Effect of Roadway Geometrics and Travel Characteristics on Crash Frequency for Multi-lane Divided Highway

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Submitted By

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Certified that the contents and form of thesis titled "Effect of Roadway Geometrics and Travel Characteristics on Crash Frequency for Multi-lane Divided Highway" submitted by Sarah Basit have been found satisfactory for the requirement of the degree.

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Associate Professor (Dr. Anwaar Ahmed, PhD)

To my beloved parents, encouraging siblings,
supportive husband and beautiful daughter.

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LIST OF ACRONYMS

RTC	Road Traffic Crash
RCF	Road Crash Fatalities
RCI	Road Crash Injuries
NTRC	National Transport Research Center
AASHTO	American Association of State Highway and Transportation Officials
NHA	National Highway Authority
NH&MP	National Highway and Motorway Traffic Police
PR	Poisson Regression
NB	Negative Binomial
ZIP	Zero Inflated Poisson
ZINB	Zero Inflated Negative Binomial
GB & AJK	Gilgit Baltistan and Azad Jammu Kashmir
WHO	World Health Organization
GT	Grand Trunk
N-5	National Highway-5 (Grand Trunk Road)
TRB	Transportation Research Board
TRR	Transportation Research Record
TRRL	Transportation Road Research Laboratory
PCR	Pavement Condition Rating
IRI	International Roughness Index

ABSTRACT

Rapid motorization particularly increases in use of vulnerable transportation means (motorcycles and rickshaws) has resulted into enormous increase in road traffic crashes in Pakistan. Road crash fatalities and injuries have emerged as a moral and social challenge for community with over Rs 100 billion annual economic losses to the nation. Each year approximately over 30,000 individual lose their lives and approximately 400,000 sustain injuries due to road traffic crashes. Better understanding of the factors responsible for road crashes is mandatory for selecting appropriate road safety commuter measures. Since fatalities due to road crashes are amenable to remedial measures, therefore it is possible to observe drop in annual number of fatalities of any country if effective road safety counter measures are adopted. Roadway geometry is an important factor associated with road traffic crashes. Highways with appropriate geometric characteristics can help in significant reduction in annual road traffic crashes. Thus there is need to adopt appropriate methodology that can help to identify problematic highway segments that need remedial measures. The main focus of this study is to develop a statistical model of road crash frequency using data on roadway geometrics and travel characteristics. A detailed review of past studies revealed that at national level no research effort has been made to identify geometric deficiencies responsible for road traffic crashes. At international level, numbers of studies have been carried out using advanced statistical techniques that helped to establish the relationship between crash frequency and highway geometric features. Present study using 5-year traffic accident data for 280 Km of one of the national highway of Pakistan (Grand Trunk road from Rawalpindi to Lahore) developed negative binomial regression model. Model results revealed that segment length, lane width, number of U-turns, posted speed limit, number of lanes, number of access points of highway segment, percentage of single unit truck in traffic stream, and road segments in urban area are significantly associated with road crash frequency. Comparative analysis and appropriate statistical tests revealed that negative binomial regression model is superior as compared to Poisson regression models, zero inflated negative binomial and zero inflated Poisson regression models. The results of this study

can be used by National Highway Authority and Ministry of Communication as an input for formulation of multipronged road safety improvement policy for Pakistan and for development of effective road safety counter measures targeted at crash-prone highway segments.

CHAPTER 1. INTRODUCTION

1.1 Background

Nation's economic power is mainly governed by its efficient transport system and sustainable infrastructure. Economic stability is contingent on strength and efficiency of its transport system, out of which road networks act as an elementary component. Road infrastructure facilitates need of its users naturally and built environment. Furthermore, it has strategic importance while keeping in view the national defense requirements of logistics. Being an indispensable factor, every country is engaged in up-gradation of its infrastructure, concurrently ensuring road safety for motorists, cyclists, pedestrians and adjacent communities. If we only talk about the developing countries, unfortunately this dilemma reinforces because of numerous factors. An introductory study was commenced by the overseas unit of U.K. Transport and Road Research Laboratory (TRRL, 1972). They predicted that funds generated by World Bank are the sole source for evaluating the methodology for valuation of road accidents in developing countries. In contrast the road accidents are still consuming limited financial funds that these countries themselves cannot afford. Major studies published by the World Health Organization, TRL and others have identified the consequence of road crashes leading to death, predominantly in developing and transitional countries. To support their conclusion, they carried out a study which focused on estimating the economic cost of accidents with respect to Gross National Product (GNP) of developing countries. They drew different fatal and non-fatal accidents statistics to visualize the trends on regional and state basis. Furthermore, they also examined the trends by age, sex, road type, social behaviors and road users. In their report, they provided respective fatality rates of prior mention regions in units of deaths per 10,000 vehicles and per 100,000 populations respectively.

Jacobs and Cutting (1986) in their study "Further Research on Accident Rates in Developing Countries" found that African and Asian countries suffer high road traffic crashes (RCI) and road crash fatalities (RCF) dilemma. The mortality rate of these countries is considerably amplified, compared to other developed nations round the world. As per World Health Organization's publication "Global Status Report on Road Safety-2013", apparently 1.24 million RTC and RCF occur worldwide (WHO, 2013). The report stated that the road crash injuries (RCI) percentage increased to 50 million due to road traffic crashes while the number of injured could be as high as 50 million. Out of 1.2 million, 1.08 million deaths occur in low to middle income countries (WHO, 2013).

Pakistan being a low income country has high road crash fatalities and injuries rate measuring approximately 30,000 RCF and 400,000 RCI annually. WHO (2009) estimated 52,537 annually reported RCF in Pakistan whereas latest publication estimated that there are almost 30,130 annually reported RCF in Pakistan. The enormous increase in motorization has amplified the proportion of vulnerable road users on roads of Pakistan and has brought with it higher number of road crash fatalities and injuries. The country is experiencing a serious problem of road crashes and their cost has reached to Rs 100 billion per annum (Baguley and Jacobs, 2000; Ahmad, A., 2007). According to Ghaffar et.al (2004) and Fatmi et al.(2007), the road crashes stand second amongst the leading cause of disability, the fifth among overall healthy life-year losses and the eleventh among untimely fatality in Pakistan. Past studies in Pakistan provide different estimates of traffic accidents. They found that approximately 1,500 individuals per 100, 000 population encounter injuries due to road accidents in Pakistan annually. The crash reporting agencies in Pakistan publish different estimates of RCF and RCI annually. According to NTRC, approximately 1.4 million RTC occurred in Pakistan in 1999 that resulted in 7,000 mortalities.

1.2 Problem Statement

Due to high burden of road traffic crashes in Pakistan, there is a strong need to investigate factors responsible for road traffic crashes. Various factors like speed, roadway geometrics, level of enforcement, seatbelt, child restraint motorbike helmet laws and their enforcement levels have been found associated with road traffic crashes in past studies. At national level, different researchers have explored the relationship between crash frequency and factors like age, gender, visibility level, fatigue and over speeding etc., but geometric features remained unexplored. Statistical model that relates the road traffic crashes fatality rate with geometric features like lane and shoulder width, median width and type, number of lanes, access, number of intersection/ U-turns, length and radius of horizontal/ vertical curves and speed/percentage of different truck classes have been used effectively at international level. Present research is the first effort at national level, which relates accident frequency with road geometrics to explore Pakistan specific roadway geometric issues responsible for road traffic crashes.

1.3 Research Objectives

The prime objective of this research is to explore the relationship between crash frequency and different geometric features such as lane and shoulder width, median width and type, number of lanes, access points, intersection, U-turns, bridges and horizontal curves, horizontal curve number, length and radius, speed, annual average daily traffic and truck percentage on road crash frequency

1.4 Overview of Study Approach

To achieve the research objectives, a detailed approach as shown in *Figure 1.1* is developed and the following research tasks are outlined:

- Review of earlier researcher’s findings and synthesis of information on roadway geometric features responsible for road traffic crashes.
- Collection and collation of data for model development.
- Study of modeling approaches and selection of suitable model functional form.
- Estimation of count data model.
- Analysis of model results and discussion.
- Conclusions and recommendations.

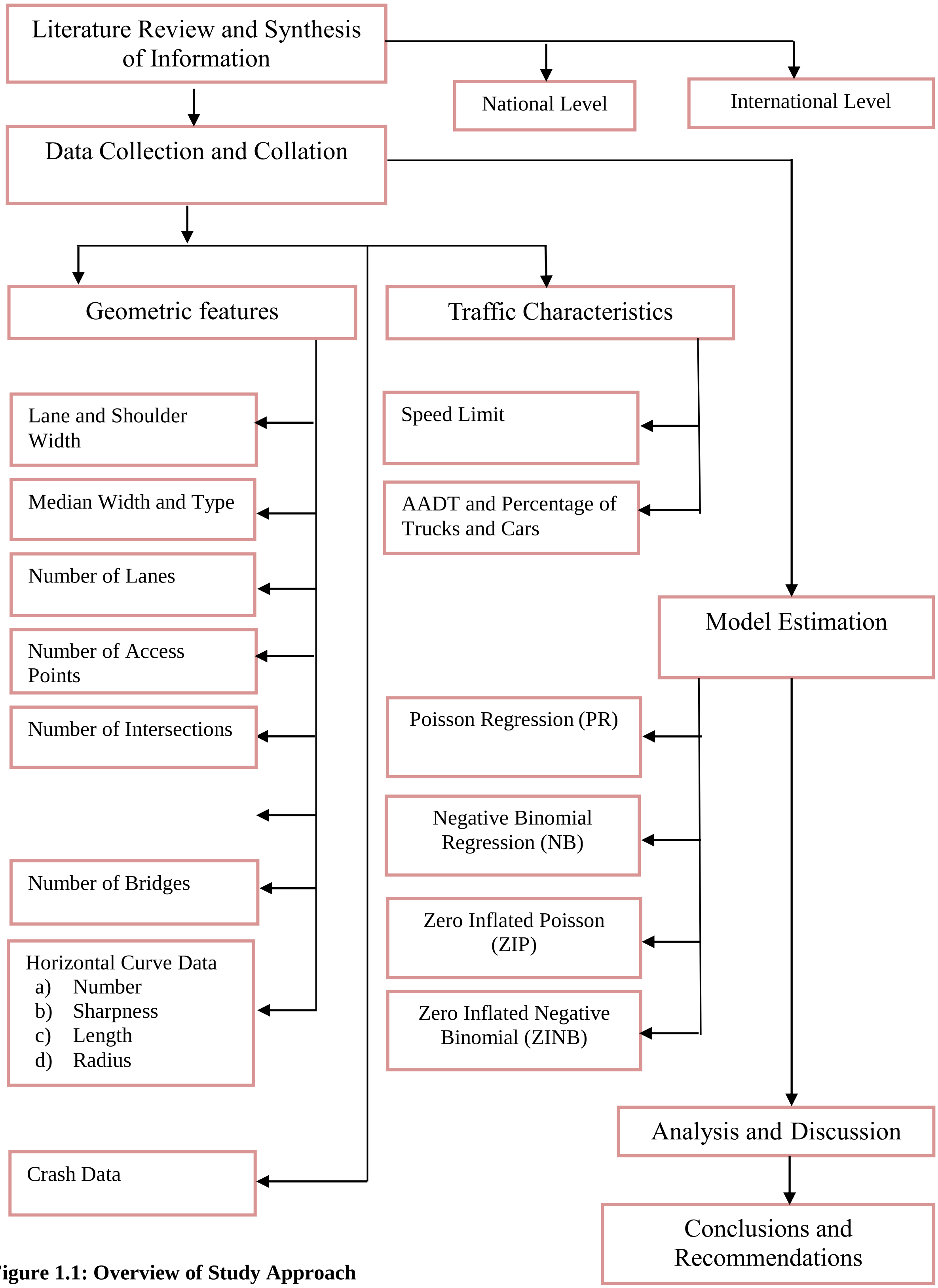

Figure 1.1: Overview of Study Approach

1.5 Thesis Organization

This study is organized into five chapters. Chapter 1 highlights the problem statement, study objectives and overview of research. Chapter 2 provides a summary of international and national researches carried out on roadway geometrics. Chapter 3 covers the collection and collation of data. Chapter 4 discusses modelling methodology, model results, discussion and analysis. Lastly, the research summary, conclusions, and recommendations are presented in Chapter 5.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

Identification of factors responsible for RTC is a complex procedure. The road crash analysis and past researches has shown that road crashes generally happen because of three major governing factors.1) driving; 2) environment/ road factor and 3) vehicle related factors. Out of these three factors, geometrics related crashes are comparatively easy to identify as compared to human and environment factors.

Shinar (2007) proposed three contributing factors for the cause of road accidents on roadway (see Figure 2.1). According to him, 90 % are the human factor, 30 % are the road and environmental factors and 10 % are the flaws associated with vehicle. Maximum percentage of accidents is related to driver or human errors. They may generally arise due to fatigue and long hour driving. The alcoholism and old age can lessen driver’s road obstacle judgment and reduce his decision power due to lethargies. Over speeding is another factor which stands for the reckless and careless high speed driving habit of a driver. The second factor road and environment is actually any abrupt change in geometrics of highway or any change in the weather condition at the spot of accident occurrence. The weather changes refer to rain, storm, fog, slippery roads, animals and poor lightening. These all factors affects driver’s vision and reduce his ability of making decision to stop or pass them without crashing. Also vehicle brake failure, bursting of tire and any other mechanical fault of a vehicle may cause an accident.

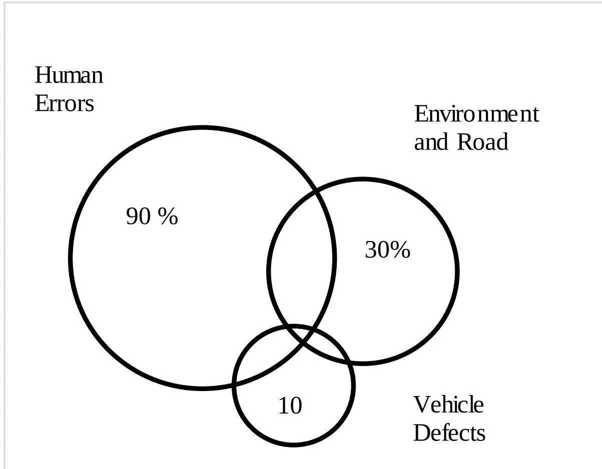

Figure 2.1: Major Contributing Factors of Road Crashes
(Shinar, 2007)

By designing a geometrically superior road, we can significantly reduce crashes annually. So, better understanding of the factors responsible for road crashes is mandatory for reducing overall crash rate. Many efforts have been made internationally in terms of reasonable statistical prediction models of automobile crashes. The fundamental objective of these prediction models is to evaluate the anticipated safety performance on the highway segments. They even help you to determine the candidate sites for maintenance and improvement activities which in turns is evaluated using engineering principles for remedial measures.

Jovanis and Chang (1986) discovered that accident frequency has a strong relation with the vehicle miles travelled. They predicted that accidents are directly related to vehicle mile traveled by the vehicles. As the trucks VMT increases, there would be marginal reduction in vehicle-vehicle collision. They used the linear regression approach in their research and dealt with normal distribution which motivates traditional linear regression and hypothesis testing. To deal with accident data we come across with the problem of homoscedasticity which portraits the situation when variance of the dependent variable is the same for all the data. This violates the hypothesis test as the confidence intervals are affected by this and significance of the variables cannot be achieved. The other problem is low and no accident frequency on all road sections of data set. This problem leads to negative accident occurrences which leads to unfair results and invalidates the model. To overcome these shortcomings of homoscedasticity and negative accident occurrence, they suggested Poisson regression for predicting variables because of its superiority statistical approach and small sample size. Poisson regression can deal effectively with the no and less accident frequency data thus providing reasonable significant variables. They collected the data from the Indiana Toll Road in 1978 of 157 miles long. The data included daily accident, traffic volume/traffic composition and weather condition.

Poch and Mannering (1996) used Poisson and negative binomial regression approach to identify the traffic and geometric features responsible for RTC. They developed four types of the model which include total crashes, approach turn crashes, rear end crashes and angle crashes and concluded that the negative binomial regression approach is more appropriate for determining the crash frequency as compared to Poisson regression approach.

While following general approach used by Poch and Mannering (1996), Milton and Mannering (1998) collectively worked on Poisson and negative binomial regression models for evaluating the crashes on the basis of highway geometrics and traffic related parameters. Their study data sources were the Washington State's department of transportation information and planning support's database for geometric features and Washington State patrol accident database for highway accidents. Their research focused on the principal arterials, minor arterials and collectors for Eastern Washington and Western Washington. They selected 45 independent variables and 16 additional derived independent variables of various combinations of the prior ones. The predictions resulted from their model approaches were later on compared with the reported accident statistics. Model coefficients were estimated through maximum likelihood method. The authors found that the horizontal curvature, tangent length, daily traffic, number of lanes and speed between curves were considerably associated with crash frequency. They also proposed that if the crash occurrence is more dispersed as compared to mean, negative binomial approach is more appropriate approach for analysis.

Shankar et. al.(1995) collected data on rural roads of Washington state to estimate the effects of geometric and environmental features on crash frequency. They used both Poisson and negative binomial approaches for their analysis. Chang and Mannering (1998) analyzed nested logit model while using vehicle occupancies with crash data. They found that nested logit model are more feasible for estimating accident severity data.

2.2 Median Width, U-Turns at Unsignalized Median Openings

Knuiman et al (1999) in attempt to explore the relation between median width and crash frequency found that median should be wide enough to allow sufficient space for an out of control vehicle to recover without crossing over the median in opposite direction. The homogeneous highway sections data with non-barrier, curbed medians, barrier-median was collected from the Highway Safety Information System of Utah and Illinois States. They highlighted a very serious problem of provision of additional lane for improving the capacity of the roadway by lending the space from the center median without acquiring the desired right of way. Their findings indicates that decreasing any median width that is greater than 6.1 to 9.2 meters or less to enhance the capacity would probably be accompanied by a decrease in level of safety on the road. They calculated accident rates corresponding to serious injury, property damaged, multivehicle accident, head on or swipe on accidents, opposite direction accidents, single vehicle accident, single vehicle rollover accidents. Also used a log linear function for evaluating the effects of medians widen on crash frequency.

Cribbins et al.(1968) evaluated the effect of median openings on accident frequency and concluded that with low traffic, wide median and less built up area around the road, median opening has slight impact on crash frequency. However, when there is more traffic volume and development on periphery of road, the median openings should be reduced as it increases the accidents rates. They also showed 35 percent crashes are related to median opening on four lane divided highways. The study also proved that besides the median opening, access points and storage lanes are significant factor for the road traffic crashes.

2.3 Horizontal Alignments

Horizontal curves have always been considered as an important parameter when dealing with the safety issue of a road. Different researches have shown that accident frequency is high on curves than on tangents using different attributes of horizontal curve such as insufficient radius; deficient super elevation; curve sharpness; and introduction of spirals. Glennon et al. (1985) studied the geometrics, traffic and roadside elements on horizontal curves to see the pattern of crashes. Authors found that the shaper curves, lengthy sections, unsafe roadsides elements, low skid resistance and narrow shoulders have high probability for traffic accidents as compared to tangent sections. Zegeer et al.(1901) carried out a study to determine the horizontal curves characteristics which contribute for safety measurements and to evaluate the accidents cost resulting from horizontal curve characteristics. Maximum and minimum grade, maximum super elevation, maximum and minimum distance to adjacent curve, roadside recovery area, outside/inside shoulder width and type, surface width and type, surface and terrain type and presence of transition spiral were the main variables extracted from Washington State database. Statistical analysis resulted from 10,900 horizontal curves, authors concluded that the probability of accidents increases on sharper curves, narrow curves with insufficient width, section with missing transition curves and inadequate super elevation and high traffic volume. They also predicted that with the increase of length of horizontal curve, the accident frequency also increases.

