COMPARATIVE SPEED STUDY ON A PARTICULAR ROADWAY SECTION OF DHAKA CITY

Civil and Environmental Engineering

By

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An undergraduate thesis submitted to the Department of Civil & Environmental Engineering of Islamic University of Technology, Board Bazar, Gazipur in partial fulfillment of the requirements for the degree

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DECLARATION

We hereby declare that the undergraduate project work reported in this thesis has been performed by us and this work has not been submitted elsewhere for any purpose (except for publication).

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Dedicated

To

Our Beloved Parents

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Abstract

Road crashes are a leading cause of deaths and serious injuries around the world. Several studies justifies that speed is the major cause related to the risk of getting involved in a road accident. This paper represents the speed scenario of a particular roadway section of Dhaka-Mirpur route. The speed data of various types of vehicles that use the particular roadway were taken for this study. Along with vehicle speeds, some other safety parameters were also taken. To get a complete speed scenario of this road section data were taken on both weekdays and weekends in four different time periods that include Morning-peak, Off-peak, Evening-peak and Night time. Both paired and unpaired T- test analysis was performed taking 90% confidence interval. It is found when comparing between different vehicles that CNG Auto rickshaw and Truck is significant. Vehicle speed varies in the Morning-peak than other time periods in weekdays and in the Evening-peak in the weekends, was found while comparing between different time periods. Again, comparing between different days mainly car, bus and truck were found statically significant. Possible reasons are discussed behind these findings and some Promising measures that demand priority consideration in improving road safety through mitigating the problem of speeding to have a regulated traffic flow are also suggested in this paper.

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Notation

MP : Morning-peak

OP : Off-peak

EP : Evening-peak

N : Night

Chapter 1 Introduction

1.1. Background

With the development of science and technology people experience a large number of motor vehicles which is the main and easier way of travelling for people and Carrying goods from one place to another. For example Roads, highways and streets are fundamental to transportation system and over 70% of passenger travel and much of goods mover is over the highways (Sheikh, 2009). But at the same time we are sacrificing a large number of valuable human lives or being severely injured each day around the world. Road crashes are the major cause for it.

Road crashes are a leading cause of deaths and serious injuries around the world. First of all, speed is related to the risk of getting involved in a road accident. Faster speeds leave less time to react to changes; they lead to longer stopping distances and to less maneuverability. Secondly, there is a direct relationship between impact speed and the severity of an accident e.g. (Nilsson, 1982; Elvik et al., 2004). Evans (2004) reported that a 1% increase in speed increases the fatality risk by 4–12%.With regard to speed and accident risk on rural roads Kloeden et al. (2001) estimated that the risk of involvement in an injury accident is more than twice as high when traveling 10 km/h above the average speed of non-accident involved vehicles, and nearly six times higher when traveling 20 km/h above that average speed.

According to the *World Report on Road Traffic Injury Prevention* (2004), worldwide an estimated 1.2 million people are killed in road accidents each year and as many as 50 million are injured. Projections indicate that these figures will increase by about 65 percent over the next 20 years unless there is new commitment to prevention. It also said that road traffic accidents as the 6th place (was the 9th in 1990) of a major cause of death worldwide, will rise to become the 3rd leading cause of DALYs (Disability Adjusted Life Years) lost by 2020; the 2nd leading cause of DALYs lost for low and middle income countries; fatalities will increase worldwide from 0.99-2.34 million (representing 3.4% of all deaths); fatalities will increase on average by over 80% in low-income and middle-income countries and decline by almost 30% in high-income countries. Furthermore, road traffic deaths are predicted to increase by 83 percent in low income and middle income countries and to decrease by 27 percent in high income countries. Of the total 1.2 million deaths, by far the majority – over 80 percent of road accident fatalities occur in the so called developing and emerging countries, even though these countries account only about one-third of the total motor vehicle fleet. Accident rates in developing countries are often 10 to 70 times higher than in developed countries. Developing countries suffer staggering annual loss exceeding US$ 100 billion for road accidents, which is nearly equivalent to the double of all developing assistance (Hoque, 2001).

According to WHO (2004), traffic deaths have risen from approximately 999,000 in 1998 to just over 1.1 million in 2002, an increase of around 10%. Low-income and middle-income countries account for majorities of these increases. This situation is very much alarming for Bangladesh where some 12% of GDP and 20% of the annual development budget is spent on transport, and 9.4% of the national employment is in the transport industry (Hoque et al., 2003) . Hoque et al. (2010, 2011) identified the principal contributing factors of accidents in Bangladesh are adverse roadway and roadside environment, poor detailed design of junctions and road sections, excessive speeding, overloading, dangerous overtaking, reckless driving, carelessness of road users, failure to obey mandatory traffic regulations, variety of vehicle characteristics and defects in vehicles and conflicting use of roads. Others include a low level of awareness of the safety problems, inadequate and unsatisfactory education, safety rules and regulations and traffic law enforcement and sanctions.

Excessive and inappropriate speeding of motor vehicles and risk taking behavior of road users have been shown to contribute substantial portion of accidents in Bangladesh. This is manifested by the fact that as many as 55 people are reported killed in road traffic crashes each day iRAP (2011) and by the end of today, it will disappointingly be the same or even more. Bangladesh Road Transport Authority (BRTA) declared ‘over speeding’ and ‘reckless driving’ as the main causes of road crashes.

The 9th International Conference on Safe Community revealed that in Bangladesh, more than 2,000 people are killed in road accidents every year, which are about 6 persons every day. According to BRTA, Bangladesh has a fatality rate of 55 persons per 10,000 vehicles (60/10,000; another study at The Financial Express, July 2005). Transport Research Laboratory (U.K) found from Asia/Pacific fatality rates (1996), which showed that Bangladesh's death rate for traffic accidents is twice of the rate that of India and from another study- 33 per 1000 vehicles according to the Financial Express, July (2005) and 30 times that of developed countries like Japan. A survey conducted by the Accident Research Centre of Bangladesh University of Engineering and Technology in 2004 shows that more than 2,000 people die each year in road accidents (Sheikh, 2009).

According to the official statistics, there were at least 3334 fatalities and 3740 injuries in 4114 reported accidents in Bangladesh during 2011. It is estimated that the actual fatalities could well be 10000-12000 each year. Significant fluctuations in the numbers of fatalities and injuries as reported by police clearly reflect the problems of reporting and recording inconsistencies (BRTA). The number of fatalities has been increasing from 1009 in 1982 to 3334 in 2003, nearly 3.5 times in 22 years period (Hoque, 2008). The statistics revealed that Bangladesh has one of the highest fatality rates in road accidents, over 100 deaths per 10,000 motor vehicles (Haque & Meraz, 2005).

The World Health Organization (WHO) estimates that the total number of deaths in Bangladesh is almost five times higher than the official figures (WHO, 2009). National and regional highways were featured in nearly 65 percent of the total accidents. Buses and trucks account for over 70 percent of the single vehicle accidents and their share in multi-vehicle accident is around 50 percent whereas they constitute only 9 percent of the total registered vehicles (Hoque et al., 2012). It is very certain that this situation has been deteriorating with rapid growth in population, motorization, urbanization and lack of investment in road safety. Again the combination of rapid urbanization and motorization has made the problem more severe.

Excess and inappropriate speed is a very important factor in the road safety problem (ETSC, 1995). By contrast, most governments regard speeding as a major road safety problem. The government of New Zealand, for example, has published an extensive review of the relationship between speed and accidents, entitled "Down with speed" (Patterson et al., 2000). The Australian Transport Safety Bureau -2001, likewise identifies speed enforcement as one of the key actions of its national road safety strategy 2001-2010 (Australian Transport Safety Bureau, 2001).Some of the main findings of the research presented by Elvik et al. (2004) are summarized as Follows:

- ✓ There is a strong statistical relationship between speed and road safety. When the mean speed of traffic is reduced, the number of accidents and the severity of injuries will almost always go down. When the mean speed of traffic increases, the number of accidents and the severity of injuries will usually increase.
- ✓ The relationship between speed and road safety is causal and can be explained in terms of elementary laws of physics and biomechanics. Speed is clearly a very important risk factor with respect to both accident occurrence and injury severity.
- ✓ The relationship between speed and road safety can to some extent be modified by the road environment, by vehicle-related factors, and by driver behavior, but the effects of speed on road safety appear to be remarkably consistent across different contexts.

1.2. Objective of the Study

Studying the above discussion it is very clear that several factors work behind a road accident. But over speeding ignoring the posted average speed limit makes the situation more severe. The main Objectives of the Study are:

- ✓ Studying the traffic composition.
- ✓ Studying the speed of different motor vehicles using a speed gun at different hours. Especially in the Peak hours and Off-Peak hours.
- ✓ Finding out the proportion of over speeding motor vehicles.

