dimensions is in meters

FIGURE A 4.5 ROAD SIGN

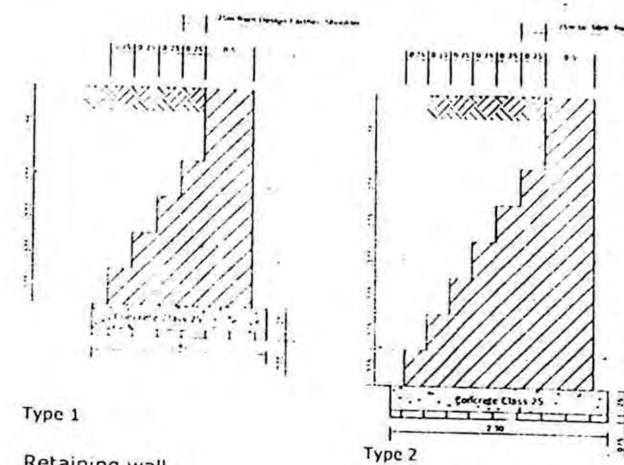
Government of Bangladesh Roads and Highways Department Roads Safety Measures of National and Regional Roads		
Road Signs and Markings, General	Drawing No. GEN. 07	
	Scale: Not to Scale	
	Design: FGP/RR	Control: IFA
COWI-DRD-SMEC JV In association with SARM and SCPL		

Approved Senior Highway Engineer	Date: 17-10-2010	Approved for Construction Project Director RHD	Date: 18-10-2010

M/S. SYED MOZIBOR RAHMAN
"1st" General Category Contractor (RHD)



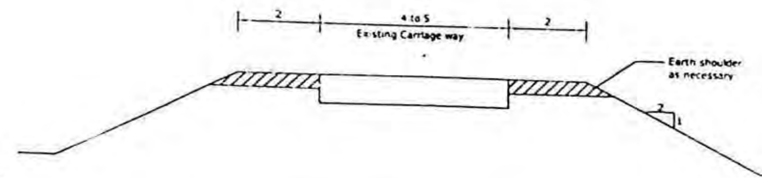
Plan of T-Junction



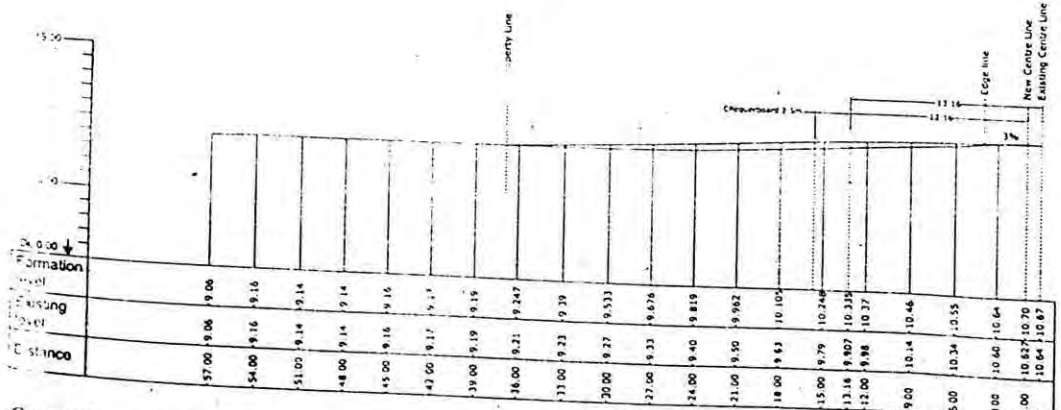
Type 1

Type 2

Retaining wall
Scale 1:50



Typical Cross section of side road
Not to scale



Centre line profile of side road
Not to scale

All dimensions in meters

Approved Senior Highway Engineer	Date: 17-10-2000	Approved for Construction Project Director RHD	Date: 18-10-2000

Government of Bangladesh
Roads and Highways Department
Roads Safety Measures of National and Regional Roads

Dhaka-Aricha Road, N5 Giora Busstand, AR7 Side Road Plan,Profile,Cross Sections and Retaining wall	Drawing No. N5.AR7.04 Scale 1:500	
	Design: IFA/RR	Control: GP

COWI-DRD-SMEC JV
in association with SARM and SCPL

FIGURE A 4.6 INTERSECTION IMPROVEMENT

বাংলাদেশ ফরম নং ৫৩৫৫

প্রাথমিক তথ্য বিবরণী

0005046

3 JUN 2002

(নিয়ন্ত্রণ নং ২৪৩)

...থানায় পেশকৃত ফৌজদারী বিধান কোডের ১৫৪ নং ধারায় দর্ভব্য অপরাধ সংক্রান্ত প্রাথমিক তথ্য

উপজেলা সাটুরিয়া থানা জেলা মানিকগঞ্জ

নং ৭/৪০ ইং ২/৬/০২ বং অনুমান ১১.০০টা

ঘটনার তারিখ ও সময়

পেশ করার তারিখ ও সময়	ঘটনার স্থান, থানা হইতে দূরত্ব ও দিক এবং দাগিস্থানীন এলাকা নং	থানা হইতে প্রেরণের তারিখ
২/৬/০২ [illegible]	ঘটনাস্থল:- বাদীর [illegible] [illegible]	6/6/02

বিঃ দ্রঃ— প্রাথমিক তথ্য অবশ্যই সংবাদদাতার স্বাক্ষর অথবা টিপসই সম্বলিত এবং লিপিবদ্ধকারী অফিসার কর্তৃক সত্যায়িত হইতে হইবে।

সংবাদদাতা এবং অভিযোগকারীর নাম ও বাসস্থান/ঠিকানা	আসামীর নাম ও বাসস্থান/ঠিকানা	ধারাসহ অপরাধ এবং লুণ্ঠিত মালামালের সংক্ষিপ্ত বিবরণ	তদন্ত চালনার কার্য তৎপরতা এবং বিলম্বে তথ্য রেকর্ড করার কৈফিয়ত	মামলার ফলাফল
মোঃ কালু মিয়া [illegible] থানা সাটুরিয়া জেলা মানিকগঞ্জ।	অজ্ঞাতনামা [illegible]	292/304(ক) দঃ বিঃ [illegible]	বাদীর লিখিত অভিযোগ [illegible]	

(প্রাথমিক তথ্য নিম্নে লিপিবদ্ধ করিতে হইবে)

স্বাক্ষর ...

