BLACKSPOTS IDENTIFICATION AND STATISTICAL ANALYSIS OF ACCIDENT FREQUENCY DATA: MOTORWAY (M-2) LAHORE-ISLAMABAD

SYYED ADNAN RAHEEL SHAH

(2010 – NUST – MS PhD – Tn – 05)

A thesis submitted in partial fulfillment of

the requirements for the degree of

Master of Science

in

Transportation Engineering

NATIONAL INSTITUTE OF TRANSPORTATION (NIT)

SCHOOL OF CIVIL & ENVIRONMENTAL ENGINEERING (SCEE)

NATIONAL UNIVERSITY OF SCIENCES & TECHNOLOGY (NUST)

SECTOR H-12, ISLAMABAD, PAKISTAN.

(2012)

Certified that the contents and form of thesis titled **"Blackspots Identification and Statistical Analysis of Accident Frequency Data: Motorway (M-2) Lahore-Islamabad"** submitted by **Syyed Adnan Raheel Shah** have been found satisfactory for the requirement of the degree.

Supervisor: _____

Assistant Professor (Dr. Muhammad Babar Khan, PhD)

DEDICATED

TO

My Parents and Elder Brother

ACKNOWLEDGMENTS

I am thankful to Almighty Allah, who gave me strength and patience to complete my research. I would like to gratefully acknowledge the enthusiastic supervision of Dr.Muhammad Babar Khan, being supervisor for this study, whose countless inspiration and guidance made it possible to complete my research work. In addition Dr.Muhammad Irfan, Engr.Mansoor Ahmed Malik, and Engr.Rabia Haroon in the capacity of committee member, gave me guidance and feedback throughout the thesis process. I would also remember kind guidance of Dr.Anwaar Ahmed and Engr.Saqib during my research. Moreover I would also like to acknowledge Shehbaz Mirza, Research Officer NTRC, Nasir Iqbal, Safety Co-Ordinator NH&MP, Saqib, Senior Patrolling Officer NH&MP, and Shahid, Programmer/Data Base Operator NH&MP for their continuous support in data acquisition.

I would like to thank the academic members of the National Institute of Transportation who provided a lot of knowledge during my year in the postgraduate program. In the end, I pay my earnest gratitude with sincere sense of respect to my parents and elder brother for their encouragement, sincere prayers and good wishes for successful completion of my research work.

(Syyed Adnan Raheel Shah)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AASHTO	- American Association of State Highway and Transportation Officials
JETRO	- Japan External Trade Organization
MOC	- Ministry of Communication
NHA	- National Highway Authority
NH&MP	- National Highway and Motorway Police
NHTSA	- National Highway Traffic Safety Administration
NLRA	- National Licensing Regulatory Authority
NTCIP	-National Trade Corridor Improvement Program
NTRC	- National Transport Research Centre
RTA	- Regional Transport Authority
TRRL	- Transport and Road Research Laboratory

ABSTRACT

Highway Safety is one of the most important aspects of transportation engineering as traffic accidents are unavoidable in human life. Developing nations including Pakistan are faced with new dimension of highway safety challenges after the advent of motorways, safety management of motorways demand more meticulous addressal of safety issues due to involvement of high speed dynamics. This Study presents a method by which the accident-prone locations on roads, commonly termed as accident blackspots, can be identified. Motorway (M-2) connecting Lahore to Islamabad, one of the major motorways of Pakistan has been selected for study. The reasons for the accidents can be attributed to the lack of driving skill, lack of education, economic values, lack of signage, geometric design problems and improper design of pedestrian crossing. There are however, other factors, which contribute directly or indirectly to the accidents include road, vehicle, road user and environmental factors.

After analysis it was found that, accidents are majorly caused by careless driving (25%), dozing at wheel (23%), tyre burst (18%), brake failure (9%) and pedestrian crossing (6%).A large number of accidents have been occurring over a small section of Kallar Kahar (Salt range) 221km to 229km, 8 km length due to a combination of 7% slope and less than 100m radii curves causing brake failure. Moreover, pedestrian accidents near Lahore from 0 km to 18 km are also making a range of blackspots. Realignment of salt range under different geometric design options with respect to economic feasibility has been discussed. Proper traffic guidance and control system to guide road users ensuring safe movement of vehicles has been recommended and some of the low cost facilities such as pedestrian crossings underpasses near Lahore, traffic calming techniques at salt range to maintain 40km/h speed temporarily(till realignment is done), dozing alert alarm to minimize dozing, tyre checking gauges to counter tyre burst, increase in emergency climbing at salt range to confront brake failure, and advertisement through print and electronic media to increase awareness have also been proposed in order to improve the safety of the road and minimize the accidents.

Chapter 1

INTRODUCTION

1.1 BACKGROUND

Mobility is the essence of our freedom. This is the basic layer of our modern, fast development. No progress in the mobility of our community is drowning. While mobility is a major component of the interaction in our society, it is our enemy. We have to pay a price in terms of injuries and property damage from exposure to mobility as a result of accidents. This may seem pessimistic to think that accidents related to mobility are inevitable, but really, it's true.

At the time, people prefer to manage their vehicles in the mobility, Murphy's Law prevails: anything that can go wrong will go wrong. Only full automation can prevent accidents, but people, construction and operation of automation systems. The development of the transport system has generated the power that human beings possess a high civilization on Earth. However, this growth has led to security problems that our transport system has to improve efficiency and comfort to deprive us of our lives. Attempts to solve this problem have been, and will be a lot of different areas. In particular, traffic engineers investigating accidents passionate analysis and prediction of possible accidents on our systems. The dashboard security of Pakistan is a mixed picture. In some sectors of the transport system of Pakistan, namely, air and maritime security level is equal to anyone in the world, and rail services are also offered with an acceptable degree of risk, although there are many opportunities for improvement.

Road safety is a major public health problem, when statistics show that more than 3,000 people worldwide die each day due to the death of accidents. In addition, traffic accidents result in economic losses estimated at a total cost of road accidents than U.S. $ 518 billion a year. Economic costs of great economic burden on developing countries. Reflects the cost of accidents is estimated at U.S. $ 100 million in developing countries, which is twice the annual amount of development assistance in these countries. More than 1.17 million people die annually in road accidents worldwide. About seventy percent of these deaths occur in developing countries. More

than 10 million are injured or maimed every year (WHO 2004). In traffic accidents tendency of accidents is also increase with increase in vehicle population. According to Ahmed (2007), on road safety in Pakistan, estimates that between 7,000 and 10,000 people die each year in Pakistan. To better understand the extent of loss of 7,000 or 10,000 lives is 20 to 25 Boeing 747 Jumbo accidents cases per year in Pakistan alone. Imagine a protest that such a large amount of aircraft causes a collision when they occur. Accident is a quiet killer. It's so deadly, but kills quietly, while the player moves on this page to somebody dies in a traffic accident.

It is also believed that crashes cost approximately 1% to 3% of annual GDP. Estimated losses for developing countries are about U.S. $ 100 billion a year. The amount is about twice the official development assistance total worldwide were in developing countries. The cost to the economy of Pakistan road accident is about 2% of GDP in the year of about U.S. $ 1 billion a year, confirmed by independent studies. Put in terms of the number of lost each year is one-third of the total grant aid to Pakistan, which has access to the political and economic costs of high level (WHO 2004).On the other hand, as per studies by Bishai et al. (2003), in Pakistan there were 1.9 million vehicles on the road, and the total population of 110 million upto 1998. In 1997, a total of 3.5 million vehicles were totally in the country. The estimated mortality rate was 18.7 per 10,000 vehicles. Park vehicles in 2000 were estimated as 4.3 million. Low-income and middle-income countries have traffic deaths (21.5 and 19.5 per 100 000 population, respectively) more than in high-income countries (10.3 per 100,000). More than 90% of deaths in the world occur on roads in low-income and middle-income countries, which have only 48% of registered vehicles. Predictions are that road traffic injuries will rise to become the fifth leading cause of death in 2030(WHO 2009).Pakistan road upgrade over time, particularly roads and highways are a perfect example. National Trade Corridor Improvement Plan (NTCIP) is a series of roads connecting the port of Qasim with Central Asia. Motorway (M-2) is also a part of that corridor connecting Lahore to Islamabad, a controlled accessed highway of 367km length. A low income county likes Pakistan having $870 per capita income. In 2007, with more than 5 Million registered vehicles there were more than fifty five hundred fatal accidents and almost thirteen thousand non-fatal injury accidents were reported (WHO 2009).In developing countries accidents are increasing with the passage of time. Majority of accidents are in African countries while Asia has a reasonable figure in this regard.

1.4 RESEARCH OBJECTIVES

The aim of this study is to identify the major accident location on Motorway (M-2) Lahore to Islamabad and to analyze major causes of accident; following are the key research objectives which will be dealt in this thesis.

- To identify the contributory factors of accidents on Motorway (M-2) Lahore to Islamabad based on the findings obtained from crash investigation and data analysis.
- Identification of locations at which usually high numbers of accident /crashes occur. Detailed functional evaluations of high accidents locations to determine contributing causes of accidents and to analyze the reasons for prevailing conditions of road safety.
- Development of general statistical measures of various accident related factors to give insight into general trends, common casual factors, driver profiles, and procedures that allows the identification of hazard before large numbers of accident occurs. And to suggest immediate mitigating actions that can be taken to reduce the number and severity of road accidents.
- To discuss the good practice of developing countries in the field of road safety and traffic engineering, together with relevant material from standard guide lines and design guide of developed countries to act as source of information for professionals in our country.

1.5 SCOPE OF STUDY

This study analyzes the factors affecting road safety. Contains information on road safety, road infrastructure and traffic management. Provides advice on accidents prevention and highlights the key factors of safety. Examines the influence of the National Highway and Motorway Police (NH&MP) and proposes measures that can be used to reduce road accidents.

1.6 THESIS ORGANIZATION

This thesis is organized into five chapters.

Chapter 1 provides a background and the thesis motivation, objectives and scope of the research study that developed the need of this research. Study objectives, its significance and scope are also presented.

Chapter 2 is devoted to the literature review. In the first part, accident related terms and statistics are elaborated. In the later part of the chapter, different practices worldwide for blackspots identification and analysis are discussed in detail to develop a concept and better understanding of accident analysis.

Chapter 3 is concerned with the research methodology employed in the study. The process of research design, selecting a data, method to summarize accident data, method of data gathering, conducting blackspots accident analysis is presented for quantitative phase of the study. It includes indication of the tools, techniques and methods of analysis.

Chapter 4 describes the data analysis and results. The chapter is devoted to data analysis of accidents and accidents blackspots identification. It also includes accident analysis of blackspots and indication of safety issues causing repetitive accidents on blackspots for the study section.

Chapter 5 is concerned with the conclusions and future recommendations. Conclusions and recommendations are drawn from key research findings. Future directions are also identified.

Chapter 2

BASIC TERMINOLOGIES AND LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is a review of the literature and theory about the accidents and safety issues. It describes about the accidents analysis procedures and state of art practices for accident blackspots identification. Accident data collection procedures, summarizing the data, accident cause identification and methods adopted to analyze accidents in the world have been assessed. Safety issues, accident porn location identification and remedial measures have also been discussed.

2.2 ROAD TRAFFIC ACCIDENTS

In the dictionary the word accident Literally means , a befalling; an event that takes place without one's foresight or expectation; an unseen, sudden, and unexpected event; chance; contingency; often, an undersigned and unforeseen occurrence of an afflictive or unfortunate character; a casualty; a mishap; as, to die by an accident.

"Accident" is the commonly accepted word for an occurrence involving one or more transportation vehicles in a collision that results in property damages, injury, or death. The term "accident" implies a random event that occurs for no apparent reason other than "it just happened." Have you ever been in a situation where something happened that was unintended? Your immediate reaction might have been "sorry, it was just an accident."

The word “accident” began to disappear from professional literature in the late 1960s as more science was focused on the problem. In recent years, the National Highway Traffic Safety Administration has suggested replacing the word "accident" with the word "crash" because "crash" implies that the collision could have been prevented or its effect minimized by modifying driver behavior, vehicle design (called "crashworthiness"), roadway geometry, or the traveling environment. The word "crash" is not universally accepted terminology for all transportation

modes and is most common in the context of highway and traffic incidents. In this chapter both terms, "crashes" and "accidents," are used because while crashes is the preferred term, in some situations the word "accident" may be more appropriate. (Garber et al., 2009)

2.3 CAUSES OF ACCIDENTS

The occurrence of a transportation crash presents a challenge to safety investigators. In every instance the question arises, "What sequence of events or circumstances contributed to the incident that resulted in injury, loss of lives, or property damage?". In some cases the answer may be a simple one. For example, the cause of a single car crash may be that the driver fell asleep at the wheel, crossed the highway shoulder, and crashed into a tree. In other cases the answer may be complex, involving many factors that, acting together, caused the crash to occur.

Most people know that the *Titanic,* an "unsinkable" ocean liner, went to the bottom of the sea with nearly 1200 passengers and crew. Common belief is that the cause of this tragedy was that the ship struck an iceberg. However, the actual reason is much more complex and involved many factors. These include too few life boats, lack of wireless information regarding ice fields, poor judgment by the captain, an inadequate on-board warning system, overconfidence in the technology of ship construction, and flaws in the rivets that fastened the ship's steel plates.

Based on these illustrations and other similar cases it is possible to construct a general list of the categories of circumstances that could influence the occurrence of transportation crashes. If the factors that have contributed to crash events are identified, it is then possible to modify and improve the transportation system. In the future, with the reduction or elimination of the crash-causing factor, a safer transportation system is likely to result. (Garber et al., 2009)

2.4 FACTORS INVOLVED IN TRAFFIC ACCIDENTS

While the causes of crashes are usually complex and involve several factors, according to Garber et al.(2009) they can be considered in four separate categories. These are actions by the driver or operator, mechanical condition of the vehicle, geometric characteristics of the roadway, and the physical or climatic environment in which the vehicle operates. These factors will be reviewed in the following section.

2.4.1 The Driver

The major contributing causes of many crash situations are the performance of the driver of one or both (in multiple vehicle crashes) of the vehicles involved. Driver error can occur in many ways. These include inattention to the roadway and surrounding traffic, failure to yield the right of way and or traffic laws. These "failures" can occur as a result of unfamiliarity with roadway conditions, traveling at high speeds, drowsiness, drinking, and using a cell phone or other distractions within the vehicle.

2.4.2 The Vehicle

The mechanical condition of a vehicle can be the cause of transportation crashes. Faulty brakes in heavy trucks have caused crashes. Other reasons are failure of the electrical system, worn tires, and the location of the vehicle's center of gravity. Off-road crashes require early notification to rescue teams, especially in rural areas.

2.4.3 The Roadway

The condition and quality of the roadway, which includes the pavement, shoulders, intersections, and the traffic control system, can be a factor in a crash. Highways must be designed to provide adequate sight distance at the design speed or motorists will be unable to take remedial action to avoid a crash. Traffic signals must provide adequate decision sight distance when the signal goes from green to red. The super elevation on highway curves must be carefully laid out with the correct radius and appropriate transition sections to assure that vehicles can negotiate curves safely.

2.4.4 The Environment

The physical and climatic environment surrounding a vehicle can also be a factor in the occurrence of transportation crashes. The most common is weather. All transportation systems function at their best when the weather is sunny and mild and the skies are clear. Weather on roads can contribute to highway crashes; for example, wet pavement reduces stopping friction and can cause vehicles to hydroplane. Many severe crashes have been caused by fog because vehicles traveling at high speed are unable to see other vehicles ahead that may have stopped or

slowed down, creating a multivehicle pile-up. Geography is another environmental cause of transportation crashes. Mountain ranges have been the site of air crashes. Flooded river plains, swollen rivers, and mud slides on the pavement have caused highway crashes.

2.5 ACCIDENT OUTCOMES

2.5.1 Fatality

Conceptually, the more clearly type of injury in a car accident, death, or death. However, the definition of fatal road traffic is much more complicated than random thoughts can testify, and includes many inherently arbitrary criteria. The United States, for example, the definitions used in reporting Fatality Analysis System (Fars) administered by the National Highway Traffic Safety (NHTSA), a person who dies within 30 days after an accident on a public road with the American car, the death is the result of the collision. America Consequently, if the driver has a non-fatal myocardial infarction, resulting in an accident causing death is inevitable traffic. However, if the heart attack causes death prior to the accident, that is an accident.

To make matters more complex the definition of Road Accident Fatality can differ in the same country during different years. For example, fatality is defined in France as a person who dies in the 6 days (pre 2005) after the accident; in the 30 days (post 2005) after the accident, as defined by International Transport Statistics Database. (Garber et al., 2009)

2.5.2 Injuries

It is highly uncertain exactly how many road traffic crash injuries occur in the world. Whether an injury is reported may depend upon compensation and medical procedures as well as on the amount of harm. Usually two types of injuries are recorded:

- Major Injury(Serious)
- Minor Injury(Slight)

Usually permanent damage or serious injury like bone breaking or disability is major injury. In other words these are known as serious and slight injuries.

2.5.3 Property Damage

Data on collision damage is even more uncertain than for injuries. In some jurisdictions, the reporting criteria of damage or accident for a certain amount of money required by law. Because of inflation, this requirement may include accidents weaker over time, until the amount has changed dramatically, reducing the number of accidents reported. Drivers tend to report only damage to the car falling, that if they see an advantage in a statement, regardless of their legal obligations..

2.6 APPROCHES TO HIGHWAY SAFETY

Improving road safety includes consideration of three factors affecting road traffic: the driver, the vehicle, and soil. Unfortunately, the traffic engineer effective control over only one of these items on the floor. Traffic engineers can also play the role of defenders of knowledge driver training and improved procedures for licensing and include the necessary security The features of the vehicle. These factors, however, were depending on the political and legislative process and under the direct supervision of an engineer. With reference to road safety ITE Traffic Safety Toolbox, Roess et al. (2010) lists three main strategies that can be used to improve road safety

1. Exposure Control

2. Risk management failures

3. Injury Prevention

Another basic, with reference to safe roads: A Guide for Road Security techniques, Roess et al. (2010) quotes a similar strategy, divided into five categories:

1. Exposure Control

2. Accident prevention

3. Behavior modification

4. Injury Prevention

5. Injury Management

These categories are described as below:

2.6.1 Exposure Control

Exposure control is common to both lists, and consists of traveling motorists. This, of course, turned out Strategy difficult to implement in the United States, given that the car is the preferred choice travelers. March to the nationally increase vehicle miles traveled has been simmering over 35 years. Efforts to reduce the use of cars and travel cover a wide policy range of issues, planning and design. Policy and practices to reduce car use are:

- Diversion of travel to public transportation modes
- Substitution of telecommunications for travel
- Implementation of policies, taxes, and fees to discourage auto ownership and use
- Reorganization of land uses to minimize travel distances for various trip purposes
- Driver and vehicle restrictions through licensing and registration restrictions

Most of these strategies should be carried out during periods, and many physical changes require the system urban infrastructure and changes in behavior passengers. Some require a huge investment (Such as providing good public transport and the restructuring of urban land use), while others have not shown the potential to influence Major changes in travel patterns.

2.6.2 Accident Prevention

Control of accidents and accident prevention are such to face a number of common characteristics. They are however not the same thing. Accident prevention involves actions to reduce the number of accidents that occur on a certain level of demand. Integrated disaster risk management But it also includes measures to reduce the severity When an accident occurs. Reducing accidents overlay control of serious accidents and injury control strategies. Accident prevention is a set of policies Education, including pilot and pedestrians, the elimination driving record drivers with "bad" (for the suspension or revocation of the license), as well as providing road design and improved management of devices that facilitate Best management practices and limiting cases pilot error. Risk management or reduction of severity, often includes Development and environmental protection and middle of the road. Guardrail installed properly and impact-attenuating devices will reduce the impact of energy transferred accidents, and can direct the path of the vehicle of objects or areas that will lead to more serious collision. Usually accidents are prevented by safety measures, taken to avoid serious human loss.

2.6.3 Behavior Modification

It is an important component of the strategy to prevent accidents and mitigation. Influence the choice of mode important steps to change behavior that is difficult to successfully achieve. Often this requires the provision of a very stylish and comfortable alternative transit and implementation of policies that make public transport much more attractive than Suburban engine and other trips. It a slow process, often with massive subsidies maintains reasonable travel expenses, as well as high parking and other costs associated with lead. The use of dedicated lanes for cars and other high employment Limited forms to facilitate the movement, offering visual difference in travel time between the public transport and private vehicles, is another useful strategy. If the drivers and riders cannot be successfully interchange alternative methods, training of drivers and pedestrians the overall strategy of the program behavior modification. Many states offer insurance discounts if basic driving safety course is completed every three years. However, there is some statistical evidence that driver training has a measurable impact on accident prevention.

The final strategy is behavior modification. This can be very effective, but expensive. The speed limit will be too, if they obeyed organs is strict, and penalties for violating the road. In recent years, the use of automated Ticket for drivers who do not respect the red lights have become very popular. Speed control as possible with current technologies. Issues at stake the automatic application are technical legal imagine. While enrollment in a moving vehicle with a red Light can be saved automatically, does not prove that is the engine of the car. In most machines, ticket states result in a fine, but do not include a "point" in the licensee, since it can be shown that the owner was the driver at the time of the crime.

2.6.4 Injury Control

Accident injury management focuses on survival for accidents. This is the first victims the best design of the car, as a rule should be followed. The special designs of the vehicles that have performed with improved survival in an accident accounts are:

- Safety belts, safety belts, and laws requiring use
- Seating himself and laws requiring use
- Door locks anti-explosion

- Soft touches
- Absorption of message control and the strain energy area
- Side door beams
- Airbags
- Headrest and limitations
- Safety glass
- Internal Forgiveness After injury

2.6.5 Post-Injury Management

Although it is included as part of the injury prevention links, are treated as a separate category link. Accidents usually occur during the three critical periods:

- During the accident occurrence, or within minutes of it. Death is usually related to head or heart trauma or extreme loss of blood.
- Within one to two hours of the accident occurrence. In this period, death is usually due to the same causes noted above: head or heart trauma and/or loss of blood.
- Within 30 days of admission to the hospital. Death usually results from cessation of brain activity, organ failure, or infection.

About 50% of fatal accidents occur in the first category, 35 percent in the second and 15 percent third. There's little that can be done for the death during or immediately after the accident and Last difficult to improve in the developed countries the country with the highest quality of health. More room for improvement in the second category. Death within one to two hours after the accident can be reduced in systems that provide rapid emergency medical response and quality values on the site and during transport to the hospital. These systems include a rapid emergency notification Fast delivery of services related equipment for Site technicians, skilled emergency physicians attending emergency medical needs of victims and well-staffed equipped trauma center at the hospital. Of survival often depends on rapid stabilization of the victim Scene and fast transport to trauma center communications, supplies should be in place to meet a variety of needs. A simple solution is the ability to send an ambulance or helicopter medical evacuation often a matter of life and death.

2.6.6 Planning Actions to Implement Policy Strategies

The planning of business strategy and actions that may be effective in the implementation of discuss security issues. Roess et al. (2010) noted that the list includes the implementation of actions number of measures that traffic engineers usually work in terms of design and control. No unexpected, since the main purpose of traffic features is the provision of safe and effective. The list includes design features such as exchange of design and layout, horizontal and vertical lines, road design and protection, as well as other measures. Safety measures Includes a full range of controls for the implementation: markings, warning signs (regulatory, manual) and traffic lights. It also includes the use of modern intelligent transport systems (ITS), and information services for motorists and fast delivery emergencies vehicles.

It also includes the planning of large areas that are not domain exclusive engineering traffic. These include public transport planning and promotion its use, as well as significant changes in land use and policies. Although this text does not deal in detail these broader issues, the traffic engineer should know and they should be actively involved in planning for create policies and strategies for implementation.

2.6.7 National Policy Initiatives

Some aspects of the accident and the fight with destiny can be solved by funding initiatives and programs. Roess et al. (2010) says that these programs usually begin the federal or state law. At the federal level, accordance with appreciation the implementation of a link land for federal aid highway. Some Examples of these measures in US include:

- State vehicle-inspection programs and requirements
- National speed limit (eliminated in 1996)
- National 21-year-old drinking age
- Reduction in DWI requirements to 0.08 blood
- content (from 0.10)
- State DUI/DWI programs
- Federal vehicle design standards

Traffic engineers should be involved in the creation and implementation of these programs and the provision of guidance and information for decision-makers in the professional and community organizations. As traffic injuries and deaths, all levels of government try to solve

this problem by programming. These programs must be grounded in research and should focus on how to improve safety. Motorway police have been developed in strict in most highways over the past decade. A safety institute has been developed by federal government that may play an important role in the enforcement of federal and provincial governments to focus on this problem.

2.7 SAFETY MEASUREMENTS

Quantities that can be measured in the field of road safety, almost always fare. Roess et al. (2010) states that there is no harm (deaths, injuries or damage to property), divided by the indicator of the impact of the damage. Simply list is almost never used. The annual number of deaths is the rate that is the number of deaths per year. General rates for vehicle traffic deaths include deaths per capita, the vehicle is registered in licensed driver or vehicle miles traveled. There is a rate that is higher than in any other general smysle.Stavke to be chosen depending on the issue, and often that data is available. It is important to specify exactly what rate is measured and how it relates to the problem.

2.7.1 Crash Rates

Road safety record is almost always indicate prices. In other words, a bit of harm (deaths, injuries or damage to property), divided by the indicator of exposure to this damage. Overall rates of traffic deaths deaths per capita, the vehicle is registered in the licensed driver, the vehicle or mile path. Simply list is almost never used. The annual number of deaths is the rate that is the number of deaths per year.

There is a rate that is higher than in any other general sense. Rate to be chosen depending on the issue, and often that data is available. It is important to specify exactly what rate is measured and how it relates to the problem.

2.7.2 Accident Statistics

Accidents statistics are measures or estimates of the number and severity of accidents/crashes. They should be presented in a way that is intended to provide insight into the general state of highway safety and into systematic contributing causes of accidents. These insights can help develop polices, programs, and specific site improvements intended to reduce the number and severity of accidents. Care must be taken, however, in interpreting such

statistics, because incomplete or partial statistics can be misleading. Further it is important to understand what each statistics cited means and (even more important) what it does not mean. It is, therefore, important to understand what various statistics mean and how they are numerically constructed.

2.7.3 Types of statistics

Accident statistics generally address and describe one of three principle informational element:

- Accident occurrence
- Accidents involvements
- Accident severity

Accident occurrence relates to the number and type of accidents that occur, which are often described in terms of rates based on population or vehicle miles traveled. Accidents involvements concerns the number and type of vehicles and drivers involved in accidents with population based rates a very popular method of expression. Accident severity is generally dealt with by proxy: the number of fatalities and fatality rates are often used as a measure of the seriousness of accidents.

Roess et al. (2010) divided accident statistics in these three categories can be stratified and analyzed in an almost infinite number of ways, depending upon the factors of interest to the analyst. Some common types of analysis include:

- Trend over time
- Stratification by highway type or geometric elements.
- Stratification by driver characteristics(gender, age)
- Stratification by contributing cause.
- Stratification by accident type
- Stratification by environmental conditions.

Such analysis allow the correlation of accident type with highway types and specific geometric elements, the identification of high risk driver population, quantifying there extent on accidents and fatalities, and other important determinations.

2.7.4 Accident Rates

Simple statistics citing total numbers of accidents, involvements, injuries, and/or deaths can be quite misleading, as they ignore the base from which they arise. Roess et al. (2010) showed an increase in the number of highway fatalities in a specific jurisdiction from one year to the next must be matched against population and vehicle usage patterns to make any sense. For this reason, many accident statistics are presented in the form of rates. Accident rates generally fall into one of the two broad categories: population based rates, and exposure based rates. Some common based rates include:

- Area population
- No of registered vehicles
- Number of licensed drivers.
- Highway mileage

Exposure based rates attempt to measure the amount of travel as a surrogate for the individual's exposure to potential accident situations. The most common bases for exposure based rates are:

- Vehicle miles traveled (VMT)
- Vehicle hours traveled (VHT)

Vehicle miles traveled (VMT) is defined as the number of miles traveled nationally by vehicles for a period of 1 year. A measure of the extent of motor vehicle operation; the total number of vehicle miles traveled within a specific geographic area over a given period of time.The most common rate is rate per 100 million vehicle miles (RMVM), defined as the number of crashes per 100 million vehicle miles of travel. It is obtained from the expression:

$$RMVM = (Ax100,000,000) / VMT \quad (2.1)$$

Where

A = number of crashes, total or by type at the study location, during a given period.

Vehicle hours traveled (VHT**)** is defined as the number of hours traveled by vehicles in the study area during the study period. For the vehicle entering the study area, most common rate is rate per million of entering vehicles (RMEV) and is defined as the number of crashes per million vehicles entering the study location during the study [period. It is expressed as:

$$RMEV = (Ax100,000,000) / V \quad (2.2)$$

Where A = number of crashes, total or by type at the study location, during a given period.

V = average daily traffic (ADT) x 365

2.7.5 Severity Index

A widely used statistics for the description of relative accident severity in the severity index (SI), defined as the number of fatalities per accident.

$$SI = Fatalities/ Total No of Accidents \quad (2.3)$$

The severity index is another statistics that should be compared with previous years and local and national norms so that conclusions may be drawn with respect to the general severity of accidents in the subject jurisdiction.

2.8 CONTENTS OF ACCIDENT DATA COLLECTION

The data obtained from NH & MP was stratified and summarized in five different types of groups depending on the interest of our analysis; the flow chat of accident analysis is shown in the Figure 2.1.Detail is as under.

- **Trend over Time:** The data obtained shows the accident timing that at what time of the day the accident has accrued i.e. during the day/night. Day of the week, month of the year.

- **Accident Severity:** The data shows that weather the accident is fatal (F), serious injury (SI), minor injury (MI) or property damage only (PDO). If one or more people died in an accident it is called fatal accident and if one or more people get seriously injured it is called serious injury.
- **Contributing elements:** The following are the contributing elements shown in the data: Human factor (Reckless driving, pedestrians, Slow moving Motorized vehicles, Dozing at the Wheel, Careless Driving etc.), Environmental factors (Poor Visibility, Slippery Road etc.), Vehicle related factors (Tyre Burst, Brake failure, Tie Rod etc.).
- **Environmental condition** In our data the Environmental condition are depicted in a very clearly manner i.e. Slippery Road, Poor Visibility due to Weather Condition, Bad Weather Condition etc. Environmental condition helped to categorize crashes. It also helped in identifying effects of season of the year on accidents and safety deficiencies that might exist at a particular location, but on M-2 due to congestions on roads and little bit reduction in speed especially in a rainy season the environmental factors have no significant effect on accident causes due to the extra care of drivers.
- **Contributing Cause:** The following are the few contributing causes which are obtained from the data i.e. Over speeding, dozing at the Wheel, pedestrians crossing, Careless Driving (Negligence of Driver), Poor Visibility due to Weather Condition, Tyre Burst, Mechanical faults etc.

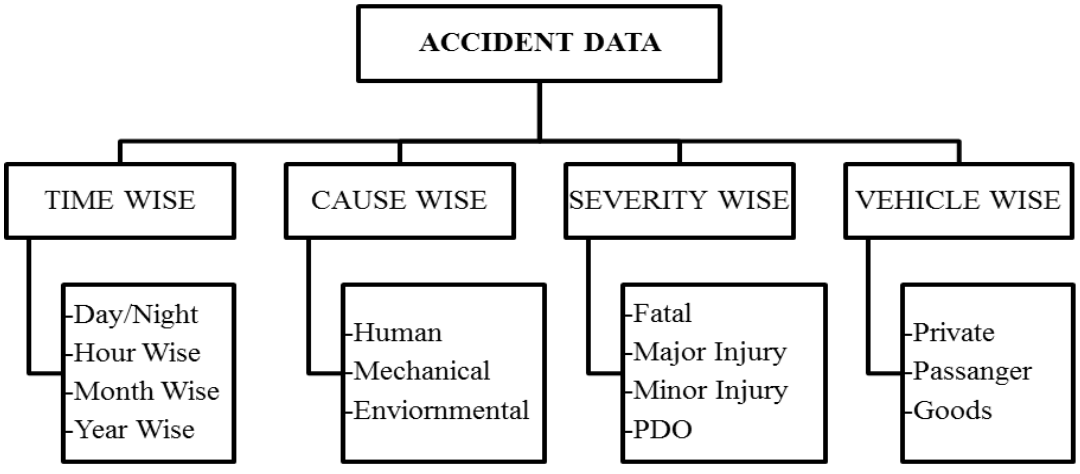


Figure 2.1: Flow Chart of Accident Data Collection

2.9 ACCIDENT BLACKSPOTS

Accident blackspots are identified on the basis of accident data. A blackspot was originally defined as “a road location with high concentration of accidents”. The term “Blackspots” is said to derive from the method that was originally used to identify hazardous sites. Some time ,the sections of length from 1 to 3 km are selected on which most frequently the accidents were occurring, because the pedestrians performs 60% of their journey from 1 to 3 km on average. Blackspots are identified as a location where 5 or more accidents occurred in the last three to five years over a section of one to three kilometers is considered to be accident blackspot. In different countries, blackspots were identified according to different patterns.