- ✓ Comparing the composition and speed variations between the weekdays and weekends.
- ✓ Comparing those respective speeds with the posted average speed limit.
- ✓ Comprehend the data of road crashes as a result of speed.
- ✓ Examining the fatalities as a result of over speed.
- ✓ Examining the Suitability of the roadside condition.

1.3. Scope & Significance of the Research

We will perform our research on a highway with a specific curve after comparing with other curves existing on that particular highway. The selection of the curve is based on location, length, steepness, curvature shape, visibility, roadway environment and other obstacles where a high accessibility of a good number of motor vehicles are available. This is because curvature are comparatively more risk prone to road crashes and speed will increase the possibility of a motor vehicle in causing a crash This study will be based on road crashes as a result of over speed. After completing the research it is expected that this study will meet the following queries:

- ✓ What are the composition and speed variations between the Peak hours and Off-Peak hours?
- ✓ What are the composition and speed variations between the weekdays and weekends?
- ✓ When the drivers usually speed up their vehicles?
- ✓ By what extent the drivers exceed the posted speed limit?
- ✓ What is the relation between speed and fatality of a crash?

1.4. Outline of Thesis

The thesis is organized into five chapters. After the introduction in first chapter, the other four chapters will cover the following topics:

Chapter 2- Literature Review:

In this chapter we will discuss studies related to speed and crush. At the beginning we highlight earlier studies and their shortcomings by other studies. And then we further discuss some recent studies on crash occurrence due to over speeding of vehicle. Finally we will present accident severity in Bangladesh and influence of speed behind those accidents.

Chapter 3- Methodology:

In this chapter we will discuss regarding the site selection from where we will measure the speed of various motor vehicles using a speed gun. The sources of the database used in this study as well as methodology followed in statistical analysis will be described in this chapter. This chapter also justifies the methodology used in this study comparing them with the methodologies used in other similar studies.

Chapter 4- Data Analysis & Discussion:

Using the available data of speed and crash, a crash frequency model will be developed in this chapter. Description of model development and evaluation and explanation of significant variables for each case study will be given as well.

Chapter 5- Conclusion:

The findings of this study will be discussed in this chapter. Some recommendations for the observed problems will be given to overcome those difficulties in near future for easy traffic flow and safety of highways.

Chapter 2 Literature Review

2.1. Introduction

In this chapter we have discussed studies related to speed and crush. At the beginning we highlighted earlier studies and their shortcomings by other studies. And then we further discussed some recent studies on crash occurrence due to over speeding of vehicle. Finally we presented accident severity in Bangladesh and influence of speed behind those accidents.

2.2. Speeding and Risk of Accidents

A large body of evidence indicates that there is a positive association between speed and the risk of crash involvement. Evidences from several extensive studies worldwide suggest that small increase in travel speed result in large increase in crash risk (Armour and Cinquegrana, 1990; kloeden et al., 2001; GRSP, 2008; Fleiter et al., 2009). This evidence includes the findings from case control studies and from studies of fatality and casualty rates before and after changes to speed limits, and evidence from comparisons of fatality rates for countries with different maximum speed limits.

In urban areas the frequency of interaction with other vehicles and, in particular, with turning vehicles is much greater and so small differences in travelling speed can have larger effects on the risk of involvement in a casualty crash than on rural roads with fewer intersections and lower traffic volumes. The urban speed and crash risk study Kloeden et al. (1997) found that in a 60 km/h speed limit area, the risk of involvement in a casualty crash was found to approximately double with each 5 km/h increase in travelling speed above 60 km/h.

It was found that the risk of involvement in a casualty crash increased more than exponentially with increasing free travelling speed above the mean traffic speed and The effect of hypothetical speed reductions on all of the 167 crashes investigated indicated large potential safety benefits from even small reductions in rural travelling speeds(Kloeden et al., (2001) .

2.3. Earlier Studies on Speed Related Crashes

Some earlier studies (Solomon, 1964; Cirillo, 1968; Research Triangle Institute, 1970) found significant effect of speed on crash occurrence. In each study the essence of the method was to estimate pre-crash travelling speeds for vehicles involved in crashes on designated stretches of road, and to compare these speeds with speed measurements for traffic not involved in crashes. The studies were conducted on rural roads, and all reported that the relationship was U-shaped, with crash risk being elevated at both relatively low and relatively high speeds.

The first and best known attempt to quantify the relationship between speed and crash involvement was that of Solomon (1964), undertaken in six hundred miles of main rural highway in the United States in the late 1950s.The aim of Solomon’s study was to relate crash involvement to various driver and vehicle factors, including speed. Information from the accident records of nearly 10,000 drivers was compared with speed measurements and interview data from 290,000 drivers not involved in crashes.

He found that the daytime involvement rates took the form of a U-shaped curve, being greatest for vehicles with speeds of 22 mph or less (43,238 per 100 mvm), decreasing to a low at about 65 mph (84 per 100 mvm), then increasing somewhat for speeds above this (reaching 139 per 100 mvm for speeds of at least 73 mph); The night-time rates took the same form especially for speeds in excess of 60 mph but they were higher for the lowest speed category (Kloeden et al., 2001). Solomon also expressed the involvement rates as a function of deviation from mean speed, to overcome irregularities due to the highway sections having a range of speed limits and mean speeds. Under this configuration the involvement rates were again U-shaped, being maximum for vehicles with speeds of more than 35 mph below the average, minimum for speeds of 5 to 10 mph above the average, and somewhat elevated for further deviations above the average. Solomon’s well-known U-shaped curve showed that crash involvement rates are lowest at speeds slightly above average traffic speeds.

The greater the deviation between a motorist's speed and the average speed of traffic—both above and below the average speed—the greater the chance of involvement in a crash. The correlation between crash involvement rates and deviations from average traffic speed gave rise to the often-cited hypothesis that it is speed deviation, not speed itself that increases the probability of driver involvement in a crash.

Solomon's U-shaped relationship was replicated by Munden (1967) using a different analytic method on main rural roads in the United Kingdom, by Cirillo (1968) on U.S. Interstate highways, and by Harkey et al. (1990) on rural and urban roads posted at speeds ranging from 25 to 55 mph (40 to 89 km/h) in two U.S. states.

For example, Cirillo (1968) published results of a study similar to Solomon's, but undertaken on interstate highways rather than rural highways. Cirillo's (1968) results were expressed in terms of deviation from mean speed and were similar to those of Solomon: the accident involvement rates followed a U-shaped curve, being highest for vehicles travelling about 32 mph below the mean speed, falling to a minimum for vehicles travelling around 12 mph above the mean speed, then rising moderately with further deviations from the mean. . Hauer (1971), in his subsequent theory of traffic conflict provided a theoretical basis for Solomon's findings.

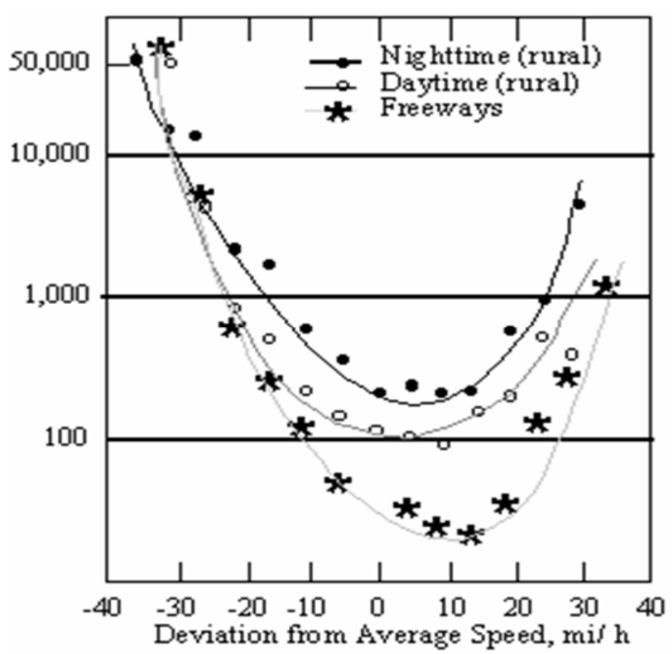

Figure 2.1: Deviation from Mean speed and Accident involvement Rates

All of the U.S. studies, but most particularly Solomon’s, have been criticized for their dependence on crash reports for the pre-crash speeds of the crash-involved vehicles, which could bias the results (White and Nelson, 1970). Solomon’s study has also been criticized for unrepresentative comparative traffic speed data, lack of consistency between the crash and speed data, and combining crash rates of free-flowing and slowing vehicles, which could explain high crash involvement rates at low speeds. When Solomon’s data are disaggregated by crash type, the U-shaped relationship is only fully replicated for one crash type—nighttime head-on collisions (Cowley, 1987).

Another study by West and Dunn (1971) investigated the relationship between speed and crash involvement, replicating Solomon’s U-shaped relationship. However, when crashes involving turning vehicles were removed from the sample they investigated, the U-shaped relationship was considerably weakened—the curve became flatter—and the elevated crash involvement rates that Solomon had found at the low end of the speed distribution disappeared; crash involvement rates were more symmetric above and below mean traffic speeds .