পদ মর্যাদা ...

টিপসই/তাহার পাশাপাশে সংবাদদাতার স্বাক্ষর অথবা টিপসই থাকিতে হইবে।

তাং ২/৬/০২

ভারপ্রাপ্ত কর্মকর্তা

সাটুরিয়া থানা

জেলা মানিকগঞ্জ

FIGURE A 4.7

SPECIMEN OF FILLED UP FIR

[illegible]

1 দুর্ঘটনার ক্রমিক নং

2 প্রাথমিক তথ্য বিবরণী নং

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার

বাংলাদেশ পুলিশ

সড়ক দুর্ঘটনার রিপোর্ট ফরম

3 থানা

4 জিলা/মেট্রো পুলিশ

5 দুর্ঘটনা কবলিত গাড়ীর সংখ্যা

6 হতাহত ড্রাইভারের সংখ্যা

7 হতাহত যাত্রীর সংখ্যা

8 হতাহত পথচারীর সংখ্যা

9 দুর্ঘটনার মাত্রা
- F মৃত্যু সংঘটিত দুর্ঘটনা
- G মারাত্মক ক্ষত জনিত দুর্ঘটনা
- S সাধারণ ক্ষত জনিত দুর্ঘটনা
- M. মটর সংঘর্ষ

10 দিন

দুর্ঘটনার তারিখ — 11 তারিখ 12 মাস 13 বৎসর ....../....../......

14 দুর্ঘটনার সময়

রিপোর্ট করার তারিখ

রিপোর্ট করার সময়

15 সংযোগ স্থলের ধরণ
- 1 সংযোগ স্থল নাই
- 2 +
- 3 T
- 4 ┿
- 5 O
- 6 রেলওয়ে ক্রসিং
- 7 অন্যান্য

16. ট্রাফিক নিয়ন্ত্রণ
- 1 অনিয়ন্ত্রিত
- 2 মধ্য লাইন
- 3 পথচারী পারাপার
- 4 পুলিশ নিয়ন্ত্রিত
- 5 ট্রাফিক বাতি নিয়ন্ত্রিত
- 6 পুলিশ ও ট্রাফিক বাতি নিয়ন্ত্রিত
- 7 থামা/যেতে দিন সংকেত
- 8 অন্যান্য ....

17 সংঘর্ষের ধরণ
- 1 মুখোমুখি
- 2 পশ্চাৎ ভাগ
- 3 সমকোণ
- 4 পার্শ্ব ঘর্ষণ
- 5 উল্টে যাওয়া
- 6 রাস্তার উপরে বস্তুকে আঘাত
- 7 রাস্তার বাহিরে বস্তুকে আঘাত
- 8 দাঁড়ানো গাড়ীকে আঘাত
- 9 পথচারীকে আঘাত
- 10 জন্তুকে আঘাত
- 11 অন্যান্য ....

18 চলাচল
- 1 এক মুখী রাস্তা
- 2 উভমুখী রাস্তা

19 রোড ডিভাইডার
- 1 আছে
- 2 নাই

20 আবহাওয়া
- 1 ভাল
- 2 বৃষ্টি
- 3 ঝড়
- 4 কুয়াশা

21 আলো
- 1 দিন
- 2 ভোর/সন্ধ্যা
- 3 আলোকিত সড়ক (রাতে)
- 4 অনালোকিত সড়ক (রাতে)

22 রাস্তার জ্যামিতিক বিন্যাস
- 1 সোজা ও সমতল
- 2 বাঁকানো
- 3 অসমতল
- 4. বাঁকা ও অসমতল
- 5. চূড়া

23 রাস্তার উপরি ভাগের অবস্থা
- 1 শুকনা
- 2 ভেজা
- 3 কর্দমাক্ত
- 4 জলমগ্ন/প্লাবিত
- 5 অন্যান্য ....

24 রাস্তার প্রকারভেদ
- 1 পাকা
- 2 ইটের রাস্তা
- 3 কাঁচা

25 রাস্তার প্রকৃতি
- 1 ভাল
- 2. এবড়ো থেবড়ো (রাফ)
- 3 মেরামত কাজ চলছে

26 রাস্তার শ্রেণী
- 1 ন্যাশনাল
- 2 রিজিওনাল
- 3 ফিডার
- 4 রুরাল রোড
- 5 সিটি রোড

27 রাস্তার বৈশিষ্ট্য
- 1 সাধারণ
- 2 সেতু
- 3 কালভার্ট
- 4 সংকীর্ণ/নালা রাস্তা
- 5 স্পীড ব্রেকার

28. এলাকার ধরণ
- 1. শহর
- 2 গ্রাম এলাকা

অফিস ব্যবহারের জন্য

29 XY MAP 0 1	32 ROUTE	35 NODE MAP	
30. X 3 0	33. KM	36 NODE 1	
31. Y 0 7	34. 100m	37 NODE 2	

অবস্থান

নগর/শহর/গ্রাম নাম : .... দূরত্ব : .... (কি মি/মি)