The key findings of their research are summarized as: 1) the mild curve reduces the accident frequency by 80 % as it’s depends on central angle and percentage of flattering; 2) increasing the roadway width on horizontal curves, the accidents are reduced by 21% ; 3) widen paved are expected to reduce accidents by 29%; 4) when a spiral is added between two curves, it will reduce crash percent by 5 %; when the super elevation rate of 0.02 is provided, it yields to accident reduction as 11%. Authors proposed that for 3R activities (Resurfacing, Restoration, and Rehabilitation), the curves should be recalculated for crash cost to determine whether geometric improvements are needed or not.

2.4 Cross Sectional Elements:

Out of all geometric elements, the cross sectional elements are the most dominant parameters which are responsible for road crashes and may include lane and shoulder width, shoulder type, roadside features, bridge and median width. Some studies also include the addition of through lanes, passing lanes, median designs and right turn lanes in the category of design alternatives. The cross sectional elements are very important for the safe vehicle movement and for the proper regulation of traffic.

Perchonok et al (1978) carried out a study using data from states of California, Georgia, Maine, South Dakota, Tennessee, and Wyoming. The authors also trained the investigating police officers in each state to collect additional data, relevant to the study. That data were then extended with highway photo log data obtained from state highway departments. They collected data on total of 7,972 accidents from 1975 to 1977, which varied by state to state. The authors analyzed the accident characteristics of single vehicle road crashes with the roadside elements and cross sectional elements. Authors included bridge or overpass entrances tree, culverts, embankments, ground, wooden utility poles, sign posts, fences and guardrail in their data base. They found out that the most dangerous roadside hazards are the bridge/overpass entrances, where 75 % injury and fatalities occur. Similarly trees, field approaches, culverts and embankments all had injury rates well above average. Culverts, tree, bridges/underpass entrance had high fatality rate associated with them.

Zegeer et al. (1987) run an analysis on 1,944 road sections comprising of 7,922 kms of two lanes highway in seven US states. The road sections were categorized in much elaborated and defined form than previous studies. Measure of lane width and shoulder type, roadside condition, horizontal alignment, terrain type, intersection number and driveway frequency were taken as independent variables. Computerized road inventories, photo logs and site inspections were employed to characteristic road sections.

The authors concluded that shoulder specially lane conditions directly affect head on and sideswipe accidents.

Wang et al. (1998) estimated the effects of different cross-sectional highway elements on crash rate and afterwards established a crash estimation model for rural, multilane and non-freeway highways. Authors utilized Poisson regression approach for predicting crashes and indicated that they increase with the exposure to roadside obstacles, number of driveways per segment length and presence of intersections. The crash count can be reduced as a result of increased outside shoulder and median width. The authors also predicted low accidents on roadways owing partial control access compared to those owing no access control. Their model acted as a design guide for predicting crashes for different highway design alternatives; and for reckoning crash reductions accredited to variations in cross sections; and for judging the prospective safety effects of upgrading a two-lane rural highway to a multilane rural highway. The study proposed a quantifiable relationship among crash frequency and numerous cross-section-associated highway design components on multi-lane, non-freeway and rural arteries.

Lee and Mannering (2002) studied runoff traveled way crashes using data from state of Washington. The variables that used were included travelled way geometry and characteristics and run off travelled way crash frequency. The researchers used negative binomial and zero inflated negative binomial regression. Model results revealed that similar factors were responsible for crashes in urban and rural areas and run off travelled way crash rates can be considerably reduced by; 1) lane and shoulder widths; 2) provide wide medians; 3) provide wide entrances and exit approaches to bridges; 4) minimize roadside obstacle and 5) provide mild side slopes at the road edges.

Zegeer and Council (1992) examined the correlation of various roadside elements with the crash rate. Authors investigated the impact of lanes and shoulders, roadside condition, roadside recovery distance, clear zone, side slope, specific roadside obstacles, utility poles, other obstacle types, bridges, median design, multilane design alternatives, other cross-sectional features on road traffic crashes. Zegeer and Parker

(1983) evaluated crashes caused by utility poles. Study results revealed that the utility poles and sign boards with wooden posts are more prone to accidents than with metal supports using data from 9,583 utility poles along 4,000 Kilometers (KMs) of urban and rural highways

2.5 Median Design

A median barrier is a longitudinal arrangement which is used to minimize the opportunity of errant vehicle to come across the path of traffic stream travelling in the opposing direction. The elements of the median which can become a cause for crashes may include median width, median slope, median type showing whether the median is a raised or it is depressed. Another parameter was presence or absence of a median barrier. Wide medians are considered desirable as they lessen the prospects of head-on crashes. Median design and slope can affect rollover crashes and remarkably increase the single vehicle crashes and head-on crashes with contrasting traffic. The installation of median barriers usually increases overall crash rate because of large number of collisions with the barrier but at the same time it cut down crash severity due to head-on collisions with conflicting traffic.

Garner and Dean (1973) analyzed crash frequency with respect to median types and widths using data from state of Kentucky. Authors concluded that the roads with 30ft wide medians have lower accident compared to narrow median. They recommended that for minimizing crash rate, minimum median widths of 30 to 40 feets, median slopes of 6:1 and paved shoulders of 12 feets on those specific road sections should be provided.

2.6 Bridges

Bridges can be hazardous for drivers if they are not wide enough, having poor sight distance, absence of delineators on bridge edges and poor signing (Ogden, 1989). Different studies have analyzed the crash rate on bridges due to absence of road furniture (signs and pavement marking) but less work is done on accident occurrence due to flaws in geometric features. A well-known crash model was developed by Turner in 1984. He collected the data of 2,087 bridges on two lane roads in Texas. The crash prediction model involved the relative bridge width which is the difference calculated from roadway width minus total bridge width. Model results revealed that the vehicle crash rate decreases with increase in relative bridge width. So, accordingly the bridge width should be 6 ft wider than the roadway width that can be achieved by providing 3 ft shoulders on each side of bridge.

Ogden (1989) in his research presented an approach and guidelines to determine the culverts and bridges hazardous parameters in Victoria, Australia. He studied different bridge crash prediction models and mentioned the factors which are responsible for bridge crashes. He found that the bridge and culvert sites should be assessed by bridge width, traffic volume and bridge length. He prescribed different treatments for avoiding crashes at bridges in terms of delineators, safety barriers and improvement in alignment. Behnam and Laturos in 1973 carried out a study on bridge crashes on two lane two way highway of United States. They utilized multivariate regression analysis while considering average daily traffic, sight distance and degree of curvature as explanatory variables.

2.7 Lane and Shoulder Width

Griffin and Mak (1987) studied the impact of accident on road widening on road crashes for the state of Texas. They used weighted least square regression for multi vehicle crash. They sub divided their segments into four categories of average daily traffic i.e. 401, 401-700, 701-1000, 1001-1500 and run separate regressions for each of them. They observed no significant relation between multi-vehicle accidents and width whereas the single vehicle crashes reduced for roads which have wider lane width for different average daily traffic classes. Authors observed that road width doesn’t act as a cost effective factor for village roads having ADT below 1,000 vehicle per day.

Zegeer et al.(1980) studied the width of lane and shoulder to explore the correlation with traffic crashes . Authors found out that in California, about twice as many accidents occurred on roads with 0.3 to 0.9 m shoulder width as compared to over

1.8 m shoulder width. Therefore reduction in accidents is related with increased shoulder width. Ogden (1997) presented his work on safety effects of paved shoulders while carrying out his study in the rural roads of Victoria, Australia. He took data before and after the accident occurrence for comparison. Analysis revealed that shoulder paving can act as a crash reduction parameter, and two lane two way roads 41 % crashes can be reduced by shoulder paving.

2.8 Number of Lanes

Kononov et al. (2008) explored the correlation between traffic lanes on freeways and safety. Their relation with each other was determined with safety performance functions which are in actual accident estimation models relating vehicular traffic exposure in terms of average annual daily traffic to human safety in units of total crashes occurred over a specified unit time (crashes per mile per year). Authors used linear regression approach for developing their models. Their safety performance function's (SPF) showed that on uncongested road segments, the accidents increase with moderate rate with increase in traffic because of addition of lanes on urban freeways. But when we come across with segments having critical vehicular traffic density, the number of accidents began to rise rapidly. This happens because of high average annual daily traffic experienced over those specific segments which lead to traffic congestion with low operating speed.

2.9 Intersection

Vogt and Bared (1998) using data of States of Minnesota and Washington rural roads, developed two types of models; 1) segment model and 2) intersection model. Authors selected three types of intersections; 1) three legged, 2) four legged and 3) stop controlled on minor legs. With the help of reported data of Highway safety information system (HSIS), photo logs, construction plans, videotapes, weather data and inventory data bases, they segregated 1300 road segments with 700 intersections. The main variables that were selected are; crash counts, roadway and shoulder width, number of lanes, islands and channelization, horizontal alignment and vertical profile, angles at intersection, posted speed limits and truck percentages. Authors used Poisson, Negative Binomial and Extended Negative Binomial regression techniques. They found traffic volume as the most significant variable responsible for road traffic crashes and roadside shoulder width, roadside conditions and highway alignments also played a dominant role in traffic crashes. Whereas in intersection models; intersection geometry angle, roadside hazards, number of lanes and shape/ dimensions of channelization came out to be significant variables. In spite of missing number of crashes and other related data, their models were able to give reasonable descriptive and predictive values due to large sample size.

2.10 Speed

Garber et al (2000) studied how roadway geometrics, trafiic flow and speed can effective the crash pattern collectively. Using data from different data collection stations of Virginia department of transportation and crash data from police departments, models were developed. Authors developed different deterministic models and concluded that nearly for all traffic prevailing condition, crash frequency tends to increase as the speed standard deviation increases.

Malyshkina and Mannering (2007) studied speed limit effect using Indiana interstate and non-interstate accident data (year 2004 and 2006) on road traffic crashes. Authors estimated various statistical models on different type of roadways on the basis of injury severity index. Their results showed that there is no speed significant effect on interstate highways traffic crashes. However, high crash rate was found to be associated with non-interstate highway due to increased speed limit. Milton and Mannering (1998) also showed different trends of effect of speed limit on collectors and arterials. But overall it was observed that with the increase in speed limit, the accident frequency increases. Zeeger et al. (2001) utilized roadway, driver, vehicle and environmental factors responsible for sever accidents in North Carolina (1993-1997). They used statistical analysis and figured out those highways with high posted speeds experience more crashes which results in more severe damage to driver and individuals involved.

Table 2.1: Summary of the Findings - International Research Effort

Authors	Year of Study	Modelling Techniques	Factors related to Road Traffic Crashes
Cribbins et al.	1968	Descriptive statistics	Median width, traffic volume, level of service, intersection openings, access point index, speed limit, signalized openings and median openings
Garner and Dean	1973	Descriptive statistics	Median types and widths
Behnam and Laturos	1973	Multivariate regression	Average daily traffic, sight distance and degree of curvature
Zegeer and Parker	1983	Variable correlation and descriptive statistics	Roadside obstacle (utility poles)
Turner	1984	Linear regression	Bridge width
Glennon et al.	1985	Linear regression	Horizontal curves length
Zegeer et al.	1987	Logarithmic regression	ADT, length of curve, and degree of curve
Griffin and Mak	1987	Linear regression	Lane width and lane widening
Ogden	1989	Variables correlation and descriptive statistics	Bridges/culverts widths
Jovanis and Chang	1990	Linear regression	Trucks vehicle miles travelled
Zegeer et al.	1991	Linear regression	Horizontal curves
Zegeer and Council	1992	Variables correlation and descriptive statistics	Lanes and shoulders width, Side slope, utility poles, bridges and median design
Poch and Mannering	1996	Poisson and negative binomial regression	Left turn traffic volume and opposing traffic volume

Table: 2.1 Summary of the Findings - International Research Effort (Continued)

Authors	Year of Study	Modelling Techniques	Factors related to Road Traffic Crashes
Milton and Mannering	1996	Poisson and negative binomial regression	Length of section, median, Average annual daily traffic, percentage of double trucks, number of trucks, lane width, presence of wall, sharp curve, radius, curve length and speed
Shankar et al.	1995	Poisson and negative binomial regression	Traffic volume, geometric features, human and weather factors
Wang et al.	1998	Poisson regression	Traffic, roadway/ roadside condition, intersection, access points
Ogden	1997	Linear regression	Paving shoulders
Chang and Mannering	1998	Nested logit regression	Vehicle occupancies
Vogt and Bared	1998	Poisson model, negative binomial model and extended negative binomial regression	Roadway and shoulder width, roadside hazard, islands, speed limits, number of lanes and truck percentages
Lee and Mannering	1999	Negative binomial and zero inflated negative binomial	Lane, median and shoulder width, traffic volume, number of lanes and vertical curves
Garber et al	2000	Multiple linear regression, robust regression	Speed, lane and shoulder width
Zeeger et al.	2001	Binomial proportion	Roadway, driver, vehicle and environmental factors
Malyshkina and Mannering	2010	Multinomial logit regression	Speed limit
Kononov et al.	2008	Linear regression	Number of lanes

2.11 National Research Effort

Numerous efforts have been made to evaluate current road safety in Pakistan. Descriptive statistics have been used to explore the impact of different factors i.e age, gender, fatigue and weather condition, underage driving, negligence in traffic rules and violation. Annual publications of these statistics help us to get an idea of different trends and crash rate in Pakistan. Figure 2.2 shows graphical representation of fatalities and injuries across all provinces of Pakistan. Minimal differences were observed between fatalities and injuries in Sindh and Balochistan. The maximum fatalities and injuries occurred in Punjab. sfff

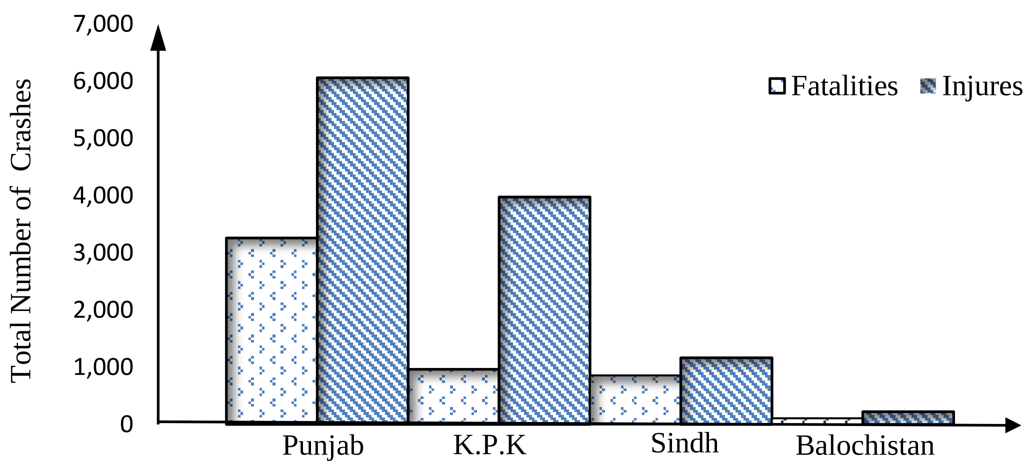

Figure 2.2: Fatalities and Injuries Across Provinces for the Year 2010
(*NTRC, 2011*)

Provincial road crash counts of Pakistan for the year 2001 – 2010 is given in Figure 2.3. It shows temporal graph indicating road crashes from 2001 to 2010 for four provinces of Pakistan. A total of 9,808 crashes were reported for the year 2010, out of them 5,577 occurred in Punjab, 2,732 in KPK, 1,273 in Sindh and 226 in Baluchistan. There were total of 2510, 690, 825 and 72 fatalities in Punjab, Khyber Pakhtunkhwa, Sindh and Baluchistan respectively.

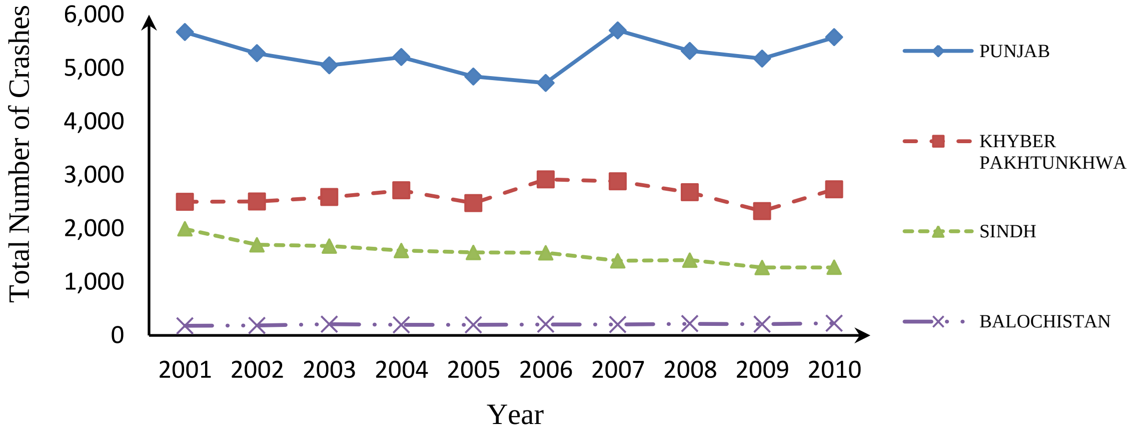

Figure 2.3: Total RTC Occurring in Different Provinces, 2001- 2010
(*NTRC, 2011*)

Figure 2.4 shows the growth trend of road fatalities and injuries for Pakistan for the year 1981 to 2012. In 1981, the road fatalities were 4,167 and which then raised to 5,323 in the year 2012, whereas road injuries count increases from 10,310 to 11,475 during the last three decades.

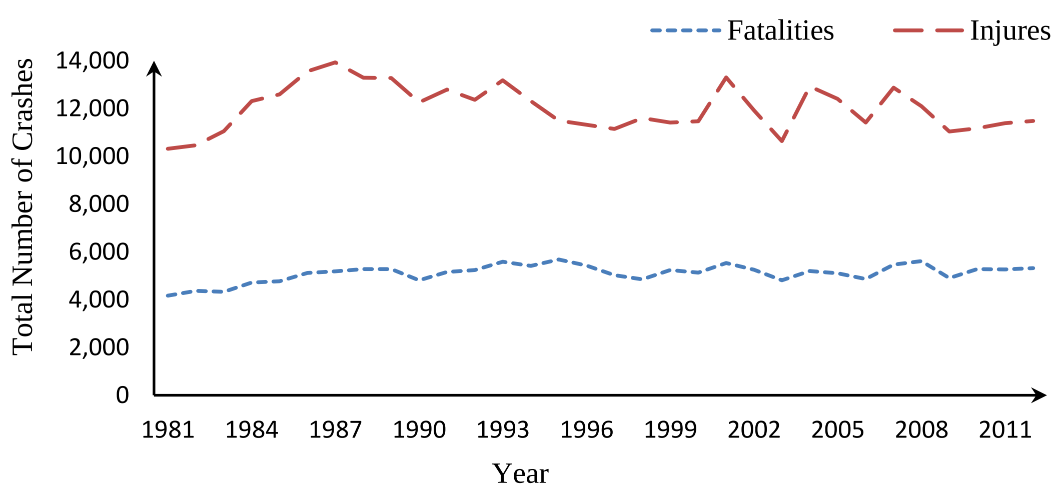

Figure 2.4: Pakistan RTF and Injuries Past Trend, 1981 – 2012
(SIP, 2012, NTRC)

Shah et al. (2007) considered road user age, gender, accident occurrence place and motorization as dependent variables in their prediction model. They concluded that accidents are directly associated with population and vehicle number. Mir et al. (2010)

also used statistical approach to investigate the road fatalities associated with commercial vehicles, driver's driving behaviors and fatigue, seat belt usage, alcohol usage and vehicle mechanical faults were used as explanatory variables in their research. Authors concluded that not using seat belt, vehicle mechanical faults and alcohol usage are the main cause of high number of road traffic crashes.