In Malaysia , Mustakim et al. (2008) developed a ranking of blackspots of road traffic accidents for F50 (Malaysia) by use of accident point weightage of Sohadi et al.(1994) to identify hot spots and analysis of factors influencing the risk of injury increases if you crash. On the basis of Accident weightage points have been identified black spots.

$$APW = 6(Fatal) + 3(Serious) + 0.8(Slight) + 0.2(Property\ Damage) \tag{2.4}$$

In Denmark by Vistisen (2002), the national highway is the main developer of the theoretical foundations of safety hotspot. Highways Agency has classified road network in the state and regional roadways, intersections and roundabouts. Road sections are divided into several groups, some geographical, geometric, and environmental (site) characteristics. From these groups a model describing the change in the number of accidents in the groups is used. These models are simple accidents (several options), in connection with the characteristics of the environment, the various traffic flows are not included directly in the performance of the model. The proposed method was found to give a more accurate assessment of treatment effectiveness that this method is currently used in Denmark. The best evaluation of the effectiveness of treatment will improve the basis for prioritizing blackspots and safety.

In China according to Mike (2009), the blackspot is defined as the place of, or excerpts from more than five deaths in 3 years. Methods work best when they focus on higher priority issues of accidents and mitigation measures to coordinate the design, implementation and public education activities. Program of "blackspots" continues, and has proven to be effective. In

Flanders, the following definition of an accident blackspot is used (Geurts 2004), based on reports from police about accident. At each site over the past three years, three or more accidents purchased. Then the site is considered to be dangerous if their priority evaluation (S) is calculated by a formula of 15 or more:

$$S = LI + 3.SI + 5.DI \tag{2.5}$$

Where,

LI = Total number of slight injuries

SI = Total number of serious injuries

DI = Total number of deadly injuries

Each point is defined as a black dot should be longer than 100 meters. Three years of accident data is used to identify black spots.

In Germany, according to Elvik (2008), the blackspots are identified by map sites of accidents. For 1 or 3 years is used to identify black spots. Blackspot is determined as follows: the site is considered to be "common place of the accident," if a large number of accidents occur on a very small stretch of road in the road network, for example, if the number of accidents reached or exceeded one year and / or three years on the map. Spots typical of frequent accidents may be mentioned the intersection of roads / highways and roads / off-road trail crossings, bends, dents, and crossing slopes. In Hungary, the two definitions of road accident blackspots are used. Elvik (2008) described about outside urban areas, the blackspot is defined as a place where at least four accidents were recorded during the three years in a stretch of road more than 1,000 meters. In settlements, the black point is defined as a place where at least four accidents were recorded during the three years in the stretch of road is over 100 meters. Search for access points, where the accident or the card lists the scale of the data by using a "sliding window". The window is either 1000 meters or 100 meters wide. Under different definitions, accident locations are identified; sometime fatality is given more importance and sometime property damage.

In Norway, there is a difference between the blackspots and black section. Black spot is a place with a length exceeding 100 meters, where at least four were injured in the last 5 years. Black section of road segment length not exceeding 1000 meters, where at least 10 accidents were reported injured in the last 5 years. The period used to identify black spots or black areas have recently been extended by 4 to 5 years (Statens vegvesen, 2006).Blackspots and black areas are determined by applying a sliding window, which is attached to the accident. Black areas are often composed of several blackspots that are close to each other. Blackspot determination being used in Portugal according to Elvik (2008), an accident blackspot is a road section with a maximum length of 200 m, with 5 or more accidents and a severity indicator greater than 20, in the year of analysis. No distinction is made between intersection and non-intersection accidents. The total number of accidents is used. The severity index is calculated by the following weighted sum:

$$100 \times \text{number of fatalities} + 10 \times \text{number of serious injuries} + \text{Number of slight injuries} \quad (2.6)$$

In Switzerland, comparison sites are determined by the classification of different types of road sections and intersections. For each group, accidents are estimates. On the basis of an accident, the critical values of the number of accidents recorded at least two years for a site to be identified as black spots were developing. In recent foot injury that sites compared with the threshold values them. Location of the accident with the number of casualties exceeds the threshold value is considered blackspot Thresholds vary depending on the type of road and relate to a period of 2 years.

2.10 PAST RESEARCH ON ACCIDENT BLACKSPOTS

In different countries, different approaches or practices are adopted to define and identify the high crash locations. Some examples from European countries and Pakistan shows the multiplicity of definitions of road accident black spots currently used.

2.10.1 Local Perspective

According to National Transport Research Centre (NTRC 1985) study, in 1981 there were 9,647 injury accidents reported to the police in three out of four provinces of Pakistan (Data for Baluchistan was not available), of which 3,458 were fatal. About 4,000 people died in these

accidents and a further 10,366 were injured. Research work has shown that in a group of countries a statistical relationship can be established between fatality rates (per licensed vehicle) and levels of vehicle ownership (vehicles per head of population). The equation (statistically significant at the 1 per cent level) was of the form:

$$\frac{F}{V} = 0.00078\left(\frac{V}{P}\right)^{-0.44} \tag{2.7}$$

Where,

F = Road Fatalities

V = Number of Vehicles

P = Population

Unfortunately not a great deal of detailed information exists about the pattern of accidents in Pakistan as a whole. According to the identification of causes, road accidents were blamed on road user error in 90 per cent of the cases by police, on the road condition and the environment it was 6 percent and on vehicle defects 4 per cent.

Islamabad Road Accident study by National Transport Research Centre (NTRC-130) was conducted in 1990 to investigate the conditions under which most of the accidents occurred in and around Islamabad during the period of January 1986 to August 1987 and identify the black- spots using computer software. Since early 70s, the techniques of accident black-spot investigation have proved to be highly successful in countries such as U.K., U.S. and Australia. Because of these highly cost effective results, the Overseas Unit of the Transport and Road Research Laboratory (TRRL), U.K. put a high priority on testing the technique in developing countries. With a view to determine the viability of introducing the system in Pakistan the road accident report booklet was modified and translated in "Urdu" with the aim of reconciling two conflicting needs (I) to minimize the time and effort required by the reporting policeman to complete the booklet, and (II) the need to maximize the recorded details of the accident for subsequent investigation and analysis. In particular, the booklet was designed so that the key

details of the accident can be directly stored on Computer. The black-spot could not be identified due to incomplete information regarding the exact locations of the accidents. This objective can only be achieved if the reporting Officer clearly sketches the location map as per instructions issued with the accidents reporting booklet.

The primary objective of the Road Accident Investigation by National Transport Research Centre in 1994 (NTRC-179), study was to investigate the conditions under which most of the accidents occurred in Pakistan. A total of 1585 accidents have been analyzed in this study using computer software to identify the blackspots, for the period of September, 1987 to December, 1993. The accident reports were received from 3 Provinces i.e. Punjab, Sind and Baluchistan and Federal Capital Islamabad. A total of 1585 accidents were reported by the Police during this period in which 2385 vehicles were involved i.e. 1.5 vehicle per accident. The maximum vehicles involved in one single accident were 3. Out of these accidents 1221 (77%) were fatal and 1214 accidents occurred in the day light. The peak month of the accidents was February in which 189 (12%) accidents occurred, while Sunday turned out to be the most hazardous day in which 249 (16%) accidents occurred.The peak hour of the day was 08 to 09 AM in which 233 (15%) accidents occurred. It seems from the above data that buses / mini buses are the common vehicles involved in the accidents i.e. 930 (39%) of the total accidents. The blackspots could not be identified due to incomplete information regarding the exact location of the accidents.This objective can only be achieved if the Reporting Officers clearly sketch the location map as per instructions issued with the accidents reporting booklet. Statements/reports of the drivers reporting officer etc. also need clearly written to be these could be read by the office staff.

The accident data of Rawalpindi – Peshawar section of N-5, for the period of 4th June 2001 to 26th December, 2001 have been studied for identification of accident black spots and analyzed for determination of causes of accidents and recommendations of remedial measures. The data was studied in detail and all such locations where five or more accidents took place during the last seven months were identified as accident black spots. In this regard the following eleven locations were identified as accident black spots. The accident data have been analyzed in detail with the main objective of finding out actual causes of these accidents and for recommendation of remedial measures. There were total 82 accidents which occurred on these

black spots. Based on the available data and visit of the sites it has emerged that out of total 82 accidents only five accidents took place due to vehicle error such as tyre burst, tie rod breakage and break failure etc. The rest of all accidents either occurred due to the mistakes of road users or due to defective road environment.

With quite credible achievements in building all types of roads, the motor vehicles fleet for carrying goods and passengers has increased at a much higher growth rate. An accident in Pakistan – A Review (NTRC-254) study was carried out for the time span of (1981-2000) analyzing causes of accidents. Data analyzed according to user type shows that the fatalities in respect of pedestrian, the person riding on a motor vehicle and motor cyclists are leading by 37.1%, 36.9 % and 16% respectively. Riding a bicycle and all others contributes 5.5 % and 4.5% fatalities respectively. The analysis of hourly classification has been examined that about 75% of the accidents are occurring between the 8 AM to 8 PM. Less than 5 % accidents occurs before dawn and about 11 % accidents occur after 8 Pm. Details in respect of month wise accidents have been seen that compared to other months more accidents occur during Jan-march (1st quarter).From the data analyzed it can be seen that 86.10 percent accidents in the country are occurring due to driver's fault which includes over speeding, rash/negligent driving Detailed separate information in respect of accidents on urban/rural & highways was not available; however details regarding accidents on national highways in all four provinces and accidents in urban areas of Karachi and motorways are available. The share of motorways, provincial and national highways described as totally 36.7% for urban roads, 28.7% for provincial roads, 31.5% for national highways and motorways 3.1%.Fatalaity wise 28.2% for Urban roads, 31.3% for provincial roads, 39.4% for national highways and motorways 1.1%.

Hafeez et al. (2008) observed that it is important to identify and analyze the presence of blackspots on the road with the key causes of accidents that have occurred previously. It is difficult to study and analyze the available data on accidents, mainly due to geometrical conditions and vehicle speed. In this study it was established that most blackspots are caused by user's speed and aggression. Geometric conditions have relatively low contribution to the accident. In addition, most accidents occurred during daytime in general, in one night. In order to maintain road safety, urban encroachment on the rights of it must be cleared from the road and

services must be submitted to the local traffic. Under the corrective measures, such as road markings, signs, organs, signals and geometric improvements can reduce the accident blackspots.

2.10.2 International Perspective

In an accident study, Mustakim et al. (2011) used a relation to identify blackspots and analyzed accidents with respect to different parameters and discussed approaches to identify hot spots and analysis of factors influencing the risk of injury increases if you crash. Methodology adopted in the analysis process involved the accident, the creation of general trends in the accident, factor analysis, field research and the development of predictive models of accidents on the multiple linear regression. Accident analysis included the distribution based on peak hours, type of vehicles involved, type of fault and blackspots ranking of top ten locations. Accident location map was also drawn to have a complete view on accident blackspots. An accident predictive study at their severity levels was considered by Wang et al. (2011), site ranking, to identify hotspots of accidents. As a result of a two-stage model of accident hot spots on the M25 and the volume was identified. The ranking results using a two-stage model are compared with other methods of rankings, such as the naive method for ranking of multidimensional Poisson log-normal and the method fixed proportions. Compared with traditional analysis based on the frequencies, two-stage model has the advantage of using more detailed data at the level of accidents is possible to predict low frequency (e.g., fatal). Research concluded that the two-stage mixed model is a promising multidimensional tool for predicting the frequency of accidents by severity and site ranking.

Taking into account the interests of serious accidents, Vadlamani et al. (2011) noted that large trucks involved in a disproportionately small share of total accidents, but a disproportionate share of casualties. Large truck accidents often result in significant traffic congestion because of its large size and physical difficulties in the elimination of the accident scene. Thus, prevention of accidents of heavy trucks is essential for improving road safety and operation. The study identifies high-risk sites (Hot spots) large truck crashes in Arizona and is considering the possible risk factors associated with the design and operation of high-risk sites. Access points documented field studies revealed numerous potential risk factors, including the activity of weaving at the entrance to the highway and ramps, the lack of acceleration lanes on the ramps

near the small shoulders to accommodate large trucks, the width of the narrow streets, lack of signage, and lighting conditions in the tunnel.

Lord et al. (2010) found that getting a better understanding of factors affecting the likelihood of accidents at the center of research for many decades. However, in the absence of detailed behavior could improve the identification of causation with a failure of the vehicle, most researchers have solved this problem by developing in terms of understanding the factors that affect the frequency of accidents, the number of accidents occurring in a geographical area (usually the leg or intersection) for a period of time. His study provides a detailed analysis of the key issues associated with the block data on the frequency and the strengths and weaknesses of different methodological approaches that researchers use to solve these problems. By Sims et al. (2010), hotspot (or "blackspot"), identification is an important element of transport technology, offering the advantages of high investment security, and responds to community sites and media interest with a high accident frequencies. One is the low frequency of accidents and subsequent long-term data collection is necessary to make statistically sound decisions. Determination of the classification of critical points of collision dominant collision frequency at each site, rather than counting the total grinding was studied using data from a metropolitan Adelaide. This method was tested on historical data and modeling, and found that the low predictive value and efficiency.

Rokade et al. (2010) studied accidents for Bhopal, which predicted accidents, the dependent variable against several independent variables, each of whom shall be appointed variable in the model to predict the number of road accidents, while the independent variables may be quantitative variables such as size of the road, horizontal curvature, traffic volume, speed, and qualitative variables as the type of the field the side, and median. With this study, an attempt was made to develop a model predicting failures to take corrective action measures for the further study of future trends take action to mitigate the effects of reducing the number of accidents in some measurements and take other safety measures. Mahmoudabadi, A. (2010) worked on two highways to estimate the frequency of accidents, used weighted linear regression common in recent years, and neural network models have also been used as models for predicting crashes. In the study, traffic volume, surface area, heavy traffic, accidents, and monthly data were analyzed in two main roads with the name of Iran in Tehran, Qom and Karaj-

Qazvin-Zanjan, and three different types of models, including simple and weighted linear regression and artificial neural networks has been developed to estimate the number of accidents per month, based on previous input variables.

Milton et al. (2008) have shown the method that can be used to better understand the distribution of severity of injury accidents on road sections, as well as the effect of traffic, road and weather conditions in these distributions. This approach allows us to assume that the estimated model parameters can vary randomly along the road segments to account for unobserved effects potentially related to the road characteristics, environmental factors and driver behavior. Meuleners et al. (2008) evaluated the effectiveness of blackspot programs in Western Australia. Reducing accidents in the treated areas and the economic benefits of this treatment were evaluated. The results showed that the programs were effective in general, lower rates of all accidents reported by 15%. Savings from the collision were 50.8Million Australian dollars, of which 89% is to reduce injury accidents. This resulted in a net saving to society 40.4 million Australian dollars (35.1 million due to an injury accident) minus capital expenditures of medical centers, maintenance and operating costs. Costs and benefits of all treatment centers were 4.9.

Road accidents are unfortunate, which are a serious problem for the government. Preventive measures to reduce the rate of accidents at dangerous places need identification for prior treatment. Daud et al. (2007) believes that in order to efficiently allocate resources for the treatment of the accident, engineers in general, ranking of accident based on the average number of accidents during the period of time. Identification, classification and sitting of hazardous events in the group, the question is a key challenge for researchers of road safety. The number of accidents varies between sites, so the Bayesian hierarchical model suitable for use in considering these two stages of change. This study illustrates the use of the rear half of the classification of accidents acne. Kockelman et al. (2007) attempted to establish the relationship between the choice of speed and accidents. The work studied the speed of the car (and variations), one loop detectors several roads in southern California and the collision data. Driver behavior, road design, weather conditions and other factors play a role in the accident. This article focuses on the driver's behavior has the effect of creating accidents in the form of choice for speed control of the design features of the road and weather conditions. The methodology was adopted to find

the relationship between the rate of change of velocity (measured by standard deviation), and the probability of an accident. The method of least squares, weighted least squares regression and binomial models were used, whiles the control of the weather and road lighting and other key variables.

Chung et al. (2005) summarizes the performance of the four paradigms of machine learning, forms of injury severity. In the past, research has focused on the difference between no damage and the types of injuries. In this article, we expanded the search for the five classes of damage to the ability to turn off an injury, injuries, disabling injuries, fatalities and nonfatal injuries. The methodology of neural networks, decision trees, hybrid decision trees and neural networks has been used to construct models that can predict the severity of injuries. Data on road accidents between 1995 and 2000 were analyzed. Singh et al. (2004) accepted that one of the poorest states in India and the densely populated capital of Bihar, Patna is noisy, crowded, polluted and had chaotic streets. The total number of deaths and mortality associated with the city rising from 100 incidents anxious, to 45 in 2000. Pedestrian fatalities as a percentage of all traffic accidents are also very high. In recent years, these constitute more than 90% of all traffic accidents. In addition, a working group of adults (18-60 years) constitute over 80 percent of all victims. The new bypass on the National Highway (NH - 38) is the most prone to accidents in the city, where about 15% of accidents occurred in 2000. It was believed that the audit of traffic safety at this stage should be a multidisciplinary group of experts to propose corrective actions.

2.11 SUMMARY

This chapter has discussed the basic terminologies of the traffic safety which usually work as base line to understand the procedures of data collection, especially contents of collected data. Accident blackspots identification perceptions and methods are different according to different countries; these are related to technology, advancement and economy. Data collection details directly effect on identification procedures. Developing countries have nearest approaches to Pakistan as had same circumstances. The past research conducted in Pakistan was a blind effort to focus accidents on major highways; clear lack of policy related to accident management can be seen. Only one institution that is National Transport Research Centre (NTRC) is working on accident related issues. A gap between institutions and agencies can be seen from the available studies. Recently a Road safety institute has been established which may lead to fill the

existing deficiency. Another factor which has been also identified that majority of the research is focused on National Highway N-5,which is 1756 km connection Karachi to Torkham.It may be of core importance but accident studies should be conducted for all roads and cities of country so that a procedural trend should be developed. Motorways are still to under focus but with a system like National Highway & Motorway Police (NH&MP) the data collection and maintenance procedure has improved. A clear impact on safety can be observed by the patrolling procedure. Overall the accident study procedures adopted by researchers in Pakistan is not as progressive as adopted in developed countries that can be improved by an agency-institution link. If data collection is conducted according to recent trends like latest researches, an equal level research can be flourished. The past research conducted worldwide is far developed than Pakistan; in depth analysis under different statistical techniques are done which lead towards high class safety measures and prediction of accident severity.

Chapter 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter is explanation of the procedure to achieve the research objectives defined for this study. After selection of road section, accident data collection is done through different sources. Site visits to observe the safety conditions and comparison of data collected and actual site condition is also performed. Accident data is summarized on the basis the basis of different categorizes. Accident blackspots identification and accident data analysis procedure has also been discussed.

Accident concentration is analyzed by the combination of accident severity at certain location; sometime financial values are also included. Despite the poverty, the developing countries the opportunities in the arts, "learn and draw lessons" work already completed by the developed countries in the field of road safety. Circumstances in developed and developing countries are different. The methodology of data analysis of the accident in the light of local factors is to determine the cause of the accident and the identification of black spots. The methodology adopted in thesis is as under:

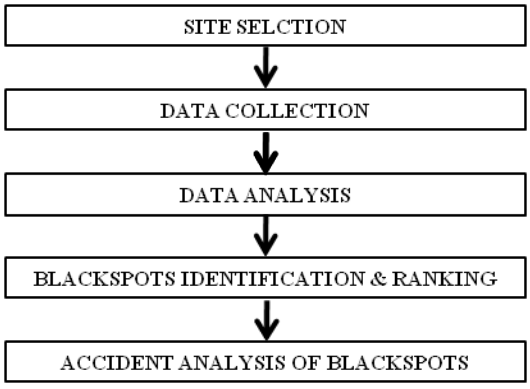


Figure 3.1: Framework for Accident Analysis

3.2 DATA COLLECTION AND RECORD SYSTEMS

Investigation of accidents is quite different the methods used to monitor the transit parameters. Because accidents are rare and unpredictable time and place, cannot be directly observe and studied in the field. All crash data comes from secondary sources, mainly police and records of a motorcycle accident. All information and data comes from these reports and systems for store and retrieve this information in a convenient and effective is an absolute necessity (Roess et al., 2010). Information necessary for a number of reasons, including:

- Identification of locations at which unusually high numbers of accidents occur.
- Detailed functional evaluations of high-accident locations to determine contributing causes of accidents.
- Development of general statistical measures of various accident-related factors to give insight into general trends, common causal factors, driver profiles, and other factors.
- Developments of procedures that allow the identification of hazards *before* large numbers of accidents occur.

3.2.1 Accident Reporting

Accident data of motorway (M-2) was obtained from the National Highway and Motorway Police (NH&MP), responsible for the administration and collection of accident data. The accident database up gradation of M-2 reflects an understanding of the importance of this fact in the Headquarter. A good accident report form was designed to include the following basic information of the accident must be registered in the recovery of equipment NH&MP. Accident data collection form contains following structure, which in detail presents the case study of certain accident has been attached in Appendices.

3.2.2 Manual Filing System

While state and national computerized registry systems are extremely valuable in the development of statistics Analysis and a common understanding consideration of the site requires a detailed that exist only in the written report of the accident. Thus, it is still used to keep manual records are written in accident reports from police in a particular location can be restored and accident reports are usually sent and reviewed. Central file reports of accidents, usually written by the most valuable source of information for traffic management for detailed

study of the high accident place, while the state (or municipality) computer Registration system useful for the production and Analysis of statistical data. In NH&MP these forms are collected and stored in store room on monthly basis.

3.2.3 Computer Record System

Computer records have the advantage of being able to maintain a high the number of accidents, the key space. Computer systems also can be correlated with the records of the accident other data and information. Certain details of the accident Chart with accompanying descriptions often lost, and the information is limited to materials that can easily be expressed as a series of alphanumeric characters.

Motorway police has systematic approach that it converts information provided on form to the computer system and an excel sheet data is developed. Computer recording systems have two main functions:(1) to produce regular statistical reports required regularly (usually once a year), the choice of the accident data to provide an overview of the accident trends and issues, and (2) that can produce (on request) large amount of data on accidents at this location or set of locations. In addition, most of the computer Registration system to create a file of other accidents information systems throughout the state, including highway Network system code, files on the volume of regular traffic Programs and files are improving the project. They may be linked to calculate statistics, performance and various statistical analyses. Common types of statistical reports that are available from state computer accident systems include:

- Numbers of accidents by location, type of accident, type of vehicle, driver characteristics, time of day, weather conditions, and other stratifications
- Accident rates by highway location and/or segment, driver characteristics, highway classification, and other variables
- Correlation of types of accidents vs. contributing factors
- Correlation of improvement projects with accident Experience.

Most states also handle requests outstanding professional experience Special reports and statistical correlations, although take a little longer to arrive because the polls must be specially programmed. Regular statistical reports, in most countries, however, provide a wide range of useful information to the engineer, who must always be aware of the possible specific functions National and local systems are available for use.

3.2.4 Problems in Data Collection

After the accident, the patrol officer radio transmits a high-ranking police, fax, and paper in the first 24 hours. Microcomputer Accident Analysis Package (MAAP) Performa officials gathered in one place for four days, and the reports are published twice a year. The shortcomings of the reports were to identify the stakeholders to use the data, and the limited opportunities for change in the process of recording and monitoring. Furthermore, the definition of accidents and injuries that are not compatible with international standards practiced in other countries. NH-MP accident reports should be simplified and standardized, and should take steps to improve its use for prevention. Majorly there are two problems in accident data collection procedure, first process is very slow that it takes four days to cover whole documentation procedure due to typical police structure and secondly under reporting is a common phenomenon which makes data unreliable because other sources on matching the events show different statistics.

3.3 SUMMARIZING ACCIDENT DATA

Accident data is used to determine the safety problems that may exist in a given site. According to Garber et al. (2009), it can be used to identify the accident at a site, from which possible causes are identified, leading to the identification of possible remedial actions. Analyses are carried out in five different ways as mentioned below:

- Causes
- Severity
- Contributing circumstances
- Environmental conditions
- Time period

3.3.1 Summary by Causes

The reason for quantitative analysis of specific causes of accidents flat roof, for example, to accelerate the emergence of animals, stroke, etc. In such a drunk driver analysis helps to prioritize the needs for corrective action. Some time there is detail about accident but the foremost question is about the key reason of occurrence. That is named as cause of accident which is the actually the root of problem.

3.3.2 Summary by Severity

The analysis helped identify the severity of each accident occurring in one of three classes of severity:

- Fatal
- Major
- Minor
- Property Damage

Fatal accidents are the leading at least one person was killed. Accidents due to serious injury but not death, is classified as major. Accident causing low level injury of any kind is minor, but the damage to vehicles includes damage to the property.

3.3.3 Summary by Contributing Elements

Each accident site appears in one of the three factors that contribute to establish a link between the accident and the impact of factors:

- Human factor
- Environmental factors
- Vehicle related factors.

3.3.4 Summary by Environmental Conditions

The analysis allowed the classification of accidents, based on conditions that existed at the time of the accident. He also helped to determine the effects of the season in case of accidents and safety deficiencies that may exist in a certain place.

3.3.5 Summary by Time Period

This analysis is the classification of incidents at different times to determine if accidents are much higher in a certain period of time. This method of summarizing data also facilitates the identification during which the occurrence of accidents above. Three different time periods are used as follows:

- Two Hourly
- Day/Night

- Monthly

3.3.6 Severity Index

A widely used statistic for the description of relative accident severity is the severity index (SI), defined as the number of fatalities per accident. For the data of the previous example, there were 7.5 fatalities in a total of 2,360 accidents. This yields a severity index is 0.0318 deaths per accident. The severity index is another statistic that should be compared with previous years and state and national norms, so that conclusions may be drawn with respect to the general severity of accidents in the subject jurisdiction.

3.4 BLACKSPOTS IDENTIFICATION AND ACCIDENTANALYSIS

Identifying 'sites with promise,' also known as black spots, hot spots, or high-risk locations, has received considerable attention in the literature. This is not surprising, since there is public and professional pressure to allocate safety investment resources efficiently across the transportation system and to invest in sites that will yield safety benefits for relatively modest cost. Due to the significant importance of identifying black spot, a large number of techniques have been employed to improve the detection accuracy. The historical and conceptual development of such procedures is reviewed chronologically in this section to help familiarize you with the black spot identification problem background.

Perhaps the simplest way to identify sites with promise is by simply ranking them in descending order of their accident frequencies and/or accident rates. Although this method has the benefit of straightforwardness, the efficiency of identifying truly high-risk sites leaves considerable room for improvement. To overcome this deficiency, a substantial body of research has been devoted to providing more efficient and justifiable site identification techniques.

3.4.1 Identification of Top Ranked Hazardous Locations

Blackspots are identified numerically by counting the reoccurrences of accidents within patch of 1 km. Following is the formula to evaluate reoccurrence of accidents at same location on Motorway M-2 Lahore to Islamabad. By using the Accident Point Weightage (APW) formula of Mustakim at el. (2011) and Sohadi et al.(1994) as this method is based on the value that is been contribute by The Transport Research Laboratory (TRL) from Interim Guide on Identifying, Prioritizing and Treating Hazardous Locations on Roads, accidents can be classified

into four main categories. For fatalities it will be multiplied with 6.0, for serious injuries it will be multiplied with 3.0, for slight injuries it will be multiplied with 0.8 and for property damage only it will be multiplied with 0.2.

$$APW = 6(X_1) + 3(X_2) + 0.8(X_3) + 0.2(X_4) \quad (4.1)$$

Where,

X_1 = Number of fatal

X_2 = Number of serious injury

X_3 = Number of slight injury

X_4 = Number of damage only

Depending upon the value of accident point weightage, accident blackspots are ranked and are dealt accordingly for safety treatments. Top ranked blackspots are identified from the ranked list on the basis of analysis and causes are observed involved in accidents.

3.4.2 Site Investigation

Site is investigated and accident history of that location is assessed and accident contributing factors are observed. According to Roess et al. (2010), one of the most important road safety investigation and analysis of data on accidents specific site identify factors that contribute to the development and remediation Measures leading to greater security. Once the location has been identified as statistically "High accident", more information is needed in two main areas:

- Occurrence of accidents in the area under consideration
- Environmental conditions and existing physical in place

The analysis of this information is to determine the environmental and physical condition of potentially or actually contribution to the observed occurrence of accidents. Armed with analyzes these engineers can design counter-measures to address the problem (s). The best information on the frequency of accidents performed by analysis of all accident reports for the Location during the period of study. This can be done recording with the computer, but a more

detailed analysis from available data on police accident reports in the folder. Environmental and Physical established a thorough investigation of the site relevant staff in the field.

3.4.3 Evaluation of Safety at Selected Location

Already existing safety conditions are examined that had been installed or executed to avoid accidents, and safety flaws are also found causing accidents. All the necessary measures and previous studies related to the locations are analyzed, and safety improvements are also evaluated which were inducted with the passage of time. A graphical scheme, describes all the physical and environmental conditions on the accident location or site. For each type of accident, three questions should be asked:

1. What driver actions lead to the occurrence of such accidents?
2. What existing conditions at the site could contribute to drivers taking such actions?
3. What changes can be made to reduce the chances of such actions taking place?

A sketch or map should show all the geometric features, location, and description of all control devices (signals, signs, markings, lighting, etc.), as well as all the relevant characteristics of the road environment, such as the location of routes, What's on the roads, land use, etc. The plan should include area large enough for the site include all potentially relevant targets and features. The analysis diagrams and collision status is simple: The reasons that led to the accident observed indicate in the scheme of the collision design, management, operation, and environmental characteristics are the conditions chart. This means almost all of the traffic engineering knowledge, experience, and knowledge and application of judgment. This professional analysis is illustrative and descriptive .The factors that may affect the occurrence of accidents and / or severity one place are large. Symmetric approach, however can be adopted, this is only if all the relevant factors detection and effective solutions. Traffic Safety is not an isolated problem for the study of traffic engineers. Rather, traffic engineers have everything to do with one of the goals of strengthening traffic safety for all traffic patterns, and control measures operational plans highlighted in the text.

3.4.4 Development of Effective Countermeasures

From the literature review, Roess et al. (2010) described that accident reducing measures which are already adopted in the world to counter similar type of safety flaws. Especially

economically and socially suitable measures are recommended. Ultimate purpose and place of any general or specific safety Analysis is the development of specific programs or website improvements for mitigating circumstances leading to these accidents. In each case, however, characteristics must be studied and analyzed in detail. A national program should take into account regional and local statistics; recovery requires detailed and collision. Cons-policy measures used to attack System security issues prevailing in road network. These measures often include education and / or monitoring of drivers, vehicles and roads design features. Safety related manuals provide such systemic problems indication methods and the types of policy approaches that are used for treatment. There are software solutions classes of problems, such as blurred driving with alcohol or drugs. There are programs solution design rules, such as bumpers and delivering high impact airbags and other safety devices in vehicles and on the road. The main thing is that the scale efforts aimed at addressing systemic and persistent problems that have been studied, and as a research identify opportunities for improvement. The list of measures against accidents at specific locations enormous, because the number of accidents can do is, for practical purposes, is almost infinite.