রাস্তার নাম : .... মধ্যে — রোড/স্থান (১) .... দূরত্ব : .... (কি মি/মি)

রোড/স্থান (২) .... দূরত্ব : .... (কি মি/মি)

দ্বিতীয় রাস্তার নাম (শুধুমাত্র সংযোগ স্থানের দুর্ঘটনার ক্ষেত্রে) : .... দূরত্ব : .... (কি মি/মি)

দুর্ঘটনা স্থানের চিত্র : দুর্ঘটনার স্থান থেকে কিলোমিটার, ফিট, পোষ্ট, সেতু বা রাস্তার সংযোগ স্থান বা অন্যান্য যে কোন চিহ্নিত স্থান হইতে দূরত্ব দেখাইতে হবে।

সংঘর্ষের রেখা চিত্র : দুর্ঘটনা কবলিত গাড়ী সমূহের চলাচলের দিক এবং অবস্থান সহ দুর্ঘটনা স্থানের রাস্তার পূর্ণ চিত্র।

দুর্ঘটনার সংক্ষিপ্ত বিবরণ

....

সাক্ষী
- ১ নাম ও ঠিকানা ....
- ২ নাম ও ঠিকানা ....

বিবরণ লিপিবদ্ধকারী অফিসার

নাম/পদবী .... তারিখ ....

অনুসন্ধানকারী অফিসার

নাম/পদবী .... তারিখ ....

তত্ত্বাবধানকারী অফিসার

নাম/পদবী .... তারিখ ....

আইনের ধারা

কেসের অবস্থা
- 1 চার্জসীট
- 2 ফাইনাল রিপোর্ট
- 3. তদন্তাধীন

FIGURE A 4.8 NEW ACCIDENT FORM

দুর্ঘটনায় ২এর অধিক যানবাহন, ৬এর অধিক যাত্রী অথবা ৩এর অধিক পথচারী হতাহত হইলে অতিরিক্ত ফরমের দরকার হইবে। অতিরিক্ত ফরমে দুর্ঘটনার ক্রমিক নম্বর, থানা ও জেলা/মেট্রোপুলিশ এবং দুর্ঘটনার বৎসর উল্লেখ করিয়া এক সাথে গাঁথিয়া দিতে হইবে।

যানবাহন ১

মালিকের নাম

মালিকের ঠিকানা

যানবাহন প্রস্তুতকারী

রেজিষ্ট্রেশন নম্বর — 38. জেলা — 39. নম্বর

40. বৈধ ফিটনেস সার্টিফিকেট: 1 আছে 2 নাই 3 প্রযোজ্য নয়

বীমাকৃত: 1 ৩য় পার্টি 2 কমপ্রেহেনসিভ

41. যানবাহনের ধরণ

1 বাইসাইকেল, 2 রিক্সা, 3 ঠেলাগাড়ী, 4 মটর সাইকেল, 5 বেবী টেক্সী, 6 টেম্পু, 7 মাইক্রো বাস, 8 মিনি বাস, 9 বাস, 10 কার, 11 জীপ, 12 পিক আপ, 13 ছোট ট্রাক, 14 ভারী ট্রাক, 15 আর্টিকুলেটেড ট্রাক, 16 ট্যাংকার, 17 ট্রাক্টর, 18 পশু চালিত, 19 অন্যান্য

42. যানবাহন চালানোর কৌশল

1 বামে মোড়, 2 ডানে মোড়, 3 'U' মোড়, 4 আড়াআড়ি অতিক্রম, 5 ওভারটেকিং, 6 অগ্রসর, 7 পিছনের দিকে চালানো, 8 হঠাৎ যাত্রা করা, 9 হঠাৎ থামা, 10 পার্ক অবস্থায়, 11 অন্যান্য

43. যানবাহনের মালামাল-বোঝাই: 1 আইনানুগ 2 বেআইনী/বিপজ্জনক বোঝাই

44. যানবাহনের ত্রুটি: 1 ত্রুটি মুক্ত 2 লাইট 3 ব্রেক 4 স্টিয়ারিং 5 টায়ার 6 বহুবিধ 7 অন্যান্য

45. যানবাহনের ক্ষতি (দুর্ঘটনা জনিত): 1 নাই 2 সামনে 3 পিছনে 4 ডানে 5 বামে 6 ছাদে 7 বহুবিধ 8 অন্যান্য ....

চালক ১

নাম

ঠিকানা

ড্রাইভিং লাইসেন্স — 46. জেলা — 47. নম্বর

লাইসেন্সের ধরণ এবং যানের শ্রেণী — মেয়াদ অতিক্রমের তারিখ

48. চালকের লিঙ্গ: 1 পুরুষ 2 স্ত্রী

49. চালকের ক্ষত: F মৃত্যু, G মারাত্মক ক্ষত, S সাধারণ ক্ষত, N অক্ষত

50. চালকের বয়স

51. মাদক কিনা: 1 সন্দেহ আছে 2 সন্দেহ মুক্ত

52. সীট বেল্ট/হেলমেট: 1 পরিহিত 2 পরিহিত নয়

যানবাহন ২

মালিকের নাম

মালিকের ঠিকানা

যানবাহন প্রস্তুতকারী

রেজিষ্ট্রেশন নম্বর — 38. জেলা — 39. নম্বর

40. বৈধ ফিটনেস সার্টিফিকেট: 1 আছে 2 নাই 3 প্রযোজ্য নয়

বীমাকৃত: 1 ৩য় পার্টি 2 কমপ্রেহেনসিভ

41. যানবাহনের ধরণ

1 বাইসাইকেল, 2 রিক্সা, 3 ঠেলাগাড়ী, 4 মটর সাইকেল, 5 বেবী টেক্সী, 6 টেম্পু, 7 মাইক্রো বাস, 8 মিনি বাস, 9 বাস, 10 কার, 11 জীপ, 12 পিক আপ, 13 ছোট ট্রাক, 14 ভারী ট্রাক, 15 আর্টিকুলেটেড ট্রাক, 16 ট্যাংকার, 17 ট্রাক্টর, 18 পশু চালিত, 19 অন্যান্য ....