West and Dunn's (1971) analysis supports the conclusion that the characteristics of the road are as responsible for creating the potential for vehicle conflicts and crashes as the motorist's driving too slowly for conditions.

2.4. Over Speeding as a Cause of Accidents

Most studies pointed to the fact that over speed than mean speed as a cause of crash occurrence. For example, An Australian study Fildes et al. (1991), which examined crash involvement rates as a function of speed on urban arterials as well as on two-lane rural roads, found that crash involvement rates increases linearly as a function of speed and no evidence of the U shaped relationship. Crash involvements were lowest at speeds below average traffic speeds and highest at speeds above the average with no advantage at the average. The findings point to a linear and positive association between crash probability and the speed of crash involved vehicles.

On the basis of data from 48 states, Lave (1985) developed models for a range of road classes (e.g., Interstates, arterials, collectors) to investigate the relationship between average traffic speed, speed dispersion, and fatality rates, attempting to hold constant some of the other factors that affect highway fatality rates using standard statistical techniques. He found that speed dispersion was significantly related to fatality rates for rural Interstates and rural and urban arterials. After controlling for speed dispersion, average traffic speed was not found to be significantly related to fatality rates for any road type.

A related study by Garber and Gadiraju (1988) found, as Lave (1985) had, that average traffic speeds are not significantly related to fatality rates. They examined the relationship between crash rates, speed dispersion, average traffic speed, and other measures that influence speed—design speed and posted speed limits—on several different classes of roads in Virginia. They found that crash rates declined with an increase in average traffic speeds when data for all road classes were combined. When crash rates were modeled as a function of speed dispersion for each road class, however, crash rates increased with increasing speed dispersion.

2.5. Recent Studies on Speed Related Crashes

Analyses of a number of large data bases in the United States indicated that speeding or excessive speed contributed to around 12 per cent of all crashes reported to the police and to about one-third of fatal crashes (Bowie and Walz, 1991). In Australia, it has been reported that excessive speed is an important factor in approximately 20 per cent of fatal crashes Haworth and Rechnitzer (1993) and speed is a probable or possible cause in 25 per cent of rural crashes (Armour and Cinquegrana, 1990).

In GRSP (2008) substantial facts of a significant relationship between mean speed and crash risk have been documented. Some selective few are:

- The probability of a crash involving an injury is proportional to the square of speed.
- The probability of a serious crash is proportional to the cube of the speed.
- The probability of a fatal crash is related to the fourth power of the speed.

Empirical evidence from speed studies in various countries has shown that an increase of 1km/h in mean traffic speed typically results in a 3 percent increase in the incidence of injury crashes (or an increase of 4–5 percent for fatal crashes). Travelling at 5 km/h above average in 60 km/h urban areas and 10 km/h above average in rural areas, are sufficient to double the risk of a casualty crash.

2.6. Crashes due to Exceeding Posted Speed Limit

Posting appropriate speed limits are necessary to ensure a reasonable level of safe and efficient travel on highways and streets. An unrealistic posted speed limit generally reduces driver compliance rates, and in turn increases the number of accidents, related injuries, and fatality rates (Najjar et al., 2000). AASHTO definition for operating speed is “the highest overall speed at which a driver can travel on a given highway under favorable weather conditions and under prevailing traffic conditions without at any time exceeding the safe speed as determined by the design speed on a section-by-section basis.”

A study performed by the Transportation Research Board (TRB) in 1998 under the request and funding of the National Highway Traffic Safety Administration (NHTSA), the Federal Highway Administration (FHWA), and the Centers for Disease Control and Prevention, reviewed the current practices for setting and enforcing speed limits on all types of road as described by (TRB, 1998). According to the study, speed limits are one of the oldest strategies for controlling driving speeds. With two exceptions - during World War II and the enactment of the NMSL of 55 mph (89 km/h) in 1974 - setting speed limits in the United States has been the responsibility of state and local governments (TRB, 1998).Speed limits in speed zones are determined administratively based on an engineering study, considering factors such as operating speeds of free-flowing vehicles, crash experience, roadside development, roadway geometry, and parking and pedestrian levels. In many speed zones, speed limits are set to coincide with the 85th percentile speed, the speed at or below which 85 percent of drivers travel in free-flow conditions at representative locations on the highway or roadway section. This approach assumes that most drivers are capable of judging the speed at which they can travel safely. The 85th percentile speed is commonly used by highway agencies for describing actual operating speeds and establishing speed limits.

The 85^{th} percentile speed is in the speed range with the lowest accident involvement rate, since a study revealed that vehicles traveling one standard 15 deviation above the average speed under free flow conditions have the lowest involvement rate; average speed plus one standard deviation is approximately the 85th percentile speed (Agent et al., 1998). In addition, raising the speed limit to the 85th percentile speed causes no increase in crashes. Speed limits determined by the 85th percentile are favored as they are the most realistic and in turn decrease compliance problems and speed variation and lead to better traffic flow (Thornton and Lyles, 1999). Drivers are expected to reduce speeds under deteriorated conditions such as poor visibility, adverse weather, congestion, warning signs, or presence of cyclists and pedestrians, and most state statutes reflect this requirement.

Exceeding these design speeds or average speeds increase crash occurrences. For example, kloeden et al. (2001) found that the risk of a free travelling speed passenger vehicle being involved in a casualty crash, relative to the risk for a passenger vehicle travelling at an average speed, increased at greater than an exponential rate that travelling speeds below the mean traffic speed were associated with a lower risk of being involved in a casualty crash. During their study on the relationship between free travelling speed and the risk of involvement in a casualty crash in 80 km/h or greater speed limit zones in rural South Australia was quantified using a case control study design. The crashes involving the 83 case passenger vehicles were investigated at the scene by the Road Accident Research Unit and reconstructed using the latest computer aided crash reconstruction techniques. The 830 control passenger vehicles were matched to the cases by location, direction of travel, time of day, and day of week and their speeds were measured with a laser speed gun.

Their results showed that the risk of involvement in a casualty crash is more than twice as great when travelling 10 km/h above the average speed of non-crash involved vehicles and nearly six times as great when travelling 20 km/h above that average speed. The mechanisms explored for this increase in risk (where higher speeds are associated with longer stopping distances, increased crash energy and more likely loss of control) also suggest that a reduction in the absolute speed of traffic is much more important in reducing crash frequency than a reduction in traffic speed differences. Even a 5 km/h reduction in the speed of all the rural free travelling speed vehicles would lead to a 31 per cent reduction in these casualty crashes. It was also found that 24 per cent of all the casualty crashes investigated would have been avoided if none of the vehicles had been travelling above the speed limit and that lowering the maximum speed limit on undivided roads to 80 km/h could be expected to lower casualty crash frequency by 32 percent. Wilmot and Jayadevan (2006) on their study has shown that the crash rate of certain types of crashes on two-lane rural roads has increased significantly with an increase in speed limit in Louisiana in the past for 1999-2004.

Most road safety experts agree that the single most important contributor to road fatalities around the world is poor speed selection (GRSP, 2008). According to GRSP (2008), excessive and inappropriate speed is the biggest road safety problem in many countries. Sanderson and Fildes (1984) found that the severity of accidents increases constantly with the incidence of excessive speeds. Fleiter et al. (2009) reported that despite increasingly sophisticated speed management strategies, speeding remains a significant contributing factor in 25 percent of Australia's fatal crashes annually. Excessive speed is also a recognized contributor to road trauma in rapidly motorizing countries such as China, where increases in vehicle ownership and new drivers, and a high proportion of vulnerable road users all contribute to a high road trauma rate.

Some other facts about speed being the prime cause of accident are documented in (GRSP, 2008). Some selective few are:

- Errors such as loss of control of vehicle, speeding, misjudgment and improper overtaking contributed to 44 percent of all police-reported crashes in Kenya.
- Speed was the main contributory factor in 50 percent of road crashes in Ghana between 1998 and 2000.
- In South Africa, speed has been an important factor in 50 percent of crashes involving commercial road transport and public passenger vehicles.

2.7. Crash Severity due to Over Speed

The relationship between vehicle speed and crash severity is unequivocal. The Insurance Institute for Highway Safety (1991) pointed out that single vehicle crashes account for more than half of the fatal crashes on interstate highways and such crashes are likely to be associated with high speeds.