Bhatti et al. (2011) studied the relationship between road traffic fatalities and highway work zone for Karachi city, using data from year 2006-2008. Road surface type, road user, crash type and work zones were used as explanatory variables. Study results revealed that fatalities rates were higher in the highway work zones compared to other segments of highway. They also found out that opposite-direction crashes and traffic crashes involving pedestrians and on wet road surfaces were significantly correlated with the highway work zone.

CHAPTER 3. RESEARCH METHODOLOGY

3.1 Introduction

This study attempted to predict significant geometric features which are responsible for road crashes with the help of statistical modeling. In this study, the relation between crash frequency and traffic and geometric features is analyzed by using Negative Binomial regression.

3.2 Study Strategy

For the analysis, Grand Trunk road section i.e. Rawalpindi to Lahore (N-5) has been selected which serves as the backbone for Pakistan’s economy. It bears the highest traffic burden of trade. The total length of the selected segment (from Rawalpindi to Lahore) is 280 KMs and it passes through the urban and rural areas. The number of lanes throughout its length is two except few segments. The road has different types of median ranging from grassy, paved and barrier with varying widths. There are number of intersections, bridges, access points at several locations and hundreds of horizontal curves having different radii. The speed is constantly varying on N-5 due to rapid transition between urban and rural areas and because facility being a non-access controlled. The annual daily traffic has considered variations over different segments of the highway. There are numerous U-turns provided for facilitating movement of inhabitants living on both sides of the road. As it serves as a trade corridor thus experiences heavy percentage of single unit and 2- 3 -4 and 5- axle trucks.

3.3 Accident Data Collection and Collation

Crash data record of all national highways of Pakistan is collected by National Highway and Motorway Police (NH&MP) in their area of jurisdiction and Provincial

Police at nearby police stations where FIR is recorded. The crashes are then reported to headquarters at national and provincial levels. Record of individual crashes were obtained from accident report form having proper time, date and location. The frequent crash places are marked as black spot and further reported on the basis of severity index as fatal, non-fatal and property damaged. The victims of crashes are classified as passengers, pedestrians and drivers. Data are also collected on vehicle number, type and license. In the end short detail of every crash is written with an appropriate reason in few coded words. A collision diagram is drawn for better understanding of scenario if necessary.

Based on NH&MP reported data of last five years (2009-2013) (Figure 3.1), a total of 368 crashes were reported. Data from number of years helped to explore the variability of crash frequency and to get more pronounced result.

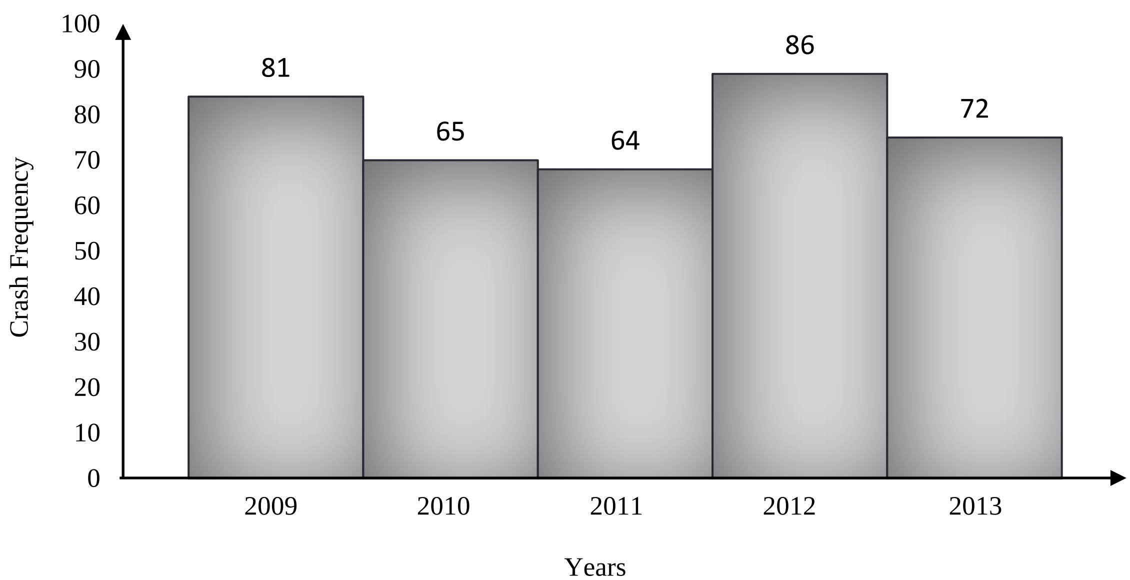

Figure 3.1: Distribution of Crashes for Year 2009-2013 on N-5

The reason for crash is recorded defined in terms of driver's fault, mechanical faults, improper U-turns, weather conditions (Figure 3.2).

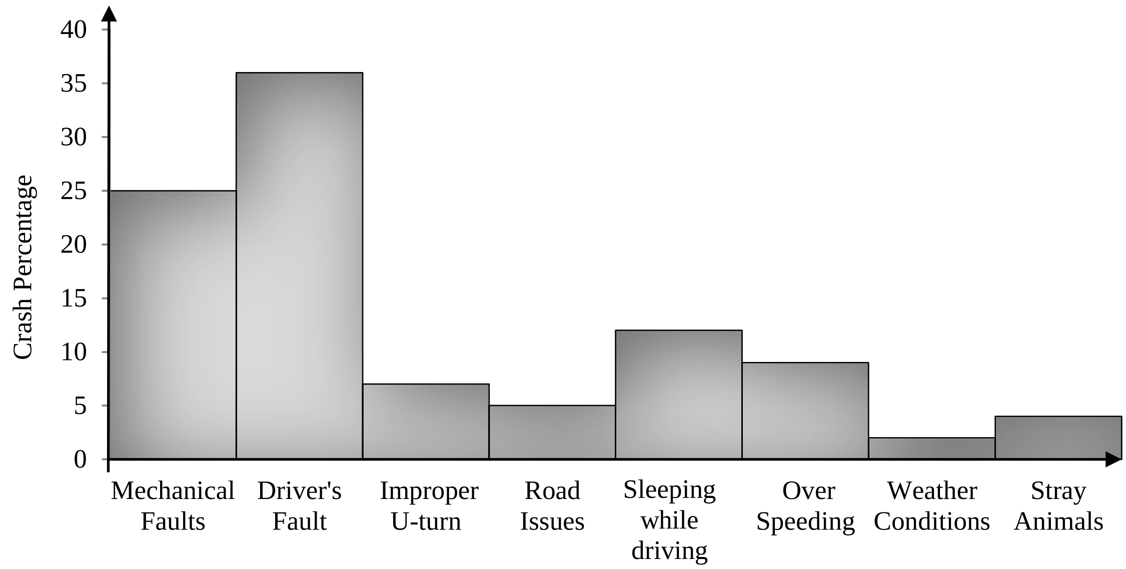

Figure 3.2: Reasons for Road Crashes on N-5

The highest crash frequency is observed at two sections of GT road those are Rawalpindi – Gujar Khan section and Sohawa – Jehlum section (Figure 3.3). The first section possess high average daily traffic whereas the second section is a hilly area with very sharp horizontal curves.

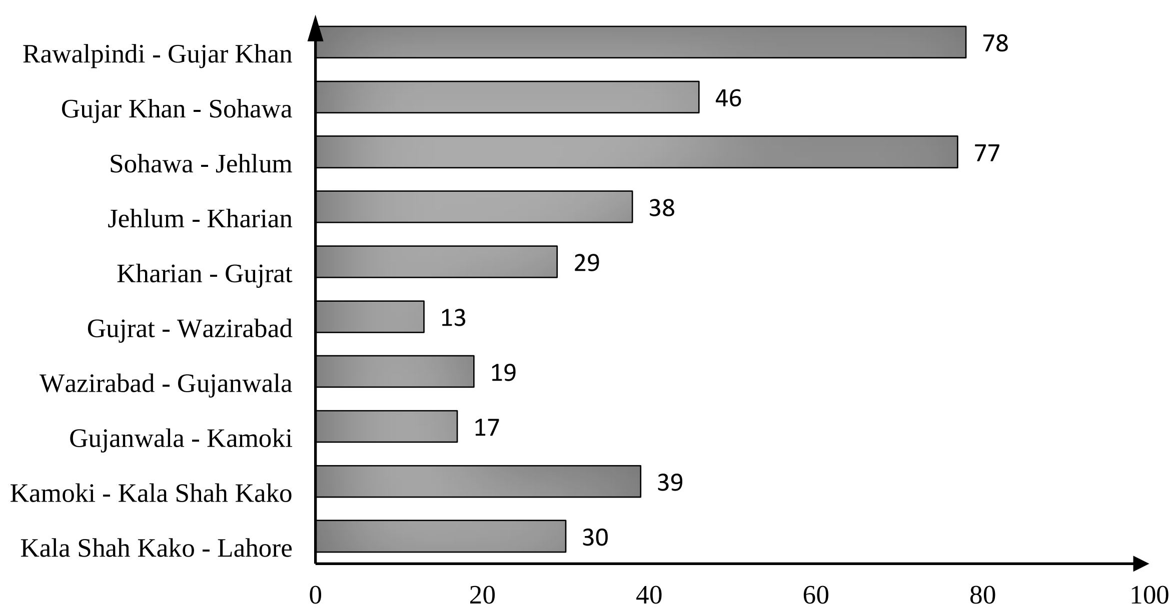

Figure 3.3: Road Crash Frequency at Different Segments of N-5

At most of the segments no accidents were observed however there were segments at which maximum of 11 crashes were observed as shown (Figure 3.4).

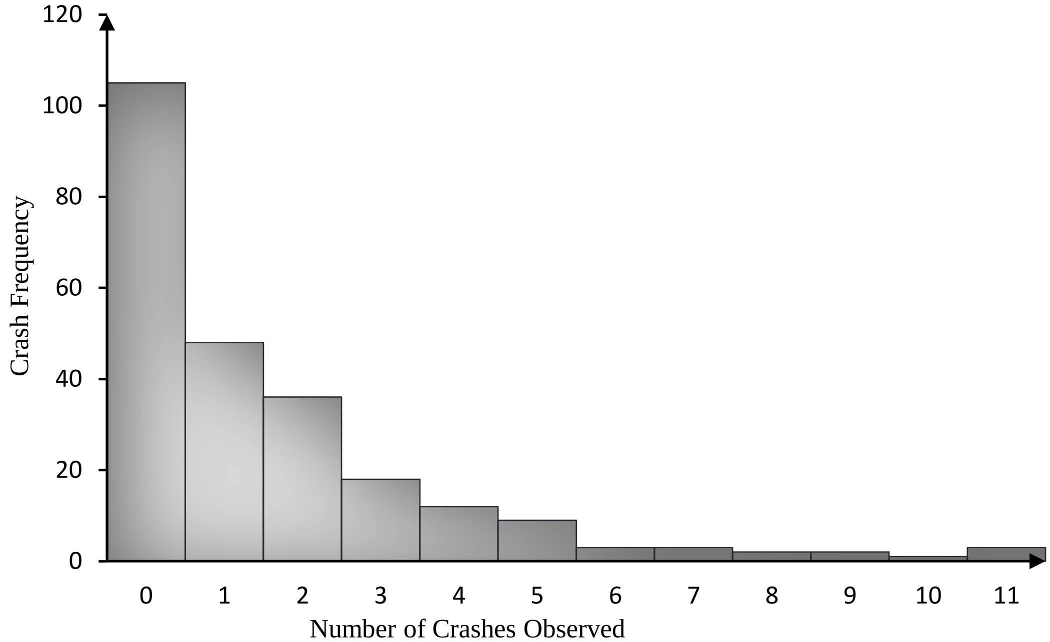

Figure 3.4: Number of Crashes on Different Segments of N-5

3.4 N-5 Geometric Attributes and Road Traffic Crashes

The data on geometric features of GT road was collected from National Highway Authority (NHA) which is responsible for 4.6 % of total road network (2,600,00 KMs) of Pakistan. The prime objective of database department of NHA is to collect data on all national highways of Pakistan, collate and manage it. It collects data related to geometric features of roadways, structures inventories, roadside obstacles, roadway furniture, annual daily traffic, maintenance and rehabilitation logs and any other additional geometric improvement in terms of new intersection/interchange/bridges.

In this research, N-5 was divided into numerous segments which were of unique nature. A total of 241 segments were defined. A segment is defined as a particular road length during which road cross section remains constant or unchanged. In other words, we can say a section of homogenous characteristics for which all specified geometric features do not change. The variation in cross section includes either the deletion or addition of median, median width variation, change in lane width and inside/outside shoulder widths, variation in number of lanes and area type. In an effort to make homogeneous sections, some very small segments were also made where roadway characteristics were rapidly changing. The maximum segment length was of 5.5 Km and minimum length was of 0.11 Km. Higher number of crashes were observed for longer segments lengths (Figure 3.5)

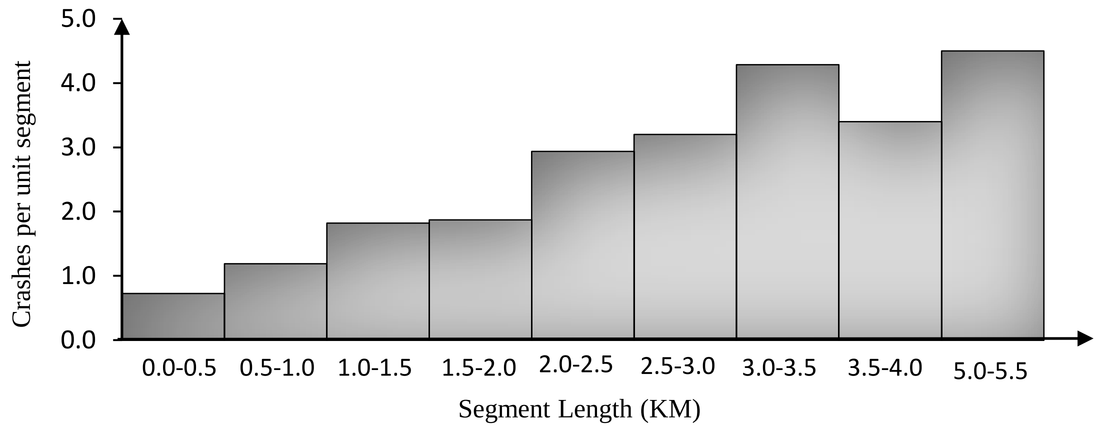

Figure 3.5: Segment length and crashes per unit segments on N-5

The descriptive statistics revealed that urban areas are associated with higher number of traffic crashes compared to rural areas. Out of total, 368 crashes reported on N-5 (2009-2013), 186 crashes occurred in urban areas and 182 occurred in rural areas (Figure 3.6).

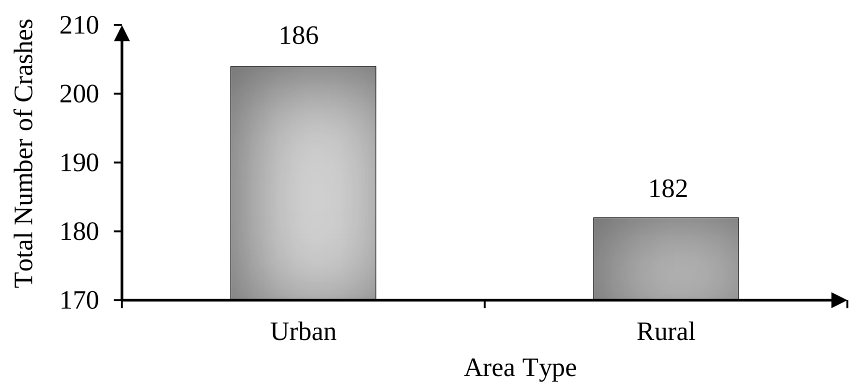

Figure 3.6: Urban Verses Rural Crashes

The bar chart shows that when there are more number of U-turns in a segment, the crash probability increases (Figure 3.7) that means crash per unit segment are maximum for segments having seven U-turns.

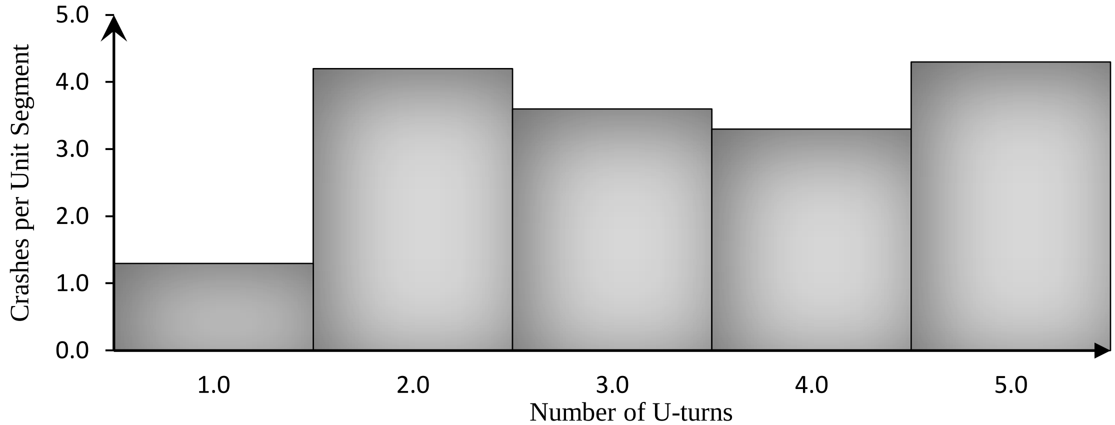

Figure 3.7: Crashes as Function of Number of U-turns on N-5

Due to partial access control on N-5, more crashes are observed in segments having multiple access points. The minimum side access that has been observed within a segment is 1 whereas the segments passing through urban areas have open access from both sides. Therefore, it shows that with the increase in access points, the number of accidents also increases (Figure 3.8).