42. যানবাহন চালানোর কৌশল

1 বামে মোড়, 2 ডানে মোড়, 3 'U' মোড়, 4 আড়াআড়ি অতিক্রম, 5 ওভারটেকিং, 6 অগ্রসর, 7 পিছনের দিকে চালানো, 8 হঠাৎ যাত্রা করা, 9 হঠাৎ থামা, 10 পার্ক অবস্থায়, 11 অন্যান্য

43. যানবাহনের মালামাল-বোঝাই: 1 আইনানুগ 2 বেআইনী/বিপজ্জনক বোঝাই

44. যানবাহনের ত্রুটি: 1 ত্রুটি মুক্ত 2 লাইট 3 ব্রেক 4 স্টিয়ারিং 5 টায়ার 6 বহুবিধ 7 অন্যান্য

45. যানবাহনের ক্ষতি (দুর্ঘটনা জনিত): 1 নাই 2 সামনে 3 পিছনে 4 ডানে 5 বামে 6 ছাদে 7 বহুবিধ 8 অন্যান্য ...

চালক ২

নাম

ঠিকানা

ড্রাইভিং লাইসেন্স — 46. জেলা — 47. নম্বর

লাইসেন্সের ধরণ এবং যানের শ্রেণী — মেয়াদ অতিক্রমের তারিখ

48. চালকের লিঙ্গ: 1 পুরুষ 2 স্ত্রী

49. চালকের ক্ষত: F মৃত্যু, G মারাত্মক ক্ষত, S সাধারণ ক্ষত, N অক্ষত

50. চালকের বয়স

51. মাদক কিনা: 1 সন্দেহ আছে 2 সন্দেহ মুক্ত

52. সীট বেল্ট/হেলমেট: 1 পরিহিত 2 পরিহিত নয়

হতাহত যাত্রীর বিবরণ

একজন যাত্রীর জন্য একটি লাইন পূরণ করুন

* = নীচের বক্স দেখুন

নাম ও ঠিকানা	53. গাড়ী নম্বর	54. লিঙ্গ	55. বয়স	56. * ক্ষত	57. * অবস্থান	58. * কার্যক্রম
1.						
2						
3						
4.						
5						
6						

হতাহত পথচারীর বিবরণ

একজন পথচারীর জন্য একটি লাইন পূরণ করুন

* = নীচের বক্স দেখুন

নাম ও ঠিকানা	59. গাড়ী নম্বর	60. লিঙ্গ	61. বয়স	62. * ক্ষত	63. * অবস্থান	64. * কার্যক্রম
1						
2						
3.						

শুধুমাত্র নমুনার জন্য বৃত্ত দিবেন না

56. যাত্রীর ক্ষত / 62. পথচারীর ক্ষত: F মৃত্যু, G মারাত্মক ক্ষত, S সাধারণ ক্ষত

57. যাত্রীর অবস্থান: 1 গাড়ীর ভিতরে 2 গাড়ীর বাইরে 3 গাড়ীর ছাদে

58. যাত্রীর কার্যক্রম: 1 নাই 2. যানে উঠিতেছিল 3. যান হইতে নামিতেছিল 4 পড়িয়া যাওয়া 5 অন্যান্য

63. পথচারীর অবস্থান: 1 পথচারী পারাপারে 2 পারাপারের ৫০ মিঃ মধ্যে 3 সড়ক দ্বীপ/ডিভাইডারে 4 রাস্তার উপরে 5 ফুটপাতে 6 রাস্তার পাশে 7. বাস স্টপে

64. পথচারীর কার্যক্রম: 1 নাই 2 রাস্তা পারাপার হওয়া 3 রাস্তার উপর দিয়ে চলা 4 রাস্তার পাশ দিয়ে চলা 5. রাস্তার উপরে খেলা করা

সম্ভাব্য কারণ: 1 মাত্রাতিরিক্ত গতি, 2 বেপরোয়া চালনা, 3 চালকের ক্লান্তি, 4 অতি সন্নিকটে গাড়ী চালনা, 5 চালকের ভুল সংকেত, 6. ভুল ওভার টেকিং, 7 ভুল মোড়, 8 মদ্যপ চালক, 9. পথচারীর কার্যক্রম, 10. যাত্রীর কার্যক্রম, 11 রাস্তার অবস্থা, 12 রাস্তার বৈশিষ্ট্য, 13 আবহাওয়া, 14. যানের ত্রুটি, 15 বিপজ্জনক বোঝাই, 16 টায়ার ফাটা, 17 পশুর কার্যক্রম, 18 অন্যান্য ....