The probability of injury, and the severity of injuries that occur in a crash, increase exponentially with vehicle speed. Joksch (1993) found that the risk of a car driver being killed in a crash increased with the change in speed to the fourth power. The probability of death from an impact speed of 50 mi/h (80 km/h) is 15 times the probability of death from an impact speed of 25 mi/h (40 km/h). The outcomes of some recent studies of speed's detrimental effect on crash severity have been well documented in (GRSP, 2008). All research studies show that as speeds increase, the number and severity of injuries also increase and the higher the impact speed, the greater the likelihood of serious and fatal injury. Some outcomes of recent studies are:

- The probability of serious injury for belted front-seat occupants is three times as great at 30 miles/h (48 km/h) and four times as great at 40 miles/h (64 km/h), compared with the risk at 20 miles/h (32 km/h).
- For car occupants in a crash with an impact speed of 50 miles/h (80 km/h), the likelihood of death is 20 times what it would have been at an impact speed of 20 miles/h (32 km/h).
- Pedestrians have a 90 percent chance of surviving car crashes at 30 km/h or below, but less than a 50 percent chance of surviving impacts at 45 km/h or above. The probability of a pedestrian being killed rises by a factor of eight as the impact speed of the car increases from 30 km/h to 50 km/h).

In another study it is estimated that For Sweden, perfect compliance with speed limits could reduce the number of road accident fatalities by 38% and the number of injured road users by 21%, (Elvik and Amundsen, 2000).

2.8. Crash Characteristics in Bangladesh

Hoque et al. (2010, 2011) identified several contributing factors of accidents in Bangladesh. The most significant factors are adverse roadside environment, poor detailed design of junctions and road sections, excessive speeding, overloading, dangerous overtaking, reckless driving, carelessness of road users, failure to obey mandatory traffic regulations, variety of vehicle characteristics and defects in vehicles. Several road environmental factors that are particularly prevalent in rural roads are major roadway defects in design and layout, shoulders, roadsides, bridge and its approaches, delineation devices and lack of access control. Unregulated private/business access to inter-urban highways led to endless linear settlement resulting in high risk for pedestrians and other vulnerable road users. BRTA in its investigation identified fifteen major causes of road trauma in Bangladesh (BRTA, 2008). Reckless driving and over-speeding have been reported as the most frequent causes of accident. The prevalence of the above factors could be found in some of the recent devastating crashes.

More frequent accident types on the national highways were identified (Newaz et al., 2006). Of the total reported accidents, hit pedestrian emerges as the most common type of accidents amounting to 40 percent of total accidents and 47 percent of all fatal accidents. This is followed by head on (18%), rear end (13%) and overturning (11%) types of accidents. These four accident type groups accounted for 82 percent of all accidents and 86 percent of all fatal accidents. The greater incidence of head-on types collision on national highways as compared with its share in total accidents, highly justifies the necessity of separating opposing traffic stream. The incidence of aggressive speeding was also evident on national highways. An examination of the distribution of accidents on a national highway corridor was made according to specified speed zones. It showed that higher incidence of accidents occurred on the designated highway segments of high-speed limit zones (Figure 1).

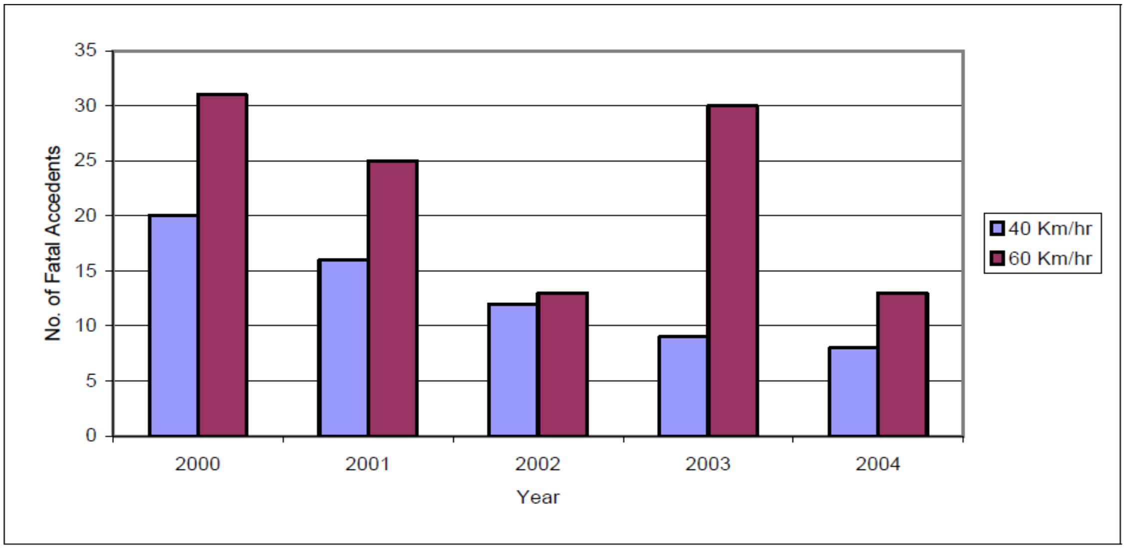

Figure 2.2: Distribution of Fatal Accidents on National Highway Corridor (Dhaka-Aricha Highway Section) with Varying Speed Limits (Newaz et al., 2006).

2.9. Fatalities due to Accidents in Bangladesh

In most cases 'Vulnerable Road Users' (VRUs) are much more susceptible to crashes where vehicle speeds are high (Newaz et al., 2006). This is of particular concern in Bangladesh.

The World Health Organization (WHO) estimates that the total number of deaths in Bangladesh is almost five times higher than the official figures. Road crashes in Bangladesh kill 4000 and injure 5000 per year. Actual fatalities could well be 20,038 each year. Death rate of 12.7 deaths per 100,000 populations. Road crashes cost US $2000 million, nearly 2% of GDP. Reported fatalities increased 4 times in 26 years. Bangladesh has a very high fatality rate, over 100 deaths per 10,000 motor vehicles (WHO, 2009). A Household survey conducted by Transport Research Laboratories (TRL) concluded that actual number of deaths is four times the number officially reported by police and the actual number of serious injuries 75 times greater (Aeron-

Thomas et al., 2004). Out of 3531 accidents in 2008 only 150 were simple injury and the rest were either fatal or grievous which indicates that road users are very much exposed to higher risks and are likely to have a fatal injury in the event of an accident(BRTA, 2008). This higher incidence of fatal accidents urges the necessity of widespread implementation of effective measures related to the reduction of both accident severity and accident frequency resulting from over speed.

2.10. Conclusion

Bangladesh with low and rapidly growing motorization has a serious and worsening road safety problem (BRTA, 2008). This is manifested by the fact that as many as 55 people are reported killed in road traffic crashes each day iRAP (2011) and by the end of today, it will disappointingly be the same or even more. Excessive and inappropriate speeding of motor vehicles and risk taking behavior of road users have been shown to contribute substantial portion of accidents in Bangladesh. Also Bangladesh Road Transport Authority (BRTA) declared ‘over speeding’ and ‘reckless driving’ as the main causes of road crashes. Buses and trucks exceed the posted speed limits in most instances. For example, in a study on a 40 km/h speed limit section of a highway, the average spot speed of buses was nearly 70 km/h. Even on an 80 km/h speed limit section of another highway, around 12% drive at a speed higher than the posted speed limit and around 4% exceed it by 10km/h or more (Haque et al., 2012). Adverse roadway environmental factors are also very much prevalent which are aggravating the situation.

Chapter 3 Methodology

This chapter contains the site selection, data collection method, formulation of data and the methodology used in the analysis of crash data in this study. The key steps to select the site are presented first, followed by the theoretical framework of different statistical interferences like, confidence interval for the mean with unknown variance, testing differences between two means, both independent samples and paired observations. The development of these models will help us to make comparison between vehicle speeds in different period of time in different days of a week.

3.1. Site Selection Criteria

Dhaka Mirpur highway is a very important road in the roadway network of Dhaka city. It is a shortcut which connects Mirpur area with Dhaka-Mymensingh highway. In our preliminary survey for choosing site location we investigated from Kamar para, near Abdullahpur to Rupnagar Police Station, which is about 11km. We have considered six locations comparing with many other locations in this road network on basis of some road factors. Among these six locations we have chosen a single location for our data collection. There are some common problems in these six site locations of the roadway:

1. No street lights: There are no street light in this road, so at night vehicle have higher percentage chance of accident occurrence.
2. Less shoulder width: Recommended width-
    - At least 10ft for heavily traveled and high speed highways.
    - At least 4ft for (preferable 6 to 8ft) for low-type highways.

    In many places the shoulder width does not abide by recommended width.

3. Short sight distance: There are many sharp curves in this roadway. Trees at both side of the road blocks driver’s sight distance.

4. Less distance for perception-reaction: Vehicles move at very high speed in this road so it needs longer stopping distance, breaking distance, passing distance.
5. No speed limit signs: Bus, truck and other vehicle drivers have tendency to over speed because there is no restriction of speed.
6. No road divider: Often bus drivers, truck drivers and other vehicles want to overtake illegally. For this phenomena both side of road are covered and for this reason chance of head on crash increases.
7. No speed breaker: There’s not even a single speed breaker in the entire roadway. So, vehicles over speeding tendency increase.
8. Sharp curves: There are many sharp curves which blocks perception reaction distance.
9. Less visible road marking: In many places of the road the pavement marking have been erased or became less visible due to less maintenance.