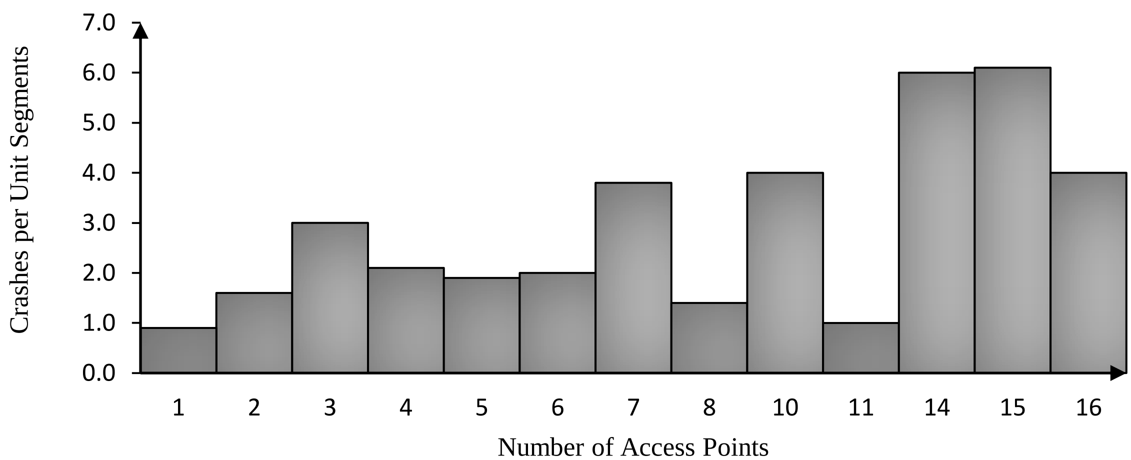

Figure 3.8: Crashes as Function of Number of Access Points on N-5

The number of crashes for typical lane width of 3.3, 3.6 and 3.8 meters on N-5 for five years data (2009-2013) are presented in Figure 3.9. It can be observed that segments with 3.8 meters lanes are exposed to highest number of crashes and segments with 3.3 meter has limited crashes.

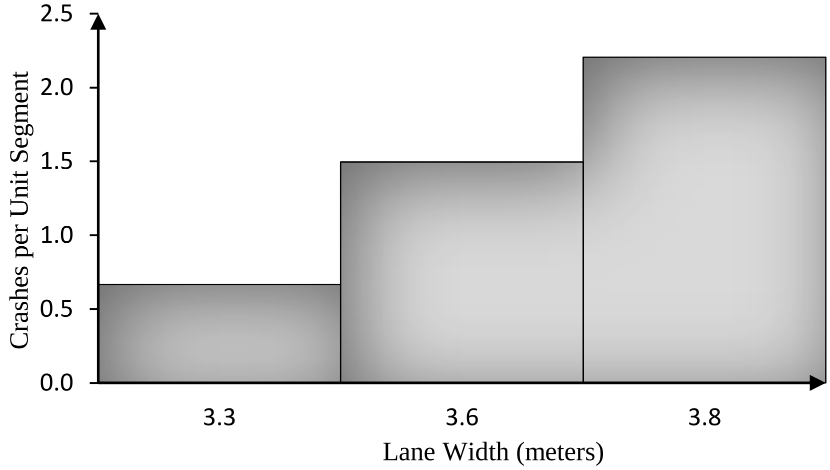

Figure 3.9: Crashes as Function of Lane Width on N-5

The typical number of lanes observed over N-5 are two and three lanes. Though, N-5 is four lane facility (two lanes on each side) however, there are urban areas where the segments are expanded to three lanes to facilitate the addition traffic load. The Figure 3.10 shows that with an increase in number of lanes, the accident rate also reduce as additional lanes facilitates the traffic volume to move freely over the road without collision with each other and roadside elements.

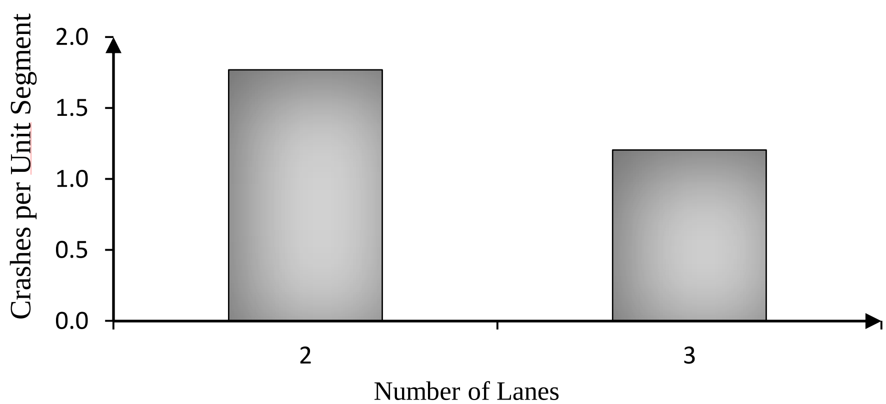

Figure 3.10: Crashes as a Function of Number of Lanes on N-5

The speed limit on N-5 is continuously varying as it passes through both urban and rural areas. Posted speed in urban areas is 70 km/hr and in rural areas 100 km/hr.

Initial analysis of data revealed that there are more crashes in urban areas as compared to rural areas (Figure 3.11).

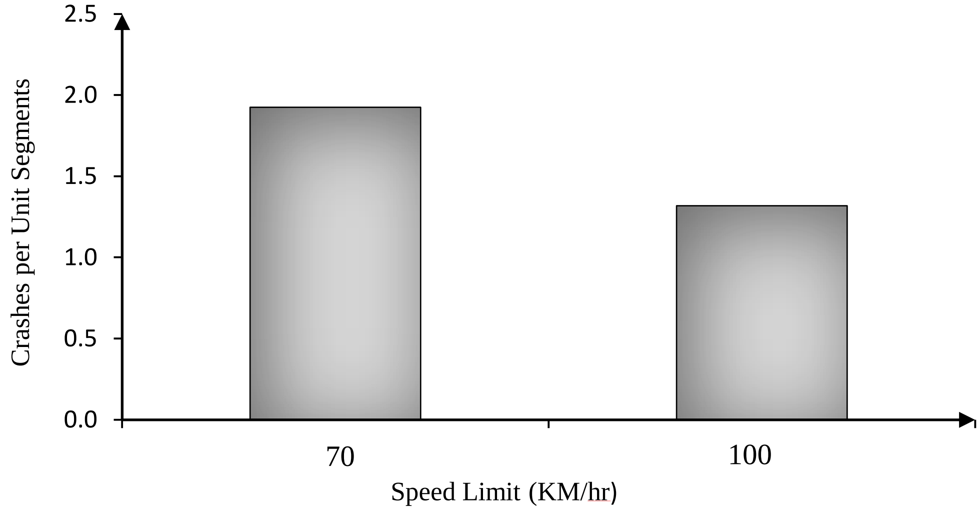

Figure 3.11: Crashes as a Function of Speed Limits on N-5

Initial analysis of the data revealed that crashes vary with the percentage of single unit trucks. Those segments that have high single unit trucks percentage (8% and high) have high crash rate (Figure 3.12).

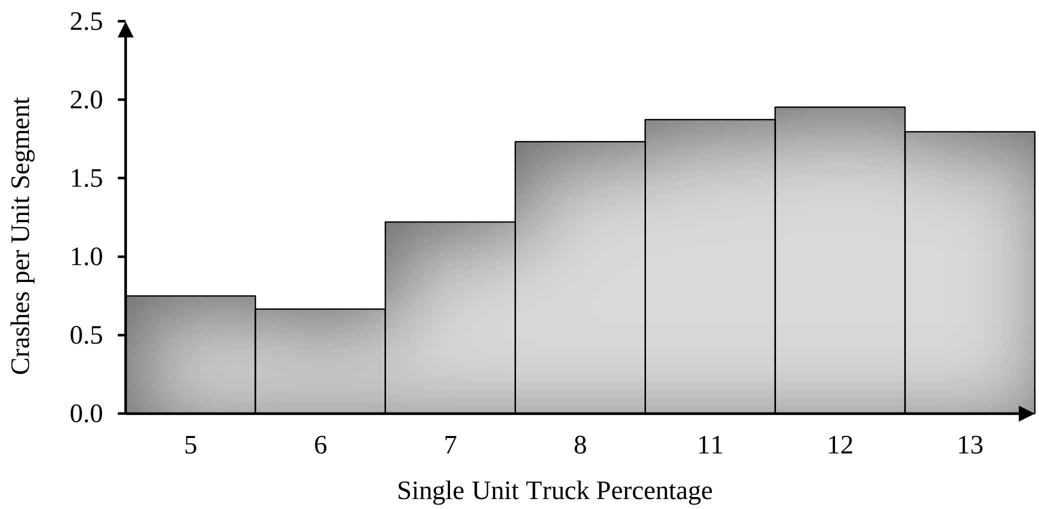

Figure 3.12: Single Unit Truck Percentage Verses Crash Frequency on N-5

3.5 Selection of Response (Y) and Explanatory Variables (X)

Total number of crashes over five year period (2009-2013) was selected as response variable. Data on large number of explanatory variables (Lane and shoulder width, median width and type, number of lanes, access points, intersection, U-turns, bridges and horizontal curves, horizontal curve number; direction, sharpness, length and radius, speed, annual average daily traffic and truck percentage) was collected. Different combinations of explanatory variables and indicator variable were also used. A description of all these variables is presented in Table 3.1 as follows:

Table 3.1: Description of Response and Explanatory Variables

Serial No	Selected Variable and Description
1	*Total Crashes(2009-2013):* Total number of reported crashes from 2009-2013 on individual road segments
2	*Segment ID*: A unique road segment number or name
3	*Beginning km Stone of Segment*: The beginning of road segment in terms of Km stone
4	*Termination km Stone of Segment*: The termination of road segment in terms of Km stone
5	*Road Segment Length:* The total road segment length (in kilometers)
6	*City Name*: The City name in which the specific road segment occurs
7	*Indicator variable for Area Type:* This is an indicator variable which indicates whether the selected road segment is present in an urban area or rural area. (1 for urban, otherwise 0)
8	*No of Lanes:* The total number of lanes in a particular road segment
9	*Lane Width:* The width of single lane in a particular road segment (in meters)
10	*Road Segment Width:* The total road segment width including lanes, inner and outer shoulder (in meters)
11	*Left Shoulder Width*: The width of left shoulder in a particular road segment (in meters)
12	*Right Shoulder Width*: The width of right shoulder in a particular road segment (in meters)
13	*Indicator variable for Grass Median:* This is an indicator variable which indicates whether the road segment has grass median or not (1 for Grass median, otherwise 0)
14	*Indicator variable for NJ Barrier:* This is an indicator variable which indicates whether the road segment has NJ barrier or not (1 for NJ barrier, otherwise 0)
15	*Median Width:* This represents the width of the median(in meters)

Table: 3.1 Description of Response and Explanatory Variables (Continued)

Serial No	Selected Variable and Description
16	*No of U-Turns:* The total number of U-turns in a particular road segment
17	*No of Side Access*: The total number of access points in a particular road segment
18	*No of Intersections*: The total number of intersection in a particular road segment
19	*No of Bridges:* The total number of bridges in particular road segment
20	*No of Horizontal Curves*: The total number of horizontal curves in a particular road segment
21	*Type of Curve*: Indicates type of curve in a particular road segment whether it's a reverse, compound or broken back curve
22	*Point of Intersection*: The point of intersection's RD of each horizontal curve in a particular road segment
23	*Tangent Length*: This represents the tangent length between two horizontal curves in a particular road segment (in meters)
24	*Curve Radius* : The radius of each curve in a particular road segment (in meters)
25	*Curve Length*: The length of each curve in a particular road segment (in meters)
26	*Central Angle of Curve*: This represents central angle of the each curve in a particular road segment (in degree)
27	*Degree of Curve:* Indicates the degree of horizontal curvature in a particular road segment
28	*Indicator Variable for Direction of Curve:* This is an indicator variable which indicates direction of curve in a particular road segment (1 for right, otherwise 0)
29	*Indicator Variable for Reverse Curve:* This is an indicator variable which indicates whether a reverse curve is present in a particular road segment or not (1 if present, otherwise 0)
30	*Indicator Variable for Compound Curve:* This is an indicator variable which indicates whether a compound curve is present in a particular road segment or not (1 if present, otherwise 0)
31	*Indicator Variable for Curve Sharpness:* This is an indicator variable which indicates whether the degree of curve is greater than 2 in a particular road segment or not (1 if present, otherwise 0)
32	*Speed:* The posted speed limit in a particular road segment (in kilometer per hour)
33	*Average Daily Traffic:* The total average daily traffic observed within a particular road segment
34	*2-Axle & 3-Axle Single Unit Truck Percentage:* The percentage of Single unit trucks (2-Axle and 3-Axle) in a particular road segment

The descriptive statistics of different variables used for model estimation is summarized in Table 3.2.

Table 3.2: Descriptive Statistics of Different Variables

Details	Mean	Std. dev	Min	Max
***Response Variable*:**				
Total number of reported crashes (2009-2013) per segment	1.52	2.06	0.0	11
Geometric Characteristics:				
Road segment length (kilometres)	1.09	0.83	0.11	5.54
Area type indicator variable (1 if road segment is in urban area, 0 otherwise)	0.46	0.50	0.0	1.0
Number of lanes in a particular road segment	2.27	0.44	2.0	3.0
Lane width (meters)	3.62	0.089	3.3	3.8
Left shoulder width (meters)	1.54	0.14	1.5	2.0
Right shoulder width in a particular road segment (meters)	0.63	0.17	0.6	1.5
Grass median indicator variable (1 if present, otherwise 0)	0.77	0.41	0.0	1.0
NJ barrier indicator variable for (1 if present, otherwise 0)	0.22	0.41	0.0	1.0
Median width variable (meters)	7.62	16.67	0.0	150
Number of U-turns in a particular road segment	0.93	1.05	0.0	5.0
Number of intersection in a particular road segment	0.10	0.46	0.0	4.0
Number of access points in a particular road segment	2.04	2.96	0.0	16
Number of bridges in a particular road segment	0.16	0.42	0.0	3.0
Number of horizontal curves in a particular road segment	0.91	1.19	0.0	7.0
Curve radius (meters)	154.1	265.7	0.0	1146
Curve Sharpness indicator variable (1 if present, otherwise 0)	0.78	1.47	0.0	8.05
Traffic Characteristics:				
Speed limit (in kilometer per hour)	86.91	14.91	70	100
Average daily traffic (ADT) in a particular road segment	15560	3070	12,889	22,362
Percentage of single unit trucks in a particular road segment	10.20	2.88	5.0	13.0
Percentage of multiple unit trucks (4-Axle, 5-Axle & 6-Axle)	1.54	0.182	1.26	1.87

3.6 Methodological Approach

The selected dependent variable (total number of crashes) is a non-negative count variable. Two commonly used approaches for modeling count data variable are Poisson and negative binomial regression. Poisson regression is valid only if mean of count data is equal to variance. If this property doesn't hold good, (i.e. variance is considerably larger than mean), the data cannot be modeled with Poisson regression and negative binominal regression is favored over Poisson regression. Preliminary analysis showed that the variance of data was significantly different from standard deviation which refers to over-dispersion characteristic of Poisson regression. Therefore, negative binomial was favored over Poisson regression as NB regression relaxes the strict requirement of variance being equal to standard deviation. The negative binomial regression is basically the extension of Poisson regression which includes gamma distribution error term.

To further explore the best model occur between Poisson regression (PR) and negative binomial (NB), another statistical test was carried out and general guidelines provided by Washington et al (2003) were used. Both over dispersion parameter α and Voung Statistic were calculated to select the most appropriate model (Table 3.3).

Table 3.3: t Statistics of the NB Over Dispersion Parameter

<table>
<tr><td></td><td></td><td colspan="2">t Statistic of NB Over dispersion Parameter α</td></tr>
<tr><td></td><td></td><td><| 1.96 |</td><td>>|1.96|</td></tr>
<tr><td rowspan="2">Vuong Statistic for ZINB and NB Comparison</td><td>< - 1.96</td><td>ZIP or Poisson as alternate to NB</td><td>NB</td></tr>
<tr><td>> 1.96</td><td>ZIP</td><td>ZINB</td></tr>
</table>

After running the negative binomial regression we got over dispersion parameter α as 3.709 which is significantly greater than 0 (>1.96). This again justifies the appropriateness for using NB rather than Poisson regression to estimate the model coefficients. For estimating which model was more suitable between NB and ZINB, Vuong Statistic was then compared. After analyzing data set with ZINB, we got Voung statistics value of 1.4 which eventually suggested that the test was inconclusive. Therefore, there was no statistical support to select ZINB model over standard NB model. So, the final regression model which we selected for our analysis was negative binomial.

To understand Poisson regression for crash frequency analysis, we need to consider a set of "i" road segments. Let us consider n_{ij}, the number of road crashes as random variable for claiming count during any period "j".

$$P(n_{ij}) = \frac{e(-\lambda)\lambda i^{ni}}{ni!} \tag{1}$$

where P(nij) represents the probability of *n* crashes occurring on segments *i* in the period *j* and λij is the expected crash frequency of roadway segment n_{ij} with mean and variance.

$$E(n_{ij}) = Var(n_{ij}) = \lambda ij \tag{2}$$

λij is a explanatory variables function which is expressed by using a log-linear function.

$$\lambda_{ij} = e^{(\beta X ij)} \tag{3}$$

Here β stands for vector term of unknown regression coefficients and can be evaluated by standard maximum likelihood methods (Greene, 1997). X_i represents highway segment geometric features (explanatory variables) and other relevant roadside furniture for highway segment *i* in period *j*. To relieve the non- negativity constraint of accident prediction, an exponential rate function $e\,(\beta X_{ij})$ is assumed here.

Under Poisson regression, λ_{ij} is assumed to be homogenous or constant within the segments. However, if variance is over or under dispersed relative to mean then crashes probability cannot be estimated through Poisson regression. Therefore, Greene in 1992 presented negative binomial regression which is an extension of Poisson regression. It facilitates variance to be different from mean of the dependent variable. So, the formulation of negative binomial model can be achieved by rewriting Equation 2 such that,

$$\lambda_{ij} = e^{(\beta X_{ij} + \varepsilon_{ij})} \tag{4}$$

where $e^{(\varepsilon_{ij})}$ is a Gamma-distribution error term which allows variance to exceed the mean. This gamma distribution has mean equals to 1 and variance as α. The negative binomial regression has the following formulation where Γ stands for gamma function:

$$\mathrm{P}(nij) = \frac{\Gamma\left(\frac{1}{\alpha} + nij\right)}{\Gamma\left(\frac{1}{\alpha}\right) nij!} \left[\frac{\left(\frac{1}{\alpha}\right)}{\left(\frac{1}{\alpha} + \lambda ij\right)}\right]^{1/\alpha} \left[\frac{\lambda ij}{\left(\frac{1}{\alpha} + \lambda ij\right)}\right]^{nij} \dots \tag{5}$$

Standard likelihood functions can be used to estimate λ_{ij} (Greene, 1997). By using the Equation 4, the negative binomial standard likelihood function is:

$$\mathrm{L}(\lambda ij) = \prod_i \frac{\Gamma\left(\frac{1}{\alpha} + nij\right)}{\Gamma\left(\frac{1}{\alpha}\right) nij!} \left[\frac{\left(\frac{1}{\alpha}\right)}{\left(\frac{1}{\alpha} + \lambda ij\right)}\right]^{1/\alpha} \left[\frac{\lambda ij}{\left(\frac{1}{\alpha} + \lambda ij\right)}\right]^{nij} \tag{6}$$

The over dispersion parameter α guide us about the choice of selecting negative binomial relative to Poisson regression. Negative binomial facilitates the variance to exceed the mean. If the over dispersion parameter valus isn’t appreciably different from zero, the negative binomial expression reduces to the Poisson regression.