65 [ ][ ]

66 [ ][ ]

67 [ ][ ]

APPENDIX - B
PHOTOGRAPHS

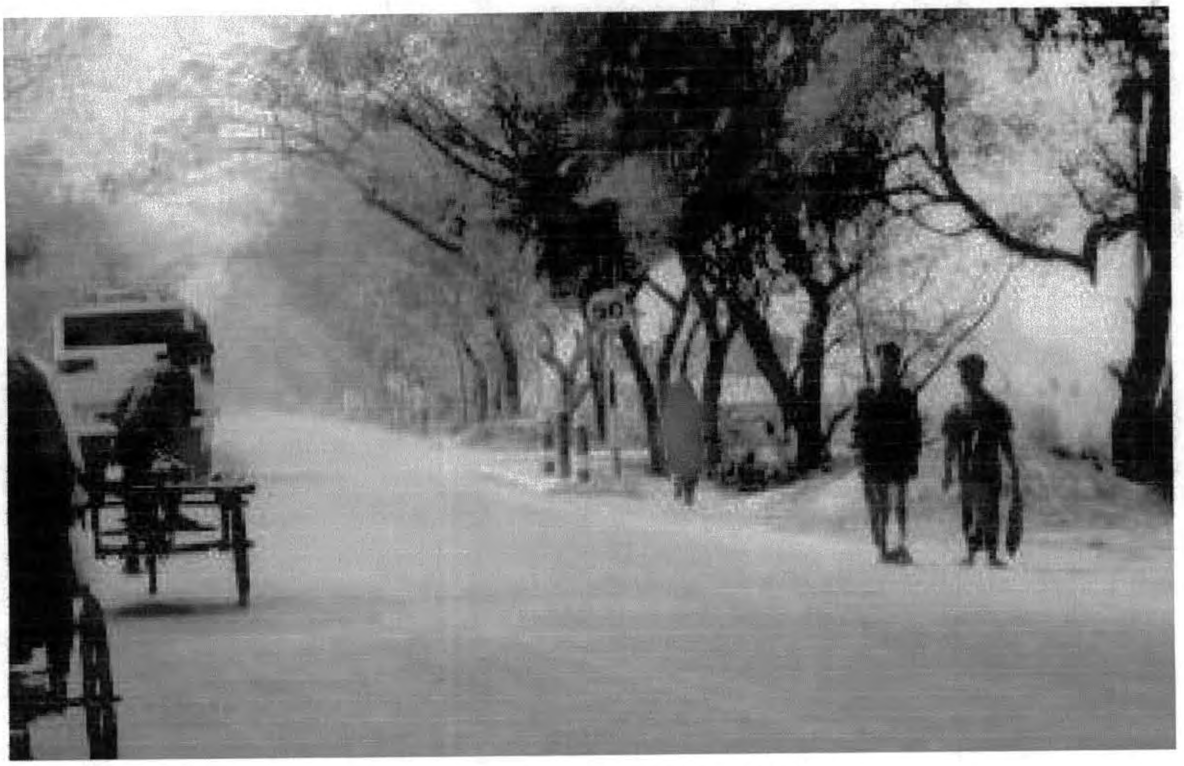


Figure B 4.1 Warning Gate With Speed Reducing Sign at Balitha

Figure B 4.2 High Embankment is a Unsafe Geometry by itself

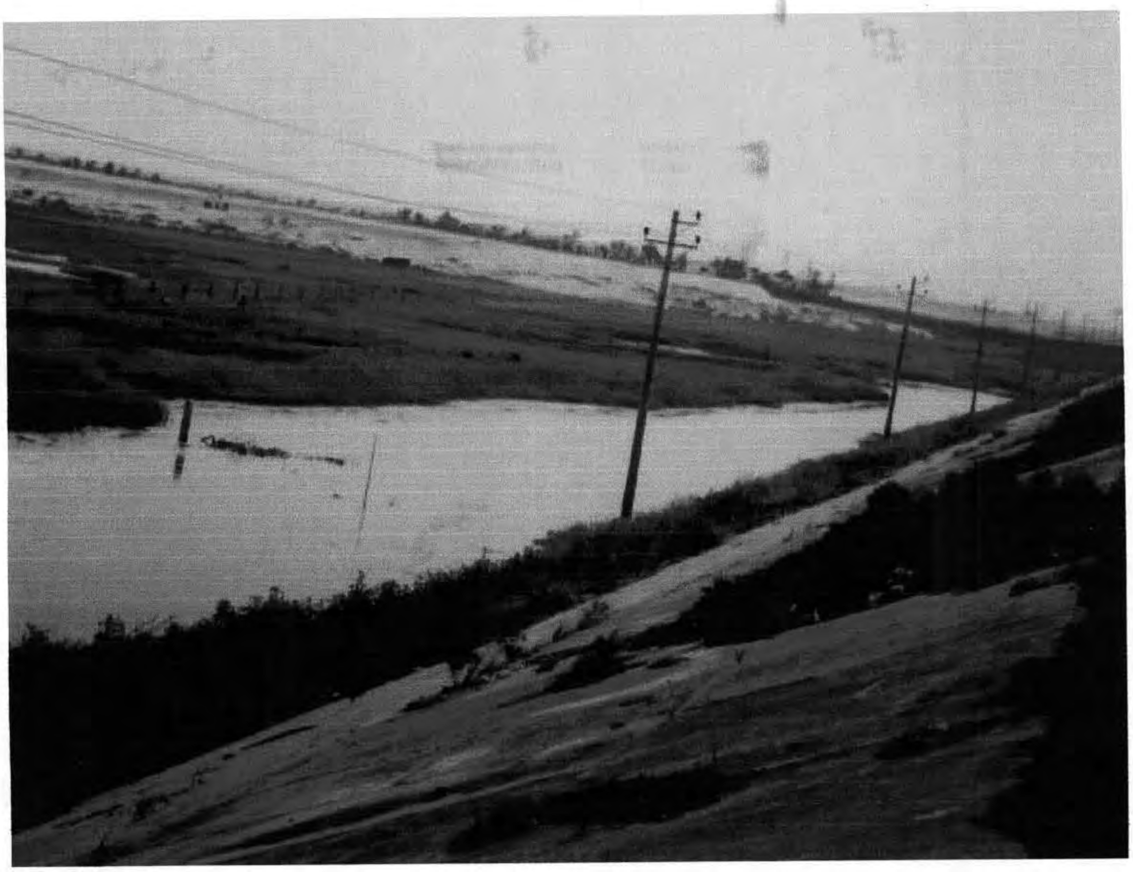


Figure B 4.3 Lack of Adequate Recovery Area is a Common Feature along this Corridor