3.5 SUMMARY

This chapter provides a procedure to conduct the accident analysis for a certain section of highway and identification procedure to locate accident blackspots. It also provides an overview of the important the question of road safety and accident investigations. The issue is complex and covers a wide range of procedures. All that traffic engineer, field research, planning and design, monitoring and control relates to the provision of security for vehicles. Traffic engineer, not only in focus on road safety, as well as many other professionals Lawyers plan for state employees, and have a continuing interest in travel safely. Conducting accident related research need a series of steps that may lead to the identification of safety flaws. The procedure adopted for identification of blackspots is simple that at any location hazardous location can be identified, while detail analysis of available data makes easier to justify the causes and countermeasures.

Chapter 4

DATA ANALYSIS AND RESULTS

4.1 INTRODUCTION

In this chapter data collection procedure, data collation procedure, data summarizing process and analysis of the accident data has been described. An accident is defined as an error in driver, vehicle, roadway system and it must be recognized that different types of accidents are caused due to different factors. It is not enough to find out about the number of accidents occurring at a given location, unless information regarding cause of accidents, environment factors and physical characteristics of vehicle and the driver involved in those accidents is also known. Accidents do not happen by themselves but are caused by the extraneous factors.

It is usually possible to identify the cause of accidents at any given location by analyzing the accident record data. For instance predominance of rear end accidents will indicate slippery pavement whereby the drivers have difficulty in stopping in time. Predominance of night-time accidents at the location will indicate serious problems with night time visibility. Bad-weather accidents can-result due to a road pavement which becomes dangerously slippery when wet or it may be due to inadequate signs for inclement weather. Predominance of accidents during peak hour or weekends depicts congestion. Similarly, there are numerous other types of accidents which occur due to a variety of reasons. The job of the accident analyst is therefore to relate the accidents experience at any location to one or more causes.

4.2 METHOD OF ANALYSIS

Accidents, tragically, are not often due to ignorance, but are due to carelessness, thoughtlessness and over confidence of drivers. Roadway, Human, vehicle and environmental factors play roles before, during and after a trauma event. Accidents, therefore, can be studied in terms of agent, host and environmental factors and epidemiologically classified into time, place and person distribution. This thesis lays emphasis on accident studies on the 358 km long Motorway M-2 section between Lahore to Islamabad.

Following is the sequence in which the subject section from Lahore to Islamabad was analyzed.

1. Road conditions
2. Accident data
3. Accident data analysis
4. Blackspot analysis

4.3 ROAD DESCRIPTION

The primary objective of the study was to investigate the conditions under which most of die accidents occurred on Motorway M-2 section between Lahore to Islamabad. In 2001, National Highway Authority handed over the enforcement to National Highway and Motorway Police (NH&MP).

The road section from Lahore to Islamabad was constructed in year 1980. Ever since no major improvements have been done and the volume of the traffic has increased manifold during the past years. The Land passes through urban towns like Kala Shah Kaku, Sheikhupura, Khanqah Dogran,Kot Sarwar, Pindi Bhattian, Salem, Lilla, Kot Momin, Kallar Kahar, Balksar, and Chakri before ending just outside the twin cities Rawalpindi and Islamabad. General alignment is a straight run and also has some sharp horizontal curves. Speed limit is 120 km/hr for light traffic and 110-90km/hr. for heavy transport vehicles .

4.3.1 Road Condition

It is a Dual Carriage Way, flexible and rigid pavement. The road comprises six lanes with a width of 3.5 meters each, coupled with 2 to 3 meters outer shoulders and 1.7 meters inner shoulders forming a total paved width of 33 meters with a median barrier of upto 0.6 meter. It has a divider/median on structures within urban areas, while the rest of the road has 8 meters wide-open space**.**

The main reason for the increasing numbers is the fact that safety awareness is still lower even though Motorway police is trying to make efforts in this regards. Motorways are tolled national highways with controlled access and high speed free flowing traffic lanes. Although the

access control policy and the designed speed are different between Motorways and National Highways, the functional difference is not so clear at present because of the role of National Highways. It is expected that Motorways carry interprovincial traffic between major cites at high-speed. On the other hand, National Highways carry a large volume of long-distance traffic because inter-provincial connection is the major role of National Highways. M-2 is a Motorway connecting Rawalpindi and Lahore at a distance of 358 km, but traffic demand for M-2 is small and most drivers between the two cities prefer N-5 that connects the two cities at a shorter distance of 275 km. The recent dualization and improvement are leveling up National Highway close to Motorway in terms of road network hierarchy. Meanwhile, development of feeder road network systems that connect National Highways is so insufficient due to lack of adequate investment that the hierarchy system has a gap between National Highway Network and the lower network systems.

Total length of Motorway (Islamabad-Lahore Section (M-2) is 358 km. Total 10 service areas, 11 interchanges, 43 flyovers, 158 under passes,26 bridges, 42 nallas, 28 police stations and touches 7 districts. on M-2 are as under: -

Breakdown of Sectors(Beats)

1. Beat No.5	315Km – 353Km	Islamabad Trunal to Chakri Interchange	38 km
2. Beat No.6	267Km – 314Km	Chakri Interchange to Balksar	47 km
3. Beat No.7	214Km – 266Km	Balksar to Lilla Interchange	52 km
4. Beat No.8	213Km – 163Km	Lilla Interchange to Sial Chowk	50 km
5. Beat No.9	162Km – 120Km	Sial Chowk to Pindi Bhattioan	42 km
6. Beat No.10	119Km – 082Km	Pindi Bhattion to Khankadogara	37 km
7. Beat No.11	082Km – 047Km	Khankadogara to Sheikhupura	35 km
8. Beat No.12	047Km – 001Km	Sheikhupura to Shahpure Interchange	47 km

Here is the map attached showing the territory of Motorway(M-2),best available map to show motorway linking Lahore to Islamabad. These beats are also shown in Fig 4.20.Each beat is administrated by a DSP rank officer named as chief patrolling officer.

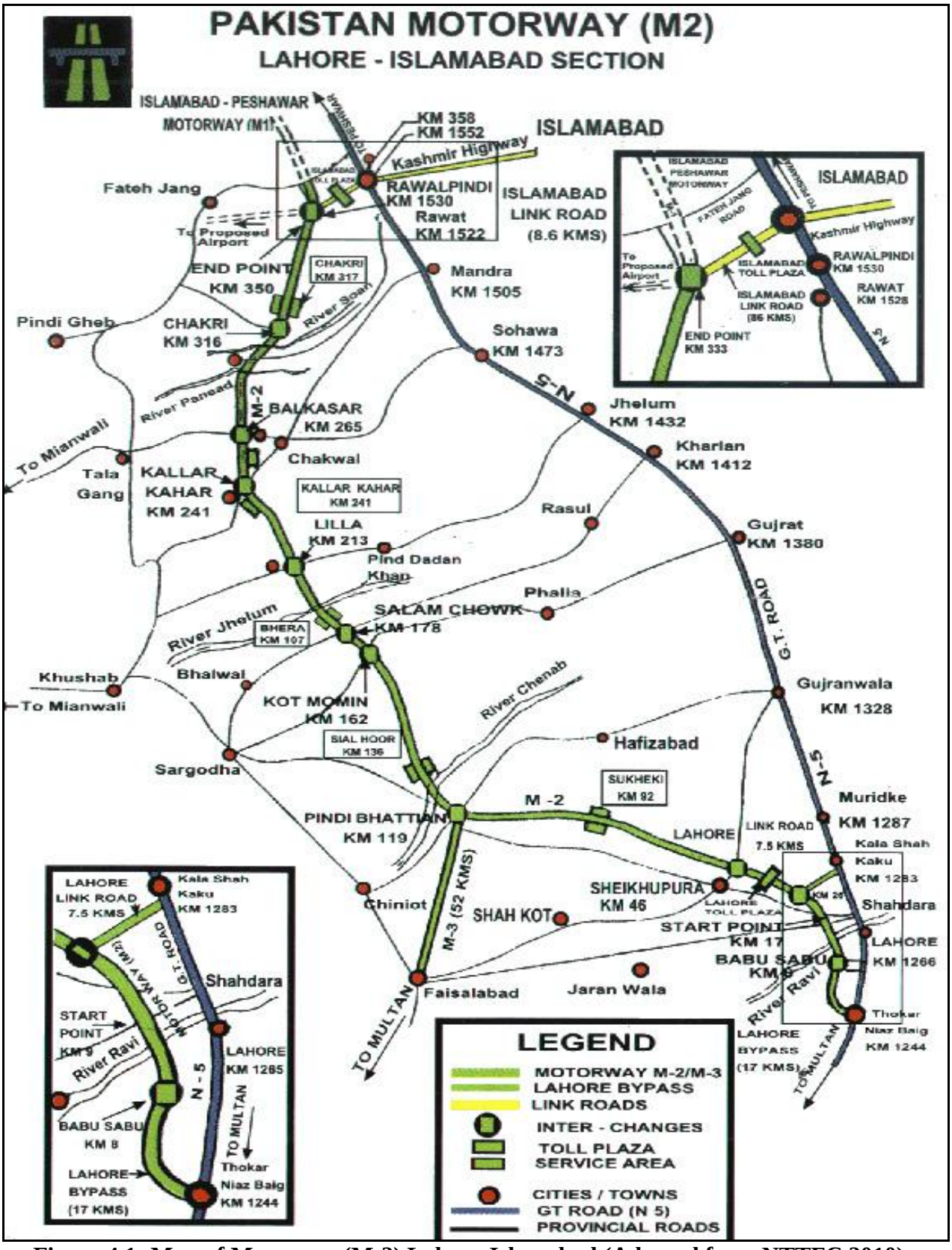


Figure 4.1: Map of Motorway (M-2) Lahore-Islamabad (Adopted from NTTFC,2010)

4.3.2 Operation and Maintenance Statistics

It is necessary to observe the expenses of facilities provided on the Motorway .National Highway Authority are the major agency to handle the highways of Pakistan. At the time of construction of motorway, there were many concepts related to design and execution but finance was the core issue of construction of such mega projects. Daewoo Company of Korea was the major construction firm involved in execution process. Now there are many for operation and maintenance. National Highway and Motorway Police is for law enforcement, Frontier Works Organization is for repair and maintenance of structures, Special Communication Organization deals with the emergency telephones, Pakistan Revenue Automation Limited is working for weigh Stations, Daewoo is still maintain the service area of Motorways and National Highway Authority is supervising and financing all the working process. Here is some detail of the operation and maintenance detail for Motorway (M-2) in Table 4.1.A reasonable amount is invested on some facilities, contributing in safety and maintenance.

Table 4.1: Operation and Maintenance Budget of Motorway (M-2) (NHMP, 2012)

List of Operations & Management of M-2			
Sr. No	**Items**	**Agency**	**Yearly Expenditure** (Rs. Millions)
1.	O& M of M-2	NH & MP	195
2.	Maintenance of M-2	FWO	110
3.	Emergency Phones	SCO	11
4.	Weigh Stations	PRAL	14
5.	Mobile workshops	Services Group	12
6.	Service Areas (BOT)	Daewoo	Nil
7.	Procurement of Toll Tickets	NHA	5
8.	O/M of Camp	NHA	7
9.	Utility Bills	NHA	40
10	NHA Establishment	NHA	5
11.	O/M. of Toll Automation	PRAL	37
	Total		436

4.4 ACCIDENT DATA ANALYSIS

The accident data of Motorway, from Lahore to Islamabad for the period of 2009 to 2011 have been analyzed for determination of causes of accident, identification of blackspots and recommendations of remedial measure. A summary of crashes can be used to identify safety problems that may exist at a particular site. It can be used to identify the crash at a site, from which possible causes may be identified, leading to the identification of possible remedial actions (countermeasures). Predominance of accidents during peak hour or weekends depicts congestion. Similarly, there are numerous other types of accidents which occur due to a variety of reasons. The job of the accident analyst is therefore to relate the accidents experience at any location to one or more causes.

4.4.1 Time Wise Analysis

Time wise distribution of accident data enables to determine the effect of visibility, peak hour traffic and season of year on accident occurrence. The occurring periods will show the considerable factors that impact on traffic during specific timings. Three different time periods can be used:

- Hour
- Day
- Month
- Year

4.4.1.1 Year Wise Analysis

Accidents are summarized according to different aspects, but simplest comparison is made through its statistics year wise. The overall trends are inspected on the basis of the years. Yearly data analysis shows that accidents recorded in the first year are 95 accidents in 2009 and from there the accident numbers are in increasing mode. In 2010, 96 accidents were recorded and then until 2011 the numbers has increased to112.If one by one accidents are analyzed than fatal accidents are increasing trend, while serious injury accidents are not only increasing year by year but also have a high value indication seriousness of the situation.

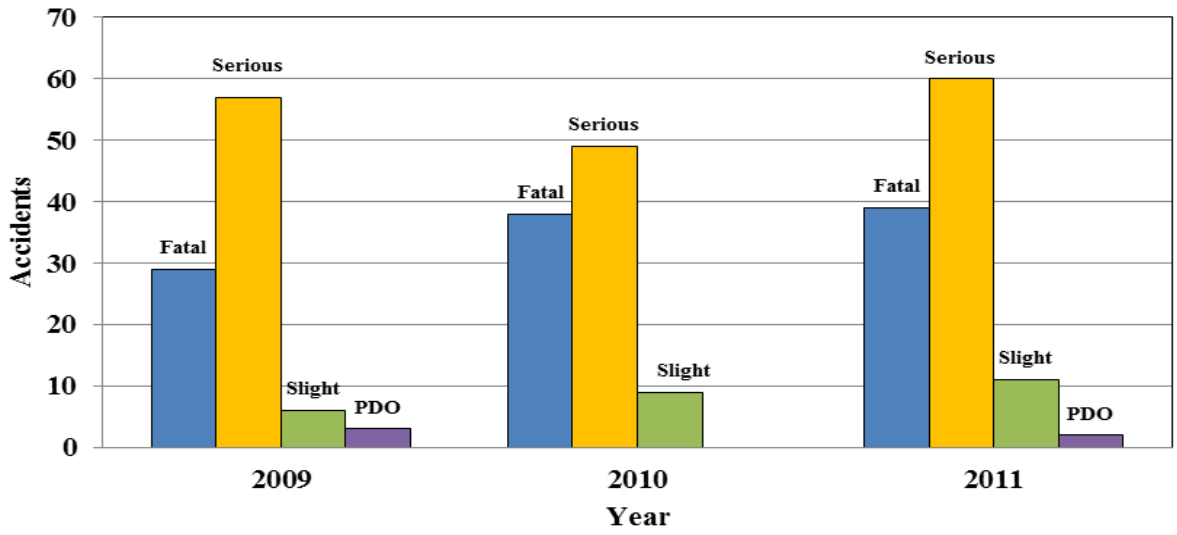


Figure 4.2: Year Wise Accidents Distribution Based on Type of Accidents on M-2

4.4.1.2 Month Wise Analysis

Through analysis of data, it was found out that accidents are high in summers as compare to winters. In January an average of 14 accidents are recorded and then the number are decreasing up till month of March with 26 recorded accidents.

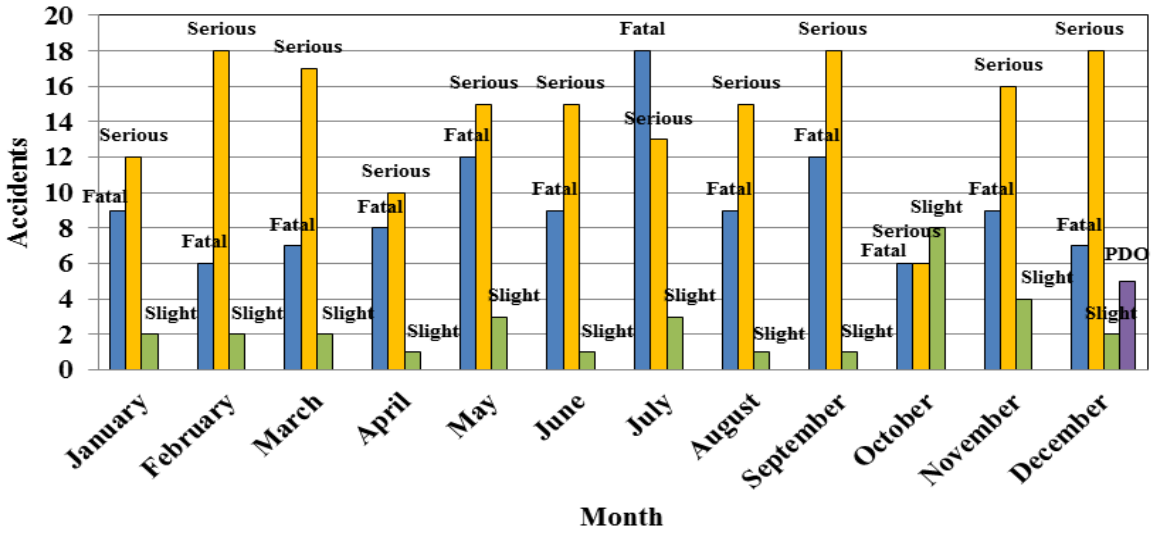


Figure 4.3: Month Wise Accidents Distribution Based on Type of Accidents on M-2

Then the accidents numbers are on the rise with the peak in July with 32 accidents. August and September are considered to be monsoon season with peculiarities of heavy rains. Month wise analysis depicts considerable effect of climate on accident occurring.

4.4.1.3 Day Wise Analysis

Day wise study of accident data leads to identification of maximum accident occurrence during particular days. Study of condition associated with that particular days helps determining the reasons for reoccurrences of accidents at same days. As peak days are observed during traffic study, same day wise accidents are also observed, especially on weekends when traffic between Lahore, Faisalabad and Islamabad increases. Fatal accidents are found higher on Thursday and Friday, same as on Sunday and Monday while serious injury accidents are on Tuesday, Wednesday and Thursday.

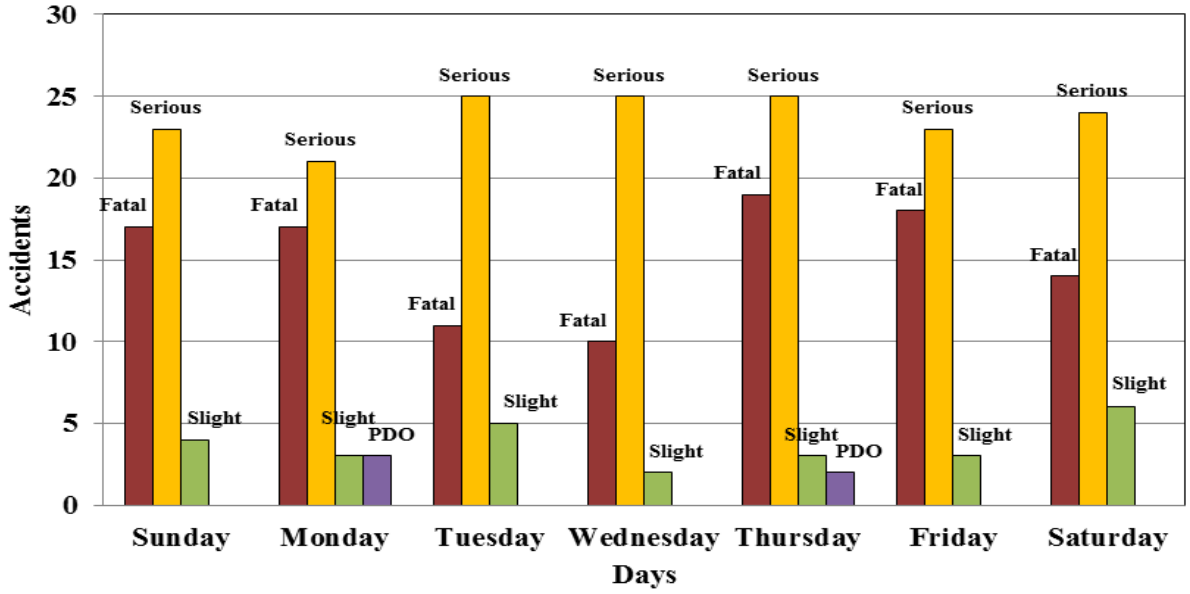


Figure 4.4: Day Wise Accidents Distribution Based on Type of Accidents on M-2

4.4.1.4 Day/ Night Analysis

Day time period is considered to be 0600 to 1800 hours whereas night time period is 1800 to 0600 hours. Fig 4.5 reveal 43% accident occurred during day and 57 % occurred during night that means probability of accident occurrence during day is relatively lesser than the night time. This is justified by the fact that the vision is more in day time that in night time. So as the volume increases so as the exposure to traffic safety. Lighting conditions should be improved. Economic conditions for light improvement should also be discussed and already existing examples worldwide could be followed, which tend to expresses that it is not possible to install lighting throughout motorway, but certain important locations can be installed with the lights.

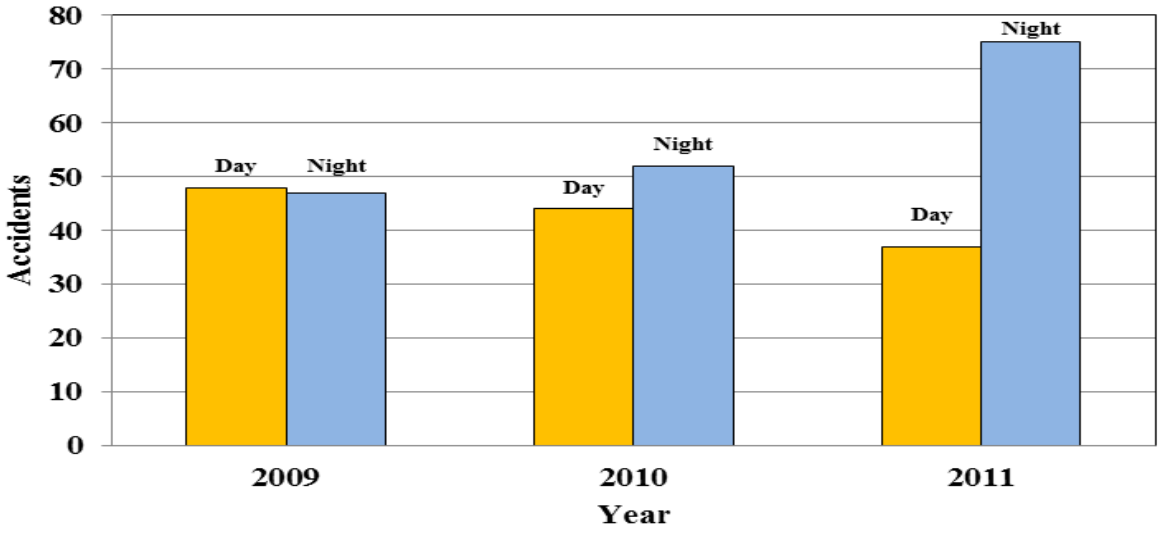


Figure 4.5: Day/Night Time Wise Analysis

4.4.1.5 Hour Wise Analysis.

Hour wise study of accident data leads to identification of maximum accident occurrence during particular interval of time. Study of condition associated with that particular time span helps determining the reasons for reoccurrences of accidents at same hour of the day.

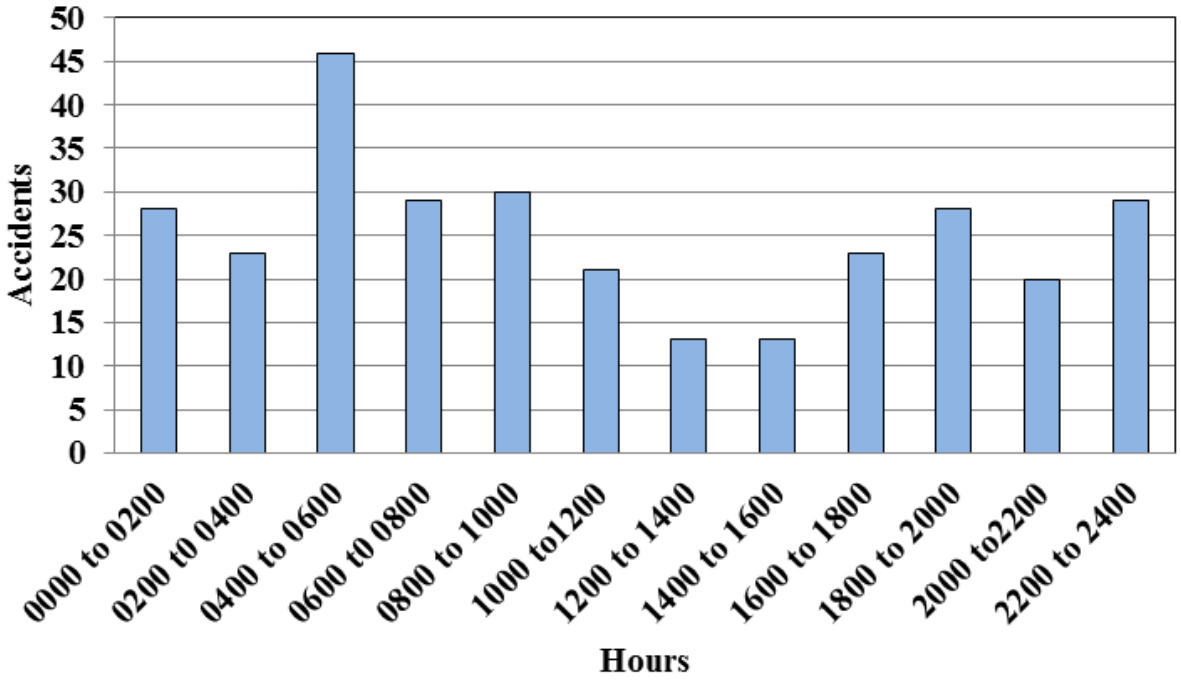


Figure 4.6: Hour wise Distribution of Accidents in the Study Stretch of M-2

In the analysis of M-2, maximum of 46 accidents occurred during 0400 to 0600 hours i.e. 15% of total accidents showing dozing impact and 30 occurred during 0800 hours to 1000 hours i.e. 10%. Fig 4.6 shows hourly trend of accidents occurrences and figures out 0000 to 0200 hours, 0200 to 0400 hours, 0400 to 0600 hours and 2200 to 2400 as hours having minimum numbers of accident, probably due to less traffic.

4.4.2 Sector Wise Analysis

Motorway(M-2) has been divided in two sectors,first half portion (towards Islamabad) is known as North while other half portion (towards Lahore) is known as South.North portion has slightly higher ratio of accidents than that of South. Moreover varying driving proficiency levels of different vehicle category drivers plays an importanat role in accidents.

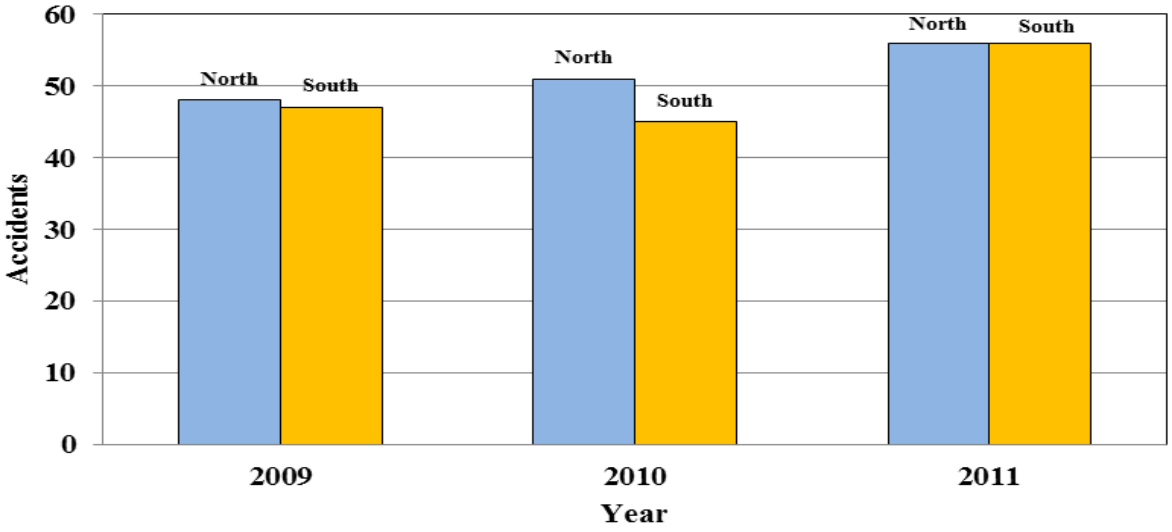


Figure 4.7: Sector Wise Distribution of Accidents in the Study Stretch of M-2.

4.4.3 Beat Wise Analysis

Motorway M-2 consists of 358 km which has been divided in to several sections which are known as beats of 5 to 12 beats,theses beats are easily indicator of locating accident location and study certain region of motorway.Beat 7 is 52km long from Balkasar to Lilla and contains area of salt range, so accidents are higher in this region. There are eight beats which are the specific portions, each is administrated by a DSP rank officer. Beat 5 which the first beat of Motorway (M-2) is of 38km from Islamabad to Chakri, Beat 6 is of 47 km, from Chakri to

Balkasar, Beat 7 is of 52 km from Balkasar to Lilla, Beat 8 is 50km from Lila to Sial Chowk,Beat 9 is from Sial chowk to Pindi Bhattian, Beat 10 is of 37 km from Pindi-bhattian to Khanka-Dogran,Beat 11 is of 35km from Khanka-Dogran to Sheikhupura and Beat 12 is of 47km from Sheikhupura to Lahore(Shahpure Interchange).

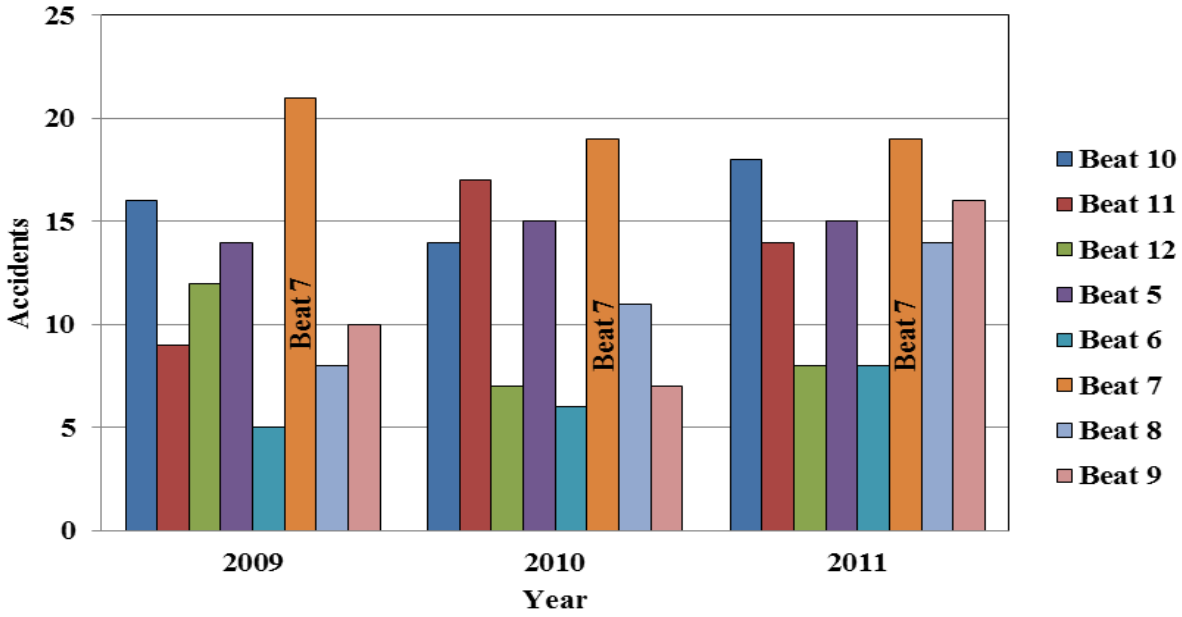


Figure 4.8: Beat Wise Distribution of Accidents in the Study Stretch of M-2.

4.4.4 Direction Wise Analysis

Direction of Motorway is encoded with two specfic wording Alpha and Bravo,Alpha indicates direction from Islamabad to Lahore,Bravo indicates Lahore to Islamabad.56% of accidents are on alpha direction while 46% are on bravo direction. While moving from Islamabad to Lahore there are many sections having problems of slopes.28o km to 286km area has sharp downward slope, Salt range has also a slope of 7% which not according to standard but also contribute accident when vehicles remain in condition of testing. Mechanically there is certain limit up to which vehicle can sustain pressure and temperature, after that brakes fail. Certain critical lengths are also followed that a slope can have a certain length after those vehicles cannot keep control. South bound lane has more accidents only because of slope like phenomenon while North bound lane has problems of climbing that heavy vehicles find difficult to climb such a sharp slopes and adopted alternative routes.