The considerable six sites are compared by some parameters. The worst location is selected. Table 3.1 presents the comparison among those sites.

Table 3.1.: Comparison between the surveyed sites.

Parameters	**Considerable Site Location**					
	Site1	Site2	Site3	Site4	Site5	Site6
Street Light	No	No	No	No	No	No
Shoulder Width	Ok	Not Ok	Not Ok	Ok	Ok	Ok
Sight distance	Good	Bad	Good	Bad	Good	Good
Clear Road Marking	Not visible	Not Visible	Not visible	Not Visible	Visible	Visible
Speed Breaker	No	No	No	No	No	No
Sharp curve	Less Risky	Risky	Less Risky	Risky	Less Risky	Less Risky

Site 2 has the worst condition among the six chosen sites. So, comparing with other sites we have decided to select site 2 as our data collection location. The pictures of the six sites and the final site are showed below:

Figure 3.1: Considerable Six Different Sites.

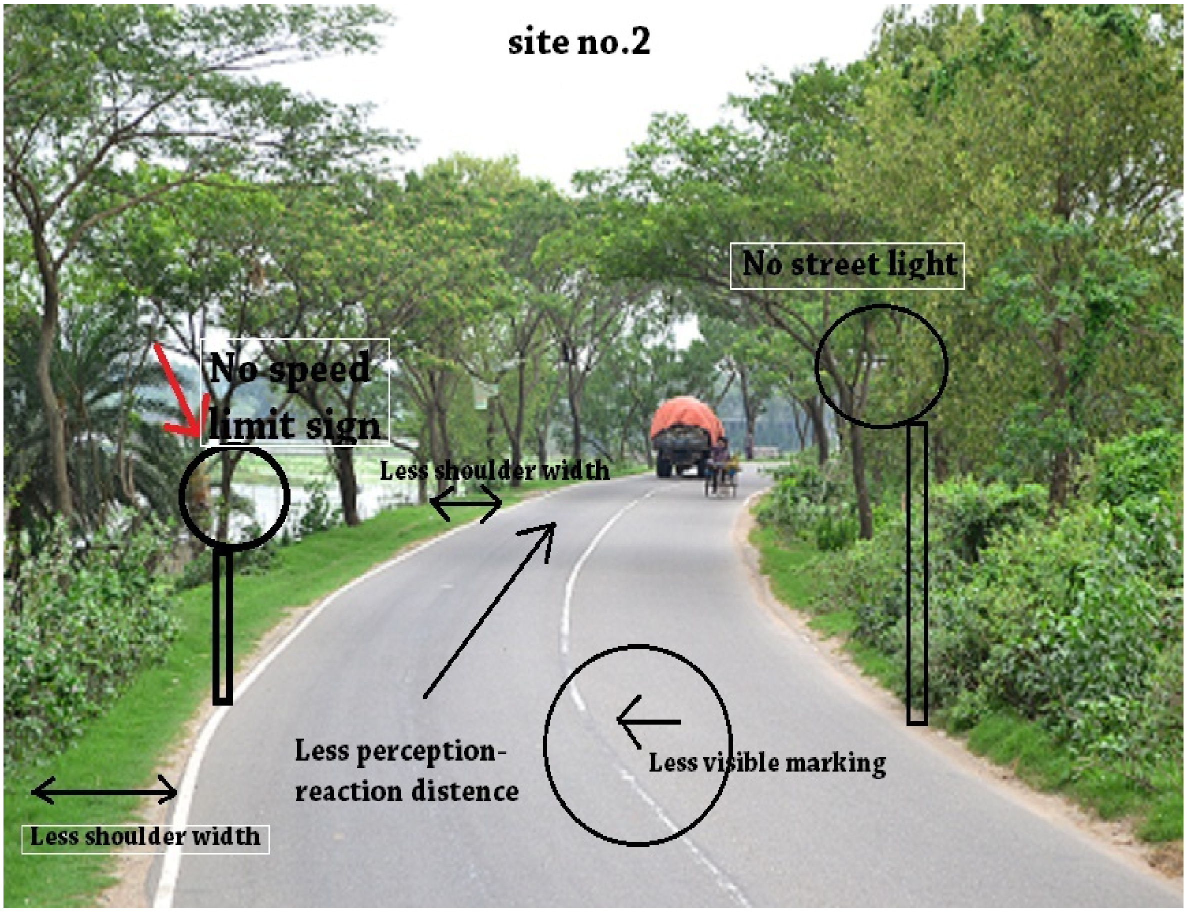

Figure 3.2: Selected site for Data Collection

3.2. Data Collection Procedure

In site location we will collect data using speed gun at different hours of a day and in different days of a week.

- Using the *speed gun*, speeds of different vehicles will be measured.
- The work will be carried through 4 different days in a week
- It will include 3 *weekdays* and 1 *weekend* for estimating the vehicle flow as well as the speeding tendency.
- Some facts will be followed along with measuring the speed of vehicles.
- In example: Overtaking tendency of the vehicle, position of the vehicle, pedestrian crossing the road on that particular time

- Driver’s characteristics, i.e. seat-belt on driver’s vest, indicator light on/off, pressing horn or not will be followed.

Data collection and schedule table is represented in Table 3.2 and 3.3 respectively.

Table 3.2**:** Data Collection Sample Table.

Serial No	Type of Vehicle	Speed of Vehicle	Overtaking Tendency	Seatbelt on Driver’s Vest	Indicator Light (On/Off)	Blow Horn at that time	Talking over Mobile phone	Vehicle Position (Actual/ Wrong)
1.								
2.								
3.								
4.								
5.								

Table 3.3: Data Collection Schedule Table.

Day	Time	Time	Time	Time
Sunday	Morning peak (8.00a.m-9.00a.m)	Off-peak (11.00a.m-12.00p.m),	Evening peak (6.00p.m-7.00p.m)	Night (9.00p.m-10.00p.m)
Monday	Morning peak (8.00a.m-9.00a.m)	Off-peak (11.00a.m-12.00p.m),	Evening peak (6.00p.m-7.00p.m)	Night (9.00p.m-10.00p.m)
Weekend	Morning peak (8.00a.m-9.00a.m)	Off-peak (11.00a.m-12.00p.m),	Evening peak (6.00p.m-7.00p.m)	Night (9.00p.m-10.00p.m)

3.3. Statistical Analysis

3.3.1. Confidence Interval for the Mean with Unknown Variance

When the population variance unknown and the population is normally distributed, a (1-α) 100% confidence interval for μ is given by

$$\overline{X} \pm t_{\frac{\alpha}{2}} \frac{s}{\sqrt{n}}$$

Where *s* is the square root of the estimated variance (s^2), $t_{\frac{\alpha}{2}}$ is the value of the *t* distribution with *n-1* degrees of freedom.

Interestingly, inspection of probabilities associated with the *t* distribution shows that the *t* distribution converges to the standard normal distribution as $n \rightarrow \infty$. Although the *t* distribution is the correct distribution to use whenever the population variance is unknown, when sample size is sufficiently large the standard normal distribution can be used as an adequate approximation to the *t* distribution.

3.3.2. Testing Differences between Two Means: Independent Samples

There are several hypothesis testing options. One of them is a test of whether the mean of one population is greater than the mean of another population (a one-tailed test).

The competing hypotheses for a directional test, that one population mean is larger than another, are

$$H_o: \mu_1 - \mu_2 \leq 0$$

$$H_a: \mu_1 - \mu_2 > 0$$

A test statistic for a difference between two population means with equal population variances is given by

$$\boldsymbol{t^{*}} = \frac{(\overline{X_1} - \overline{X_2}) - (\mu_1 - \mu_2)}{\sqrt{s_p{}^2(\frac{1}{n_1} + \frac{1}{n_2})}}$$

where the term $(\mu_1 - \mu_2)$ is the difference between μ_1 *and* μ_2 under the null hypothesis. The degrees of freedom of the test statistic in this equation are $n_1 + n_2 - 2$, which are the degrees of freedom associated with the pooled estimate of the population variance $s_p{}^2$. A (1-α) 100% confidence interval for the difference between two population means $(\mu_1 - \mu_2)$, assuming equal population variances is

$$(\overline{X_1} - \overline{X_2}) \pm t_{\frac{\alpha}{2}} \sqrt{s_p{}^2(\frac{1}{n_1} + \frac{1}{n_2})}$$