Figure B 4.4 Road Adjacent Areas Remain Fully or Partially Water logged Round the year

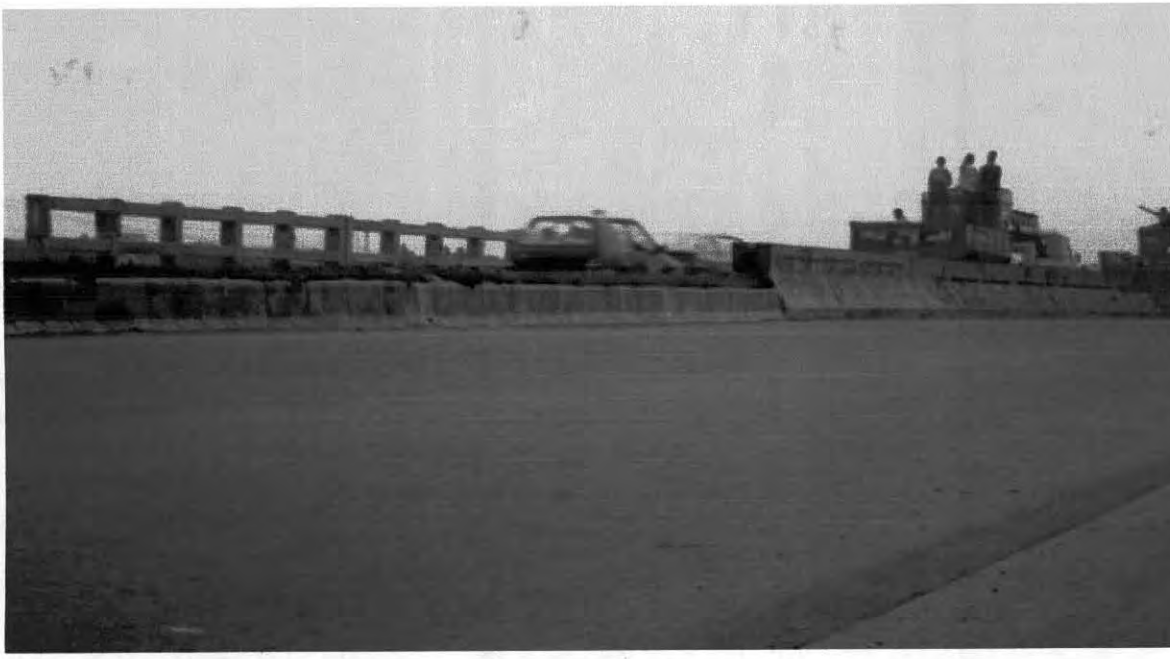


Figure B 4.5 Pavement is of Smooth Non-skid Surface that gets Slippery During Inclement Weather

Figure B 4.6 Excessive shoulder drop along the Highway (3-5cm) is Very Hazardous Especially when Loaded Vehicle Reaches the Edge

Figure B 4.7 Risky Crossing of Pedestrians Across the Barrier is a Common Practice at Savar