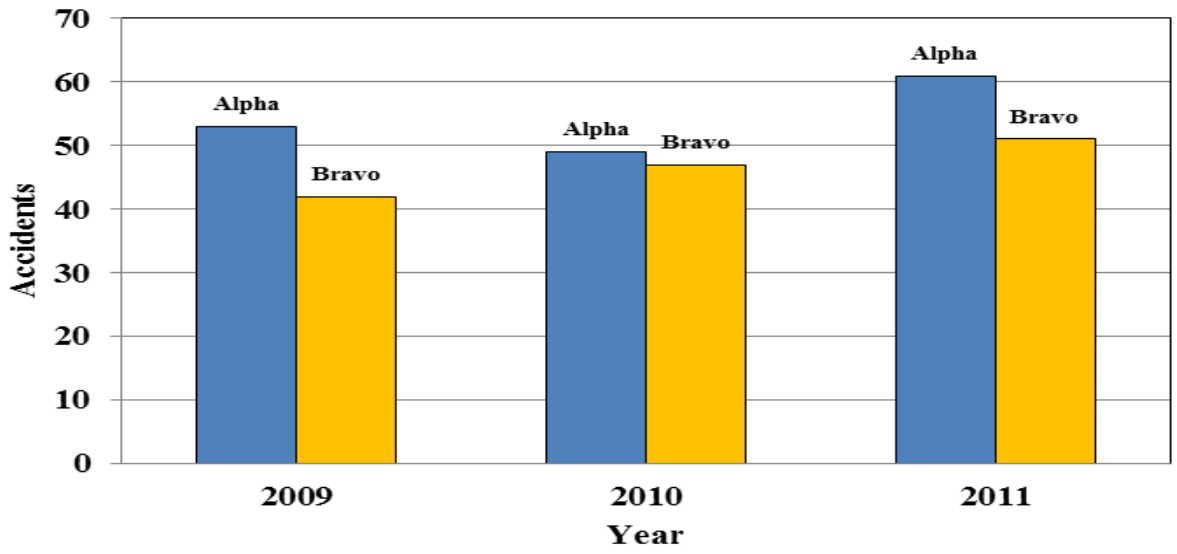


Figure 4.9: Direction Wise of Accidents in the Study Stretch of M-2.

4.4.5 Severity Wise Analysis

Severity analysis are helpful in determination of accident costs, assessing impact of accident on human life and property damage, most important aspect in gauging safety efficiency of transportation system. From 2009 to 2011, a total of 303 accidents occurred. Out of which 106 were fatal, 166 major, 26 minor and 5 property damage were recorded. Overall view of accident severity is shown in Figure 4.10.

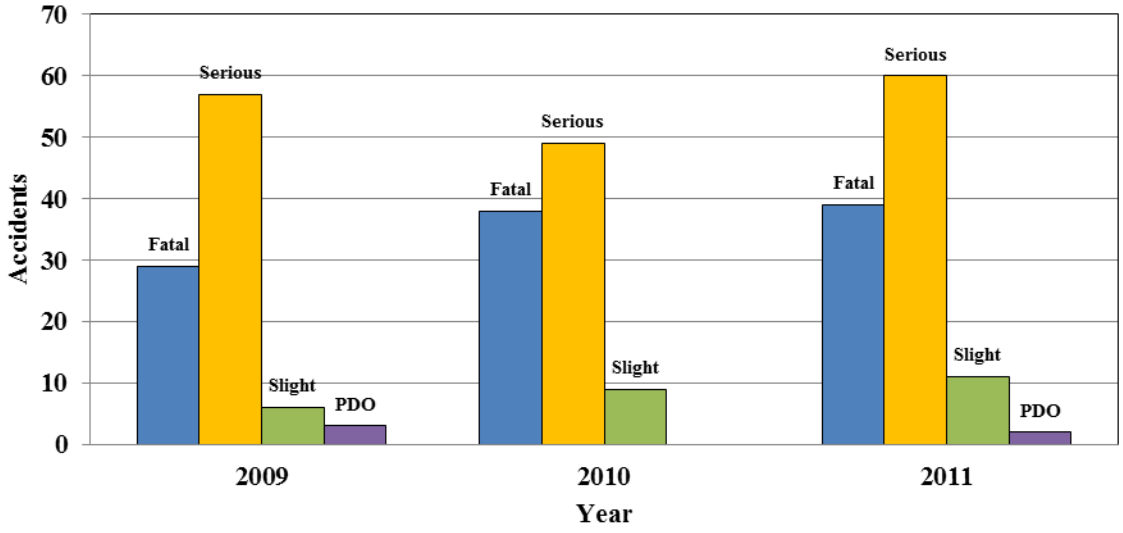


Figure 4.10: Accident Distribution Based on Accident Severity on M-2.

In the total 272 number of accidents, around 131 were recorded fatalities with 214 major injured and 386 as minor injured. The rate of fatalities is very high i.e. 18% people involved in accidents are dead.

4.4.6 Causality vs. Year

Casuality versus year analysis helps in finding out the relation between accident severity and years.Accident outcomes can be discussed and compared.As fatality is increasing from 2009 to 2011 and in parellel,Major or serious injury can also be compared as major injury accidents are also increasing.Safety conditions should be reviewed.Year wise increase also tend to show that traffic load is also increasing so safety issues needed to be adressed more viguriously. . It further presents better understanding of influence of season of year on accident severity.Further data mining of accidents from 2009 to 2011 by Road user type (human involvement) is tabulated in Table 4.3.

Table 4.2: Causality V/S Year Wise Distribution of Accidents on M-2

Year	Drivers/Passengers/Pedestrian			
	Major Injuries	**Minor Injuries**	**Fatalities**	**Total**
2009	284	23	42	349
2010	203	22	56	281
2011	343	32	84	459
Total	**830**	**77**	**182**	**1089**

Results shows that fatality rate is high in pedestrian category with 35% of total fatalities recorded, than it is high in passengers with 40% and in drivers it is recorded as 6% of the total fatalities. Analysis of the injuries revealed that passenger type users are with the worst record with 80% of the total injured. Human factors in association with the accident are termed as users and death ratio increases with the increase of highway users. Year wise facility users are increasing and different type of vehicles are using facility, but the lack of education and traffic law issues are still there, economic down fall has sustained the human education level while affectivity of safety procedure has increased this mismatch shows a clear gap between mass awareness and traffic law enforcement.

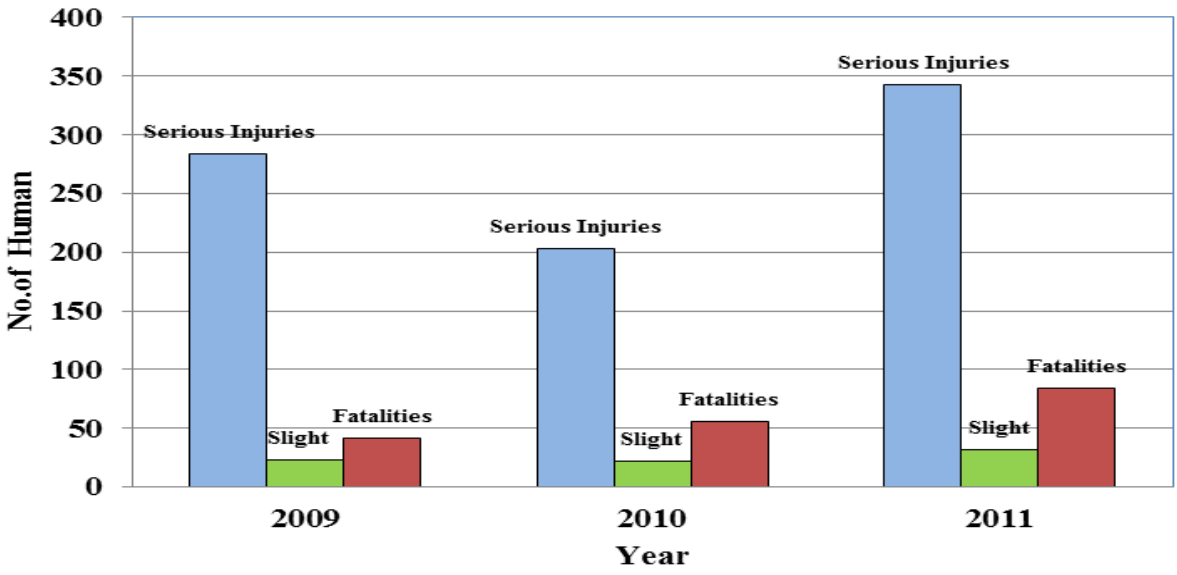


Figure 4.11: Causality Based on Accident Severity on M-2

Human involvement is described that in all accidents 10% Passengers killed, 70% passengers injured,2% pedestrian killed,5% drivers killed and 13% drivers injured.

Total Fatalities = 182

Total Major Injuries = 830

Total Minor Injuries = 077

4.4.7 Severity Index

A widely used statistic for the description of relative accident severity is the severity index (SI), defined as the number of fatalities per accident. For the data of the previous example, there were 7.5 fatalities in a total of 2,360 accidents. This yields a severity index was 0.0318 deaths per accident. The severity index is another statistic that should be compared with previous years and state and national norms, so that conclusions may be drawn with respect to the general severity of accidents in the subject jurisdiction.

Severity Index = No of Fatalities / Total Accidents

SI = 182/303 = 0.60 deaths per accidents (Overall)

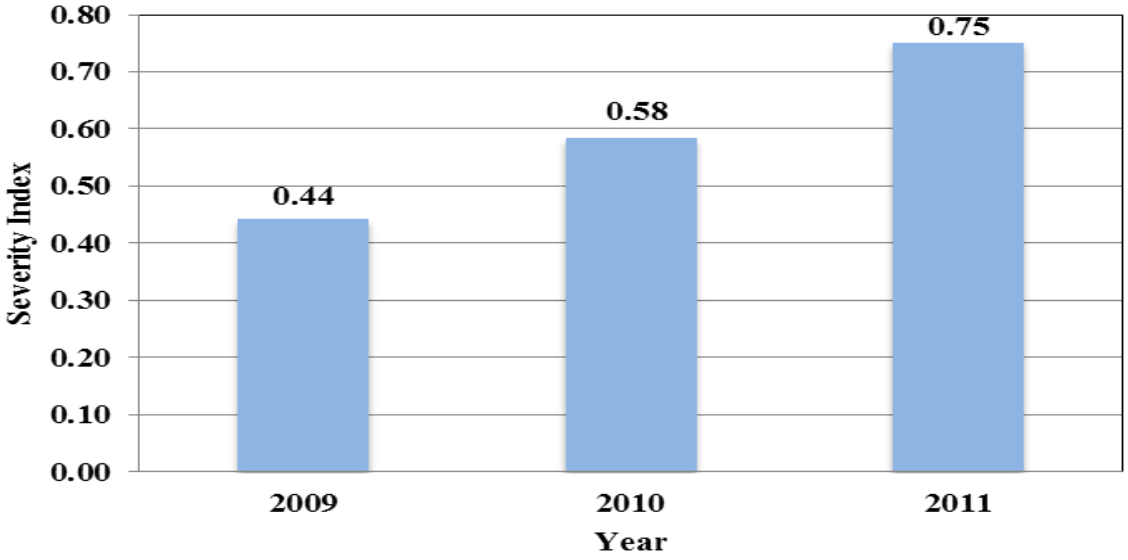


Figure 4.12: Severity Index for Motorway M-2(2009-2011)

Severity Index is a parameter to determine the accident severity, year wise comparison gives better information about the accidents.

The number of injuries per accidents is calculated,

Major Injured per accident = 830 / 303 = 2.73

Minor Injured per accident = 077 / 303 = 0.25

Also, the Fatalities per km are:

Fatalities per Km = 182 / 358 = 0.50

Major Injured per km = 830 / 358 = 2.31

Minor Injured per km = 077 / 358 = 0.22

4.4.8 Collision Type Wise Analysis

This analysis is extremely useful in quantifying accidents as per their collision type. Collision factor can precisely identify the required direction of remedial efforts. Collision type shows impact of speed during study that majority of accidents are complete destruction of vehicle and total property has been damaged. Vehicle has no chance to mechanically unfit for travelling.

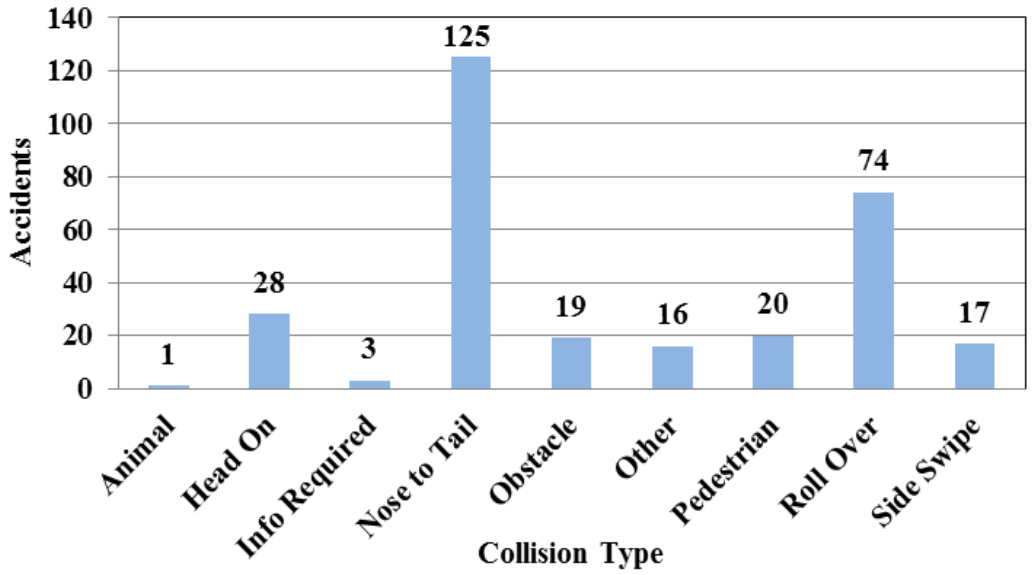


Figure 4.13: Collision Type Based on Accident Severity on M-2

Majorly accidents are collision by Nose to tail 40%,secondaly 25% Roll over,Head on is 9%,Pedestrian accidents are 7%,side swipe,obstacle 6% and 5 % are others.

4.4.9 Weather Wise Analysis

These analysis are carried out to highlight the share of vehicle categories in causing death, major and minor injuries. Fig 4.14 reveals that dry weather impacts more on accidents.

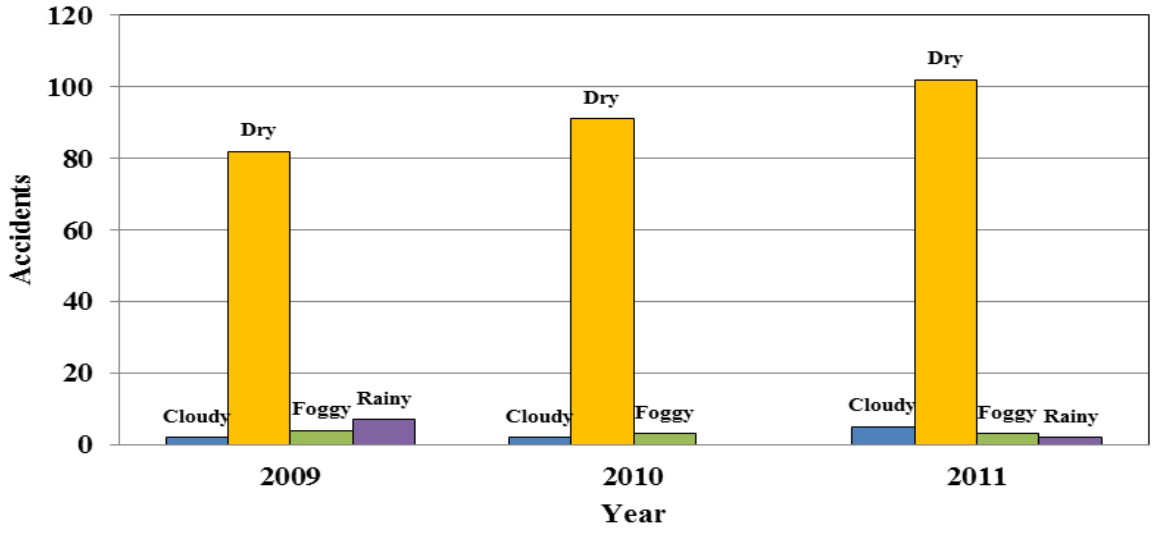


Figure 4.14: Weather Condition Based on Accident Severity on M-2

Observations indicate that cloudy weather 3%,Foggy 3%,Rainy % factors involved but major accidents are in dry weather i.e;91%.Cloudy weather 3%,Foggy 3%,Rainy % factors involved but major accidents are in dry weather i.e;91%.

Usally for weather condition slippry locations are identified and signs are installed so that during change of weather there should be warning of slipping to reduce speed accordingly.

4.4.10 Light Condition Wise Analysis

Lighting conditions in accordance to vision perspective, matters a lot during driving.

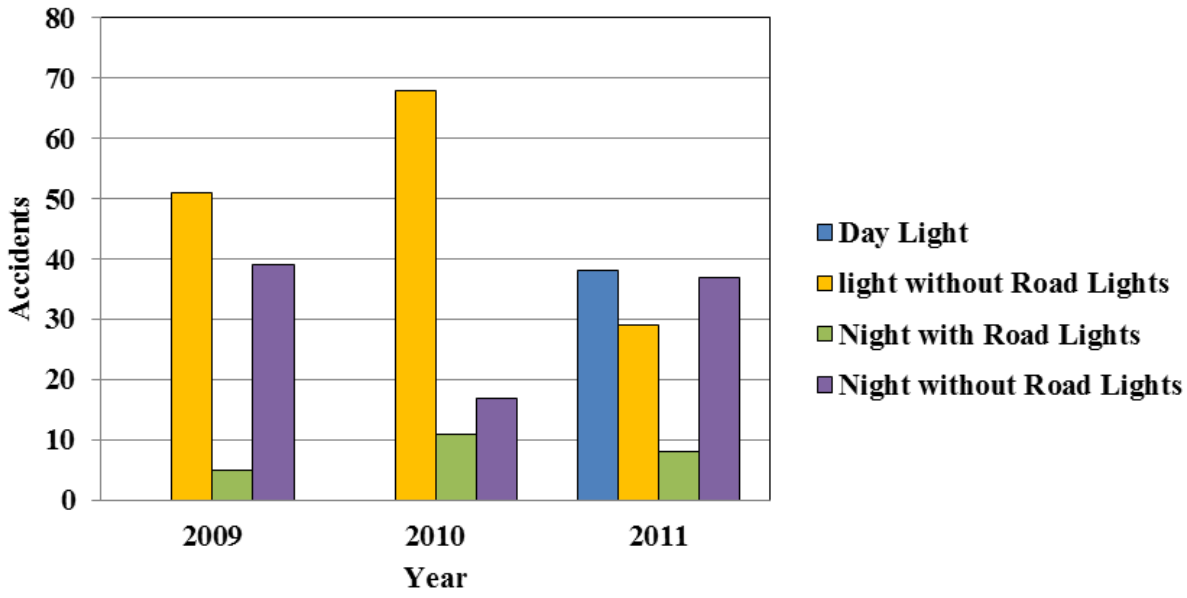


Figure 4.15: Light Condition Wise Based on Accident Severity on M-2

Enviornmental factors influced by light condition are also a factor to affect on accident occurance,Light without road lights has 148 accidents,nights without road lights 93 accidents,day lights have issue 38 accidents and 24 are accidents night with road lights.Day light situatiion affected 12 % accidents,night without road light affected 8% accidents,night without road lights affected 31% accidents and 49% accedents affected by light without road lights.Sometime safety measure are related to proper maintainace of markings and luminious tapes which indicate the direction especially.Very few location have proper lighting and Salt range which ha light problem accomplish with geometic desighn problems,lighting should be installed.

4.4.11 Road Geometry Condition Wise Analysis

Geometric design also effect on driving and causes accidents due to abnormalities.

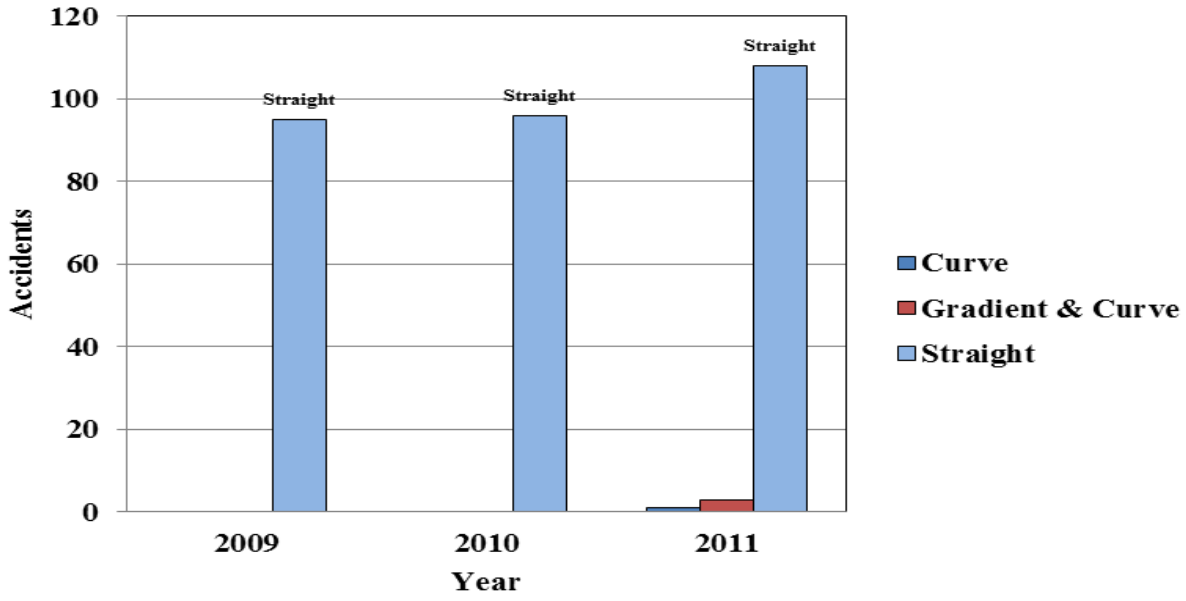


Figure 4.16: Road Geometry Based on Accident Severity on M-2

These analysis are carried out to highlight the share of road condition contributing accidents ,although it is considerd that accidents are affected by road condition but most of accedents are occuring on straight sections ,very less number are on curves or other road section conditions.99% accident occurance is on straight roads while 1 % is in gradatient curves.More broader view is required for the accident investigator that in detail road geometry could be explained.

4.4.12 Contributory Element Wise

There are certain reasons which contribute in an accident but key causes should be identified. Data analysis shown in Figure 4.17 gives detail of that. Careless driving, Dozing at wheel, Tyre burst and brake failure are major causes. Data is spread year wise to find seasonal effect on contributory elements. The result of data analysis from 2009 to 2011 is tabulated in Figure 4.18. Following factors were considered as major causes of accidents:

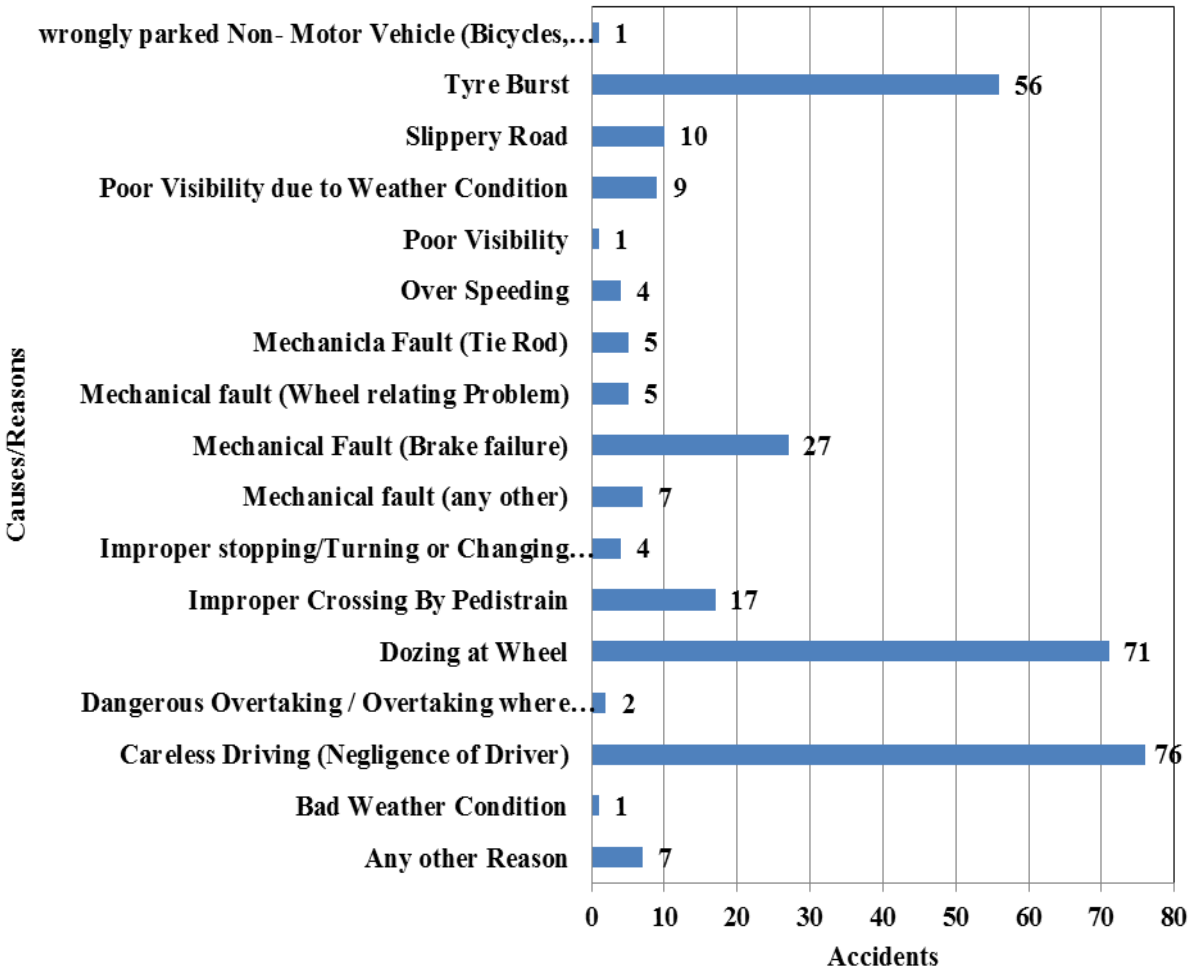


Figure 4.17: Causes of Accident Distribution Based on Accident Severity on M-2

Bad Weather Condition, Careless Driving (Negligence of Driver), Dangerous Overtaking / Overtaking where prohibited, Dozing at Wheel, Improper Crossing By Pedestrian, Improper stopping/Turning or Changing Direction including Sudden Lane Changing by Motor vehicles and converging to Highway, Mechanical Fault (Brake failure), Mechanical fault (Wheel relating Problem), Mechanical Fault (Tie Rod), Over Speeding, Poor Visibility, Poor Visibility due to Weather Condition, Slippery Road, Tyre Burst and others are considered as the factors considered as major factors.Careless Driving (23%), Dozing at wheel (21%), Tyre Burst (19%), Mechanical Fault: Brake Failure (17%) and Pedestrian crossing (2%).This shows that these are 80% contributing factors of accidents. According to year based analysis careless driving, Dozing on wheel, tyre burst and brake failure are the major cause of accidents.

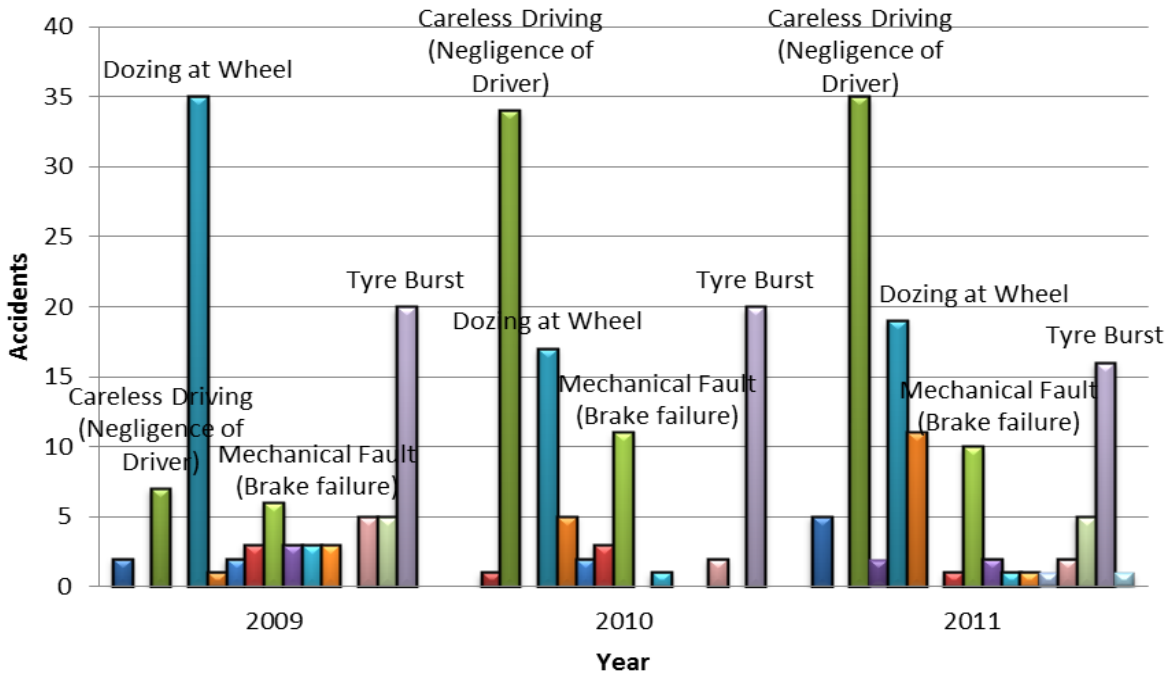


Figure 4.18: Causes of Accident Distribution Based on Accident Severity on M-2

4.5 BLACKSPOTS IDENTIFICATION ANALYSIS

4.5.1 Ranking of Blackspots

The entire section of Motorway between Islamabad to Lahore is unsafe from safety point of view. The main reason is traffic has direct access to the Motorway, which results in congestion and accidents. Analysis of accident data within the study area showed that about 303 accidents occurred on the study stretch of M-2 in the year 2009 to 2011.

A further analysis of this data also revealed that about 182 persons were killed and about 907 persons were injured on the study stretch in the same years (2009-11).Maximum accidents were occurred at km 229, km 224, km 223, km 47 and km 195.Blackspots are identified numerically by counting the reoccurrences of accidents within patch of 1 km. Accident point weightage contains 6 of fatal accidents,3 of major injury,0.8 of minor injury and 0.2 property damage only. Relative importance of parameters involved show that fatal is given more importance because property damage detail is not recorded in Pakistan in term of financial and insurance loss. Following are reoccurrence of accidents at same location on Motorway M-2 Lahore to Islamabad.

Table 4.3: Ranking of Blackspots on Motorway (M-2) Lahore to Islamabad.