CHAPTER 4. MODEL ESTIMATION RESULTS AND DISCUSSION

Crash prediction model results revealed that our findings are consistent with previous studies. Past studies helped us to figure out that the traditional linear regression isn't appropriate approach for estimating a crash frequency model. Therefore, Poisson and negative binomial regression is more suitable technique for modeling crash frequencies. The final decision of selecting negative binomial was based upon over dispersion parameter and Voung's statistics and two models were estimated. In preliminary model all those variables that are important (as per basic intuition) were retained. In the final model only those variables that are significant at 95% level of confidence were retained. The details of these models are provided in Table 4.1 and Table 4.2.

Table 4.1: Model Estimation Results – Preliminary Model

Variables description	Estimated Coefficient	t-Stat	p Value
Response Variable: Total number of road traffic crashes			
Constant	-18.03	-4.02	0.0001
% of Single unit truck on a particular road segment	0.20	3.35	0.0008
Lane width (meters)	3.14	3.10	0.0019
Number of lanes of a particular road segment	0.97	2.86	0.0042
Road segment length (kilometres)	0.29	2.72	0.0064
Number of side access in a particular road segment	0.07	2.26	0.0234
Area type indicator variable (1 if road segment is in urban area, 0 otherwise)	0.71	1.58	0.1134
Speed limit (kilometer per hour)	0.01	1.22	0.2207
Number of U-turns in a particular road segment	0.09	1.05	0.2916
Over dispersion parameter (α)	0.51	3.709	0.0002

Table 4.2: Model Estimation Results – Final Model

Variables description	Estimated Coefficient	t-Stat	p Value
Response Variable: Total number of road traffic crashes			
Constant	-19.85	-4.59	0.0000
Road segment length (kilometres)	0.45	4.50	0.0000
Lane width (meters)	4.12	4.08	0.0000
% of Single unit truck on a particular road segment	0.21	3.51	0.0004
Number of lanes of a particular road segment	0.99	2.79	0.0052
Area type indicator variable (1 if road segment is in urban area, 0 otherwise)	0.43	2.61	0.0090
Over dispersion parameter (α)	0.62	3.97	0.0001

The segment length variable has a significant impact on crash frequency as indicated by highest t-stat value in the model (t – stat = 4.50). Model estimation results show that longer segments are associated with higher number of road traffic crashes as compared to shorter ones. Our finding is consistent with the past research (Milton and Mannering, 1996) which states that more distance travelled is in actual measure of exposure to traffic and other roadside obstacles. The lengthy sections with uniform roadway cross section not only contain more number of U- turns, access points and horizontal curves but also they tempt drivers to exceed speed limits.

Another geometric feature which is considered to have significant influence on crash frequency is lane width (t – stat = 4.08). More crashes are observed on wider lane widths than on narrow lanes. Different researches have different outcomes when incorporating lane width variable in their analysis. Our model results are consistent with past study of Milton and Mannering (1996) which states that wider lane width has a tendency to increase crashes for highways. Although increased lane width always comforts driver in terms of openness, decision time, sufficient sight distance and safety against side swap collisions but results show that if lane width is increased from a standard value, the people would expect to drive fast. Another possible reason is that the wider lane width allows accompanying vehicles to enter in the lanes of ongoing vehicles.

If we provide a narrow lane width, the driver would remain conscious of it and try to reduce his speed to travel safely. However this finding is inconsistent with the research carried out by Griffin and Mak (1987), who estimated an indirect relation of lane width on crash frequency.

Analysis revealed that the segments having high single unit truck percentage record more crashes (t – stat = 3.51). This finding is inconsistent with previous studies (Miaou, 1994; Milton and Mannering, 1996). They estimated a decreased crash rate with an increase in percentage of single unit truck and supported their conclusion by briefing the reason that single unit trucks reduce other vehicle's ability of overtaking and frequent lane changes. But this may be applicable to a partial restricted facility since truck travel characteristics are different in different countries, therefore this particular situation cannot be valid everywhere. Hence, increase in truck percentage can increase crash rate. Due to lack of traffic surveillance regulations, the trucks who are supposed to travel in extreme left lanes may suddenly over take vehicle from the wrong direction. The vehicle driver who is driving at his own passion cannot judge it within limited time and may result into a crash. Moreover, the average travelling speed of 2 axle and 3 axle single unit trucks is 50 kilometer per hour and to overtake them vehicles try to travel with comparatively high speed. This causes an increase in side swipe collisions if passing maneuvers are not made with appropriate judgment of the gap.

The explanatory variable for the number of lanes has a significant influence on crash rate as indicated by estimated model parameter (t – stat = 2.79). This intuition is consistent with past studies (Milton and Mannering ,1996; Kononov et al., 2008). They indicated that the increase in number of lane, tends to increase traffic volume within a particular road segment which further expedite the phenomenon of frequent lane changing. However, many explanations are possible for this intuition. This most likely due to the fact that increased number of lanes facilitates more traffic volume to travel on roadway which enhances vehicle-vehicle collisions. Another good reason is when you eases drivers with many number of lanes, they will try to travel at much higher speed and you cannot restrict them from changing lane which act as a major conflict between vehicle overtaking and decision time. On contrary, this finding is inconsistent with study carried out by Lee and Mannering (2002). They estimated an indirect relation of crashes with number of lanes and predicted that as the number of lanes increases, they provide driver less chance to leave the highway whereas less number of lanes reduce the sight distance. The reason for reduced sight distance is the presence of a heavy vehicle or a slow moving vehicle, or any other right-turning vehicle at intersections.

Model results revealed that more crashes are reported in urban areas than in rural areas as indicated by significant t-stat value (t – stat = 2.61). This finding is consistent with the past research (Milton and Mannering, 1996).The urban area facilitates more exposure to intercity traffic because of highly congested urbanization thereby increases the chances of conflict between high speed vehicles and pedestrians movement. This may be attributed to the fact that comparatively more number of U-turns are provided in urban territories for surrounding city movement which results in more fatal pedestrian collisions. Another probable reason is the provision of uncontrolled pedestrians' access which facilitates unrestrained entrance of invaders on travelled way. However, this finding is inconsistent with the study carried out by Zeeger et. al. (2001). They estimated a high crash rate associated with rural areas rather than urban areas. They justified it with the fact that the driver traveling through rural area is expected to drive fast due to less exposure to traffic and minor pedestrian's interventions which in turns increase the rural high speed crash rate. Therefore, area type is a parameter which strongly needs to be correlated with posted speed whenever estimated.

Past studies have revealed that speed limit is significantly associated with road crash frequency (Garber et al. 2000, Malyshkina and Mannering, 2007, Zeeger et al., 2001). Model results revealed that speed limit is associated with crash frequency but are not significant at 95% level of confidence (t – stat = 1.22). Although the variable is not significant but was retained being an important one. The increase in speed always has a tendency to increase road accidents. At high speed driver has less time to see and judge an obstacle in front of him thereby reducing his ability to take reaction decision against it. An extra time is needed to stop vehicle from crashing which cannot be possible at high speed. Secondly at high speeds, driver error is highlighted and the price of crash in more sever in terms of monetary and life loss. Due to severe collisions at high speed, there is great transfer of energy to the inhabitants, resulting in more severe injuries. However, speed limit is a variable which is highly correlated with area type and terrain type and should not be evaluated separately.

Another insignificant variable which is retained in our preliminary model due to it's importance is the number of access points per unit length within a road segment (t – stat = 2.26). The analysis suggests that multiple access points within a roadway segment can badly affect crash rate and is consistent with past research (Zeeger et. al. (2001). In a high access controlled facility, if we remain successful in reducing conflicts with pedestrians/other vehicles, we can never avoid injuries associated with high speeds. This is a direct intuition which derives from the phenomenon of reduced accessibility and increased mobility. On contrary, if we increase accessibility, it will allow errant vehicles to enter in main stream without yielding and may contribute to most of the side swipe collision. Moreover, if the pedestrian movement on both sides of a road isn't restricted by any fence or barrier, it will facilitate any trespasser/pedestrian to enter into the roadway.

U-turns being less significant at 95% level of confidence (t – stat = 1.05) is reserved in our preliminary model because they always constitute a major safety concern and has positive correlation with crash rate. This finding is again consistent with past researches which state that median openings and U-turns should be reduced when there is more traffic volume and built-up area on both peripheries of the road (Cribbins et al. 1968). The U-turns are normally provided at those sections which are mostly in urban areas for crossing vehicles and facilitating vehicle self-regulation. The high crash rate may be attributed to insufficient storage length, absence of auxiliary lanes and high taper rate.

CHAPTER 5. CONCLUSIONS AND RECOMENDATIONS

5.1 Synopsis of the Research

This research addressed the issue of high traffic crash rate in Pakistan due to deficiencies in roadway geometric design. It started with an extensive literature review of roadway geometrics features associated with road traffic crash frequency both at national and international level. The review of past international research efforts helped to identify the procedures adopted in different countries for establishing the relationship between road traffic crash frequency and different geometric features. For estimation of appropriate statistical model, past 5-years data (2009-2013) from 280 Km of national highway system of Pakistan (N-5) (Grand Trunk road from Rawalpindi to Lahore) on roadway geometric features and traffic crashes were collected from NHA and NH&MP. Road segments were generated on the basis of constant or uniform roadway cross sections and different statistics were drawn to understand accident pattern on N-5. A comprehensive excel data sheet was developed for collation of all geometric attributes for analysis. Similarly road crash data (accidents data) obtained from NH&MP were collated and recorded for predefined segments according to running distance. Numbers of crash frequency models were tried and negative binomial model was selected based on different statistical tests. Model results revealed that lane width, number of U-turns, posted speed limit, lanes number, number of access points of highway segment, percentage of single unit truck in traffic stream, and urban area (highway segment is located in urban area) are the geometric features that are significantly associated with road crash frequency. Comparative analysis and appropriate statistical tests revealed that negative binomial regression model is superior as compared to, Poisson regression models and zero inflated negative binomial and zero inflated Poisson regression models.

5.2 Conclusions

This research represents an attempt to explore an empirical relationship between road traffic crash frequency and roadway geometric features. The study results revealed that crash frequency is significantly associated with segment length, lane width, number of U-turns, posted speed limit, lanes number, number of access points of highway segment, percentage of single unit truck in traffic stream, and urban area (highway segment is located in urban area). Also, it was revealed that negative binomial regression provided good fit due to its desirable statistical properties in describing road traffic crash frequency.

5.3 Recommendations & Directions for Future Research

The purpose of this study was to identify the important geometric characteristics that are associated with road traffic crashes and provide a platform for National Highway Agencies and traffic organizations like NH&MP and Road Safety Institute to initiate suitable road safety counter measures. Study shall also aid highway design engineers to evaluate accident prone locations on the basis of crashes due to geometric deficiencies. Single unit truck cannot be restricted on highways however; by with appropriate enforcement of segments with high percentage of single unit trucks number of crashes can be reduced. The standard lane width for high-type highways is 3.6m (AASHTO, 2004). Crashes can be minimized ensuring that lane width is not exceeded this limit. Highway should have the appropriate number of lanes, and capacity expansion should be carried out after establishing the need based on actual traffic volume. Also, it is recommended that urban areas should have higher enforcement level compared to rural areas, since due to pedestrian and other slow movement activity; these areas have higher risk of exposure to crashes. It is recommended that at national level a comprehensive study be carried out using data from number of highways and incorporating more geometric variables such as vertical curve details, pavement condition data (rutting, pavement condition rating (PCR) and international roughness index (IRI)) and roadside elements (utility poles, sign boards).

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APPENDIX

Appendix A: Motor vehicle Registered in Pakistan

Years	Motor Cars & Jeeps	Motor Cabs /Taxis	Buses/Mini Buses	Trucks	Motorcycles	Rickshaws & Qingchi	Others	Total
2002	1,279,362	90,077	155,555	169,274	2,341,051	120,569	814,239	4,970,127
2003	1,289,854	90,424	165,846	177,478	2,379,260	127,360	834,424	5,064,646
2004	1,298,353	90,460	166,136	179,727	2,609,442	138,153	848,688	5,330,959
2005	1,318,488	91,893	168,713	182,516	2,649,910	101,058	861,851	5,374,429
2006	1,372,191	105,373	175,589	189,950	2,757,842	136,394	896,014	5,633,353
2007	1,440,801	103,397	184,368	199,447	2,895,734	143,215	940,851	5,907,813
2008	1,549,854	104,431	187,367	202,574	3,039,815	156,068	961,646	6,201,755
2009	1,657,860	106,463	195,163	210,944	3,215,583	167,910	1,005,441	6,559,364
2010	1,726,347	122,882	198,790	216,119	4,305,121	201,827	1,081,916	7,853,002
2011	1,826,090	123,446	201,167	223,152	5,321,066	239,152	1,146,364	9,080,437

Source: Provincial excise and Taxation Department Punjab, Sindh, NWFP, Balochistan, AJK and Northern Areas

Appendix B: Crash Statistics by Province, 2001- 2010

		No. of Accidents				No. of Causalities (persons)		
Province	Year	Fatal	Non-fatal	Others	Total	Killed	Injured	Total
PUNJAB	2001	2,629	3,042	0	5,671	3,272	7,214	10,486
	2002	2,565	2,712	0	5,277	3,124	6,387	9,511
	2003	2,344	2,709	0	5,053	2,806	6,300	9,106
	2004	2,460	2,745	0	5,205	3,088	6,629	9,717
	2005	2,275	2,567	0	4,842	2,732	5,758	8,490
	2006	2,170	2,552	0	4,722	2,669	5,825	8,494
	2007	2,909	2,796	0	5,705	3,315	6,508	9,823
	2008	2,609	2,713	0	5,322	3,141	5,688	8,829
	2009	2,445	2,733	0	5,178	2,866	5,820	8,686
	2010	2,691	2,886	0	5,577	3,260	6,061	9,321
Average Crashes		2,510	2,746	0	5,255	3,027	6,219	6,246
KHYBER PAKHTUNKHWA	2001	659	1,839	0	2,498	709	3,006	3,715
	2002	649	1,854	0	2,503	746	2,795	3,541
	2003	613	1,973	0	2,586	832	3,235	4,067
	2004	706	2,005	0	2,711	891	4,012	4,903
	2005	476	1,999	0	2,475	867	4,063	4,930
	2006	818	2,100	0	2,918	898	4,261	5,159
	2007	775	2,106	0	2,881	917	4,079	4,996
	2008	733	1,943	0	2,676	913	3,396	4,309
	2009	658	1,667	0	2,325	786	3,287	4,073
	2010	817	1,915	0	2,732	966	3,976	4,942
Average Crashes		690	1,940	0	2,631	853	3,611	4,464
SINDH	2001	984	894	115	1,993	1,079	1,640	2,719
	2002	904	693	99	1,696	976	1,236	2,212
	2003	885	673	113	1,671	976	1,310	2,286
	2004	861	618	109	1,588	943	1,334	2,277
	2005	835	611	106	1,552	920	1,217	2,137
	2006	835	631	80	1,546	943	1,312	2,255
	2007	783	507	107	1,397	872	1,159	2,031
	2008	787	549	74	1,409	900	1,240	2,140
	2009	736	436	99	1,271	832	1,093	1,925
	2010	738	466	68	1,273	858	1,168	2,026
Average Crashes		825	608	97	1,540	930	1,271	2,201
BALOCHISTAN	2001	43	134	2	179	44	214	258
	2002	55	129	1	185	67	240	307
	2003	64	145	1	210	67	216	283
	2004	56	142	0	198	59	247	306
	2005	88	108	0	196	97	179	276
	2006	64	143	0	207	68	229	297
	2007	79	123	0	202	43	269	312
	2008	87	131	1	218	105	216	321
	2009	90	120	0	210	44	278	322
	2010	98	128	1	226	108	223	331
Average Crashes		72	130	1	203	70	231	301

(NTRC, 2011)

Appendix C. Traffic Crashes Record, 1981- 2012

Year	Total number of accidents	Accidents		Persons		Vehicle Km travelled (Million)
		Fatal	Non-fatal	Killed	Injured	
1981	11,317	3,571	7,746	4,167	10,310	8,979
1982	11,454	3,646	7,808	4,371	10,469	10,019
1983	12,735	3,745	8,990	4,337	11,049	11,118
1984	11,923	4,070	7,853	4,721	12,307	13,310
1985	10,953	4,017	6,936	4,769	12,591	15,016
1986	11,404	4,302	7,102	5,121	13,553	16,725
1987	13,550	4,468	9,082	5,191	13,936	17,916
1988	12,950	4,493	8,457	5,276	13,283	19,333
1989	14,445	4,373	10,072	5,284	13,274	21,204
1990	13,571	4,066	9,505	4,807	12,258	22,985
1991	18,275	6,591	11,684	5,162	12,795	24,622
1992	14,804	5,841	8,963	5,244	12,360	28,564
1993	15,405	6,550	8,855	5,594	13,183	31,394
1994	15,274	6,188	9,086	5,416	12,307	33,541
1995	13,222	5,556	7,666	5,684	11,491	35,374
1996	9,974	4,347	5,627	5,424	11,319	35,374
1997	9,610	4,191	5,419	5,027	11,149	37,781
1998	9,663	4,041	5,622	4,858	11,597	39,965
1999	10,080	4,340	5,740	5,240	11,413	43,726
2000	9,735	4,193	5,542	5,130	11,469	48,023
2001	10,651	4,491	6,160	5,532	13,307	53,605
2002	10,033	4,379	5,654	5,248	11,922	54,674
2003	9,377	4,045	5,332	4,813	10,643	61,872
2004	10,308	4,184	6,124	5,199	12,927	66,491
2005	9,896	4,250	5,646	5,112	12,401	70,407
2006	9,492	4,115	5,377	4,868	11,415	82,470
2007	10,466	4,535	5,931	5,465	12,875	93,867
2008	10,466	4,610	5,856	5,615	12,096	103,353
2009	9,496	4,145	5,351	4,907	11,037	109,584
2010	9,747	4,378	5,369	5,280	11,173	115,087
2011	9,723	4,280	5,443	5,271	11,383	121,575
2012	9,987	4,348	5,639	5,323	11,475	127,007

(SIP, 2012 Page 100; NTRC, 2003 Page 12-13)