3.3.3. Testing Differences between Two Means: Unpaired Observations

The most common test for the difference between two population means μ_1 and μ_2, is the one presented below where the null hypothesis states that the two means are equal,

$$H_o: \mu_1 - \mu_2 = 0$$

$$H_a: \mu_1 - \mu_2 \neq 0$$

The test static for unpaired observation is,

$$\boldsymbol{t^{*}} = \frac{(\overline{\boldsymbol{X_1}} - \overline{\boldsymbol{X_2}}) - (\boldsymbol{\mu_1} - \boldsymbol{\mu_2})}{\sqrt{\frac{\boldsymbol{s_1^2}}{\boldsymbol{n_1}} + \frac{\boldsymbol{s_2^2}}{\boldsymbol{n_2}}}}$$

Where $(\overline{X_1} - \overline{X_2})$ is the average sample difference between the observation 1 and observation 2, s_1 and s_2 is the sample standard deviations of these differences, and the sample size, $n_1 \, and \, n_2$ is the number of unpaired observations of sample 1 and sample 2 respectively. When the null hypothesis is true and the population means are $n_1 \, and \, n_2$, the static has a *t* distribution with n-*1* degrees of freedom. Finally, a (1-∞) 100% confidence interval for the mean difference $(\mu_1 - \mu_2)$ is

$$(\overline{\boldsymbol{X_1}} - \overline{\boldsymbol{X_2}}) \pm \boldsymbol{t}_{\alpha/2}\sqrt{\frac{\boldsymbol{s_1^2}}{\boldsymbol{n_1}} + \frac{\boldsymbol{s_2^2}}{\boldsymbol{n_2}}}$$

Chapter 4 Data Analysis and Discussion

4.1. General:

We have taken data of speed and other safety parameters of Car, Microbus, Jeep, CNG Auto rickshaw, Motor cycle, Pickup van, Small bus, Bus and Truck on two weekdays (Sunday and Monday) and one weekend (Friday). Data were taken for Morning peak (8.00a.m-9.00a.m), Off-peak (11.00a.m-12.00p.m), Evening peak (6.00p.m-7.00p.m) and night (9.00p.m-10.00p.m) for each day.

From the speed data we got the following mean speeds for each type of vehicles on different days.

Table 4.1: Mean speeds for each type of vehicles on different days.

Days	Car	Microbus	Jeep	CNG Auto rickshaw	Motorcycle	Pickup	Small bus	Bus	Truck
Sunday	54.72	57.04	57.47	49.61	57.20	51.00	54.52	58.35	52.39
Monday	56.87	54.83	55.19	52.63	51.92	51.61	52.25	52.07	36.06
Weekend	57.06	59.90	59.57	48.68	52.14	52.14	55.22	58.55	51.94

Graphical representation of mean speed of different vehicles is shown as below:

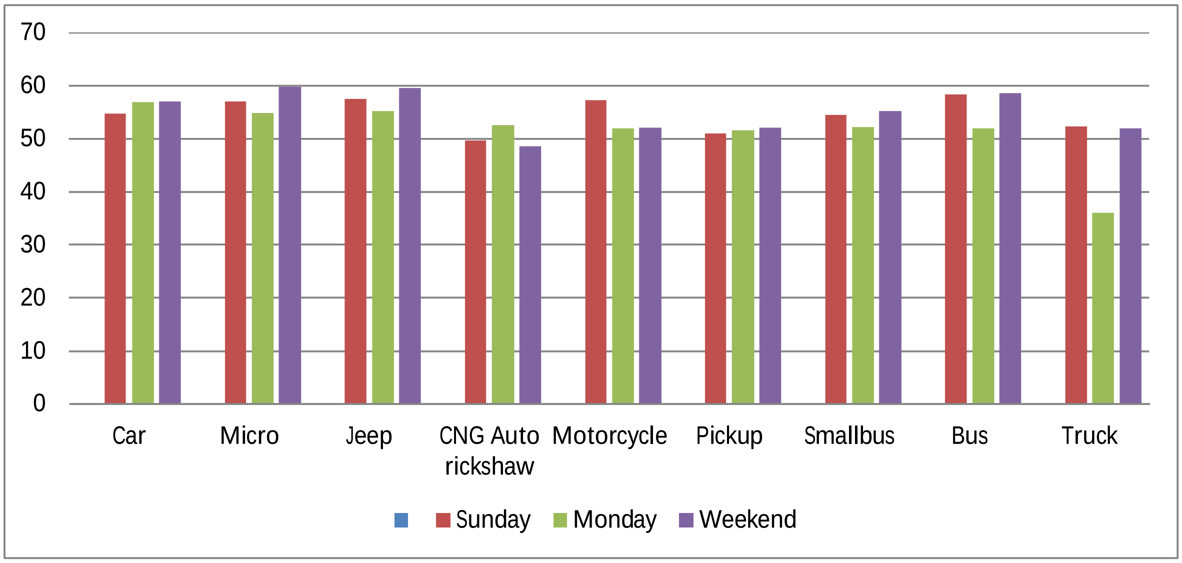

Figure 4.1: Mean Speeds of Different Vehicles in Weekdays and Weekend.

4.2. Comparison between Vehicles, Time periods and Days

We performed the following "T-test" of speed data of the vehicles taking 90% confidence interval both for Equal and Unequal variances:

1. For comparison of speeds of the vehicles with each other for each day.
2. For comparison between the different time periods.
3. For comparison between the days for a particular vehicle.

4.2.1. Comparison of speeds of the vehicles with each other for each day

Tables 4.2, 4.3 and 4.4 depict comparison of speed of different vehicle with each other for Sunday, Monday and Weekend respectively.

Table 4.2: Comparison of Speed of Different Vehicles with Each Other For Sunday.

Vehicles	**H_0:time1=time2 (P value) H_1:time1≠time2 (P value) (For equal variance)**	**Significance**	**H_0:time1=time2 (P value) H_1:time1≠time2 (P value) (For unequal variance)**	**Significance**
Car vs Micro	0.085	Significant	0.0924	Significant
Car vs Jeep	0.0668	Significant	0.0686	Significant
Car vs CNG	0.0017	Significant	0.0004	Significant
Car vs Motor Cycle	0.1928	Insignificant	0.1754	Insignificant
Car vs Pickup	0.0164	Significant	0.0177	Significant
Car vs Small bus	0.8927	Insignificant	0.8877	Insignificant
Car vs Bus	0.003	Significant	0.0023	Significant
Car vs Truck	0.2347	Insignificant	0.1801	Insignificant
Micro vs Jeep	0.7987	Insignificant	0.7956	Insignificant
Micro vs CNG	0.0001	Significant	0.0001	Significant
Micro vs Motor Cycle	0.938	Insignificant	0.9332	Insignificant
Micro vs Pickup	0.0009	Significant	0.0008	Significant

Micro vs Small bus	0.1524	Insignificant	0.1351	Insignificant
Micro vs Bus	0.3496	Insignificant	0.3539	Insignificant
Micro vs Truck	0.0351	Significant	0.0179	Significant
Jeep vs CNG	0.0001	Significant	0.0001	Significant
Jeep vs Motor cycle	0.8967	Insignificant	0.8941	Insignificant
Jeep vs Pickup	0.0007	Significant	0.0007	Significant
Jeep vs Small bus	0.1016	Insignificant	0.0994	Significant
Jeep vs Bus	0.5558	Insignificant	0.5683	Insignificant
Jeep vs Truck	0.0196	Significant	0.0135	Significant
CNG vs Motor Cycle	0.0002	Significant	0.0004	Significant
CNG vs Pickup	0.4368	Insignificant	0.4234	Insignificant
CNG vs Small bus	0.0054	Significant	0.0048	Significant
CNG vs Bus	0.0001	Significant	0.0001	Significant
CNG vs Truck	0.1399	Insignificant	0.148	Insignificant
Motor Cycle vs Pickup	0.005	Significant	0.0046	Significant
Motor Cycle vs Small bus	0.1904	Insignificant	1	Insignificant
Motor Cycle vs Bus	0.5197	Insignificant	0.5317	Insignificant
Motor Cycle vs Truck	0.0364	Significant	0.0353	Significant
Pickup vs Small bus	0.0563	Significant	0.0557	Significant
Pickup vs Bus	0.0001	Significant	0.0001	Significant
Pickup vs Truck	0.5167	Insignificant	0.4908	Insignificant

Small bus vs Bus	0.012	Significant	0.0138	Significant
Small bus vs Truck	0.2964	Insignificant	0.2825	Insignificant
Bus vs Truck	0.0015	Significant	0.0018	Significant

Table 4.3: Comparison of Speed of Different Vehicles with Each Other For Monday.