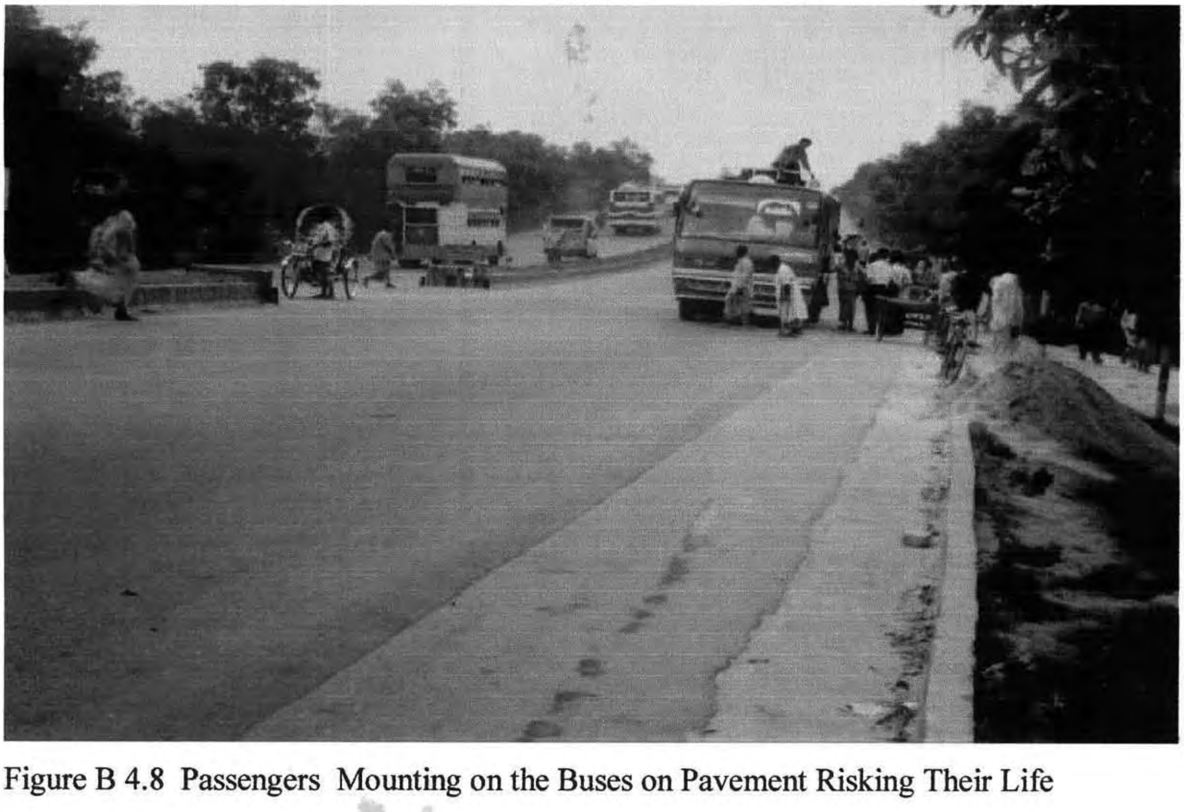


Figure B 4.8 Passengers Mounting on the Buses on Pavement Risking Their Life

Figure B 4.9 Sharp Bend on High Embankment Further Aggravate the Risk of Overturn Accident

Figure B 4.10 Temporary Shops, Bazaars, Venders mosque near Pavement Invites Hazard

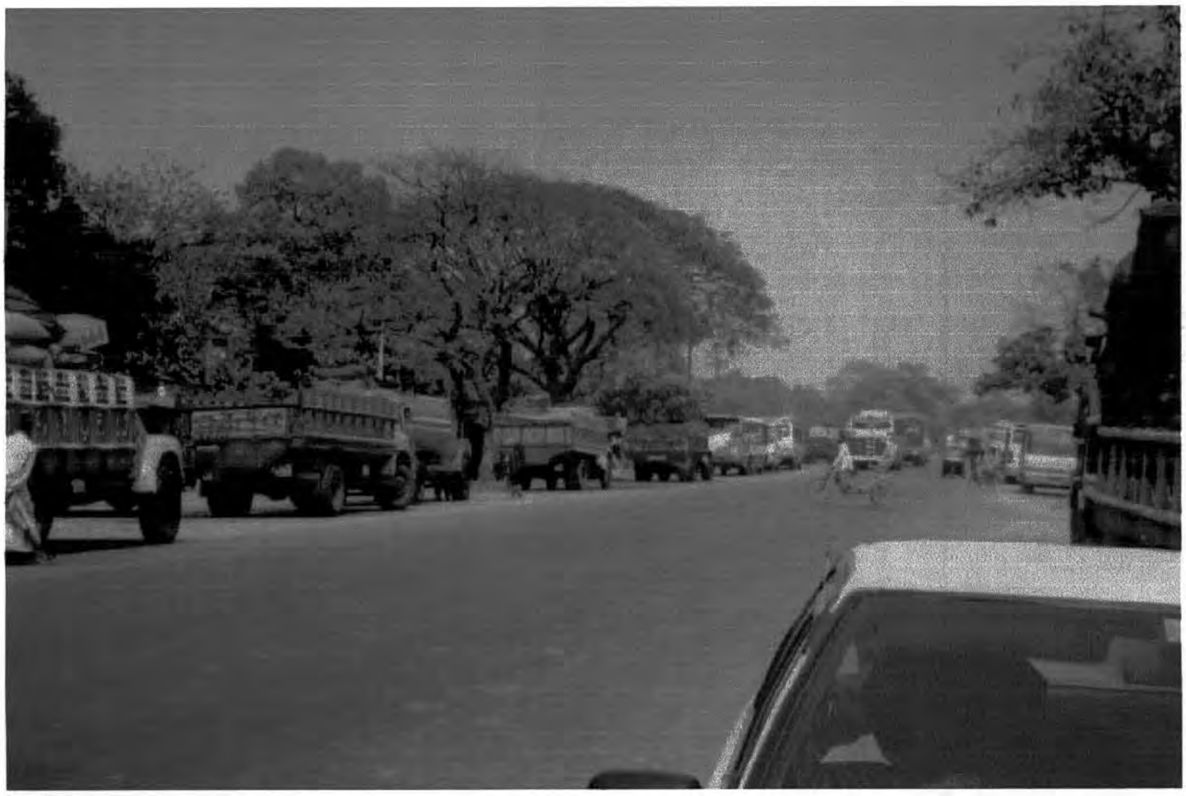


Figure B 4.11 Illegal Car parking Reduces the Effective Roadway Width (Nayarhat Area)