Appendix D: Data Sheet for Segments Generated for N-5

RESPONSE VARIABLE		EXPLANATORY VARIABLE																														
		Geometrics Characteristics																											Traffic Characteristics			
		Section Identifiers				Location Variables			Cross Section Related							Access			Horizontal Curvature													
																			Curve 1													
Acci. Freq	Segment ID	Beginning Adjusted Route Milepost (1540)	Beginning Milepost	Ending Milepost	Road segment length in Km	median type	City	Urban/Rural	no of lanes	lane width	Road Segment width	L.shoulder Width	R. shoulder Width	Median width	no of u-turns	No of Side Access	No of Intersections	no of bridges	No of Hor. Curve in Selected Segment	Type of Curve	Point of Intersection	Tangent length	Radius R	Curve Length (L)	Central Angle of Curve (Δ)	Degree of Curve (Da)	Degree of Curve(Dc)	Direction of Curve	Speed	ADT	Single unit truck %	4-Axle, 5-Axle & 6-Axle
0	S1	1.0	1540	1539	1.00	grass	Rawalpindi	Urban	3	3.6	11.0	2	0.6	3	0	0	2	0	1	Simple	1538785.449		569	306.79	30.526	1.0024	1.0024	LEFT	70	13,372	11	1.63
0	S2	1.35	1539.0	1538.7	0.35	grass		Urban	3	3.6	11.0	2	0.6	1	0	1	0	0											70	13,372	11	1.63
1	S3	1.8	1538.7	1538.2	0.48	grass		Urban	3	3.6	11.0	2	0.6	1	0	0	1	0	4	Reverse	1538057.200	386.277	744	660.43	50.502	0.4611	0.4611	RIGHT	70	13,372	11	1.63
1	S4	2.8	1538.2	1537.2	1.00	barrier		Urban	3	3.6	11.0	2	0.6	0.6	0	1	0	1	3	Reverse	1537151.850	375.228	73	34.948	27.262	7.5106	7.5128	LEFT	70	13,372	11	1.63
0	S5	3.1	1537.2	1536.9	0.29	grass		Urban	3	3.6	11.0	2	0.6	1	0	0	0	0											70	13,372	11	1.63
0	S6	4.0	1536.9	1536.0	0.91	grass		Urban	3	3.6	11.0	2	0.6	2	1	0	0	0	1	Simple	1535026.218		1146	416.43	20.493	0.3	0.3	RIGHT	70	13,372	11	1.63
1	S7	4.3	1536.0	1535.7	0.29	barrier		Urban	3	3.6	11.0	2	0.6	0.6	1	0	0	0	1	Simple	1534144.906		229	154.74	38.433	2.301	2.301	LEFT	70	13,372	11	1.63
0	S8	4.7	1535.7	1535.3	0.37	grass		Urban	3	3.6	11.0	2	0.6	2	1	0	0	0	1	Simple	1533865.714		572	122.7	12.166	1.0004	1.0004	LEFT	70	13,372	11	1.63
0	S9	5.3	1535.3	1534.7	0.64	grass		Urban	3	3.6	11.0	2	0.6	2	0	0	0	0	2	Reverse	1533023.649	286.797	458	253.32	31.416	1.1505	1.1505	RIGHT	70	13,372	11	1.63
0	S10	5.6	1534.7	1534.4	0.27	barrier		Urban	3	3.6	11.0	2	0.6	0.6	0	1	0	0											70	13,372	11	1.63
2	S11	6.1	1534.4	1533.9	0.50	grass		Urban	3	3.6	11.0	2	0.6	1	0	0	0	0	1	Simple	1532277.161		229	106.63	26.411	2.301	2.301	LEFT	70	13,372	11	1.63
3	S12	6.4	1533.9	1533.6	0.26	grass		Urban	3	3.6	11.0	2	0.6	5	0	0	0	0	1	Simple	1531718.56		286	263.87	52.495	2.0008	2.0008	RIGHT	70	13,372	11	1.63
2	S13	7.3	1533.6	1532.7	0.95	barrier		Urban	2	3.3	4.0	2	0.6	0.6	1	0	0	2	1	Simple	1530903.263		3434	205.84	3.2604	0.1001	0.1001	RIGHT	70	13,372	11	1.63
0	S14	7.6	1532.7	1532.4	0.26	grass	Islamabad	Urban	2	3.3	4.0	2	0.6	7.6	2	15	0	0	1	Simple	1530361.333		343	63.353	10.341	1.4006	1.4007	LEFT	70	13,372	11	1.63
1	S15	8.1	1532.4	1531.9	0.51	grass		Urban	2	3.8	7.5	2	0.6	5	0	0	0	0	1	Simple	1529723.313		286	182.78	36.354	2.0008	2.0008	LEFT	70	13,372	11	1.63
5	S16	9.3	1531.9	1530.7	1.22	grass		Urban	2	3.6	7.2	2	0.6	6	2	3	0	0	1	Simple	1528371.794		438	41.098	5.2241	1.1831	1.1831	LEFT	70	13,372	11	1.63
2	S17	10.7	1530.7	1529.3	1.38	grass		Urban	2	3.3	6.6	2	0.6	8	0	1	0	0	1	Simple	1527967.576		482	375.75	44.42	1.1123	1.1123	RIGHT	70	13,372	11	1.63
0	S18	11.4	1529.3	1528.6	0.76	grass		Urban	2	3.6	7.0	2	0.6	13	0	1	0	0	1	Simple	1526978.298		613	315.25	29.28	0.5605	0.5605	LEFT	70	13,372	11	1.63
0	S19	12.2	1528.6	1527.9	0.71	grass		Urban	2	3.6	7.0	2	0.6	11	1	0	0	0	1	Simple	1526421.870		1459	256.22	10.033	0.2333	0.2333	RIGHT	70	13,372	11	1.63
0	S20	12.6	1527.9	1527.4	0.49	grass		Urban	2	3.6	7.0	2	0.6	20	0	1	0	0	1	Simple	1525556.971		1459	552.37	21.411	0.2333	0.2333	LEFT	70	13,372	11	1.63
0	S21	14.3	1527.4	1525.7	1.65	grass		Urban	2	3.3	6.0	2	0.6	4	2	2	0	0											70	13,372	11	1.63
0	S22	14.4	1525.7	1525.6	0.11	Paved Median		Urban	2	3.3	6.0	2	0.6	0.6	0	0	0	0	1	Simple	1523586.930		438	257.45	33.413	1.1831	1.1831	RIGHT	70	13,372	11	1.63
0	S23	14.7	1525.6	1525.3	0.33	grass		Urban	2	3.3	6.0	3	0.6	2.5	0	0	0	0	1	Simple	1523164.127		511	242.02	27.085	1.0718	1.0718	LEFT	70	13,372	11	1.63
6	S24	15.8	1525.3	1524.2	1.06	grass		Urban	2	3.6	7.0	1.5	0.6	6	0	0	0	0	1	Simple	1522338.34		1168	302.85	14.514	0.2927	0.2927	RIGHT	70	13,372	11	1.63
4	S25	17.6	1524.2	1522.4	1.81	grass		Urban	2	3.6	7.0	1.5	0.6	5	3	1	0	0											70	13,372	11	1.63
2	S26	18.3	1522.4	1521.7	0.73	grass	Rawat	Urban	2	3.6	7.0	1.5	0.6	7	1	1	0	0	1	Simple	1520163.302		365	257.26	40.235	1.3413	1.3413	RIGHT	70	13,372	11	1.63
2	S27	20.6	1521.7	1519.4	2.32	grass		Rural	2	3.6	7.0	1.5	0.6	8	2	3	0	0	1	Simple	1519286.15		1751	480.94	15.44	0.1938	0.1938	RIGHT	100	13,372	11	1.63
1	S28	21.3	1519.4	1518.7	0.69	grass		Rural	2	3.6	7.0	1.5	0.6	7	1	1	0	0	1	Simple	1516837.056		467	415.14	50.555	1.1337	1.1337	LEFT	100	13,372	11	1.63
5	S29	23.3	1518.7	1516.7	1.94	grass		Rural	2	3.6	7.0	1.5	0.6	4	1	3	0	0											100	13,372	11	1.63
0	S30	24.3	1516.7	1515.8	0.97	grass		Rural	2	3.6	7.0	1.5	0.6	5	1	0	0	0	1	Simple	1514066.356		949	444.31	26.501	0.3614	0.3614	RIGHT	100	13,372	11	1.63
0	S31	24.9	1515.8	1515.1	0.65	grass		Rural	2	3.6	7.0	1.5	0.6	14	1	0	0	0											100	13,372	11	1.63
3	S32	26.9	1515.1	1513.1	2	grass		Rural	2	3.6	7.0	1.5	0.6	7	3	3	0	1	1	Simple	1511976.284		1824	1428.7	44.521	0.1851	0.1851	RIGHT	100	13,372	11	1.63
4	S33	28.6	1513.1	1511.4	1.7	grass		Rural	2	3.6	7.0	1.5	0.6	16	1	1	0	0	1	Simple	1510124.851		1168	520.49	25.323	0.2927	0.2927	LEFT	100	13,372	11	1.63
6	S34	30.9	1511.4	1509.1	2.34	grass		Rural	2	3.8	7.5	1.5	0.6	7	2	3	0	0	1	Simple	1507849.816		1168	455.52	22.211	0.2927	0.2927	LEFT	100	13,372	11	1.63
0	S35	31.2	1509.1	1508.8	0.25	grass		Rural	2	3.8	7.5	1.5	0.6	0.6	0	0	0	0											100	13,372	11	1.63
4	S36	33.8	1508.8	1506.2	2.62	grass		Rural	2	3.8	7.5	1.5	0.6	7	1	6	0	0	1	Simple	1504673.264		1459	253.02	9.5559	0.2333	0.2333	RIGHT	100	13,372	11	1.63
5	S37	34.6	1506.2	1505.4	0.82	grass		Rural	2	3.8	7.5	1.5	0.6	5	1	2	0	0	2	Compound	1500264.807	1230.311	3649	296.72	4.3934	0.0925	0.0925	LEFT	100	13,372	11	1.63
9	S38	38.5	1505.4	1501.5	3.88	grass	Mandra	Urban	2	3.8	7.5	1.5	0.6	7	4	10	0	0	1	Simple	1498174.852		876	209.74	13.432	0.3915	0.3915	RIGHT	70	13,372	11	1.63
4	S39	39.3	1501.5	1500.7	0.84	grass		Rural	2	3.8	7.5	1.5	0.6	8	0	0	0	0	1	Simple	1497130.021		876	268.86	17.353	0.3915	0.3915	RIGHT	100	13,372	11	1.63
2	S40	42.2	1500.7	1497.8	2.82	grass		Rural	2	3.8	7.5	1.5	0.6	7	2	7	0	0	2	Reverse	1495984.270	2607.945	438	222.54	29.072	1.1831	1.1831	LEFT	100	13,372	11	1.63
3	S41	43.2	1497.8	1496.8	1.05	grass		Rural	2	3.8	7.5	1.5	0.6	15	1	2	0	0	1	Simple	1492952.022		423	189.77	25.412	1.2113	1.2114	LEFT	100	13,372	12	1.58
3	S42	45.2	1496.8	1494.8	1.97	grass	Gujar Khan	Urban	2	3.8	7.5	1.5	0.6	7	2	6	0	0	2	Compound	1492383.055	641.061	4378	161.44	2.0645	0.0751	0.0751	RIGHT	70	13,916	12	1.58
1	S43	46.9	1494.8	1493.1	1.7	grass	Gujar Khan	Urban	2	3.8	7.5	1.5	0.6	2	2	2	0	1	1	Simple	1489737.341		438	114.8	15.012	1.1831	1.1831	LEFT	70	13,916	12	1.58
11	S44	47.7	1493.1	1492.3	0.77	barrier	Gujar Khan	Urban	2	3.8	7.5	1.5	0.6	0.6	2	15	0	0											70	13,916	12	1.58
4	S45	48.8	1492.3	1491.2	1.13	grass	Gujar Khan	Urban	2	3.8	7.5	1.5	0.6	2	0	15	0	0	1	Simple	1487485.019		7297	61.287	0.2852	0.0443	0.0443	RIGHT	70	13,916	12	1.58
8	S46	49.2	1491.2	1490.8	0.4	grass	Gujar Khan	Urban	2	3.8	7.5	1.5	0.6	5	1	15	0	0											70	13,916	12	1.58
4	S47	50.5	1490.8	1489.5	1.32	grass		Rural	2	3.8	7.5	1.5	0.6	7	2	3	0	0	1	Simple	1485548.455		1605	840.63	30.001	0.2125	0.2125	RIGHT	100	13,916	12	1.58
0	S48	51.0	1489.5	1489.0	0.48	grass		Rural	2	3.8	7.5	1.5	0.6	4	2	0	0	0											100	13,916	12	1.58
4	S49	52.1	1489.0	1487.9	1.13	grass		Rural	2	3.8	7.5	1.5	0.6	7	1	2	0	1	2	Reverse	1484207.690	540.534	730	347.46	27.165	0.4707	0.4707	LEFT	100	13,916	12	1.58
1	S50	53.0	1487.9	1487.0	0.9	grass	Bhai Khan	Rural	2	3.6	7.0	1.5	0.6	3	1	0	0	0											100	13,916	12	1.58
5	S51	56.3	1487.0	1483.8	3.23	grass	Missa	Rural	2	3.6	7.0	1.5	0.6	7	0	2	0	0	2	Compound	1481529.014	1502.690	1459	394.98	15.302	0.2333	0.2333	LEFT	100	13,916	12	1.58
0	S52	58.6	1483.8	1481.4	2.34	grass	Missa	Rural	2	3.6	7.0	1.5	0.6	8	1	2	0	0	2	Reverse	1478652.835	907.482	1605	912.55	32.341	0.2125	0.2125	RIGHT	100	13,916	12	1.58
2	S53	62.2	1481.4	1477.8	3.57	grass		Rural	2	3.6	7.0	1.5	0.6	7	2	0	0	0	6	Reverse	1477024.381	423.574	584	145.49	14.165	0.5853	0.5853	LEFT	100	13,916	12	1.58
3	S54	63.7	1477.8	1476.3	1.52	grass	Khabal Awan	Rural	2	3.6	7.0	1.5	0.6	15.5	1	3	0	1	2	Reverse	1473227.612	483.927	438	391.99	51.175	1.1831	1.1831	LEFT	100	13,916	12	1.58
1	S55	65.0	1476.3	1475.0	1.36	grass	Sohawa	Urban	2	3.6	7.0	1.5	0.6	10	2	1	0	0	2	Reverse	1471698.958	480.395	438	486.13	63.365	1.1831	1.1831	LEFT	70	12,889	12	1.58
4	S56	65.9	1475.0	1474.1	0.88	Paved Median	Sohawa	Urban	2	3.6	7.0	1.5	0.6	4	1	15	0	0	2	Reverse	1470654.437	424.645	438	103.87	13.353	1.1831	1.1831	LEFT	70	12,889	12	1.58
3	S57	67.1	1474.1	1472.9	1.16	grass	Rakha	Urban	2	3.6	7.0	1.5	0.6	3	2	2	0	0											70	12,889	13	1.41
2	S58	69.1	1472.9	1471.0	1.97	grass		Rural	2	3.6	7.0	1.5	0.6	7	1	2	0	2	4	Reverse	1468743.891	399.484	1751	268.01	8.4605	0.1938	0.1938	LEFT	100	12,889	13	1.41
2	S59	69.6	1471.0	1470.4	0.57	barrier		Rural	2	3.6	7.0	1.5	0.6	0.6	0	0	0	0											100	12,889	13	1.41
0	S60	70.6	1470.4	1469.5	0.93	mountain		Rural	2	3.6	7.0	1.5	0.6	66	0	0	0	0	5	Reverse	1466464.029	235.623	730	61.104	4.4751	0.4707	0.4707	LEFT	100	12,889	13	1.41
3	S61	71.9	1469.5	1468.1	1.35	barrier	Bakhrala	Rural	2	3.6	7.0	1.5	0.6	0.6	0	0	0	1	3	Reverse	1465196.153	199.564	365	108.64	17.034	1.3413	1.3413	LEFT	100	12,889	13	1.41
1	S62	72.7	1468.1	1467.4	0.75	open land	Dhoke	Rural	2	3.6	7.0	1.5	0.6	40	1	1	0	0	2	Reverse	1464021.823	554.948	1168	191.84	9.245	0.2927	0.2927	LEFT	100	12,889	13	1.41
0	S63	73.0	1467.4	1467.0	0.39	grass		Rural	2	3.6	7.0	1.5	0.6	11	0	1	0	0											100	12,889	13	1.41
6	S64	73.5	1467.0	1466.6	0.41	grass	Tarraki	Rural	2	3.6	7.0	1.5	0.6	23	1	0	0	0	1	Simple	14626048.020		846	801.57	54.152	0.4037	0.4037	LEFT	100	12,889	13	1.41
4	S65	74.2	1466.6	1465.8	0.73	grass		Rural	2	3.6	7.0	1.5	0.6	9	1	0	0	0	1	Simple	1462003.479		438	131.51	17.124	1.1831	1.1831	RIGHT	100	12,889	13	1.41
1	S66	75.1	1465.8	1464.9	0.89	grass		Rural	2	3.6	7.0	1.5	0.6	16	0	0	0	1	2	Compound	1461519.498	445.666	730	254.48	19.585	0.4707	0.4707	RIGHT	100	12,889	13	1.41
0	S67	75.7	1464.9	1464.4	0.58	barrier		Rural	2	3.6	7.0	1.5	0.6	0.6	1	0	0	0	1	Simple	1460339.965		161	411.26	146.46	3.3408	3.341	LEFT	100	12,889	13	1.41
3	S68	76.4	1464.4	1463.6	0.75	grass		Rural	2	3.6	7.0	1.5	0.6	25	2	0	0	0	1	Simple	1460344.088		438	174.7	22.514	1.1831	1.1831	RIGHT	100	12,889	13	1.41
1	S69	76.9	1463.6	1463.1	0.5	grass		Rural	2	3.6	7.0	1.5	0.6	28	0	1	0	0	2	Reverse	1459561.888	454.232	365	301	47.156	1.3413	1.3413	LEFT	100	12,889	13	1.41
0	S70	78.6	1463.1	1461.4	1.7	open land		Rural	2	3.6	7.0	1.5	0.6	62	1	0	0	0	2	Compound	1458487.914	893.992	1314	217.01	9.2758	0.261	0.261	LEFT	100	12,889	13	1.41

Appendix **D**: Data Sheet for Segments Generated for N-5 (Continued)