KM	Fatal	Serious Injury	Slight Injury	PDO	Total	APW	Ranking
229	5	2	1	0	8	37	**1**
224	4	3	0	0	7	33	**2**
223	2	6	1	0	9	31	**3**
47	4	0	0	0	4	24	**4**
195	3	1	1	0	5	22	**5**
286	1	5	0	0	6	21	**6**
22	2	2	0	0	4	18	**7**
23	3	0	0	0	3	18	**7**
137	2	2	0	0	4	18	**7**
154	2	2	0	0	4	18	**7**
9	2	1	0	0	3	15	**8**
13	2	1	0	0	3	15	**8**
155	2	1	0	0	3	15	**8**
225	2	1	0	0	3	15	**8**
346	2	1	0	0	3	15	**8**

Following are some facts:

- Top three accident locations show that Salt range is the most problematic area.
- In this procedure the accident blackspots identification depends upon fatal accidents not on number of accidents.
- All type of accidents get appropriate portion in the finding formula, with priority wise proportion.
- This procedure may lead to a suitable accident prone location because recorded data is not in detail regarding finance and insurance related to property damage, so fatality remains the priority.
- Ranking procedure describes blackspots in descending order.
- Salt Range can be observed as a most dangerous zone from the blackspots identification procedure because of higher fatal accidents.

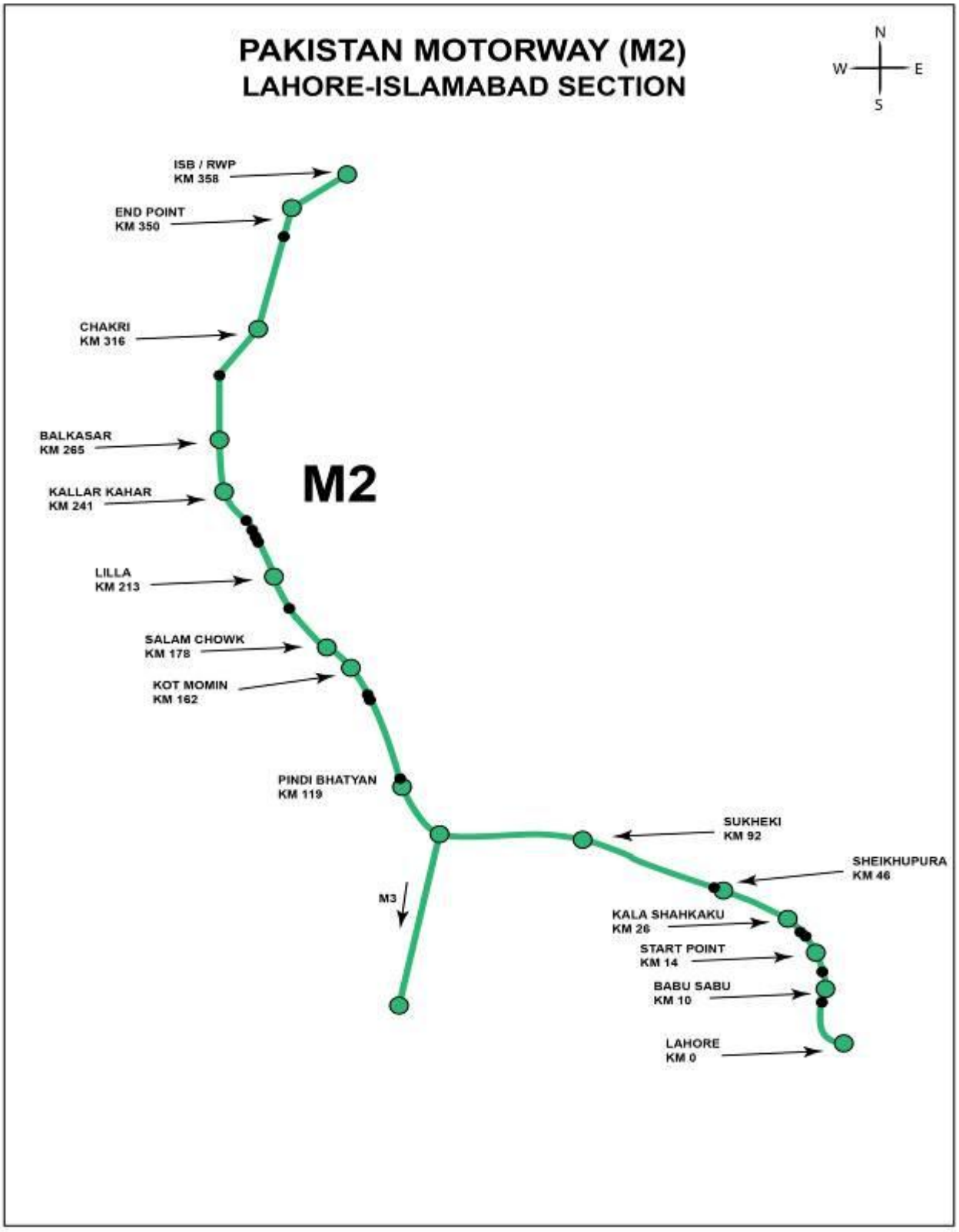


Figure 4.19: Blackspots Map for Motorway M-2

4.5.2 Causes of Accidents on Blackspots

Rank 1: Accident blackspot number 1 is located at 229km (Kallar Kahar), having highest accident severity. On detail observation of accident occurrence all the accidents have same cause of accidents i.e.; Mechanical Fault (Brake failure),4 drivers killed,38 passengers killed,1 driver injured and 115 passengers injured during last three years. Majority of accidents were in the night.

Rank 2: Accident blackspot number 2 is located at 224km (Kallar Kahar), having 2nd highest accident severity. On detail observation of accident occurrence almost all the accidents have same cause of accidents i.e.; Mechanical Fault (Brake failure), 1 drivers killed, 6 passengers killed, 2 driver injured and 10 passengers injured during last three years.

Rank 3: Accident blackspot number 3 is located at 223km (Kallar Kahar), having 3rd highest accident severity. On detail observation of accident occurrence all the accidents have same cause of accidents i.e.; Mechanical Fault (Brake failure), 2 drivers killed, 35 passengers killed and 20 passengers injured during last three years. Majority of accidents were in the night.

Rank 4: Accident blackspot number 4 is located at 47 km (Sheikhupura), having 4th highest accident severity. On detail observation of accident occurrence almost all the accidents have same cause of accidents i.e.; driver: Dozing on wheel, tyre burst, careless driving etc. 2 drivers killed, 7 passengers killed and 6 drivers injured during last three years. Majority of accidents were in the night.

Rank 5: Accident blackspot number 5 is located at 195km(Near Lilla) due to similar level of severity, having 5th highest accident severity. On detail observation of accident occurrence all the accidents have shown that 195km has issue with driving and tyre burst.

Rank 6: Accident blackspot number 6 is located at 286 km (Nearer to Chakri), having 6th highest accident severity. On detail observation of accident occurrence all the accidents have shown that 9km have issue of pedestrian crossing, careless driving, and slippery road.

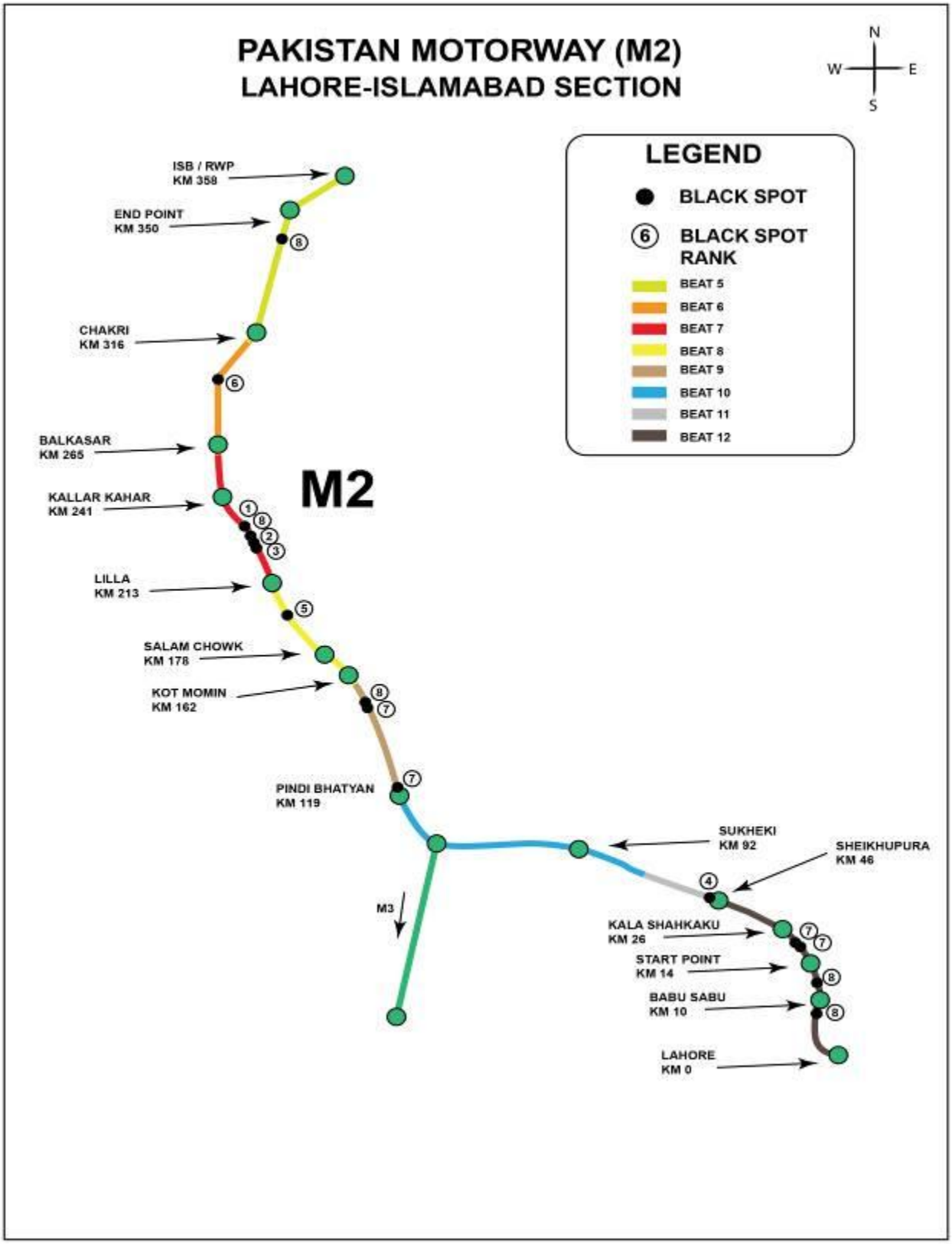


Figure 4.20: Beat Wise Blackspots Map of Motorway (M-2)

Rank 7: Accident blackspot number 7 is located at 22 km(Lahore),23 km(Lahore),137 km(Sial Mor), and 154 km (Kot Momin) due to similar level of severity, having 7th highest accident severity. On detail observation of accident occurrence all the accidents have shown that 22km have issue of pedestrian crossing, 23km has issue pedestrian crossing, 137km has been made blackspot due to careless driving, and 154km has issue with driving and tyre burst.

Rank 8: Accident blackspot number 8 is located at 9 km(Lahore),13 km(Lahore),155 km (Kot Momin) ,225km (Kallar Kahar) and 346km (Rawalpindi) due to similar level of severity, having 8th highest accident severity. On detail observation of accident occurrence all the accidents have shown that 9km have issue of pedestrian crossing, 13km has issue pedestrian crossing, 155km has been made blackspot due to careless driving, 225km, has issue with Mechanical Fault (Brake failure) and tyre burst and 346km has issues of driving and tyre burst.

4.5.3 Case Study of Kallar Kahar Bus Accident

A school bus accident, which occurred on September 27, 2011, on Motorway (M-2) near a town of Kallar Kahar in Chakwal district of Punjab, Pakistan. As a result of accident involving hired bus carrying students from Millat School (located in Faisalabad) was returning to town after a trip to the field and a picnic in Islamabad. During the trip on the motorway M-2, the bus skidded due to the mechanical brake failure and plunged into a ravine. At least 37 people were killed in the accident, and at least 70 were injured. It was reported that, although the bus had a capacity of 70 passengers, which had at least 110 people. However, the bus rolled over before passengers could move. A student who survived the crash told that most of the children looked at the teacher, who was lying on the road when the bus overturned. Children who were in the bus, at the time, hit suffered the greatest losses. News correspondents reported that the bus was traveling in one of the coolest parts of the road. Pakistan is one of the worst records of road accidents and behavior, is accused of bad roads and defective vehicles. An official of National Highway and Motorway Police have shown that the bus was an old model, which was driven by an inexperienced driver who had never ridden on the road. According to different reports, school administration for over loading and bus owner for providing a vehicle without specific route permit were declared responsible. After the accident bus was almost destroyed, this can be can be seen in Figure 4.21.

Figure 4.21: Kallar Kahar Accident Bus after Accident on Motorway M-2

4.5.3.1 Case Summary

- Accident Date: 27-09-2011(Monday)
- Vehicle type: Bus (FS 4186)
- Location: Kallar Kahar (229Km)
- Type of Passengers: School children and Teachers
- Accident Severity and Loss: **Fatal & 37 died, 70 passenger injured**
- Cause of Accident: Mechanical Fault (Brake Failure)
- Type of Collision: Side swipe
- Time/Light Condition: 19:57/ (Night without Road Lights)

Contributing Factors: Driver skill was very low, vehicle not in very good condition, over loading, over speeding

4.5.3.2 Fact Findings Report

- The driver of the bus was unfamiliar with the mountainous terrain in Salt Range.
- The driver did not avail emergency climb at S-229

- 1981 model bus, having seating capacity of 57, was condemned and auctioned by PAF
- MVE (Motor vehicle Examiner), Faisalabad issued a fitness certificate valid up to 29/12/2011.
- RTA, Sialkot issued Route Permit for Sialkot-Faisalabad route valid upto15/09/2012
- The school management compromised upon the safety of 112 persons.
- As per MVE, Chakwal unfamiliarity and negligence of the bus driver are the major causes of accident.
- Slope of the area was another contributory factor.
- Bus covered 12 km distance in 37 minutes, hence, no over speeding was proven

Comments: Already Kallar Kahar is declared for low speed range, driver was unable to control an overloaded bus due to lesser skill.

4.6 ACCIDENT ANALYSIS OF BLACKSPOTS AT SALT RANGE SECTION

Salt range has been found as the top most hazardous location, as highest numbers of accidents are occurring on it. According to Haider (2001), the motorway design i.e., geometric design is based on a design speed of 120kph along the full length of this motorway except in the hilly terrain. Where the speed of vehicles was compromised probably based on economic factors. Overall profile of motorway (M-2) is shown in Fig 4.22.

4.6.1 Site Investigation and Accident History

In the Salt Range the geometric design of road could have been further improved, at this point height is 428m while length of the highway section is about 10 km, where the average slope should be 4.28%. However, with in this portion there are 3 sections with a gradient of up to 7% and a section with the reverse grade. Moreover, there are turns with < 100m radii and they are 5 sharp turns. These curves are dangerous to fast moving vehicles. Overall profile of Motorway (M-2) Figure 4.22 also shows clearly of that area, while Figure 4.23 shows the profile of Salt Range, with 7% of slope.

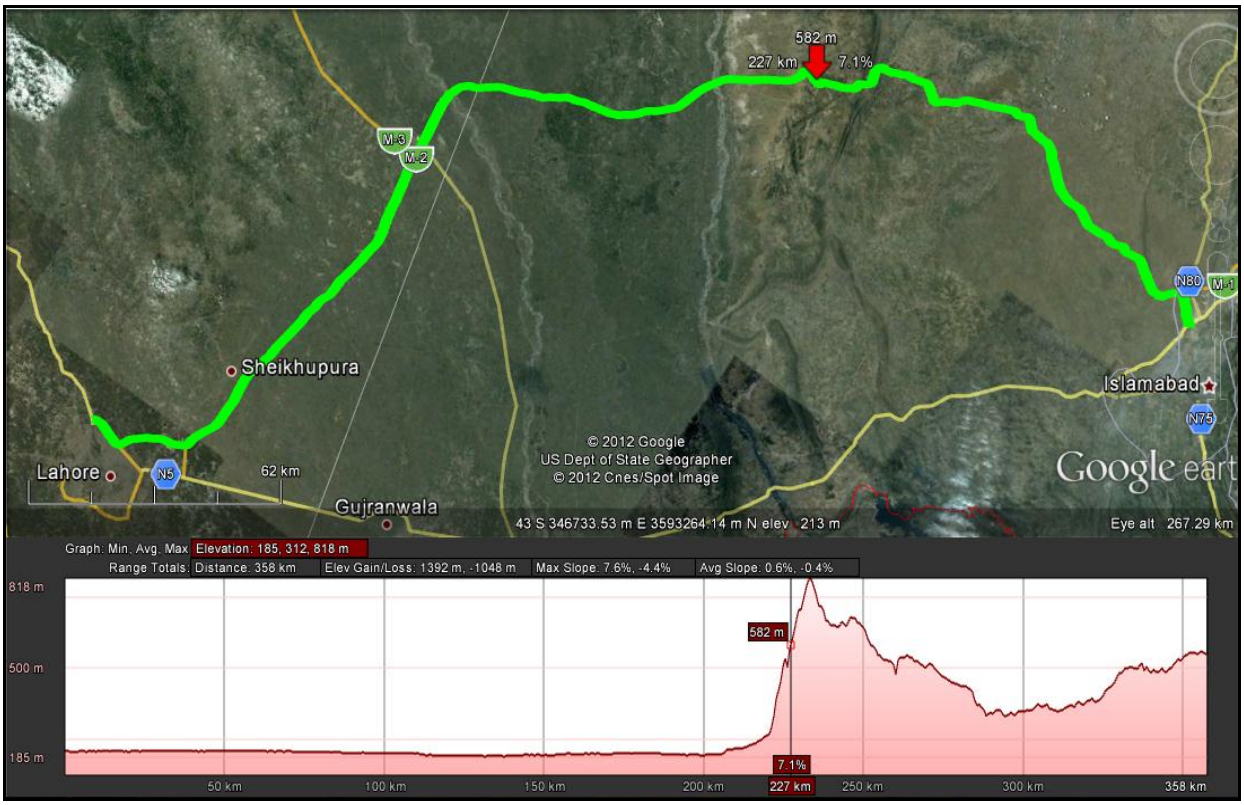


Figure 4.22: Vertical Profile of Motorway M-2

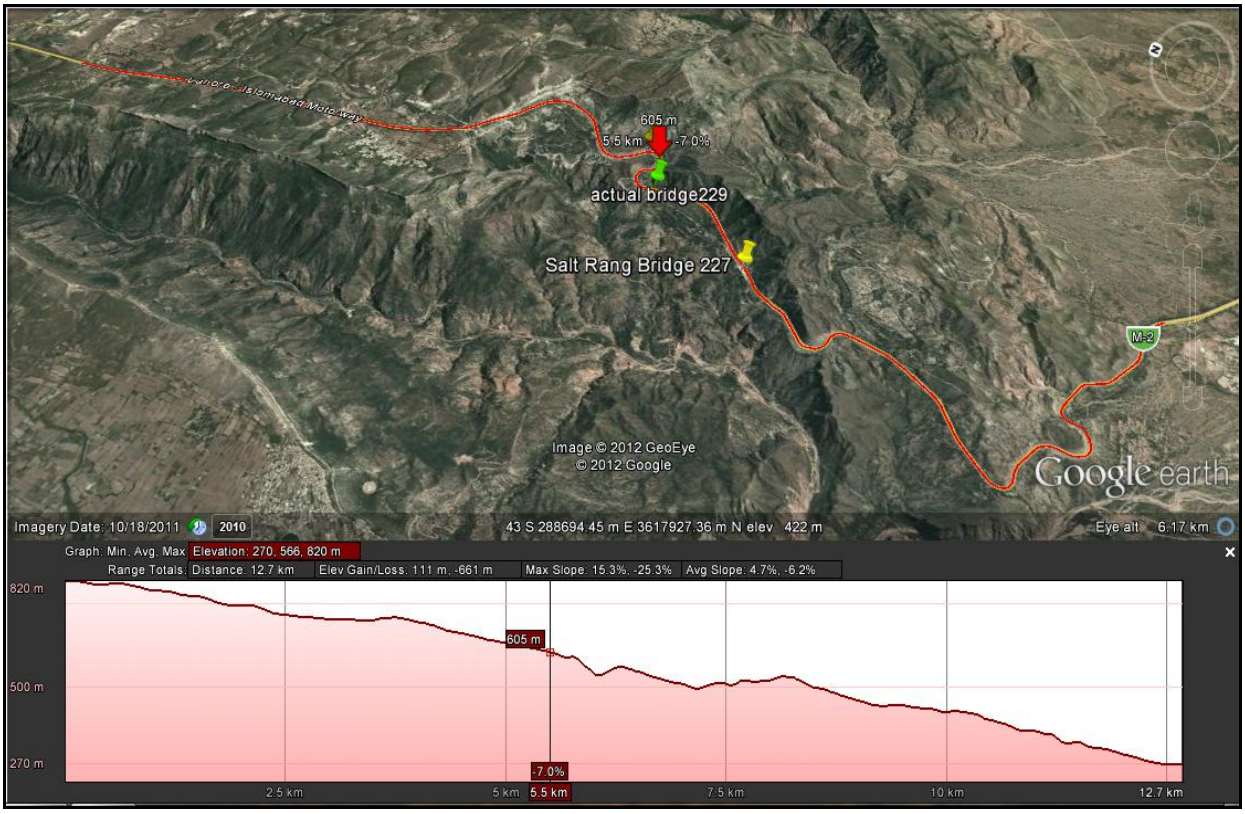


Figure 4.23: Vertical Profile of Salt Range (M-2)

The actual speed observed at two of the most critical curves show that all types of vehicles except buses are over speeding at these curves. This means that these vehicles are not moving at speed while traversing/negotiating these curves. The over speeding at these curves is probably due to higher downhill gradient i.e.,>7%. According to (AASHTO 2004), for freeways maximum allowed grade for mountainous terrain is < 7% to maintain function of a freeway.as shown in Table 4.4.

Table 4.4: Maximum Grades for Rural and Urban Freeways (AASHTO, 2004)

METRIC						
Type of Terrain	**Design Speeds(Km/h)**					
	80	90	100	110	120	130
	Grades (%)					
Level	4	4	3	3	3	3
Rolling	5	5	4	4	4	4
Mountainous	6	6	6	5	-	-

- Because the horizontal and longitudinal alignment of very complex designs, posted speed of the Motorway section in the Salt Range as defined in the Design Standard for Motorways in Pakistan is 50 kph for salt range , 120 kph in flat and 90Kph in rolling terrain. Vehicles moving towards Islamabad encounter a 7% upward slope which tends heavy vehicles to change their route and use N-5 while the other portion towards Lahore also acts as a reducing agent of 10 to 15kph speed.

- Blackspots of accidents on the road, a section aimed at two sites in the south bound lanes: 223km, 224 km and 229 km. The major cause of fatal accidents is a combination of the slope of 7% and circular turning with a radius of curvature of < 100 m at the same time, the majority of serious accidents in these two blackspots due to large vehicles.

- The radii of various curves in salt range does not match with the design speed of 50-60kph, thereby meaning that the design speed cannot be maintained on some of these is probably because of the reason that increase in radii could change the alignment, which could increase in the cost of the project. Curve shown in Fig 4.24.

- Some very sharp curves are followed by S-Type curves immediately without any transition in between them. This situation is the most dangerous as far as driver behavior is concerned, consequently warrant to the safety of the highway.

Figure 4.24: Horizontal Profile of Salt Range (229km Curve)

- Geological condition of the study area is very unstable and prone to natural disasters. Major disaster erosion and landslides, limestone cliffs on a large scale about 230 km and a landslide at km 223 and km 228 are of small scale. While the National Highway Authority has executed various measures, conservatives, including the adjustment of retaining walls, providing a buffer zone (pocket) for retaining walls and drainage improvements at the edge of the lower slopes, etc., it is impossible to completely avoid natural disasters effect on Motorway traffic. According to observation, there is a ripple on the road to 224-225 km, the cause of which is unclear.

A motorway should be used by the long distance freight traffic, on the other hand on Lahore-Islamabad motorway; the trucks are reluctant to travel because of the following main reasons:

- The axel load controls being enforced on the motorway, whereas the alternate route having being tolled has no such restrictions.

- The steep gradient in the salt range, as majority of truck fleet in Pakistan consists of Old Bedford trucks(above 69%).The low engine power of these trucks further cause more difficulties for them to negotiate higher longitudinal grades.

4.6.2 Present Safety Condition of Salt Range

- Already road marking has been properly marked and maintenance of marking is done regularly.

- Signs named as Rock Falling, Reduce speed, keep low gear; especially speed limit signs at suitable interval have been installed.

- A speed limit of 40km/h has been assigned for LTV and 30km/h for HTV after Kallar Kahar bus accident. Previously it was 50km/h and 40km/h respectively.

- To avoid over speeding of buses, Motorway Police has adopted a procedure to note timing of every vehicle, as fixed 25min to cover 20km (from 240km to 220km)portion.

4.7 STUDIES CONDUCTED FOR REALGINEMT OF SALT RANGE (M-2)

The Pakistani government understood the issues in road layout in the section of the Salt Range shortly after the M-2 was opened in 1997. Thus, the National Highway Authority (NHA) conducted many studies to explore possible restructuring, but the plans do not include major bridges and tunnels, and the total length of the adjustment has increased significantly due to large scale diversion of so improving the plans were not accepted. As part of the medium term and the National Trade Corridor (NTC) Improvement Program (NTCIP), the National Highway Authority has given priority to solving the problems in the Salt Range section of the M-2, and requested that the Japan External Trade Organization (JETRO) to conduct feasibility study. While in Pakistan, the research team confirmed the National Highway Authority and the Department of Communications (MOC), the NHA will be applied to the Government of Japan for financial support of the project, the feasibility study, if it can be established. Actually that

Japanese firm was interested in the supply and installment of Japanese product on their suitable rates while Pakistan was having shortage of economy for this specific project.

4.7.1 Study to Realign Salt Range Project

Japan External Trade Organization- JETRO (2008) conducted the study with the help of Tobishima Corporation., Nippon Steel Engineering Co. Nippon Steel Co., and Central Consultant Inc. The projected demand for vehicle movement in the study should be based on the expected demand for transport to the main highway network throughout the country. Therefore a traffic demand forecast was made of the National Trade Corridor traffic Research. In addition, the research team found that the capacity region of the Salt Range M-2 is reduced, and this part becomes a bottleneck in the future if the existing alignment cannot be improved. The results of the future demand for bandwidth is expected of the Salt Range M-2 are shown in Table 4.5.

Table 4.5: Traffic Demand Forecast for the Salt Range (JETRO, 2008）

Year	Growth Rate	Passenger Car	Minibus	Bus	Truck 2-Axles	Truck 3-Axles	Trailers	Total
2005	-	5,411	1,313	2,520	592	235	38	10,109
2015	3.6	19,480	4,727	9,072	2,131	846	137	36,393
2020	6.2	33,548	8,141	15,624	3,670	1,457	236	62,676
2025	9.5	51,405	12,474	23,940	5,624	2,233	361	96,036

4.7.2 Identification and Analysis of Issues and Projects Content

After completion of Motorway (M-2), the National Highway Authority conducted many studies on the restructuring of the Salt Range. However, these studies did not consider structures such as bridges and tunnels, a large scale. Thus, the total length of the adjustment should be greatly expanded with a detour in order to facilitate large-scale vertical alignment. In the latter study, the recommended length of 31 km route, which is 21 km longer than the existing alignment, and the project cost is estimated at 4.9 billion rupees. The main problems identified in the research team for this restructuring plan, recommendations were as:

- Although the slope of the design maximum of 4%, there is a continuous tight turns require slowing down, so it is impossible to obtain function of a motorway.

- In order to maintain a minimum standard for free motion of vehicles structures, high continuous retaining walls are required. In addition, larger scale excavation and foundation will be necessary that actual construction is very difficult.

4.7.3 Overview of Proposed Engineering Methods

National Highway Authority wanted to get help from japan to realign this section and also some financial benefits were required. So proposals including plan to use a tunnel and high pier steel girder bridges, which are rarely used in Pakistan were floated. In addition, increase in length, as NHA is concerned with the length of the path for restructuring, and longer routes loose user attraction. Thus, the National Highway Authority was not satisfied with the preceding analysis plan. After adjustment of these conditions and problems in the study area, the research team used the following policy. In addition, the transition (spiral) curves are used for both ends of the curve to ensure a smooth ride.

- **Opinion to Improve the South Bound Lanes**

- If alignment throughout the northern and southern bands associated improvements necessary, the total project cost will be high. In addition, road safety can be achieved if the combination of the gradients were spoken calmly and strong S-curves (hairpin bends) could be avoided by taking a larger radius of horizontal curve, although still strong.

- Accident blackspots are concentrated in areas with a combination of 7% down and bends with a radius of curvature of less than 100 m Thus, the aim of improving the curves of the study. Thus, a partial reorganization in order to avoid the problematic sections (km 223-225 km and 229 to 231) is offered on the south bound lanes.

- Southbound lane is usually encountered with natural disaster and rock falling phenomenon as investigation have united against the measures can be achieved by changing the way south to the north of the existing bands related consolidated to ensure a certain distance of the tracks.

- In terms of the above, the team proposes a plan to improve South-related band maximum use of existing roads, including existing channels related to the north, to raise the minimum radius of closed curves with the same low gradient.

- **Opinion to Improve the North Bound Lanes**

- In order to avoid an escalation to reduce the speed of vehicles at least 45 kph at 90 kph, an entirely new arrangement is proposed with a maximum gradient of 4% or less, as the entire section is mounted.
- To apply the maximum slope of 4%, it is necessary to achieve a sufficient length of the road. However, since the proposed route passes through steep terrain, the minimum bending radius of not less than 300 m is used to cover the estimated speed of 90 km / h.
- To meet the requirements of the project, embankments, bridges, elevated console and a high tunnel is used.
- To reduce the cost of the project, the use of the strip north bound lanes for heavy vehicles was also considered.

4.7.4 Description of the Realignment of Salt Range Project

- **Basic Opinion to Determine the Content of the Project**

Geometric standard is set to "Road Standards in Pakistan" (NHA 1992) used in the study. Here the study area of mountainous terrain, with a speed of 90 kph is considered. Although the cross-section geometric design and the typical standard speed of 90 kph applies in general, values below the minimum level used as the absolute values of cross sections with geographic restrictions. In addition, the protection extends to the slopes in anticipation of cuts, if necessary, taking into account the topographical & geological conditions are extremely unfavorable. In the study, the restructuring plans are considered in three phases on the basis of reports, studies and existing data and information. Then the preliminary design is made to the route selected for the second phase of the study.

- **Realignment Plan**

With regard to the reorganization of the road, on the basis of field research, exploration and boring, plans to rebuild the right, as described below, were chosen to address the M-2 in the study area (often accidents, natural disasters and difficulties climbing routes on the north due to trucks shown in Figure 4.25 and Figure 4.26.

- Motorway improvement plan includes the south to tinker with the existing sections of the adoption curve of larger radius curve to the horizontal. In addition, efforts to avoid the inclination of 7% in sections with a small radius curve in the planning of the restructuring.
- In order to balance the amount of reduction in the ground and fill the horizontal alignment is at the top of the mountain at the bottom of the Salt Range in the section where the new alignment across the river, the alignment is fixed to the top of the intersection to minimize the scale of the bridge to avoid the long bridge term. In the section where the proposed route runs along the existing Motorway, the alignment occurs in the southeastern part of the existing ways to minimize the height of the piers offer all the time. To determine the gradient, the maximum slope of 3% will be accepted at the site tunnel, while the absolute maximum gradient of less than 5% were employed on the ground and bridge-sections, which is determined by the maximum slope adjustment speed up the weight, at least twice slower.
- In a study is planned to increase the partial restructuring of the existing M-2 to the south connected routes and restructuring opportunities for the Northbound to three lanes each were planned, and proposed to government in the explanation of the draft report. However, due to the high cost of the project, the research team asked the National Highway Authority to consider a new line with two lanes exclusively for trucks. At the request of the National Highway Authority, the research team of JETRO (2008) selected alternatives, and feasibility of options shown in Table 4.6 have been studied.
- At the lower section of the Salt Range area, three-span continuous composite beam steel cable suspension bridge cable type is proposed, while the continuous composite steel girder bridges, which offers a new alignment crosses the existing M-2.
- To schedule a tunnel, the tunnel length of more than 1km, it is center of north bound lanes. The design speed in the tunnel section is defined as 60 kph, as it is for the exclusive use of large vehicles. The upper part consists of three circles form intends to take into account an economic point of view. For geometric design, and members of the section, the horizontal radius of curvature is set to 750 m, determine the vertical gradient of 3.0% cross slope is defined as 5.0% (lower right) and shoulder fixed at 0.3 m, and the Kohat Tunnel. To determine if clearance of the track.