Vehicles	**H_0:time1=time2 (P value) H_1:time1≠time2 (P value) (For equal variance)**	**Significance**	**H_0:time1=time2 (P value) H_1:time1≠time2 (P value) (For unequal variance)**	**Significance**
Car vs Micro	0.1899	Insignificant	0.1634	Insignificant
Car vs Jeep	0.4254	Insignificant	0.3734	Insignificant
Car vs CNG	0.0454	Significant	0.0348	Significant
Car vs Motor Cycle	0.0368	Significant	0.0323	Significant
Car vs Pickup	0.0094	Significant	0.0115	Significant
Car vs Small bus	0.0452	Significant	0.0119	Significant
Car vs Bus	0.0123	Significant	0.0121	Significant
Car vs Truck	0.0001	Significant	0.0001	Significant
Micro vs Jeep	0.8377	Insignificant	0.8421	Insignificant
Micro vs CNG	0.2295	Insignificant	0.257	Insignificant
Micro vs Motor Cycle	0.1497	Insignificant	0.1932	Insignificant
Micro vs Pickup	0.0852	Significant	0.1101	Insignificant

Micro vs Small bus	0.1641	Insignificant	0.1422	Insignificant
Micro vs Bus	0.1174	Insignificant	0.1355	Insignificant
Micro vs Truck	0.0001	Significant	0.0001	Significant
Jeep vs CNG	0.2589	Insignificant	0.2582	Insignificant
Jeep vs Motor cycle	0.1871	Insignificant	0.1942	Insignificant
Jeep vs Pickup	0.138	Insignificant	0.1246	Insignificant
Jeep vs Small bus	0.1752	Insignificant	0.164	Insignificant
Jeep vs Bus	0.1688	Insignificant	0.1544	Insignificant
Jeep vs Truck	0.0001	Significant	0.0001	Significant
CNG vs Motor Cycle	0.7827	Insignificant	0.7841	Insignificant
CNG vs Pickup	0.6778	Insignificant	0.6715	Insignificant
CNG vs Small bus	0.8691	Insignificant	0.8635	Insignificant
CNG vs Bus	0.8084	Insignificant	0.8052	Insignificant
CNG vs Truck	0.0001	Significant	0.0001	Significant
Motor Cycle vs Pickup	0.9084	Insignificant	0.9057	Insignificant
Motor Cycle vs Small bus	0.8927	Insignificant	0.892	Insignificant
Motor Cycle vs Bus	0.9539	Insignificant	0.9533	Insignificant
Motor Cycle vs Truck	0.0001	Significant	0.0001	Significant
Pickup vs Small bus	0.7989	Insignificant	0.7749	Insignificant
Pickup vs Bus	0.8432	Insignificant	0.8437	Insignificant
Pickup vs Truck	0.0001	Significant	0.0001	Significant
Small bus vs Bus	0.9381	Insignificant	0.9304	Insignificant

Small bus vs Truck	0.0001	Significant	0.0001	Significant
Bus vs Truck	0.0025	Significant	0.0027	Significant

Table 4.4: Comparison of Speed of Different Vehicles with Each Other For Weekend.

Vehicles	**H_0:time1=time2 (P value) H_1:time1≠time2 (P value) (For equal variance)**	**Significance**	**H_0:time1=time2 (P value) H_1:time1≠time2 (P value) (For unequal variance)**	**Significance**
Car vs Micro	0.0771	Significant	0.0594	Significant
Car vs Jeep	0.188	Insignificant	0.1044	Insignificant
Car vs CNG	0.0001	Significant	0.0001	Significant
Car vs Motor Cycle	0.0052	Significant	0.0011	Significant
Car vs Pickup	0.0052	Significant	0.0011	Significant
Car vs Small bus	0.3217	Insignificant	0.2376	Insignificant
Car vs Bus	0.313	Insignificant	0.2786	Insignificant
Car vs Truck	0.0421	Significant	0.0026	Significant
Micro vs Jeep	0.8307	Insignificant	0.8219	Insignificant
Micro vs CNG	0.0001	Significant	0.0001	Significant
Micro vs Motor Cycle	0.0001	Significant	0.0001	Significant
Micro vs Pickup	0.0001	Significant	0.0001	Significant

Micro vs Small bus	0.0034	Significant	0.0026	Significant
Micro vs Bus	0.3038	Insignificant	0.3079	Insignificant
Micro vs Truck	0.0001	Significant	0.0001	Significant
Jeep vs CNG	0.0001	Significant	0.0001	Significant
Jeep vs Motor cycle	0.0001	Significant	0.0001	Significant
Jeep vs Pickup	0.0001	Significant	0.0001	Significant
Jeep vs Small bus	0.0064	Significant	0.0063	Significant
Jeep vs Bus	0.4642	Insignificant	0.4566	Insignificant
Jeep vs Truck	0.0001	Significant	0.0001	Significant
CNG vs Motor Cycle	0.0156	Significant	0.0148	Significant
CNG vs Pickup	0.0156	Significant	0.0148	Significant
CNG vs Small bus	0.0001	Significant	0.0001	Significant
CNG vs Bus	0.0001	Significant	0.0001	Significant
CNG vs Truck	0.0478	Significant	0.0408	Significant
Motor Cycle vs Pickup	1	Insignificant	1	Insignificant
Motor Cycle vs Small bus	0.0398	Significant	0.0407	Significant
Motor Cycle vs Bus	0.0001	Significant	0.0001	Significant
Motor Cycle vs Truck	0.907	Insignificant	0.8984	Insignificant
Pickup vs Small bus	0.0398	Significant	0.0407	Significant
Pickup vs Bus	0.0001	Significant	0.0001	Significant
Pickup vs Truck	0.907	Insignificant	0.8984	Insignificant
Small bus vs Bus	0.0178	Significant	0.0186	Significant

Small bus vs Truck	0.071	Significant	0.0498	Significant
Bus vs Truck	0.0002	Significant	0.0001	Significant

From the data analysis, Truck for Monday and CNG auto rickshaw for both Sunday and weekend was found most significant. From null hypothesis and alternative hypothesis, we found that Truck and CNG auto rickshaw cause variance from rest of the vehicles of that particular day.

Monday:

"Truck" is the most significant among all vehicles for Monday. The facts behind this are:

- Truck is overloaded all the time, so it cannot achieve higher speed in the curved section,
- Truck needs a larger turning radius,
- Public transports remain in good number on Monday, so speeding tendency of truck is lowered
- As the experiment was carried over a one-lane highway, lesser lane width with no island, different vehicles were coming from opposite direction.

Sunday & Weekend:

For both Sunday and weekend it is found that CNG Auto rickshaw got the lowest mean speed among all vehicles. The reasons are:

- Sunday being the first working day of the week, so traffic volume remains high, as a result auto rickshaw cannot speed that much,
- On weekend, number of passengers are relatively low, than other days, so they maintain a low speed to look for passengers,
- As CNG auto rickshaw is a three-wheeler vehicle with a single front wheel, it should maintain low speed while turning in the curved sections, otherwise it will overturn.
- Such a "delta" configuration three-wheeler can easily roll if the driver turns while braking,
- Moreover auto rickshaw does not have the capacity to attain a higher speed as the engine capacity is not that much comparing with other vehicles.

4.2.2. Comparison between the Different Time periods

Comparison between Morning-peak (MP), Off-peak (OP), Evening-peak (EP) and Night (N) for Sunday, Monday and Weekend was done. The comparison between different time periods of weekdays and weekends is represented by table 4.5.

Table 4.5: Comparison between Different Time periods of Weekdays and Weekend.

Comparisons	**H_0:time1=time2 (P value) H_1:time1≠time2 (P value) (For equal variance)**	**Significance**	**H_0:time1=time2 (P value) H_1:time1≠time2 (P value) (For unequal variance)**	**Significance**
MP vs OP (Sunday)	0.0027	Significant	0.0029	Significant
MP vs EP (Sunday)	0.0001	Significant	0.0001	Significant
MP vs N (Sunday)	0.0001	Significant	0.0001	Significant
OP vs EP (Sunday)	0.0085	Significant	0.0085	Significant
OP vs N (Sunday)	0.1344	Insignificant	0.1358	Insignificant
EP vs N (Sunday)	0.3295	Insignificant	0.3324	Insignificant
MP vs OP (Monday)	0.0097	Significant	0.009	Significant
MP vs EP (Monday)	0.0015	Significant	0.0015	Significant
MP vs N (Monday)	0.8028	Insignificant	0.8107	Insignificant
OP vs EP (Monday)	0.5585	Insignificant	0.5546	Insignificant
OP vs N (Monday)	0.0792	Significant	0.0816	Significant
EP vs N (Monday)	0.0237	Significant	0.0293	Significant

MP vs OP (Weekend)	0.9249	Insignificant	0.9281	Insignificant
MP vs EP (Weekend)	0.0547	Significant	0.066	Significant
MP vs N (Weekend)	0.4753	Insignificant	0.485	Insignificant
OP vs EP (Weekend)	0.0207	Significant	0.0206	Significant
OP vs N (Weekend)	0.4228	Insignificant	0.4224	Insignificant
EP vs N (Weekend)	0.1432	Insignificant	0.1411	Insignificant

SUNDAY FINDINGS:

From t-test:

- Morning peak speed is less than all other times.
- Highest speed at evening
- Speed reduces little at night compared to evening peak

Possible reasons of less speed in morning (8-9am):

- ✓ 1st working day of the week. All working institutions (i.e. offices, schools, colleges, food and garments industries etc.) are open.
- ✓ Everyone uses Mirpur highway as a shortcut to reach their destination.
- ✓ Many people comes to Dhaka from Gazipur to earn their livings

Possible reasons of highest speed at evening (6-7pm):

- ✓ Maximum office hour ends at 5pm, but because most people have no hurry that's why they prefer other routes. So, there's less vehicle in Dhaka-Mirpur Highway.
- ✓

Possible reasons of reduced speed at night (8-9pm):

- ✓ Trucks are allowed to enter Dhaka city after 9pm. So, during this hour vehicle like trucks tend to increase in this road section. Thus, traffic increases and speed decreases

MONDAY FINDINGS:

From t-test:

- Vehicle speed is higher at morning peak(8-9am) than noon/off-peak(11am-12pm)
- Greater speed at evening compared to morning peak and off-peak

Possible reasons of less speed at off-peak:

- ✓ Unlike Sunday people do not enter Dhaka city after passing weekend vacation. So, there is fewer vehicles in morning peak. Thus speed is higher in morning peak at Monday.