RESPONSE VARIABLE		EXPLANATORY VARIABLE																														
		Geometrics Characteristics																											Traffic Characteristics			
		Section Identifiers				Location Variables			Cross Section Related							Access			Horizontal Curvature – Curve 1													
Acci. Freq	Segment ID	Beginning Adjusted Route Milepost (1540)	Beginning Milepost	Ending Milepost	Road segment length in Km	median type	City	Urban/Rural	no of lanes	lane width	Road Segment width	L.shoulder Width	R. shoulder Width	Median width	no of u-turns	No of Side Access	No of Intersections	no of bridges	No of Hor. Curve in Selected Segment	Type of Curve	Point of Intersection	Tangent length	Radius R	Curve Length (L)	Central Angle of Curve (Δ)	Degree of Curve (Da)	Degree of Curve(Dc)	Direction of Curve	Speed	ADT	Single unit truck %	4-Axle, 5-Axle & 6-Axle
2	S71	80.6	1461.4	1459.4	2	grass		Rural	2	3.6	7.0	1.5	0.6	8	0	0	0	0	3	Reverse	1456347.304	362.057	4378	39.981	0.3124	0.0751	0.0751	RIGHT	100	12,889	13	1.41
0	S72	80.9	1459.4	1459.1	0.33	grass		Rural	2	3.6	7.0	1.5	0.6	6	1	0	0	0	3	Reverse	1455391.425	177.380	2189	136.24	3.3357	0.1542	0.1542	LEFT	100	12,889	13	1.41
3	S73	81.2	1459.1	1458.8	0.27	grass		Rural	2	3.6	7.0	1.5	0.6	5	0	0	0	0											100	12,889	13	1.41
0	S74	81.5	1458.8	1458.5	0.33	grass		Rural	2	3.6	7.0	1.5	0.6	8.5	1	0	0	0	1	Simple	1454802.718		4378	246.48	3.1332	0.0751	0.0751	RIGHT	100	12,889	13	1.41
3	S75	82.4	1458.5	1457.6	0.9	grass		Rural	2	3.6	7.0	1.5	0.6	6	1	0	0	0	1	Simple	1453807.740		876	261.05	17.045	0.3915	0.3915	RIGHT	100	12,889	13	1.41
0	S76	83.2	1457.6	1456.8	0.8	grass		Rural	2	3.6	7.0	1.5	0.6	5	0	0	0	0	1	Simple	1453249.239		204	207.29	58.074	2.4815	2.4816	LEFT	100	12,889	13	1.41
1	S77	84.6	1456.8	1455.5	1.32	open land		Rural	2	3.6	7.0	1.5	0.6	150	0	0	0	0	3	Compound	1452519.647	387.304	876	315.79	20.394	0.3915	0.3915	RIGHT	100	12,889	13	1.41
1	S78	85.3	1455.5	1454.7	0.77	open land		Rural	2	3.6	7.0	1.5	0.6	77	1	0	0	0	1	Simple	1450940.842		584	427.91	41.595	0.5853	0.5853	LEFT	100	12,889	13	1.41
0	S79	86.0	1454.7	1454.0	0.71	grass		Rural	2	3.6	7.0	1.5	0.6	12	0	0	0	0	2	Compound	1450438.251	412.390	1459	197.68	7.4538	0.2333	0.2333	RIGHT	100	12,889	13	1.41
2	S80	86.7	1454.0	1453.3	0.63	grass		Rural	2	3.6	7.0	1.5	0.6	6	0	0	0	0	1	Simple	1449534.459		438	194.75	25.291	1.1831	1.1831	LEFT	100	12,889	13	1.41
0	S81	87.2	1453.3	1452.8	0.58	grass		Rural	2	3.6	7.0	1.5	0.6	5	1	0	0	0											100	12,889	13	1.41
11	S82	88.7	1452.8	1451.3	1.44	grass	Dina	Urban	2	3.6	7.0	1.5	0.6	10	3	3	0	0	2	Reverse	1448173.935	590.448	730	274.38	21.323	0.4707	0.4707	LEFT	70	12,889	13	1.41
3	S83	89.8	1451.3	1450.2	1.15	grass	Dina	Urban	2	3.6	7.0	1.5	0.6	1.5	0	15	0	0	2	Compound	1449516.855	458.697	3000	106.56	0.1128	0.1128	2.0207	LEFT	70	12,889	13	1.41
0	S84	91.5	1450.2	1448.5	1.71	grass	Dina	Urban	2	3.6	7.0	1.5	0.6	9	0	15	1	1	1	Simple	1448137.449		5000	75.512	0.0653	0.0653	0.5155	RIGHT	70	12,889	13	1.41
2	S85	92.5	1448.5	1447.5	0.93	grass		Urban	2	3.6	7.0	1.5	0.6	7	1	1	0	0	1	Simple	1446688.04		5000	107.58	0.0653	0.0653	1.1358	RIGHT	70	12,889	13	1.41
0	S86	93.0	1447.5	1447.0	0.56	grass		Urban	2	3.6	7.0	1.5	0.6	5	1	0	0	0	1	Simple	144650.297		1000	151.59	0.3423	0.3423	8.4108	LEFT	70	12,889	13	1.41
1	S87	93.3	1447.0	1446.7	0.23	grass		Urban	2	3.6	7.0	1.5	0.6	3	0	0	0	0	1	Simple	1445718.753		1000	180.25	0.3423	0.3423	10.194	RIGHT	70	12,889	13	1.41
1	S88	95.3	1446.7	1444.7	2.00	grass		Rural	2	3.6	7.0	1.5	0.6	180	1	0	0	0	1	Simple	1444681.496		5000	106.89	0.0653	0.0653	1.1329	LEFT	100	12,889	13	1.41
0	S89	96.9	1444.7	1443.2	1.59	grass		Rural	2	3.6	7.0	1.5	0.6	9	2	3	0	0	3	Compound	1443631.041	571.344	1500	420.87	0.2255	0.2255	16.043	RIGHT	100	12,889	13	1.41
0	S90	98.2	1443.2	1441.8	1.34	grass		Rural	2	3.6	7.0	1.5	0.6	28	1	0	0	1	1	Simple	1441653.731		800	280.59	0.4258	0.4258	20.055	LEFT	100	12,889	13	1.41
11	S91	101.2	1441.8	1438.8	3.05	grass		Urban	2	3.6	7.0	1.5	0.6	6	7	15	0	0	3	Compound	1440514.858	1305.091	5000	11.563	0.0653	0.0653	0.0757	LEFT	70	12,889	13	1.41
5	S92	103.6	1438.8	1436.4	2.34	grass		Urban	2	3.6	7.0	1.5	0.6	8.5	4	7	0	0	1	Simple	1436239.171		5000	8.077	0.0653	0.0653	0.0533	LEFT	70	12,889	13	1.41
1	92-1	104.0	1436.4	1436.0	0.45	grass	Jehlum	Urban	2	3.6	7.0	1.5	0.6	5	1	15	0	0	1	Simple	143563.767		200	96.319	27.354	2.5153	2.5154	RIGHT	70	14,423	13	1.41
11	S93	107.1	1436.0	1432.9	3.06	Barrier	Jehlum	Urban	2	3.6	7.0	1.5	0.6	0.6	2	7	0	1	2	Reverse	1433504.685	1139.429	1000	63.724	0.3423	0.3423	3.3904	LEFT	70	14,423	13	1.41
7	S94	109.5	1432.9	1430.5	2.45	grass		Rural	2	3.6	7.0	1.5	0.6	136	5	5	0	1	2	Compound	1431646.168	2077.719	500	341.23	1.0845	1.0845	39.061	LEFT	100	14,423	13	1.87
6	S95	111.6	1430.5	1428.4	2.1	grass	Sarai Alamgir	Urban	2	3.6	7.0	1.5	0.6	4	2	15	0	0	2	Reverse	1428326.285	631.723	200	241.13	69.045	2.5153	2.5154	RIGHT	70	14,423	13	1.87
4	S95-1	112.3	1428.4	1427.7	0.62	grass		Rural	2	3.6	7.0	1.5	0.6	4	2	2	0	0											100	14,423	13	1.87
0	S96	112.8	1427.7	1427.2	0.56	Barrier		Rural	2	3.6	7.0	1.5	0.6	0.6	0	1	0	1	2	Reverse	1426480.498	280.828	900	184	0.3812	0.3812	11.425	LEFT	100	14,423	13	1.87
0	S97	113.2	1427.2	1426.8	0.4	Paved Median		Urban	2	3.6	7.0	1.5	0.6	4	1	0	0	0	1	Simple	1425841.249		1000	56.778	0.3423	0.3423	3.1511	LEFT	70	14,423	13	1.87
0	S98	114.4	1426.8	1425.6	1.2	grass		Urban	2	3.6	7.0	1.5	0.6	7	1	0	0	0	2	Compound	1425725.864	980.946	1500	36.851	0.2255	0.2255	1.2427	LEFT	70	14,423	13	1.87
2	S99	115.1	1425.6	1424.9	0.67	grass		Rural	2	3.6	7.0	1.5	0.6	6	0	2	0	0	1	Simple	1424249.279		400	275.01	1.2557	1.2557	39.233	RIGHT	100	14,423	13	1.87
0	S100	115.7	1424.9	1424.3	0.58	grass		Rural	2	3.6	7.0	1.5	0.6	9	0	0	0	0	1	Simple	1423842.7		600	222.72	0.5718	0.5718	21.161	LEFT	100	14,423	13	1.87
0	S101	116.7	1424.3	1423.3	1.04	grass		Rural	2	3.6	7.0	1.5	0.6	10	1	1	0	0											100	14,423	13	1.87
2	S102	117.7	1423.3	1422.3	0.95	grass		Rural	2	3.6	7.0	1.5	0.6	8	2	1	0	0	1	Simple	1421815.942		5000	37.69	0.0653	0.0653	0.2555	RIGHT	100	14,423	13	1.87
0	S103	118.1	1422.3	1421.9	0.45	grass		Rural	2	3.6	7.0	1.5	0.6	20	0	0	0	0	2	Reverse	1421339.422	194.399	200	75.724	21.414	2.5153	2.5154	LEFT	100	14,423	13	1.87
2	S104	118.8	1421.9	1421.2	0.66	grass		Rural	2	3.6	7.0	1.5	0.6	6	1	1	0	0	3	Reverse	1420864.57	124.300	1000	26.869	0.3423	0.3423	1.3222	LEFT	100	14,423	13	1.87
0	S105	119.5	1421.2	1420.6	0.68	grass		Rural	2	3.6	7.0	1.5	0.6	8.5	0	0	0	0	1	Simple	1419667.009		400	47.544	1.2557	1.2557	6.4836	LEFT	100	14,423	13	1.87
0	S106	119.7	1420.6	1420.3	0.26	grass		Rural	2	3.6	7.0	1.5	0.6	5	0	0	0	0	1	Simple	1419481.658		600	100.22	0.5718	0.5718	9.3413	RIGHT	100	14,423	13	1.87
0	S107	120.3	1420.3	1419.7	0.63	grass		Rural	2	3.6	7.0	1.5	0.6	3	0	0	0	0	1	Simple	14199.924		300	163.23	1.5435	1.5436	31.103	RIGHT	100	14,423	13	1.87
0	S108	120.9	1419.7	1419.1	0.6	grass		Rural	2	3.6	7.0	1.5	0.6	5	0	0	0	0											100	14,423	13	1.87
2	S109	121.5	1419.1	1418.5	0.56	grass		Rural	2	3.6	7.0	1.5	0.6	57	0	0	0	0	3	Reverse	1418037.767	264.133	250	137.59	2.1731	2.1731	31.316	LEFT	100	14,423	13	1.87
1	S110	122.9	1418.5	1417.1	1.4	grass		Rural	2	3.6	7.0	1.5	0.6	10	2	0	0	1	1	Simple	141752.685		350	335.7	1.3813	1.3813	54.572	LEFT	100	14,423	13	1.87
0	S111	124.3	1417.1	1415.7	1.43	grass		Rural	2	3.6	7.0	1.5	0.6	24	0	2	0	0	3	Reverse	1415852.574	697.281	2000	355.62	0.1711	0.1711	10.112	LEFT	100	14,423	13	1.87
0	S111-1	125.0	1415.7	1415.0	0.64	Barrier		Rural	2	3.6	7.0	1.5	0.6	0.6	0	0	0	0											100	14,423	13	1.87
2	S112	127.5	1415.0	1412.5	2.5	Barrier	Kharian	Urban	2	3.6	7.0	1.5	0.6	0.6	0	0	0	0	1	Simple	1412774.933		800	111.17	0.4258	0.4258	7.5743	RIGHT	70	13,307	12	1.87
2	S113	129.6	1412.5	1410.4	2.13	grass		Rural	2	3.6	7.0	1.5	0.6	5.5	3	3	0	0											100	13,307	12	1.8
1	S114	130.0	1410.4	1410.0	0.37	Barrier		Urban	2	3.6	7.0	1.5	0.6	0.6	0	0	0	0	1	Simple	1409452.082		5000	18.131	0.0653	0.0653	0.1228	LEFT	70	13,307	12	1.8
5	S115	132.0	1410.0	1408.0	2.05	grass		Rural	2	3.6	7.0	1.5	0.6	5	0	4	1	0											100	13,307	12	1.8
1	S115-1	132.8	1408.0	1407.2	0.8	grass		Rural	2	3.6	7.0	1.5	0.6	3	0	1	0	0	1	Simple	1406455.235		5000	171.81	0.0653	0.0653	1.5808	LEFT	100	13,307	12	1.8
0	S115-2	133.2	1407.2	1406.8	0.42	grass		Urban	2	3.6	7.0	1.5	0.6	5	0	15	0	0											70	13,307	12	1.8
3	S116	135.4	1406.8	1404.6	2.14	grass		Rural	2	3.6	7.0	1.5	0.6	5	2	4	0	0	1	Simple	1404353.535		5000	88.807	0.0653	0.0653	1.0104	RIGHT	100	13,307	12	1.8
0	S116-1	135.8	1404.6	1404.2	0.38	grass		Urban	2	3.6	7.0	1.5	0.6	3	1	1	0	0											70	13,307	12	1.8
1	S116-2	137.4	1404.2	1402.6	1.65	grass		Rural	2	3.6	7.0	1.5	0.6	4	1	5	0	0	1	Simple	1402342.685		5000	75.624	0.0653	0.0653	0.516	LEFT	100	13,307	12	1.8
1	S116-3	138.7	1402.6	1401.3	1.26	grass		Urban	2	3.6	7.0	1.5	0.6	5	2	15	0	1	3	Reverse	1401546.43	250.528	1300	233.72	0.2627	0.2627	10.18	RIGHT	70	13,307	12	1.8
1	S116-4	140.0	1401.3	1400.0	1.32	grass		Rural	2	3.6	7.0	1.5	0.6	4	0	2	0	0	1	Simple	1399511.017		5000	37.046	0.0653	0.0653	0.2528	RIGHT	100	13,307	12	1.8
2	S117	142.6	1400.0	1397.4	2.57	Barrier	Lala Musa	Urban	2	3.6	7.0	1.5	1.5	0.6	2	15	2	0											70	13,307	12	1.8
0	S118	144.1	1397.4	1395.9	1.51	grass	Lala Musa	Urban	2	3.6	7.0	1.5	1.5	3	1	4	0	0											70	13,307	12	1.8
0	S118-1	144.8	1395.9	1395.2	0.71	grass		Rural	2	3.6	7.0	1.5	1.5	6	1	1	0	0	1	Simple	1396179.984		5000	10.998	0.0653	0.0653	0.0734	RIGHT	100	13,307	12	1.8
2	S118-2	145.1	1395.2	1394.9	0.33	grass		Urban	2	3.6	7.0	1.5	1.5	6	4	15	0	0											70	13,307	12	1.8
0	S119	146.6	1394.9	1393.4	1.49	grass		Rural	2	3.6	7.0	1.5	1.5	4	2	2	0	0	1	Simple	1393549.982		5000	39.006	0.0653	0.0653	0.2649	LEFT	100	13,307	12	1.8
1	S119-1	147.1	1393.4	1392.9	0.51	grass		Urban	2	3.6	7.0	1.5	1.5	5	2	15	0	0	1	Simple	1392388.897		5000	4.545	0.0653	0.0653	0.0307	RIGHT	70	13,307	12	1.8
0	S120	148.0	1392.9	1392.0	0.88	grass		Rural	2	3.6	7.0	1.5	1.5	3.5	1	1	0	0											100	13,307	12	1.8
1	S120-1	148.5	1392.0	1391.5	0.48	grass		Urban	2	3.6	7.0	1.5	1.5	4	1	15	0	0											70	13,307	12	1.8
0	S120-2	148.9	1391.5	1391.1	0.44	grass		Rural	2	3.6	7.0	1.5	1.5	3	1	0	0	0											100	13,307	12	1.8
3	S120-3	150.6	1391.1	1389.4	1.67	grass		Urban	2	3.6	7.0	1.5	0.6	3	3	0	0	0											70	13,307	12	1.8
0	S120-4	151.2	1389.4	1388.8	0.64	grass		Rural	2	3.6	7.0	1.5	0.6	4	0	0	0	0	1	Simple	1388691.981		5000	76.95	0.0653	0.0653	0.5254	LEFT	100	13,307	12	1.8
0	S121	151.8	1388.8	1388.2	0.56	grass		Urban	2	3.6	7.0	1.5	0.6	4	1	1	0	0											70	13,307	12	1.8
1	S122	153.5	1388.2	1386.5	1.68	grass		Rural	2	3.6	7.0	1.5	0.6	4	1	5	0	0											100	13,307	12	1.8
0	S123	155.2	1386.5	1384.9	1.69	grass		Rural	2	3.6	7.0	1.5	0.6	25	1	0	1	1	4	Reverse	1385540.004	214.704	500	143.26	1.0845	1.0845	16.246	LEFT	100	13,307	12	1.8
2	S124	156.5	1384.9	1383.5	1.31	grass		Urban	2	3.6	7.0	1.5	0.6	4	4	1	0	0	1	Simple	1383715.547		1000	113.21	0.3423	0.3423	6.291	LEFT	70	13,307	12	1.8
1	S124-1	158.2	1383.5	1381.8	1.76	grass	Gurat	Urban	2	3.6	7.0	1.5	0.6	2	4	11	0	0											70	13,397	12	1.8
7	S125	163.6	1381.8	1376.4	5.38	grass	Gurat	Urban	2	3.6	7.0	1.5	0.6	2	10	15	4	0	2	Compound	1378103.918	969.711	2000	563.05	0.1711	0.1711	16.075	RIGHT	70	13,397	13	1.8
1	S125-1	164.6	1376.4	1375.4	1.02	grass		Rural	2	3.6	7.0	1.5	0.6	2	1	0	1	0											100	13,397	13	1.26
0	S125-2	165.1	1375.4	1375.0	0.43	grass		Urban	2	3.6	7.0	1.5	0.6	2	1	3	0	0											70	13,397	13	1.26
1	S126	166.4	1375.0	1373.7	1.3	grass		Rural	2	3.6	7.0	1.5	0.6	2	4	1	0	0											100	13,397	13	1.26

Appendix **D**: Data Sheet for Segments Generated for N-5 (Continued)