Table 4.6: Alternatives for the Route Realignment Plan (JETRO, 2008）

Options	Improvement Contents	Project Cost	Safety	Rock Falling Prevent	Measures for North Bound Goods Vehicles
Proposal-1	* New realignment of the north bound lanes with 3 lanes. * Partial realignment of the south bound lanes with 3 lanes.	High	Good	fine	To maintain minimum speed of 45 km/h for the north bound goods vehicles.
Proposal-2	* New realignment route with 2 lanes exclusively used for the North bound large size vehicles. * Partial reorganization of the existing M-2 with 5 lanes, namely the two-lane north bound traffic except vehicles and a large 3-way south bound traffic.	High	Good	fine	To maintain minimum speed of 45 km/h for the north bound goods vehicles.
Proposal-3	* The new restructuring of routes with 2 lanes used exclusively for large vehicles in both directions for each direction of movement. In this case, the partition layout suggested climbing rails ground to the north bound track to minimize the effect of slow vehicles moving goods ordered. * Limited improvement of sharp horizontal curves within the existing 6 lanes width.	Medium	Medium It is possible to prevent traffic accident of the south bound traffic. However, there is a new risk of head-on collision.	May or May not	To maintain min. speed of 45 km/h for the north bound goods vehicles.
Proposal-4	* Partial realignment of the existing carriageway of both directions with 6 lanes.	Low	Good	fine	No improvement

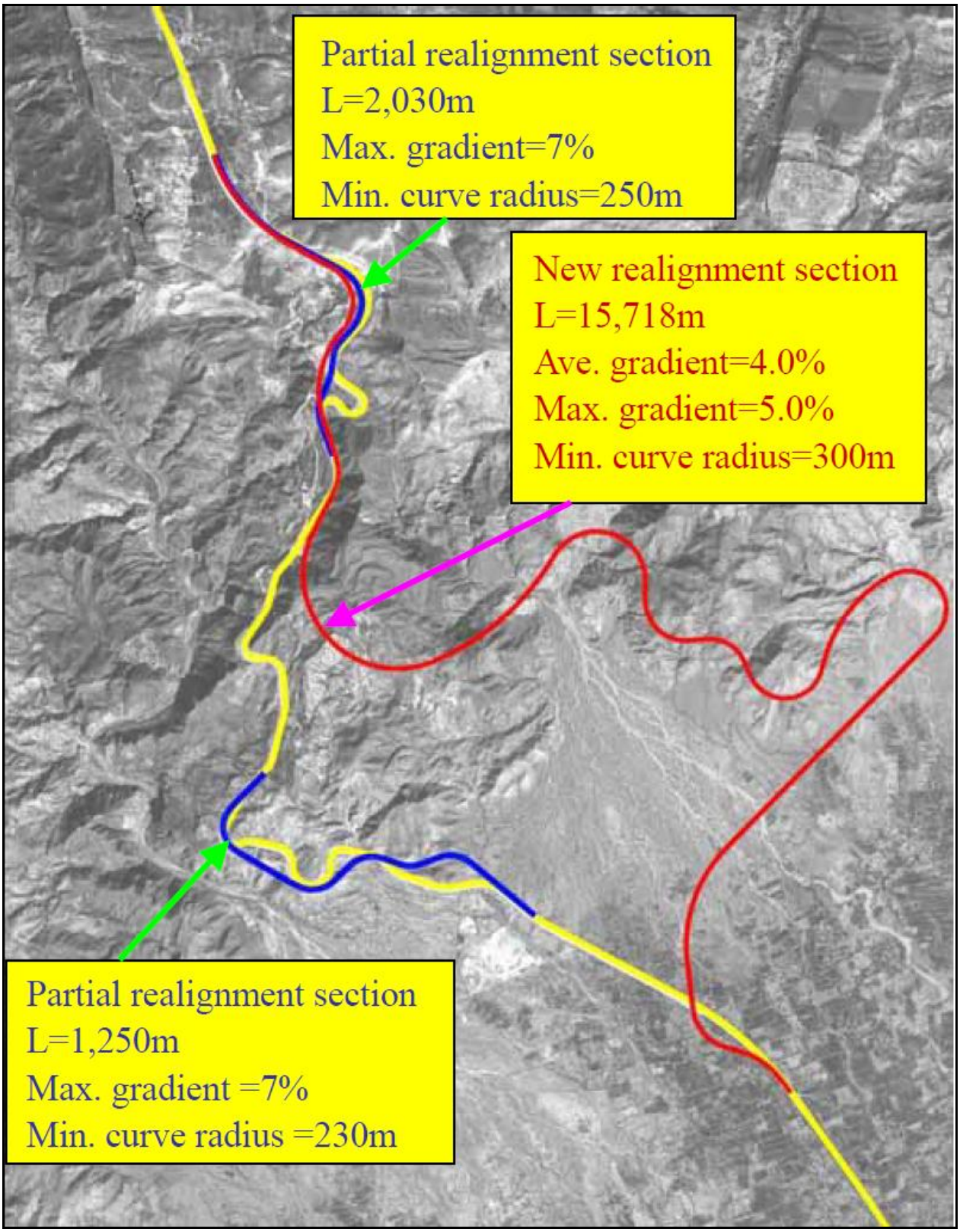


Figure 4.25: Route Realignment Plan of Alternnative-2(Adopted from JETRO, 2008)

Figure 4.26: Route Realignment Plan of Alternnative-2(Before Realignment)

Figure 4.27: Route Realignment Plan of Alternnative-2(Proposed Realignment)

- **The Results of the Preliminary Design**

A comparison of these plans restructuring, preliminary design of road sections, bridges and sections of the tunnel section was achieved. At this stage of design work has been done on the basis of bilateral section of the new tuning and 5 lanes of partial redistribution of the sections in response to the observation of the NHA. These realignment plans by JETRO (2008) also show some higher interest related to the investment and earning. Most of the expensive material is to be purchased from Japan showing marketing prospective.

- **Preliminary Estimate of Construction Cost**

As a result of conceptual design, preliminary construction cost of each option is calculated as shown in Table 4.7. The cost estimates, reports and other materials purchased in Japan is more than 30%, except for the Option-4.

Table 4.7: Results of Preliminary Cost Estimation for Alternatives (JETRO, 2008)

Proposals	Cost in Pakistan (Rs.)	Cost of Materials and others Procured from Japan (Yen)	Total (Rs.)
Option-1 (Japanese cost)	7,806,974,200	9,941,718,052 (38.9%)	12,777,833,226
Option-2 (Japanese cost)	7,242,179,937	6,557,033,467 (31.2%)	**10,502,696,671**
Option-3 (Japanese cost)	5,369,537,992	5,966,549,851 (35.7%)	8,352,812,918
Option-4 (Japanese cost)	2,698,776,635	738,104,520 (12.0%)	3,067,828,895

Option-2 is the best considered options in comparison to others.

4.7.5 Environmental and Social Sustainability

Pakistan calls for environmental impact assessment (the "EIA") at the national and provincial road or major road projects, except for maintenance, repair or reconstruction of existing roads with a total value of Rs 50 million and above. Because the project cost more than Rs. 50 million must be carried out an EIA after graduation. F / S, although there are no environmental and social factors to be considered as the project site is approximately 15 kilometers of highways situated in the Salt range in the province of Punjab, the National

Highway Authority is responsible for informing the Department of Environment Government of Punjab province for project approval.

4.7.6 Economic Feasibility

- **Evaluation of the Project Cost**

The total project cost is calculated for the four alternatives proposed, based on the following costs shown in Table 4.8. The currency used in calculating the cost of the project and the Pakistani rupee Japanese yen. The exchange rate is Yen 1.0 = Rs. 0.5.

Table 4.8: Project Cost for 4 Alternatives (JETRO, 2008)

Sr.No	Cost Item		Alternative-1	Alternative-2	Alternt-3	Alternt-4
1	Direct	1@8%	25,903	22,074	15,805	6,269
2	Engineering cost	1@1%	2,072	1,766	1,264	501
3	Administration	1@1%	259	221	158	63
4	Compensation	1@1%	259	221	158	63
5	Land acquisition	1@1%	259	221	158	63
6	Contingency	1@10%	2590	2207	1581	627
	Total Project Cost		31,342	26,710	19,124	7,586
	Expressed in million Rs.		62,684	53,420	38,248	15,172

Note: Prices are as of December 2007. (Unit: Million Yen)

- **Summary of Economic Assessment**

- **Placement of the Economic Evaluation**

  - Future traffic volume is estimated in this study has been approved upto year 2033

  - To implement the project, some studies and detailed design work will begin in 2010 and construction will begin in 2011 and was completed in 2014. For this assessment, the construction cost divided proportionally over four years.

  - Prices in the assessment of December 2007, and the exchange rate Yen= 1.0, PRs =0.5.

- **Benefits**

  After the economic benefits expected from the project:

- Operating costs of vehicles (hereinafter referred to as "VOC") savings

- Travel time savings

- Prevention of accidents by reducing accidents

- Cost savings resulting from an accident and traffic control

- Improved road safety and driving comfort

The economic benefits discussed in this evaluation include the savings in operating costs of vehicles and time savings in a way which established the method of calculation of equilibrium in terms of money.

At the time of evaluation of the economic benefit, since the volume of traffic on the future of M-2 includes the National Highway traffic converts N-5, the benefits will be taken as the initial movement of the M-2, and the traffic converts. As majority of heavy traffic like trucks prefer to use N-5 as the design problems discourages to climbing .Description of Vehicle operating cost, and the time value of each type of vehicle in Pakistan is estimated based on data from several other reports on the projects of roads and highways and motorway projects in Pakistan. Using the cost per unit of VOC in the vehicle type, time value of the vehicle type and volume of traffic in the future economic benefits are estimated for a period of 20 years from 2015 to 2034 comparison "with" with "no" If, after calculation of the total annual travel time and total annual Vehicle Operating Cost. The annual benefit amount shown in Table.4.9

Table 4.9: Annual Benefit Amount (JETRO, 2008）

Year	VOC Saving	Travel Time Saving	Total
	Option-1		
2015	981	722	683
2025	2,777	2,260	5,037
2034	6,222	5,223	11,445
	Option-2		
2015	793	722	**1,515**
2025	2,341	2,260	**4,601**
2034	5,292	5,223	**10,515**

Option-3			
2015	542	459	1,001
2025	1,477	1,277	2,754
2034	3,228	2,820	6,048
Option-4			
2015	156	130	286
2025	438	382	820
2034	971	860	1,831

(Unit : Million Rs.)

- **The Results of The Evaluation**

To evaluate the project and the amount of annual benefit expenditure during the evaluation period has been updated to the current value of 12%, and cash flow analysis was conducted to assess the feasibility of the project the use of anticipated benefits and costs calculated as in Table 4.10. The evaluation showed that the four variants are possible. Discount rate of 12% is used in many reports and project reports from the road and the road, and it is considered reasonable.

Table 4.10: Result of Evaluation (JETRO, 2008）

Index	**Option-1**	**Option-2**	**Option-3**	**Option-4**
EIRR	17.0%	**17.7%**	16.0%	12.9%
NPV(million)	5,581	**5,675**	2,544	246
B/C	1.6	**1.7**	1.4	1.1

- **Sensitivity Analysis**

In general, the project circumstances change depending on future economic and social conditions. Thus, the sensitivity analysis of option 2, with the highest TRE, was carried out In the case of an increase of ten and twenty percent increase in the cost of the project, as in the case of a reduction of ten and twenty percent reduction in benefits. The results of sensitivity analysis shows that 20% increase in the costs and benefits will not affect the viability of the project.

4.8 ACCIDENT ANALYSIS OF BLACKSPOTS NEAR LAHORE

Pedestrian crossing on motorways is prohibited as it is dangerous to cross a highway with speed more than 90km/h.

4.8.1 Site Investigation

The region where pedestrian accidents are more are series wise as 9km, 13km, 22km and 23km.This region is near Lahore. First we can observe the populations around this region, slum villages like as it is extension of Niaz Baig village. Figure 4.28 shows that population is increasing on both sides of the motorway. Within this region speed limit varies from 50kph to 100kph due to populated area and lower education level within the territory is one of the major causes of pedestrian accidents.

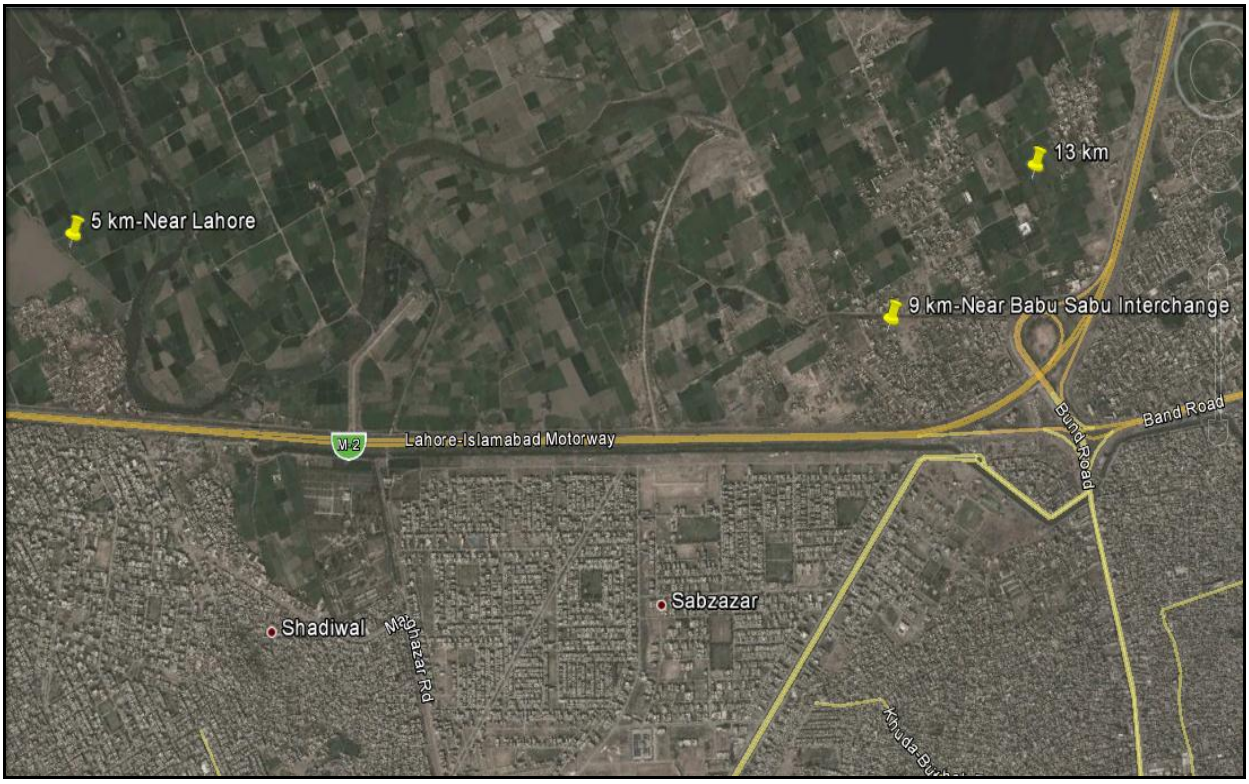


Figure 4.28: Map of the Pedestrian Problematic Area near Lahore (0km-15km)

Toll collection of this portion increases the importance of the location as traffic coming from Bakar Mandi and band road also uses this section, causing a reasonable traffic load on this section from Babu Sabu to Thokar Niaz Baig. This increase in traffic will also demand safety measures for the pedestrians of this section. When motorway was designed, population in this

area was a village and without future prospective motorway was passed through the area. Later with the increasing population pedestrian crossing bridges were installed.

4.8.2 Present Safety Conditions

While site investigation, this section can be observed according to different conditions. At 5km a huge number of population is residing and that population is not of educated on. There is strong tendency of crossing motorway without any help of pedestrian facility that is bridge. Pedestrian bridges have been provided at 5km, 8km, 10km, and 18km but public never tries to use this facility as to save time. Pedestrian bridge provided on 10km can be seen in Figure 4.29.

Figure 4.29: Pedestrian Bridge- Motorway (10 km)

Findings show that due to lesser education and increasing population, solution should be deviced to stop pedestrian crossing. Panel wall was also a weaker safety element as some portion was easily demolished by public and some was broken with settlement. Weekly crossing should be monitored by Motorway police. Additionally as a safety measure to stop spotted shortcut pedestrian crossing a perfect solution was deviced by National Highway Authority that after providing pedestrian bridges, safety panel wall of 5ft height was provided to stop pedestrian crossing and that wall was closed after attaching it with the pedestrian bridges. The concept was

that population should be given no option to cross road without pedestrian bridge. But public challenged the safety designers and removed the concrete made wall and used the wall as drying slate of animal dung cakes. Population residing specially near 8km has a business of cattle farming that includes a continuous crossing of highway. On other hand villagers tend to cross motorway as usual as an ordinary highway. The concept of safety wall panel was there to stop crossing of pedestrian but in Figure 4.30 removal can be observed.

Figure 4.30: Removal of Safety Wall- Motorway M-2 (0-10km)

.National Highway Authority (NHA) has constructed panel wall as it was easy to construct and construction cost was less than the other choices. But due to soil erosion and public crossing tendency has leaded the circumstances severe as removal of existing panel wall became easier. According to safety point of view safety wall should be something of different type. Un educated public has a problem that they are not aware of motorway rules, law and order issue can also be observed as this section is taken light because it is almost in the city and away from major section of road. Proper patrolling that is indeed law enforcement is not properly considered otherwise understanding of rules may be of at different conditions. Repair work is also not considered since construction which makes also a safety issue here, as if repair may had made a different opinion that this section is something special not to cross. Safety is not on

obligation to create problem for human life but to make safer, so safety should be considered under different alternatives that if the population within this area is have problems in crossing the motorway and there life surrounds that area then other alternatives for safe crossing could be adopted.

Figure 4.31: Present Condition of Safety Wall Near Lahore (0km-15km)

While observing the areas near 10km and 13km, the problem of crossing motorway also exists but removal can also observed due to erosion of soil after rains as shown in Figure 4.31. Another point that can be observed that whenever a person want to cross a highway with a reasonable wait on one's head, it is difficult to cross it through pedestrian bridge. Any other short cut attracts more for the procedure, so people try to cross directly and are hit by vehicles. Many other options like pedestrian underpass are there to overcome safety issues. Animals which are the other source of accidents use to cross due to presence of dairy farms of local types could also be controlled by a proper safety wall and a rounded crossing. Increasing population in the area demands a proper reconsideration of issues and solutions. With the increasing development of Lahore city Population will surely tend to move within this area and existing population is also an existing factors. As National Highway Authority (NHA) is generating a high toll from this section due to four way traffic of Motorway, Band road, Bakar mandi road and Thokar so proper attention for redesigning of safety facilities and repair work should be done.

4.9 SUMMARY

Road safety is a major concern in the present situation. There are many steps required to achieve the road safety measures. This chapter has discussed the location of motorway (M-2) and present condition of road and law enforcement. In addition discussed methods by which the accident-prone locations on roads, commonly termed as accident blackspots, are identified. Top fifteen accident blackspots are identifies and ranked severity wise. The reasons for the accidents observed as the lack of driving skill, lack of education, economic values, lack of signage, geometric design problems and improper design of pedestrian crossing. There are however, other factors, which contribute directly or indirectly to the accidents include road, vehicle, road user and environmental factors. Motorways of Pakistan are part of National Trade Corridor Project which is designed to link three sea ports (Karachi, Bin Qasim and Gawadar) with the rest of the county then leading to Afghanistan, Central Asia and China. Selection is of this 358 km long Motorway section (M-2) connection Lahore to Islamabad for accident study was considered under current circumstances of increasing safety issues, especially after the accident of a school bus at Kallar Kahar causing 37 fatalities. From the results of the analysis, it is concluded that this Motorway section needs improvement from safety point of view. Accidents are majorly caused by Careless Driving (25%), Dozing at wheel (23%), Tyre Burst (18%), Brake Failure (9%) and Pedestrian Crossing (6%).From the blackspots identification, from fifteen accidents prone location two sections were found problematic on the basis of location problems. Top most sever section was Salt range, a large number of accidents have been occurring over such a small section of Kallar Kahar (salt range) 221km to 229km, 8 km length due to a combination of 7% slope and less than 100m radii curves causing brake failure. Second section was near Lahore, as pedestrian accidents near Lahore from 0 km to 18 km are also making a range of blackspots. Realignment of salt range under different geometric design options with respect to economic feasibility has been discussed. Safety issues with the Motorway should be strongly addressed.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

A well-developed infrastructure and transportation system is critical to the economic rise of a country and is a major determinant of competitiveness. Pakistan's government gives due attention to the creation of transport and communication systems for the Pakistan. Among the various modes of transport, road transport is the basis of the transport system in Pakistan, which accounts for 90% of domestic passenger and 96% of freight traffic. To create the infrastructure to support growth, the Government of Pakistan has taken major initiatives as Improvement Program for National Trade Corridor (NTCIP) to modernize and simplify trade logistics and transport in the country. The basis for the development and improvement of North-South Corridor was built in NTCIP. NTC's strategic direction is to increase efficiency by providing world-class infrastructure, supply chain efficient and smooth interface between the public and private sectors.

With the construction of highways, safety is one of the main factors associated with human life and transport in different areas to perform efficiently in order to achieve improvements in the various modes. This was accompanied by delays in their fields. Roads developed in this series to link Karachi with Central Asia are named as motorways under National Trade Corridor Improvement Program. In parallel with the construction process, safety is an issue. Developing countries, including Pakistan faces new challenges of road safety measure, after the arrival of roads, highway safety issues management addressal security require more stringent with regard to the participation of a wide dynamic speed. This study presents a method in which a accident-prone location in road accidents known as blackspots can be identified. Motorway (M-2) connecting Lahore to Islamabad, one of the main roads in Pakistan was selected for the study. The cause of these accidents can be attributed to a lack of driving skills, lack of education, economic values, lack of signs, geometric design problems and poor design of pedestrian crossing. However, there are other factors that are directly or indirectly include road accidents, car, road users and environmental factors. Usually driver skill is the key feature that should be improved to overcome accident increase.

5.2 CONCLUSIONS

With the supports of motorway M-2 Lahore to Islamabad most of the population of our country is connected with the provincial and federal capital and therefore in a position of undisputed national communications infrastructure. It also reflects the national picture for foreign visitors. In addition to the road feel a high, safe and comfort while traveling on the road. Therefore, it is important that this part is in excellent service and ensuring the safety and aesthetic point of view.

5.2.1 Findings of Accident Analysis

After analyzing the detail accident statistics from year 2009 to 2011, following conclusions were made in the course of the study;

- **Major Causes of Accidents on Motorway M-2**

Top most cause of accidents on motorways is Careless Driving (25%), dozing at wheel (23%), Tyre Burst (18%), Mechanical Fault: Brake Failure (9%) and Pedestrian Crossing (6%).This shows that these are 80% contributing factors of accidents.

- **Light condition of Accidents on Motorway M-2**

The accidents within the region without road lights are 80%,as in the area where accidents are due to night vision issues are 31% and in day time due to some fog or weather are 49%. 95% of the motorway M-2 is without lights.

- **Time of Accidents on Motorway M-2**

In the night time accidents related to timing ,highest accident timing are 0400-0600AM(15%) may be due to dozing-critical timing, then 2200-2400PM(10%),then 0800-1000AM(10%),0000-0200AM(9%),0600-0800AM(9%),1800-2000PM((9%).Timing issue is also related to traffic peak hours and drivers behavior like sleeping hours that tend to increase accidents.

- **Collision type of Accidents on Motorway M-2**

Nose to tail accidents are (41%), Roll over (25%), Head On (9%) and Pedestrian (7%). reflecting the drivers skill to avoid accident severity.

- **Severity Index**

The analysis shows that the frequency of accidents on M-2 is increasing with respect to the impact of the traffic movement are growing rapidly. Severity Index increased from 0.44 to 0.75 during year 2009 to 2011.

- **Fatality**

Deadly accidents on motorway M-2 are high, as 35% of all accidents.

- **Sector**

The sector wise portion of accidents are 51% at Northern sector while 49% at Southern sector. The upper half towards Islamabad is northern, while lower half towards Lahore is Southern.

- **Beat Wise**

Motorway is divided in sections called beats; beat wise accidents on motorway M-2 are Beat7, Beat10 and Beat5 higher of all accidents.

- **Vehicles**

Bus bombing serves as the main cause of accidents reflects the poor condition of the road vehicle users and bus bodies.

- **Road Condition and Speed**

However, designated speed for motorway is 120kph but also have 50kph in hilly area which is against the motorway theory, plays an important role in the recurrence of accidents at this location. Interviews with users of the highway, officials and NH&MP, and personal observations confirm this fact.

- **Contributing factors**

Maximum accidents attributed to human error, lack of education or speeding, as human behavior play an important role. Thus, these problems require strict administrative remedies instead of expensive engineering solutions.

5.2.2 Blackspot Locations and Causes of Repetitive Accidents

- **Rank 1:** Accident blackspot number 1 is located at 229km (Kallar Kahar), having highest accident severity. On detail observation of accident occurrence all the accidents have same cause of accidents i.e.; Mechanical Fault (Brake failure),4 drivers killed,35 passengers killed,1 driver injured and 115 passengers injured during last three years. Majority of accidents were in the night.
- **Rank 2:** Accident blackspot number 2 is located at 224km (Kallar Kahar), having 2nd highest accident severity. On detail observation of accident occurrence almost all the accidents have same cause of accidents i.e.; Mechanical Fault (Brake failure), 1 drivers killed, 6 passengers killed, 2 driver injured and 10 passengers injured during last three years.
- **Rank 3:** Accident blackspot number 3 is located at 223km (Kallar Kahar), having 3rd highest accident severity. On detail observation of accident occurrence all the accidents have same cause of accidents i.e.; Mechanical Fault (Brake failure), 2 drivers killed, 35 passengers killed and 20 passengers injured during last three years. Majority of accidents were in the night.
- **Rank 4:** Accident blackspot number 4 is located at 47 km (Sheikhupura), having 4th highest accident severity. On detail observation of accident occurrence almost all the accidents have same cause of accidents i.e.; driver: Dozing on wheel, tyre burst, careless driving etc. 2 drivers killed, 7 passengers killed and 6 drivers injured during last three years. Majority of accidents were in the night.
- **Rank 5:** Accident blackspot number 5 is located at 195km(Near Lilla) due to similar level of severity, having 5^{th} highest accident severity. On detail observation of accident occurrence all the accidents have shown that 195km has issue with driving and tyre burst.
- **Rank 6:** Accident blackspot number 6 is located at 286 km (Nearer to Chakri), having 6^{th} highest accident severity. On detail observation of accident occurrence all the accidents have shown that 9km have issue of pedestrian crossing, careless driving, and slippery road.
- **Rank 7:**Accident blackspot number 7 is located at 22 km(Lahore),23 km(Lahore),137 km(Sial Mor), and 154 km (Kot Momin) due to similar level of severity, having 7^{th} highest accident severity. On detail observation of accident occurrence all the accidents have shown that 22km have issue of pedestrian crossing, 23km has issue pedestrian crossing, 137km has been made blackspot due to careless driving, and 154km has issue with driving and tyre burst.

- **Rank 8:** Accident blackspot number 8 is located at 9 km(Lahore),13 km(Lahore),155 km (Kot Momin) ,225km (Kallar Kahar) and 346km (Rawalpindi) due to similar level of severity, having 8th highest accident severity. On detail observation of accident occurrence all the accidents have shown that 9km have issue of pedestrian crossing, 13km has issue pedestrian crossing, 155km has been made blackspot due to careless driving, 225km, has issue with Mechanical Fault (Brake failure) and tyre burst and 346km has issues of driving and tyre burst.

5.3 COUNTERMEASURES

This conclusion requires a systematic and comprehensive approach to security issues with M-2. As in orthodox adjustment plan should focus on technology, education and enforcement, but in the matter of design, if the security is replaced by the sleek design and large M-2. Following the recommendations will help to reduce accidents and improve the safety of the M-2:

5.3.1 Countermeasures with Respect to Accident Causes on Motorway M-2

Following are strategies developed to counter cause of accidents on motorways:

- **Government Policy for Careless Driving**

Highest cause of accident needs to be dealt by the licensing authority, some policy related to drivers mental grooming should be made. Year wise or whenever there is a license renewal or procedure related to refresher course should be adopted that can increase the mental level and skill of driving.

- Driving license should be linked with CNIC/NADRA.
- A National Licensing Regulatory Authority (NLRA) should be established to regulate the licensing policy.
- Driving training schools should be established at District level and their training is made mandatory for driving license.
- Computerized point scoring system for licenses must be introduced under NHSO 2000.
- Provincial governments (RTA) should enlist renowned private vehicle manufacturers for vehicular testing and issuance of fitness certificates through their workshops.

- Trauma centers should also be developed for emergency treatment, usually heavy loss are occurring due late treatments to the injured passengers.

➢ **For Officials (Motorway Police)**

- One of the most critical zones of Motorway (M-2) patrolling should be increased usually observed that police have no speed guns for this section in the night and patrolling is poor. This section should be enforced with permanent check posts and speed guns active for 24 hrs.

- The Fine in the region of Salt range should be doubled for over speeding that will make drivers more careful.

- Number of Speed check post should be increased in Salt range as drivers tend to over speed in the mid of two check points.

- Data collection procedure takes usually four days to compile which makes procedure less reliable, it should be converted to online system and Excel sheet should contain as many rows as in the form(i.e.,77)while the existing excel sheet contains(26).Detail remains missing to analyze accidents.

- Under reporting should be avoided.

➢ **For Dozing at wheel**

Second highest cause of the accidents, can be dealt with two major ways. One awareness related to sleeping before the traveling on motorways should be increased. Secondly is using the dozing alarm device as shown in Figure 5.1. Dozing on wheel can be reduced by providing awareness to drivers to take a proper sleep before driving. Many times one has to drive when tired. We need a safety gadget or device dose alerts to warn / inform the driver before falling asleep at the wheel. If you feel sleepy, but you have to stay on track and you just want to get to your destination without causing a serious accident.

This intelligent device is designed to detect when the driver is in danger of falling asleep and immediately alert / companions to avoid possible accident. Gadget of low weight is put on the left ear and activates an alarm monitor driver’s drowsiness as shown in Figure 5.2. Motorway Police should introduce these devices to drivers while entering motorway and can be collected back at end points. This device has prices from range of 0.5$ to 30$. Procedure can be adopted

by Motorway Police, from the AADT one can easily calculate that the vehicles per hours, maximum time for covering the distance of 358km is 5 hours.

Figure 5.1: A Sample of Dozing Alert Alarm to Overcome Dozing

Thus the numbers of vehicles covering motorway M-2 at a time are 13000.Thus requiring with some addition, 14000 devices which could cost on economical rate 3$ would cost Pakistani Rs.4200000/- which can be recovered in one day toll collection.

Figure 5.2: Dozing Alert Alarm Mechanism –Buzzing on 15 Degree Head Bend

For buses while entering the motorway during video making device should be installed on driver ear ,and all the passengers should be given indication about working of device that whenever driver try to sleep that beep will alarm. Thus passenger will also remain alert regarding dozing of drivers. For drivers of cars or individual drivers, device should be installed or given during toll collection. That beep will remain a hindrance against dozing. That device could be collected back at the interchanges when vehicles going out from motorway territory. This process should be first tested on some sample of vehicles then can be tested.

- **For Tyre Burst**

Third major cause of accidents is tyre burst covering (18%) of accidents. Detail awareness should be spread about taking care of tyres. Motorway police can use technology to tyre checking that all the doubted vehicles should be checked for tyre quality. For example by general look if tyre strength is suspected thus test should be conducted. The tyre testing gauge costs 3$ to 40$.At each interchange 20 devices are kept then it cost near about Rs.200000/- at the economical rate of 5$ for 400 devices.