Possible reasons of highest speed at evening (6-7pm):

- ✓ Like Sunday maximum office hour ends at 5pm, but because most people have no hurry that’s why they prefer other routes. So, there’s less vehicle in Dhaka-Mirpur Highway.

WEEKEND FINDINGS:

From t-test:

- Speed at evening peak is lesser than morning peak and off peak periods

Possible reasons of slower speed at evening peak (6-7pm):

- ✓ Normally at weekend working institution are closed. So, vehicle speed is high in morning peak and off peak

- ✓ People enjoy and relax in weekends. So, they tend to stays at home in morning and enjoys the evening by going outside.
- ✓ Trucks and huge buses move all day-long in this curved route. So, at evening traffic congestion increases. Thus, vehicle speed decreases.

4.2.3. Comparison between the Days for a Particular Vehicle

For a particular vehicle, comparison between Sunday, Monday and weekend was carried-out. Comparison among the days for a particular vehicle is shown in Table 4.6.

Table 4.6: Comparison between the days for a particular vehicle.

Vehicles	**H_0:time1=time2 (P value) H_1:time1≠time2 (P value) (For equal variance)**	**Significance**	**H_0:time1=time2 (P value) H_1:time1≠time2 (P value) (For unequal variance)**	**Significance**
Car (Sunday vs Weekend)	0.0747	Significant	0.0826	Significant
Micro (Sunday vs Weekend)	0.0634	Significant	0.0607	Significant
Jeep (Sunday vs Weekend)	0.2258	Insignificant	0.2106	Insignificant

CNG (Sunday vs Weekend)	0.5327	Insignificant	0.5347	Insignificant
Motor Cycle (Sunday vs Weekend)	0.0061	Significant	0.0109	Significant
Pickup (Sunday vs Weekend)	0.4873	Insignificant	0.4906	Insignificant
Small bus (Sunday vs Weekend)	0.6737	Insignificant	0.6731	Insignificant
Bus (Sunday vs Weekend)	0.8699	Insignificant	0.8693	Insignificant
Truck (Sunday vs Weekend)	0.8185	Insignificant	0.8153	Insignificant
Car (Monday vs Weekend)	0.8997	Insignificant	0.8987	Insignificant
Micro (Monday vs Weekend)	0.0006	Significant	0.0005	Significant
Jeep (Monday vs Weekend)	0.0234	Significant	0.023	Significant
CNG (Monday vs Weekend)	0.0451	Significant	0.0444	Significant
Motor Cycle (Monday vs Weekend)	0.9147	Insignificant	0.9223	Insignificant
Pickup (Monday vs Weekend)	0.7973	Insignificant	0.7918	Insignificant
Small bus (Monday vs Weekend)	0.0988	Significant	0.1048	Insignificant
Bus (Monday vs Weekend)	0.0002	Significant	0.0004	Significant

Truck (Monday vs Weekend)	0.0001	Significant	0.0001	Significant
Car(Sunday vs Monday)	0.1052	Insignificant	0.1063	Insignificant
Micro(Sunday vs Monday)	0.1407	Insignificant	0.1422	Insignificant
Jeep(Sunday vs Monday)	0.2511	Insignificant	0.2557	Insignificant
CNG (Sunday vs Monday)	0.147	Insignificant	0.1363	Insignificant
Motor Cycle (Sunday vs Monday)	0.0501	Significant	0.043	Significant
Pickup (Sunday vs Monday)	0.7848	Insignificant	0.779	Insignificant
Small bus (Sunday vs Monday)	0.2356	Insignificant	0.234	Insignificant
Bus (Sunday vs Monday)	0.0003	Significant	0.0007	Significant
Truck (Sunday vs Monday)	0.0001	Significant	0.0001	Significant

There is a change in mean speeds for different vehicles on Sunday, Monday and weekend. And statically we find significant difference in speed data's for some particular vehicles when we performed the "t-test" for comparison between "weekend and Sunday"; "weekend and Monday" and "Sunday and Monday".

Comparing between weekend and Sunday we get significant difference in speeds for car, microbus and motorcycle. The possible reasons behind this may be- on weekend the road is not used by many people especially office goers which make the road free from various traffic and other obstructions. Thereby the drivers face no problem while speeding. So the drivers of car, microbus and motorcycle usually run at a higher speed than weekdays.

But the situation is different for Sunday. Sunday being the first day of the week the number of vehicles carrying a good number of people mostly office goers' increases rapidly, which creates a disturbance against the speeding for all vehicles. Many people from outside Dhaka spend their weekend in their hometown and return on Sunday for their job in this way. This large number of people is carried by mainly buses. Movement of these large vehicles in this single lane road prevents them to maintain their desired speed. It is also a very likely cause in reducing the speed of smaller vehicles.

Again on Monday, being the following day of the week the traffic flow comes to a usual pattern thereby an increasing speed is shown here. Still a significant difference results when comparing the Monday and weekend speeds data for microbus, jeep, CNG auto rickshaw, bus and truck. Particularly both for buses and trucks there is a huge difference in mean speeds between weekend and Monday. On that particular road section buses and trucks are always found heavy loaded. During weekdays their number increases with increasing demand by people both for transporting them by buses and supplying their daily needs by trucks. Although the road surface is in well condition but being a one lane road, less width of the lane, frequent curvature, delay to perceive vehicles coming from opposite direction by the drivers make them obligated to reduce their speeds for safety purposes. Due to unavailability of traffic police in certain location, a sudden stop or U-turn by a larger vehicle makes other vehicles also to gradually reduce their speed particularly on weekdays. But for weekend the drivers face less flow of traffic which helps to speed up their vehicles.

Chapter 5 Conclusion

5.1. Recommendation for Policy Makers

By analyzing the data and observed results, some recommendations have been drawn for the policy makers. Some general requirements have discussed along with the key findings from our analysis. Table 5.1 represents those recommendations.

Table 5.1: Recommendation for the policy makers.

Recommendation	**General Requirements**	**Major findings from our analysis**
Increasing road width	Huge buses and trucks block lane and Increases traffic congestion in Friday evening peak. So, overtaking tendency increases.	Weekend's evening peak is statically significant; its speed is lower than other time periods.
Need of Traffic police in particular time periods	At weekdays' morning peak and at weekend's evening peak traffic congestion is high. So, overtaking tendency is high.	For weekdays' morning peak and for weekends evening peak speed is statically significant compared to other time periods.
Speed bump	High speed car bus crashes with Low speed CNG auto rickshaw and truck, due to high difference in speed.	CNG cause variance in both Sunday and weekends and Truck cause variance in Monday.

Provide streetlight	Speeding tendency at evening and night in weekdays. Speeding tendency high at weekend's night.	For weekdays evening peak and night time and for weekends night time speed is statically significant compared to other time periods.
Providing attainable maximum speed limit sign	Because curves are prone to crashes. Vehicle moves at more than 50km/hr speed. So, speed should be around 40-50km/hr in curved road or Sometimes less than 40km/hr is desired for better safety.	From our data average speed in Sunday, Monday and weekend is 54.24, 52.52, 57.25 km/hr respectively.

If the policy makers adopt these measures, safety of that particular roadway section can be attained. Number of crashes can be reduced, easy traffic flow and regulated traffic flow can be achieved by following these steps.

5.2. Recommendation for Future Studies

Apart from the study that has been carried out, there is scope for further studies especially on the following area:

- Along with the speed data of vehicles, some other factors like overtaking tendency of the vehicle, seatbelt on driver's vest, indicator light, if the driver was talking over mobile phone or not, position of the vehicle were also observed.
- Studies can be done to improve the safety condition of that particular roadway on the above observed factors to reduce the number of crashes.

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