RESPONSE VARIABLE		EXPLANATORY VARIABLE																														
		Geometrics Characteristics																											Traffic Characteristics			
		Section Identifiers				Location Variables			Cross Section Related							Access			Horizontal Curvature													
																			Curve 1													
Acci. Freq	Segment ID	Beginning Adjusted Route Milepost (1540)	Beginning Milepost	Ending Milepost	Road segment length in Km	median type	City	Urban/Rural	no of lanes	lane width	Road Segment width	L.shoulder Width	R. shoulder Width	Median width	no of u-turns	No of Side Access	No of Intersections	no of bridges	No of Hor. Curve in Selected Segment	Type of Curve	Point of Intersection	Tangent length	Radius R	Curve Length (L)	Central Angle of Curve (Δ)	Degree of Curve (Da)	Degree of Curve(Dc)	Direction of Curve	Speed	ADT	Single unit truck %	4-Axle, 5-Axle & 6-Axle
0	S127	167.0	1373.7	1373.0	0.61	grass		Urban	2	3.6	7.0	1.5	0.6	2	2	4	0	0											70	13,397	13	1.26
2	S128	167.7	1373.0	1372.3	0.74	grass		Rural	2	3.6	7.0	1.5	0.6	2	0	1	0	0	1	Simple	1371930.264		140	104.87	4.0533	4.0536	42.551	RIGHT	100	13,397	13	1.26
1	S129	170.7	1372.3	1369.4	2.95	grass		Rural	2	3.6	7.0	1.5	0.6	112	0	0	0	1	1	Simple	1371746.237		100	89.463	5.4346	5.4355	51.153	LEFT	100	13,397	13	1.26
0	S130	171.9	1369.4	1368.2	1.2	grass		Rural	2	3.6	7.0	1.5	0.6	56	0	0	0	0											100	13,397	13	1.26
0	S131	173.4	1368.2	1366.6	1.58	grass		Rural	2	3.6	7.0	1.5	0.6	56	0	0	0	0	3	Reverse	1369275.59		300	90.196	1.5435	1.5436	17.133	LEFT	100	13,397	13	1.26
2	S132	175.6	1366.6	1364.4	2.13	grass	Wasirabad	Urban	2	3.6	7.0	1.5	0.6	3	0	15	1	1	7	Reverse	1366569.722	76.332	600	74.1	0.5718	0.5718	7.0434	RIGHT	70	16,061	13	1.26
0	S133	177.5	1364.4	1362.5	1.94	grass	Wasirabad	Urban	2	3.6	7.0	1.5	0.6	3	3	15	0	0	1	Simple	1364327.253		800	123.03	0.4258	0.4258	8.484	RIGHT	70	16,061	13	1.26
0	S134	178.6	1362.5	1361.4	1.13	grass		Rural	2	3.6	7.0	1.5	0.6	3	1	3	1	1											100	16,061	6	1.62
0	S135	181.0	1361.4	1359.0	2.38	Paved Median		Rural	2	3.6	7.0	1.5	0.6	5	1	1	1	0	1	Simple	1360721.552		4000	30.497	0.0836	0.0836	0.2613	LEFT	100	16,061	6	1.62
0	S136	181.7	1359.0	1358.3	0.7	grass		Urban	2	3.6	7.0	1.5	0.6	5	2	15	0	0											70	16,061	6	1.62
1	S137	182.9	1358.3	1357.1	1.16	grass		Rural	2	3.8	7.5	1.5	0.6	5	1	4	0	0	1	Simple	135738.997		5000	44.82	0.0653	0.0653	0.3049	RIGHT	100	16,061	6	1.62
0	S138	183.6	1357.1	1356.4	0.74	grass		Urban	2	3.8	7.5	1.5	0.6	7	1	0	0	1											70	16,061	6	1.62
0	S139	184.7	1356.4	1355.3	1.05	grass		Rural	2	3.8	7.5	1.5	0.6	5	1	0	0	0											100	16,061	6	1.62
1	S140	185.1	1355.3	1354.9	0.44	grass		Urban	2	3.8	7.5	1.5	0.6	5	1	1	0	1											70	16,061	6	1.62
0	S141	186.2	1354.9	1353.8	1.11	grass		Rural	2	3.8	7.5	1.5	0.6	5	0	4	0	1											100	16,061	6	1.62
1	S142	186.5	1353.8	1353.5	0.32	grass		Urban	2	3.8	7.5	1.5	0.6	4	1	1	0	0											70	16,061	6	1.62
0	S143	187.1	1353.5	1352.9	0.56	Paved Median		Urban	2	3.8	7.5	1.5	0.6	1	0	0	0	0											70	16,061	6	1.62
1	S144	187.5	1352.9	1352.5	0.42	grass		Rural	2	3.8	7.5	1.5	0.6	1	0	2	0	0											100	16,061	6	1.62
1	S145	188.2	1352.5	1351.8	0.7	grass		Rural	2	3.8	7.5	1.5	0.6	4	1	1	0	0	1	Simple	1351660.46		5000	406.27	0.0653	0.0653	4.392	LEFT	100	16,061	6	1.62
0	S146	188.7	1351.8	1351.3	0.5	grass		Rural	2	3.8	7.5	1.5	0.6	3	1	2	0	0											100	16,061	6	1.62
1	S147	189.3	1351.3	1350.7	0.6	grass		Rural	2	3.8	7.5	1.5	0.6	4	1	2	0	0											100	16,061	6	1.62
4	S148	191.7	1350.7	1348.3	2.42	Paved Median	Ghakahr	Urban	2	3.8	7.5	1.5	0.6	1	5	15	0	1	1	Simple	1348381.254		3543	300.35	0.0942	0.0942	4.5125	RIGHT	70	16,061	6	1.62
1	S149	192.1	1348.3	1347.9	0.41	grass		Rural	2	3.8	7.5	1.5	0.6	4	0	2	0	0											100	16,061	7	1.62
0	S150	193.0	1347.9	1347.1	0.81	grass		Rural	2	3.8	7.5	1.5	0.6	7	1	0	0	0	1	Simple	1346743.811		1417	92.569	0.2415	0.2415	3.4432	LEFT	100	16,061	7	1.62
0	S151	193.8	1347.1	1346.2	0.84	grass		Rural	2	3.8	7.5	1.5	0.6	4	0	0	0	0											100	16,061	7	1.62
0	S152	194.3	1346.2	1345.7	0.55	grass		Urban	2	3.8	7.5	1.5	0.6	4	1	15	0	0											70	16,061	7	1.62
0	S152-1	194.6	1345.7	1345.4	0.29	grass		Rural	2	3.8	7.5	1.5	0.6	4	0	1	0	0											100	16,061	7	1.62
1	S153	195.1	1345.4	1344.9	0.51	grass		Rural	2	3.8	7.5	1.5	0.6	1	0	1	0	0											100	16,061	7	1.62
0	S154	195.8	1344.9	1344.3	0.61	Barrier		Rural	2	3.8	7.5	1.5	0.6	0.6	0	3	1	0											100	16,061	7	1.62
3	S155	197.1	1344.3	1343.0	1.3	Barrier		Urban	2	3.8	7.5	1.5	0.6	0.6	1	0	1	0											70	16,061	7	1.62
2	S156	198.0	1343.0	1342.0	0.98	grass		Urban	2	3.8	7.5	1.5	0.6	5	2	15	0	0	1	Simple	1343195.587		2835	2.186	0.1208	0.1208	0.0239	LEFT	70	16,061	7	1.62
0	S157	198.6	1342.0	1341.4	0.61	Paved Median		Rural	2	3.8	7.5	1.5	0.6	1	1	1	0	0											100	16,061	7	1.62
0	S158	201.8	1341.4	1338.2	3.12	grass	Gujranwala	Urban	3	3.6	7.5	1.5	0.6	5	2	0	1	1	1	Simple	1340178.339		2835	12.384	0.1208	0.1208	0.1501	LEFT	70	20,584	7	1.62
1	S159	205.7	1338.2	1334.4	3.89	Paved Median	Gujranwala	Urban	3	3.6	7.5	1.5	0.6	1	3	0	4	0	1	Simple	1337938.829		2835	57.048	0.1208	0.1208	1.0911	RIGHT	70	20,584	7	1.62
3	S160	209.2	1334.4	1330.8	3.57	Barrier	Gujranwala	Urban	3	3.6	7.5	1.5	0.6	0.6	0	0	0	0	7	Reverse	1337153.324	204.867	2126	122.94	0.161	0.161	3.1848	LEFT	70	20,584	7	1.62
1	S161	210.3	1330.8	1329.7	1.09	Paved Median	Gujranwala	Urban	3	3.6	7.5	1.5	0.6	1	3	0	0	0	1	Simple	1335116.373		2126	42.339	0.161	0.161	1.0828	RIGHT	70	20,584	7	1.62
2	S162	215.9	1329.7	1324.2	5.54	Paved Median	Gujranwala	Urban	3	3.6	7.5	1.5	0.6	1	5	2	4	0	5	Reverse	1334860.509	2447.119	2126	41.768	0.161	0.161	1.0733	LEFT	70	20,584	7	1.62
0	S163	216.1	1324.2	1323.9	0.24	grass	Gujranwala	Urban	3	3.6	7.5	1.5	0.6	11	0	0	0	0											70	20,584	7	1.62
0	S164	216.6	1323.9	1323.4	0.5	grass		Rural	3	3.6	7.5	1.5	0.6	7	1	3	0	0	1	Simple	1330995.081		2835	35.125	0.1208	0.1208	0.4236	LEFT	100	20,584	5	1.34
0	S165	217.5	1323.4	1322.5	0.9	Barrier		Rural	3	3.6	7.5	1.5	0.6	0.6	0	1	0	0											100	20,584	5	1.34
1	S166	218.6	1322.5	1321.4	1.15	Barrier		Rural	3	3.6	7.5	1.5	0.6	0.6	0	3	0	0	1	Simple	1329665.788		2835	27.294	0.1208	0.1208	0.3306	RIGHT	100	20,584	5	1.34
2	S167	219.8	1321.4	1320.2	1.16	Barrier	Eminabad	Urban	3	3.6	7.5	1.5	0.6	0.6	1	3	0	0											70	20,584	5	1.34
0	S168	220.9	1320.2	1319.1	1.12	Barrier		Urban	3	3.6	7.5	1.5	0.6	0.6	0	15	0	0											70	20,584	5	1.34
1	S169	221.4	1319.1	1318.6	0.48	grass		Rural	3	3.6	7.5	1.5	0.6	8	1	5	0	0											100	20,584	5	1.34
2	S170	222.7	1318.6	1317.3	1.27	Barrier		Rural	3	3.6	10.5	1.5	0.6	0.6	0	4	0	0											100	20,584	5	1.34
1	S171	223.4	1317.3	1316.6	0.74	Barrier	Chianwali	Urban	3	3.6	10.5	1.5	0.6	0.6	0	15	0	0											70	20,584	5	1.34
0	S172	223.7	1316.6	1316.3	0.31	Barrier		Rural	3	3.6	10.5	1.5	0.6	0.6	0	1	0	0	1	Simple	1323298.313		2835	18.352	0.1208	0.1208	0.2215	LEFT	100	20,584	5	1.34
1	S173	224.1	1316.3	1315.9	0.36	grass		Rural	3	3.6	10.5	1.5	0.6	7	1	1	0	0											100	20,584	5	1.34
0	S174	224.6	1315.9	1315.4	0.56	Barrier		Urban	3	3.6	10.5	1.5	0.6	0.6	0	1	0	0											70	20,584	5	1.34
2	S175	225.3	1315.4	1314.7	0.65	Barrier		Rural	3	3.6	10.5	1.5	0.6	0.6	1	1	0	0											100	20,584	5	1.34
0	S176	225.8	1314.7	1314.2	0.52	Barrier		Rural	3	3.6	10.5	1.5	0.6	0.6	0	1	0	0											100	20,584	5	1.34
0	S177	226.3	1314.2	1313.7	0.49	grass		Rural	3	3.6	10.5	1.5	0.6	7	1	0	0	0	1	Simple	1320916.367		2835	11.475	0.1208	0.1208	0.1355	LEFT	100	20,584	5	1.34
0	S178	227.3	1313.7	1312.7	1.01	Barrier		Rural	3	3.6	10.5	1.5	0.6	0.6	0	2	0	1											100	20,584	5	1.34
2	S179	231.2	1312.7	1308.8	3.9	Barrier	Kamoki	Urban	3	3.6	10.5	1.5	0.6	0.6	2	0	0	1											70	18,537	5	1.34
0	S180	231.9	1308.8	1308.1	0.68	Barrier		Rural	3	3.6	10.5	1.5	0.6	0.6	0	2	0	0	1	Simple	1315834.563		2835	7.057	0.1208	0.1208	0.0834	LEFT	100	18,537	7	1.37
1	S181	232.4	1308.1	1307.6	0.49	grass		Rural	3	3.6	10.5	1.5	0.6	8	1	2	0	0											100	18,537	7	1.37
2	S182	233.1	1307.6	1306.9	0.75	Barrier		Rural	3	3.6	10.5	1.5	0.6	0.6	0	5	0	0											100	18,537	7	1.37
0	S183	233.6	1306.9	1306.4	0.48	grass		Rural	3	3.6	10.5	1.5	0.6	8	1	0	0	0											100	18,537	7	1.37
7	S184	235.4	1306.4	1304.7	1.74	Barrier		Rural	3	3.6	10.5	1.5	0.6	0.6	0	4	0	0											100	18,537	7	1.37
0	S184-1	235.9	1304.7	1304.1	0.54	grass		Rural	3	3.6	10.5	1.5	0.6	7	1	0	0	0											100	18,537	7	1.37
0	S185	236.4	1304.1	1303.6	0.53	Barrier		Rural	3	3.6	10.5	2	0.6	0.6	0	0	0	0											100	18,537	7	1.37
1	S186	237.5	1303.6	1302.5	1.04	Barrier		Urban	3	3.6	10.5	2	0.6	0.6	0	0	1	0											70	18,537	7	1.37
0	S187	238.1	1302.5	1301.9	0.66	Barrier		Rural	3	3.6	10.5	2	0.6	0.6	0	0	0	0											100	18,537	7	1.37
0	S188	238.7	1301.9	1301.3	0.61	grass		Rural	3	3.6	10.5	2	0.6	7	1	0	0	0											100	18,537	7	1.37
0	S189	239.3	1301.3	1300.7	0.53	Barrier		Rural	3	3.6	10.5	2	0.6	0.6	0	0	0	0											100	18,537	7	1.37
2	S190	239.7	1300.7	1300.3	0.47	grass		Rural	3	3.6	10.5	2	0.6	8	1	2	0	0											100	18,537	7	1.37
0	S191	240.9	1300.3	1299.1	1.14	Barrier		Rural	3	3.6	10.5	2	0.6	0.6	0	2	0	1	1	Simple	1306921.234		2835	217.11	0.1208	0.1208	4.2318	LEFT	100	18,537	7	1.37
0	S192	241.2	1299.1	1298.8	0.3	Barrier		Urban	3	3.6	10.5	2	0.6	0.6	0	0	0	0											70	18,537	7	1.37
0	S193	241.7	1298.8	1298.4	0.48	Barrier		Rural	3	3.6	10.5	2	0.6	0.6	1	1	0	0											100	18,537	7	1.37
3	S194	244.8	1298.4	1295.2	3.13	Barrier		Rural	3	3.6	10.5	2	0.6	0.6	1	2	0	2	2	Reverse	1305303.997	2493.079	2835	332.94	0.1208	0.1208	6.4347	RIGHT	100	18,537	7	1.37
2	S195	245.4	1295.2	1294.6	0.58	grass		Rural	3	3.6	10.5	2	0.6	6	1	4	0	0											100	18,537	7	1.37
0	S196	245.8	1294.6	1294.2	0.44	Barrier		Urban	3	3.6	10.5	2	0.6	0.6	0	2	0	0											70	18,537	7	1.37
2	S197	246.1	1294.2	1293.9	0.26	Barrier		Rural	3	3.6	10.5	2	0.6	0.6	0	2	0	0											100	18,537	7	1.37
1	S198	246.6	1293.9	1293.4	0.55	grass		Rural	3	3.6	10.5	2	0.6	7	1	4	0	0											100	18,537	7	1.37
0	S199	246.9	1293.4	1293.1	0.33	Barrier		Rural	3	3.6	10.5	2	0.6	0.6	0	1	0	0											100	18,537	7	1.37

Appendix **D**:Data Sheet for Segments Generated for N-5 (Continued)

RESPONSE VARIABLE		EXPLANATORY VARIABLE																														
		Geometrics Characteristics																											Traffic Characteristics			
		Section Identifiers				Location Variables			Cross Section Related							Access			Horizontal Curvature													
																			Curve 1													
Acci. Freq	Segment ID	Beginning Adjusted Route Milepost (1540)	Beginning Milepost	Ending Milepost	Road segment length in Km	median type	City	Urban/Rural	no of lanes	lane width	Road Segment width	L.shoulder Width	R. shoulder Width	Median width	no of u-turns	No of Side Access	No of Intersections	no of bridges	No of Hor. Curve in Selected Segment	Type of Curve	Point of Intersection	Tangent length	Radius R	Curve Length (L)	Central Angle of Curve (Δ)	Degree of Curve (Da)	Degree of Curve(Dc)	Direction of Curve	Speed	ADT	Single unit truck %	4-Axle, 5-Axle & 6-Axle
7	S200	250.0	1293.1	1290.0	3.02	Barrier	Muridke	Urban	3	3.6	10.5	2	0.6	0.6	3	15	0	0	3	Reverse	1299168.072	565.547	2835	63.932	0.1208	0.1208	1.1732	RIGHT	70	18,537	7	1.37
2	S201	250.6	1290.0	1289.4	0.6	grass	Muridke	Urban	3	3.6	10.5	2	0.6	6	1	2	0	0											70	18,537	7	1.37
0	S202	250.9	1289.4	1289.1	0.38	Barrier		Rural	3	3.6	10.5	2	0.6	0.6	0	4	0	0											100	18,537	7	1.37
2	S203	251.7	1289.1	1288.4	0.71	grass		Urban	3	3.6	10.5	2	0.6	6	1	15	0	0											70	18,537	7	1.37
5	S204	252.2	1288.4	1287.8	0.55	grass		Rural	3	3.6	10.5	2	0.6	6	1	3	0	0											100	18,537	7	1.37
0	S205	253.1	1287.8	1287.0	0.85	Barrier		Urban	3	3.6	10.5	2	0.6	0.6	0	15	0	0											70	18,537	7	1.37
3	S206	253.7	1287.0	1286.4	0.6	grass	ala Shah Kak	Urban	3	3.6	10.5	2	0.6	6	1	0	0	0											70	22,362	7	1.37
1	S207	254.4	1286.4	1285.6	0.79	Barrier	ala Shah Kak	Urban	3	3.6	10.5	2	0.6	0.6	1	0	0	1											70	22,362	7	1.37
2	S208	255.4	1285.6	1284.6	0.95	grass	ala Shah Kak	Urban	3	3.6	10.5	2	0.6	6	1	1	0	0	1	Simple	1292646.541	#########	2835	124.81	0.1208	0.1208	2.3122	LEFT	70	22,362	8	1.37
3	S209	256.4	1284.6	1283.6	1.02	Barrier		Rural	3	3.6	10.5	2	0.6	0.6	0	0	0	0											100	22,362	8	1.35
2	S210	257.0	1283.6	1283.0	0.61	grass		Rural	3	3.6	10.5	2	0.6	6	1	1	0	0											100	22,362	8	1.35
4	S211	258.9	1283.0	1281.1	1.91	Barrier		Rural	3	3.6	10.5	2	0.6	0.6	0	4	0	1											100	22,362	8	1.35
2	S212	260.4	1281.1	1279.6	1.47	Barrier		Rural	3	3.6	10.5	2	0.6	0.6	1	1	0	1											100	22,362	8	1.35
0	S213	260.8	1279.6	1279.2	0.41	Barrier		Rural	3	3.6	10.5	2	0.6	1.6	1	0	0	0											100	22,362	8	1.35
5	S214	261.6	1279.2	1278.4	0.76	grass	Ferozewala	Urban	3	3.6	10.5	2	0.6	6	1	3	0	0											70	22,362	8	1.35
1	S215	263.5	1278.4	1276.5	1.96	Barrier	Ferozewala	Urban	3	3.6	10.5	2	0.6	0.6	1	0	0	3											70	22,362	8	1.35
2	S216	265.9	1276.5	1274.1	2.34	Barrier	Ferozewala	Urban	3	3.6	10.5	2	0.6	1.6	2	0	0	0											70	22,362	8	1.35
0	S217	266.7	1274.1	1273.3	0.81	Paved Median	Ferozewala	Urban	3	3.6	10.5	2	0.6	3	1	0	1	0											70	22,362	8	1.35
0	S218	267.1	1273.3	1272.9	0.38	Paved Median	Shadara	Urban	3	3.6	10.5	2	0.6	4	1	0	0	0											70	22,362	8	1.35
0	S219	269.4	1272.9	1270.7	2.29	Paved Median	Shadara	Urban	3	3.6	10.5	2	0.6	2	2	0	1	0	1	Simple	1277898.425		213	68.05	2.4142	2.4143	18.203	LEFT	70	22,362	8	1.35
5	S220	270.2	1270.7	1269.8	0.85	Paved Median	Shadara	Urban	3	3.6	10.5	2	0.6	22	0	0	0	0	4	Reverse	1277751.527	275.015	354	150.97	1.3701	1.3702	24.245	RIGHT	70	22,362	8	1.35
0	S221	270.8	1269.8	1269.2	0.56	Paved Median	Lahore	Urban	3	3.6	10.5	2	0.6	1	0	0	0	1											70	22,362	8	1.35
0	S222	271.3	1269.2	1268.7	0.56	Barrier		Urban	3	3.6	10.5	2	0.6	0.6	0	0	0	0	1	Simple	1275955.464		354	339.95	1.3701	1.3702	54.582	RIGHT	70	22,362	8	1.35