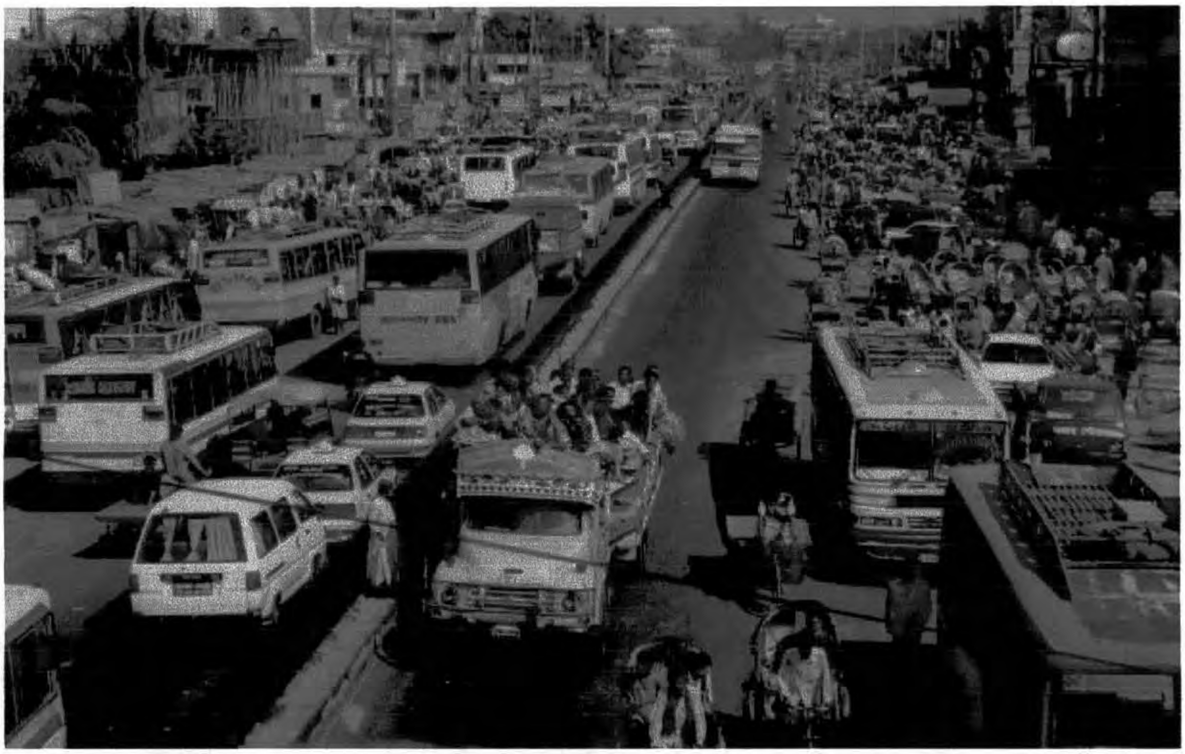


Figure B 4.12 Taking Passenger on Roof/Freight Top is a Common Dangerous Practice in this Corridor

Figure B 4.13 Dangerous Contra Flow of Truck is a Common Scene in the Dual Carriageway Section of Dhaka-Aricha Highway, due to which Head on Collision still continues to occur.

Figure 5.1 Sharp Bend Always Invites Hazard

Figure 5.2 High Pedestrian Concentration is Hazardous

Figure 5.3 Dangerous Pedestrian Crossing

Figure 5.4 Illegal Parking reduces the effective width

Figure 5.5 Over Taking Veh. Forces the Overtaken Veh. on Extreme edge

Figure 5.6 High Embankment is a Unsafe Geometry by Itself

Figure 5.7 High Embankment Risks Plunging into water

Figure 5.8 W-Beam Type Guard rail is an Ideal solution

Figure 5.9 Broken Guard Post is a Common Scene in this Highway

Figure 5.10 Median has Varied Height & Shape

Figure 5.11 New Jersey Type Median Could be an Ideal Solution

Figure 5.12 Frequent Opening at Median Invites right Angle Collision

Figure 5.13 Chevron Should be Continuous

Figure 5.14 High Vertical Drop near Bridge is Hazardous

Figure 5.15 Widening of Pavement at Golara

Figure 5.16 Newly Constructed bus shed at Baliha is Already Damaged

Figure 5.17 Separate of MV and NMV lane at Golara Bridge

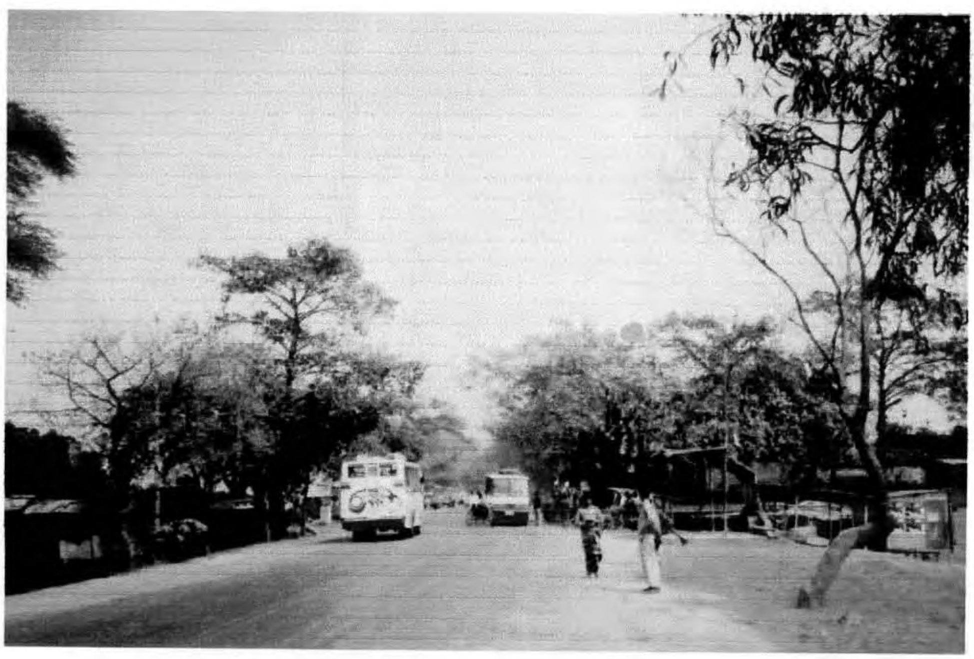


Figure 5.18 Drying of Crop on Road is Hazardous