Procedure: Usually never use tires older than six years, regardless of whether it was or not. To check the age of tires looking DOT number stamped on the sidewall of the tire, it will look something like "DOT XXXX 2209", and in this example, the tire was manufactured in the 22th week of 2009.Through equipment following is the procedure:

1. Locate the Tread. Tread depth of the tire is formed grips the road. It consists of a central structure of the groove width of three-quarters of the tire and the entire outer circumference. The depth of these slots should be uniform in all parts of the tread shin. Less grip, the less traction and driving safety may be different auditing standards have. There tire brand of depth variation. This approach can be further developed in the discussion of this issue with the companies producing tires.

2. Tread-Depth Gauge. Carefully inspect the tire and remove small objects stuck in the tread. Check the wear is extremely uneven. Specify the driver to replace the tire immediately if you notice excessive wear, dents, cracks or deep cuts the tread or sidewall. Pavement wear indicator integrated search. They are usually found at the bottom of the central groove tires. Check the

wear indicator is visible on the same level with the surrounding tread, if so, the driver should be penalized. Input for excessive tread wear in calibration of measuring points, as shown in Figure 5.3. If irregular wear of course, put the template in the game with the most worn part begins. Keep the meter perpendicular to the ground; put it between two blocks of wear indicators.

Figure 5.3: Tyre Checking Procedure with Gauge

Then extend the little finger of the dipstick at the back of the throat. Now read the value of this prevails. Minimum required and analyzed depth of winter tires should be at least 5.0 mm. Summer tires should be at least 3.0 mm. If the depth of the tread on these figures, it is time to change tires. Please note that these values are ideal for road safety, because they are much higher than the legal minimum depth of 1.6 mm. For different types of vehicles, standard varies as the standard of the design and shape of tyre also changes. Motorway Police can check the tread depth with a gauge at entering locations like toll plazas. The vehicle entering the toll plaza showed is observed while passing by naked eye, suspect tyres should be stopped and checked by guage. It takes few seconds to pay toll and collecting Card and same is the duration of checking vehicle tyre without interrupting traffic, even if observation takes time, the suspect vehicles can be sidelined and then checked in detail.

Figure 5.4: Tyre Tread Depth Should be Checked at Toll Plaza

- **For Brake Failure**

It has the fourth highest cause of the accident having 9%.Usually it is difficult to perform individual brake check but on the other hand, brake failure causes can be identified and can be minimized. Those causes and remedies will be described in blackspot analysis.

- **For Pedestrian Crossing**

Fifth most accident causes of accident having 6% .Although motorway is totally banned for pedestrian but where ever motorway passes from some village or populated area pedestrian accidents increases. Detail and remedy will be explained in blackspot analysis.

- **For Light condition on Motorway M-2**

The accidents are within the region without road lights are 80%, very less area of motorway M-2 is installed with the lighting. Only 0-10km,14-16km,256km,265km,273km,344-348km are entitled with road lights. Weigh station are only entitled with the lights. Solar road lights should be installed which could be continuous source of safety as light problem could be solved. According to current market rates w.r.t NHA a solar light post costs Rs. 0.5 Million.

Thus it is not possible to install as a whole on Motorway but on Salt Range it is necessary to be installed which cost near about Rs.17 Million according to NHA that can be considered. According to standards for lighting issues are solved by luminous tapes installed on curves but due to extra ordinary conditions, here lighting is recommended. Solar lights are continuous source of light as no power shortage effects on it and for a reasonable duration theses poles can work properly. These are installed on trial basis that if worked effectively further installation will be considered.

Figure 5.5: Solar Road Lights Should be Installed at Salt Range on Motorway (M-2)

5.3.2 Countermeasures for Blackspots

- **For Salt Range 220km to 230km**

Within this region 223km, 224km and 229km sections are the top three blackspots with more than 50 fatalities and more than 150 injuries in past three years. After visiting the location and accident analysis of blackspots the region of motorway M-2, from 220km to 231km has a concentration of accidents. The region is known as Kallar Kahar-Salt Range. At this level it is the highest level of road, having highest bridge of Asia and 7% slope with sharp turning curves. An ideal location for accidents is there, so ideal solutions are required. It is immediate necessity

to realign the geometry of Salt range which costs near about Rs.12 Billion under the recommendation of JETRO and NHA but due to lack of Finance temporarily traffic calming should be used to maintain low speed.

Figure 5.6: A View of Kallar Kahar- Salt Range

Although Standard speed limit is 40-50Km/hr. for LTV and 30-40Km/hr. for HTV, indication signs are there to check brakes before entering, keeping low gear at every 500meter but still there are issues with the brake failure, since brake fails at slope when sudden brakes are applied especially, local buses don't have power brakes thus accidents occur and they don't follow the indication to have low gear proceeding. A look on the area can be taken in Fig 5.6.

- **Traffic Calming Technique**

It requires road lights there. Still permanent solutions are required to control speeding and brake failure. To make the drivers follow speeding limit here marking to narrow the width of lanes can be adopted from 3.5 m to 3 m that will make the drivers reduce speed automatically. Following are series of treatments to be adopted for calming shown in Figure 5.7 to Figure 5.12.

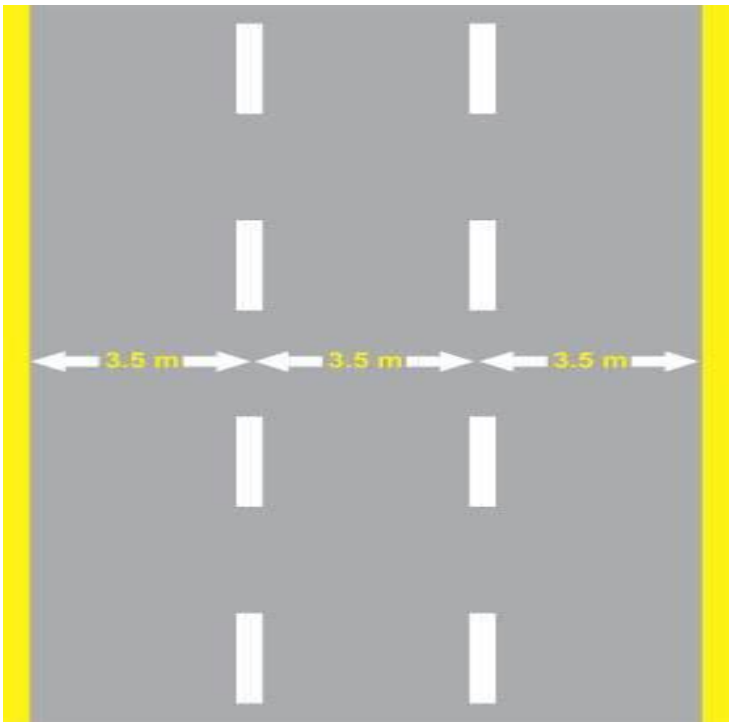


Figure 5.7: Actual Condition on Salt Range

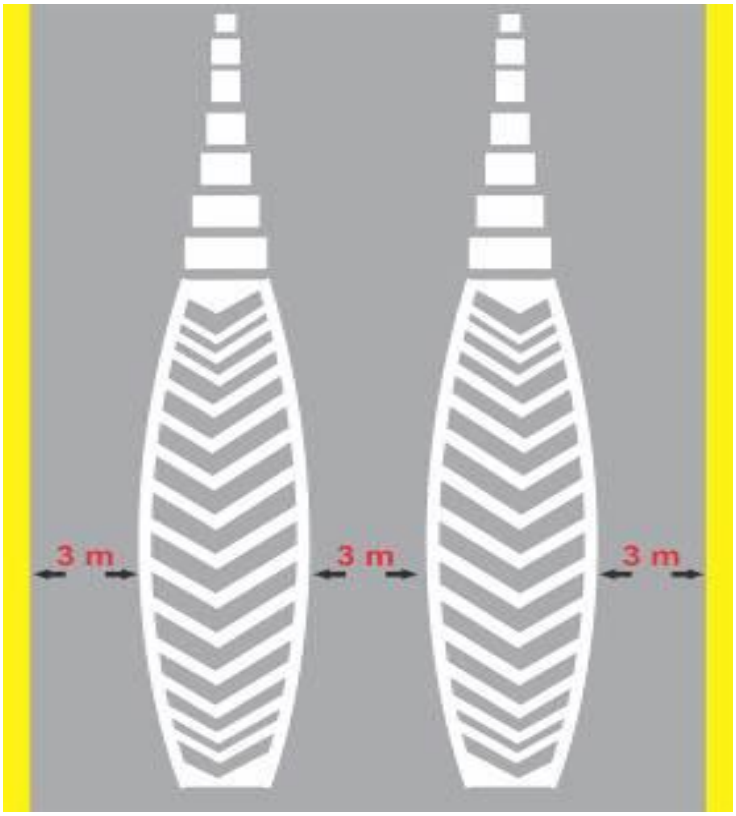


Figure 5.8: Traffic Calming: Marking on Salt Range

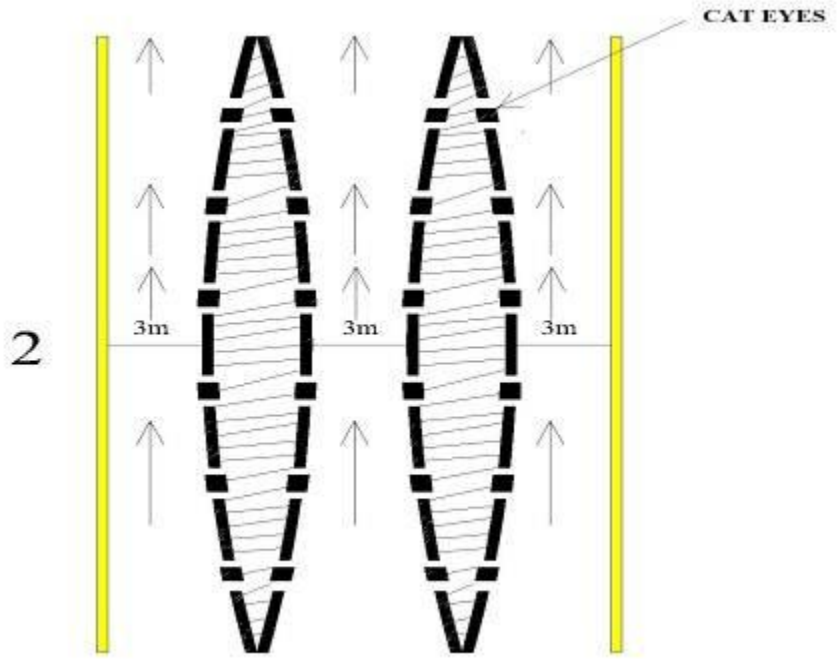


Figure 5.9: Traffic Calming: Plan of Lane Narrowing and Cat Eyes on Salt Range

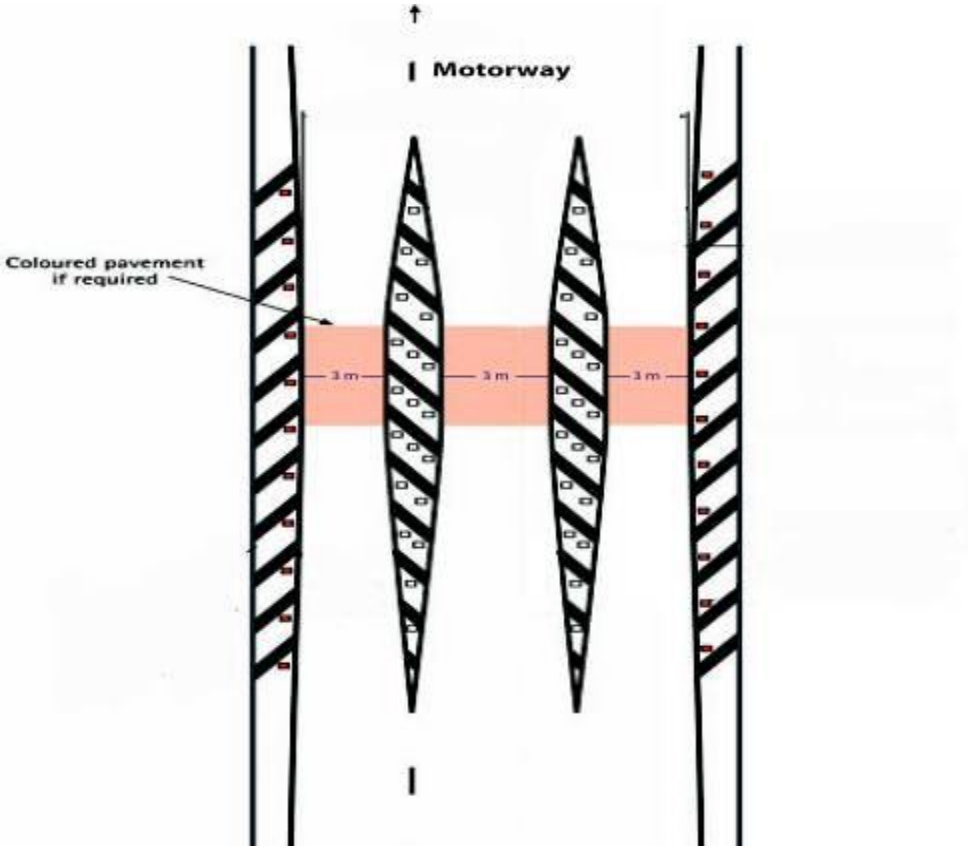


Figure 5.10: Traffic Calming: Narrowing Width and Cat Eyes on Salt Range

Figure 5.11: Traffic Calming: A General View before Narrowing Width on Salt Range

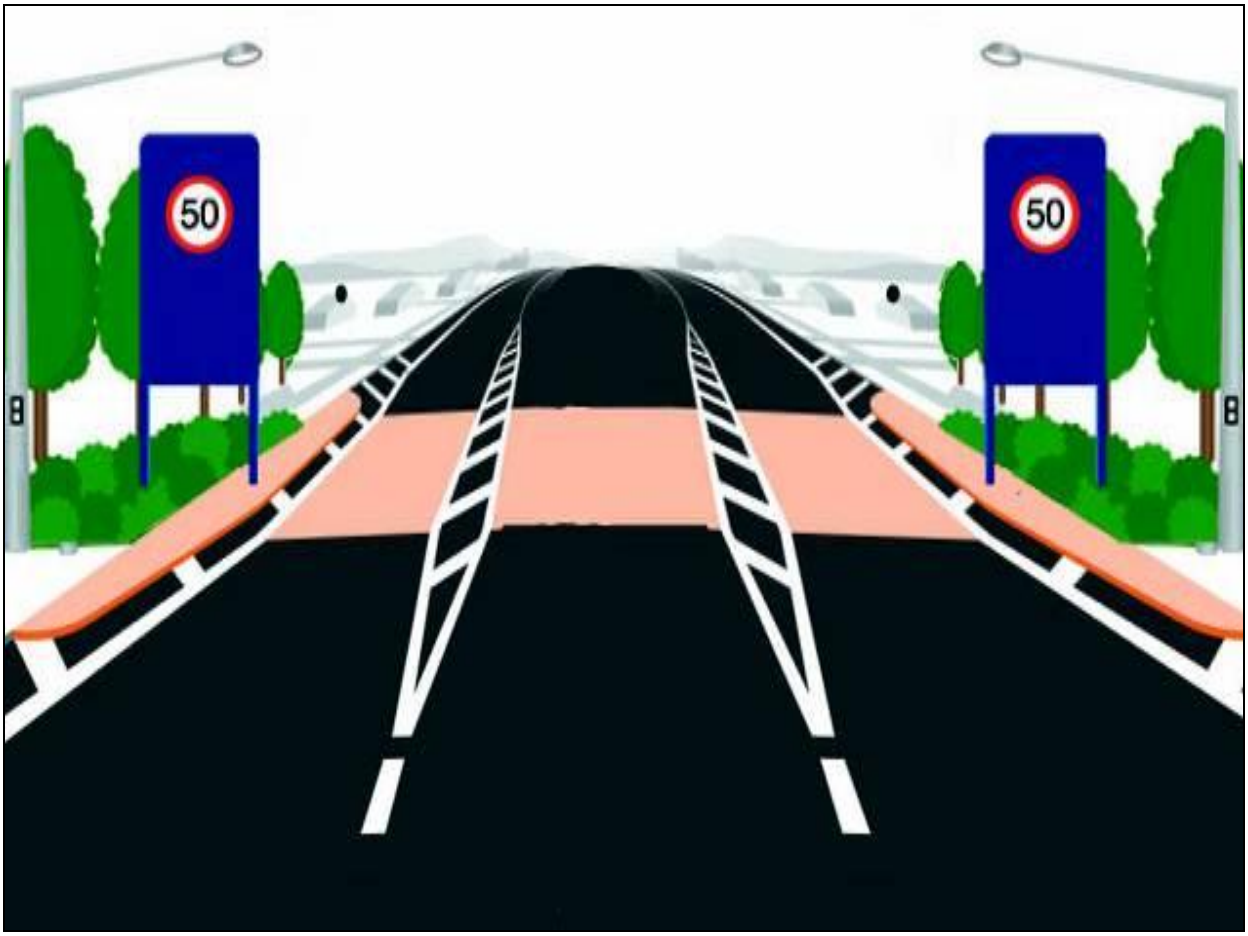


Figure 5.12: Traffic Calming: A General View after Narrowing Width on Salt Range

A series should be started from 219km to 234 km that will make the drivers speed slowly and automatically shift to low gear, as the marking shown in figure should start from level road to the slope.The sign boards should be also provided to indicate that Traffic Calming Devices will lead from which 235km and end on which 220km.

- **Emergency Climbing Ramp**

Evacuation slide runaway truck, with a quick stop ramp truck accident or a bed is a device that allows for vehicles with brake problems, to stop safely. Usually it is a long sand or gravel track full, adjacent to the road with a steep slope, and is designed for large trucks. Includes dynamic deep gravel trucks to disperse in a controlled and relatively harmless, allowing the operator to safely stop. Emergency escape ramps are usually strong and sustained notes, and in the mountains. Long descending grades allow high vehicle speeds to be reached, and truck brakes can overheat and fail through extensive use. Ramps often built up a significant change in the curvature of the road or a place that requires a suspension of the vehicle, for example, to the intersection in the village. They may vary depending on region / country to another.

Figure 5.13: Motorway Emergency Climbing Ramp

Motorway(M-2) has two in Salt Range as shown in Figure 5.13.Similar type of emergency climbing should be increased and usage procedure should also be demonstrated through media for general public by motorway police thus the awareness about benefits of emergency climbing could be increased.

- **For Lahore Section (0km to 25km)**

The region where pedestrian accidents are more are series wise as 9km, 13km, 22km and 23km.This region is near Lahore. First we can observe the populations around this region are rural or slum villages like. Already pedestrian bridges have been provided at 5km, 8km, 10km, and 18km but public never tries to use this facility as to save time and effort especially when there is weight with them.

- **Pedestrian Under Pass**

Pedestrian underpass can be constructed to provide suitable passage, two underpasses in all critical zones which are four thus at least four or more underpasses should be constructed as population is growing day by day

Figure 5.14: Pedestrian Underpass for Motorway M-2 (0-10km)

. Design of pedestrian underpasses may vary according to the available space at different locations, it will facilitate the population even public can easily transport animals and goods. Analysis already had shown that pedestrian crossing has created a series of problems for the pedestrian crossing and there are lot of issues with the crossing, a reasonable investment from highway authority to construct underpass for pedestrians will solve this problem. Walkways and underpasses allow a continuous stream of people separated from the vehicle. However, this should be a last resort, and it is usually better to install safety lanes, which are accessible to all pedestrians. Individual items are very expensive, and viaducts, in particular, are a measure of visually intrusive. These measures include ramps or lifts. Wide ramps for wheelchairs and cyclists, but the results are long-distance and transit time prevents further use.

Figure 5.15: Pedestrian Underpass for Motorway M-2 (0-10km)

Studies have shown that many pedestrians do not use the bridge or underpass, if you can cross the street at about the same time or less. Viaducts work best when relief allows the structure without ramps (for example, an overpass on the highway below.) Underground work best when they are designed to be free and accessible. The difference is the most reasonable and appropriate in extreme cases where pedestrians have to cross barriers such as roads or railways.

Examples of underground pedestrian crossings can be seen around the world. In England and Wales, Ireland, Hong Kong and some Commonwealth countries (such as South Africa, Australia and New Zealand), an underground term usually refers to a specially constructed underground for pedestrians and cyclists / or under a road or railway, allowing them to reach the other side safety. In the United States, for example, the California Department of Transportation for road pass in depressed. This term is also used in some parts of Pennsylvania in the United States, and Harrisburg, Duncannon, and Wyoming. Underground passages are less common in North American cities and European cities of the same size. They are made when necessary for pedestrian railroad or limited access road as a road, and, of course, appear at the outlet of an underground rapid transit system, but only rarely are built so that people can cross the normal city street. When built, underground pedestrian term is likely to be used, because the word "underground" is generally used to refer to rail systems are such that the subway in New York in the United States. In the Philippines, you can see in Makati in Manila and in some places, such as Quiapo and near Manila City Hall, commonly called "Lagusnilad". Metro to be built for the benefit of wildlife and Animal Crossing

Previously there was a safety panel wall which needs immediate repair; according to the public damaging behavior, construction of a full permanent concrete wall in replacement to panel wall. From different spots wall was damaged by public and changing circumstances. Although it will increase cost for repair work but a permanent wall replacing the existing panel wall will work betterlier. After providing a pedestrian under pass and constructing concrete wall the accidents will tend to reduce because very less opportunity will be there to cross highway directly and underpass will be more feasible and easier to cross as shortest path to be covered. The public crossing with goods and animals will also find it a better solution. In future more betterment with lighting facility to give additional benefit can be added.

5.2.3 Media Power for Mass Awareness

Media power is recognized as one of the most effective way to increase mass awareness.

- **Broad Cast Yourself**

Usually media is found one of the most impressive way of spreading information, so it can be used to educate public about the safety issues of traffic especially about motorways so

that people take care of those principles which confer the safety maintenance and efforts by governments.

Figure 5.16: A Sample of Meaningful Add for Traffic Safety.

Motorway police should be connected with the media, so that fast awareness through electronic media could spread. The meaning full skits, adds can be originated to convince and teach safety issues and traffic rules to the public. Print media should also be considered for awareness.

- **Training/Education**

Literacy rate of Pakistan is very low; especially the drivers of HTV are educated almost nil so special procedures should be designed to educate them. Following are some points to increase driver's education level.

• Driver's education process should be formulized in such a way that awareness of consequences of driving mistakes should be increased. Usually driving learning procedure in Pakistan is through relations, thus the limited education is transferred to the new drivers. This program can develop the standard a lot.

• Process of precautionary measures to avoid or removing obstacles causing accidents should be done in such a way that driver are forced to follow rules and other factors like pedestrians and animals should be enforced to keep away from Motorway M-2.

• Although higher price of fines can also be recommended but may lead to divert traffic towards other routes so this option is not as better than other law enforcement options.

• Safety pamphlets should be distributed among drivers to educate them with the key causes of accidents like, mechanical problems, drivers carelessness, dozing on wheel so that they may take care of those issues.

• Driver learning courses should be connected with the driving license renewal procedure and strict transparency should be adopted during this procedure. Highway safety department should take the test about the sufficient knowledge related to traffic safety. Gulf Countries like standard procedure could be adopted to increase the worth of Pakistan driving license.

5.4 FUTURE WORK AND RECOMMENDATIONS

This thesis, is addressing the accident analysis of motorway section (M-2), it opens up a lot of areas and procedure to analyze accident porn locations in future research. The first portion is related to Blackspots identification procedure and site investigation. After identification countermeasures are adopted, to improve the safety condition of that area. Secondly accident causes are addressed that which type of issues are causing to increase accidents. Those are separately identified and addressed. Calculations are depending on police data which is most reliable in case of Motorways. With the increase in population it was necessary to analyze safety issues on highways.

In future if accident analysis and blackspots identification is conducted for cities and provinces data sources can be changed and hospitals can also be included. Survey Questionnaire procedure can also be adopted with in the cities to check the accident related perceptions. A guide line has been provided in this thesis which will help to identify better factors regarding accident increase in cities. Cost issues are also dealt worldwide if future data collection procedure also include that factors, better analysis and improvement in safety efforts can be done.

REFERENCES

AASHTO.(2004). “A Policy On Geometric Design Of Highways And Streets”, *American Association of State Highway and Transportation Officials.*

Ahmed, A. (2007). "Road Safety in Pakistan." *National Road Safety Secretariat Ministry of Communications, Government of Pakistan*.

Brown, B. F., C Forgues, M (1992). "Identification Of Dangerous Highway Locations:Results of Community Health Department Study In QUEBEC." *Transportation Research Board* 1376, 78-85.

Chong, M., Abraham, A., and Paprzycki, M. (2005). "Traffic Accident Analysis Using Machine Learning Paradigms." *Informatica*, 29, 89-98.

Bishai,D., AA, H., A, G., RH, M., and O, K. (2003). "Rates of public investment for road safety in developing countries: case studies of Uganda and Pakistan." *Research Report by Health Policy and Planning 18*.

Daud, N., and Ibrahim, K. (2007). "Ranking Accident Blackspots With Reference To Cost Of Accidents Using Hierarchical Bayesian Approach." *International journal of Energy And Environment*, 1(2).

Davis, G. A., and Yang, S. (2001). "Bayesian Identification of High-Risk Intersections for Older Drivers via Gibbs Sampling " *Transportation Research Board* 1746, 84-89.

Deacon, J. A., C. V. Zegeer, and R. C. Deen (1975). "Identification of Hazardous Rural Highway Locations." *Transportation Research Record* 543(National Research Council, Washington, D.C.).

Downing, A., Jacobs, G., Aeron-Thomas, A., and Sharples, J. (2000). "Rewview of Road Safety in Urban Areas."Transport Research Laboratory October.

Downing, A. J. (1985). "Road accidents in Pakistan and the need for improvements in driver training and traffic law enforcement." *PTRC. Summer Annual meeting, University of Sussex,* Proc of Seminar H. London: PTRC Education and Research Services.

Elvik, R. (2008). "State of the Art Approaches to Black Spot Management and Highway Safety Analysis for road Networks." *The Institute of Transport Economics (TOI)* 883.

Fukuda, T., Ishizakai, T., Fukuda, A., Tangpaisalkit, C., and Sinlapabutra, T. (2005). "Empirical Study On Identifying Potential Black Spots Through Public Participation Approach:A Case Study Of Bangkok." *Journal of the Eastern Asia Society for Transportation Studies*, 6, 3683 - 3696.

Guert, C., Astrop, A., and Jacobs, G. (1997). "Socio-economic aspects of road accidents in developing countries." *TRR*, 247.

Mike, G (2009). "People's Republic of China: Road Safety Improvement." *Asian Development Bank.*

Garber, N. J., and Hoel, L. A. (2009). *Traffic and Highway Engineering*, Cengage Learning.

Geurts, K., Wets, G., Brijs, T., and Vanhoof, K. (2004). "Identification and Ranking of Black Spots:Sensitivity Analysis." *Transportation Research Board* 1897 34-42.

Hafeez, I., and Kamal,M.(2008). “Accidents Black Spots on Highways and Their Low Cost Remedial Measures”, Proceedings of Fourteenth International Conference on Urban Transport and the Environment in the 21st Century, 1 - 3 September 2008, Malta.

Haider,S.W.(2001). “ Experience of Lahore-Islamabad Motorway Project - Lessons learnt and suggestions for future improvements”, 68th session of Pakistan Engineering Congress,January 19-21,2001.

Hakkert, A. S. a. D. M. (1978). "Estimating the Number of Accidents at Intersections from a Known Traffic Flow on the Approaches." *Accident Analysis and Prevention*, Vol.10(No.1).

Hauer, E. (1992). "Empirical bayes approach to the estimation of “unsafety”: The multivariate regression method." *Accident Analysis & Prevention*, 24(5), 457-477.

Hauer, E. (1996). "Identification of Sites with Promise." *Transportation Research Record* 1542(TRB, National Research Council).

Hauer, E., D. W. Harwood, F.M. Council, and M. S. Griffith. (2002). "Estimating Safety by the Empirical Bayes Method: A Tutorial." *Transportation Research Record* 1784(TRB, National Research Council).

Hauer, E., J, Kononov, B. A., and Griffith, M. S. (2002). "Screening the Road Network for Sites with Promise." *Transportation Research Record* 1784(TRB, National Research Council).

Hauer, E. a. B. N. P. (1984). "Problem of Identifying Hazardous Locations Using Accident Data." *Transportation research Record* 975(TRB, National Research Council).

Higle, J. L., and Hecht, M. B. (1989). "A comparison of Techniques for the Identification of Hazardous Locations." *Transportation Research Record* 1238(TRB, National Research Council, Washington).

Higle, J. L.,and Witkowski, J. M. (1988). "Bayesian Identification of Hazardous Locations." *Transportation Research Record* 1185(National Research Council).

Japan External Trade Organization (JETRO), (2008). “Feasibility Study on the Realignment of Motorway M-2 in Salt Range Area in Pakistan: Study on Economic Partnership Projects in Developing Countries in FY 2007” Draft Final Report

Kockelman, K., and Ma, J. (2007). "Freeway speeds and speed Variations Preceding Accidents, within and Across Lanes." *Journal of the Transportation Research* 46(1), 43-62.

Kockelman, K. M., and Ma, J. (2007). "Freeway Speeds And Speed Variations Preceding Crashes, Within And Across Lanes." *Journal of the Transportation Research Forum*.

Kononov, J., and Janson, B. N. (2002). "Diagnostic Methodology for the Detection of Safety Problems at Intersections." *Transportation Research Record*, 1784(02-2148), 51-56.

Laughland, J. C., Haefner, L. E., Hall, J. W., and Clough, D. R. (1975). "Methods for Evaluating Highway Safety Improvements." *NCHRP Report* 162.

Lord, D., and Mannering, F. (2010). "The statistical analysis of crash-frequency data: A review and assessment of methodological alternatives." *Transportation Research Part A: Policy and Practice*, 44(5), 291-305.

Mahal, D., Hakkert, A. S., and Phrasker, J. N. (1982). "A system for the allocation of Safety Resources on a Road Network." *Accident Analysis and Prevention*, 14.

Mahmoudabadi, A. (2010). "Comparison of weighted and simple linear regression and artificial neural network models in freeway accidents prediction (Case study: Qom & Qazvin Freeways in Iran)." *Second International Conference on Computer and Network Technology*, IEEE.

Mak, K. K., Chira-Chavala, T., and Hilger, B. A. (1985). "Automated Analysis of High-Accident Locations." *Transportation Research Record* 1068.

May, J. (1964). *A Determination of an Accident Prone Location*, Traffic engineering.

McGuigan, D. R. D. (1982). "Nonjunction Accident Rates and their Use in 'Black-Spot' Identification." *Traffic Engineering and Control*.

Meuleners, L. B., Hendrie, D., Lee, A. H., and Legge, M. (2008). "Effectiveness of the Black Spot Programs in Western Australia." *Accident Analysis & Prevention*, 40(3), 1211-1216.

Michael. L, O. (1996). *Multiple Linear Regression Analysis Using Microsoft Excel*.

Milton, J. C., Shankar, V. N., and Mannering, F. L. (2008). "Highway accident severities and the mixed logit model: An exploratory empirical analysis." *Accident Analysis & Prevention*, 40(1), 260-266.

Mustakim, F., and Fujita, M. (2011). "Development of Accident Prediction Model for Rural Roadway." *World Academy of Science*, 58.

Mustakim, F., Yusof, I., Rahman, I., and Samad, A. A. A. (2008). "Blackspot Study and Accident Prediction Model Using Multiple Liner Regression." *First International Conference on Construction In Developing Countries (ICCIDC–I)*Karachi, Pakistan.

National Highway & Motorway Police (NHMP),(2012). *Basic_NH&MP_Course_Book_(English Version)*.

Norden, M., Orlansky, J., and Jacobs, H. (1956). *Application of Statistical Quality-control Techniques to Analysis of Highway-accident Data*, Highway Research Board.

National Transport Research Center (NTRC), (1985). "Road Accident Counter Measures in Pakistan." *National Transport Research Center* NTRC-85.

National Transport Research Center (NTRC), (1990). "Islamabad Road Accident Analysis." *National Transport Research Center*, NTRC-130.

National Transport Research Center (NTRC), (1994). "Road Accident Investigation." *National Transport Research Center*, NTRC-179.

National Transport Research Center (NTRC), (1995). "Accident Black Spots Study on National Highway (N-5) Hassanabdal Attock." *National Transport Research Center*, NTRC-185.

National Transport Research Center (NTRC), (2001). "A Review of Road Safety in Pakistan." *National Transport Research Center*

National Transport Research Center (NTRC), (2003). "A review Of road safety in Pakistan." *National Transport Research Center*

National Trade & Transport Facilitation Committee (NTTFC), (2010). "Road Accident Counter Measures in Pakistan." http://nttfc.org/lahore-isbMap.asp.

Persaud, B., C. Lyon, T. Nguyen. (1999). "Empirical Bayes Procedure for Ranking Sites for Safety Investigation by Potential for Safety Improvement." *Transportation Research Record*, 1665.

Persaud, B. N. (1991). "Estimating Accident Potential of Ontario Road Sections." *Transportation Research Board* 1327, 47-53.

Renshaw, D. L., and Charter, E. C. (1980). "Identification of High Hazard Locations in Baltimore County Road-Rating Project." *Transportation Research Record* 753(TRB, National Research Council).

Roess, R. P., Prassas, E. S., and McShane, W. R. (2010). *Traffic Engineering*, Pearson.

Sayer, I. A. (1994). "Accident blackspot investigation." *Overseas Centre Transport Research Laboratory* (TRL) Crowthorne Berkshire, United Kingdom.

Simon, W., and Cheng, W. (2005). "High Risk Crash Analysis." *Arizona Department of transportation*, 558.

Sims, A. G., Somenahalli, SVC (2010). "Hot Spot Identification using frequency of distinct crash types rather than total crashes." *Australasian Transport Research Forum*

Singh, S. K., and Misra, A. (2004). "Road Accident Analysis: A Case Study of Patna City." *Urban Transport Journal*, 2(2), 60-75.

Singh, P., Jain, S. S., and Landge, V. S. (2006). "Stochastic modelling for traffic crashes on non urban highways in India."

Sohadi, R. U. R., and Baguley, C. J. (1993). "The identification, prioritisation and analysis of accident blackspots in Malaysia "Overseas *Centre Transport Research Laboratory* (TRL) Crowthorne Berkshire United Kingdom.

Statens, V. (2006). "Hand Bok 115." *Analyse Av Ulykkesster*, vegdirektoratet,Oslo.

Stokes, R. W., and Mutabazi, M. I. (1996). "Rate-Quality Control Method of Identifying Hazardous Road Locations." *Transportation Research Record*, 1542.

Tamburri, T. N., and Smith, R. N. (1970). "The safety Index: Method of evaluating and Rating Safety Benefits." *Highway Research Record* 332.

Vadlamani, S., Chen, E., Ahn, S., & Washington, S. (2011). "Identifying Large Truck Hot Spots Using Crash Counts and PDOEs." *Journal of Transportation Engineering*, 137(1).

Vistisen, D. (2002). "Model And Methods for Hot Spot safety work." *Departement for informatics and mathematical models*, Technical University of Denmark,Lyngby.

Wang, C., Quddus, M. A., and Ison, S. G. (2011). "Predicting accident frequency at their severity levels and its application in site ranking using a two-stage mixed multivariate model." *Accident Analysis & Prevention*, 43(6), 1979-1990.

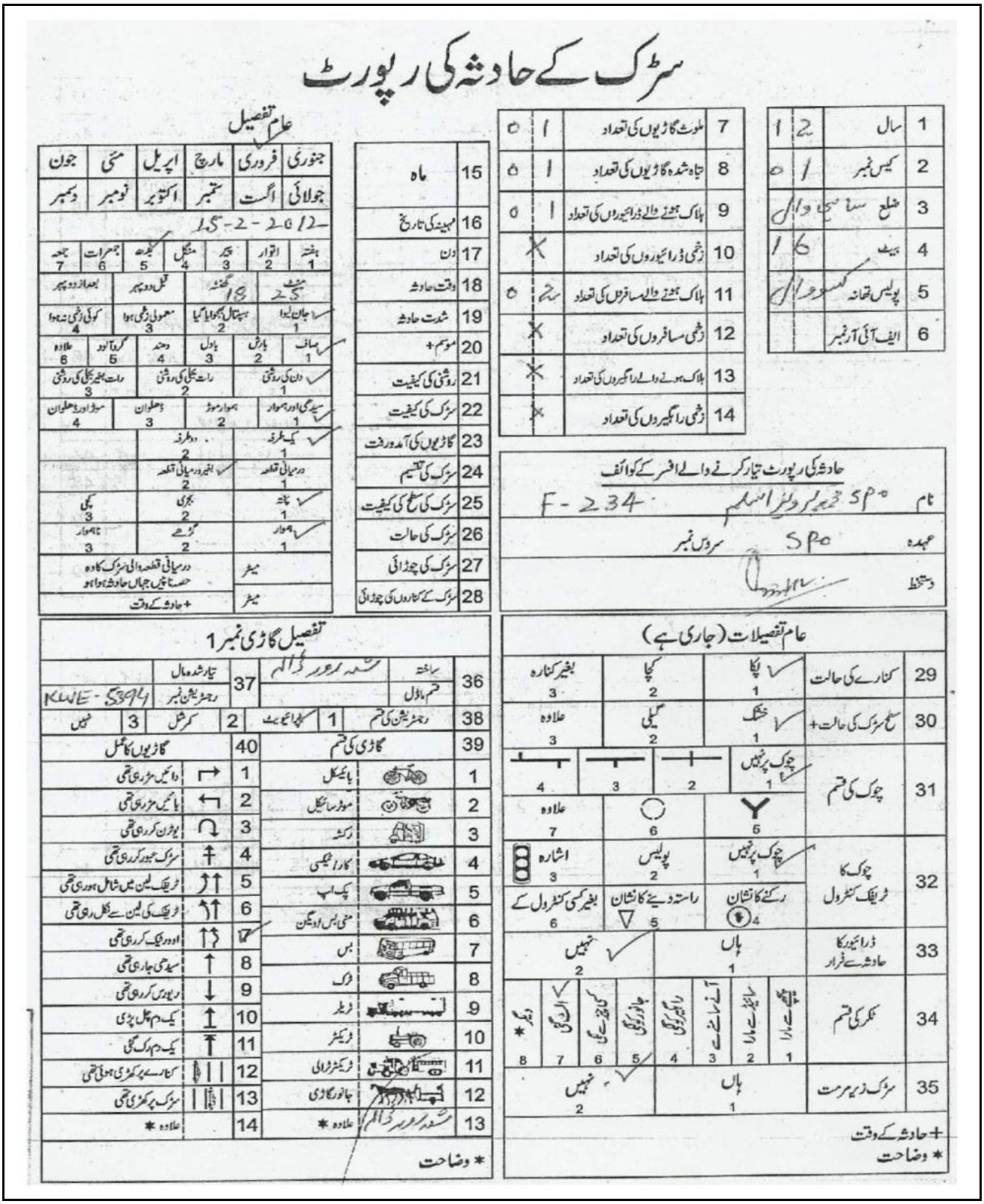
World Health Organization(WHO),(2004). *World Report On Road Traffic Injury Prevention*, World Health Organization.

World Health Organization(WHO),(2009). *Global status report on road safety; time for action*, World Health Organization.

Wright, C. C., Abbess, C. R., and Jarrett, D. F. (1988). "Estimating the Regression-to-Mean Effect Associated with Road Accident Black Spot Treatment." *Accident Analysis and Prevention*, 20.

APPENDICES

APPENDIX: I **Sample of Accident Data Collection Form**



سڑک کے حادثہ کی رپورٹ

1	سال	12
2	کیس نمبر	01
3	ضلع	سانگھڑ
4	بیٹ	16
5	پولیس تھانہ	کنڈوڑو
6	الیف آئی آر نمبر	

7	ملوث گاڑیوں کی تعداد	01
8	تباہ شدہ گاڑیوں کی تعداد	01
9	ہلاک ہونے والے ڈرائیوروں کی تعداد	01
10	زخمی ڈرائیوروں کی تعداد	X
11	ہلاک ہونے والے مسافروں کی تعداد	00
12	زخمی مسافروں کی تعداد	X
13	ہلاک ہونے والے راہگیروں کی تعداد	X
14	زخمی راہگیروں کی تعداد	X

حادثہ کی رپورٹ تیار کرنے والے افسر کے کوائف

نام F-234 محمد پرویز اسلم SPO

عہدہ SPO سروس نمبر

دستخط

عام تفصیل

جنوری	فروری	مارچ	اپریل	مئی	جون
جولائی	اگست	ستمبر	اکتوبر	نومبر	دسمبر

15-2-2012

ہفتہ 1	اتوار 2	پیر 3	منگل 4	بدھ 5	جمعرات 6	جمعہ 7

صبح 2.5 گھنٹہ 12 قبل دوپہر بعد از دوپہر

ساجان لیوا 1 ہسپتال پہنچایا گیا 2 معمولی زخمی ہوا 3 کوئی زخمی نہ ہوا 4

صاف 1 بارش 2 بادل 3 دھند 4 گرد آلود 5 علاوہ 6

دن کی روشنی 1 رات بجلی کی روشنی 2 رات بغیر بجلی کی روشنی 3

سیدھی اور ہموار 1 ہموار موڑ 2 ڈھلوان 3 موڑ اور ڈھلوان 4

یک طرفہ 1 دو طرفہ 2

درمیانی قطعہ 1 بغیر درمیانی قطعہ 2

پختہ 1 بجری 2 کچی 3

ہموار 1 گڑھے 2 ناہموار 3

میٹر درمیانی قطعہ والی سڑک کا وہ حصہ جہاں حادثہ ہوا ہو

میٹر

+ حادثہ کے وقت

15	ماہ	
16	مہینہ کی تاریخ	
17	دن	
18	وقت حادثہ	
19	شدت حادثہ	
20	موسم +	
21	روشنی کی کیفیت	
22	سڑک کی کیفیت	
23	گاڑیوں کی آمدورفت	
24	سڑک کی تقسیم	
25	سڑک کی سطح کی کیفیت	
26	سڑک کی حالت	
27	سڑک کی چوڑائی	
28	سڑک کے کناروں کی چوڑائی	

عام تفصیلات (جاری ہے)

29	کنارے کی حالت	پکا 1	کچا 2	بغیر کنارہ 3
30	سطح سڑک کی حالت +	خشک 1	گیلی 2	علاوہ 3
31	چوک کی قسم	چوک پر نہیں 1	2	3
		4	Y 5	○ 6
		علاوہ 7		
32	چوک کا ٹریفک کنٹرول	چوک پر نہیں 1	پولیس 2	اشارہ 3
		رکنے کا نشان 4	راستہ دینے کا نشان 5	بغیر کسی کنٹرول کے 6
33	ڈرائیور کا حادثہ سے فرار	ہاں 1	نہیں 2	
34	ٹکر کی قسم	پیچھے سے مارا 1	سائیڈ سے مارا 2	آمنے سامنے سے 3
		راہگیر کو لگی 4	جانور کو لگی 5	کسی چیز سے لگی 6
		الٹ گئی 7	دیگر * 8	
35	سڑک زیر مرمت	ہاں 1	نہیں 2	

+ حادثہ کے وقت

* وضاحت

تفصیل گاڑی نمبر 1

36	ساختہ	مسمات مرسڈیز ڈالفم		
	قسم ماڈل			
37	تیار شدہ مال			
	رجسٹریشن نمبر	KUH E - 5374		
38	رجسٹریشن کی قسم	1 کمرشل	2 پرائیویٹ	3 نہیں

39	گاڑی کی قسم		40 گاڑیوں کا عمل
1	بائیسکل		1 دائیں مڑ رہی تھی
2	موٹر سائیکل		2 بائیں مڑ رہی تھی
3	رکشہ		3 یوٹرن کر رہی تھی
4	کار / ٹیکسی		4 سڑک عبور کر رہی تھی
5	پک اپ		5 ٹریفک لین میں شامل ہو رہی تھی
6	منی بس / ویگن		6 ٹریفک کی لین سے نکل رہی تھی
7	بس		7 اوورٹیک کر رہی تھی
8	ٹرک		8 سیدھی جا رہی تھی
9	ٹریٹر		9 ریورس کر رہی تھی
10	ٹریکٹر		10 یک دم چل پڑی
11	ٹریکٹر ٹرالی		11 یک دم رک گئی
12	جانور گاڑی		12 کنارے پر کھڑی ہوئی تھی
13	مسمات مرسڈیز ڈالفم	علاوہ *	13 سڑک پر کھڑی تھی
			14 علاوہ *

* وضاحت

گاڑی نمبر 1 کی تفصیلات (جاری ہیں)

41	گاڑی کا نقصان	مکمل تباہ ہوگئی 1	معمولی نقصان ہوا 2	نقصان نہیں ہوا 3	
42	پیچھے سے ٹکر لگی	پیچھے سے ٹکر نہیں لگی 1	اگلی گاڑی سے 2	اگلی گاڑی سے نہیں 3	
43	گاڑی پر وزن کی کیفیت (سامان یا مسافر)	غیر قانونی وزن	قانونی ٹھیک وزن 1	آگے کی طرف 2	پیچھے کی طرف 3
		سائیڈ میں 4	اوپر کی طرف 5	اندر 6	
44	ٹائر پھٹا	نہیں پھٹا 1	2	3	4
		5	علاوہ 6		
45	گاڑی کی بتیاں	کیا گاڑی کی بتیاں خراب تھیں یا اسکے غلط استعمال سے حادثہ ہوا؟ نہیں* 1	ہاں* 2		
46	بریک کے نشان کی لمبائی	[illegible] میٹر			
	* وضاحت				
	گاڑی نمبر 1 کے ڈرائیور کے بارے میں تفصیل				
47	جنس	1 مرد	2 عورت		
48	عمر	سال			
49	زخموں کی نوعیت	مر گیا 1	ہسپتال میں داخل ہوا 2	معمولی زخمی ہوا 3	زخمی نہیں ہوا 4
50	لائسنس نمبر	نام [illegible]			
	پیشہ ڈرائیونگ	خود ستارہ [illegible]			

تفصیل گاڑی نمبر 2

36	ساختہ / قسم ماڈل		37	تیار شدہ مال / رجسٹریشن نمبر	
38	رجسٹریشن کی قسم	1 پرائیویٹ	2 کمرشل	3	
39	گاڑی کی قسم		40	گاڑیوں کا عمل	
1	بائیسکل		1	دائیں مڑ رہی تھی	
2	موٹر سائیکل		2	بائیں مڑ رہی تھی	
3	رکشہ		3	یوٹرن کر رہی تھی	
4	کار / ٹیکسی		4	سڑک عبور کر رہی تھی	
5	پک اپ		5	ٹریفک لین میں شامل ہو	
6	منی بس / ویگن		6	ٹریفک کی لین سے نکل ر	
7	بس		7	اوورٹیک کر رہی تھی	
8	ٹرک		8	سیدھی جا رہی تھی	
9	ٹریلر		9	ریورس کر رہی تھی	
10	ٹریکٹر		10	یک دم چل پڑی	
11	ٹریکٹر ٹرالی		11	یک دم رک گئی	
12	جانور گاڑی		12	کنارے پر کھڑی ہوئی تھ	
13	علاوہ *		13	سڑک پر کھڑی تھی	
			14	علاوہ *	

* وضاحت

گاڑی نمبر 2 کی تفصیلات (جاری ہیں)

41	گاڑی کا نقصان	مکمل تباہ ہوگئی 1	معمولی نقصان ہوا 2	نقصان نہیں ہوا 3	
42	پیچھے سے ٹکر لگی	پیچھے سے ٹکر نہیں لگی 1	اگلی گاڑی سے 2	اگلی گاڑی سے نہیں 3	
43	گاڑی پر وزن کی کیفیت (سامان یا مسافر)	غیر قانونی وزن	قانونی ٹھیک وزن 1	آگے کی طرف 2	پیچھے کی طرف 3
		سائیڈ میں 4	اوپر کی طرف 5	اندر 6	
44	ٹائر پھٹا	نہیں پھٹا 1	2	3	4
		5	علاوہ 6		
45	گاڑی کی بتیاں	کیا گاڑی کی بتیاں خراب تھیں یا اسکے غلط استعمال سے حادثہ ہوا؟ نہیں* 1	ہاں* 2		
46	بریک کے نشان کی لمبائی	میٹر			
	* وضاحت				
	گاڑی نمبر 2 کے ڈرائیور کے بارے میں تفصیل				
47	جنس	1 مرد	2 عورت		
48	عمر	سال			
49	زخموں کی نوعیت	مر گیا 1	ہسپتال میں داخل ہوا 2	معمولی زخمی ہوا 3	زخمی نہیں ہوا 4
50	لائسنس نمبر	نام			

تفصیل گاڑی نمبر 3

36	ساختہ / قسم ماڈل		37	تیار شدہ مال / رجسٹریشن نمبر	
38	رجسٹریشن کی قسم	1 پرائیویٹ	2 کمرشل	3	
39	گاڑی کی قسم		40	گاڑیوں کا عمل	
1	بائیسکل		1	دائیں مڑ رہی تھی	
2	موٹر سائیکل		2	بائیں مڑ رہی تھی	
3	رکشہ		3	یوٹرن کر رہی تھی	
4	کار / ٹیکسی		4	سڑک عبور کر رہی تھی	
5	پک اپ		5	ٹریفک لین میں شامل ہ	
6	منی بس / ویگن		6	ٹریفک کی لین سے نکل	
7	بس		7	اوورٹیک کر رہی تھی	
8	ٹرک		8	سیدھی جا رہی تھی	
9	ٹریلر		9	ریورس کر رہی تھی	
10	ٹریکٹر		10	یک دم چل پڑی	
11	ٹریکٹر ٹرالی		11	یک دم رک گئی	
12	جانور گاڑی		12	کنارے پر کھڑی ہوئی	
13	علاوہ *		13	سڑک پر کھڑی تھی	
			14	علاوہ *	

گاڑی نمبر 3 کی تفصیلات (جاری ہیں)

گاڑی کا نقصان	مکمل تباہ ہو گئی 1		معمولی نقصان ہوا 2		نقصان نہیں ہوا 3	
پیچھے سے ٹکر لگی	پیچھے سے ٹکر نہیں لگی 1		اگلی گاڑی سے 2		اگلی گاڑی سے نہیں 3	
گاڑی پر وزن کی کیفیت (سامان یا مسافر)	قانونی وزن 1	غیر قانونی وزن: آگے کی طرف 2	پیچھے کی طرف 3	سائیڈ میں 4	اوپر کی طرف 5	اندر 6
ٹائر پھٹا	نہیں پھٹا 1	2	3	4	5	علاوہ 6
گاڑی کی بتیاں	کیا گاڑی کی بتیاں خراب تھیں یا انکے غلط استعمال سے حادثہ ہوا؟				نہیں* 1	ہاں* 2
بریک کے نشان کی لمبائی	میٹر					
* وضاحت						

گاڑی نمبر 3 کے ڈرائیور کے بارے میں تفصیل

جنس	1	مرد	2	عورت
عمر	سال			
زخموں کی نوعیت	مر گیا 1	ہسپتال میں داخل ہوا 2	معمولی زخمی ہوا 3	زخمی نہیں ہوا 4
لائسنس نمبر		نام		
پیشہ				

زخمی راہگیروں کی تفصیلات

	راہ گیر نمبر 1				راہ گیر نمبر 2			
جنس	1	مرد	2	عورت	1	مرد	2	عورت
عمر	سال				سال			
تاریخ پیدائش								
نام								
پتہ								
زخموں کی نوعیت	1	مر گیا	2	ہسپتال گیا	1	مر گیا	2	ہسپتال گیا
	3	معمولی زخمی ہوا			3	معمولی زخمی ہوا		
راہ گیر کی حرکات	1	سڑک پر چل رہا تھا			1	سڑک پر چل رہا تھا		
	2	سڑک پار کر رہا تھا			2	سڑک پار کر رہا تھا		
	3	سڑک پر کھیل رہا تھا			3	سڑک پر کھیل رہا تھا		
	4	سڑک کے کنارے جا رہا تھا			4	سڑک کے کنارے جا رہا تھا		
	5	علاوہ *			5	علاوہ *		
سڑک کراس کرنے والے مسافر کا مقام	1	زیبرا کراسنگ پر تھا			1	زیبرا کراسنگ پر تھا		
	2	زیبرا کراسنگ پچاس میٹر کے اندر تھی			2	زیبرا کراسنگ پچاس میٹر کے اندر تھی		
	3	زیبرا کراسنگ پچاس میٹر کے اندر نہیں تھی			3	زیبرا کراسنگ پچاس میٹر کے اندر نہیں تھی		
سکول کے طلباء	0	سکول کے طلباء نہیں			0	سکول کے طلباء نہیں		
	1	طلباء سکول جاتے یا آتے ہوئے			1	طلباء سکول جاتے یا آتے ہوئے		
	2	طلباء مگر سکول آتے یا جاتے ہوئے نہیں			2	طلباء مگر سکول آتے یا جاتے ہوئے نہیں		

وضاحت

زخمی مسافروں کے حادثہ کی تفصیل

		مسافر نمبر 1						مسافر نمبر 2					
51	گاڑی نمبر	1		2		3		1		2		3	
52	جنس	1	مرد ✓	2	عورت			1	مرد ✓	2	عورت		
53	عمر	[illegible] سال						36 سال					
	تاریخ پیدائش												
54	حادثہ کی نوعیت	مر گیا 1 ✓		ہسپتال گیا 2		معمولی زخمی ہوا 3		مر گیا 1 ✓		ہسپتال گیا 2		معمولی زخمی ہوا 3	
55	گاڑی میں کہاں بیٹھا تھا	1	سیٹ پر ✓	2	اوپر			1	سیٹ پر ✓	2	اوپر		
		3	کھڑا تھا	4	لٹکا ہوا تھا			3	کھڑا تھا	4	لٹکا ہوا تھا		
	نام	[illegible]						[illegible]					
	پیشہ	[illegible]						[illegible]					
	پتہ	[illegible] 34/10R						[illegible] 34/10R					

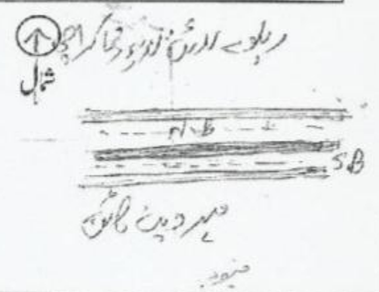
		مسافر نمبر 3						مسافر نمبر 4					
51	گاڑی نمبر	1		2		3		1		2		3	
52	جنس	1	مرد ✓	2	عورت			1	مرد	2	عورت		
53	عمر	55 سال						سال					
	تاریخ پیدائش												
54	حادثہ کی نوعیت	مر گیا 1 ✓		ہسپتال گیا 2		معمولی زخمی ہوا 3		مر گیا 1		ہسپتال گیا 2		معمولی زخمی ہوا 3	
55	گاڑی میں کہاں بیٹھا تھا	1	سیٹ پر ✓	2	اوپر			1	سیٹ پر	2	اوپر		
		3	کھڑا تھا	4	لٹکا ہوا تھا			3	کھڑا تھا	4	لٹکا ہوا تھا		
	نام	[illegible]											
	پیشہ												
	پتہ	[illegible]											

جائے حادثہ

62	1	دیہی علاقہ	2	گاؤں / عمارت	1	شہر / قصبہ	مقام کی نوعیت
63	شہر قصبہ یا گاؤں کا نام - 117/12-[illegible]						
64	سنگ میل کا مقام کلومیٹر	1047 نزدیک ترین	65	جائے حادثہ سنگ میل سے	میٹر دور		
	نزدیک ترین پولیس چوکی سے فاصلہ کلومیٹر	جہاں سنگ میل نہ ہو	3 کلومیٹر [illegible]				

جائے حادثہ کی تفصیلات - برائے تمام حادثات

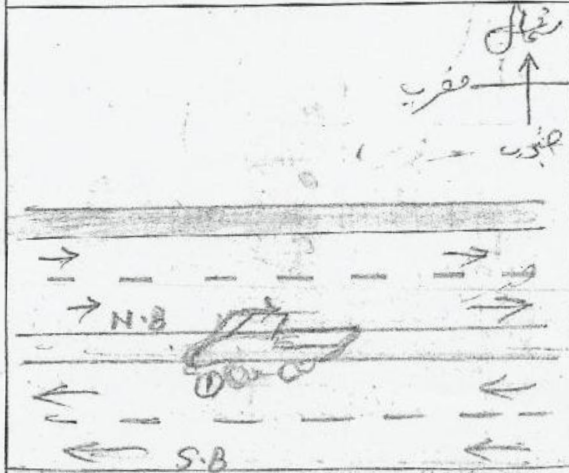
جہاں ممکن ہو سڑک کے نام جائے حادثہ اگر چھوٹی سڑک پر ہو تو نزدیک ترین بڑی سڑک کا نام جائے حادثہ کا نزدیک ترین مکان یا جگہوں سے تعلق وغیرہ



شمال کی طرف اشارہ

66 Map		67 Map Code	
68		69	
70 Main Road		71 Main Road	
72 Node 1		73 Node 2	
74 Sector		75 Sector	
76 Duration of travel of vehicle at		North 1 East 2 South 3 West 4	

حادثہ کا نقشہ



نمبر 1 مقام ... سے جہاں پر ... ڈالہ ... سے ٹکرا کر الٹی ہونے کا بیان ہوا ہے ۔

ڈرائیوروں کے بیانات

گاڑی نمبر 1 کے ڈرائیور کا بیان

موقع پر فوت ہو گیا ۔

گاڑی نمبر 2 کے ڈرائیور کا بیان

x .

گاڑی نمبر 3 کے ڈرائیور کا بیان

x .

گواہوں کے بیانات

نام: خادم اصغر ولد سید بشیر حسین شاہ

پتہ: 116/12.L کسووال 0307-2405118

نے بیان دیا ہے کہ ڈالہ والا ٹرک کو اوورٹیک کر رہا تھا کہ دوران ڈالہ بے قابو ہو کر column ستون سے ٹکرا کر الٹی ہو گیا

نام: محمد زبیر ولد محمد داؤد ساکن 117/12.L کسووال

پتہ

نے استفسار کرنے پر بتایا کہ ڈالہ ڈرائیور نے ٹرک کو اوورٹیک کرتے وقت بے قابو ہو کر column ستون سے ٹکرا گیا جسکی وجہ سے تین افراد ڈالہ کے نیچے آ گئے ۔

نام: محمد وسیم ولد عبد الغفور ساکن 117/12.L کسووال

پتہ

نے بتایا کہ ڈالہ ٹرک کو اوورٹیک کرتے وقت بے قابو ہو کر سنٹرل ریلنگ میں جا کر الٹی ہو گیا اور تین بندے ڈالہ کے نیچے آ گئے ۔

پولیس کی تفصیلات

77

حادثہ کے سلسلے میں افسران کی کارروائی
(جس میں حادثے کی وجہ اور افسران کی رائے شامل ہو)

ڈالہ پر تین عدد گدھے لوڈ تھیں ۔ ڈرائیور تیزی سے ٹرک کو اوورٹیک کرنے لگا اور ڈالہ کو کنٹرول نہ کر سکا جسکی وجہ سے ڈالہ سنٹرل میڈین ریلنگ میں لگے ہوئے Stone columns سے ہٹ ہونے کے بعد الٹی ہو گیا اور گاڑی کے سامنے کیبن میں بیٹھے ہوئے ڈالہ کے نیچے آ گئے جنکو نکالا گیا ۔ دو آدمیوں کی موقع پر ہی Death ہو گئی جبکہ ایک شدید زخمی حالت میں ہسپتال بھجوایا گیا جسکی Death ہو گئی ہے

تفتیش کا نتیجہ = حادثہ ڈرائیور کی غفلت کی وجہ سے پیش آیا ۔ گاڑی میں جانور سوار تھے اور ڈرائیور کو چاہیے تھا کہ گاڑی کی کم سپیڈ پر چلاتا ۔

Forwarded

Printed by: PCP PRESS, LAHORE (NHMP/314)

APPENDIX: II **Accident Point Weightage Calculations**

$$APW = 6(Fatal) + 3(Major) + 0.8(Minor) + 0.2(Property\ Damage)$$

KM	Fatal	Major	Minor	PDO	Total	APW
1	1				1	6
2		1			1	3
5		1			1	3
7	1				1	6
8	1				1	6
9	2	1			3	15
13	2	1			3	15
15	1				1	6
16		1			1	3
20			1	1	2	1
21		1			1	3
22	2	2			4	18
23	3				3	18
25		1			1	3
27				1	1	0.2
28	1				1	6
31		3	1		4	9.8
32		1			1	3
35	1				1	6
37	1				1	6
38			1	1	2	1
40	2		1		3	12.8
41	2		1		3	12.8
42		1			1	3
43		1			1	3
45	1				1	6
46	1				1	6

47	4				4	24
48		1			1	3
49		1			1	3
50	1				1	6
52		1			1	3
55	1	1			2	9
56		2			2	6
57		1			1	3
58	1				1	6
59		1			1	3
60	1	1			2	9
61	1				1	6
63		1			1	3
66		3			3	9
68		1			1	3
70	1				1	6
71	1	2			3	12
72	1				1	6
73	1	2			3	12
74	1		2		3	7.6
76		2			2	6
78	1				1	6
79		1			1	3
80	1				1	6
81		1			1	3
82	1				1	6
84	1				1	6
86			1		1	0.8
87	1				1	6
88		3	1		4	9.8
97		1			1	3

98		1			1	3
99			1		1	0.8
100		2			2	6
102		2			2	6
104	1				1	6
105		2			2	6
107		2			2	6
108		1			1	3
109	2				2	12
111			1		1	0.8
115		2			2	6
116		2			2	6
117		1			1	3
119	1				1	6
120	1				1	6
121		1			1	3
125	1	1			2	9
127		1	1		2	3.8
129	1	1	1		3	9.8
135			1		1	0.8
137	2	2			4	18
140	1	1			2	9
141		1			1	3
146	1	1			2	9
149		1		2	3	3.4
150	1				1	6
154	2	2			4	18
155	2	1			3	15
158		1			1	3
161		1			1	3
168		1			1	3

170		3			3	9
175	1				1	6
176		1			1	3
177		3			3	9
178	1				1	6
179		1			1	3
181		1			1	3
185		2			2	6
188		2			2	6
191	1				1	6
192		2			2	6
195	3	1	1		5	21.8
196	1	2			3	12
200		1			1	3
203	1	1			2	9
209		1			1	3
211		1			1	3
212		1			1	3
214		1			1	3
217	1				1	6
218		1			1	3
220		1			1	3
222	1				1	6
223	2	6	1		9	30.8
224	4	3			7	33
225	2	1			3	15
229	5	2	1		8	36.8
230		2			2	6
234	1	1			2	9
236		2			2	6
238		1			1	3

239	2				2	12
240		1			1	3
241		1			1	3
242	1				1	6
244	1				1	6
245	1				1	6
246	1	1			2	9
248		1			1	3
249		1			1	3
250		1			1	3
252			1		1	0.8
253	1				1	6
254	1				1	6
255		1			1	3
258	1	1			2	9
261		1			1	3
262		1			1	3
267		1			1	3
268		1			1	3
274		2			2	6
276			1		1	0.8
281	1				1	6
283		1			1	3
285		1			1	3
286	1	5			6	21
287	1				1	6
288		1			1	3
298		1			1	3
300		1			1	3
301		1			1	3
303	1				1	6

305		1			1	3
308			1		1	0.8
313	1				1	6
315		1	1		2	3.8
316		1			1	3
317			1		1	0.8
318			1		1	0.8
320		1	1		2	3.8
322		1			1	3
323	1	1			2	9
327		1			1	3
328		1	1		2	3.8
329	1	2			3	12
330	1				1	6
331	1	1			2	9
332		3			3	9
336			1		1	0.8
338		1			1	3
339	2				2	12
341		2			2	6
342		1			1	3
344		2			2	6
346	2	1			3	15
347		2			2	6
348	1				1	6
349	1	1			2	9
351	1	1			2	9